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Skills for Employment Tanzania

Training Manual

Fish Farming

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Swisscontact

Swisscontact works in Tanzania as a facilitator in skills development to complement government efforts in youth empowerment.

Economic, social, and academically disadvantaged youth are supported through tailor-made vocational skills development opportunities to increase their employment chances and entrepreneurship opportunities. Projects are guided by a unique youth and market-driven learning group model, which is focused on sub-sectors and jobs which have a potential to offer (self-)employment opportunities. These are agriculture/agribusiness, and other rural trades or services.

Swisscontact projects in Tanzania employ an Inclusive Markets system approach which considers the limits and opportunities of the existing vocational skills development system. Projects seeks to improve the prospects of self-employment among the youth through a sustainable and systemic contribution to improved access, relevance, and quality of vocational skills development. Since ownership is critical for sustainability, our projects apply a participatory approach which involves joint action planning with partners.

Introduction to the Small-Scale Fish Farming Course

This training course is designed to guide participants in small-scale fish farming, a growing opportunity for income generation in Tanzania. The course targets young people from rural and peri-urban areas, especially those with limited formal education and income. Many of these learners have never had access to practical skills training and may have little experience with structured learning.

The training equips them with practical, hands-on knowledge to become fish farmers or to work on existing fish farms. It also opens up related business opportunities, such as providing fingerlings, feed, or offering basic advice to other small-scale farmers.

This course is part of Swisscontact's effort to support self-employment and livelihood improvement through skills development that is simple, practical, and market-oriented. The emphasis is on learning by doing—80% of the training is practical and takes place on a fish farm, using real tools and resources to ensure the skills are job-ready and useful.

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1 Module 1: Introduction

Fish farming involves the controlled cultivation of fish species for various purposes, including food consumption (personal use) and income generation.

Fish farming in Tanzania has huge, untapped potential. Small-scale farmers engage mostly in semi-intensive and extensive farming of freshwater fish. Aquaculture production in Tanzania is characterized by numerous small earthen ponds, with the most cultivated fish being tilapia followed by African catfish.

Farming and related activities include managing the pond, caring for the fish, conducting administration and recordkeeping, then harvesting, processing and selling fish as a business. There are skills that a farmer should acquire to perform good practice in fish farming.

The skills needed for fish farming include:

- Administrative skills for record-keeping.
- Numeracy for calculations and measurements.
- Operational skills for tasks like feed making, formulation, and sampling.

In Tanzania, where fish farming is diverse, individuals may need skills in feed formulation for tilapia farming or operational skills for cage aquaculture in Lake Victoria.

There are several production systems for grow-out fish production; these include ponds, cages, tanks and raceways. However, this manual focuses on pond culture. Successful tilapia and catfish grow-out is dependent on use of quality seed, feed and application of best management practices.

This training will equip participants to either work on a fish farm or run their own ponds/farms. They could also potentially participate in secondary, related economic activities such as:

- Provide farming inputs for fish farming (suppliers)
- Provide basic extension services e.g. advice on fish farming and feeding
- Brokering between fish sellers and buyers

1.1 Benefits and Risks

1.1.1 Reasons and benefits of fish farming

There are many reasons why people may want to start farming with fish. The reasons and benefits include:

- **Meeting growing demand:** The increasing population in Tanzania has led to a rise in the demand for local protein sources, with fish being a key component of the diet. The current aquaculture production is of 18,717MT less than 4% of overall fish production. Tanzania has shortage of fish supply of >50% of her total demand 750,000MT p.a. (Ministry of Livestock and Fisheries, 2022)
- **Integration with other farming activities** such as livestock and poultry.
- **Food source for the family** and community, this provides access to food as source of protein.
- **Income generation**: fish farming serves as an income source through the sale of fish products.
- **Employment opportunities:** fish farming creates jobs for local communities particularly in rural and coastal areas employment opportunities across the value chain in hatcheries, farm operations, processing, and marketing.
- **Integration with agriculture:** fish farming can be integrated with other farming activities such as poultry, livestock keeping and horticultural crops.
- **Low environmental impact** through conservation of biodiversity by reducing fishing activities on the wild stock and their ecosystem.
- **Food security:** fish farming contributes to food security by providing a consistent and accessible source of protein for communities, particularly in regions with limited access to marine fisheries.
- **Reducing pressure on wild fisheries:** overfishing and depletion of wild fish stocks are concerns. Fish farming helps reduce the pressure on natural fisheries by providing an alternative to wild-caught fish thus contributing to the sustainability of fishery resources.
- **Adaptation to climate change:** climate change has affected natural fish habitats and availability. Fish farming provides a controlled environment, mitigating the effects of climate variability.
- **Meeting health standards:** fish is a nutritious food source that prevent certain diseases such as heart disease, stroke, arthritis, depression and anxiety and type 2 diabetes.

1.1.2 Risks and challenges of fish farming

Despite the many reasons to farm with fish, there are also risks and challenges to be anticipated when starting out with fish farming:

- **Natural disasters**:
  - Drought lead to reduced water availability in ponds that causes fish stress, reduce dissolved oxygen, and limit the space available for fish movement. This negatively affects fish health, growth, and overall production.
  - Floods lead to loss of fish stock, introduce pathogens, parasites and contaminants into fishponds, and damage pond infrastructure, cages and equipment.
- **Diseases and fish mortality**: Diseases outbreak has implication on reduced fish growth rates, decreased feed conversion efficiency, stress and aggressive behaviour of fish. Mortality directly results in the loss of fish stocks and if severe can result to economic loss.
- **Invasive species and predators** may prey on native fish species in the pond and lead to disruption of the natural balance, and potential decline of native species.
- **Theft** in fish farming pose a significant challenge to farmers, resulting in economic losses and disruptions to operations.

1.2 Fish Farming Value chain

The fish farming value chain encompasses various stages and activities involved in the production, processing, and distribution of fish and fish products. Here are the key elements of the fish farming value chain:



- **Suppliers:** these provide various goods and services to the fish farm and contribute to the economy by paying for these goods and services. Suppliers include:
  - **Hatcheries**: provide quality fish fingerlings or fry for stocking ponds.
  - **Feed suppliers**: supply nutritious and well-formulated fish feed.
  - **Equipment suppliers**: provide necessary equipment for fish farming operations such as pond construction materials, aeration systems, nets etc.
  - **Labour**: supply skilled and unskilled labour for various farm activities such as pond preparation, feeding, harvesting, and other day to day tasks.

- **Producers/Fish farms:**
  - Stocking and grow-out: raise fish from fingerlings to market size.
  - The producers work on production of fish according to the customer demand.

- **Processors:** these actors process fresh fish for sale and distribution, using different methods to extend the shelf life and market forms of the fish.
    - **Primary processors**: prepare fish for distribution and sale by cleaning, gutting, and basic processing.
    - **Secondary processors**: value addition and preparation of processed fish products (fillet, smoked fish, dried fish, fried fish and foiled fish).

- **Distributors:** these are the people who get the fish to the consumers.
    - **Wholesalers**: purchase large quantities of fish products for resale to retailers.
    - **Retailers**: sell fish products to end consumers.

- **Consumers:** purchase and consume fish products.

Support services to the fish farming value chain actors include research and development, extension services, regulatory agencies, and financial institutions.

1.3 Types of fish farming systems

Fish farming systems vary based on the production methods, intensity, and level of control over environmental factors. The different types of fish farming systems include**:**

Extensive fish farming	Semi-intensive fish farming	Intensive fish farming	Integrated fish farming	Cage culture	Recirculating Aquaculture systems	Aquaponics

Each one is discussed below:

- **Extensive fish farming:** involves minimal intervention in the natural environment.
    - **Ponds**: commonly uses earthen ponds.
    - **Stocking density**: low stocking density.
    - **Feeding**: relies on natural food sources present in the pond.
    - **Management**: low management input, allowing fish to grow at their natural pace.



- **Semi-intensive fish farming:** a middle ground between extensive and intensive systems.
  - **Ponds**: uses constructed ponds with some management practices.
  - **Stocking density**: moderate stocking density.
  - **Feeding**: supplemental feeding with formulated feeds.
  - **Management**: involves some level of water quality management and disease control.
  - **Examples**: Tilapia farming in lined ponds with supplemental feeding.



- **Intensive fish farming:** involves high stocking density and controlled environmental conditions.
  - **Ponds or tanks**: often uses tanks or raceways with controlled water flow.
  - **Stocking** density: high stocking density to maximize production.
  - **Feeding**: relies heavily on formulated feeds for optimal growth.
  - **Management**: requires strict water quality management, aeration, and disease control.
  - **Examples**: high-density catfish farming in recirculating aquaculture systems (RAS).



- **Integrated fish farming:** combines fish farming with other agricultural activities.
  - **Components**: includes the integration of fish with crops, livestock, or other agricultural practices.
  - **Examples**: Aquaponics (integration of fish farming with hydroponic plant cultivation).



- **Cage culture:** involves confining fish in floating cages or pens in natural water bodies.
  - **Setup**: cages are anchored or floating, allowing fish to grow in a controlled environment.
  - **Feeding**: fish are typically fed with formulated feeds.
  - **Benefits**: efficient use of water bodies, reduced land requirements.
  - **Examples**: marine or freshwater cage culture for species like salmon or tilapia.



- **Recirculating Aquaculture Systems (RAS):** a closed-loop system that recirculates and treats water for reuse.
  - **Setup**: tanks with controlled conditions, often indoors.

- **Feeding**: relies on formulated feeds with precise control over feeding rates.
- **Benefits**: minimizes water usage, maximizes water quality control.
- **Examples**: Intensive farming of species like tilapia.



- **Aquaponics:** Integrates fish farming with hydroponic plant cultivation in a symbiotic relationship.
  - **Components**: fish waste provides nutrients for plants, and plants help filter and clean the water.
  - **Benefits**: Sustainable and resource-efficient, with dual production of fish and plants.
  - **Examples**: Combining tilapia or other fish with the cultivation of herbs or vegetables.



1.4 Innovation in fish farming

Various innovations in the operation and equipment used in fish farming have been developed in recent years. These include:

1. Technological innovations
2. Mono-sex stocking
3. New natural feed production

1. New or improved technologies include:

- **Water quality sensors:** these are crucial for monitoring and maintaining optimal conditions in aquaculture systems. These sensors measure parameters such as dissolved oxygen, pH, ammonia, and temperature. They enhance fish health, growth rates, and overall farm productivity. They also help to prevent disease outbreaks and minimizes environmental impact by ensuring the responsible use of water resources.



- **Fish counter:** use various technologies, such as image recognition or acoustic methods to automatically count and monitor fish populations in aquaculture systems. Fish counters aid in stock management, allowing farmers to track growth rates, assess stocking densities, and optimise feeding practices.



- **Automatic feeders** use sensors to monitor fish behaviour and adjust feeding schedules accordingly. They dispense feed in precise amounts, reducing waste and optimising feed conversion ratios. They enable farmers to remotely manage feeding operations.



- **Other technologies:**
    - **Underwater drones:** these devices can be used to monitor fish health, inspect underwater infrastructure, and collect real-time data on environmental conditions.









- **Smart farming Apps:** mobile applications that provide farmers with real-time data, analytics, and insights for better decision-making.

2. **Mono-sex stocking** involves the introduction of only male or female fish into the aquaculture system, reducing the risk of unwanted reproduction. This technique enhances growth rates and improves feed conversion efficiency since energy is not diverted towards reproduction. It also allows for better control over population dynamics.

3. **New natural feed production**

- **Black Soldier Fly production**: Black Soldier Flies (BSF) are cultivated to produce larvae rich in protein and fat, serving as a sustainable alternative to traditional fishmeal in aquafeed. This innovation supports the development of more environmentally friendly and cost-effective feeds.
-





- **Azolla**: is a fast-growing aquatic fern that can be used as a natural feed supplement in fish farming. Azolla is rich in protein and other nutrients, providing a nutritious and sustainable feed source for fish. Its cultivation can also contribute to nitrogen fixation and improve water quality.



1.5 Fish species that are farmed

The most common fish species that are farmed in Tanzania are tilapia and catfish. They are farmed in different areas based on the market preferences and demand in different locations in the country. Each species has different characteristics as discussed in the table below.

	Tilapia	Catfish
Characteristics	Tilapias are hardy fish, adaptable to a variety of environments. They have a rapid growth rate and can tolerate diverse water conditions.	Catfish are hardy, adaptable fish that can tolerate a range of water conditions. They have a firm texture and a mild, slightly sweet flavour.
Yield	They are known for their high reproduction rates and efficient feed conversion.	Catfish farming yields can be substantial, and they are known for efficient feed conversion. Hybrid catfish, resulting from crossbreeding, is often preferred for commercial farming.
Advantages	**Adaptability:** Tilapia can thrive in a wide range of environmental	**Hardiness:** Catfish are resilient and can withstand suboptimal water conditions.

	Tilapia	Catfish
	conditions, including brackish water. **Fast growth:** Tilapia has a rapid growth rate, reaching market size relatively quickly. **Diet:** They are omnivorous and can be fed with a variety of feeds, including plant-based options.	**Efficient feed conversion:** They convert feed into flesh efficiently, contributing to cost-effective farming. **Versatility:** Catfish can be farmed in various production systems, including pond, raceway, and recirculating aquaculture systems (RAS).
Disadvantages	**Disease susceptibility:** Tilapia can be susceptible to certain diseases, especially in crowded or suboptimal conditions.	**Handling stress:** Catfish can be stressed by excessive handling, which may affect growth rates. **Disease risk:** Like any aquaculture species, catfish are susceptible to certain diseases, particularly in crowded or unsanitary conditions.
Market demand	Tilapia has a strong market demand due to its mild flavour, versatility in cooking, and relatively low cost compared to some other fish species.	Catfish has a strong market demand due to its taste and affordability. It is commonly consumed in various forms, including fillets and processed products. The market demand is influenced by consumer preferences for domestically produced and sustainable freshwater fish.

1.6 Permits and permissions

Some permissions and permits may be needed to draw water from public water sources such as rivers or lakes. Farmers may need permits to practice farming on different types of land; the Department of Agriculture may have to provide such permissions or permits for using land for agricultural purposes and for using water sources.

- **Water sourcing**: to access and utilize water for fish farming, individuals or businesses in Tanzania may need permits from relevant authorities. These permits ensure responsible and sustainable use of water resources. Farmers should adhere to the terms of their water permits, which may include restrictions on withdrawal rates, water quality monitoring, and environmental impact assessments. This may also relate to the discharge of water from fish farming into other water bodies such as rivers, streams, lakes or dams.
- **Land access**: obtaining permits for land use is essential for establishing fish farms. Farmers should secure the necessary permissions from local authorities or land management agencies. Compliance with land-use regulations and obtaining the required permits ensures that fish farming activities are conducted in authorized and suitable areas.

1.7 Responsible fish farming

- **Environmental responsibility**: waste, wastewater.
    - **Waste management plans**: Fish farmers in Tanzania should develop and implement waste management plans to handle fish waste and wastewater responsibly.
    - **Avoiding pollution**: Measures such as proper pond design, aeration systems, and regular monitoring help prevent water pollution. Sedimentation ponds can be used to settle suspended solids before releasing water.

- **Community responsibility**: community health, sharing water sources.
    - **Community engagement**: Fish farmers should engage with local communities to address concerns, promote transparency, and ensure that their activities do not negatively impact community health.
    - **Water source sharing**: If fish farmers are sharing water sources, collaborative agreements and communication with other users are crucial to avoid conflicts and ensure sustainable water use.

1.8 Family Health

Families often live on farmland and farm fish together. Their day-to-day domestic activities may have an effect on the land and on the fish bonds. Be aware of the following family health issues when operating a family fish farm.

- **Latrine positioning**
    - **Safe distance**: Latrines should be positioned at a safe distance from water sources, including fishponds, to prevent contamination. A minimum distance of 30 meters is recommended.

- **Community education**: Farmers should educate their families and neighbours about the importance of proper latrine positioning to prevent waterborne diseases.

- **Safe toilet practices**
  - **Promoting hygiene**: Encourage safe toilet practices, including the use of latrines, proper disposal of human waste, and handwashing. Hygiene practices contribute to overall community health.
- **Mosquito control (malaria prevention)**
  - **Environmental management**: Implement practices to control mosquitoes in and around fishponds, such as keeping pond banks clean, regularly cutting grass, and removing weeds.
  - **Community education**: Educate family members and neighbours about the importance of controlling mosquitoes to prevent malaria. This includes keeping the surroundings clean and removing potential breeding sites.
- **Health practices** (Controlling snails and mosquitoes):
  - **Pond maintenance**: Regularly clean and maintain ponds to remove snail habitats and potential mosquito breeding sites.

2 Module 2: Pond Design and Construction

A fishpond is a land-based water enclosure or a restricted body of water where fish are reared under extensive or semi controlled environmental conditions. Ponds must be constructed properly to allow suitable environmental conditions which provide the optimum growth of cultured fish species. Ponds are generally used in extensive fish farming systems and to some extent in more intensive production.

2.1 Types of ponds

Ponds are classified according to:

- **Mode of construction** (barrage ponds, diversion ponds, sunken ponds)
- **Materials** used in construction (concrete, earthen, tarpaulin, polytank)
- Intended **usage** (nursery pond, grow-out pond, broodstock pond, quarantine pond, conditioning pond, sedimentation pond)
- **Drainability** (drainable or undrainable)

2.1.1 Below/in-ground ponds

There are two types of below or in-ground ponds. These are earthen ponds and barrage ponds.

Earthen ponds

- These are traditional structures for fish farming.
- The location for earthen pond is limited to area where there is clay soil which can hold water or underground water.
- The earthen pond is an excavated area of an average depth of 1.2 – 1.5m.
- The dug-out soil is used to construct strong dikes round the pond to prevent soil erosion and flooding during rainy season
- The water of an earthen pond is generally filled to 1.2m deep.
- Earthen ponds may be lined with HDPE plastic sheeting which has various advantages.



Earthen fishpond (Source Aquacom 2023)

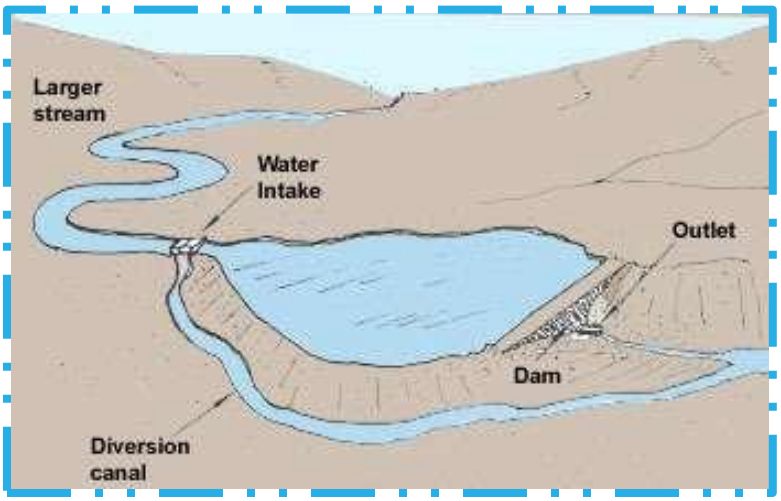


Earthen fishpond being lined with HDPE plastic sheeting (Source YPO 2025)

Barrage ponds

- These ponds are generally constructed along the main path of flow of stream or river water.
- Water enters the pond through an inlet point, and an outlet is constructed to allow water to flow out of the pond.

- The advantage of this pond is its low construction cost and enough water all through the cultivation period.
- However, these types of fishponds are usually associated with high risk of flooding particularly during the rainy season and this may result into losses of cultured fish.
- To protect this, a dike from floods, a spill way should be constructed.



Barrage Pond in a V shaped (Source: FAO 2010)

2.1.2 Above ground ponds

There are different options for above ground ponds including constructed, immovable concrete ponds, and movable tanks.

Concrete ponds

- A Concrete fishpond is usually constructed with concrete and additionally reinforced with concrete to make it stronger.
- Construction of concrete fishponds is usually done by aquaculture engineers.
- Concrete fishponds are constructed using cement, blocks, and aggregate of appropriate ratio.
- Concrete fishponds can be constructed into different shapes and sizes.
- The shape of the concrete pond can be round, rectangular, square, or cut corner while the size of the pond can be large, medium, or small depending on the usage and the density of the fish to be cultured.



Concrete fishponds (Source Aquacom 2023)

Movable plastic tanks

- The plastic pond is the plastic material that allows the control of water that provides the right conditions for fish growth.
- Moving plastic tanks for fish farming include open – top- vertical tanks.
- These tanks come into different sizes and shapes. Depending on the intended use and density of the fish to be cultured.



Different design of movable plastic tanks (Source: Aquacom 2023)

2.2 Site evaluation and selection

The success of an aquaculture operation largely depends on the proper selection of the site to be developed. Factors to consider when selecting a site include land, soil type and water as well as economic and social factors.

Several problems could arise if you do not choose a good place for your farm.

- Your pond may not hold water for long enough to raise fish
- Ponds may flood, causing fish to escape or unwanted fish to enter
- Pond walls may collapse if soil type is not good
- Ponds may not drain completely
- Harvesting fish may be difficult
- Your water source might be poor, causing fish to die or not grow well
- Your pond may not produce enough live food for the fish
- Your pond may be inaccessible, creating logistical challenges
- Yields may be poor, leading to reduced profits

2.2.1 Factors to consider in site selection

- **Accessibility**

  The site for pond construction should be easily reached by vehicles especially large vehicles such as pickup trucks for easily transportation of materials to and fish from the farm.

  Road infrastructure should be well and clearly addressed.

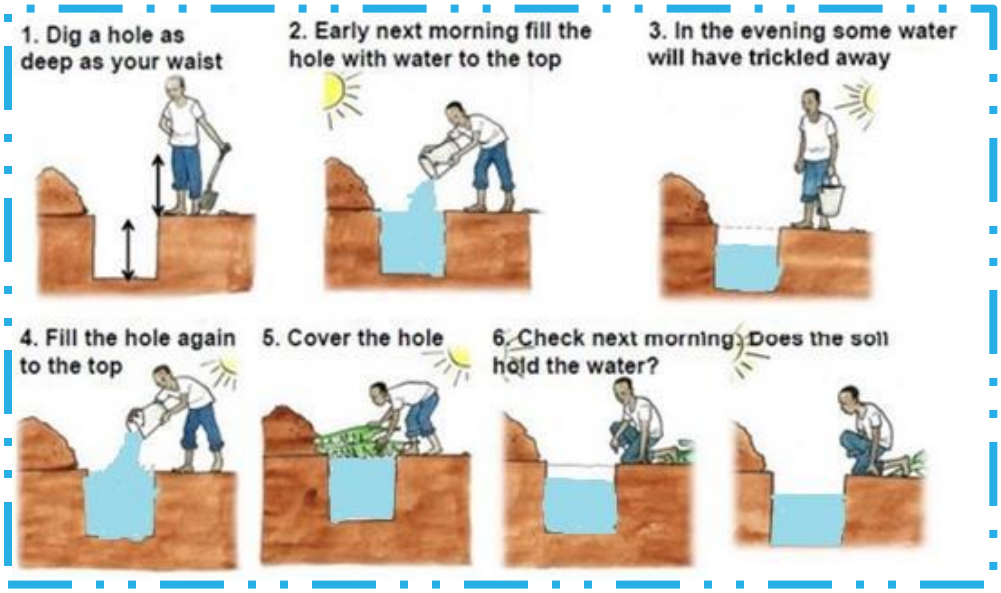
- **Soil type**

  Soil type is the most critical physical characteristic related to pond construction. Soils are made up of a mixture of living organisms, organic particles (decayed plant and animal materials), mineral particles (such as sand, clay, stones or gravels which have been broken down from larger rocks), water and air. Soils that hold water for extended periods and minimal water loss through evaporation are good for fishpond construction.

  - Soils are generally classified as clay, silt or sand. Clay soils do not allow water to pass through easily, while sandy soils allow water to pass through easily.
  - Soils that consists of too much sand or clay are not suitable for pond construction.
  - Topsoil is high in organic material and should not be used to construct pond dikes.
  - Soils with 20 – 35% clay are the best for building ponds.
  - Use soils with a high percentage of clay (30-35% or more) to build pond dikes and trenches.
  - The requirements for construction a fishpond depend on the type of the soil.
  - For concrete tanks, the soil should be strong enough to hold the foundation of the tanks.
  - For earth ponds, consistency and permeability of the soil type is essential for constructing strong dykes.

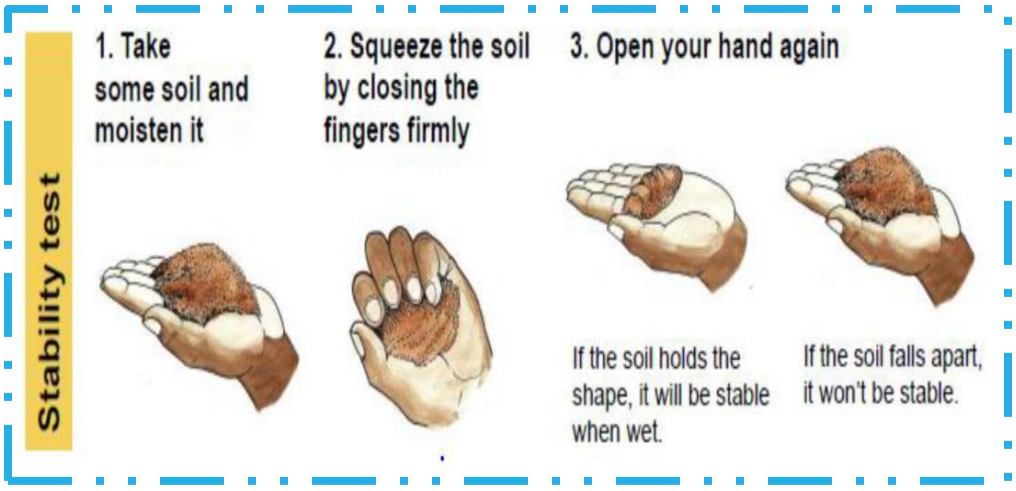
- Soil type should also have right chemical properties for good water qualities.
- The following methods can be used to determine the right soil for fishpond construction.

The dig-and-fill test



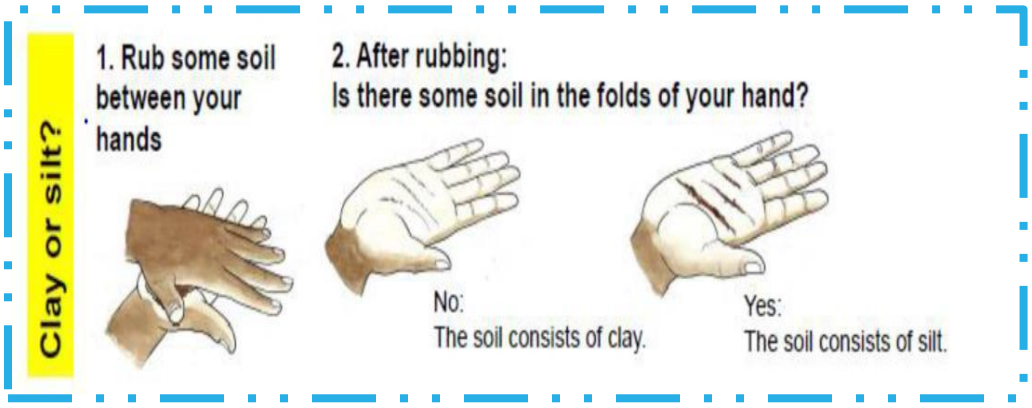
The permeability test of the soil (Source: Agyakwah et al., 2020).

Squeeze-the-ball test



Squeeze-the-ball test of the soil (Source: FAO, 1984)

Rub - the – soil test



The field test of soil seepage (Source: Agyakwah et al., 2020).

- **Water sources**

  Physical, chemical, and biological water quality properties must be considered during site selection. Your pond must be near a good, year-round supply of water such as a river, stream, lake or reservoir, canals, underground water source or rainwater.

  - Rainwater is safe for fish farming, but ponds which rely on rainwater will dry up during drought or the dry season.
  - Lake or reservoir water is usually good, but it may have wild fish in it
  - Water should not be too muddy water from a stream.
  - Check the seasonal fluctuations in the quantity of available water.
  - Water can be supplied via channel, storage tank or pipeline by gravity or by pumping to the ponds. The most economical method is by gravity.
  - The distance between the source of water and the pond should be minimal to reduce the cost of pumping the water to the fishpond.
  - Water should not smell or taste bad or be milky or brownish in colour.
  - Cover the mouth of the inlet pipe with a mosquito net to prevent wild fish from entering the pond.
  - Consider other users - there should be peace and order among all users of the water source and no competition for such an important resource in the community.

Advantages and disadvantages of various water sources:

Source	Advantages	Disadvantages
Springs	• Constant temperature • Few or no known pathogens	• One must use pumping machines to pump the water onto the farm - this can increase your cost of production.
Wells (pumped or artesian)	• No predators • Pathogens hardly present	• Tends to have high proportions of dissolved gases like carbon dioxide. Low in oxygen.
Rivers, lakes and streams, run-off or rain.	• Large volumes of water • Inexpensive	• Easily contaminated, predators can easily come for fish. There could be high level of pollutants and suspended organic matter.
Groundwater	• Inexpensive • Few predators	• Very difficult to drain, harvesting is difficult, and organic materials can build up very quickly.
Pipe-borne	• Very high quality • No predators or pathogens	• Chlorine and other added disinfectants can be toxic to fish. • It is expensive to use treated water for fish farming. • It can be unreliable due to frequent shutdowns.

- **Water discharge**:

  Health and safety: Any water overflowing or being discharged from fishponds must be carefully managed so that it does not have any negative impact on the community (e.g. polluting drinking water sources) or the environment.

  Use in agriculture/horticulture: Wastewater from ponds has varying degrees of nutrients in it from fish waste products, from fish feed and from water nutrients. This water can be a valuable resource as fertilizer and water for growing horticultural crops. Careful

planning of the channels or streams of wastewater to channel it into irrigating crops should be considered when constructing pond in order to use this useful byproduct of fish farming.

- **Landscape; slope**

  Consult with an aquaculture expert or Extension Officer to verify that the proposed site is suitable for production. Consider the factors below.

  - Slope of land and pond design
  - Sloping land has shallow soil; flat land usually has deep soil
  - Land with a steeper slope holds fewer and smaller ponds
  - The pond bottom must have sufficient slope for good drainage
  - If the slope is too gentle, the pond will not be easily drained
  - If the slope is too steep, it may be too shallow at one end or too deep at the other end
  - In general, flat land with a gentle slope is most suitable for pond construction
  - The number and sizes of ponds to be constructed
  - Availability of good quality water sources
  - Amount of water needed for each pond in your farm
  - Climate and rainfall patterns
  - Environment - do not locate your farm in a wetland or floodplain of a river
  - Proximity to customers and farm workers

- **Natural predators**
  - Predators vary from area to area, and they must be known before constructing a fishpond.
  - Understanding the type of existing predators is important to facilitate pond designing and construction.
  - Assessment of fish predators prior to pond is also essential to incorporate prevention measures such as nets during pond construction.
  - Common fish predators are birds, frogs, insects, snakes, and large lizards (monitors).

- **Community issues**

  Check that the area identified for the pond location does not have any land use conflicts with the local community e.g. cattle grazing, transversal rights and so on. If such exist, then negotiate a common agreement on the use of the land with the local community or authorities.

- **Economic and social factors**

  The following economic and social factors should be considered when selecting a pond site:

  - quantity and quality of available manpower
  - social and religious customs
  - consumer habits and their demand for fish products
  - availability and cost of construction materials and equipment
  - transportation, communication and other infrastructural (e.g., electricity, etc.) facilities
  - security of tenure
  - industrial and agricultural planning in the area
  - accessibility and nearness to markets.

2.3 Pond design and Construction

Ponds can be constructed in different shapes and sizes as there is no recommended standard shape or size. Ponds can be round, rectangular or square, large, medium or small. Choose the shape and size that that is most suitable to the location and the operational capacity of the farming team. Consider the following guidelines:

***Pond size*:** The size of a prospective fishpond should be based on the purpose of the pond. Smaller ponds are easier to manage. A minimum size of 300 m2 is recommended for small-scale commercial production.

***Shape*:** Rectangular ponds are usually the easiest to build and manage. However, ponds must sometimes be built with irregular shapes to fit the topography and shape of the available space.

Depth:

- The pond depth is usually in the range 1–2m, depending on topography, water source and soil.
- Ideally, pond water depth should be 0.8 m at the shallow end and increase gradually to 1.2 m at the deep end, with 30–50 cm of freeboard.
- Ponds entirely dependent on seasonal rains must be deeper (i.e., 1.0–1.5 m) in order to hold water longer into the dry season.
- Maintaining the right depth of water helps to regulate temperature, inhibit growth of underwater plants and maintain dissolved oxygen (DO) levels at the pond bottom.

Slope of the pond bottom: The pond bottom must have a slope sufficient for good drainage. In general, slopes with a drop of 2 cm for every 10 m along the pond bottom are appropriate. If the slope is too gentle, the pond will not be easily drained. If the slope is too steep, it may be too shallow at one end or too deep at the other end.

If your soil has a reasonable percentage of clay (20-30%), you can construct the dikes with 2:1 slope (2 m horizontally for every 1 m vertically). If your soil has a low percentage of clay (20% or less), you should increase the dike slopes to 3:1 to prevent slumping and erosion of the pond banks.

2.3.1 Construction of earthen ponds

There are different stages to the construction of earthen ponds. The include preparation of the land, then the actual digging/construction and finishing by installing relevant equipment.

1. **Preparation**

Step	Action
1	**Site clearing** • Clear and remove all trees and other vegetations within the proposed site. 
2	**Measurement and pegging** • Draw lines according to the layout, design, and dimensions of the pond. • Pegging and fixing stakes or posts to mark the length and width of the pond.

Step	Action
	• Stretch out string between the tops of pegs and posts to mark the complete profile of the pond (dikes, inlets and outlets. 

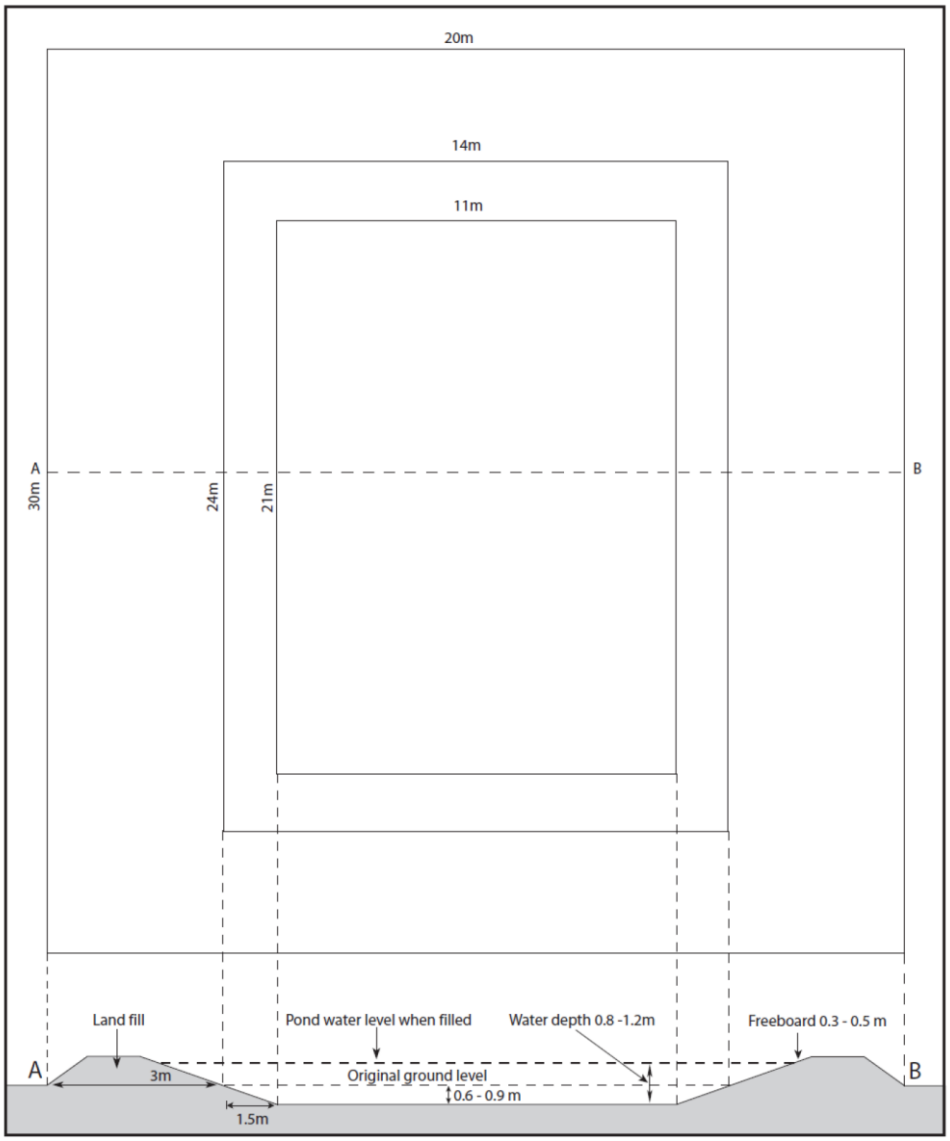
3	**Excavation or Digging**
	• The excavation or digging processing is carried out within the marked profile of the fishpond.
	• Excavation can be done either mechanically or manually.
	• The pond depth is usually in the range 1–2 m, depending on landscape, water source and soil.
	• Ideal pond has a slope of 20cm between the shallow and the deeper ends of the pond.
	• The construction approach you choose will depend on the nature of the land.
	• **Digging from the deeper end allows you to**:
	  ○ Insert your outlet easily.
	  ○ Prevent flooding during construction.
	  ○ Set out the slope effectively.
	• The workers should start by digging all around the deeper end and using the excavated soil to form the dike.
	• **Digging from the middle allows you to**:
	  ○ Spread the soil material evenly.
	  ○ Make construction less tedious.

Step	Action
4	**Construction of dikes** • Pond dikes are the most important part of earthen fishpond construction. • After excavation, bring back the surface soil to cover the waste material and the dike top. • Ideal pond dike has a width of 2 – 3m. • Compact the pond dikes to minimize water going through, and to re-enforce the dikes from sliding off or flaking out. • Pond dikes can be compacted by hand or a compactor machine. • Plant grasses or vegetable to protect pond dikes from soil erosion.  The complete height and width of dike

Digging guidelines:

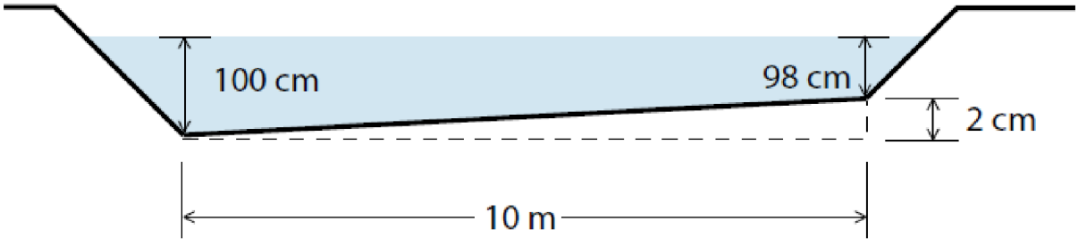
The workers should be organized in a row with shovels and digging forks. The central 21m x 11m area is dug out first, and the excavated soil is used to build the dike. The digging begins at the shallow end of the pond, at the string marking the central area.

The pond is dug to about 20cm deep at the shallow end, increasing gradually in depth towards the other end. At the deepest part, the string marking the central area should be about 30cm deep. As the soil is dug out, it should be placed in the space marked out for the dike, between the 24m x 14m rectangle and the 30m x 20m rectangle.

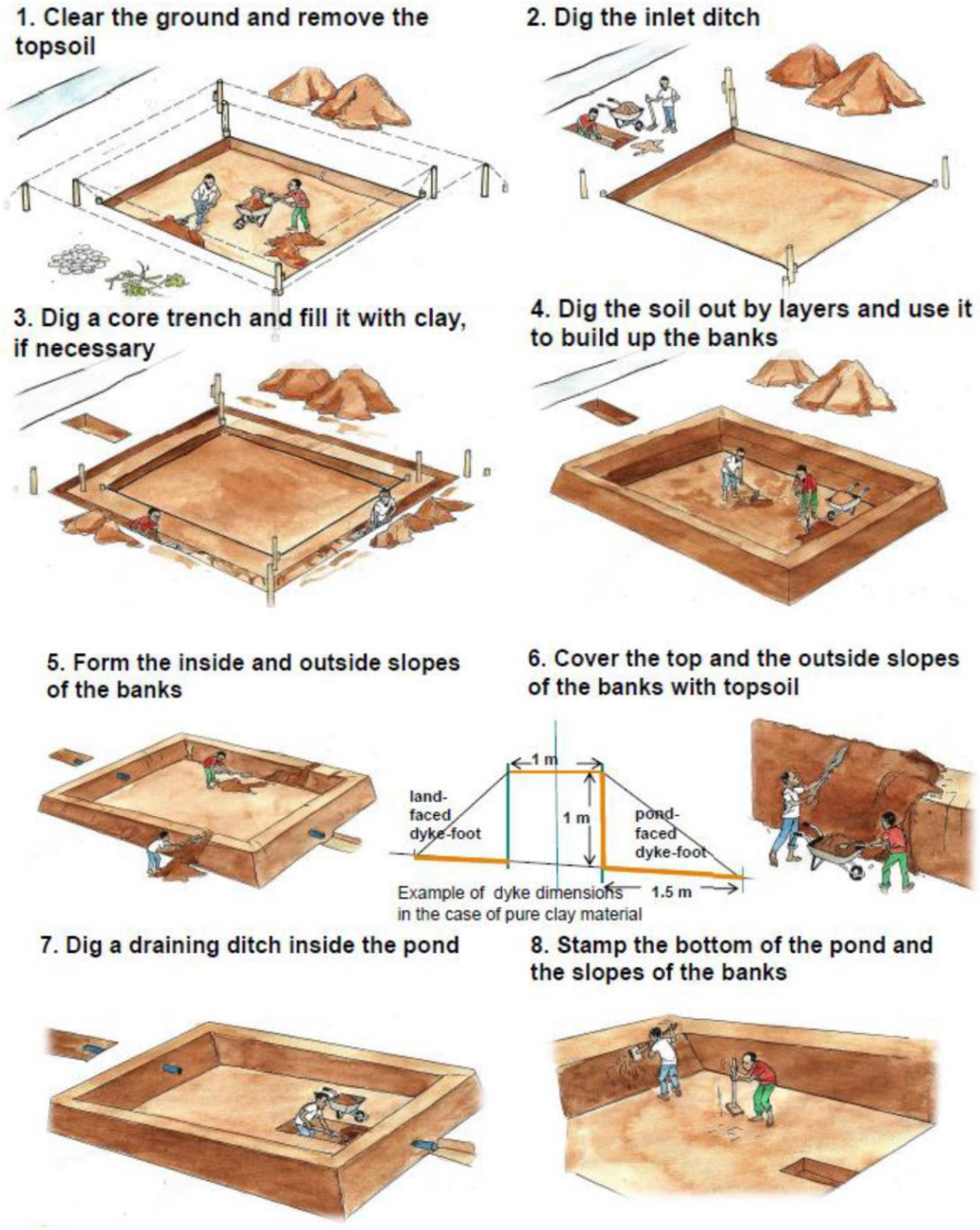


Ground plan for a hand-dug pond (top) and cross-section of pond along A-B (bottom)

(Source: Nandlal and Pickering, 2004)



The sloping of the pond.



2.3.2 Pond lining

In traditional fish farming, earthen ponds are commonly used because they are affordable and easy to construct. However, they often suffer from water loss through seepage, soil erosion, and difficulty in managing water quality. One important innovation that helps solve these problems is pond lining using black plastic sheeting (also called geomembrane liners).

What is a pond liner?

A pond liner is a waterproof material placed along the bottom and sides of a fish pond to prevent water from seeping into the soil. The most common type used by small-scale farmers is **black plastic sheeting made from high-density polyethylene (HDPE)** or similar materials.

Benefits of using black plastic sheeting

- **Reduces water loss**: Prevents seepage, helping the pond hold water longer, even in sandy or loose soils.
- **Improves water quality**: Makes it easier to manage pH, fertilisers, and nutrients because the soil is sealed off.
- **Easier cleaning and maintenance**: The smooth surface prevents the buildup of mud and is easier to clean.
- **Prevents burrowing animals**: Blocks crabs and other animals from digging through pond dikes and causing leaks.
- **Extends pond life**: Protects Pond walls from erosion and collapse.
- **Increases productivity**: With better water control and reduced losses, fish grow faster and healthier.

Materials and preparation

- **Black plastic sheeting or HDPE liner** (minimum 0.5mm thickness for small ponds; thicker sheets for larger ponds)
- **Soft sand or cloth layer** (optional) under the liner to prevent sharp stones or roots from puncturing it
- **Fixing materials**: Nails, sandbags, or weights to hold the edges of the liner in place around the pond

Steps to install a pond liner

1. **Construct the pond**: Shape the pond with gentle slopes and smooth sides, removing sharp objects from the soil.
2. **Prepare the base**: Add a thin layer of soft sand or cloth at the bottom for protection if needed.
3. **Place the liner**: Spread the black plastic sheeting across the entire pond bottom and up the dikes, allowing extra material at the edges.
4. **Fix the edges**: Use weights, sandbags, or bury the edges in soil to keep the liner from shifting.

5. **Check for holes**: Before filling, inspect for any punctures and patch them if necessary.
6. **Fill with water slowly**: Fill the pond while gently adjusting the liner to avoid tearing.

Limitations and considerations

- **Initial cost**: Higher than traditional earthen ponds, but cost is recovered over time through better fish survival and lower water loss.
- **Risk of damage**: Liners can be punctured by sharp tools, animal claws, or UV exposure if not covered properly.
- **Maintenance**: Check regularly for tears or holes, especially near the edges.





Pond lining (Source YPO 2025)

2.3.3 Installing pond inlets

- A water inlet is required to fill the pond with water.
- Place the inlet at a point nearest to the water source. This will usually be at or near the shallow end of the pond.
- An inlet pipe should be 25 – 50mm (1 – 2 inches) in diameter, and long enough to reach across the dike from one side to the other.
- Once the position of the inlet is decided, dig a ditch across the dike.
- This should be dug to a level that allows water to flow from the channel or pipe connecting the water source and the pond.
- The inlet pipe can be placed in the ditch in the dike, and the dike rebuilt over it.
- Alternatively, if an open channel is used to allow water into the pond, erosion of dike soil can be prevented by using roofing sheets or hard plastic to line the bottom of the channel.

2.3.4 Installing the pond outlet

- The water outlet is made at the bottom of the dike at the deepest end of the pond.
- The outlet is usually made from High Density Pressure Polyvinyl Pipes (pressure pipes) and should be at least 100 mm (3.94 inches) in diameter depending on the size of the pond

It is sensible to dig a ditch through the area demarcated for the outlet before the dike is built. It should reach from the deepest part on the inside of the pond through the dike to a lower level outside of the pond to allow water to drain from the pond.

If the outlet is below ground level on the outside of the pond, it will be necessary to dig a drain to take the water away from the outlet.

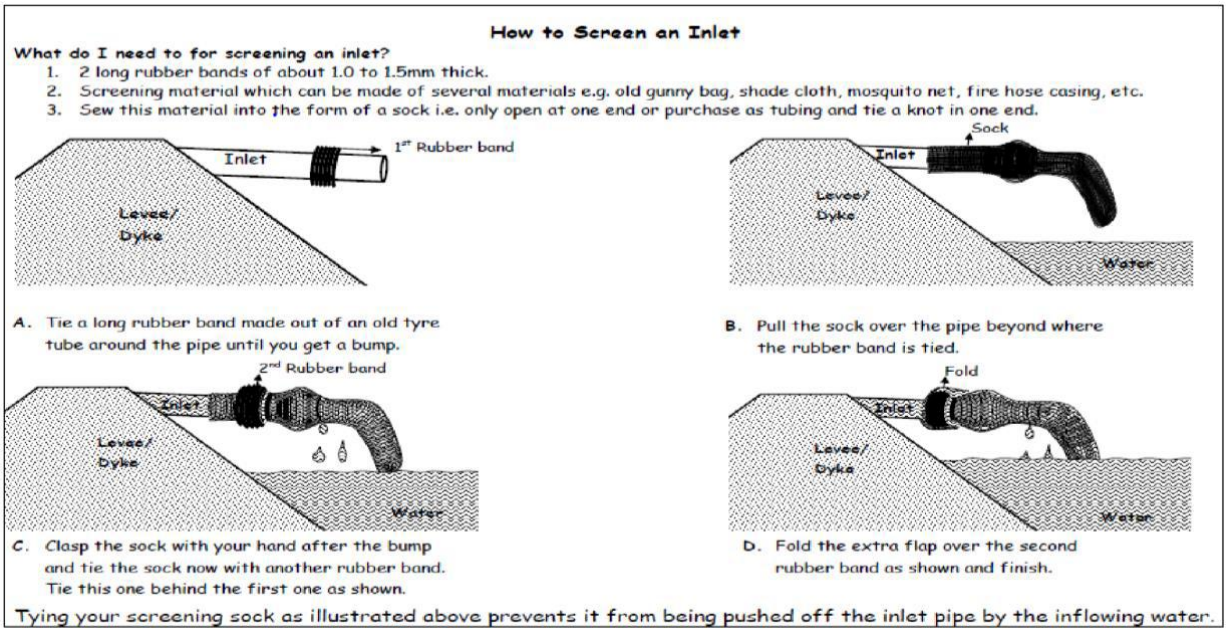
Sizes of outlet pipes for ponds with monks

Pond Size (m2)	Inside Diameter of Pipe (cm)
< 200	Not less than 10
200 – 400	10 – 15
400 – 1,000	15 – 20
1,000 – 2,000	20 – 25
2,000 – 5,000	25 – 30
> 5,000	40 or more

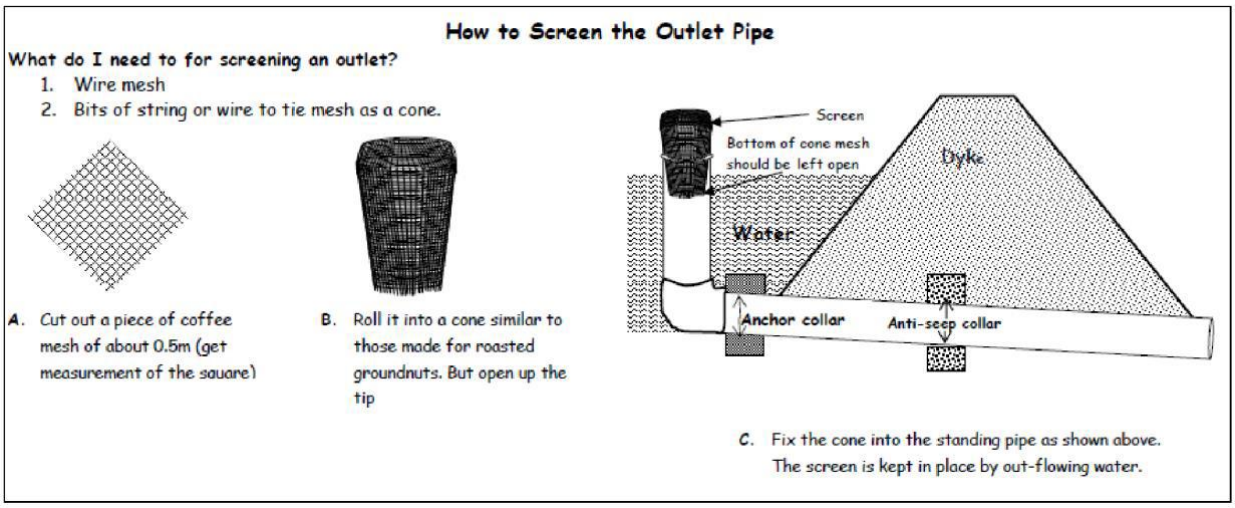
Source: FAO, 2002

Screening pond inlets and outlets

Screens must be placed on the inlet, outlet and overflow pipes to prevent fish from escaping from the pond and to stop other fish and unwanted organisms from entering the pond.



How to Screen the Inlet Pipe (Source: Isyagi et al., 2009)



How to Screen the Outlet Pipe (Source: Isyagi et al., 2009)

2.3.5 Installing overflow structures

A pond overflow structure is required to control the water level in the fishpond particularly during the rainy season. An overflow pipe is placed at the freeboard level to allow out excess water from the pond. The design of overflow structure differs depending on the type of the fishpond constructed.

- If there is too much water in your pond, some may flow over the banks. This may wash the banks away and some of your fish may get out.
- You can use an overflow to keep the water in your pond from rising over the banks.
- It is best to place your overflow in the bank at the lower end of your pond right above the outlet so that the water that overflows can run off in the outlet ditch.

2.3.6 Filling the pond

There are different methods that may be used to fill the pond once it is constructed. These methods include:

- ***Gravity flow*:** Ensure that the level of the drainage canal is at least 30cm below the level of the pond bottom and at least 1.5m below the level of the inlet canal. Canal slopes generally range from 0.25 to 1%, but for large ponds the slope should be about 0.5%.

  Have in place a filtration system, to filter incoming water.
- ***Pumping*:** Avoid pumping water if there is a cheaper way of doing it. Pumping increases the cost of operation. Use the most economical water source.

2.3.7 Cost of constructing an earthen pond

The cost estimates for earthen pond construction depends on the location and the size of the fishpond to be constructed. In most case the following are costs associated with construction of an earthen pond

Cost of constructing an earthen pond (*use this table to populate***)**

S/No.	Description	Quantity	Rate	Total cost
1	Land acquisition			
2	Consultation fee (site visit & design)			
3	Labour cost for site preparation			
4	Tape rule/measing tape			
5	String/twine			

S/No.	Description	Quantity	Rate	Total cost
6	Payloader/bulldozer/excavator			
7	Plumbing works			
8	Sand and gravel			
9	Compactor machine			
10	Shovels, hammer and hoes			
11	Wheelbarrows			
12	Administrative office and store			
13	Carpenter's level			
14	Cement			

2.3.8 Construction of concrete ponds

There are different stages to the construction of earthen ponds. The include preparation of the land, then the actual digging/construction and finishing by installing relevant equipment. All the activities in constructing concrete fishponds are explained below.

Step	Action
1	**Preparation** • Like the earthen pond, the site must be cleared, lined, and pegged. • Excavation before constructing the foundation is essential. • The extent of excavation involved varies depending on the slope/landscape of the proposed site.

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td></td><td>

During excavation, the topsoil layer containing humus and other organic matter should be totally taken off followed by levelling.
Line up and repeg the excavated area to get exactly pond dimensions as designed.

<table>
<tr><td></td><td></td></tr>
<tr><td>Excavation</td><td>Pegging after excavation
(Source: Aquacom 2023)</td></tr>
</table>
</td></tr>
<tr><td>2</td><td>
Materials assembly

A small assortment of construction materials is required for the construction of a concrete fishpond.
Cement bricks, cements, sand, gravels, wire mesh, Iron rods, nails, binding wires, pipes and plumbing accessories, woods, and water

<table>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">Example of materials needed for constructing concrete tank.</td></tr>
</table>
</td></tr>
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Step	Action
3	**Equipment assembly** • Concrete mixer, excavator, compactor machine, wheelbarrow, measuring tap, backets, rake, safety glasses, protective gloves, hoes, shovels, hammer, and carpenter's level (spirit level)
4	**Building the foundation** • The foundation for concrete pond can be made of stone, concrete or cement blocks.   Foundation preparation after excavation and levelling.
5	**Backfilling** • Excavated soil is returned to fill the pond after preparation of the foundation. • Proper compaction of the soil is required to strengthen the base structure.
6	**Wall works** • This involves elevating the wall with the cement blocks and the application of cement mortar. • Watering of the built wall is required to strengthen the walls.

Step	Action
	
	Complete concrete fish tank after wall works
7	**Wall reinforcement** • Wall reinforcement is necessary to increase its strength. • The main wall reinforcement is steel reinforcement and fixing, and wire mesh reinforcement after walling.
	 
	Steel rod reinforcement before complete wall works
8	**Plumbing work**

<table>
<tr><th>Step</th><th>Action</th></tr>
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The installation of water controlling structures is done before concrete and plastering work.
In most case, PVC pipes are used for installation of the water controlling structures. The size of the PVC pipes used differs with the size of the concrete pond and the amount of water to be controlled.
Inlet structure: This is the distribution channel of water in the fish. The inlet is placed above the wall, and it must be installed with a gate valve to control in coming water. The nature of inlet depends on the type of pond or culture facilities.
Outlet structure: The outlet of the concreate fishpond is positioned the centre of the floor. This will enable easy and effective washing and cleaning of the tank.
Overflow structure: The overflow outlet is positioned closer to the wall so that the upstand pipe could be supported by the wall if necessary.

</td></tr>
<tr><td>9</td><td>Concrete work

The first stage is to level the base of pond.
The size of the concrete will depend on the size of the pond and the volume of the water to be filled.
The mixing ratio used for concrete (cement, sand, gravels, water) depends on the recommendation from professional engineers.



Concrete activity before and after completion</td></tr>
<tr><td>10</td><td>Plastering works</td></tr>
</table>

Step	Action
	• The outside and inside of the pond walls must be plastered. • Internal plastering is done after reinforcement of wire mesh. • Plastering involves two stages: the initial plastering and subsequent cement rendering making up to a finished thickness of approximate 20mm. • To improve the watertightness of the walls, a water sealant compound such as waterproof is used in the internal plaster.
	
	Plastering works after wire mesh reinforcement
11	**Installation of storage tanks** • Storage tanks are necessary in the fish farm to store water which can be used as a backup water supply if needed. • On the other hand, if the main source of water is municipal, water should be stored before use to allow the elimination of chemicals used to treat the water. • The size of the storage tanks will depend on the capacity of the farm.
12	**Landscaping** • After the construction works, ensure that the area in the vicinity of the structure is kept free from debris and heaps of earth.

Step	Action
	• Level the surrounding area of the structures and provide grass turfing or stone pitching where appropriate to prevent possible damage due to erosion. • The tank is liable to damage by impact from heavy objects such as large boulders, falling trees and other heavy articles. Therefore, remove any such objects that may endanger the structure.

2.3.9 Cost of construction a concrete pond

The cost estimates for concrete pond construction depends on the location and the size of the fishpond to be constructed. In most case the following are costs associated with construction of a concrete pond

Costs of construction

- Costs of constructing a concrete fishpond come from the following major works: Permits, pond layout and design, land clearing, earthworks, water systems installations and construction services.
- These costs will differ from site to site depending on several factors such as nature of the land, availability of manpower, etc.

Costs of equipment and materials

- Equipment and materials are required during the construction of concrete fishponds.
- The costs vary according to the size of the fishpond to constructed.

Concrete fishpond construction and equipment costs *(use this table to populate)*

S/No.	Description	Quantity	Unit cost	Total cost
1	Land acquisition			
2	Permits fees			
3	Consultation fee (Site visit, layout & design)			

S/No.	Description	Quantity	Unit cost	Total cost
4	Site preparation			
5	Excavation cost			
6	Water Holding tanks			
7	Tape rule			
8	String/Twine			
9	Plumbing works			
10	Constructing materials Sand, sand & gravel			
11	Compactor machine			
12	Shovels, hammer & hoes			
13	Wheelbarrows			
14	Administrative office & store			
15	Carpenter's level			
16	Construction services			
17	Plumbing accessories			

3 Module 3: Pond Preparation

All ponds, whether new or already in production, need to be properly prepared before starting a new batch of fish culturing. While some elements are the same between new and existing ponds, there are slight, important differences that need to be followed based on the status of the pond.

3.1 New Ponds

Every pond must go through a stage of cleaning and dressing to make it suitable for fish growth. The cleaning and dressing processes involve clearing and burning weeds, disinfection, filling and fertilizing.

3.1.1 Preparation of new earth ponds

- **Liming**

Lime is used to disinfect ponds and neutralize acidic pond water. When quicklime (CaO) absorbs water, it transforms into calcium hydroxide $Ca(OH)_2$, which raises pH and draws oxygen from the water. The effect of quicklime is to kill animals and plants, and any pathogenic bacteria.

Liming is done a week prior to the fertilization of the pond. However, it can be done during the culture period if recommended.

The dose of lime is determined by the pH of the soil; it is therefore important to know the status of soil pH of the pond before applying lime.

Apply the appropriate quantity of lime as shown in the table below or 1kg of lime per $5m^2$ for new ponds.

Lime application rate(g/m^2) depending on soil condition

Soil PH	Soil condition	Liming material (g/m^2)		
		Quick lime (CaO)	Hydrated lime [Ca (OH)2]	AGRIC LIME
4 - 5	Highly Acidic	150	150	200

Soil PH	Soil condition	Liming material (g/m^2)		
		Quick lime (CaO)	Hydrated lime [Ca (OH)2]	AGRIC LIME
5 – 6	Acidic	100	100	150
6 – 6.5	Low acidic	60	60	60
6.5 -7	Neutral	20	20	40
7 -9	Highly alkaline	-	-	-

Follow these steps when liming a pond:

Step	Action
1	Put on appropriate farm attire (i.e., overalls, safety goggles, gloves and nose mask).
2	Apply the appropriate rate of lime. More lime may be required in acidic soil areas.
3	Broadcast (spread) lime according to the direction of the wind, ensuring that it covers all surfaces of the pond. Lime should be left in the pond for at least 24 hours before filling the pond. Leave water in the pond for at least two weeks before stocking.
4	Do not apply lime on a rainy day, since the concentration could be diluted, making it ineffective.

- **Filling**

After drying and liming the pond should be blocked and filled with water. Consider the following when filling your pond.

- Before filling the pond make sure that the outlet is tightly closed.

- Ensure that the inlet and outlet pipes are covered with nylon netting. This will prevent the entry of wild fish fry or eggs, river snails or small crustaceans like crabs, prawns or any other unwanted organisms.
- A day after pond liming, fill the pond with water to a depth of 1.2m.
- Fill the pond slowly to avoid the collapse of pond dikes due to uneven wetting.
- If the pond is filled by an overhead pipe, place a stone/gravel/block/wood at the bottom to break the fall of the water onto the floor of the pond.
- New ponds often seep when filled with water for the first time because soil partly take up the water. Therefore, it is important to keep adding some water for several weeks and slowly the pond should start to hold the water.
- Ensure that water does not flow out of your pond.
- There should be enough clean and unpolluted water from its source to fill your ponds.

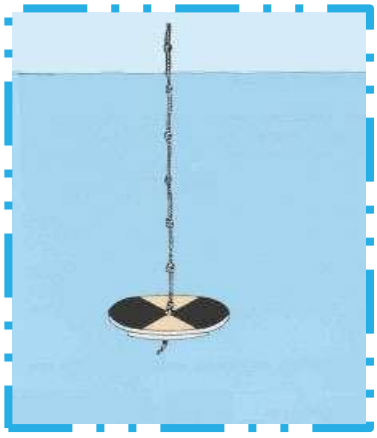
Fertilization of earthen fishponds is limited under the following conditions.

- If fish production does not depend on the use of natural food
- If the exchange rate of the water is excessive
- If there is too much aquatic vegetation
- If the water is too muddy or dark coloured
- If the plankton turbidity is too high

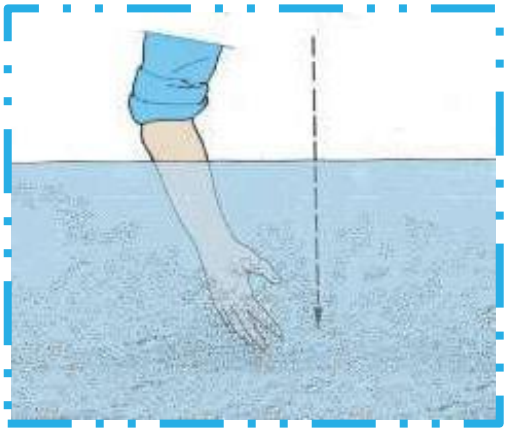
- **Fertilization with manure or fertilizer**

Fertilizing the pond with organic or inorganic fertilizer before stocking stimulates the growth of small plants and animals that are a food source for the fish in the pond.

- Fertilization is only essential for extensive and semi-intensive farming systems but may not be necessary for intensive systems.
- Fertilization usually starts 10 – 15 days prior to fish stocking.
- Fertilization of the earthen fishpond involves the use of manure or inorganic fertilizers.
- A combination of manures and inorganic fertilizers is more effective than using either of these alone.
- The quantity of fertilizers to be applied is decided based on many factors such as soil condition and pH, size of the pond, type of fertilizer and intended use of the pond.
- Therefore, proper analysis of water is crucial before deciding on the need for fertilization (figure 3 & 4: FAO 2010).
- If the water is green, it is a sure sign that it is fertilized.
- Simple water analysis can either be done by Secchi disc or hand.



Analysing the need for fertilization by Secchi Disc



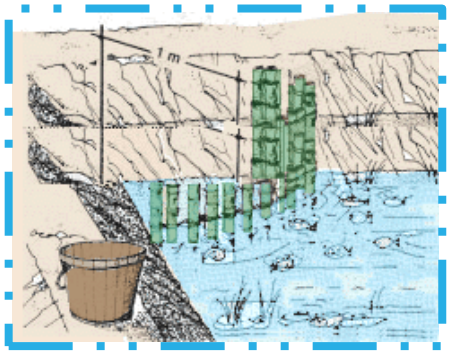
Analysing the need for fertilization by a hand

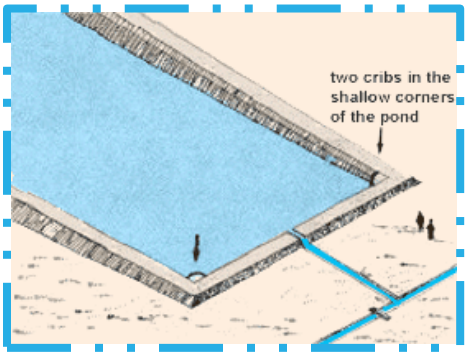
Providing natural fertilizer

Examples of organic fertilizers are chicken, cattle and pig droppings (application rate is between 50-100 grams per square meter). Droppings should be cured, if possible

When the manure is heaped on the ground, a long stick is placed at the peak. After several days (depending on the quantity of manure), the stick is removed. A cold stick indicates the manure is cured whereas a warm stick indicates the manure is not cured.

- The use of animal manure will require building of one or two cribs (60cm deep) at the corner of a fishpond depending on the size of the pond.
- Cribs can be built with bamboo or wood.





Building crib for fertilization process (Source: FAO 2010)

- Animal manure from either sheep, goats, cattle, pigs, or poultry is packed in a sack, then the sack with the manure is placed into a crib.



Fertilization process *(Source: Agyakwah et al., 2020)*

- The quantity of animal manure (kg/m^2) applied differs with the sources.

Table 4: The amount of animal manure required for pond fertilization (kg/100m^2)

Source of manure	**Quantity(kg/100m^2)**		**Fertilization schedule**
	Minimum	Maximum	
Poultry	2	3	Weekly
Pig dung	8	10	Weekly
Cow dung	10	15	Weekly

(Source: Modified from FAO 2010)

- The combination of poultry, pig, and cow manures can be made in the ratio of 1:2:3 out of 10kg/100m^2 respectively and be applied on weekly basis.

Providing artificial fertilizer

Examples of inorganic fertilizers are NPK (15:15:15) and superphosphate (application rate is 5 grams per square meter)

For artificial fertilizer (DAP) weigh 5g/m^2 and apply by diluting it in a container with pond water then broadcast it in pond.



YPO Trainees weighing and applying artificial fertilizer (DAP)

- **Removal of debris**

With the help of a scoop net remove all debris from the manure after fertilization to keep the pond water clean.

3.1.2 Preparation of new concrete ponds

- **Filling with water**

For concrete ponds after construction and finishing, fill it with water fully for one week to allow the floor and surface to absorb water for making walls and floor strong. The water also dilutes and removes toxic fumes from the raw construction materials.

- **Draining**

After one week drain the pond to allow for effective liming.

- **Liming**

Follow the same procedure as for earthen ponds.





Application of lime

- **Refilling**

Refill the pond with water up to knee level or above.

- **Fertilization with manure or fertilizer**

Use the same fertilizer procedure that is used for earthen ponds.

- **Removal of debris**

Use a scoop net to remove all debris from the manure to keep pond water clean.

3.2 Existing ponds

Every pond must go through a stage of cleaning and dressing between batches of fish to make it suitable for fish growth. The cleaning and dressing processes involve clearing and burning weeds, complete draining and bottom drying, disinfection, blocking and filling.

Here are some steps to follow when preparing an existing pond for stocking with fingerlings.

1. Ensure that the pond is completely drained. Close the inlet pipe and cover the opening with folds of fine mesh net to prevent the introduction of unwanted fish and any other biological agents.

2. Eradicate all wild fish and any fish left over from the previous culture. The presence of any kind of fish will negatively affect the growth and survival of the new stock.
3. Complete eradication may be done by drying the pond bottom within one to two weeks. If ponds cannot drain completely, apply environmentally friendly fish-killing agents (piscicides) such as rotenone, nim extracts or lime, to eliminate the unwanted fish.
4. Excessive silt and weeds are removed, and pond dykes are repaired. At least seven to ten days before stocking with fry, dry ponds should be treated to eliminate any predatory fish or other pests.

3.2.1 Preparation of existing earth ponds

- **Drain**

After total harvesting, drain the pond by removing all water through the outlet system.

- **Dry**

Leave the pond for a week to allow drying by sunlight. This kills microorganisms and invasive species that may remain from previous fish harvests.

- **Remove vegetation growth**

Remove any vegetation growing in the pond such as weeds and plants that may be poisonous or stressful to fish.

- **Check/inspect dyke, inlets and outlets; maintain as needed**

Checking for seepages and cracks on dikes if any. Check the outlet for blockages of mud, stones or other debris. Maintain and repair if there is any damage.

- **Liming**

Repeat the liming process above but the amount of lime for existing ponds will have an application rate of 1kg of quicklime for every 10m2 of pond area.



Limed concrete ponds in Mazimbu YPO field training

- **Refilling**

Follow water filling procedures as for new ponds.

- **Fertilization with manure or fertilizer**

Follow fertilizer procedures as for new ponds.

- **Removal of debris**

Use a scoop net to remove any particles discharged during fertilization.

3.2.2 Preparation of existing concrete dams

- **Drain**

After total harvest drain the pond by draining all water through the outlet system and leaving it to dry in the sun.

- **Maintenance: repair walls if needed; service inlets and outlets**

Check walls and dykes for cracks or seepage and check if there is any blockage in water inlets and outlets, repair whatever needs repair or maintenance.



Pond outlet repairing

- **Cleaning: brushing walls and floor**

Use hard brushes and brooms to clean walls and floor, remove all green grown moss and mud in a pond.

- **Liming**

Repeat the liming process above but the amount of lime for existing pond will be application rate of 1kg of quicklime for every 10m^2 of pond area can be used for established ponds.



Weighing and applying lime

- **Refilling**

Refill existing ponds with water in the same way as new ponds.

- **Fertilization with manure or fertilizer**

Fertilise the pond the same way as for new ponds.

- **Removal of debris**

Use a scoop net to remove any particles discharged during fertilization.

4 Module 4: Fish nutrition and feeding

4.1 Nutritional needs of fish

Fish need two types of nutrients for health and growth. These are:

Macronutrients	Micronutrients
• Protein • Carbohydrates • Fats • Water	• Vitamins • Minerals

- **Macronutrients:** These are essential for fish growth and health. The following are examples of macronutrients:
  - **Protein:**
    - **Role:** Essential for growth and tissue repair.
    - **Sources:** Fish meal, blood meal, insect meal (e.g., BSF meal), fresh Azolla.
    - **Deficiencies:** Stunted growth; weak immune system.
  - **Carbohydrates:**
    - **Role:** Energy source.
    - **Sources:** Rice polish, rice bran, maize bran.
    - **Deficiencies:** Reduced energy for metabolic processes.
  - **Oil/Fat:**
    - **Role:** Energy storage and essential fatty acids.
    - **Sources:** Vegetable oil seedcakes (e.g., soya, sunflower, cotton, palm).
    - **Deficiencies:** Impaired growth and reproduction.
- **Micronutrients:** The following are examples of micronutrients:
  - **Vitamins:**

- **Role:** Essential for various metabolic functions.
- **Sources:** Present in feed ingredients or supplements.
- **Deficiencies:** Various health issues.

- **Minerals:**
  - **Role:** Skeletal development, enzyme function.
  - **Sources:** Bone meal, salt.
  - **Deficiencies:** Bone deformities, poor growth.

4.2 Feeding considerations

When planning to feed schedules and feeding fish, the following must be taken into consideration:

- **Type of fish**: tilapia or catfish
- **Mode of feeding**: consider manual vs. automatic feeding based on farm size and resources. Varies based on fish behaviour e.g., surface feeders (Nile tilapia), bottom feeders (catfish).
- **Size or age of fish**: younger fish require more frequent feeding, and they feed on powder form unlike juvenile and adult fish, which feed on pelleted feed.
- **Frequency of feeding**: based on fish species and size; generally, 2 – 3 times a day.
- **Type of feed**: consider nutritional content and availability. Pelleted or non-pelleted feeds are based on fish size and feeding behaviour.
- **Cost and accessibility**: choose feed ingredients based on availability and affordability in the local area. Balancing nutritional needs with budget constraints.
- **Quantity**: adjust based on fish size and growth rates.
- **Accessibility** of types of food
- **Observation of the eating rate of fish**: monitor how quickly fish consume feed to adjust feeding practices and/or detect health issues.

4.3 Feed ingredients

- **Protein sources:** use locally available sources like fish meal, bloodmeal, insect meal (BSF), and Azolla.
- **Carbohydrates/energy sources:** use rice polish, rice bran, and maize bran.
- **Oil**: include vegetable oil seedcakes such as sunflower, cotton, and palm.

- **Minerals and vitamins**: add bone meal and salt to meet mineral requirements.

4.4 Forms of feed

Fish feed is available in different forms. These include:

- **Pelleted feed:** Commercial or farm-made; provides convenience and nutrient balance.

Characteristics	Advantages	Disadvantages
Compact, uniform pellets with balanced nutrients.	Convenient handling and feeding.	Costlier than some non-pelleted options.
	Allows for precise nutrient control.	Limited variety in texture compared to natural feed.
	Reduces waste and improves feed efficiency.	





- **Non-pelleted feed:** Flakes or powder; suitable for smaller fish/certain fish species/specific feeding methods.

Characteristics	Advantages	Disadvantages
Available in flakes or powder forms.	Suitable for smaller fish or specific feeding methods.	Difficult to control nutrient balance.
	Mimics natural feeding behaviour.	May result in more waste compared to pelleted feed.





YPO Fish Feed

4.5 Feed formulation

The following factors should be considered before feed formulation:

Nutritional requirements: determine the required protein, energy sources (carbohydrates, fats), vitamins and minerals based on fish species and growth stage.

Ingredient availability and cost: Use locally available ingredients to reduce costs and promote sustainability. Evaluate the cost of each ingredient and consider alternative sources to formulate a cost-effective feed.

Feed palatability and acceptance: formulate a feed with ingredients that are palatable to the target fish species to ensure proper consumption. Test the acceptability of the feed through small-scale trials before large-scale production.

Processing and stability: consider the processing methods (extrusion, pelleting) to enhance the digestibility and stability of the feed. Ensure that the formulated feed maintains stability in water to avoid rapid disintegration and nutrient loss.

Storage and shelf life: evaluate the storage requirements to maintain feed quality and prevent spoilage. Formulate feeds that have a reasonable shelf life without compromising nutritional integrity.

Feed performance: monitor the growth performance of fish fed with the formulated feed to assess its effectiveness. Evaluate the efficiency of feed utilization by calculating the Feed Conversion Ratio (FCR).

Formulated feed requires highly skilled and experienced experts. Youth Power Organization formulated fish feed has tested successful in terms of nutrition, palatability, satiety, smell, appearance, flavour and shelf life.

Ingredients for 5kg fish feed. CP of YPO fish feed is 40:

Ingredients	Quantity	Function
Fish Meal	2kg	Source of protein, YPO fish meal is not the same as local fish meal in markets, it is special fish meal ordered from Lake Victoria regions, it has 60% CP.
Blood Meal	150g	Addition source of protein with 80% CP, with that high protein content it is recommended to not exceed 20% in total fish feed mass due to presence of amino acid and a high concentration of zinc and iron.
Rice Polish	1.5kg	Source of carbohydrate. YPO choses rice polish for palatability and easy digestion to fish especially fingerlings. However, rice polish has less nutrients than unpolished rice due to it having its bran and germ removed,

Ingredients	Quantity	Function
Bone Meal	900g	Contains a complete array of macro and micro minerals and protein component is highly digestible. It must be fine powder rather than larger crystals for fish feed.
Vitamin Premix	50g	Vitamin and mineral premixes formulated to ensure a healthy and stronger fish with an efficient feed conversion ratio
Vegetable Oil	400ml	Due to essential fatty acid content, it is a key ingredient to not only support and promote growth, survival, health and welfare of fish and also ensure they remain highly nutritious.
Mineral Salt	55g	Salt increases appetite and act as humectants by reducing water activity and has a significant impact on growth, feed utilization and physiological parameters in the intestine and blood.
Ginger Powder	25g	To improve satiety and attraction to fish feed
Cardamom Powder	25g	To improve satiety and attraction to fish feed

4.6 Feed application

Certain factors and considerations need to be kept in mind and applied when feeding fish. These include:

Feeding chart and feeding schedule (see example in Section 6.8: Record Keeping):

- **Species and growth stages:** different fish species and growth stages require varied feeding schedules.
- **Frequency and quantity:** specify the number of feedings per day and the quantity based on growth rates.

Time of the day:

Adjust feeding times for optimal digestion. Consider optimal digestion times, typically mornings and evenings. Align feeding with the natural behaviour of the fish.

Location:

Establish feeding stations to condition fish. Train fish to associate specific locations with feeding. This will enhance efficiency and reduce competition during feeding.

Measurement of feed:

Use appropriate tools like measuring cups or scales for accurate and consistent measurements.

Quantity/feeding rate:

Follow recommended rates based on fish growth rate. Prevent overfeeding or underfeeding through regular assessments.

Feed application methods:

There are different ways of providing feed to fish in ponds:

1. **Manual feeding**: This is divided into two forms of feeding which are;
   (i) **Broadcasting**: sprinkling feed evenly across the pond surface.

   (ii) **Feeding stations**: concentrating feed in specific areas.



YPO trainees demonstrate manual fish feeding

2. **Automatic feeding**: has the advantage of feeding consistently and reduced labour requirements compared to manual feeding.



Automatic fish feeder

4.7 Packaging and Storage

Proper storage of fish feed is essential to maintain its safety, quality, and nutritional content. Using effective storage techniques helps prevent spoilage, nutrient degradation, and contamination. Here are key strategies to ensure the safety and nutritional integrity of stored fish feed:

- **Secure storage facilities:** utilize locked storage facilities to prevent unauthorized access and safeguard against theft.
- **Pest proofing measures:** implement rodent-proof containers and structures to protect feed from pests, ensuring the feed remains uncontaminated.
- **Dry storage conditions:** maintain dry storage conditions to prevent moisture absorption, which can lead to mould growth and spoilage.
- **Protection from water exposure:** store feed in areas protected from direct water exposure, preventing the feed from getting wet and losing nutritional value.
- **Sheltered from direct sunlight:** avoid exposing feed to direct sunlight as it can degrade certain nutrients. Store feed in shaded areas or covered structures.



YPO trainees showing different fish feed storage containers and sacks

4.8 Recordkeeping

YPO Feeding chart _____ **Name of the fishpond:** _____

Date	Fish quantity	Amount of feed required per day			Type of feed (pellets/powder/crumbles)	Amount of feed fed per day	Amount of remained feed per day
		Morning	Afternoon	Evening			

Nile Tilapia feeding schedule (template):

Stage	Age	Feed type	Frequency	Feed size	Total daily feed	Feeding times	Kind of monitoring
Stage 1	Fry (0 – 2 weeks)	High-protein starter feed (crumbles or powder)	4 – 6 feedings per day	Appropriate for the size of the fry	5 – 10 % of body weight	Spread evenly throughout the day	Monitor closely for any signs of stress or overfeeding
Stage 2	Fingerlings (2 – 8 weeks)	Transition to a grower feed with balanced protein and energy	3 – 4 feedings per day	Larger pellets suitable for fingerlings	5 – 8 % of body weight	Morning, afternoon, and evening	Adjust feeding amounts based on growth rates and observe fish behaviour.

Stage	Age	Feed type	Frequency	Feed size	Total daily feed	Feeding times	Kind of monitoring
Stage 3	Juveniles (8 – 16 weeks)	Grower feed with balanced protein, energy, and essential nutrients	2 – 3 feedings per day	Larger pellets appropriate for juvenile size	4 – 6 % of body weight	Morning and evening	Monitor growth and adjust feed amounts accordingly
Stage 4	Sub-adults (16 – 24 weeks)	Transition to an adult maintenance feed	Two feedings per day	Suitable for sub-adult size	3 – 5 % of body weight	Morning and evening	Continue to monitor growth and adjust feed amounts as needed.
Stage 5	Adults (24 weeks onwards)	Adult maintenance feed with lower protein content	1 – 2 feedings per day	Appropriate for adult tilapia	2 – 4 % of body weight	Once in the morning and optional feeding in the evening	Adjust feeding frequency and amounts based on fish size and environmental conditions.

5 Module 5: Natural Fish Feed Production

Fish food is found naturally in the pond and may include detritus, bacteria, plankton, worms, insects, snails, aquatic plants, and fish. Their abundance greatly depends on water quality. The natural fish feed can be increased by using fertilizer, azolla, Black Soldier Flies (BSF), worms, lemna, and others. Different natural fish feed contains different nutritional contents of which protein is considered the most important nutrient for better fish growth. Azolla, algae, and BSF are common, cheap, and nutritious natural fish feed.

5.1 Types of natural fish feed

- **Aquatic plants**: e.g. algae, Azolla.

Aquatic natural fish feed is plants which grow naturally in the pond e.g. algae, Azolla, water cabbages, water lettuce, Lemna, and others. Aquatic plant growth is accelerated by different factors in pond water such as availability of manure or fertilizer, oxygen, and the type of soil and water.

- **Insects and larvae**: e.g. worms, mosquito larvae, fly larvae.

Insects and larvae can be natural fish feed occurring naturally in the food chain or introduced by supplements or. Some insects such as water striders, beetles etc, can be eaten by fish.

Larvae such as maggots, housefly larvae and BSF larvae can be supplemented as fish feed.

- **Other**: terrestrial plants, microorganisms, others.

Vegetables and plants such as moringa, oleifera, leucine, spinach etc. are highly nutritious supplements to the diet of plant-eating fish. They are particularly useful for raising fish like tilapia.

They also provide additional protein and vitamins that can improve the growth and health of fish. However, they need to be carefully supplemented since some contain anti-nutritional factors such as saponins and phenols which should not exceed 20% in diet.

5.2 Azolla

Azolla is a free-floating water fern consisting of short, branched, floating stems, bearing roots which hang down in the water. Azolla has many nutrient benefits compared to any other fodder. The high cost of fish feed can be reduced by growing Azolla as a supplement in fish feed. Azolla is a plant protein which can improve the growth of fish without any cost.

- **Characteristics**:
  - Azolla prefers shade and requires light (30% to 50%) for photosynthesis.
  - Since Azolla is a water-based crop, one should ensure sufficient water for its cultivation. It is always recommended to have at least five inches of water in a pond for proper growth of Azolla.
  - Azolla grows well where the optimum temperature range is 20 – 35^0C.
  - Azolla requires a water pH value of 5.0 – 7.0 and a relative humidity of 80% – 90%.
  - High summer temperatures, water scarcity and low humidity, along with poor quality of water make it difficult to cultivate Azolla.

- **Equipment needed:**
  - Azolla seeds
  - Shallow pond/tray
  - Pond liner for the earthen pond to prevent water loss
  - Manure
  - Fertile soil
  - Freshwater

- **How to produce Azolla:**

1. Digging a shallow pond of any desired size per length and width but the depth should be at least 12cm.	2. Placing a pond liner or cementing a pond to minimize water loss.
	

3. Adding manure (dry cow dung manure recommended) and fertile soil in a 1:3 ratio respectively in a pond. If using a bucket, then one bucket of manure with three buckets of soil. The same applies to kg.

4. Mixing soil and manure thoroughly together.





5. Adding water (leave a free space above for overflow).
6. Planting Azolla by throwing them on the surface of the water in the pond.



- **Harvesting and sale:**

  Azolla harvesting is quite simple, using a hand or filter to scoop it out of the water.



- **Sale:**

Azolla can reach up to TZS 10,000 per Kg. Buckets or sulphate bags are used in the packaging of Azolla. The Azolla should be packed with some water to keep it fresh.



Local market:

Azolla can be used to feed fish, chicken, pigs, cattle, ducks, etc. Since it is cheap and can easily be cultivated many local farmers prefer it.

5.3 Black Soldier Flies



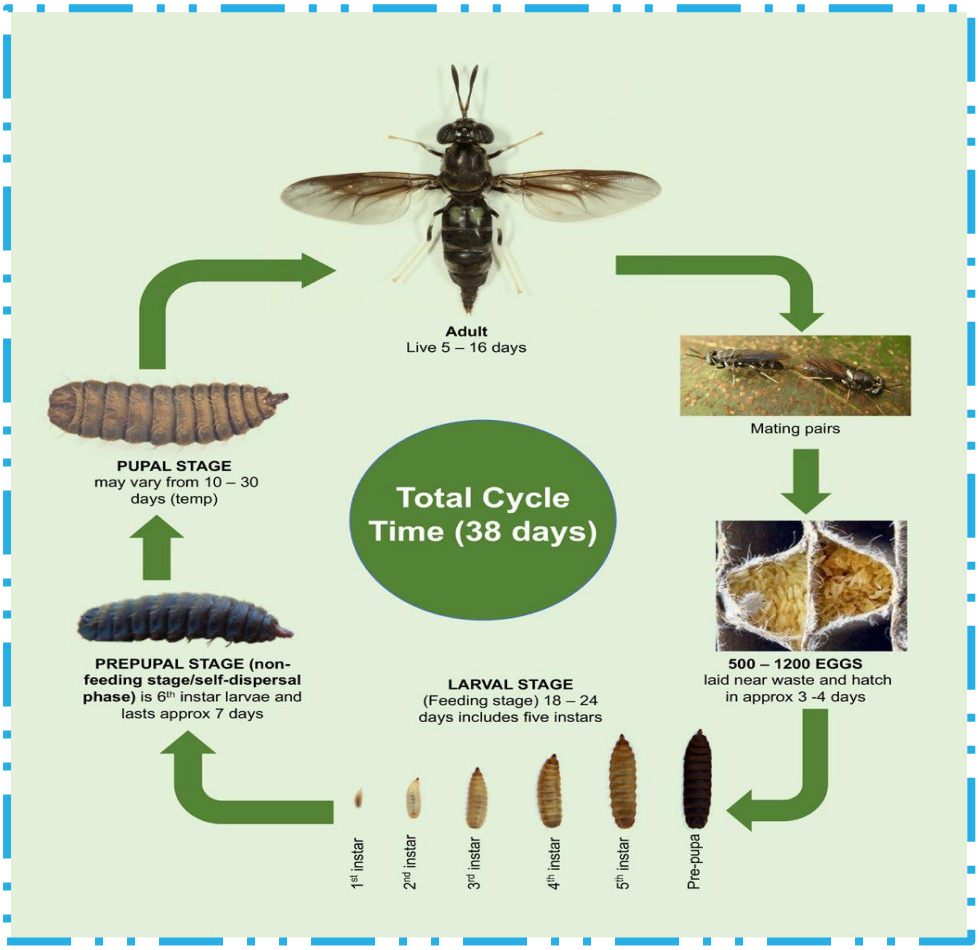
The production of the BSF using the waste products of smallholder farmers allows farmers to produce protein-rich animal feed without having to buy expensive animal feed with foreign protein sources such as soybean- and fishmeal. Using BSF larvae as feed would decrease the costs of animal feed for farmers and can lead to a more food-secure economy. The larvae of the BSF can convert organic waste to protein. The protein content of the dried BSFL is between 35 and 50%.

- **Characteristics**:

  The life cycle of BSF is 38 days: with the larval stage being only two to three weeks from hatching.

  - The BSF can adjust to different circumstances very quickly. In contrast to the housefly, BSF is not a pest as they do not bite, or sting and are not able to transfer zoonotic diseases.
  - Adults do not have a mouth; therefore, the larvae consume a lot of organic substrates during their larval stage. The larvae can feed quickly and can reach their harvesting stage in 10 – 14 days.
  - They can survive huge differences in temperature, humidity, and feed substrate.

- They do prefer a warm temperature (around 27°C). When the temperature gets too high (above 30°C) or too low (under 25°C), the developing time of the larvae will increase, but the larvae are most likely to survive.



- **Equipment needed:**
  - Face masks
  - Basins or trays
  - Gloves
  - Kitchen scale
  - Marker pen
  - Frame/net house, mesh
- **Source material:**
  - BSF eggs and organic waste (kitchen waste)

- Chicken manure
- Fruit and vegetable waste from households, markets and farms
- Bread and grains
- Meat and dairy products
- Water and liquids

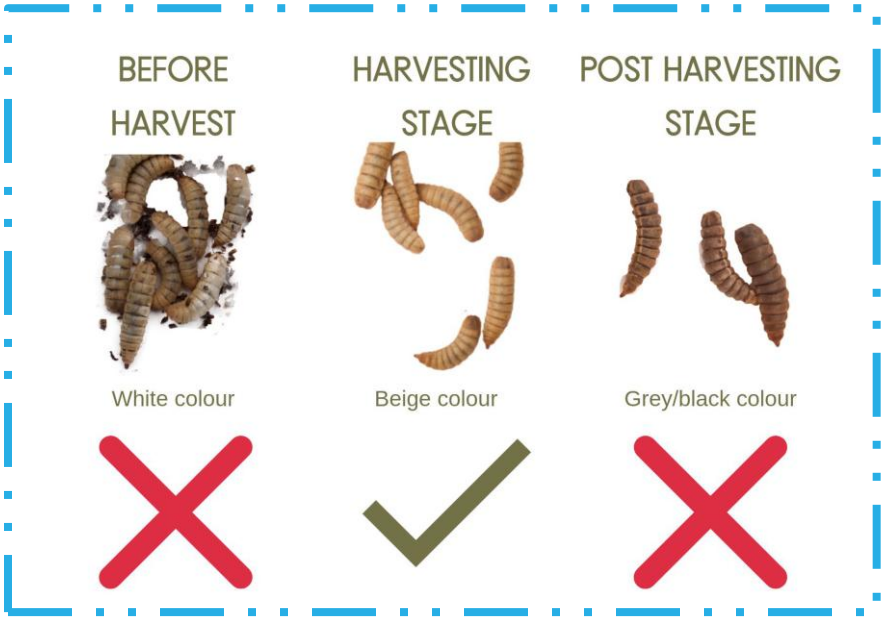
- **How to produce BSF**

1. Construct a house or frame for BSF incubation and growth.	
	
2. Prepare trays	3. Fill trays with media (organic wastes) chicken manure, fruit waste, vegetable waste, bread and grains, meat, potato, dairy products, water, and liquids mix them thoroughly.
	

4. Add BSF eggs on top of the media or leave the media outdoors (near dumps) for 2 – 4 days for BSF to lay eggs on it.	5. Place trays in a frame (make sure the frame is intact and no holes or space for the fly to escape.
	

- **Processing:**

  The harvesting of the BSFL needs to happen when the protein content of the larvae is the highest. This can be recognized by their beige colour. Before the harvesting stage, the larvae have a white colour. When the larvae are past their harvesting stage, they turn into a black/grey colour and are most likely to escape the crates.



After BSFLs are separated from waste by a sieve or mesh, the harvested larvae needs to be processed. The cleaning of the larvae needs to be done via blanching. The larvae need to be boiled for three minutes in water. This is to kill and clean the larvae and kill bacteria. After this process, the larvae need to dry in the sun. Let them dry for two weeks. Then the final product is ground into powder for feeding the fish.

- **Sale:**

  The powder or dried larvae can be packed in plastic bags for selling to local farmers. The price of BSFL reaches up to TZS 5,000 per kg.

- **Local market**:

  Local fish farmers, chicken farmers, cattle farmers.

  The production of the larvae has a few risks which are not severe. These risks are mites, birds, and houseflies.

  - Birds are attracted towards the larvae and are likely to consume them when possible. To reduce the risk a net is used on the frame.
  - Mites are attracted to chicken manure.
  - The pupae of houseflies compete with BSF larvae for substrate.

5.4 Pond fertilizing for algae growth

Algae, a natural fish food, grows in ponds. The grown of algae can be stimulated by fertilizing the pond with manure which accelerates the growth of aquatic plants in pond water. Fertilize the pond with manure five days before stocking fingerlings so that they have good feed to feed on and grow.

- **Objective and process:**

Since adding nutrients to the water stimulates algae growth as fish food, it is important to check pond water conditions before fertilization. Some ponds have algae due to fish excreta as manure.

Fertilisation is done according to the type of fertiliser.

- **Sources of fertilizer:**

Can be natural (manure) or artificial fertilizer. Manure can be cow, chicken, pig or manure from other livestock. Artificial fertilisers are DAP, NPK, Urea etc.

- **Application of manure:**

1. Put 100g/m^2 of cow manure in a sulphate bag.
2. Tie the plastic bag of manure with a rope, then attach the rope anywhere outside the pond and make sure it is tight.
3. Put the sulphate bag with manure in pond water while the rope is tied somewhere outside the pond, make sure the bag of manure does not touch the bottom of the pond.
4. Leave it until the pond is fully fertilised.

The fertilisation period varies according to pond water observation and testing. Fertilisation can be done twice per month depending on water quality.

Use a Secchi disc to observe if the pond is fully fertilised and then remove the fertiliser. If it is overfertilized add fresh water and test again with a Secchi disc.

- If a Secchi disc is inserted in pond water and at 20 cm knot it is still visible, then apply fertiliser.

- If at 10 knots and it is invisible, then remove fertiliser and add clean water.

6 Module 6: Stocking

6.1 Sourcing fingerlings

Fingerlings can be obtained from different sources such as wild seed, local farmers' hatcheries, private centres, and government centres.

It is recommended to purchase fingerlings from reputable sources that are certified by authority. Do not purchase fingerlings from any centre considering people's opinions or the history of the centre.

For the best fingerlings, visit the centre for physical observation and assessment.



Government centre of fish farming and fingerlings production and supply, Kingolwira, Morogoro

(Source: Youth Power Organization communication department)

When choosing the source of fingerlings, the distance from the farm to the hatchery must be considered and the aim is to minimize stress to fingerlings while they are being transported. Buying fingerlings from sources which are located more than 500km by car can lead to stress and mortality or lethargy to fingerlings, especially when transportation management is poor.

The best way is to select the best centre which is located near the fish farm to minimise stress to fingerlings.

6.2 Quality assessment of fingerlings

Poor quality fingerlings are judged by farmers as having low productivity, low survival rate after stocking or slow growth. However, this can only really be judged *after* buying the fingerlings. Buying fingerlings is a cost; so the quality must be judged at the time of buying them, otherwise the farmer may incur some losses from poor quality fish. Practise on-the-spot physical observation for quality fingerlings during the process of buying them in order to minimise the risk and to track the management of fingerlings.

Quality indicators:

- **Size:** age – by sampling (weighing) fingerlings to select the desired size for production.
- **Colour:** quality fingerlings are bright (bright-dark). Avoid pale-coloured fingerlings.
- **Strength/swimming:** level of activity – vigour and activeness of fingerlings is important.
- **No deformities:** injuries, or signs of disease – signs of haemorrhage, swelling belly and injuries should be avoided.
- **Behaviour:** gasping, rubbing on walls, upside-down swimming and any informal fish behaviour should be avoided.

Always visit the site for quality observations before ordering fingerlings, it is better to incur visiting costs to avoid the loss after stocking.

6.3 Conditioning at the hatchery

Fingerlings need to be conditioned at the hatchery before they are transported to the fish farm. This is to minimise stress and related deaths of the fingerlings. Make sure you place an order of fingerlings at least 24 hours before buying for the seller to condition and prepare the fingerlings.

Check that the hatchery has conditioned the fingerlings: no feeding before transportation.

6.4 Packaging and transport

Fingerling packaging is a very important practice in fish farming and production since it decides the number of fish to be stocked. Fingerlings may die of stress during transportation so they must be transported properly and for the shortest time possible. After transportation, fingerlings may die from diseases and infections acquired during packaging and transportation. It is very crucial to do it properly.

Packaging:

Materials for fingerlings packaging are plastic bags, sulphate bags or bucket/ container, rubber band, oxygen tank, marker pen.

- **Steps for fingerlings packaging**

Place the clear plastic bags inside woven plastic fibres (polypropylene) bags for extra strength and protection during transport.

1. Adding clean water in clear plastic bags.	2. Adding fingerlings in a clear plastic bag with clean water.	3. Adding oxygen
		
4. Bags well sealed.		
		



A clear plastic bag filled with fingerlings, water and oxygen packed ready for transportation.

(Source: Youth Power Organization communication department)

Transport considerations:

- **Time of transport**

Fingerling transportation must not be done during sunny days. Avoid direct sunlight on plastic bags and high temperatures. It is recommended to transport fingerlings early in the morning.

- **Mode of transport/type of vehicle**

The mode of transport of fingerlings depends on location, infrastructure, and distance. Fingerlings may be transported by air, motor car, motorcycle or bicycle. From one region to another region, it is advised to use a plane, while within the same region it is recommended to use a car. Motorcycles and bicycles are not recommended unless roads cannot be reached by car.

6.5 Acclimatisation and release

This is the process in which tilapia fingerlings adjust to a change in the new water environment to maintain fitness across a range of environmental conditions. **Note** that there is no need to acclimatise catfish fingerlings – they can be released directly into the pond.

When fingerlings arrive at the destination and if tight oxygenated plastic bags were used for transportation the following steps must be taken:

1. Unload the bags and put them in the shade for about 15 minutes.
2. Temperature acclimatisation procedures: put the plastic bag with fingerling in their pond for about 20 – 30 minutes to let the temperature in the plastic bag blend in with the temperature of pond/destination water.
3. Open the bag after 20 - 30 min and gradually let pond water into the bag until the water temperature is the same.
4. Release the fingerlings into the pond.

If canvas bags or cans were used during transportation the following steps must be taken:

1. Let them stand still for 10 to 15 minutes.
2. Gradually add pond water into the can with by adding quantities in using a bottle or jug.

When the water temperature in the can becomes like the pond water temperature, release the fingerlings into the pond.

The following picture shows the acclimatisation and release process:

Acclimatisation	Release
	

6.6 Record keeping

Stocking record

Records must be kept regarding the stocking of fingerlings for fish farming as fingerlings are the start of the farming process. All growth and subsequent sales and profits are compared to stocking data.

Example of stocking record

Date	Pond #	Pond size (m^2)	No.of fish stocked	Total wt (kg)	Spe-cies	Source/ Hatchery	Cost	Mort-ality	Replace-ments	Rem-arks

7 Module 7: Fish Farm Management

Fish farming (Aquaculture) is an essential growing industry in many countries including Tanzania. It is the fastest growing sector in food production as it fills the gap existing due to decline in wild fisheries. The success and sustainability of a fish farm need proper management practices which include a range of activities for the ongoing operation of the farm.

Good farm management practices include all activities that enable your fish to grow at an optimum rate. Some basic principles for fish farm management are:

- Have several ponds in order to harvest fish throughout the year.
- Stock the ponds at different times in order to harvest year-round.
- Keep records of all activities (fertilizing, stocking, mortalities, feeding, harvesting, purchases, etc.) on the farm.
- Fish farming yield can be improved by growing only male tilapia. This is because male tilapia grows faster than females because all of their food is used solely for growth.

Pond Management

A pond must be kept in a particular condition in order to ensure continual production.

Important things to note in pond management:

- Ensure that water is from a good source.
- Aeration may be required at certain times of the day.
- Always maintain a minimum level (1 meter) of water in the pond.
- Make sure the pond screens are securely in place to prevent entry or escape of fish, larvae, eggs, toxins and pathogens.
- Remove weeds growing excessively in ponds.
- All leakages in and around the pond must be sealed.
- Grasses should be planted along the pond walls and embankments – keep them short to prevent snakes, frogs and rats from hiding in them.
- Do not allow animals such as cattle, goats, sheep, donkeys and horses to graze around the site as they may break the pond walls.
- Do not plant big trees near the pond.

7.1 Water quality management

Water quality monitoring and maintaining is one of the best management practices for fish farming because it is crucial for the health and optimum growth of cultured fish. Deteriorated or changes in water quality will affect the health, growth cultured and performance of cultured fish.

The need of water quality maintenance will vary with fish species culture. Management level will also differ depending on the type of farming systems (extensive, semi-intensive or intensive systems) and type of water involved (fresh water or salt water)

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

Signs and effects of poor water quality	Causes of bad water quality
• Fish gasp at surface • Fish groups around fresh incoming water • Slow growth of fish • Changes in water colour (e.g., too greenish/brownish) or unpleasant smell • Increase in turbidity (water looks muddy, murky) • Build-up of nitrogen compounds such as ammonia-nitrogen ▪ Phytoplankton blooms	• Use of poor-quality feed • Overfeeding • Overstocking • Decomposition of vegetation • Polluted water source



Signs of poor water quality (source: *Agyakwah et al., 2020*)

Why manage water quality?

Advantages of good water quality management	Effects of poor water quality management
• Good harvest and fish yield • Low mortalities • Low vulnerability to fish diseases • Tasty fish – no off-flavour • Increased profitability	• Poor growth • High mortality • Poor harvest • High financial losses

How to manage water quality

- Regular monitoring of key water quality parameters
- Aerate when necessary
- Remove all dead fish as soon as you see them
- Regularly change/renew pond water (minimum 2 to 3 times a week)
- Apply appropriate stocking density
- Ensure appropriate feeding regime
- Regularly remove vegetation from ponds
- Reduce feeding and do not fertilize when pond water is bad

7.1.1 Water quality parameters

There are specific criteria and parameters for measuring water quality. These include the water pH, the quantity of dissolved oxygen in the water for the fish to breathe, the water temperature, the amount of ammonia and nitrites in the water, and the overall turbidity of the water.

Acceptable ranges for water quality parameters

- pH (6.5–8.5)
- Dissolved Oxygen (DO) (> 3 mg/ℓ)
- Temperature (25 – 30 °C)
- Ammonia (< 0.03 mg/ ℓ)
- Nitrite (< 0.6 mg/ ℓ)

- Turbidity (< 75 NTU)

7.1.2 Control and Measures

- Regular monitoring of key water parameters such DO, pH and ammonia levels
- Application of emergence aeration to increase DO.
- Remove all dead fish as soon as you observe them.
- Avoid overfeeding by feeding the fish according to the apatite.
- Follow the recommended stocking density.
- Regularly remove vegetation from ponds.
- Avoid overfertilizing the pond.

Table 5: Water quality paraments and corrective measures

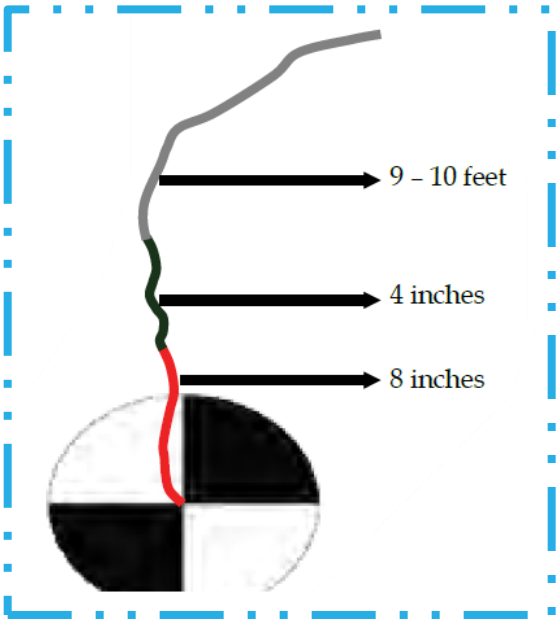
Parameter	Causes	Effects	Corrective measure
Dissolved oxygen	• Overstocking • Overfeeding • Overfertilize • High organic matter load	Fish mortality	• Aeration • Water exchange
pH	• Excess use of lime • Acidic soil	Mass mortality	Liming
Ammonia level	• Overfeeding • Overfertilize • High organic matter load		Water exchange
Turbidity	• High organic matter load	Fish mortality	Water exchange

7.1.3 Equipment for water quality management

- **Secchi disk method**

A Secchi disk is used in water turbidity observation.

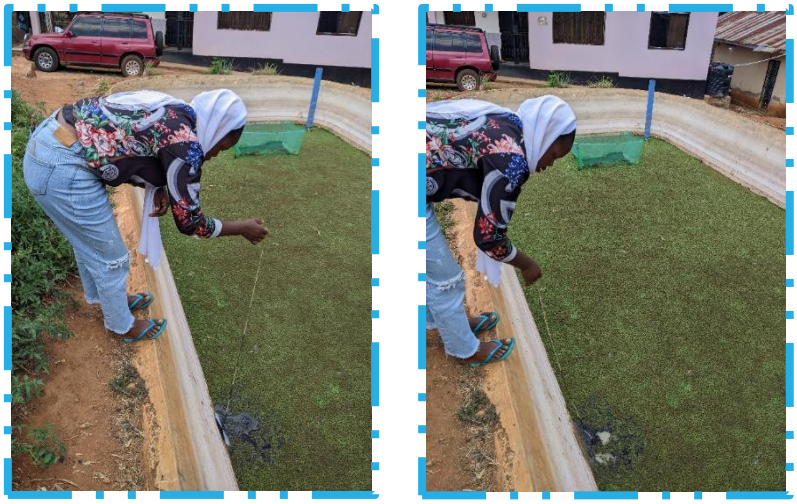
How to use it: facing the sun, the secchi disk should be plunged in the pond water to see if the white colour can be seen at a specific depth range. If the white cannot be seen at a specific depth, the water is too turbid. If it can be seen too clearly, the water may need fertilising.



The colour of submerged section of the string should also be taken into consideration. Red section of the string ad above the water indicates the presence of excessive natural feed in the water and in this condition, application of fertilizer and supplementary feed need to be stopped for the time being. White section of the string above the water indicates a shortage of natural feed in the water and accordingly fertilizer dose should be increased. Green section of the string above the water indicates the presence of optimum natural feed in the water and spawn / fry can be released in the pond.

Time of Secchi disk testing: Secchi disk should be used after sun rises.

Caution: Secchi disk cannot be used in a cloudy day or in turbid water.



Mlimani YPO student demonstrating how to use Secchi disk

Hand method: Hand should be plunged in the pond water and palm should be observed. If the palm is not seen after plunging the hand before the elbow, this will indicate the presence of excess natural feed in the water. Invisibility of palm after plunging the hand up to elbow will indicate the presence of optimum feed and visibility of palm will indicate lower presence of natural feed in pond water. The test is not applicable in turbid water.

Scoop net

Used in fish farming for handling fish or any tangible waste polluting pond water.



Mazimbu YPO students demonstrating how to use scoop net

Water exchange:

When water is polluted or fish stress such as gasping is noticed, water flushing should be conducted: release water using the outlet and replace with fresh water from the inlet.

When observing invasive species such as frogs or snails, lime should be applied, however, since fish are already in the pond liming process should be supervised by an expert.

Treatment also may be applied if any sign of diseases or infection is observed.

7.2 Fish handling practices

"Fish handling" is taking your fish out of water for a particular reason such as when transferring them from one tank or pond to another.

Fish should be handled carefully to minimize stress and physical damage and minimize exposure to contaminants. It is important to be gentle with your fish and keep the amount of handling to a minimum, to avoid injury and stress that can lead to disease or death.



YPO Kauzeni trainees demonstrate correct way of handling fish

The following handling guidelines will help keep your fish in good condition:

- Handle the fish in the cool of morning or afternoon or under shade.
- If holding them crowded in containers for a time, make sure water is clean, and has air bubbling through or running water flowing through the container.
- Fry are delicate and squash easily. Keep them in the water so they can swim. Avoid leaving them piled up together in a net or at the bottom of a container with no water to swim.
- Fish in small containers should not be too overcrowded (no more than 200 fry per litre of water).
- If you see fish in a small container all crowding at the surface to gulp air (piping), then either provide vigorous air bubbles through the water or transfer some of the fish to another container.

- Scoop nets should be of soft material that will not bruise or hurt the fry. Nets should be fine-mesh, as coarse-mesh nets will catch the fish by the gills and cause injury.
- Avoid dropping fish on the ground or making them panic so they start flapping around.
- When holding or carrying a broodstock fish in your hands, wear gloves and cover the eyes with one hand so that the fish will remain calmer

Biosecurity measures

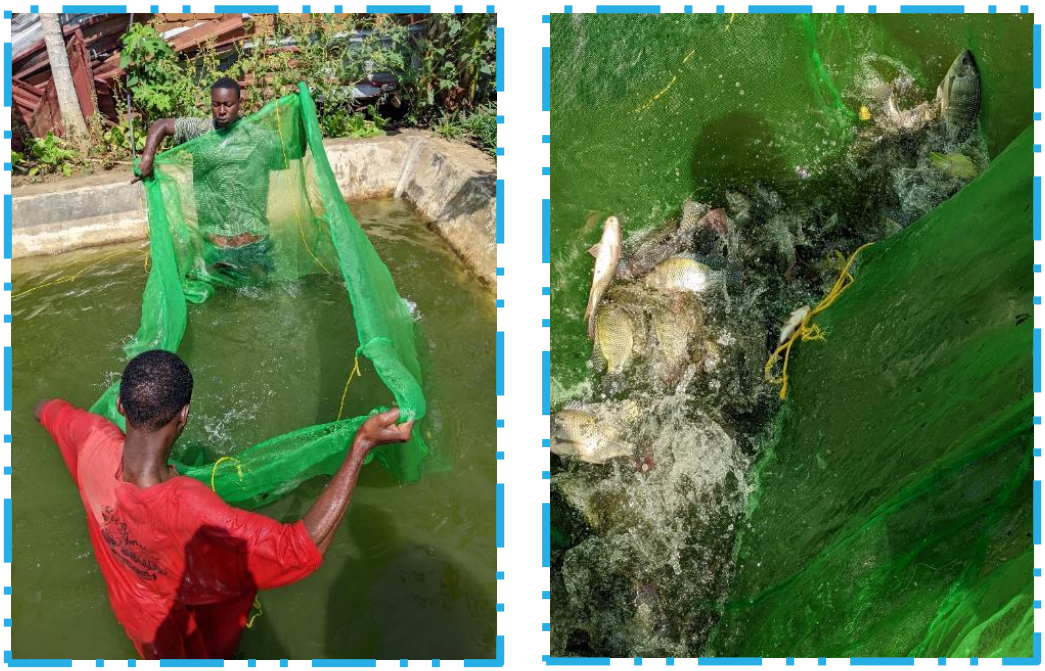
- People can bring pathogens to a farm, mainly when they have visited other fish farms.
- Visitors from farms where they have disease or mortality problems should be restricted from entering the farm.
- The employees and staff should wear clean clothes.
- People working at the ponds should wash their hands before work, after eating and after going to the toilet.
- Contact with the water should be kept to a minimum.

7.3 Growth performance management

The objective of fish farming is to grow fish from fingerlings to a size where they are big enough to eat. This should be done as fast and efficiently as possible. The monitoring of progress of the growth of fish up to market size is called '*growth performance management*' and it is a critical element of fish farm management. It is conducted by:

- **Daily monitoring**: visual observation for:
    - Monitoring of fish behaviours (feeding and swimming behaviours) is essential to assess well-being of the fish.
    - Loss of appetite by fish/ feeding behaviours
    - Retarded growth
- **Sampling:** this allows you to check on the health, growth and general well-being of your fish.
    - It is advisable to sample frequently (i.e., monthly)
    - Sample early in the morning before feeding.
    - Scoop a sample of the population (minimum 30 pieces), place it on a scale and divide the displayed weight by the total number of fish to get the average weight of the fish.
    - The change in weight from the previous sample will tell you how your fish are growing.

- Remember, fish must always be in water to minimize stress during handling.
- Wear gloves to handle fish.
- Isolate fish that show signs of sickness and report immediately to Extension Officer if this is possible.
- Do not sample during extreme stress or poor/bad water quality.
- The following are simple sampling procedures to follow: -
  - Withdraw feed a day prior to sampling.
  - Before sampling, prepare all equipment involved in sampling and weighing practice (water containers, weighing scale, Nets/scoop nets, oxygen supplier, pen, and an exercise book.)
  - Randomly sample a minimum of 30 fish and place them into a container with oxygenated water (Record as N =30)



Fish sampling method

- **Weighing**
  - To handle the fish wear gloves
  - Prepare a weighing scale and set it to zero.
  - Weigh a container with fish and record the weight (W_1)
  - Slowly remove the fish and record the weight of the container with water (W_2)



Weighing procedures

Compare the weight of the fish to the standard growth chart to see if the fish are growing according to plan. Adjust feed accordingly if they are underweight compared to the average weight expected at their age.

Tilapia Growth Chart

Here is a **simple Tilapia Growth Chart** that shows how Nile tilapia grow from fingerlings to market size, under good farming conditions. Use this to track progress and plan feeding and harvesting.

Stage	Age (weeks)	Average Weight (grams)	Fish Length (cm)	Notes
Fingerlings	0	5 – 10 g	3 – 5 cm	Stock into pond
Early Growth	4	30 – 50 g	8 – 10 cm	Increase feed; monitor water

Stage	Age (weeks)	Average Weight (grams)	Fish Length (cm)	Notes
Juveniles	8	80 – 100 g	12 – 14 cm	Sort by size if needed
Grow-out	12	150 – 200 g	15 – 17 cm	Fish growing steadily
Sub-adult	16	250 – 300 g	18 – 20 cm	Ready for partial harvest
Market size	20 – 24	350 – 500 g	20 – 25+ cm	Final harvest size

Notes:

- **Growth depends on** feed quality, feeding schedule, water quality, pond management, and fish health.
- **Market size in Tanzania** is usually 350g or more.
- **Good feed and pond care** can help reach market size in 5–6 months.

Catfish Growth Chart

Here is a **simple Catfish Growth Chart** which shows the typical growth pattern of African catfish under good pond management conditions.

Stage	Age (weeks)	Average Weight (grams)	Fish Length (cm)	Notes
Fingerlings	0	5 – 10 g	4 – 6 cm	Stock into pond
Early Growth	4	50 – 80 g	10 – 13 cm	Feed well, monitor daily
Juveniles	8	150 – 200 g	15 – 18 cm	Sort and grade fish if needed
Grow-out	12	300 – 400 g	20 – 25 cm	Keep water quality high

Stage	Age (weeks)	Average Weight (grams)	Fish Length (cm)	Notes
Sub-adult	16	500 – 700 g	28 – 33 cm	Partial harvest possible
Market size	20 – 24	800 – 1000+ g (1 kg+)	35 – 40+ cm	Final harvest for sale

Notes:

- **Catfish grow faster** than tilapia when well fed and kept in warm water.
- **Market size** is often around 1 kg or more, depending on local buyer needs.
- **Sorting and grading** help reduce cannibalism and improve uniform growth.

- **Recording:**
  - Keeping accurate records is imperative to monitor the performance of the fish and make informed decisions. Growth and mortality are important data points to record. This includes the following parameters.
    - The daily feed consumed by fish.
    - Daily feed remains at the end of feed day.
    - Feed intake
    - Weigh during sampling
    - Sampled number of fish
    - Daily weight gain
    - Feeding conversion rate
    - Growth rate

YOUTH POWER ORGANIZATION

TILAPIA GROWTH RECORD

POND NAME:

S/N	Sampling Date	No. of Tilapia	AVG. Weight	Sex (Mono/Mixed)	Remarks

- **Mortality**

YOUTH POWER ORGANIZATION

MORTALITY DATA

POND NAME:

Date	Total Head	Sex (male/female)	Comments

- **Other Records**
  - Sampling Data

YOUTH POWER ORGANIZATION

SAMPLING DATA

POND NAME:

DATE OF SAMPLING:

Sample No.	Captured Weight (g)	Number (f)	Average Weight (g)	Comments
Sample no 1				
Sample no 2				
Sample no 3				
Sample no 4				
Sample no 5				
Sample no 6				
Sample no 7				
Sample no 8				
Sample no 9				
Sample no 10				
Average of average weights				

- **Follow-up on fish growth**

About a few hundred fish per pond should be sampled every two to three weeks. On the basis of the quantity supplied, the Feed Conversion Rate (FCR) can be calculated and so the

efficiency of production evaluated. It is good if the FCR remains below 2 – 3. If it is higher, the reasons should be determined.

The feed with food conversion ratio (FCR) less than 2 should be applied.

Typical feed sizes, feeding rates and feeding frequency:

Average weight of fish	Feed (body weight %)
10 – 15g	20
15 – 30g	15
30 – 50g	10
50 – 100g	5
100 – 200g	4
More than 200g	3

Source: FAO, https://www.fao.org/fishery/affris/species-profiles/nile-tilapia/faqs/en/

If commercial feed is used, it should be remembered that 1 kg fish should be produced using maximum 1.25 – 1.50 kg feed (FCR – 1.25 – 1.50).

- **Action based on analysis**

Once the fish is weighed, recorded and the growth rate is analysed, the farmer needs to decide if any action is required, e.g. adjusting the feeding schedule to get better growth rates or other courses of action such as:

- Changing the source of feed ingredients if FCR is higher than 2 (explained more in feed and feeding module).
- Feeding rate of fish is always adjusted after sampling and weighing procedures.
- The adjustment is based on percent (feeding rate) and the body weight of the fish.

7.4 Equipment maintenance and storage

Equipment represents an investment to the farmer, and as it has value, it must be maintained and stored properly though routine procedures. Maintaining the fish farm equipment regularly is essential to prevent cost of equipment breakdowns which can affect fish farming operations.

The cost of maintenance varies with the type of equipment but investing some costs for regular preventive equipment maintenance is crucial for the success of the fish farm.

- The following fish farm equipment must be regularly checked and maintained:
  - Water quality monitoring equipment
  - Aeration system equipment e.g., thermometer, DO meters.
  - Pumping equipment
  - Feeding equipment
- Inventory control and records
  - Keep a list of all the equipment that the farm owns. Use the list to monitor where all the equipment is being used and stored. This with help to prevent items being lost or stolen and having to be replaced.

- **Checking condition of equipment**

Check all equipment such as Secchi disk, scoop nets, harvesting net, containers and other tools and equipment. Make sure they are in good condition and clean and repair items when needed.

- **Preventive maintenance** e.g. servicing pumps

To prevent occurrence of damages in farming it is recommended to maintain and service different parts and infrastructure at least every month or as per manufacturer's instructions for electrical or mechanical equipment such as water pumps, feed machines and other items.

- **Secure storage**

Security in storage facilities should be highly established in a fish farm, for instance hiring watchman or keeping strong locks, ensuring safety and security from thieves, insects etc.

7.5 Integrated fish farming

Integrated fish farming is a practice that combines fish farming with other agricultural or livestock farming operations around the fishpond. The farming practice forms two systems which may either linked or not linked to each other.

- **Benefits of integrated fish farming**

Integrated fish culture is a modern culture management. This ensures maximum utilization of small land area through gradual vegetable culture, poultry farming and livestock.

- Year-round vegetable supply, chicken and meat for the family and combating nutritional deficiency.
- Extra earning from vegetable sale, chicken sale and livestock sales.
- Caring of fishes and at the same time attending and taking care of the vegetable, poultry and livestock with no extra labour for vegetable.
- Change of food habit through vegetable, chicken and meat consumption.
- Protection from unhealthy environment.
- Multiple use of resources ensured
- Food supply increases in the markets.
- Different crops can be grown in short time and with low investment.

Types of integration:

Aquaponics	**Fish cum poultry farming**	**Paddy cum fish farming**	**Livestock**
• *Raising fish with vegetables* • Nutrients reached water from fishponds is used to fertilize vegetables and plants purify water for fish.	• *Raising fish with poultry* • Two systems are not linked. • Wastes from poultry fertilize the fishpond.	• Practice of producing fish in combination with paddy culture • It is the production of fish in rice field.	• Fish farming can be integrated with livestock such goats and cattle. • Manure from livestock are used to fertilize fishponds.

1. Aquaponics/Horticulture

Many small fish farmers in Tanzania can improve their farms by combining fish farming with vegetable gardening.

When water is changed in the fishpond, it can be used to irrigate vegetables. This pond water is rich in nutrients from fish waste, so it helps vegetables grow well without adding fertilizer. Tilapia can eat leftover vegetable leaves such as cabbage or cassava leaves that are no longer good for sale. These leaves can be placed in the pond as part of their diet or allowed to break down and become natural food for the fish.

Tips for successful integration:

- **Build a vegetable garden near the fishpond**, especially downhill, so that water can flow from the pond to the garden easily using small channels.
- **Choose vegetables that grow well in local conditions**, like amaranth, spinach, onions, tomatoes, or leafy greens.
- **The garden size depends on how much water and waste comes from the pond**. Bigger ponds with more fish can support bigger gardens.
- **Keep the system clean**. Do not use chemicals in the garden that can flow back into the fishpond.

This method helps farmers grow both fish and vegetables at low cost, improves food security, and makes better use of water and waste.



YPO Mazimbu trainees preparing spinach seeds for integration







2. Poultry

Fish and chicken can be farmed together to reduce costs and increase production. This system is useful for small farmers because the waste from one animal becomes food or fertiliser for the other.

How the system works:

- **Chicken manure** is used to fertilise the fishpond. This increases natural fish food in the water, like plankton, so the farmer does not need to make or buy as much feed.
- **Fishpond water** can be used to clean the chicken coop and give water to the chickens, reducing the need to bring water from far.

This mixed system gives **two sources of income** — from selling both fish and chickens — using the same space and shared resources.

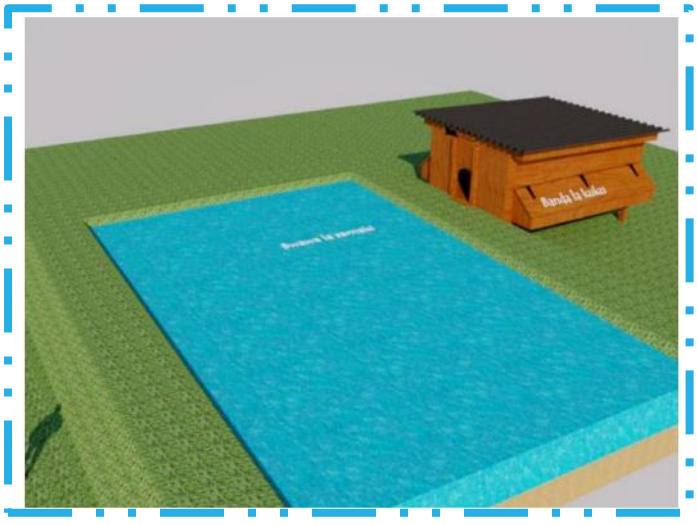
Chicken house setup:

- Build the chicken house next to the pond or on top of the pond embankment (dike).
- Keep the coop clean to avoid disease. A worker should collect chicken manure and place the right amount into the pond.
- Sick chickens must be separated. Their waste should not be used in the pond.

Recommended ratio:

- **40 chickens** are enough to fertilise **100 square metres** of fishpond.

By combining fish and poultry in this way, small farmers can improve productivity, reduce input costs, and make better use of land and labour.



3. Livestock: cattle, goats

Fish farming can be combined with goats or cows to reduce costs and increase production. In this system, manure from the animals is used to fertilise the fishpond. This improves the growth of natural food like plankton, which helps the fish grow without needing extra feed. At the same time, the livestock benefit from the fishpond by using its water for drinking or cleaning the shed.

How to set it up:

- Build the goat or cow shed near the fishpond.
- Do not allow animals to enter the pond. Instead, their manure should be collected and added to the pond by a worker.
- Keep the shed clean to avoid spreading disease to the fish or polluting the pond.

Recommended manure ratios:

- **1 cow** is enough to fertilise **200 square metres** of fishpond.
- **Goat manure** can also be used, but more goats will be needed to reach the same effect.

This type of mixed farming helps small-scale farmers use water and waste wisely, lower feeding costs, and earn income from both fish and livestock.

Challenges of integrated fish farming systems

Despite its many benefits, integrated fish farming systems also have some challenges that need to be managed including:

- Diseases outbreak
- Nutrients imbalance between the two systems

7.6 Waste management and disposal

The effective management of waste from fish farming is essential for maintaining the health of cultured fish and to reduce the environmental impacts on the surrounding area. Improper disposal of wastes to the environment can cause water pollution, oxygen depletion, and the proliferation of harmful algal blooms, not to mention litter and pollution to the local community.

Use a variety of strategies to effectively handle and dispose of various types of waste generated during fish farming operations.

Source of wastes in fishponds

- **Feed**: Waste produced from feed varies based on the following factors:
  - Nutrient composition
  - Feed consumed by fish
  - Ratio of feed size to fish size
  - Quantity of feed per time unit
  - Feeding method and storage time
- **Fertilizers**:
  - Dissolved wastes can also come from fertilizing materials
- **Chemicals:**
  - The use of chemicals in fish farming is strictly limited. Chemicals referred to here are those used for pond preparation and medication purposes.
  - Salts for fugal treatment
  - Lime to treat pond bottoms for acidity during pond preparation.

Types of waste:

- **Organic**: dead fish, fish entrails, wastewater, spent manure fertilizer, plant matter, uneaten fish feed
- **Inorganic**: plastics, nets, packaging, old equipment, etc.

Waste can also be categorised by the form that it takes:

- **Solid waste**: These can be suspended or settled wastes. Examples, un eaten feed, faecal matter, spent manure fertilizer, dead fish, and plant matter.
- **Dissolved waste**: Produced from feed metabolism in fish or decomposed uneaten feeds. Major forms of dissolved wastes are nitrogen (N) and phosphorus (P) products.

Waste management strategy and disposal

Optimizing waste management strategies in fish farming systems is essential to provide sustainable and efficient operations. The best management practices (BMPs) to reduce wastes from fish farming systems include the following.

- **Feed management**: Minimize overfeeding, High quality feeds, optimum nutrients composition of feeds.
- **Biological treatments**: Dissolves wastes in fish farming can be removed by biological means where by bacteria convert toxic ammonia int less toxic form called Nitrates.

- **Integrate fish farming** with vegetables **(see section 7.5.3)**
- **Constructed wetlands**: Constructed structures(ponds or channels) with shallow depth and planted trees for wastewater treatment purposes.

Waste disposal:

1. **Organic waste**: safe practices to prevent bio-contamination or hazards; prevent contamination of land or (ground)water, construct impermeable structures beneath fishponds, nutrient management (optimize feeding practises), waste treatment to remove organic waste from fishponds before discharge or reuse.
2. **Inorganic waste** using incineration as a disposal method, reuse inorganic waste e.g. using plastic containers for storage purpose.

7.7 Health and safety in fish farming

The following are some very important things that you should know to keep you and your family healthy. A certain kind of mosquito and some kinds of freshwater snails carry diseases that can make you very sick.

If the plants or weeds in your ponds and pens or on the banks become too thick, snails and mosquitoes can live and grow very easily.

From time to time, clean out the plants in your ponds and pens and cut the weeds and grass on the banks. Do not let the weeds and grass on the banks hang into the water so that your fish will not eat the mosquitoes and the snails.

Health: follow good health practices on the fish farm, including:

- **Latrine distance from ponds: contamination; soil types, slope**

If you have a latrine, use it. However, a latrine should be at least 10 metres away from any of your ponds or pens and from your water supply.

If you have to relieve yourself while you are working near your ponds or pens, near the stream that supplies your water or near your supply or inlet ditches, first walk at least 10 metres away.

- **Toilet practices**

Never use one of your ponds or pens as a toilet, or you and your family may become sick.

Never relieve yourself on or near your compost pile. Use your latrine or relieve yourself at least 10 metres away.

- **Safe handling of dead fish**

If you are careful about all of these things, it will help to keep you and your family from getting sick.

Safety:

Accidents and injuries can happen on fish farms. It is wise to be aware of dangers and risks that my effect workers or community members. For example, ponds/farm should be fenced to control access from vulnerable community members.

- Workers should be trained and given safe work procedures:
  - Personal Protective Equipment (PPE)
  - Life jackets for deep ponds
  - Cleaning and gutting fish: knives; injuries from fins and bones
- Acquire and maintain basic safety equipment
  - First-aid kits
  - fire extinguishers

- **Fencing** around the fish farm to restrict access from unauthorized, the fence should be durable with no gaps, the fence should be tall enough to prevent unauthorized people from climbing, should have lockable gates and warning signs which indicate that the entry is prohibited.(clear and easily understandable signs should be use to convey the message effectively)

- **Safety signs** play a crucial role in promoting awareness and ensuring the safety of personnel and visitors on fish farm. Commonly used signs in fish farms includes No entry signs, danger sign, caution sign, emergency exit sign, first aid sign, no smoking sign, biosecurity sign and safety equipment sign.

Safe work procedures:

- **PPE** Refers to specialized gears worn by workers to protect themselves against hazards and risks, example of PPE commonly used in fish farm include rubber boots, gloves, coveralls, safety goggles, hard hats, life jackets when working in deep ponds.

- **Cleaning and gutting fish**

  Safety procedures are essential to be practiced to minimize the risk of accidents, injuries and contamination. Wear appropriate PPE such as gloves to protect the hands from cuts, direct contact with fish slime, scales and bacteria, protective clothing to prevent fish slime

and fluid from coming into contact with your skin and clothes, safety goggles to protect eyes from splashes during gutting process, masks to protect yourself from airborne particles and odours, closed toe shoes to prevent feet from accidental cuts from sharp fish bones or knives.

7.8 Natural disasters and extreme weather

Aquaculture can easily be affected by natural disasters or extreme weather events. There is the risk of flood during rainy seasons and risk of drought during the dry season, and when severe, farmers might make nothing from aquaculture. Nevertheless, preparations can be made to reduce risks and economic losses.

Precautionary measures before natural disasters

1. Pay attention to the weather forecast and keep abreast of extreme weather information and alerts.
2. Before extreme weather, the marketable size fish in the pond should be harvested and sold at the right time, to avoid losses when disaster strikes.
3. Aquaculture buildings and infrastructure should be reinforced and leakage avoided.
4. Before extreme weather events, the DO in the pond water is generally low, thus close attention should be paid to water quality changes to avoid tilapia gasping for air due to hypoxia.
5. Before extreme weather events, appropriately lower the water level in tilapia ponds, because heavy rains will cause the water level to rise. Lowering the water level at the right time can effectively prevent tilapia from escaping when the water level becomes too high.
6. Reinforce the pond dikes. Before disaster, inspect the pond dikes, heighten or reinforce those dikes which are too low or too thin to avoid breakages, and thereby prevent dikes bursting and leaking when water levels rise.
7. Before extreme weather events, add nutrients such as vitamin C complex into the feed, to enhance the anti-stress capacities of the farmed species.
8. When a disaster is coming, monitor ponds more frequently, so as to find and solve problems in good time.

Timely recover the production after extreme events

After a disaster, inspect the farm in time to find out the impact and make efforts to recover production:

1. If there is any pond damage, clean up the debris in good time and remove dead fish to avoid environmental pollution or disease. Repair the damaged pond in time so as to resume production as soon as possible.

2. For those ponds without damage, the primary task is to control the reproduction of pathogens. Disinfectants such as quicklime should be spread at the right time to improve the water quality.
3. Disinfect fish with drugs in good time to prevent secondary diseases such as skin ulcers and fungal infections caused by abrasion of fish bodies.
4. For the disinfected pond, proper DO levels should be ensured. If it is convenient for filling and draining, replace part of the pond water with fresh water, and add fertilizer in timely fashion to the pond to stimulate natural food production in the pond which in turn enhances fish growth.
5. Nutrients such as vitamin C complex can be added to feed to enhance the anti-stress capacities and resilience of tilapia after disaster or extreme weather events.

- **Weather monitoring**

Weather monitoring is crucial for ensuring optimal conditions for a successful aquaculture practice. Below is how weather monitoring play crucial role:

- **Temperature management**: fish have specific temperature requirement for growth and metabolism, monitoring ambient temperature helps aquaculture regulate water temperature within ponds to ensure they remain within optimal range.
- **Oxygen level**: monitoring oxygen concentration helps prevent hypoxia (low oxygen) or anoxia (absence of oxygen) which can be detrimental to fish health.
- **Weather extremes**, such as storms, heavy rainfall or heat waves. These events can disrupt aquaculture operations, cause infrastructure damage and impact water quality.
- Helps in decision making, weather data collected over time provides valuable insights into long term trends and seasonal patterns. This allows aquaculturists to optimize production strategies, improve risk management practices and enhance overall productivity and sustainability.
- **Preparation for potential disaster:**
    - Harvesting of market-size fish
    - Lower water level to allow for rainfalls
    - Check and reinforce pond dykes
    - Secure buildings and equipment
    - Monitor ponds frequently
- **Actions after natural disasters**
    - Clearing debris
    - Repair infrastructure/dykes
    - Disinfect water: liming

7.9 Fish farm security

Involves measures taken to protect fish farms, fish stocks and related infrastructures from various threats and risks.

- **Theft:** theft can be prevented by implementing a number of security measures:
  - **Fencing** creates physical barriers which prevents unauthorized access and theft.
  - **Security guard and dogs** provide additional protection and surveillance to prevent theft and unauthorized access.
  - **Cameras:** surveillance cameras may be used to keep watch over ponds.
- **Predators:** various predators may be attracted to the fish farm to eat the fish. This can result in major effects and losses for a fish farm including:
  - Losses of the fish in the pond
  - Consume the fish feed
  - Sources of parasites and other infections to fish
  - Stress caused to the fish when dealing with predators
  - Cause physical injury to fish in the process of hunting.
  - May translocate fish to different ponds.

There are different strategies for different predators that may cause losses on a fish farm. Each of these has its own prevention and control strategies as presented in the table below:

Types of fish predators and control measures

Type of predator	Possible control measure
Birds	• Building ponds close to houses. • Stretching strings or nets across the pond • Hanging bird-scarers, tins, bamboo rattlers
Frogs and tadpoles	• Destroying eggs by scooping them from the edge of the pond with a scoop net • Pond liming, which will also kill the eggs and tadpoles. • Screen inlets if water in the pond is sourced through diversion from other water sources such as rivers or lakes.
Aquatic insects	• Draining and keeping the pond dry before refilling

Type of predator	Possible control measure
	• Pond liming, which kills insects
Human	• Building ponds close to houses. • Employing security personnel • Use of trained dogs
Snakes	• Clear all bushes and grasses around the pond/farm.
Large lizards	• Proper fencing and keeping dense bushes cut down.
Turtles	• Fencing around pond with wire mesh, trapping.

General practices against predators:

Install fine mesh fencing around fishponds to create physical barrier that prevents frogs and other predators from accessing the fish

Apply lime around the perimeter of fishponds as lime creates an alkaline environment that may prevent frogs and other predators from the fishponds due to their sensitivity to changes in pH levels.

7.10 Cost recording

Fish farmers are advised to keep track of all cost associated with farm inputs and outputs so that cost of production, sales, and net income can be easily calculated. Cost recording is essential to evaluate the overall economic performance of the fish farm as an enterprise.

The records to be kept in fish farming management include:

- **Animal feeds**

  Cost recording for animal feed involves keeping detailed track of expenses associated with purchasing, storage and using feeds for the fish.

- **Casual labour**

  Casual labour costs in fish farming management involves tracking expenses related to hiring and paying workers who perform various tasks on the fish farm.

- **Office consumables**

  Recording office consumable costs on fish farm management involves tracking the expenses associated with various supplies and materials used in the administrative and operational aspects of the farm.

- **Agricultural implements**

  Recording agricultural implements costs involves tracking the expenses associated with the tools and equipment used for various farming operations.

- **Cost recording:**
  - Per batch of fish cultured
  - Monthly cost for farming inputs

Cost recording can be done in two different ways:

1. Per batch
2. By month

Batch cost recording method:

Date	Item/input description	Quantity	Unit cost	Total	Remarks
	1. Pre-stocking costs – Land acquisition – Pond construction – Pond preparation				
	2. Stocking costs – Fingerlings – Transport				
	3. Post stock management costs – Feeds – Transport – Water quality				

Date	Item/input description	Quantity	Unit cost	Total	Remarks
	monitoring – Fish health – Pond management – Harvesting				
	4. Revenues – Sales – Net profit/loss				

Monthly cost recording method:

Date	Type of farm input	Quantity	Unit cost	Total	Remarks
01.01.2024	5g Nile tilapia fingerlings	2,000	100	200,00	10kg initial total weight
01.10.2024	Pelleted Starter Feed	1 bag of 50kg	1	85,00	1mm feed size

8 Module 8: Fish Health Management

Fish diseases, in various forms, have been tormenting the aqua culturists ever since man learned the art of fish husbandry. The stability of a fish population in a particular habitat is very often disrupted by various factors like diseases, habitat destruction, depletion of resources or other applications of environmental stressors. Fish are in a state of equilibrium with the environment. A change in the environmental parameters beyond the tolerance limit disturbs the equilibrium resulting in a stress response in fish and making them vulnerable to fish disease.

8.1 Fish behaviour

Fishes perceive the world around them by the usual senses of sight, smell, hearing, touch and taste as well as by special lateral line water-current detectors. Fish use these senses to respond to various stimuli such as feeding, physical engagement with farmers during e.g. netting, weighing and harvesting. The farmer needs to be aware of his/her fish behaviours when approaching the pond and the reactions of the fish. Are they swimming away from you or moving directly towards you? When fish are environmentally uncomfortable, stressed, sick or hungry they will always swim towards you seeking help or food.

8.1.1 Behaviour of healthy fish

Healthy fish have the following behaviours:

- **Good appetite**: eating quickly and enthusiastically.
- **Breathing well**: gills rising and falling rhythmically.
- **Behaviour of fish**: active and alert
- **Eyes** are bright and clear.
- **Healthy fins**: no sign of tears, splits, spots, or streaks of blood. ...
- **Swimming** freely and evenly.

8.1.2 Behaviour of unhealthy fish

Unhealthy fish have the following behaviours:

- Sunken or distended bellies (except when carrying eggs)
- Sticking out scales.
- Pale patches on scales.
- Tiny white spots on the fins, gills, or skin.

- Milky eye/s.
- Swimming unusually: a fish either sinking to the bottom or swimming to one side is a bad sign.

Unhealthy fish behaviour and actions to take:

Fish swimming erratically: If your fish are swimming erratically, they could just be playing or exercising, but if the fish do this consistently and seems unhealthy, the cause may be poor water quality. The pond water should be tested immediately to see if anything is improper and harming your fish. If everything is in order, the cause of your fish's erratic behaviour could be a parasite. If a fish is rubbing itself up against something in the tank or pond, and then swimming quickly away, it may have an external parasite.

Listlessness: If fish seem tired and lethargic, it can be a result of many factors. One common cause is improper water temperature. If the pond water is too hot or too cold, fish will be very inactive, and the pond water needs to be changed. Other possible causes are overfeeding and poor water quality.

Sitting at the bottom: If fish are spending lots of time at the bottom of the pond or tank, it may be normal behaviour. Many fish, like catfish, are bottom-feeders and spend their time there. Fish also often sleep at the bottom of their pond or tank. If the activity of the fish does not seem to fit either of these reasons, and fish look tired and listless at the bottom of the pond, it may be a sign of disease. If there is reason to believe that this is the case, the fish should be quarantined. A common disease that would cause this behaviour is a swim bladder infection, which is a result of a poor diet or water quality. Try fasting the fish for a day or two or feeding the fish easy-to-digest foods such as peas.

Fish gasping for air: If fish look like they are gasping for air at the top of the pond, this is a sign that either the water quality is poor or there is not enough dissolved oxygen in the water. Test the water and consider getting an aerator for the tank or flush the water if it is a pond. The key to keeping fish healthy and happy is knowing what they are saying about their behaviour.

Observation checklist for fish behaviour:

Observation Question	Findings	Action Needed
1. How are the fish swimming?		

Observation Question	Findings	Action Needed
2. Are the fish moving together in groups?		
3. Do the fish eat when feed is given?		
4. Are the fish gasping or breathing fast?		
5. What do the fish look like?		
6. Are the fins and tails healthy?		
7. How do the fish react when disturbed?		

8.1.3 Stress: causes and indicator

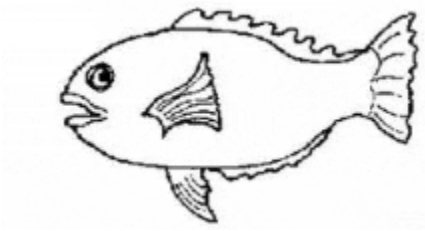
Stress is a condition in which an animal is unable to maintain a normal physiologic state because of various factors adversely affecting its well-being. Stress is caused by placing a fish in a situation that is beyond its normal level of tolerance. Specific examples of things that can cause stress (stressors) are listed below:

- **Chemical stressors:**
  - Poor water quality – low dissolved oxygen, incorrect pH
  - Pollution – intentional pollution: chemical treatments - accidental pollution: insect spray, spills
  - Diet composition – type of protein, amino acids
  - Nitrogenous and other metabolic wastes - accumulation of ammonia or nitrite
- **Biological stressors:**
  - Population density – crowding
  - Other species of fish – aggression, territoriality, lateral swimming space requirements
  - Micro-organisms – pathogenic and non-pathogenic

- Macro-organisms – internal and external parasites

- **Physical stressors:**
  - Temperature: this is one of the most important influences on the immune system of fish.
  - Light
  - Sounds
  - Dissolved gasses
- **Procedural stressors:**
  - Handling
  - Shipping and transport
  - Disease treatments

Visual cues to fish condition include:

		
Alarm	**Itching**	**Exhaustion | Disease| Death**

8.2 Treatment methods

- **Dipping**: is conducted by inserting sick fish in a highly concentrated solution for treatment for less than 10 seconds as prescribed e.g. treatment by potassium permanganate.
- **Bathing**: is conducted by placing sick fish in a bath of less concentrated solutions for treatment for more than a minute as prescribed e.g. treatment by copper sulphate.

Treatment table below:

Treatment	Instructions
Household bleach	• For non-metallic equipment only • Make a stock dilution at 250ml/ ℓ • Use diluted solution=5% stock solution (3 – 4 tablespoons/ℓ
Iodophors	**Dosage**: 250 ppm AI • **Romeiod** (0,5% AI) 50ml/ ℓ (10 tablespoons/ ℓ) • **Wescodyne**: 1.6% AI: 50ml/3ℓ (10 tablespoons/3 ℓ) • **Fam 30**: 2.75% AI 50ml/ ℓ (10 tablespoons/5 ℓ)
Benzalkonium chlorides	**Dosage**: 200ppm AI • **Roccal**: 25% AI: 4ml/5 ℓ (4 teaspoons/25 ℓ) • **Hyamine** 3500: 50% AI: 2ml/5 ℓ (2 teaspoons/25ℓ)

8.3 Fish diseases

Environmental stressors (e.g., poor water quality, loads of sedimented waste that produce toxic gases), and the presence of opportunistic or infectious pathogens (e.g., viruses, bacteria, parasites, and fungi) and non-infectious (nutritional, genetic) defects can all lead to sick fish. A change or shift in any of these factors can result in disease occurrence. Take note, that this change does not just apply to infectious diseases but also to non-infectious diseases.

Fish suffer from many diseases, including:

- **non-parasitic infection** by environmental stresses e.g. gas disease.
- **parasitic infection** by fungi, bacteria, protozoa, worms, and crustaceans.
- **viral diseases fish** may also suffer from viral diseases such as herpes, Rhabdoviruses and viral haemorrhagic septicaemia, but these are rare or do not occur in Tanzania.
- **deficiency diseases** which are caused by the lack of specific nutrients in the diet.

Common signs of diseases in fish

- Erratic swimming
- Gulping for air

- Crowding at inlets and outlets
- Rubbing body against walls or protruding objects in the pond
- Reduced or no feeding
- Pop/blind eye
- Wounds
- Swollen/ protruded abdomen (stomach)
- Mould or ulcerations on the skin

These visible signs may not be definitive indicators of disease; fish may need to have blood or slime samples taken to determine if they have any specific diseases.

- **Controlling the spread of fish diseases:**

Upon signs of diseases, quarantine and restrict the movement of fish. Control and measures are explained in the table below for common fish diseases. Remove and bury dead fish as soon as you spot them.

Common fish diseases, their symptoms, and control/ remedial measures:

Fish disease	Symptoms	Control /remedial measures
Non–parasitic infections		
Gas disease (air embolism)	• Mouth remains open, with small bubbles beneath the skin.	• Aeration of water areas, growth of water hyacinth
Depletion of oxygen	• Gills look pale.	• Sprinkling of raw cow dung, growth of water hyacinth. Raking of pond bottom and change of water
Growth of algae	• Pond water turns green, and fish gape for respiration.	
Increase of hydrogen sulphide	• Pond bottom/muck smells like rotten eggs resulting in choking respiratory.	• Aeration of pond/ water areas.

Fish disease	Symptoms	Control /remedial measures
Excess of CO2 or high pH of water	• Excessive secretion of mucus by gills and body surface	• Water exchange
Parasitic infection		
Fungal disease	• Infects fry, fingerlings and adults • Fish become weak and lethargic, ulceration of the skin, blindness ulceration of the skin, blindness, tuffs of minute white hair-like outgrowth in affected parts.	**Dip treatment in 3%:** o Common salt for 5- 10 mins. - 1:2000 parts of copper sulphate (CuSo4) for 5- 10 mins. o 1:1000 parts of potassium permanganate (KMno4) for 5-10 mins until fish shows distress. o Apply about 100 kgs/ ha quick lime in the pond o 3 – 5 % common salt bath for 5 mins. o 5: 1000 parts KMno: bath for 5 – 10 mins. o 8 – 12 kgs/haCuSo4 applied in the pond.
Gill rot	• Gill becomes greyish-white may finally drop off during the hottest time of the year	
Bacterial diseases		
Fin and tail rot	• A white line appears in the margin of the fin and spreads to all parts of the body.	• 1,2000 parts of CuSo4 for 1-2 mins • Painting/intense application of the

Fish disease	Symptoms	Control /remedial measures
	• Sores and ulcers appear in the body. Size increases, gradually exposing the muscles. • Accumulation of fluid inside the body cavity, scales protrude • Infects the eye, optic nerves, and the brain of fish. • Eye becomes opaque eyeball bursts. • Pale colour of gills with a coating of cram layer of mucus.	affected part by CuSo4 also helps. • Badly infected fish be destroyed. • 1:1000 parts of KMno4 applied in pond. • 1:2000 parts CuSo4 dip treatment for 1min for 3 – 4 days • 1:1000 parts KMno4 disinfect the pond • 5:1000 KMno4 dip treatment for 3 mins • 60 mg Chloromycetin in 4.5-litre water: bathe the infected fish. • Initial stage Chloromycetin 8 – 10 mg/litre: bathe for one hour for 2 – 3 days • Disinfect pond by 1:1000 parts KMno4. • 3 – 5 % common salt bath hourly for one week. • 1:5000 parts formalin treatment in pond/ dip hourly for 7 – 10 days
Ulcer	• Ulcers and haemorrhages on fish flesh	• Common salt for 5- 10 mins. - 1:2000 parts of copper sulphate (CuSo4) for 5- 10 mins.
Eye disease	• Injuries and white layers	• Water exchange

Fish disease	Symptoms	Control /remedial measures
Protozoal diseases		
Trichodiniasis	• Gills covered with white spots like pox. • Scales covered with white spots, falling of scales, perforation of scales. • Excessive secretion of mucus in gills. • Mucus on the caudal peduncle, infects skin and gills, dropping of scales	• 3 – 5 % common salt bath for 5 – 10 mins. • Decreasing the density of fish from affected ponds. • 3 – 5 % common salt solution bath for 5 – 10 mins. • Decreasing the density of fish in the pond. • 3 – 5 % common salt bath for 5 – 10 min. • 1:2000-part Acetic acid bath for five mins.
Helminth (worm diseases) • Dactylogyrosis • Gyrodactylosis • Black spot disease • Ligulosis (tapeworms) • Crustacean disease • Lemaeosis • Ergasilosis • Argulosis	• Black oval-shaped patches and nodules on the body. • The abdomen enlarges abnormally, and the body becomes dark. • By anchor worms, buried deep in host tissue, rubbing against pond dykes or even bottom, becomes lethargic. • Irritation in gills and fins	• 1:5000 parts formalin bath for 5 – 10 mins. • Dip in 1.1 lakh parts of Picric acid for one hour. • Removal of the molluscan population from water areas. • Removal of birds from around affected areas. • Gammaxene @ 1 ppm application in the pond.
Crustacean disease • Lemaeosis • Ergasilosi • Argulosis	• Parasites visible on gills and body surface.	• 5% common salt bath to the affected fish • Removal of eggs of Argulus by hanging corrugated sheets in water and removing

Fish disease	Symptoms	Control /remedial measures
		them and drying them after a week to kill the eggs.

Deficiency diseases

Fish may suffer from deficiency diseases if they lack nutrients in their diets. These may be identified by the following symptoms or physical abnormalities:

Symptom	Deficiency	Treatment
Broken head	Vit C	Use of recommended balanced fish feed
Mouth lesions	Vit B	Use of recommended balanced fish feed
Caudal fin erosion	Vit B	Use of recommended balanced fish feed
Hyper irritation	Vit B	Use of recommended balanced fish feed
Bent spine	Calcium	Use of recommended balanced fish feed

8.4 Biosecurity measures

Biosecurity is a fundamental component in fish health management practice to reduce the risk of introduction, establishment and spread of diseases.

8.4.1 How diseases and non-native species spread

Diseases and alien or non-native fish species may spread through a range of activities that need to be identified and controlled using biosecurity measures. These activities include:

- Introduction of new fish.
- Movement of people and machinery between and within fisheries.
- Contact with other fish from the wild.
- Movement of animals onto the fishery e.g. predators and wild birds

- Shared equipment.
- Transfer of contaminated water, for example contaminated supply rivers and streams.
- Escapees from other waters during flood events
- Transfer of plant matter and mud on angler's equipment and clothing

8.4.2 Biosecurity measures

Biosecurity measures are implemented through a range of design and operational strategies and activities including:

Design of farms

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

Operational biosecurity measures:

- PPE use in specified activities such as fish handling
- Handwashing: before and handling fish, fish products, equipment
- Foot baths
- Equipment cleaning and maintenance
- Good cleanliness and housekeeping on the farm: cleaning, tidying, rubbish management
- Good management practices

In addition, attention to the following with reduce biosecurity risks on a fish farm:

- **Water Sources**

Implementing steps to address risks can be difficult, as you often do not have the ability to choose or change the type of water source at an existing facility. In an open water situation there are fewer steps that can be taken by individual growers. This situation necessitates participation in community actions to try and protect the water source you operate in.

In situations where surface waters are used as either flow through or to fill a pond or recirculation system, water can be treated primarily with UV light or ozone. The effectiveness and cost of such a system will depend on many factors including the volume of water to be treated, the targeted disease(s), and the contact time of the treatment. You should consult someone with the appropriate technical expertise when considering such a system. If treating your water, consider treating both incoming water and effluent water. In systems where you discharge water into the same system you take your water from, such as a lake, your untreated discharge water may introduce disease into your water source which you may then bring back into your facility.

- **Aquatic Animal Health and Husbandry**

Various strategies construe good husbandry on fish farms:

  - **Minimize stress for the fish**. This can be achieved by following established best husbandry practices, maintaining appropriate stocking densities, and maintaining excellent water quality.
  - Apply **preventative vaccinations** where available and appropriate.
  - **Provide proper nutrition**. This includes considering how the feed is stored to prevent spoilage, scavenging from rodents, birds and other pests.
  - **Remove dead or dying animals** on a regular basis.
  - **Keep accurate records**: Maintain written records of aquatic animal illnesses or deaths, daily animal maintenance (feeding rates, water quality, cleaning regimen), growth rates, feed conversion ratios and new animal introductions. Accurate records can help maximize production efficiency, detect subclinical disease problems and help identify disease entry points in the event of a disease outbreak or positive tests for pathogens.

- **Farm Traffic**

Farm traffic is a large area where many different biosecurity practices and combination of practices can be implemented. A variety of practices are listed below:

- **Maintain separate equipment for each site**. This includes dedicated nets, totes, and other gear that is used only at a given location or specific task such as mortality removal, and separate raingear or boots for each location.

- **Reduce traffic between farms**. This includes designated parking outside of the farm for vehicles that are not required for use in operations. Vehicles required for operations on the farm should remain on a single farm and minimize movement between farms. Similar restrictions should apply to employees. If necessary for employees to visit multiple sites, first try to visit only one farm per day. If it is necessary to visit multiple farms in one day, visit the lowest risk farm first followed by the higher risk farms.

- **Maintain visitor logs**. This includes requiring employees who do not work on a daily basis at the facility logging in when they visit the site.

- **Select appropriate equipment**. When building or purchasing equipment, avoid porous and/or organic materials such as wood, which cannot be disinfected.

- **Establish limited access points**. All traffic onto and off a farm should be at controlled points where appropriate disinfection can occur. Changing of clothing or foot baths can be established. You may also want to establish restricted areas on a farm where sensitive activities occur, such as nursery, grow-out or broodstock rearing areas. These areas can be treated like mini farms within the farm by using separate equipment, and restricting movement of employees and vehicles.

- **Cleaning & Disinfection**

Any equipment or vehicle used at aquaculture facilities should be cleaned and thoroughly dried (preferably in direct sunlight) or chemically disinfected before being used in another location.

The first and most important step to proper disinfection of vehicles or equipment is to thoroughly clean the item. This includes scrubbing with soap and water. Soap and water can kill or remove most of the pathogens on an item. Once the item is clean you can then disinfect it. There are a large variety of disinfectants available.

To minimize tracking of pathogens among and around facilities, **footbaths** should be placed near the entrance to all animal areas. Scrub brushes should be provided to physically remove visible debris from footwear prior to use of footbaths. Boots and protective clothing should be cleaned and submersed or sprayed for an appropriate period of time (according to product

label) before entering and exiting an area. Footbath solutions should be maintained to be free of visible debris and should be checked regularly (at least weekly) to ensure that proper concentration of disinfectant is present.

8.4.3 Hygiene and Safety Risks

Fish is a high-risk food and can easily cause food poisoning if it is not handled safely and hygienically. Fish should be kept as cold as possible all the time – both when it is raw and cooked as the bacteria that will spoil the fish and cause food poisoning grow as warm temperatures (particularly 20 – 40 degrees C).

Ongoing cleaning of the cooking area and facilities is a way to reduce the risk of the fish spoiling. Clean:

- **Work surfaces** after each use.
- **Equipment and utensils** after each use and between different products
- **Food contact surfaces** and fridge handles should be disinfected on a regular basis to prevent the spread of bacteria, perhaps after each shift.
- **Floors:** clean these daily and they should be in a clean state at the end of the working day.
- **Machinery** after each day's use and between different products.
- **Shelves, cupboards** cleared weekly and cleaned.
- **Walls and ceilings** as often as necessary, some areas may need daily cleaning.
- **Toilets** daily or more frequently if required.

8.4.3.1 Fire

Fire may be a significant safety risk when preserving fish. You must have proper firefighting equipment such as a fire extinguisher, which must be serviced regularly.

Training is essential and fire procedures should be practised. Everyone should know what to do in the event of a fire.

Risk	Response
Clothing catches fire	• Roll them in a fire blanket to smoother the flames.
Prevent an oil or fat fire	• Before lighting the stove, check that the pan has oil/fat.

Risk	Response
	• Never overheat oil; watch carefully for smoke indicating it is too hot. • Always dry the food as much as possible before frying so that the water on the fish does not splatter excessively when the fish is put into the hot oil. • Never leave a pan unattended while oil is heating. • Handle and dispose of batter scraps safely
General hazards	• Don't ever trail wires across a floor. • Make sure the floor is dry and free from oil or water spills that may cause slips and falls.

8.4.3.2 First Aid

Always have a well-stocked first aid box available containing burn treatment, plasters and dressings for cuts, antiseptic and disinfectants for cleaning any injuries. Ensure there are latex gloves in case of having to handle blood.

9 Module 9: Harvesting and Processing

The following considerations should be taken before harvesting fish for market:

- Survey the market to understand current fish prices.
- Estimate your potential income from the harvest.
- Decide whether to sell your fish to retail or wholesale buyers.
- Ensure that the market has been arranged first and is ready to take the fish (advertisement).
- Decide on partial or total harvesting.
- If possible, sample your fish before sale to check the flesh quality and/or taste.

Harvesting your fish

Farmed fish can be harvested in several ways, either from a filled or drained pond, according to your needs. The following should be considered:

- Harvesting should be done based on your marketing plan.
- When fish have reached the desired size or market demand is sufficient, it is time to harvest.
- Before harvest and sales, fish should be subjected to a health inspection.
- You can harvest your pond partially or totally.
- It is advisable not to feed fish one or two days before harvesting for sale.
- Equipment used in harvesting might include a seine net, cast net, lift net, and scoop net.
- Sort your fish based on size before going to market.

9.1 Types of Harvesting

9.1.1 Partial harvesting

This is a type of harvesting that can start four months after the fish are placed in the pond. The breeder begins to harvest fast-growing fish for seasoning or to sell for subsistence. A fishing net is needed to be able to remove fish larger than the mesh of the net while keeping the smaller fish in the pool for later harvesting. Retail harvesting can be done at the last minute when the fish are large, but the availability of customers is limited. Thus, the breeder has to harvest fish little by little to avoid the spoilage of the fish caught when they cannot be bought due to the lack of storage facilities.

Advantages and disadvantages of partial harvesting

Advantages	Disadvantages
• Fish is harvested based on customer orders. • Get more value for fish by targeting specific markets e.g. hotels want fish of specific size • Less labour is needed • Fry production is reduced thus reducing stocking density and feed competition • Avoid loss of food and production by allowing longer intervals between harvesting of two batches.	• Stresses the fish that remain in the pond, leading to some mortality • Greater frequency and additional harvesting times put more stress on farm workers. • It causes stress and weight loss in reserved fish. • You must feed reserved fish until your stock is sold – this could lead to additional costs. • Requires year-round water supply.



Partial harvesting of tilapia

9.1.2 Total harvesting

This method of harvesting fish aims to remove all the fish from the pond to take them to the market. This kind of harvesting is done in two ways:

1. A net with smaller mesh is used to catch all the fish in the pond without depleting the pond's water volume, or

2. Drain all the water in the pond so that the fish gather in the shallow harvesting hole.

The second method is easier, the breeder is required to open the water outlet of the fishpond to drain most of the water, then collect the fish in the small amount of water left in the pond.

Complete harvesting is more profitable as the farmer gets time to dry the pond and apply pesticides to kill fish pathogens before resuming farming. It is advisable to let the pond dry completely for two to four weeks before refilling it with water and continuing breeding.

Advantages and disadvantages of total harvesting

Advantages	Disadvantages
• Total harvest is not tiresome as partial harvest • It leaves pond free for maintenance and repair • Lower energy requirements of labour as harvesting is easier. • Ease of harvest • Time saving	• Can spread infection to fish during harvesting • Small fish size will also be harvested (bycatch) • Underutilization of water



Total harvesting of catfish

9.2 Harvest preparation

The following steps are taken when preparing for a harvest:

1. **Equipment checks and preparation**; select the correct net mesh size.

   If it is partial harvesting, then the mesh size should be selected to catch the desired size of fish. If it is total harvest, then the net should have the smallest mesh size.

   Also checking if the net all good and set to go; if there are any holes these should be fixed before harvesting



2. **Arrange labour**

   Check to ensure labour is healthy – no open wounds, water or cold related problems. If the water level is above the waist, then avoid female labour as they may be in menstruation cycle and may not reveal this.



3. **Checking fish size in different ponds**

   Sampling one or two days before harvesting – check your fish size by sampling the fish. This is done by small partial harvesting of ten to twenty fish in ponds so as to have a picture of all fish sizes in each pond.

4. **Conditioning**: withhold feed

   If you decide which pond will be harvested, then do not feed fish the whole day of harvesting from morning up to harvesting time.

5. **Reduce the level of water** in the pond (net harvesting)

   Before harvesting make sure to reduce water to knee level depending on load of fish in the pond and type of harvest to minimize labour energy during harvesting.

9.3 Harvesting

If the fishpond is constructed with a harvesting chamber, it is easy for total harvesting. Simply reduce the water level until all fish are confined in the harvesting chamber then scoop the fish out of the pond.

For fishponds without a harvesting chamber the following procedures should be followed:

1. After harvesting net preparation, conditioning and reducing water level processes, arrange the harvesting team of minimum of four people depending on the size of the pond.
2. Two out of four members should hold start edge and end edge of the net as they are the leading, other two should be at the centre of the net holding bottom of the net to the pond floor making sure the net does not lose contact with the floor so that no fish escape.

3. Moving by fast walking from deep to shallow end of the pond where the outlet side is to confine fish there.
4. **Note:** for partial harvesting, the team starts to harvest at the middle of the pond only if pond has many fish to minimize stressing all fish in pond.
5. One member outside on dike should scoop caught fish using a large scoop net and put the fish in a drum with water
6. Two members will be weighing the different numbers of fish and recording and counting weighed fish and recording every batch of harvest.
7. Finally recorded fish will be loaded to containers to market, consumers, processing or storage













HARVEST RECORD TEMPLATE			
Pond name:		**Harvesting date:**	
Batch #	**Weight Harvested**	**Number of Fish**	**Avg Weight**
1			
2			
3			
4			
5			
6			
7			
8			

Counting and packing:

- Fish are counted after being weighed so as to record the average weight per fish.
- Counting is done by using two buckets of water handling fish by carefully scooping fish from one bucket to the other with clean hands, counting as fish are transferred.
- Live fish sales: supply in containers of water.
- After counting fish are placed head to tail in a container with packed ice to minimize fish spoilage during transportation or storage.

9.4 Post-harvest processes

Fish processing refers to the processes associated with fish and fish products between the time fish are caught or harvested and the time the final product is delivered to the customer.

- Once fish is harvested, it must undergo several steps before it's ready to be sold in the market.
- Fish is a highly perishable food, so it must be carefully handled from the moment it's caught until it's sealed in packaging material.
- Proper, efficient processing and packaging prevent deterioration and ensure a quality product.

9.4.1 Steps in fish processing

After catching or harvesting fish, they will either be kept alive to take to market, or they will die and be processed/cleaned and taken to market.

Typical handling processes are:

- Transferring the catch from the harvesting net to the container out of the pond.
- Holding the catch before further handling.
- Sorting and grading.
- Bleeding, gutting, and washing.
- Chilling.
- Storing the chilled fish.

9.4.2 Handling live fish

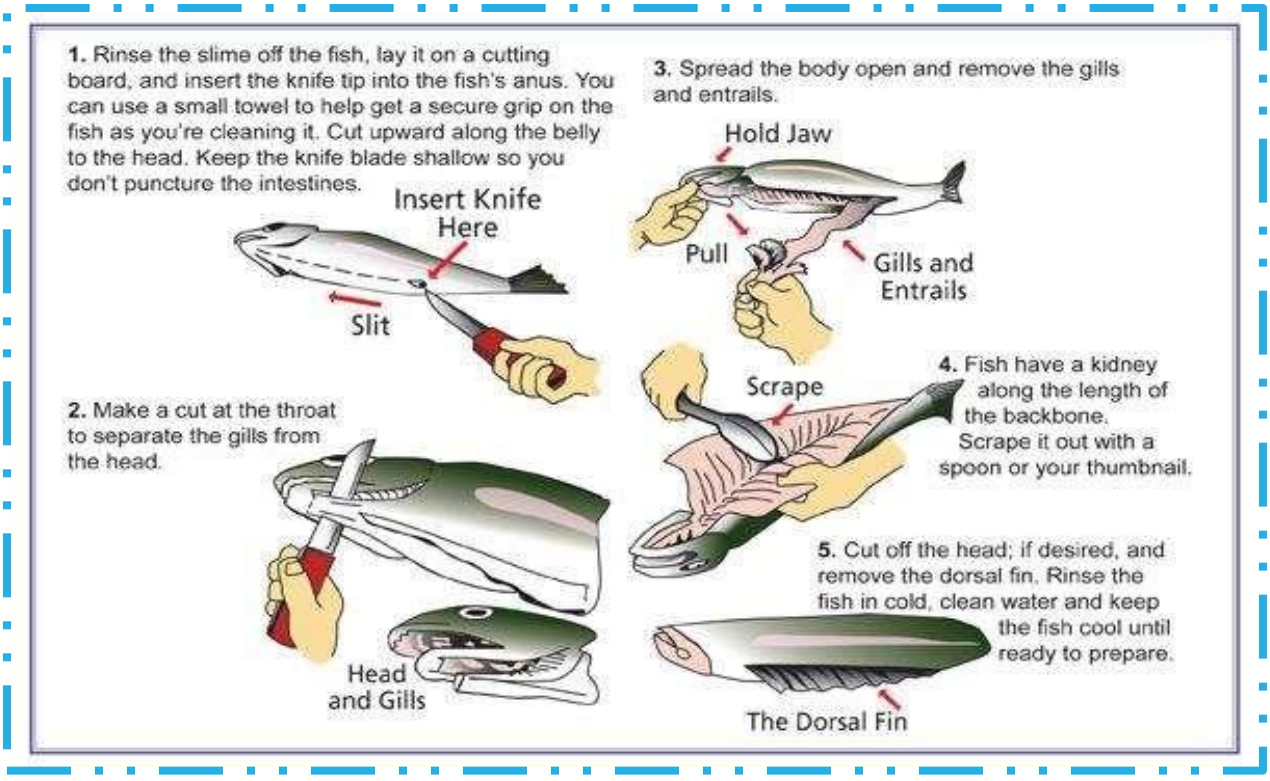
Keeping fish alive is an obvious way of keeping fish fresh until they are delivered to the buyer or are ready to be eaten. The recommended procedures are:

- The fish are placed in a container with clean water.

- Dead, damaged, or sick fish are removed. The water temperature is lowered, oxygen is added, and the fish are starved to reduce their metabolic rate. This decreases the fouling of water with metabolic products (ammonia, nitrite, and carbon dioxide) that become toxic and make it difficult for the fish to extract oxygen.
- Fish can be kept alive in floating cages, wells and fishponds. In aquaculture, holding basins are used where the water is continuously filtered, and its temperature and oxygen level are controlled.
- Get the fish as fast as possible to the processing area for further preservation and sales.

9.4.3 Processing dead fish

Gutting is the removal of the guts (intestines) of the fish. Gutting should be carried out on fish no matter what method of preservation is going to be applied. After gutting, the fish should be washed thoroughly with clean running water. Gutting and washing of the fish help to prevent bacterial attack before and during processing, preservation, and storage.



How to maintain the freshness of your fish after harvesting

- Stop feeding your fish at least one day before harvest.
- Use clean water and containers and avoid placing fish directly on the ground.

- If fish are to be sold fresh, the best way to guarantee freshness is to sell the fish alive or on ice.
- For value addition, you can freeze, smoke, salt, dry or fillet your fish.



10 Module 10: Fish Preservation

10.1 Types of preservation

Fish is very perishable and can easily spoil, causing losses to the fish farmer. Preservation of fish is done to prevent spoilage and extend the shelf life and time window for selling fish. Fish must be preserved if they are not consumed or disposed of immediately. Fish preservation is the method of extending the shelf life of fish and other fishery products by methods to keep them safe, retain quality, prevent decomposition or fermentation, and improve the quality of the fish products. Fish may be preserved in the following ways:

- Chilling
- Frying
- Drying
- Salting
- Freezing
- Smoking

10.2 Freezing

- Freezing is more effective than chilling as it preserves fish for longer.
- Freezing is achieved either by using a mixture of ice and salt or by refrigeration.
- To prevent rancidity, the frozen fish is subject to glazing with water, or it is wrapped in a cover of moisture-proof wax paper.
- Glazing is dipping the frozen fish in water so that a layer of hard ice surrounds the fish. This layer affords protection against exposure of fish fat to atmospheric oxygen, thus preventing rancidity.
- A freezer is used to freeze the fish.

Hygiene and safety risks

- Clean hands with clean water and soap before handling fish
- Clean all equipment such as containers to be used in freezing
- Clean the freezer thoroughly to make sure it is not contaminated with previous products
- Arrange fish in a freeze by head and tail opposite technique to minimize spoilage

- Electricity risk can be replaced with owning a generator as replacement when power goes off

Sales

Frozen fish have less flavour than fresh fish from the pond due to prolonged freezing; thus makes selling challenging. However, due to the high demand of fish people still buy frozen fish.

10.2.1 Chilling

Chilling is achieved by covering fish with layers of ice. However, ice alone is not effective for long preservation because melting water brings about a sort of leaching of valuable flesh contents which are responsible for the flavour of the fish. Ice is effective for short-term preservation such as is needed to transport landed fish to nearby markets or processing facilities.





Hygiene and other risks

Spoilage can be retarded but not stopped by chilling. Deteriorative changes continue at low speeds because of continuous bacterial and enzymatic activity. Microbiological, chemical, physical and sensory changes occur in the fish flesh during chilled storage. These changes can make fish inconsumable over a period. To prolong the shelf-life and retard spoilage chilling should be done carefully. Source, type, quantity and properties of ice, icing procedures and preparation of chilled water are factors affecting the storage life of fish held on ice. If these factors can be controlled, deteriorative changes in fish may be reduced.

Sales

Chilling is not as efficient as freezing which is why chilled fish should be sold or consumed soon after ice slurry starts to melt to water. Chilling is best to prevent spoilage when transporting fresh fish from one area to another.

10.3 Frying

This is dipping gutted, freshly cleaned, and marinated fresh fish in hot cooking oil. Frying reduces the water content and makes the fish harder to spoil so that it lasts longer.

- **Materials and equipment:**
  - fresh fish
  - spices (soy sauce, fish masala, vinegar, garlic, salt, etc)
  - frying pan
  - marination vessel
  - wire mesh
  - knives
  - grater
  - stove
  - PPE

Methods

1. **Preparing fresh fish (gutting, scaling, and rinsing):**

Clean your hands properly before handling fish. Remove the guts of fish and scales then rinse with clean water.



2. **Prepare marinade**

Marination is the mixture of spices responsible for the flavour, taste, and smell of fried fish. The marinade is the mixture that is used to flavour the fish.



3. Marinating fish



Use a marinading container such as a tray or bucket and thoroughly mix the prepared fish with marinade until spices in marinade blend well with the fish.

Leave it to marinate for at least an hour in cool or chilled conditions – not in the sun or in a hot place.

Remember to taste the marinade to check the flavour and balance of salt, soy sauce, garlic, vinegar, or fish masala.

Place marinated fish on wire mesh for 5 – 10 minutes for excess marinade to drain off.

4. Dip fish in boiling cooking oil for frying





10.4 Drying

Drying is the preservation of fish by removing the moisture content of the fish flesh by evaporation. *Air or sun drying* is the process in which moisture is removed by exposure to natural elements until it is dry.

Drying process:

1. Wash fish thoroughly with clean water
2. Gutt fish to remove entrails and organs
3. Rinse gutted fish with water
4. Expose fish to the direct sunlight or open space with moving air for few days until it's fully dried

Method/Process





Hygiene and safety risks

- Fish handlers should clean their hands before handling fish.
- Drying by sun should take place in a clean area with minimum human activities such as vehicles passing around or people passing frequently to minimize level of contamination.
- Ensure someone keeps watch to avoid theft by people, birds or animals.

Sales

Dried fish are ready for sale and can be kept a little longer without spoilage occurring. Due to the low water content, it is easy to carry and package as dried fish are smaller than fresh fish and can we well packaged or sold loose.

10.5 Salting

Salt is a preservative agent used to lengthen the shelf life of fish and fishery products.

- In this method the fish is salted but before allow water to flow away from fish, making sure it is dry.

- Dry salting can be done in a trough or tray by adding salt on fish surfaces making sure it is fully covered with salt then placing on a tray to be dried with salt.
- For two parts of fish, one needs one part of salt.
- Layers of fish must be separated by layers of salt.

Some people like the salty taste of fish prepared in this way, but it is always possible to wash the salt away by soaking it in freshwater before use.





Hygiene and safety risks

- Clean hands with clean water and soap before handling fish
- Clean all equipment to be used in salting such as container, knife
- Wear a clean and proper outfit for fish processing
- After applying a salt to fish make sure fish are exposed in safe and clean area to dry

Sales

Salted fish is not popular everywhere due to the high amount of salt, so it may not sell immediately. Salting is a preservation method so salted fish can stay longer in the market without spoilage.

10.6 Smoking

Smoking is an ancient process for preserving and flavouring food. This is a simple method of preservation, for consumption either directly after curing or within twelve hours of harvesting. Smoking reduces the moisture content, thus drying the fish flesh which contributes to preserving it. The heat from the smoke also kills bacteria and imparts flavour to the fish.

- Fresh unsalted fish is put over a wood or coconut husk fire. This should be kept very small, and the fish turned over every five minutes.
- In about half an hour the fish is ready for consumption or, if it is to keep for a while, it should be put in an aerated container.
- Re-smoking can keep the product in good condition for a further twelve hours.
- Any kind of fish can be smoked.

The process is used in most smoked fish products. Hot-smoked products are fully cooked and can reach temperatures as high as 82°C. Because of the high temperatures, hot smoking takes only a short time, depending on the internal temperature of the product.

Materials for smoking fish:

- Wood such as Sag wood dust, Sag wood chips (leaves), and mango wood are generally used.
- Agricultural biomass such as bagasse (plant material derived from sugar cane), coconut husks or shells and paddy husks can also be used.
- Wood or other plant material used for the generation of smoke or smoke-condensates must not contain toxic substances either naturally or through contamination, or after having been treated with chemicals, paint, or impregnating materials.
- In addition, wood or other plant material must be handled in a way to avoid contamination.









Fresh fish can be positioned slightly downwind from the fire so it is directly in the path of the smoke, or it can be placed on in the smoke above the fires if no wind causes the smoke to escape.

Hygiene and safety risks

- The risk of poisonous or sour wood is high thus be careful when selecting the type of wood used for smoking. Make sure it is not from poisonous or sour trees such as neem tree woods.
- Burning or cooking fish risk is also high, make sure you are no placing fish direct to fire or heat. The fish should not be cooked or burnt, only smoke must reach fish.
- Fire eruption risk should be avoided by choosing smoking site where there are few or no fire risks or combustible materials such as electricity wires
- Supervise any staff by staying until smoking is done
- Containers, sticks or any material used for holding fish during smoking should be thoroughly cleaned.
- Fish handler should wash his/her hands with clean water and soap.

Sales

Smoked fish smells smoky and has a distinctive tase that does not appeal to everyone. However, it is a very effective means of preserving fish and increases its shelf life. In villages such as Bagamoyo it is very appealing to the local market, but in town sales maybe low due to other types of fish being available.

11 Module 11: Sales and Marketing

11.1 Markets

When producing fish, the farmer should understand who will be buying, and how they will buy. Fish can be sold to different consumers or 'markets. These include, for example:

- **Direct to domestic consumers**: on the farm or at a specific location
- **Wholesale to a retail vendor**: someone who will sell fish at a market
- **Hospitality**: selling to restaurants and hotels for use in their menus and restaurants
- **Vendors** (fish BBQ): cook and sell fish to consumers (grilling, foil, frying).
- **Other fish farmers**: fingerlings.

Each of these markets (consumers) may need fish of different sizes, types or qualities. Knowing the market and who will buy the fish produced on the farm will help to farm and sell the right kind of fish based on the demand from the market.

The following factors should be considered and explored when producing fish as a product.

- **Cultural preferences**: understand local taste preferences and cultural considerations when marketing fish products.
- **Community engagement**: establish connections with local communities for direct sales or partnerships.
- **Seasonal variations**: consider seasonal variations in demand and adjust production accordingly.
- **Collaboration with local businesses**: explore partnerships with local restaurants, hotels, and catering services.
- **Compliance with regulations**: ensure compliance with local and regional regulations for fish sales and processing.
- **Promotion of fish farming**: educate the community about the benefits of locally farmed fish.

Market Characteristics

Understanding the diverse markets in the fish farming industry is crucial for tailoring products and marketing strategies. Let's explore into the details of different markets and consumer preferences:

- **Local markets:**
  - Traditional fish markets found in local communities or specific districts.
  - Preference: Traditional consumers often prefer purchasing fish from these markets due to the familiarity and trust associated with local vendors.
  - Consumer profile: local residents, individuals seeking fresh, locally sourced fish.
  - Opportunities: establishing strong connections with local vendors and participating in community events to build brand loyalty.

- **Urban markets:**
  - Increasing demand from urban areas.
  - Opportunities to collaborate with urban establishments such as restaurants, hotels, and grocery stores to tap into the urban market.
  - Consumer profile: diverse urban populations seeking convenient and varied seafood options.

Forms of fish:

Different consumers want to buy fish in different forms.

- **Fresh whole fish:**
  - **Preference:** traditional consumers often prefer purchasing whole, fresh fish.
  - **Consumer profile:** individuals who enjoy traditional cooking methods and value the freshness of the entire fish.
  - **Opportunities:** emphasize the quality and freshness of whole fish through effective marketing and packaging.

- **Processed fish products:**
  - **Types:** fillets, foiled, smoked, fried fish.
  - **Consumer profile:** urban dwellers, restaurants and hotels, and health conscious individuals.
  - **Fillets:** health-conscious consumers looking for convenient cooking options.
  - **Foiled:** those seeking ready-to-cook/eat convenience foods.
  - **Smoked and fried fish:** individuals interested in specific flavours and texture as well as fish that will not spoil immediately without refrigeration.

- **Opportunities:** create value-added products, market them as premium options, and target consumers seeking convenience and variety.

Sizes of fish

Consumers may want different sizes of fish for different uses or reasons. For example:

- Small-sized fish:
  - Suitable for local consumption.
  - High demand due to affordability.
- Medium to large-sized fish:
  - Target urban markets and supermarkets.
  - Hotels and restaurants may prefer these for individual servings
  - Potential for higher profit margins.

Advantages and disadvantages of markets

Advantages	Disadvantages
• Proximity to markets reduces transportation costs. • Opportunity for direct sales to local consumers.	• Limited market diversity may pose challenges for large-scale sales.

11.2 Simple Marketing Tools

Fish farmers should develop a few basic marketing tools to be able to promote their businesses and generate sales.

Marketing collateral includes simple things like:

- **Farm signage:**
  - Place visible signage along high-traffic areas to attract potential customers.
  - Place them near the entrance to the farm so that visitors and customers can get to the farm.
  - Include farm name, contact details, and a brief tagline.

- **Business card:**
  - Create professional business cards with contact information.
  - Include name, contact details, farm address or location
  - Distribute cards to potential buyers, vendors, and local businesses.

Personal sales: meeting with potential buyers is also a form of marketing. This includes meetings with fish vendors:

- Establish relationships with local vendors, markets, and hotels.
- Offer samples and provide information about the farm's practices and product quality.

Social media: a fish farm could have a simple social media account to show its activities and alert customers to when fish are available for sale. These include:

- Instagram/Facebook:
  - Share visually appealing content showcasing the farm, fish varieties, and behind-the-scenes operations.
  - Engage with the audience through comments, direct messages, and regular updates.

Media: farmers can also use local media to their advantage and to reach their target customers. These include:

- Local radio interview:
  - Arrange interviews with local radio stations to discuss the farm's story, practices, and benefits.
  - Leverage radio's wide reach to connect with a diverse audience.

11.2.1 Marketing Plan

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

- **Where can you sell your table fish?**

  It is very important to know the market before harvesting to know which size and type of fish are demanded in market. Communicate with different buyers to know who fits your product. If it is possible take samples of your fish to potential customers to show them what you produce.

- **Which kind of fish do the consumers prefer?**

  Tilapia or catfish depends on location, beliefs and requirement from customer. Before starting fish farming, it is important to know the type of fish your consumers prefer.

- **To whom to sell your fish?**

  Consumers may be from the hospitality industry (restaurants or hotels), domestic (family), fish processor or informal vendors of (e.g. grilled) fish for public consumption. These different groups have different preferences.

- **How to sell your fish?**

  Fish may be sold in different forms including fresh, preserved or processed fish based on factors such as demand, location, type of customer, season and location.

- **When to sell your fish?**

  Right time to sell your fish is when there is a demand in market or after communicating with customer.

- **At which price to sell your fish?**

  The price of fish depends on investment, season, market price and sometimes quality of fish. When fish have retarded growth (they are small) they cannot be sold at the same price as fully grown fish.

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

- **Social media (mobile phones)**

  Create posts about your fish products before you are due to harvest. Inform your market that fish will be available at a certain time and place. By posting, sharing and engaging people in the area or region and branding your fish products, this can be very useful in sales.

- **Farmer associations**

  Connecting with farmers association for more connections and recognition

- **Community radio announcements**

  Use of airtime to reach people all over the country and especially people in your area to find you easily

- **Fish dealers**

  Contact fish dealers before you harvest so that they have an opportunity to order fish in advance.

11.3 Tracking market trends

The following are market requirements:

1. **Fish specifications:**

- **Tracking market trends and conducting market analysis**

Conduct regular market research to understand the preferred sizes and types of fish in demand. Engage with local markets, wholesalers, and retailers to gather feedback.

Adjusting farming practices to breed the fish that the market wants:

- Tailor stocking density, feeding regimes, and growth management to produce fish sizes and types that align with consumer preferences.
- Utilize customer surveys or feedback forms to collect specific preferences.

- **Demand patterns:**

Analysing seasonal and holiday variations by identifying peak demand periods during seasons and holidays through historical sales data and market analysis.

Planning production cycles:

- Adjust stocking schedules to ensure fish are ready for market during peak demand periods.
- Implement staggered stocking to maintain a consistent supply throughout the year.

Implementation:

- Plan production cycles to align with heightened demand during festive seasons. Adjust marketing strategies to highlight fish consumption benefits during specific holidays.

2. **Price fluctuations:**

a) **Farming inputs:**

Track prices of key inputs:

- Regularly monitor the costs of essential inputs such as fish feed, fertilizers, and medications.

- Establish relationships with suppliers to negotiate bulk purchase discounts and secure stable pricing.

Adjusting production plans:

- Modify production schedules based on input cost fluctuations to maintain cost-effectiveness.
- Explore alternative inputs or technologies to mitigate the impact of price changes.

b) Sales prices:

Reviewing and adjusting product prices:

- Regularly assess market trends, competitor pricing, and consumer buying behaviour.
- Adjust fish prices accordingly to remain competitive and reflective of production costs.

Promotions or discounts:

- Offer promotions or discounts during specific seasons or events to stimulate demand.
- Implement loyalty programs or bundle deals to encourage repeat business.

Guidance:

- Regularly update records with sales figures, customer feedback, and pricing information.
- Remain flexible in farming practices, production planning, and pricing strategies to quickly respond to market shifts.
- Foster a culture of adaptability within the farming team, encouraging open communication and feedback.

Continuous Improvement:

- Conduct regular reviews of market strategies and outcomes.
- Implement lessons learned from each production cycle to refine future strategies.

11.4 Prices and negotiations

- **Selling channels:**
  - Agents/brokers or market vendors:

- Assess the pros and cons of selling directly to agents, brokers, or market vendors.
- Negotiate terms and pricing structures that benefit both parties.

- **Price negotiation principles:**
  - Know your costs:
    - Understand production costs to set a baseline for negotiations.
    - Factor in a reasonable profit margin while remaining competitive.
  - Flexible pricing:
    - Offer tiered pricing based on quantities or long-term partnerships.
    - Be open to negotiation but ensure profitability.

11.5 Sales records

Farmers should keep sales records so that they can track sales from batch to batch, and they know who is buying their fish which is helpful for future sales. The following data needs to be recorded:

- **Sales date:** Record the date of each sale to track trends and identify seasonality in your sales.
- **Customer information:** Collect and maintain customer details, including name, contact information, and location. This helps in building customer relationships and targeted marketing.
- **Product details:** Specify the types of fish products sold (e.g., whole fish, fried, foiled, fillets, smoked fish) and the quantity of each.
- **Quantity sold:** Document the volume or weight of fish sold for each transaction.
- **Unit price:** Record the price per unit or weight for each product sold. This information is crucial for calculating revenue and profit margins.
- **Total sales amount:** Calculate the total amount earned from each sale by multiplying the quantity sold by the unit price.
- **Payment method:** Specify the payment method used by the customer (cash, bank, online payment, etc.).
- **Transportation costs:** Document any costs associated with transporting the fish to the customer.
- **Batch or lot numbers:** If applicable, assign batch or lot numbers to the products sold. This is important for traceability and quality control.

Sales record template

Sales date	Customer information	Product details	Quantity sold	Unit price (TZS)	Total sales amount (TZS)	Transportation costs (TZS)	Payment method	Batch number	Pond number

12 Module 12: Fish farming as a Business

Fish farms should be run along clear business management principle to help track income, expenses and profitability of the enterprise.

12.1 Business principles

Basic principles of business include:

- **Expenses**: Include costs such as pond construction, equipment, fish fingerlings, feed, labour, and operational costs.
- **Revenue**: Mainly generated through the sale of harvested fish.
- **Profit**: Calculated by subtracting total expenses from revenue.

12.2 Costs

A fish production enterprise is like any other business enterprise in that it requires both start-up costs and operational costs. Start-up costs are required for setting up the fish farming enterprise, which usually includes building and equipping ponds, buying fingerlings and feed, and transport.

Types of costs: a fish farm will have two categories of cost:

- **Start-up costs** associated with setting up the business
  - Pond construction, purchasing fingerlings, equipment acquisition.
- **Operating costs** associated with running the business
  - Miscellaneous expenses such as feed, labour, water management, disease prevention, electricity, fuel, and routine maintenance costs.

12.2.1 Start-up costs

12.2.1.1 Pond construction

- **Components:** Excavation, lining materials (polyethylene, clay), construction labour, and machinery.
- **Estimated costs:** Costs can vary based on pond size, location, and construction materials. For example, a small pond (10m by 20m) might cost between TZS 1,500,000 -2,500,000), while larger commercial ponds could require a more substantial investment.

12.2.1.2 Purchasing fingerlings

- **Components:** Cost per fingerling and transportation.
- **Estimated costs:** The cost per fingerling can range depending on the species (Nile tilapia or African catfish), sex type (mono-sex or mixed sex) and size. Transportation costs can also vary based on distance.

12.2.1.3 Equipment acquisition

- **Components:** Aeration systems, nets for preventing birds, security devices against predators and thieves; harvesting tools, and processing equipment.
- **Estimated costs:** Equipment costs depend on the scale of the operation and the level of automation desired. A small-scale operation requires a small investment while larger commercial farms require sophisticated equipment.

12.2.1.4 Calculating Startup costs

Item	Unit cost	Number	Total
Total			

12.2.2 Operating costs

Various input costs are required for raising a batch of fish. These include feed, labour, water management, disease prevention and other costs as discussed below.

Feed

- **Components:** Cost of fish feed, storage and handling.
- **Estimated costs:** Feed costs depend on the type of feed used (natural/industrial/locally made feed), the fish species, and the size of the operation. It's a significant ongoing expense and can constitute a major portion of the operational budget. Generally, about 60% of the total operational cost is invested in feeding.

Labour

- **Components:** Wages for farm workers involved in feeding, pond maintenance, and harvesting.
- **Estimated costs:** Labour costs vary based on the number of workers, their skills, and the region's labour market. Skilled workers may command higher wages, impacting overall labour expenses.

Water management:

- **Components:** Aeration systems, water quality testing, and treatment.
- **Estimated costs:** Aeration system costs depend on the pond size and the desired level of oxygenation. Water testing and treatment costs are ongoing and vary based on the water quality management plan.

Disease prevention:

- **Components:** Vaccinations, medications, and biosecurity measures.
- **Estimated costs:** Disease prevention costs can fluctuate based on the prevalence of diseases in the region, the chosen preventive measures, and the overall health management strategy.

Other ongoing expenses:

- **Components:** Electricity for equipment, fuel for transportation, routine maintenance costs.
- **Estimated costs:** These costs can vary widely based on the farm's location, the efficiency of equipment, and the frequency of maintenance required.

12.3 Budgeting

Forecasting monthly costs per production batch

- **Start-up costs:** Estimate costs for pond construction, equipment acquisition, and purchasing fingerlings.

  Forecasting: Based on market rates, quotes from suppliers, and the size of the planned production batch.

- **Operating costs:** Anticipate ongoing expenses such as feed, labour, water management, and disease prevention.

  Forecasting: Use historical data, market research, and industry benchmarks to project monthly operational costs.

- **Cost reduction strategies**:
  - Use natural fish feed, alternative and locally available feed ingredients to reduce feed costs without compromising on nutritional value.
  - Efficient labour management: train workers for multitasking, time-management and task optimisation techniques.
  - Implement efficient water quality management practices such as water recycling systems, efficient use of aeration systems.
  - Disease prevention measures: emphasize proactive health management such as biosecurity protocols and proper pond hygiene to reduce the need for medications.

12.3.1 Forecast operational costs

- **Periodic review:** Regularly review and update cost estimates based on changing market conditions, inflation, and technology advancements.
- **Monitoring industry trends:** Stay informed about trends in feed prices, labour markets, and technology to anticipate potential cost fluctuations.

12.4 Recording

Keeping accurate records on the fish farm enables the farmer to track costs on an ongoing basis and make corrections as needed. It also facilitates the comparison of costs and profitability from batch to batch for better management practices.

- **Stocking and harvest data:** Record accurately the number of fingerlings stocked and fish harvested.
- **Health and growth monitoring:** Keep records of fish health, growth rates, and any observed issues.

12.5 Analysis

- **Compare operating costs to budgeted costs:** Regularly compare actual operating costs to the budgeted costs.

- **Act on results as required e.g. reduce costs:** If actual costs exceed budget, evaluate areas for potential cost reduction and Implement strategies identified during the analysis phase.

12.6 Access to finance

Before choosing a funding source, carefully assess the terms, interest rates, and conditions associated with each option. It is advisable to consult with financial advisors or business mentors to make informed decisions based on the specific needs and goals of the fish farming startup.

Options for funding a start-up fish farming business:

- **Personal savings (own money)**

To establish the fish farming enterprise, a person can save money for start-up of the business enterprise. This may take time, but then the owner does not owe money to anybody and can make all the operational and other decisions without interference. The risk is that they could lose all their savings if the business fails for any reason such as an outbreak of disease.

- **Family and friends**

Family and friends can provide the start-up funds for establishing the business if they have the capacity to give or lend money. They may, however, feel that this gives them the right to have a say over the business, or even to have some of the fish whenever they want to . Borrowing from family or friends can also become tricky if the business fails and the money cannot be paid back to the lender.

- **Saving group/cooperative**

Joining or forming a cooperative with other fish farmers can create a pooled resource for funding. Members contribute and benefit collectively. Youth may also get start-up funds from the saving and lending groups or cooperatives at very low interest rate. These groups are created to support youth enterprises especially fish farming. Official, recognised groups/ cooperatives are registered at district or national level.

- **NGO funding**

NGOs supporting development projects, particularly fish farming projects, may provide start-up funding for youth to establish a group or individual enterprise. Example of NGOs are YPO, Aquacom and others.

- **Microfinancing institutions**

Startup farmers may take loans from microfinance institutions (like Brac Microfinance, and SACCOS). The loan will have certain conditions of payment such as interest and the repayment of the loan within a certain period. There may be penalties for defaulting or late payments of the loan.

- **Bank loan**

Banks and financial institutions often offer loans specifically for agricultural projects. These loans may have favourable terms for start-up ventures. Banks (like NMB, CRDB, NBC and KCB) provide windows for loans where youth may access money for establishing a fish production business. The loan will have certain conditions of payment such as interest and the repayment of the loan within a certain period. There may be penalties for defaulting or late payments of the loan.

- **Government loan**

Various government departments provide loans to support agricultural initiatives, including fish farming practical examples are the Youth Development Fund (YDF) under the President's Office-Regional Administration and Local Government (PO-RALG), and that under the Prime Minister's Office of Youth, Women and People with Disabilities. Others are the Kilimo Kwanza Fund and, the Smallholder's Credit Guarantee Scheme.

- **Supplier credit**

Negotiate favourable payment terms with suppliers of equipment, feed, and other essentials. This can provide a form of short-term financing.

- **Leasing or Equipment financing**

Instead of purchasing expensive equipment outright, consider leasing or financing options. This can help spread the cost over time. An example of such a source is the Agricultural Inputs Trust Fund.

- **Agribusiness competitions**

Participate in agribusiness competitions that offer cash prizes or investment opportunities for innovative and promising ventures.