Draft Study Material

Fish Seed Grower

(Qualification Pack: Ref. Id. AGR/Q4908)

Sector: Agriculture

Grades 11

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Preface

Vocational Education is a dynamic and evolving field, and ensuring that every student has access to quality learning materials is of paramount importance. The journey of the PSS Central Institute of Vocational Education (PSSCIVE) toward producing comprehensive and inclusive study material is rigorous and time-consuming, requiring thorough research, expert consultation, and publication by the National Council of Educational Research and Training (NCERT). However, the absence of finalized study material should not impede the educational progress of our students. In response to this necessity, we present the draft study material, a provisional yet comprehensive guide, designed to bridge the gap between teaching and learning, until the official version of the study material is made available by the NCERT. The draft study material provides a structured and accessible set of materials for teachers and students to utilize in the interim period. The content is aligned with the prescribed curriculum to ensure that students remain on track with their learning objectives. The contents of the modules are curated to provide continuity in education and maintain the momentum of teaching-learning in vocational education. It encompasses essential concepts and skills aligned with the curriculum and educational standards. We extend our gratitude to the academicians, vocational educators, subject matter experts, industry experts, academic consultants, and all other people who contributed their expertise and insights to the creation of the draft study material. Teachers are encouraged to use the draft modules of the study material as a guide and supplement their teaching with additional resources and activities that cater to their students' unique learning styles and needs. Collaboration and feedback are vital; therefore, we welcome suggestions for improvement, especially by the teachers, in improving upon the content of the study material. This material is copyrighted and should not be printed without the permission of the NCERT-PSSCIVE.

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Module 1

Introduction to Fisheries and Aquaculture

Module Overview

India is the third-largest fish-producing country and the second-largest aquaculture fish producer in the world. The country contributes about 7% to global fish production and is home to more than 10% of the world's fish biodiversity. It is also one of the 17 mega biodiversity-rich countries globally. Fisheries and aquaculture play a vital role in ensuring food security, providing livelihoods, and supporting the rural economy of India and the world. Approximately 14 million people are engaged in fisheries and its allied activities across the country. With the growing global demand for protein-rich food, the development of sustainable and scientific fish farming practices has become increasingly important. Fish play a crucial role in national development—not only as an affordable source of high-quality protein but also as a provider of essential nutrients required for a healthy human diet. The food fish consumed by the global population is obtained from both aquaculture and capture fisheries. These fish may be sourced from either freshwater or marine environments. Among various life processes of fish, feeding remains the most dominant activity throughout their life cycle.

This module introduces students to the essential concepts of Fisheries and Aquaculture, emphasizing their significance in sustainable food production and rural livelihoods. In Session 1, students will learn about the importance of fisheries and aquaculture in ensuring food security, providing nutritional value, and supporting the socio-economic development of communities. Session 2 explores the diverse employment opportunities for a Fish Seed Grower, outlining key roles, responsibilities, and the skill sets required in this growing sector.

Learning Outcomes

After completing this module, you will be able to:

- Explain the importance of fisheries and aquaculture in food security, livelihoods, and the economy.
- Identify various employment opportunities available for a fish seed grower and understand the skills required for each role.

Module Structure

Session 1: Importance of Fisheries and Aquaculture

Session 2: Various Employment Opportunities for a Fish Seed Grower

Session 1: Importance of Fisheries and Aquaculture

Fisheries

Fisheries is an economic activity that involves harvesting fish or any aquatic organism from the wild or raising them in confinement. It may be Traditional/ Small Scale Fisheries for sustenance, or Large-Scale/ Commercial Fisheries for profit. Fisheries refer to the organized efforts involved in the capturing/Culturing, processing, managing, and marketing of fish and other aquatic organisms such as prawns, crabs, and mollusks, etc.

Types of Fisheries:

1. **Capture fisheries**: This includes harvesting of fishes and other aquatic organisms and plants from their natural environment. Capture fisheries may be different according to the habitat and the ecosystem. Like in marine fisheries, availability of one species in a particular area define the fisheries *e.g.* Tuna fisheries of the Japan, Anchovies fisheries in Peru, Sardine fisheries in Japan, Atlantic cod fisheries, Australian Rock lobster fisheries. Also, riverine fisheries, estuarine fisheries and Wetland fisheries are the important fisheries in inland areas. In capture fisheries wild species/fishes are harvested by the fishermen using different Crafts (Boats) and gears (nets). The capture fisheries may be for sustenance and also for the commercial activities. Inland waterbodies like rivers, reservoir, wetland, estuaries, streams and lakes mainly support small scale fisherman those who are engaged in fisheries for their livelihood, in case of capture fisheries in marine both commercial and small-scale fishermen are engaged.
2. **Culture fisheries:** This includes the culture (growing/Raising) of aquatic animals and plants in the controlled condition and their harvesting. Based upon the magnitude of the culture, the aquaculture may be on small scale for livelihood and source of food (backyard ponds) and on commercial scale for the consumption to export level. Aquaculture activities support the economy of the country by providing livelihoods to the millions of the people. It has the potential to fulfill the nutritional requirement as fish is termed as superfood as it is a source of vital nutrients, Omega 3- Fatty Acids and Fish oils. The fish farming can meet the food requirements of the country and also it utilizes the water and land resources of the country. Many other industries are also dependent upon the aquaculture industry- Fish

processing, Boat building, Net making, Fish feed, Ice factory, Transport, packaging etc.

What is Aquaculture

The term 'Aquaculture' means culture of all aquatic forms like fish, prawns, molluscs and aquatic plant in fresh, brackish as well as marine waters.

The 'Aquaculture' includes: -

- The type of culture systems utilized, e.g., pond culture, cage culture, pen culture, etc.
- The type of organisms cultured, e.g., fish, oyster, shrimp or prawns, etc.

The origin of aquaculture dates back to at least three thousand years ago, but unlike agriculture, which has been the most important way of obtaining food on land, aquaculture has until recently contributed very less to mankind due to age old methods in use coupled with lack of proper knowledge. But now the picture is changing rapidly as aquaculture is gaining more importance in the today's' modern world, due to increase in population and shortage of food.

Types of Aquaculture

Aquaculture is a type of agriculture where the cultivation of aquatic plants and animals are practiced in the controlled environment. Aquaculture can be defined in many ways, based on the type of culture system, aquaculture can be categorized into different categories.

Aquaculture comprise various techniques for culture of aquatic organisms. Based on the types of Water used it can be classified into Freshwater aquaculture, Marine Water Aquaculture and Brackish water aquaculture. The different types of aquacultures are discussed below in details:

1. Based on Water Type:

a. **Freshwater Aquaculture:** In this type of aquaculture, the freshwater is used in different system likes, Ponds, Tanks, Lakes, rivers etc. The species cultured are freshwater fish species like Carps, catfishes, Tilapia, Salmon, Trout, mussels, pearls, aquatic plants etc. Here in the culture system the salinity of the water is not more than 0.5 ppt.

Fig.1.1: Freshwater fish farm

b. **Brackish Water Aquaculture:** In this type of culture, the water salinity varies between 0.5. These types of waters are available in the coastal areas like, estuaries and backwaters. The major types of species cultured are Shrimps, Fishes & Crabs e.g. Black tiger shrimp- *Penaeus monodon*, White leg shrimp - *Litopenaeus vannamei,* Mud crab- *Scylla serrata,* Mullet - *Mugil cephalus,* Bhetki- *Lates calcarifer* and Milk Fish- *Chanos chanos* etc.

Figure 2.2: Brackish water fish farm

c. **Mariculture:** This type of aquacultures includes the farming of aquatic species in the ocean or along its coastline. Various fish species like Cobia- *Rachycentron canadum*, Pompano- *Trachinotus blochii*, Shrimps- *Penaeus merguensis*, Clams- *Paphia malabarica,* Mussels- *Perna viridis* and various species of Seaweeds- *Kappaphycus alvarezii*

Figure 1.3: Seaweed Culture at Mandapam, Tamil Nadu

2. Based on Aquaculture Systems:

a. **Pond Culture:** Manmade of Natural ponds are utilized for this type of culture. This type of the culture is available all over the world and one of the most types aquaculture practiced in the world. Here the water quality is maintained by various methods and techniques.

b. **Recirculating Aquaculture Systems (RAS):** In this type of culture system water is recycled and reused after treating water with mechanical and biological filtration and removal of suspended wastes. Here the water loss in minimized and thus is one of the environment friendly aquaculture systems.

c. **Raceway Farming:** This is a type of the flow-through system a series of rectangular tanks with continuous water flow along the long axis. In this system the quality of the water is maintained. In most raceway systems, dissolved oxygen is replenished by allowing the water to fall into subsequent tanks within the raceway. Raceways are mostly constructed with the concrete sometimes earthen type. The high value fish species like Salmon and trout are culture in the raceways.

d. **Aquaponics:** A typical system where the hydroponics (culture of plants without soil) system is combined with fish farming. Here fish waste is utilized to nourish plants and the plants filters the water. It also utilizes minimum space and very useful in Urban areas.

Figure 1.4: Pond based Aquaponics system

e. **Cage Culture:** This involves farming of fish or other aquatic species in floating or anchored cages in Ponds, Tanks, reservoirs, lakes and open ocean. The rectangular/square cages are made of Floating Drums, Non-corrodible rust-free irons frame and inner and outer mesh for keeping fishes. Also, the small rooms are made on the cages where the cages are bigger in size to store the feed and other small equipment. In India the cages in the reservoirs are very popular. The successful sea cage farming of the fishes like cobia and silver pompano are achieved by ICAR-CMFRI and practiced by several fish farmer along the coastline of India. In cage culture, there is no need to maintain the water quality as the fishes are kept in the natural environment of the water bodies.

Figure 1.5: Cage culture system in Reservoirs

f. **Net-pen Culture:** In this type of culture fishes are raised in natural water bodies where one side protected by erecting pens with enclosed nets. Often in practiced lakes wetlands, small reservoirs. Here also there is no need the manipulate the water quality.

g. **Raft/Long-line Culture:** One of the suitable cultures for the cultivation of the shellfishes where shellfishes are grown on rafts or long lines suspended in the water. This type of culture is also practice for seaweed culture.

3. Based on stocking density of the species:

a. **Extensive Aquaculture:** In extensive aquaculture system, fishes are reared with low stocking densities, low-input, very minimal to no feeding, no water quality management. Here the fishes are dependent on naturally occurring food in the water. Areas of pond may vary from 1 to 5 ha in and Stocking density > 0.5 pcs/sq m for Fish. The production from this type of pond may vary from 500 to 2000 kgs /ha. This type of system is low input system.

b. **Semi-intensive Aquaculture:** This method relies on moderate supplemental feed and fertilization to boost the production of the fishes. small ponds between 0.5 to 1 hectare in area is used for culture. Stocking density ranges 10000 to 15000 fish/ha. The production may vary from Harvest – 2500 to 10000 kgs. This type of system is moderate input and moderate return system.

c. **Intensive Aquaculture:** In intensive culture system high stocking density of the fishes are kept to get the higher production in lesser area. In this method fishes are feed with high quality feeds and high-water quality is maintained by uses of chemicals and fertilizers. This type of system is high input and high return system.

4. Based on type of Species Cultured:

a. **Fish Farming (Pisciculture)**: This involves the farming of various types of fish species, such as carp, catfishes, Tilapia, eels, salmon, trout etc.

b. **Shellfish Farming:** This involves the culture of Shrimps, prawns, mussels, oysters, clams, crabs, etc.

c. **Ornamental Fish culture:** Ornamental fishes which can be kept in the aquarium are culture in the smaller tanks and ponds and concrete ponds and raceways. Her booth freshwater and marine water species are culture for the commercial purpose. Ornamental fishes like Gold fish, koi carp, Siamese fighter fish, Guppy, angel fish, parrot fish etc. are cultured and traded locally and globally.

5. Based on species combination:

a. **Monoculture:** In this type of culture system only one species of fish is cultured at a time. Here the management of the culture is very easy.

b. **Polyculture:** For the better utilization of space and resources multiple species with different niches are cultured together for better yield. E.g. carp polyculture with catfishes or prawn.

c. **Integrated Multi-trophic Aquaculture (IMTA):** In this type of aquaculture system, waste/byproduct of one species is used as input for other. The species are selected in such a way that they utilize the different trophic. This provides better environmental stability and has better environmental footprint of aquaculture. Farmers combine fed aquaculture (e.g., fish, shrimp) with inorganic extractive (e.g., seaweed) and organic extractive (e.g., shellfish) aquaculture to create balanced systems for environment remediation (biomitigation), economic stability (improved output, lower cost, product diversification and risk reduction) and social acceptability (better management practices) (Barrington, 2009)

6. Based on integration with other farming: Aquaculture is also integrated with different farming system like Horticulture, Sericulture, crop farming, Livestock culture etc.

a. **Fish cum rice culture:** Fish culture can be integrated with rice farming.

b. **Fish cum horticulture system:** Fishes can also be integrated with small horticultural crops. The dykes and adjoining areas can be utilized for the production of Dwarf varieties of Coconut, Mangoes, Banana, Polar trees, Lemons, Guavav etc.

c. **Fish cum Duck culture:** Duck utilizes the juvenile frog, tadpoles, Dragonfly etc. Their droppings fertilize the pond, the duck dropping contain 25 per cent organic and 20 per cent inorganic substances. Also, when duck swims in the pond it mixes the oxygen in the water. To fertilize 1 ha fish pond number of ducks required is between 2000 and 3000

d. **Fish cum poultry culture:** In this system, the main pond dykes utilized for the Chicken shelter construction. Chicken droppings are rich source of phosphorus and nitrogen. For 1ha fish pond 25,000 chicks can be reared. In Fish cum poultry integration t 90,000 to 1,00,000 eggs and 2500 kg meat can be produced in one year.

e. **Fish cum pig culture:** In this system also, the main pond dykes utilized for the Pig shelter. Around 60-100 no of pigs are required to fertilize one hectare of fish pond.

f. **Fish cum cattle culture:** For 1 ha pond 5-6 cows can provide adequate manure. A healthy cow excretes over 4,000-5,000 kg dung and, 3,500-4,000-liter urine per year. Milk production – 9000 liters/Year and Fish production - 3,000-4,000 kg fish/ha/year can be achieved from this culture system.

Importance of Fisheries

Fishes are rich source of valuable nutrients like proteins, vitamins and minerals. Medicines and nutrient supplements are prepared from different types of fish. Fish forms the important diet in many parts of the world and most of the countries along the coastal areas are dependent on the fishing activities. Also fishing activity provides livelihoods to billions of people across the globes and so many people are engaging in fisheries directly or indirectly.

Fisheries include the activities like catching or harvesting of fish, processing of fish, farming of the fish, fish sell and other ancillary activities like, Boat Building, Net making, Ice factory and Aquarium keeping etc. Whereas aquaculture is the rearing/culture of aquatic animals and plants in controlled environment. Both fisheries and aquaculture are an economic activity which may be for sustenance and business as well.

Current scenario of Fisheries sector in India

India is the second largest fish producing country the world followed by China. India contributes about 9% to the global fish production. The country is also home to more than 11% of the global fish biodiversity and is one of the 17-mega biodiverse nation of the world. The fisheries of the India are mainly constituted of Marine Fisheries and Inland Fisheries. The total fish production during FY 2022-23 is estimated at 17.54 MMT with a contribution of 13.11 MMT from Inland fisheries sector and 4.43 MMT from Marine fisheries sector.

Fisheries sector plays an important role in the national economy and the share of Fisheries constitutes about 1.07 percent of the total national GVA and 6.86 percent of agricultural GVA. The fisheries sector of India has shown an impressive growth rate of 9.26% during the year 2020- 21 to 2021-22. Fish and fish products have presently emerged as the largest group in agricultural exports from India, with 17,81,602 metric tons in terms of quantity and Rs. 60,523.89 crores in value.

India is having the vast fisheries resources in the form of Sea, Rivers, Lakes, Canals, Estuaries, Wetland, Floodplains, streams and Reservoirs(Table 1).

Table 1. Fisheries resources of the India.

Sl. No.	Type of Water	Area
1.	Rivers	45000 Km
2.	Reservoirs	3.15 million Hectare
3.	Tanks & Ponds	2.45 million Hectare
4.	Estuarine Areas	1.44 million Hectare
5.	Flood Plain Lakes	1.2 million Hectare
6.	Coastline	11098.81 Km
7.	Exclusive Economic Zone	2.20 million km^2
8.	Continental Shelf	0.53 million km^2

The Indian fisheries are mainly divided into Marine Fisheries and Inland Fisheries. In case of marine fisheries, the major share is contributed by marine capture fisheries whereas meagre contribution is from marine cage culture and seaweed culture (both in nascent stage). In case of Inland fisheries, India ranks 1st in Inland capture fisheries and it accounts for 16 of the total inland capture fisheries production. Whereas major share of inland fisheries is contributed by Aquaculture.

A. **Marine Fisheries of India**: There are 9 maritime states of India and series of Island in Andaman & Nicobar Island and Lakshadweep Island. The production from the marine fisheries of India is 4.43 million tonnes in 2022-23.

The marine fisheries sector of India is categorized into pelagic fishes and the demersal fishes. The pelagic fisheries resources of the India are major contributor of the total marine fish landing followed by demersal fishes, crustaceans and molluscs. The major pelagic fishes of India are Indian oil sardine, Indian mackerel, Ribbonfishes, Sardines, Bombay Duck, lesser Sardines and Tunas. Demersal fisheries resources are mainly represented by Groupers, Threadfin breams, Catfishes, Sharks, Perches, and Sciaenid fishes.

B. Inland Fisheries of India: The inland fisheries resources of India are characterized by different ecosystems like rivers, lakes, flood plain wetlands, reservoir, tank, pond, upland lakes. The majority of the inland fish production is coming from inland aquaculture. The inland fish production in the year 2022-23 was 13.1 million tons out of which the first position was held by Andhra Pradesh followed by West Bengal and Uttar Pradesh. The 45.06 lakh tons was alone contributed by Andhra Pradesh. The Indian major carp (Catla, Rohu, Mrigal) is the major contributor of the inland aquaculture followed by cat fishes and other fresh water species. In the recent year the culture of other high valued fish items is also gaining attention.

India ranks 1st in inland capture fisheries production followed by Bangladesh. Some reservoirs are auctioned on lease for the harvesting of the resources where culture-based capture fisheries are practiced.

I. **Riverine fisheries of India:** With combined total length of 45000 km, the riverine fisheries of India contribute around 18.31% of total inland open water fisheries The major riverine catches include, Catla, Rohu, Mrigal, Reba, Bata, Mahasheer, Chital, Puntius, River prawns etc. The main catching gears (Net) of used in rivers are Gill nets, cast net, Traps and lift nets.

II. **Reservoir fisheries of India** : The total area of the reservoirs in India are 3.15 million hectare which contributes around 20.81% of total inland open water fisheries. The major fishes which are harvested from the reservoirs are Catla, Rohu, Mrigal, Silver carp, grass carp, Mahseers, cat fish, Singhi, Magur, Murrells, Tilapia etc. The main catching gears (Net) of used in rivers are Gill nets, Traps, cast net etc. Majority of the inland capture fishes are consumed in the local market while catch from selected reservoirs are transported to nearby states.

III. **Estuarine Fisheries of India:** The total catch from the estuaries in India is around 168, 919 tonnes with average production yield of 401 kg/ha. The major estuaries along the Indian coast are Hooghly-Matlah estuary which is falls under sunderban delta in the West Bengal. Other major estuarine system of India are, Mahanadi Estuarine system, Godavari Estuary, Tapi Estuary, Chilka Lake, Pulicat lake, Vembanad Lake, Mandovi-Zuari estuary. The major estuarine fishes of India are, Bhetki, Mullet, Hilsa, Prawns, Cat fishes, Pearl spot, and Crabs.

IV. **Inland Aquaculture:** The inland aquaculture of India is the main contributor of the overall fish production from India. The inland aquaculture is mainly contributed by Freshwater aquaculture, wherein the percentage share of the Freshwater aquaculture is increased from 34% in mid 80s to 75 % at present. The major cultivable species of the freshwater aquaculture is Indian major carps (Catla, Rohu, Mrigal), Catfish (Pangas), Scampi, Tilapia, Murrels and Rupchand (Piaractus) etc. The Indian major carps contribute around 70-75 & of the total freshwater Aquaculture production of the India, followed by Catfishes and other carps like silver carp, grass carp, common carp and Amur carp and tilapia. Also, Native Giant tiger shrimp, *Penaeus monodon* and Exotic white leg shrimp, *Litopenaeus vannamei* significantly contributes to the Brackish water aquaculture. Also, the cage culture of Freshwater fishes mainly Pangas and Tilapia is practiced in most of the reservoirs in India. Most of the cultured species produced in the India is consumed at domestic market, while high valued items like *Penaeus monodon* and *Litopenaeus vannamei* are exported to the foreign countries.

Export of Fish and Fisheries Products

The high valued fish products are exported to the other countries and significantly contribute to the total GDP of the country. The export items form the India is mainly constituting around 90% of the Seafood. India exported 17,81,602 million tonnes of Marine Products worth rupees 60,523.89 Crore during the year 2023-24. USA and China are two major importing countries. Frozen shrimp is the major item of export in terms of both quantity and value. The other major items of the seafood export are Frozen fish, Fish/shrimp meal and feed, Surimi/Surimi products. The major species of the frozen shrimps are Exotic white leg shrimp, *Litopenaeus vannamei* and Native Black tiger shrimp *Penaeus monodon*. The India exported seafood to 132 countries in the year 2023-24. USA is the single largest importer (2,97,571 MT) of frozen shrimp followed by China (1,48,483 MT), European Union (89,697 MT), Southeast Asia (52,254 MT), Japan (35,906 MT) and Middle East (28,571 MT), and Other Countries (63,521 MT). (Annual Report 2023-23, Marine Product Export Development Authority).

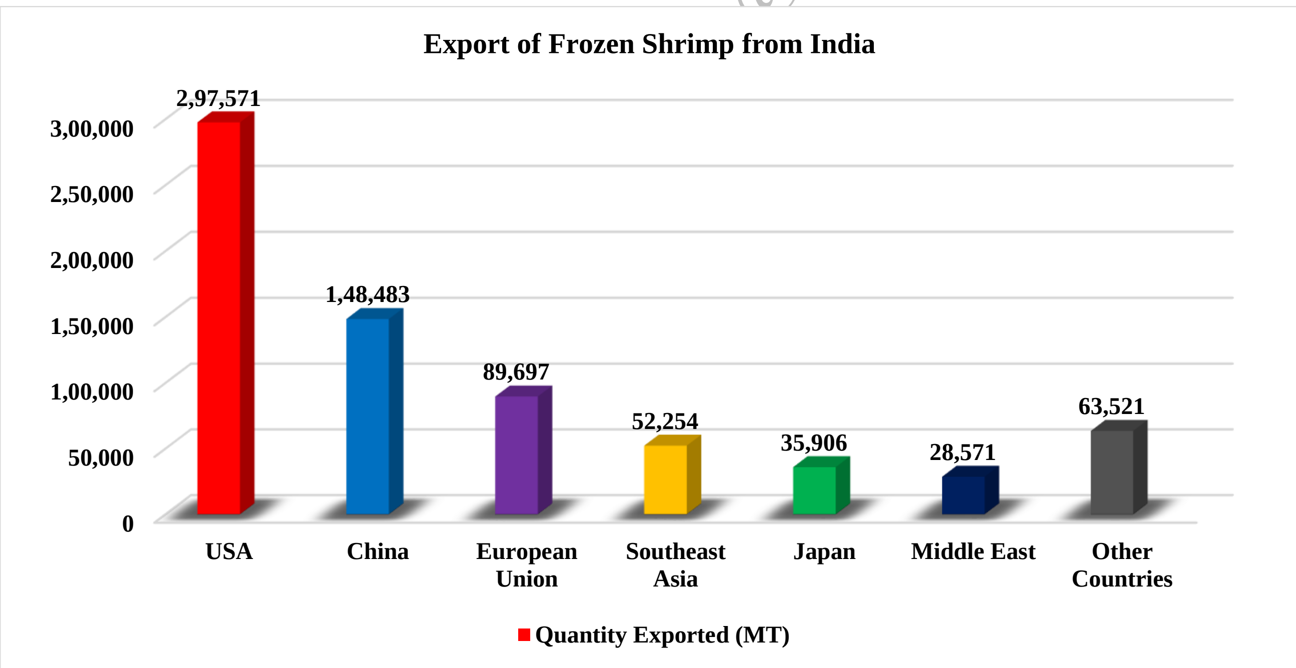


Fig. 1.6.: Frozen Shrimp Export from India to Major Countries (2023–24)

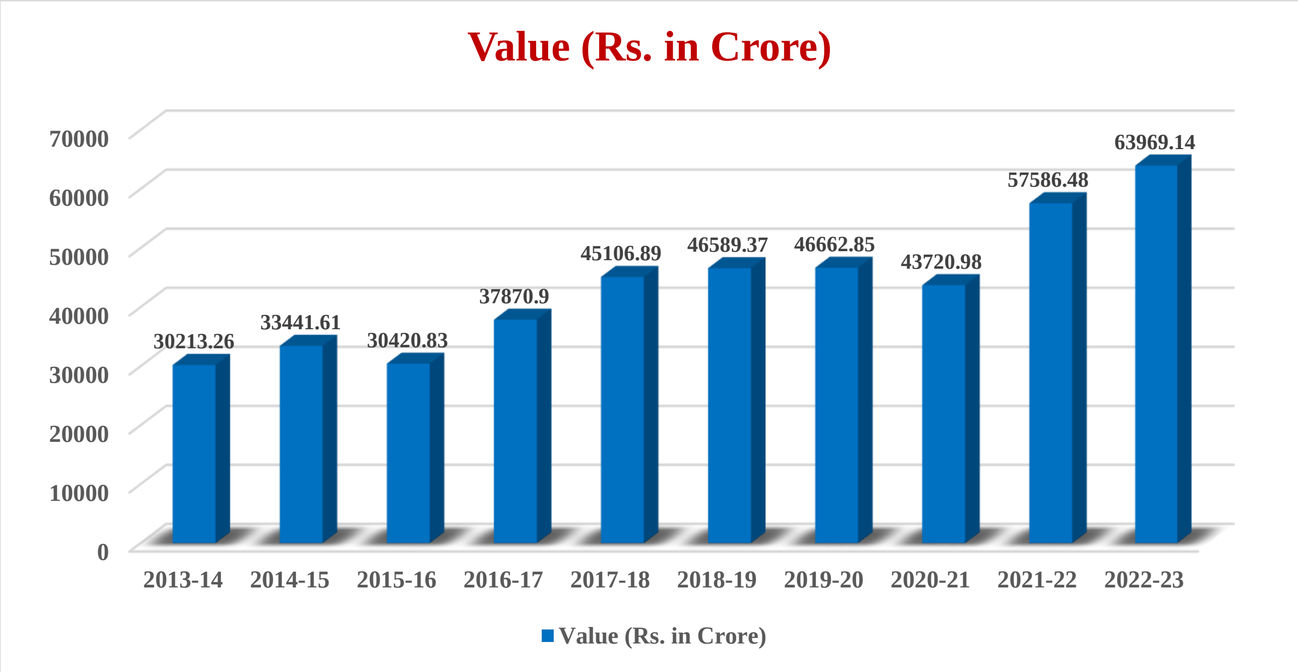


Figure 1.7 : Trends of Marine Products in value (Rupees in crore)

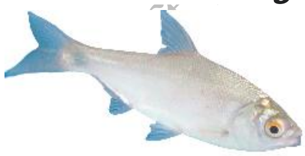
Important Cultivable Fish Species of India

India is one of the 17 mega biodiversity country and endowed with rich ichthyofaunal diversity. A total of 3247 species of fishes are present in India, and contributes around 10% of the global fish biodiversity. Out of 3247 species found in India 1569 belongs to Marine Water, 962 to Freshwater, 15 to Brackish Water, 392 to Marine and Brackish water, 108 to Freshwater and Brackish Water and 201 in Fresh water, Marine Water and Brackish water (Source: NBFGR, 2025). Due to the rich biodiversity of the fish species the species diversification in the aquaculture is possible. Several fish species in India is cultured in the different pockets of the country, but the majority of the aquaculture production contributed by Indian major carps *viz., Catla, Rohu and Mrigal.* Around 85% of the freshwater fish production comes from these fishes. In case of Coastal aquaculture, the important species are Native Black Tiger shrimp- *Penaeus monodon* and Exotic White leg shrimp- *Litopenaeus vannamei* where as in Brackish water the culture of Mullet, milk fish, bhetki, Pearl spot are important species. In case of cage culture in open sea the important species are; Silver pompano and Cobia. Some important cold-water species are Trout, Mahseer, Loach and Carps.

- **Carps:** India is known as the carp country, due to the availability of the 266 carp species. The majority of the aquaculture production (85 of Freshwater aquaculture production) in India is contributed by Indian major carps, Catla (*Labeo catla),* Rohu (*Labeo rohita*) and Mrigal (*Cirrhinus mrigala*) .

- **Cat fishes:** After carps catfishes are larger group of freshwater fishes present in Indian waters. These fishes lacks scale and have prominent barbels in 1-4 pairs on mouth region which resembles a cat's whiskers. Some catfishes have well developed air bladder which helps them to survive in low oxygen condition.

Sr. No.	Fish species	Remarks
1.	**Catla** ***Labeo catla***  *Fig 1.8: Catla*	One of the 3 major carps cultured in India. High demand in domestic market.
2.	**Rohu** ***Labeo rohita***  *Fig 1.9: Rohu*	One of the 3 major carps cultured in India. High demand in domestic market.
3.	**Mrigal** ***Cirrhinus mrigala***  *Fig 1.10: Mrigal*	One of the 3 major carps cultured in India. High demand in domestic market.
Other Important carps		
4.	**Reba** ***Cirrhinus reba***  *Fig 1.11: Reba*	Minor carps. Small indigenous fishes. High in nutrient and good market price.
5.	**Bata** ***Labeo bata***	Minor carps. Small indigenous fishes. High in nutrient and good market price.

	 *Fig 1.12: Bata*	
6.	**Kuria labeo** ***Labeo gonius***  *Fig 1.13: Kuria labeo*	Minor carps. Small indigenous fishes. High in nutrient and good market price.
7.	**Cauvery Carp** ***Hypselobarbus carnaticus***  *Fig 1.14: Cauvery Carp*	Important fish in southern India specially in Karnataka and Tamil Nadu.
8.	**Calbasu** ***Labeo calbasu***  *Fig 1.15: Calbasu*	Black carp. Good market price in Northern and central India.
9.	**Pengba** ***Osteobrama belangerii***  *Fig 1.16: Pengba*	High value fish in Northeastern States.
	Exotic carps	
10.	**Silver carp** ***Hypophthamlichthys molitrix***  *Fig 1.17: Silver carp*	One of the important exotic carp available in India. Grows to bigger size. Candidate species for Carp polyculture

11.	**Grass Carp** ***Ctenopharyngodon Idella***  *Fig 1.18: Grass Carp*	One of the important exotic carp available in India. Important fish for weed control. Candidate species for Carp polyculture
12.	**Big head carp** ***Hypophthamlichthys nobilis***  *Fig 1.19: Big head carp*	One of the important exotic carp available in India. Important fish for weed control. Candidate species for Carp polyculture
13.	**Common carp** ***Cyprinus carpio***  *Fig 1.20: Common carp*	One of the important exotic carp available in India. Now widely cultured species in India High demand in market
14.	**Amur carp** ***Cyprinus carpio***  *Fig 1.21: Amur carp*	One of the important exotic carp available in India. Now widely cultured species in India
	Catfishes	
15.	**Magur/Walking cat fish** ***Calrias magur***  *Fig 1.22: Magur*	Indigenous variety of catfish. High demand in Domestic market, Fetches high price.
16.	**Singhi/stinging cat fish** ***Heteropneustes fossilis***  *Fig 1.23: Singhi*	Indigenous variety of catfish. High demand in Domestic market, Fetches high price.

17.	**Tengra** ***Mystus tengra***  *Fig 1.24: Tengra*	Indigenous variety of catfish. High demand in Domestic market, Fetches high price.
18.	**Pabda/Butter cat fish** ***Ompok bimaculatus***  *Fig 1.25: Pabda*	Indigenous variety of catfish. High demand in Domestic market, Fetches high price.
19.	**Boal/Freshwater shark** ***Wallago attu***  *Fig 1.26: Boal*	Indigenous variety of catfish. Larger in size High demand in Domestic market, Fetches high price.
20.	**Giant River cat fish /Singhala** ***Sperata seenghala***  *Fig 1.27: Singhala*	Indigenous variety of catfish. Larger in size High demand in Domestic market, Fetches high price.
21.	**Rita** ***Rita rita***  *Fig 1.28: Rita*	Indigenous variety of catfish. Larger in size High demand in Domestic market, Fetches high price.
22.	**Pangas/Exotic cat fish** ***Pangasianodon hypophthalmus***  *Fig 1.29: Pangas*	Highly cultured species in India due to high growth rate. Good market in India.

Other Important fishes		
23.	**Golden Mahseer** ***Tor putitora***  *Fig 1.30: Golden Mahseer*	Indigenous cold-water species cultured in India. High demand in local market.
24.	**Chocolate Mahseer** ***Neolissochilus hexagonolepis***  *Fig 1.31: Chocolate Mahseer*	Indigenous cold-water species cultured in India. High demand Himalayan states.
25.	**Brown trout** ***Salmo trutta***  *Fig 1.32: Brown trout*	Exotic cold-water species cultured in India. High demand Himalayan states.
26.	**Rainbow Trout** ***Oncorhynchus mykiss***  *Fig 1.33: Rainbow Trout*	Exotic cold-water species cultured in India. High demand Himalayan states.
27.	**Chital** ***Chitala chitala***  *Fig 1.34: Chital*	Highly priced indigenous fish.
28.	**Koi** ***Anabas testudineus***  *Fig 1.35: Koi*	Small indigenous fish. High demand in Eastern and north eastern states.

29.	**Channa Sole fish** ***Channa marulius***  *Fig 1.36: Channa*	Larger variety of Channa species. Now cultured in several places due to larger size.
30.	**Nile Tilapia** ***Oreochromis niloticus***  *Fig 1.37: Nile Tilapia*	Exotic variety of fishes. Mostly cultured in Cages in reservoirs. Fast growing
31.	**Mullet** ***Mugil cephalus***  *Fig 1.38: Mullet*	Important brackish water species cultured all along the Indian coast.
32.	**Bhetki** ***Lates calcarifer***  *Fig 1.39: Bhetki*	Important brackish water species cultured along eastern coastal states. High demand in West Bengal and other neighboring states
33.	**Pearl Spot** ***Etroplus suratensis***  *Fig 1.40: Pearl Spot*	Important brackish water species cultured along southern coastal states. High demand in Kerala.
34.	**Cobia** ***Rachycentron canadum***  *Fig 1.41: Cobia*	High valued marine species, mostly cage cultured in Open seas. High price.

35.	**Silver Pompano** ***Trachinotus blochii***  *Fig 1.42: Silver Pompano*	High valued marine species, mostly cage cultured in Open seas. High price.

Practical Exercises

Activity

Visit a nearby fish farm to identify common cultivable fish species and understand their basic characteristics.

Materials required:

Pen, pencil, notebook, mobile camera (if permitted), species identification chart, etc.

Procedure:

1. Visit nearby fish farm/hatchery.
2. Observe and note down the following:
   - Note down the taxonomic feature identification
   - Write down the common name and scientific name
   - Note down culture failure facilitate such as tanks, Ponds, etc.

Check Your Progress

Fill in the Blank

1. ____________is an economic activity involving harvesting of fish or raising them in confinement.
2. Capture fisheries involve harvesting fish from their ________ environment.
3. Aquaculture refers to the culture of aquatic organisms in ________ conditions.
4. India contributes about ______% to the global fish production.
5. The three Indian major carps are Catla, Rohu, and ________.

Multiple Choice Questions

1. What does "aquaculture" primarily involve?

   a. Hunting sea animals

b. Capturing wild fish only
c. Culturing aquatic organisms in controlled conditions
d. Fishing for sport

2. Which of the following is a freshwater fish?

a. Cobia
b. Rohu
c. Silver Pompano
d. Mussel

3. Which state contributed the highest inland fish production in 2022–23?

a. Tamil Nadu
b. Andhra Pradesh
c. Gujarat
d. Kerala

4. What is the major fish group in marine pelagic fisheries?

a. Perches
b. Groupers
c. Catfish
d. Indian Oil Sardine

5. Which of the following is a type of culture fishery?

a. Riverine fishery
b. Pond culture
c. Ocean capture
d. Mangrove fishing

6. What does the term “monoculture” in aquaculture mean?

a. Culturing only one type of plant
b. Mixing plant and fish culture
c. Raising only one type of fish species
d. Using marine water only

7. Which species is *not* commonly cultured in freshwater aquaculture in India?

a. Pangas
b. Rohu
c. Litopenaeus vannamei

d. Mrigal

8. Which of these is a brackish water species?

   a. Mullet
   b. Tilapia
   c. Catla
   d. Mahseer

Match the Following

A. Fish Species	B. Culture Medium)
1. Rohu	a. Freshwater
2. White leg shrimp	b. Brackish water
3. Mussel	c. Marine water
4. Cobia	d. Marine water
5. Mullet	e. Brackish water

Subjective Question

1. What is inland fish farming?

2. What is the difference between capture and culture fishery?

3. Explain the role of fisheries in economic development and food security.

Session 2: Various Employment Opportunities for a Fish Seed Grower

In the last decade, the per capita consumption of fish in India has increased and now stands at more than 13 kg/year, due to which the aquaculture activity is expending in India. Due to the expansion of the fish farm in the different regions of the country, now there is a huge demand of the quality fish seed supply. Most of the hatchery in India now a day, starts breeding cycle in the pre-monsoon season also and extend up to post-monsoon. Several fish seed hatcheries are coming up all over the country to fulfill the seed supply. Due to increase in the hatchery, there is a huge demand of hatchery technician and persons, who can run the operation and raise the fish seed. A fish seed grower, can play different roles like hatchery operation, Broodstock rearing, raising of fish seed, seed transportation, technician etc. In this session various opportunity have been discussed which are available for fish seed grower. There are several opportunities are available in India for the fish seed grower.

Prospects in fish seed production

In India the aquaculture sector is growing very fast. The demand of fish and fish product in domestic and international market is ever increasing. To fulfill the requirement of fish supply, the diversification of aquaculture is of utmost importance. Successful fish farming depends on various inputs. One of the important inputs of the successful farming is supply of the good quality seeds. Many farmers are getting seed from distant areas, which increases the transportation cost. Sometimes farmers pay extra money to get the good quality seed. To enhance this production of the seed several hatcheries are established under central government schemes.

The fish seed production in India has increased from 357439.2 lakh tonnes fry in 2106-17 to in 3589845.82 lakh tonnes fry in 2022-23. This is possible due to the establishment of new hatcheries. The demand of quality seed in near future will be increase many folds, as many entrepreneurs are already started the aquaculture with help from central/state government schemes. There are several potential areas in which a farmers/Entrepreneurs can venture. These are:

- Establishment of brood banks for different fish species.
- Hatcheries for various fishes, shrimps, crabs and mussels.
- Fish seed distributor.
- Fingerling to yearling supplier
- Fish seed certifier
- Supplier of different chemicals and medicine
- Feed supplier for different stages of fish seed.
- Specific pathogen free fish/shrimp seed supplier
- Establishment of Brood stock multiplication unit

The Hatcheries which are located at strategic location can fulfill the demand of the local market as well distant market. Now due to the diversification of aquaculture several hatcheries for new species can be set up which can fetch higher prices than the generally cultured species. If the proper management is practiced in hatchery operation, the good quality seed can be produced. A successful fish seed supplier can produce up to 10-15 crore spawn in one season and can earn up to 20-30 lacs rupees. There is a good scope in the hatchery production in future.

Role and responsibilities of fish seed grower

A fish seed grower is a person who is engaged in the fish seed production. A fish seed grower oversees the overall activities of the seed production from selection of healthy brood fishes to culture of fingerlings. The role and responsibilities of the fish seed grower is:

1. **Selection and maintenance of the healthy broodstock:** Selection of healthy broodstock from wild/farm produced stock, their rearing, nutrition, health monitoring should be appropriate for successful spawning otherwise breeding failure will occur. Broods should be fed with specially formulated broodstock diet for production of good eggs and sperm.
2. **Pond preparation for the broodstock maintenance and rearing:** Pond for the broodstock raising should be 0.2 - 0.5 hectare in size and rectangular in shape. Free from any aquatic weed and predatory fishes. In case of carp fishes, the stocking density should not be more than 1000 kg/ha.
3. **Stress management of the broodstock:** Sometimes the spawning failure and hatching failures are observed in the hatcheries due to the stress. Broods may be stressed if optimum water quality parameters are not maintained in the broodstock pond. Also, improper handling of the broods is responsible for spawning failure. Hand net/Scoop net for brooders handling should be proper, it should not cause any physical injuries. Hormonal injection should be given at a proper place and also fishes should be very calm during administration process
4. **Nursery Pond management:** In the nursery pond, 3-4 days old spawns (3-4 mm in size) are kept for rearing up to fry stage (15-20 days). This is the most crucial phase of the fish life stage. Most of the seeds are very delicate in nature during this period. Proper care should be taken while transferring the spawn into the nursery pond. The survival of the spawns is largely dependent upon the water quality parameter of the nursery pond. Nursery pond should be free from the any aquatic insects, weed and predatory fishes. The stocking density should be proper, always avoid over stocking. Pre stocking management is necessary for good growth and survival. The nursery pond should be properly dried before stocking and it should be properly fertilized before stocking there should be some natural feed also in the pond to promote the good growth.
5. **Successful operation of breeding, spawning and hatching process:** Brooders from the broodstock ponds should be transferred in stage free condition the net netting should be proper, not more than 3-4 brooders should be transferred in handnet. The fishes which are very active should be calm by covering with the cloth and holding it properly by both the hand then injection should be given behind the pectoral fin region where skins are smooth. Brooders should be kept in the proper male to female ratio to achieve the maximum spawning. The water quality parameter in the breeding pool should be optimum also it should be disinfected before spawning and after every 4-5 cycle it should be disinfected again. the mimic of natural condition should be followed to release the eggs

and sperm in time. During incubation period the maximum care should be taken to get the good fertilization rate.

6. **Feed management of the fish seed:** Larval nutrition is an important aspect of the fish seed rearing. Proper feeding of the spawn is necessary to get the good survival rate. To feed spawns, diet should be formulated according to the species requirement and also the physiology and morphology of the fishes should be properly understood. The proper feed size should be given to the fishes to achieve the maximum acceptability rate and get a good growth.

7. **Disease management of the fish seed**: Disease management in pond is important aspect of the nursery rearing of the fishes. Due to the poor water and soil quality management the disease outbreak usually happens. Another reason of the disease outbreak is the higher stocking density, if the stocking density are high there is a competition for space and food which leads to poor growth and fishes are more prone to disease. Also, if the spawn/fry/fingerling are not feed properly it will lead to malnutrition and the chances of getting infection from a career bacterial viral fungal infections are high in malnourished individuals. At first seed should be stocked in a proper density to get the good growth rate also there should be a regular monitoring of the water and soil quality parameter from time to time to check the occurrence of any disease.

8. **Packaging and Transportation of the fish seed:** The packaging and transportation of seed is an important aspect. There are several techniques available for the transportation of seeds which includes traditional method of transporting in earthen Hundis to advanced water tank with fully maintain Oxygen ratio. Before transportation fishes should be conditioned otherwise mortality will be higher. While transporting the fishes the proper ratio of oxygen to fish should be maintained. Various methods and techniques are available for transportation of fish seed like open hundis, plastic packet, portable water tank of different materials etc.

Do’s	Don’ts
1. Regularly monitoring of soil and water quality parameters of Broodstock pond and nursery pond 2. Always select broodstock form different sources to avoid inbreeding	1. Don’t choose broodstock from same hatchery and farm. 2. Don’t mix different species. It will lead to genetic pollution. 3. Avoid overcrowding

3. Continuous Supervision of the broodstock health 4. Follow better management practices. 5. Standard practice of health, hygiene and safety. 6. Keep a tab on egg release, incubation and Hatching. 7. Maintain proper water flow. 8. Manage waste properly.	4. Avoid long distance transportation 5. While transportation ensure optimum level of oxygen 6. Don't overfeed

Relevant Government Schemes in Fisheries

The Schemes being implemented by Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying for development of fisheries include:

1. **Pradhan Mantri Matsya Sampada Yojana(**PMMSY)- PMMSY is designed to address critical gaps in the fisheries value chain from fish production, productivity and quality to technology, post-harvest infrastructure and marketing. It aims to modernize and strengthen the value chain, enhance traceability and establish a robust fisheries management framework while simultaneously ensuring the socio-economic welfare of fishers and fish farmers.

   Benefits: The Pradhan Mantri Matsya Sampada Yojana (PMMSY) offers a wide range of benefits aimed at boosting the fisheries sector in India. It provides financial assistance for developing essential fishing infrastructure such as harbors, landing centers, fish markets, feed plants, seed farms, and processing units. This scheme also supports fish farmers for constructing ponds, installation of cages, hatcheries, rearing unit, and other modern infrastructure. It also promotes the scientific management of fishery resources by supporting the preparation of fishery management plans and information systems. Additionally, PMMSY offers a subsidies to encourage various stakeholders as a business and provides financial aid for developing cold chains, processing units, and packaging facilities to enhance the export potential of fish products.

2. **Fisheries and Aquaculture Infrastructure Development Fund (FIDF)-**

   Fisheries and Aquaculture Infrastructure Development Fund (FIDF) for fisheries sector from 2018-19. FIDF envisages creation of fisheries infrastructure facilities both in marine and inland fisheries sectors and augment the fish. FIDF provides interest subvention finance to the Eligible Entities (EEs), including State Governments/Union Territories and State entities for development of identified fisheries infrastructure facilities through Nodal Loaning Entities (NLEs) namely :

- National Bank for Agriculture and Rural Development (NABARD)
- National Cooperatives Development Corporation (NCDC)
- All scheduled Banks

National Fisheries Development Board (NFDB), Hyderabad is the Nodal Implementing Agency for FIDF Scheme. A wide range of applicants are eligible to benefit from FIDF, including State Governments and Union Territories, State-owned corporations, government-sponsored organizations, fisheries cooperative federations, and collective groups of fish farmers. Additionally, Panchayati Raj Institutions, Self Help Groups (SHGs), NGOs, Scheduled Castes (SCs), Scheduled Tribes (STs), marginal farmers, women entrepreneurs, private companies, and even physically disabled individuals can apply for support under the scheme.

3. Pradhan Mantri Matsya Kisan Samridhi Sah-Yojana

PM-MKSSY intends to address the inherent weaknesses of the sector through identified financial and technological intervention for bringing in institutional reforms to support the transformation of the fisheries sector in the Long-term. The scheme focuses on formalizing the largely unorganized fisheries sector by creating digital work-based identities under the National Fisheries Digital Platform (NFDP), which will enhance service delivery. It also aims to improve access to institutional finance, including working capital, for fishers, fish farmers, and micro and small enterprises. Additionally, it offers a one-time incentive to aquafarmers for purchasing aquaculture insurance and encourages the adoption of safety and quality assurance systems in fish and fishery product value chains through performance-based grants.

The PM-MKSSY targets a broad spectrum of beneficiaries engaged directly or indirectly in the fisheries value chain. These include fish farmers, fish workers, and fish vendors, as well as micro and small enterprises such as proprietary and partnership firms, registered companies, societies, cooperatives, limited liability partnerships (LLPs), federations, and startups. It also supports village-level organizations like Self Help Groups (SHGs), Fish Farmers Producer Organizations (FFPOs), and Farmers Producer Organizations (FPOs). The scheme allows for the inclusion of any other beneficiary group as deemed appropriate by the Department of Fisheries, ensuring inclusive support and growth across all segments of the fisheries and aquaculture sectors.

4. **Kisan Credit Card (KCC) to Fishers & Fish Farmers**

In 2018–19, the Government of India extended the Kisan Credit Card (KCC) facility to fishers and fish farmers to support their working capital needs in both inland and marine fisheries sectors. This initiative enables eligible beneficiaries—including individual fishers, fish farmers, tenant farmers, Self Help Groups (SHGs), Joint Liability Groups, and women groups—to access affordable credit. In inland fisheries and aquaculture, beneficiaries must own or lease assets like ponds, tanks, hatcheries, or fishing gear and hold the necessary state-level authorizations. In the marine sector, eligibility includes those owning or leasing registered fishing vessels or boats with valid licenses for fishing or mariculture in estuarine and marine waters.

Under this scheme, farmers receive KCC loans at a subsidized interest rate of 7%. To facilitate this, an up-front interest subvention (IS) of 1.5% is provided to financial institutions by the Govt. of India. Additionally, farmers who repay their loans promptly on time receive a 3% Prompt Repayment Incentive (PRI), effectively reducing the interest rate to 4% per annum. The benefits of IS and PRI are available for loan limits up to Rs.3 lakhs. However, if the short-term loan is taken for allied activities (other than crop husbandry such as Fisheries and Animal Husbandry), the loan amount is limited to Rs.2 lakhs only.

5. **State Government schemes**

Apart from central government schemes, different state government is having different schemes for the promotion of the fisheries activity. The Office of the fisheries directorate/Commissioner office is the nodal agency for the implementation of the different schemes and project of the states.

Employment opportunities for fish seed grower

Due to the increasing demands of the fish seed every year, there are several hatcheries coming up now in different regions of the country. Also, hatcheries for marine fishes/shellfish, estuarine fishes are increasing day by day. In the last 4-5 years 922 Fish/Prawn hatcheries are established under Pradhan Mantri Matsya Sampada Yojana (PMMSY). The employment opportunities for the fish seed growers are in both public and private sectors. Also, fish seed growers can start their own hatcheries with the support of the central and state government financial assistant schemes.

They can work in the various hatchery which is established by the Central government, like the hatcheries established by Rajiv Gandhi center for aquaculture (RGCA), National Fisheries Development Board (NFDB- Hyderabad) and other institutes. Also, various hatcheries are run by state government under various project and schemes. Fish seed Grower can start their own enterprise with the help (subsidy) from Central Government and state government. There are several private hatcheries which hires fish seed grower.

The fish seed growers can join Public/Private hatcheries as

1. Technician
2. Manager
3. Consultant
4. Supervisor
5. Feed expert
6. Fish Handlers

The fish seed growers can start their own enterprise as

1. Hatchery owner
2. Brooder supplier
3. Medicine/Chemical/Equipment/Tub/Container/Oxygen tank supplier etc.
4. Transporter
5. Fry to fingering grower and seller
6. Feed supplier

Practical Exercises

Activity 1

Visit a nearby fish seed farm and observe the responsibilities of a Fish Seed Grower.

Materials required:
Pen, pencil, notebook, mobile camera (if permitted), species identification chart, etc.

Procedure:

1. Plan a visit to the nearest fish seed farm or hatchery.
2. Observe and note down the following responsibilities performed by a Fish Seed Grower:
    - Selection and maintenance of bloodstock
    - Induced breeding techniques used
    - Hatchery setup and spawning methods
    - Water quality management practices
    - Larval and fry rearing methods
3. Discuss with the fish seed grower about:
    - Daily care and monitoring practices
    - Feeding schedule and feed types
    - Packaging and transportation of fish seed

Activity 2

Enlist various government schemes related to fisheries.

Materials required:
Pen, pencil, notebook, mobile camera (if permitted), species identification chart, etc.

Procedure:

1. Research and list various government schemes that support the fisheries sector.
2. For each scheme, note down the following details:
    - Name of the scheme
    - Objective of the scheme
    - Target beneficiaries
    - Key financial support or incentives provided

Check Your Progress

Fill in the Blank

1. The PM-MKSSY focuses on creating digital work-based identities under the National Fisheries _____ Platform (NFDP).
2. The Kisan Credit Card (KCC) scheme was extended to fishers and fish farmers in _____.
3. The Kisan Credit Card (KCC) facility offers loans at a subsidized interest rate of _____%.

4. The _____ is a nodal implementing agency for the Fisheries and Aquaculture Infrastructure Development Fund (FIDF) Scheme.

Multiple Choice Questions

1. The per capita consumption of fish in India is currently over:
   a. 10 kg/year
   b. 13 kg/year
   c. 15 kg/year
   d. 20 kg/year
2. The main purpose of the Pradhan Mantri Matsya Sampada Yojana (PMMSY) is to:
   a. Improve aquaculture insurance
   b. Increase the export of fish
   c. Promote seaweed cultivation
   d. Modernize and strengthen the value chain in fisheries
3. Which scheme supports the construction of ponds, cages, hatcheries, and nurseries?
   a. PMMSY
   b. KCC
   c. FIDF
   d. PM-MKSSY
4. The Fisheries and Aquaculture Infrastructure Development Fund (FIDF) is implemented by:
   a. NABARD
   b. Ministry of Fisheries
   c. National Fisheries Development Board (NFDB)
   d. Rajiv Gandhi Center for Aquaculture
5. Under the Kisan Credit Card (KCC) scheme, the interest rate is reduced to _____% for timely loan repayment.
   a. 5%
   b. 4%
   c. 7%
   d. 9%

6. A fish seed grower can work as all of the following except:
    a. Technician
    b. Consultant
    c. Hatchery owner
    d. Accountant

Subjective Question

1. What is role and responsibilities of fish seed grower?
2. Explain major Government Schemes in Fisheries sector in India.

Module 2

Pond Construction and Management

Module Overview

Pond construction is a basic step in establishing a successful fish farm. A suitable site should have soil with good water retention, such as clay loam or silty clay, along with a stable and sufficient water source like rivers, reservoirs, or rain-fed systems. The area should be free from pollution, away from flood zones, and easily accessible for transportation and input supply. Ecological, biological, social, and economic factors must also be considered to ensure long-term sustainability and acceptability of the fish farming venture. Before construction, soil suitability can be assessed through squeeze tests, groundwater checks, and permeability tests to ensure the pond can hold water effectively. The layout and design of fish ponds depend on the topography of the land, water availability, and purpose of the farm. Ponds should be rectangular or square with a proper slope, dike width, and depth to allow efficient water management and harvesting. Different types of ponds are constructed based on specific farming activities, such as nursery ponds for hatchlings, rearing ponds for fingerling development, stocking ponds for table fish production, and brood ponds for maintaining brood stock. Additional specialized ponds include spawning, wintering, fattening, and integrated ponds. The size and depth of these ponds vary with their function, and proper equipment like digging tools, nets, aeration systems, and water testing kits are essential for their construction and maintenance.

This module provides students with a foundational understanding of the physical and technical aspects involved in establishing a successful aquaculture system. In this Session, students will learn the key criteria for selecting an appropriate site for fish farming, including topography, soil type, water availability, and climate considerations. The session also covers the basic principles of fish pond design, including layout, shape, size, and construction methods, to ensure optimal water management and fish productivity.

Learning Outcomes

After completing this module, you will be able to:

- Identify key site selection criteria and explain the basic principles involved in the design of fish ponds.

Module Structure

Session 1: Site Selection Criteria and Design of Fish Ponds

Session 1: Site Selection Criteria and Design of Fish Ponds

Selecting a suitable site is the most crucial and foundational step in the planning and construction of an aquafarm. A poor choice made at this stage can lead to higher construction and operational costs, along with potential environmental issues. The long-term success and sustainability of an aquaculture enterprise are significantly influenced by the quality of the selected site. However, identifying an ideal location is not an easy task. It requires a thorough understanding of the local geography, climatic conditions, and ecosystem, supported by technical expertise in aquaculture and engineering. Since topographical and environmental features vary from one place to another, it is difficult to adopt a uniform approach to site selection. Nevertheless, the ultimate aim should be to achieve maximum production at the lowest possible cost while ensuring environmental sustainability.

Desirable Features of a Good Aquafarm Site

An ideal site for aquaculture should have specific physical and environmental features to ensure productive and cost-efficient farming. Firstly, the area should have maximum usable space for production and minimal area occupied by bunds, roads, or other non-productive structures. The site should support efficient and reliable water exchange systems, which are essential for maintaining water quality. Good water-holding capacity of the soil is vital to prevent seepage losses. The ability to drain and harvest individual ponds separately adds to operational efficiency. The site must be free from pollution and located close to a dependable water source. A gravitational water flow system is preferred to minimize the need for mechanical pumping. Furthermore, the location should be easily accessible for transport and have nearby marketing facilities. Finally, the land should ideally be levelled with a gentle slope in one or two directions to facilitate pond construction and water management.

Key Factors in Site Selection

The selection of a site for aquaculture depends primarily on three important factors: the species to be cultured, the targeted level of production, and the physiological needs of the aquatic species. Each species has unique environmental requirements for optimal growth and reproduction. Therefore, a site must be evaluated for its suitability in supporting these biological needs. Additionally, a suitable site should allow for an effective pond layout, support infrastructure, and provide favourable conditions for aquaculture activities. It is not only important to identify whether a site is suitable, but also to assess the extent of modifications needed to make it viable for aquaculture. For, site selection the following ecological, biological and social factors need to be considered:

a. **Topography and Site Selection:** Topography is one of the most significant factors in selecting a suitable site for aquaculture development. It refers to the variation in the elevation and surface features of the land—whether the area is flat, sloping, undulating, or hilly. For aquafarming, preference should be given to sites that allow the use of gravity for water movement. Utilizing gravitational flow for both filling and draining ponds, tanks, and raceways is cost-effective and energy-efficient. Ideally, the pond bottom should be positioned at a higher elevation than the local water table to ensure complete drainage by gravity during pond management operations. Flat or gently sloping land is considered most suitable for aquaculture. The optimum land slope ranges between 0.5% and 1.0%. Slopes greater than 2% are generally avoided, as they require the construction of high and expensive embankments to retain water and stabilize the structure. The ideal topographical features for aquaculture include rectangular or square-shaped flat lands located near reliable water bodies such as creeks, rivers, canals, reservoirs, or streams. These areas should have a natural elevation between 1 to 3 meters above mean sea level, minimal vegetation cover, and a slight slope in one or two directions to assist natural water flow. Such locations are particularly well-suited for coastal aquaculture ventures, such as shrimp and fish pond construction.

b. **Soil Type and Its Quality:** The type and quality of soil at a prospective aquaculture site play a critical role in determining the productivity and sustainability of fish or shrimp farming. The soil not only affects water retention but also influences the natural food production within the pond ecosystem. For effective aquaculture, the site should consist of soft bottom soils, preferably a mixture of clay, sand, and silt. This composition ensures good water-holding capacity while supporting the growth of natural organisms that serve as food for fish and prawns. One of the key soil properties for aquafarming is its impermeability, which helps in minimizing water seepage. Soils with a high clay content, especially silt-clay or clayey loam, are excellent in this regard. A coefficient of permeability (K) less than 5×10^{-6} m/sec is generally considered ideal for aquaculture ponds, as it reflects the soil's ability to retain water effectively. Among soil types, clayey loam is regarded as the most suitable for fish and shrimp pond construction. It possesses both low permeability and high fertility. The organic matter present in clayey loam enhances the production of benthic blue-green algae and supports a variety of microorganisms. These naturally occurring organisms form a vital part of the food chain for cultured species. Loamy soils also have high fertility but may need more water retention support. The preferred soil texture also varies with the level of aquaculture intensification. In extensive culture systems, where natural food sources such as benthic organisms are crucial, loamy to sandy-bottom soils are preferred. Conversely, semi-intensive and intensive systems, which rely heavily on artificial feed, perform best on soils with sandy clay loam to sandy loam textures. These soils provide a balance between drainage and water retention while supporting artificial feeding practices.

c. **Water Supply:** Water availability, both in terms of quantity and quality, is arguably the most critical factor in selecting a site for aquaculture operations. The water source must be dependable throughout the year and capable of meeting the varying needs of different aquaculture cycles. A thorough investigation of the water supply is essential before finalizing a site. Although well water is typically clean and free from pollutants, it is often uneconomical due to the high costs associated with pumping water from deep underground sources. Based on the nature of occurrence, freshwater resources are broadly categorized into the following types:

- **Groundwater resources**: Includes wells and springs.
- **Surface water resources**: Includes rivers, streams, and reservoirs.
- **Miscellaneous resources**: Includes rainwater and recycled or treated water.

d. **Water Quality Parameters:** Water quality plays a central role in the productivity and sustainability of aquaculture systems, particularly in coastal and brackish water farming. An ideal aquaculture site should have access to clean and pollution-free sources of both freshwater and seawater to maintain the appropriate salinity levels required for species growth. Among the water quality parameters, pH and alkalinity are particularly important. Alkalinity indicates the buffering capacity of water, while pH reflects the concentration of hydrogen ions, showing whether water is acidic or basic. The pH of water has a direct influence on fish metabolism, physiological functions, and the toxicity levels of substances like ammonia and hydrogen sulphide. It also affects the solubility of nutrients and the fertility of pond water. Water with a **pH range of 6.5 to 9.0** is generally considered optimal for pond fish culture. A pH below 6.5 leads to reduced productivity, while levels above 9.0 can be harmful to the health of fish and prawns. Extremely acidic water (pH 4.5–5.5) is toxic to most warm-water species and particularly detrimental to the development of eggs and fry. At pH levels between 5.5 and 6.5, fish production remains low. Similarly, excessively alkaline water can also be harmful to aquatic life. To manage pH levels effectively, lime is commonly used to neutralize acidity. The precise measurement of water pH is carried out using a pH meter, ensuring proper adjustments are made to maintain water quality suitable for aquaculture

e. **Seed Availability:** The availability of seed for the chosen culture species is a fundamental requirement in aquaculture planning. Seed can either be sourced from the natural environment or obtained from hatcheries. To assess natural seed availability, a seed resource survey may be conducted at one or more locations near the proposed site. However, due to increasing aquaculture activities, wild seed availability near farming areas has significantly declined. In such cases, it becomes necessary to propose the establishment of a hatchery as part of the aquaculture project. If suitable hatcheries already exist nearby, they may be utilized to supply seed, which can be transported to the farm site.

f. **Feed Availability:** The availability of quality feed is another major consideration, especially in semi-intensive and intensive culture systems. Farms operating over larger areas (more than 5 hectares) require consistent supplies of high-energy, pelleted feed to sustain high growth rates and production levels. Hence, the selection of the farming system often depends on the accessibility and affordability of quality feed. Proximity to feed production or distribution centers can significantly reduce costs and improve farm efficiency.

g. **Social and economic factors-** Ecological and biological aspects are essential for selecting and managing aquaculture sites. Along with these, it is important to understand the social and economic conditions of the area. This includes knowledge of local culture, traditions, and beliefs related to aquaculture. Other factors to be considered are market structure, services linked with aquaculture such as transport, storage, and wholesale markets. The land should be free from legal issues and fish farming should be accepted by the local community. Availability of labour, electricity, healthcare, and transportation also play a key role.

Layout and design of fish pond

The layout and design of fish ponds are fundamental to the successful operation of any aquaculture system. A well-planned design ensures efficient use of space, cost-effective construction, ease of management, and smooth daily operations. The layout must consider natural site features such as topography, soil type, and water availability, and integrate various components like embankments, water supply, drainage systems, and access routes in a logical and functional manner.

Embankments (Dikes)

Embankments, also known as dikes, are essential structural components in aquafarm design. They serve as boundaries for the ponds and protect the farm area from external environmental threats such as floods, tides, and storm surges. The dikes must be constructed on firm, well-consolidated foundation soils that can bear their weight and any additional loads such as vehicular movement. Soils that are swampy, plastic, or highly organic—like peat and muck—should be avoided for foundation construction, as they are prone to decomposition and settling, which can compromise the integrity of the structure. The foundation material for embankments should have low permeability to minimize seepage. Typically, earth materials available at the site are used for dike construction. There are two primary types of embankments used in aquafarms:

- **Periphery Embankment**: Also called the main or perimeter embankment, it encloses the entire farm area and provides protection against natural hazards. Its design depends on local conditions such as elevation, flood history, and wave action.
- **Internal Embankment**: These are secondary dikes built around individual ponds within the farm. Their height is determined by the pond's designed water level. In areas with poor soil quality, berms may be added to strengthen the internal embankments.

Factors Influencing Aquafarm Design

The layout of an aquafarm must be tailored to the natural shape and topography of the land. A proper design minimizes construction costs and facilitates effective farm management. Several key factors must be considered during the design phase:

- The orientation of ponds should align with the direction of prevailing winds. Rectangular ponds should be positioned so that their longer sides run parallel to the wind direction. This enhances aeration by increasing surface turbulence, which improves oxygen levels in the water.
- The water intake point should be located in a well-protected area with year-round access to clean water. For coastal aquaculture, seawater intake locations must consider sea current direction, proximity to discharge outlets, and sources of pollution to avoid contamination.
- The design should aim for the shortest and straightest possible water distribution channels. If bends are unavoidable, they should be smooth to reduce resistance. The layout should follow the natural land contours to reduce earthwork and maintain efficient water flow.

- Discharge points for used water should be situated downstream of the water intake system. This prevents contaminated water from re-entering the culture ponds and maintains water quality.
- The farm must be designed to allow full drainage of all ponds at any time, especially during harvesting or heavy rainfall. This helps in pond cleaning, maintenance, and biosecurity.
- Freshwater wells should be located at a safe distance from the sea to avoid saltwater intrusion caused by excessive groundwater pumping.
- Pond dimensions should optimize the net water area for culture without creating difficulties in management and daily operations. Ponds must be large enough to be productive yet small enough to allow efficient monitoring and control.

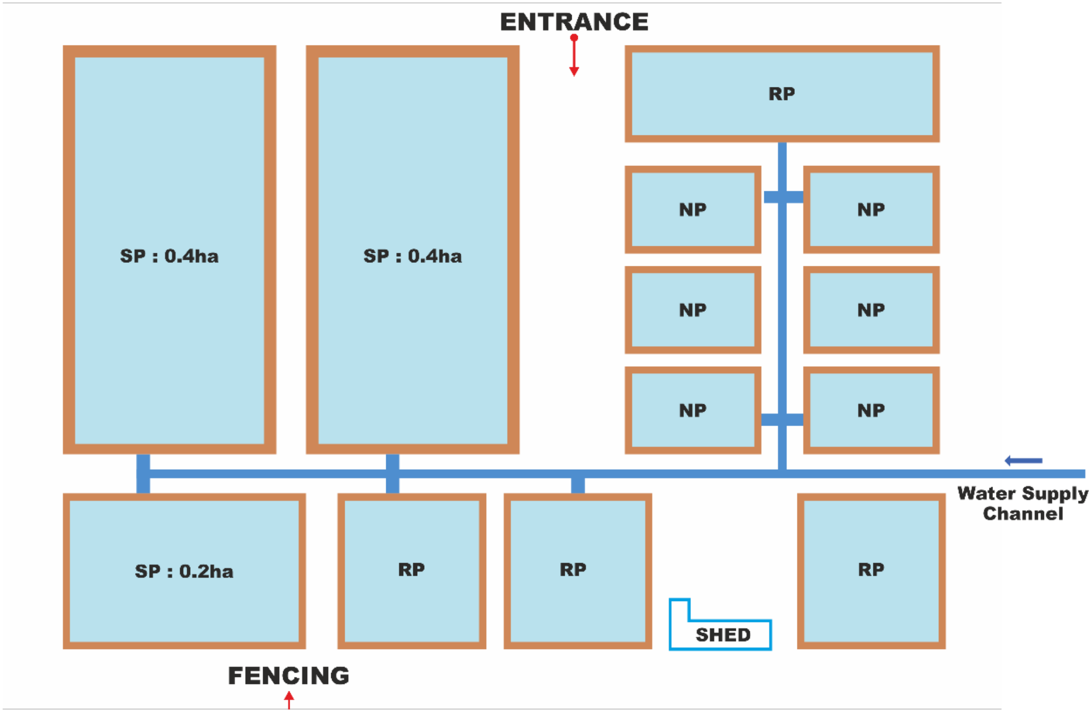


Fig: 2.1 – Model Farm Layout for Seed Production (1.5ha)

According to the specific use in farming activities, ponds can be categorized into different types as follows:

- **Nursery Ponds**: Used for rearing fish hatchlings to the fish fry stage and for producing fish fries. These fries are later reared into fingerlings.
- **Spawning Ponds**: Used for fish breeding, where fertilization of eggs and hatching take place.

- **Brood Ponds**: Used for rearing brood fishes that are needed for fish breeding operations in seed production.
- **Storage Ponds**: Generally used for keeping fishes temporarily before marketing.
- **Fattening Ponds**: These are used for the production of table-size fishes.
- **Wintering Ponds**: Used for keeping fishes during the cold season.
- **Integrated Ponds**: Used for multiple purposes such as fish farming along with cattle rearing, poultry, agriculture, and horticulture activities.

Fish ponds can also be identified based on their size, shape, and water depth. Spawning ponds are smaller than nursery ponds. A subsistence pond is smaller compared to a small-scale commercial pond or a large commercial pond. Intensive culture ponds are smaller than extensive ponds. If there is a good supply of water, fish seed, fertilizers, and feed, there is no need to construct large ponds.

A good pond should be designed to allow complete control. While designing, decisions should be made regarding the total water surface area, pond length and width, depth, dike slopes (bunds), and dike width. There is no fixed rule for pond size.

Design of Ponds

a. **Pond Size:** The size, shape, and orientation of a pond are determined by various factors, including the site's topography, land boundaries, construction and operational costs, available natural resources, and ease of management. The size of individual ponds affects the overall farm layout and the ratio of productive (water-covered) area to non-productive space. Hence, pond size should be optimized to balance construction costs, expected productivity, market demand, and farm economics. Pond dimensions vary depending on their specific function—such as fish production, fingerling development, broodstock maintenance, or spawning. For instance, **stocking ponds**, used for growing fish to marketable size, are typically large and stocked with fingerlings measuring 10–15 cm. These fingerlings are first raised in **nursery ponds**, then transferred to **rearing ponds**, and finally stocked in grow-out ponds depending on the farm's production goals.

   The size and depth of ponds also vary according to the source of water and the farming region. The following table outlines standard size and depth ranges:

Pond Type	Size (in ha)	Depth in Irrigated Areas (m)	Depth in Non-Irrigated Areas (m)
Nursery Pond	0.02 – 0.06	1.0 – 1.5	1.5 – 2.0
Rearing Pond	0.06 – 0.10	1.5 – 2.0	2.0 – 2.5
Stocking Pond	0.25 – 1.00	2.0 – 2.5	2.5 – 3.5

b. **Pond Shape and Orientation:** Several key factors influence the selection of pond shape, including the ratio between embankment length and water-covered area, the site's natural slope, and the harvesting method. Among various geometric options—such as circular, oval, square, or rectangular—**rectangular and square ponds** are the most common in commercial aquaculture due to their practicality and ease of management. When harvesting is done using nets, pond width should ideally not exceed 100 meters. Wider ponds require longer and stronger nets, more manpower, and towing equipment, which can increase operational costs and negate potential benefits. Rectangular ponds are particularly advantageous as they allow efficient water management and can be constructed side by side, improving the overall farm layout. For best results, the length-to-breadth (L:B) ratio should range from **1.5:1 to 2:1**.

Pond orientation also affects aeration. In general, the longer side of the pond should be aligned parallel to the prevailing wind direction to enhance surface water mixing. However, in regions where wind speeds are high and cause erosion of dikes, orienting the longer side **perpendicular to the wind direction** is recommended. This helps improve aeration without compromising dike stability. In hatcheries, rectangular tanks and troughs are commonly used for fry and fingerling rearing, with water flowing in from one end and draining from the other. Special care must be taken to round and smooth the pond corners to prevent waste accumulation and dead zones where fish could be stressed.

c. **Pond Bottom Design:** The bottom of the pond plays a crucial role in water management, drainage, and fish harvesting. A smooth and gently sloping bottom ensures complete water drainage and facilitates the easy collection of fish during harvest. A minimum slope of 0.1 to 0.2% is generally sufficient for this purpose. Uneven pond bottoms should be avoided as they create depressions where fish may hide, making harvesting more difficult. At the deepest point near the pond outlet, often referred to as the harvesting sump, the bottom should be excavated slightly deeper than the rest of the pond. This sump should not exceed 0.1 hectares in area, and in smaller ponds, even less, to concentrate fish for easy harvesting. The size and depth of the harvesting pit are important—it must be large enough to hold all fish in the pond just prior to harvest. Proper care should also be taken in the placement of the harvesting sump. It should be protected from siltation and equipped with a freshwater supply and aeration system to keep fish healthy while they are concentrated in the sump before harvesting. Pond bottoms should be dried, cleaned, and renovated after every harvest to maintain hygiene and prevent disease outbreaks. Regular maintenance ensures the pond remains in good condition and ready for the next production cycle.

However, nursery ponds should be small and shallow, generally with a water area of 0.02 to 0.06 hectares and a depth of 1.0 to 1.5 meters. Rearing ponds are slightly larger, ranging between 0.06 to 0.1 hectares, with a depth of 1.5 to 2.0 meters.

Dimension of stocking (fattening) ponds can be construct as follows

Type of Ponds	Depth (m)	Area (ha)
Subsistence Ponds	2.0	0.1 – 0.4
Small-scale Commercial Ponds	2.0 – 2.5	0.4 – 1.0
Large-scale Commercial Ponds	2.0 – 2.5	1.0 – 2.0

Clear the land to create a clear line of sight. Select a reference point for conducting the survey. A Temporary Bench Mark (TBM) is commonly used as a standard reference to determine elevations and set the required slopes. If an existing pond is available, it can be used as the reference point to measure the height of the dykes. In the absence of an existing pond, a fixed point on the inlet or outlet canal should be selected and used as the TBM.

Types of Ponds

Ponds are needed for different life stages of fish such as nursery, rearing, stocking, and broodstock ponds. Rectangular ponds are preferred over those with rounded corners, as they help prevent fish from escaping during harvest. The ideal length-to-breadth ratio is 3:1, with the breadth not exceeding 30–50 meters. The total farm area can be divided as follows: nursery ponds – 5%, rearing ponds – 20%, stocking ponds – 70%, and bio (treatment) ponds – 5% of the total area.

1. **Nursery Ponds**: These are small ponds built for seed rearing. The size of nursery ponds is about 0.01 to 0.05 hectares, with a depth of 1 to 1.5 meters. Spawn is stocked in these ponds and reared for a maximum of 30 days.

2. **Rearing Ponds**: These ponds are used for rearing fry and fingerlings. Their size ranges from 0.05 to 0.1 hectares, with a water depth of 1.5 to 2 meters. The rearing period lasts for 2 to 3 months. Proper management and water quality maintenance are important.

3. **Stocking Ponds**: Fingerlings (10–15 cm in length) are grown to marketable size in these ponds. The culture duration is 8 to 12 months. Stocking density depends on the target fish production. These ponds can also be used as broodstock or breeding ponds when required. The pond area is usually 1 to 2 hectares or more, but 1 hectare is considered ideal, with a depth of 2.5 to 3.0 meters.

4. **Bio (Treatment) Ponds**: These ponds are essential for fish treatment, medicinal trials, and quarantine. The water in these ponds is purified through biological methods and later used in stocking ponds. A flat bottom is recommended for easy netting.

Ponds construction

Ponds are generally constructed by digging the soil and are best suited for plain areas. The pond should be built scientifically, maintaining proper shape, size, depth, and other necessary features. In hilly areas, embankment ponds are more appropriate. In these ponds, dikes may be constructed on one or two sides depending on the requirement. Though this type of pond is cost-effective, it is not ideal for fish culture, as the size, shape, and depth cannot be fixed according to scientific standards.

Inlet and Outlet Construction

Inlet systems are constructed in canal-fed ponds to provide sufficient quality water, except in rain-fed ponds. Inlets are placed at the top level of the pond. Screens are fitted at the inlet to prevent the entry of unwanted materials into the pond. The size of the inlet pipe should be designed so that the pond can be filled within 1 or 2 days. The outlet pipe is installed at the bottom center of the pond. It is used for draining water during harvesting or for partial water exchange during the culture period to maintain water quality. The outlet should be constructed before building the dikes.

Pond Fencing

Fencing is essential for protecting the pond. Live fences also act as windbreaks, provide privacy, improve farm appearance, and support farm biodiversity. Types of fences include live fence, piled fence, woven fence, post and rail fence, wire fence, wire netting fence, net fence, and stone wall. Each type has its own advantages and disadvantages. Wire net fencing is commonly used in fish farms to prevent intruders and protect fish stock.

Pond Preparation Before Stocking After pond construction, proper preparation is necessary before stocking fish. This includes cleaning, liming, and fertilizing to make the pond suitable for fish.

Liming

Lime (calcium hydroxide) is applied to the pond bottom to kill unwanted bacteria. In newly constructed ponds, lime is used at the rate of 20–30 kg per acre and should be left for two weeks before adding water. In existing ponds, liming is done at 200–300 kg per hectare. Liming helps reduce soil acidity, improves soil fertility, supports chemical cycles, and eliminates harmful organisms. After two weeks, fill the pond with water, check all water quality parameters, and then stock the fish.

Role of lime in ponds:

- Liming helps to neutralize soil acidity (as most soils in the state are moderately acidic).
- It is done to increase the soil pH towards a more alkaline level.
- It improves the structure of the soil.
- It promotes the activity of bacteria that break down organic matter.
- It provides calcium, which is important for plant growth and for the bone formation in fish.
- It also acts as a fertilizer.

Manuring (Compost):

After 15 days of liming, fertilization should be carried out to promote the growth of natural fish food organisms such as phytoplankton, zooplankton, and both macro and micro-organisms. Manure used for this purpose can be organic or chemical. Organic manures include cow dung, pig dung, poultry manure, urine, sewage rich in nitrogen, green manure, compost, and oil cake. If the organic carbon level is low, cow dung should be applied at the rate of 2–3 tonnes per hectare in stocking ponds.

Poultry manure, when applied at the rate of 5000 kg/ha, is known to boost the growth of zooplankton. The quantity of chemical fertilizers to be used depends on the existing phosphorus and nitrogen levels in the soil. A standard fertilizer ratio of N:P:K = 18:10:4 is generally recommended for freshwater ponds. In ponds with medium fertility, urea can be applied at 200 kg/ha/year or ammonium sulphate at 450 kg/ha/year. These should be applied in split doses, alternating with organic manures.

Fertilizing:

Fertilizing the pond is essential to enhance primary productivity in extensive culture systems. In semi-intensive systems, fertilizers are also used to support fish until feed inputs reach 20–30 kg/ha/day and the nutrients from fish waste become enough to maintain plankton blooms. In intensive ponds, fertilization is often done before stocking to help develop plankton blooms, as newly stocked fingerlings or post-larvae benefit from natural food organisms.

Organic fertilizers are widely used to improve fish production. However, urea, Triple Superphosphate (TSP), and other commercial chemical fertilizers are also commonly used. A total of 14 mineral nutrients may be required for phytoplankton growth, but in most cases, only nitrogen and phosphorus are the limiting factors in fish ponds.

In ponds with low-alkalinity water, low carbon dioxide can limit primary productivity. This issue is usually corrected by liming, not by fertilization.

Materials Required for Pond Construction

1. Digging Tools

Most maintenance and repair work in fish farms focuses on dikes. The same tools used for manual pond construction are also suitable for repairing dikes. Digging tools, flatboats, wooden dugouts, and rafts are useful for digging trenches, backfilling with puddled soil to repair leaks or seepage, and deepening canals. These tools must be cleaned and rubbed with oil or grease to prevent rust. Boats should be kept under shade to avoid sun damage, and dugout boats should be filled with water when not in use to prevent cracking under sunlight.

2. Levelling Tools

Simple equipment like mud rakes is used to level pond bottoms. In Indonesia, a levelling board operated by four or more people is commonly used for this purpose.

3. Desilting Equipment

Silt removal from pond bottoms or canals can be done manually using simple metal or wooden shovels, as practiced in Thailand and Indonesia. For larger areas, portable silt or sludge pumps are useful and can be moved across different parts of the pond system.

4. Nets and Traps

- **Fingerling Seine:** A rectangular fine-meshed net (2–4 m long, 1 m wide), supported by two poles with floats on the upper side and sinkers on the lower side, used to catch milkfish fingerlings or shrimp juveniles.

- **Fingerling Suspension Net:** A rectangular or square net (2–3 m wide, 3–5 m long), usually made with 0.5 to 1.0 cm square mesh and coarse twine, used to hold fingerlings during counting or before transport.

- **Gillnet Seine:** A harvesting net (1.5–2.0 m wide, 30–50 m long) with floats on one side and lead weights on the other. Made with coarse nylon thread and 4–5 cm mesh, it is dragged across ponds for partial harvesting.

- **Screens on Water Control Structures:** Fine-meshed nylon or Manila hemp cloth is used in frames on gates to screen unwanted organisms. Bamboo screen baskets are used in nursery ponds, sometimes coated with mesh cloth.

- **Harvesting Bagnet on Gates:** These are fitted on wooden screen frames during low tide. As water drains from ponds, shrimp are carried into the bagnet and collected. This method is common in Malaysia and the Philippines.

- **Cast Net:** A versatile net used for sampling or small-scale fish catching, useful for checking growth or partial harvesting.

- **Bamboo Screen Trap:** Used in coastal ponds for partial harvesting of shrimp. In Indonesia, the shrimp fyke (bubu udang) consists of a catching fyke, antechamber, and bamboo screen set perpendicular to the pond dike. A similar trap is used in the Philippines.

5. Water Circulation and Aeration

Portable pumps help circulate water in ponds when tides are not sufficient. Paddle wheels powered by electricity or portable engines are used to improve oxygen levels. Water gates fitted with closure slabs can also aid aeration.

6. Analysis Kit

Soil and water testing kits are essential for monitoring pond conditions. For coastal farms, testing for dissolved oxygen, salinity, and pH is important. Other useful checks include nutrient levels (N-P-K) and turbidity (using a Secchi disc). Salinity can be checked with refractometers or standardized hydrometers.

Practical Exercises

Activity 1

Enlist the Criteria for Site Selection and Draw a Layout of a Model Fish Farm

Materials required:
Pen, pencil, notebook, ruler, colour pencils, chart paper, and eraser, etc.

Procedure:

1. Visit a nearby fish farm and interact with farm managers or technicians to understand how site selection is done for pond construction.
2. Collect information and observe the following aspects related to site selection:
    - Soil type and texture
    - Availability and quality of water
    - Topography and drainage conditions
    - Accessibility and transportation
    - Proximity to market, input supply, and pollution sources
    - Social acceptance and labour availability
3. Based on your visit and classroom discussion, list the criteria for ideal site selection for fish ponds.
4. Draw a neat and labelled layout of a model fish farm on chart paper.

Check Your Progress

Fill in the Blank

1. ________ soil is ideal for aquaculture due to its low permeability and high fertility
2. Water with a pH between ________ and ________ is considered ideal for fish culture.
3. The ideal length-to-breadth ratio for fish ponds is __________.
4. Nursery ponds are used to rear spawn for a maximum of __________ days.
5. Lime is used to reduce soil __________ in fish ponds.

Multiple Choice Questions

1. Which of the following factors is most critical in selecting an aquaculture site?
    a) Price of land
    b) Topography

c) Distance from city
d) Rainfall

2. Which pond is specifically used for breeding fish?
   a) Storage pond
   b) Spawning pond
   c) Nursery pond
   d) Brood pond
3. Which water quality parameter directly affects fish metabolism and nutrient solubility?
   a) Salinity
   b) Hardness
   c) pH
   d) Chlorine
4. A major advantage of rectangular ponds is:
   a) High cost
   b) Irregular shape
   c) Difficult layout planning
   d) Easy water management
5. What is the recommended size for a nursery pond?
   a) 0.01–0.05 hectare
   b) 0.5–1 hectare
   c) 1–2 hectare
   d) 0.1–0.5 hectare

Match the Following

Column A	**Column B**
1. Nursery Pond	a. Temporarily keeping fish pre-sale
2. Brood Pond	b. Used to grow fry and fingerlings
3. Storage Pond	c. Rearing hatchlings to fry
4. Rearing Pond	d. Holding mature breeding fish

Subjective Question

1. Describe the criteria of site selection for fish pond construction.
2. Explain the layout and design considerations for fish ponds.

Module 3

Soil and Water Quality Management

Module Overview

Maintenance of a healthy aquatic environment and production of sufficient fish food organisms in aquaculture ponds are two significant factors for successful culture operation. Water is of utmost importance for supporting aquatic life whereas soil is essential to withhold it. To keep the aquatic habitat suitable for existence, physical and chemical factors like colour, turbidity, temperature, odour, pH, dissolved gases oxygen, carbon dioxide, hydrogen sulphide, ammonia etc. will affect individually or synergistically while the nutrient status of soil and water play important role in regulating the production of fish food organisms or primary production in fish ponds. The bottom soil affects the storage and release of nutrients to the water through various chemical and biochemical processes for primary production in the pond. Water which is in contact with bottom soil gets nutrients from the soil, atmospheric gases and absorbs solar energy in the form of radiation essential for activities of aquatic organisms. This interdependence between the soil and water maintain a chemical equilibrium in the pond preventing bigger fluctuation lethal for aquatic life. It influences production, decomposition and consumption process in the pond system. Commercial aquaculture practices have raised questions regarding maintenance of optimum nutrients in the culture system and its impact on surrounding environment.

This module introduces students to the critical environmental parameters that influence aquaculture productivity, focusing on soil and water quality management. In Session 1, students will explore the key soil quality parameters—such as texture, pH, permeability, and organic matter content—that affect pond construction and fish health. In Session 2, the focus shifts to water quality parameters, including temperature, dissolved oxygen, pH, ammonia, and salinity, all of which are vital for maintaining optimal aquatic conditions.

Learning Outcomes

After completing this module, you will be able to:

- Describe the key soil quality parameters essential for successful aquaculture and their impact on pond productivity.
- Identify and explain the critical water quality parameters in aquaculture and how they affect fish health and growth.

Module Structure

Session 1: Soil Quality Parameters for Aquaculture

Session 2: Water Quality Parameters for Aquaculture

Session 1: Soil Quality Parameters for Aquaculture

Soil parameters are critical for successful aquaculture, particularly in pond-based aquaculture systems. Good soil quality influences water retention, pH balance, nutrient availability, and overall pond productivity. Soil plays an important role in regard to the fertility of fish ponds. The production of various fish food organisms depends largely on availability of different nutrients. Dynamics of availability of most of these nutrients is determined by the conditions prevailing in the bottom soil. In Indian geographical boundary, there are eight major types of soils.

Physical Properties of Soil

Physical properties (mechanical behaviour) of a soil mainly influence its use and behaviour towards plant and fish growth. The important physical properties are as follows:

1. Soil texture,
2. Soil structure
3. Soil porosity
4. Soil colour

1. Soil texture

Soil texture refers to the relative proportion of particles or it is the relative percentage by weight of the three soil separates viz., sand, silt and clay or simply refers to the size of soil particles. There are a number of systems of naming soil separates. According to Indian Society of Soil Science

Sr. No.	Soil Separates	Diameter (mm)
1	Clay	<0.002
2	Silt	0.002-0.02
3	Fine Sand	0.02-0.2
4	Coarse Sand	0.2-2.0

There are 12 soil textural classes represented on the soil texture triangle. This triangle is used so that terms like “clay” or “loam” always have the same meaning. Each texture corresponds to specific percentages of sand, silt, or clay. Knowing the texture helps us manage the soil.

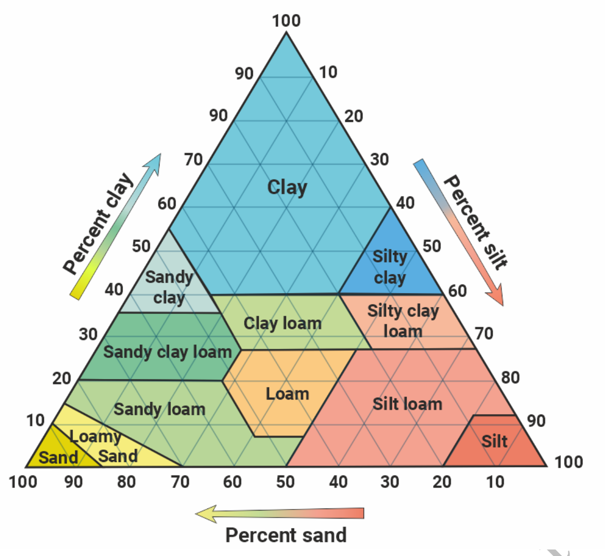


Fig. 3.1: Soil Texture

2. Soil Structure

Soil structure is the arrangement of soil particles into small clumps, called peds or aggregates. Soil particles (sand, silt, clay and even organic matter) bind together to form peds. Depending on the composition and on the conditions in which the peds formed (getting wet and drying out, or freezing and thawing, foot traffic, farming, etc.), the ped has a specific shape. They could be granular (like gardening soil), blocky, columnar, platy, massive (like modelling clay) or single-grained (like beach sand). Structure correlates to the pore space in the soil which influences root growth and air and water movement.

3. Soil Porosity

Soil porosity refers to the proportion of void spaces (pores) in the soil that are filled with air or water. These spaces are critical for the movement of air, water, and nutrients within the soil, influencing plant growth and the soil's ability to retain and drain water. The porosity of soil is typically expressed as a percentage, representing the volume of pore spaces relative to the total volume of the soil. Porous soil is not good for fish culture.

4. Soil Colour

Soil colour is an important physical characteristic that can provide insights into the soil's composition, moisture level, and fertility. It can also indicate the soil's drainage capacity and the types of minerals and organic matter present. Darker soils with more than 5% organic matter is not good for fish culture. Site can be selected based on the soil colour for fish farming.

Soil Chemical Parameters

Soil plays an important part with regard to the fertility of fish ponds. Types, characteristics and chemical conditions of soil influences the pond productivity.

In this respect the major chemical factors of importance are pH, total nitrogen, total phosphorus, organic carbon, C/N ratio, available nitrogen, available phosphorus.

1. Hydrogen ion concentration (pH)

The pH of soil in fish ponds is affected by many factors. In pond mud, organic matter breaks down slowly because there is not enough oxygen. This slow, oxygen-free (anaerobic) decomposition produces harmful substances like hydrogen sulphide, ammonia, and fatty acids, which make the soil acidic and reduce its productivity. When the soil becomes too acidic, it also reduces the availability of essential nutrients at the soil-water interface. A slightly alkaline pH is considered ideal for fish ponds, as it supports better nutrient availability and overall pond health.

pH value	Soil category
≤ 5.5	Highly acidic
5.5-6.5	Moderately acidic
6.5-7.5	Nearly neutral
7.5-8.5	Moderately alkaline
≥ 8.5	Highly alkaline

2. Electrical Conductivity (EC):

EC is a measure of how well soil suspension conducts electricity, which depends on the amount of dissolved salts **(**i.e., soil salinity**).** It's widely used in aquaculture to assess soil health and its suitability for fish pond. It is expressed as ds/m (decisiemens/m)

EC value	Soil category
≤ 0.8	Non-saline
0.8-2.0	Slightly saline
2.0-4.0	Moderately saline
≥ 4.0	Highly saline

3. Phosphorus

Available phosphorus in soil is very important for improving fish pond productivity. In freshwater systems, phosphorus is often the limiting nutrient, and adding it helps promote plankton growth, which provides natural food for fish. However, the total amount of phosphorus in the soil doesn't matter much because most of it becomes unavailable. In alkaline soils, phosphorus forms calcium phosphate, which doesn't dissolve easily. In acidic soils, it forms ferric (iron) or aluminium phosphate, which are also insoluble. As a result, phosphorus can't be used by aquatic life. Therefore, phosphatic fertilizers should be applied regularly, as the available phosphorus gets locked up over time.

Soil phosphorus value (mg/100g)	Concentration (ppm)	Soil productivity
≤ 3.0	≤ 30	Poor
3.0-6.0	30-60	Average
6.0-12.0	60-120	High
≥ 12.0	≥ 120	Excess or cause of eutrophication

4. Nitrogen

Nitrogen in soil is present mostly in organic forms as amino acids, peptides and easily decomposable proteins whereas the inorganic forms ammonia and nitrate are utilised by phytoplankton and green plants. The conversion of complex organic forms of nitrogen to simple inorganic forms are carried out in the bottom mud by anaerobic microorganisms. Hence, it is important to know the available nitrogen than the total nitrogen in soil. The range of available nitrogen 50-75 mg/ 100 g of soil is relatively more favourable for pond productivity. Loss of nitrogen also occurs in ponds through volatization of ammonia. The cause of volatization of ammonia are high pH and high temperature in pond environment. Besides organic form of nitrogen transformation into inorganic nitrogen and loss of nitrogen in pond environment, some microorganisms, blue green algae, aerobic and anaerobic heterotrophic bacteria present in the soil and water fix atmospheric nitrogen into organic nitrogen. The process of mineralization helps in the release of fixed nitrogen in available forms.

5. Organic carbon and C/N ratio

Compared to the mineral constituents of the soil, organic compounds are more varied and complex. Microbiologist believe that the bacterial activity depends not only on the carbon content but also on the ratio of C/N in the parent substance. Bacterial activity is low when the ratio falls below 10:1 and good up to 20:1. The importance of carbohydrates and C/N ratio in nitrogen fixation has been indicated by Neess (1949). Studies indicate that very high organic content is also not desirable for a pond soil. However, organic carbon less than 0.5% may be considered poor, 0.5- 1.5% as average, while 1.5-2.5% appear to be optimal for good production.

Estimation of Physical and Chemical Properties of Soil

Parameters	Estimation method	Inference
Texture	Hand feel test	Field method
	Ball test	Field method
	Jar test	Lab method

Water holding capacity	Feel test	Field method
	Gravimetric test	Lab method
Soil consistence	Ribbon test	Field method
	Digital Penetrometer	Field method
Soil porosity	Bulk and particle density	Field method
Soil colour	Visual or Munsell chart	Field method
Soil pH	Digital pH Meter	Lab method most accurate
	pH Strip	Lab method
Soil EC	Saturated paste and Digital EC meter	Lab method
	Soil suspension and digital EC meter	Field method
Soil organic carbon	Walkley & Black method	Most reliable, needs lab
	Loss on ignition method	Needs oven
	Soil colour observation	Field method, fast but less reliable
Soil Nitrogen	Organic matter method	Based on colour of the soil
	Alkaline $KMnO_4$ method	Lab method
	Nitrate/ammonium test kit	Field method using kit
Soil phosphorus	Olsen method	For neutral to alkaline soil
	Colour development	Blue colour at 660 nm
	Bray-1 method	For acidic soils
	Mehlich-3	Modern multi element testing for all soil types

Management of soil quality parameters

Sr. No	Parameters	Management practices
1	**Water holding capacity**	To increase water holding or to reduce seepage, bentonite is applied at the rate of 5-15 Kg/m2. It acts as pond bottom sealant
2	**Soil pH**	For correction of soil pH, agriculture lime is applied and its dose is estimated based on the soil pH

pH range	Lime CaCO3 Kg/ha
4.0-4.5	2000
4.5-5.5	1000
5.5-6.5	500
6.5-7.5	200

3	**Low soil organic carbon and nitrogen**	Manuring with fresh cow dung, oilcakes and rice bran 10-20 tons/ha/year depending on available carbon and nitrogen
4	**Low soil phosphorus**	Phosphatic fertilizers are applied. Single super phosphate (SSP) is recommended for aquaculture. 250 Kg/ha/year in instalments.

Practical Exercises

Activity 1

Estimation of Soil pH and Electrical Conductivity (EC)

Materials required:

Digital pH meter and probe, Digital conductivity meter and probe, Multi parameter probe, Standard buffer solution of pH 4,7 & 10, Standard conductivity solution of 1.399 dS/m, Deionized water ≥ 18 mega mho, Reciprocating shaker Beakers, pipettes, and wash bottle, Pen, pencil, notebook, etc.

Procedure:

- Weigh 10 g soil sample and add 20 ml deionized water in 50 ml centrifuge tube to make 1:2 soil- DI water solution
- Place on shaker for 30 minutes. Remove, swirl, uncap and let it stand for 10 minutes
- Calibrate pH meter using all three standard buffer solution using manufacturer's recommendations
- Insert the electrode in suspension without touching the bottom of the tube, allow meter to stabilize and read pH

- Rinse electrodes with deionized water in between two sample
- Calibrate the EC meter using standard solution
- Add 6 ml of standard in 15 ml falcon tube and put probe at the bottom of the tube. Adjust temperature coefficient knob until value matches with standard.
- Rinse electrode with deionized water and shake off excess water
- Insert the electrode in suspension touching the bottom of the tube, allow meter to stabilize and read EC
- Rinse electrodes with deionized water in between two sample

Activity 2

Estimation of water holding capacity (WHC) of soil

Materials required:

Soil sample dried and sieved, Beaker, Filter paper or cloth, Funnel or perforated container, Hot air oven, Digital balance, Distilled water, Pen, pencil, notebook, etc.

Procedure:

- Weigh empty container (W1)
- Add air dried soil in the container and record weight (W2)
- Saturate the soil with distilled water until it is completely wet but not submerged
- Allow the saturated soil to drain for 8-24 hrs by keeping the container on funnel. Cover the soil with cloth to avoid evaporation
- Weigh the wet soil after drainage (W3)
- Dry the soil in oven at 105oC set temperature and weigh the dried sample (W4)

Calculation

$$\text{WHC}(\%) = \frac{(\text{W3} - \text{W4})}{(\text{W4} - \text{W1})} \times 100$$

Inference: Warer holding capacity (WHC) more than 30% is suitable for pond construction in aquaculture. Clay soils have 30-60 % WHC and loam with 15-30% also can be accepted however sandy soils with less than 15% WHC should be avoided.

Check Your Progress

Fill in the Blank

1. Soil texture is determined by the relative proportions of ________, ________, and ________.
2. The plate-like or needle-like shaped soil particles less than 0.002 mm are called ________.
3. The available nitrogen range of ________ mg/100g of soil is considered favourable for pond productivity.
4. The EC value of ≤ 0.8 ds/m in soil is categorized as ________.
5. Phosphatic fertilizers like ________ are applied in aquaculture to increase soil phosphorus.

Multiple Choice Question

1. Which property indicates the amount of voids or air spaces in the soil?
   a. Soil texture
   b. Soil porosity
   c. Soil colour
   d. Soil density
2. The particle size of coarse sand ranges from:
   a. 0.002–0.02 mm
   b. 0.02–0.2 mm
   c. 0.2–2.0 mm
   d. >2.0 mm
3. Which of the following soil colour conditions is not suitable for fish culture?
   a. Red with 2% organic matter
   b. Black with >5% organic matter
   c. Yellow with low moisture
   d. Brown with good porosity
4. Which component is used to seal pond bottoms and increase water holding capacity?
   a. Bentonite
   b. Lime

   c. Gypsum
   d. Urea
5. What does EC measure in the soil?
   a. Carbon dioxide levels
   b. Electrical resistance
   c. Soil moisture
   d. Soil salinity
6. Which nitrogen form is most useful for phytoplankton in pond soil?
   a. Organic nitrogen
   b. Ammonia and nitrate
   c. Urea
   d. Nitrogen gas

Match the following

1. Walkley & Black method	A. Soil texture
2. B. Ribbon test	B. Soil organic carbon
3. Jar test	C. Soil consistence
4. Olsen method	D. Soil phosphorus

Subjective Question

1. Explain the physical properties of soil relevant to aquaculture.
2. Describe the chemical parameters of soil that affect aquaculture productivity

Session 2: Water Quality Parameters for Aquaculture

Water quality is one of the most important factors for successful fish culture. Poor water quality can lead to stress, disease outbreaks, poor growth, and even mass mortalities. High quality water is essential for successful pond aquaculture. Fishes are in equilibrium with potential disease causing organisms and their environment. Changes in this equilibrium, such as deterioration in water quality can result in fish becoming stressed and prone to diseases. It is essential to know water quality parameters and their management which influences growth and survival of cultured organisms. Generally, water quality is determined by biological, physical and chemical variables that affect its suitability in fish culture. The Physical condition of water is greatly influenced with depth, temperature, turbidity and light. These constitute the more important physical parameters on which the productivity of a pond depends.

Physical parameter of Water

1. **Depth:** Depth of pond has an important influence on the physical and chemical qualities of water. Depth determines the temperature, the circulation pattern of water and the extent of photosynthetic activity. In shallow ponds, sunlight penetrates up to the bottom, warms up the water and facilitates increase in productivity. Ponds shallower than 1 m get overheated in tropical summers inhibiting the survival of fish and other organisms. Generally, a depth of about 1.5- 2 m is considered ideal from the point of view of biological productivity of a pond. Deep ponds help fishes to survive in summer and winter when temperature is high and low respectively.
2. **Temperature**: Water temperature generally depends upon climate, sunlight and depth. That too, the intensity and seasonal variations in temperature of a water body have a great bearing upon its productivity. The temperature in fish ponds is generally less during the early hours of morning and reaches the maximum value in the afternoon showing diurnal fluctuations. Compared to the yields of fish in ponds in temperate zones, the natural water in tropical areas generally show a higher production due to more heat budget in the ponds system. Apart from these, temperature plays very important role in physiological processes for breeding in fish both under natural and artificial conditions. Temperature sets the pace of metabolism and for every 10^{o} C rise in temperature metabolic rate gets double. It has direct effect on growth, food requirement, oxygen demand, food conversion efficiency. Chemical changes in both soil and water are greatly influenced by temperature. Decrease in DO is directly related to increase in temperature. Fish display great variability in their tolerance to temperature. Indian major carps usually tolerate wide range of temperature and are called eurythermal. In pond condition, upper surface is warm, however, sub surface water is cool as thermal stratification has taken

place. Running aerator during calm and warm afternoon helps in breaking thermal stratification by mixing warm surface water with cool sub surface water.

3. **Turbidity**: The turbidity of water bodies may be either due to suspended inorganic substances like silt, clay or planktonic organisms. Turbidity of water varies greatly with the nature of basin and inflowing sediments. Ponds with clay bottom are likely to have high turbidity that restricts the penetration of light, therefore reduces the photosynthetic activity hence acts as a limiting factor for productivity. Turbidity caused by plankton is generally desirable in fish ponds. Nuisance underwater weeds are eliminated by plankton turbidity. Plankton blooms favour higher productivity by increasing growth of fish food organisms. Plankton turbidity is measured by disappearance of Secchi disc

Sl	Distance of Secchi disc	Effects on pond
1	≤ 20 cm	Highly productive pond, bloom condition Oxygen depletion in early morning
2	20-40 cm	Optimum for good productivity
3	≥ 40 cm	Less productive pond needs manuring, it may lead to filamentous algae formation

Clay turbidity affects dissolved oxygen in fish ponds. Sometimes it develops suddenly when surface runoff enters after heavy rain. In such cases, oxygen may reduce critically and make it necessary to aerate pond or by applying coagulating agent. Alums or aluminium sulphate are the most effective coagulant which should be applied in calm weather.

4. **Light**: It is another physical factor of importance. Availability of light energy to a fish pond greatly influences its productivity. Penetration of light is determined by turbidity which is measured optically and represents the resultant effect of several factors such as suspended clay and silt and dispersion of planktonic masses. Sufficient solar light should fall on pond surface to maintain optimum range of temperature for good productivity in the pond.

Chemical parameters of Water

As fish lives in water, attention need to be given on water quality especially chemical parameters like Ph, CO_2, dissolved oxygen (DO), Hardness, etc.

1. **pH :** The pH of water is defined as the negative logarithm of hydrogen ion activity. High yield of fish crops is usually produced in water which is just on the alkaline side of between 7.0 and 8.0. The limit above or below which pH has a harmful effect is given as 4.0 and 11.0

Sl	pH	Effects on fishes
1	≤ 4.0	Acid death point
2	4.0-5.0	No Reproduction
3	4.0-6.5	Slow growth

4	6.5-9.0	Good growth
5	9.0-11.0	Slow growth, lethal over extended period
6	9.5-11.0	No Reproduction
7	≥11.0	Alkali death point

2. **Carbon dioxide**: It is highly soluble in water, it is only a minor constituent (0.04%) of the atmosphere. At higher concentration of carbon dioxide in pond water, pH becomes less. It occurs in water in three closely related forms, i.e. free carbon dioxide, bicarbonate ion and carbonate ion. Carbon dioxide will not cause pH to fall below and at higher pH, carbon dioxide becomes negligible. There is interdependence of pH, carbon dioxide, bicarbonate and carbonate. The main reason for changes in these variables in ponds is changes in carbon dioxide concentrations resulting from respiration and photosynthesis. In respiration carbon dioxide is released and in photosynthesis it is consumed. Its concentration increases during night when there is no photosynthesis and decreases during day when photosynthesis is under progress. During overcast condition, no photosynthesis takes place and carbon dioxide concentration increases.
3. **Alkalinity** or **acid** combining capacity of natural freshwater ponds is generally caused by carbonate (CO_3) and Bicarbonate (HCO_3) or hydroxides of calcium, Magnesium, Na, K, NH4 and Fe, Ca being from the major constituent. Bicarbonate and carbonate are the major constituent of pond water and their concentrations are expressed as total alkalinity. These ions are buffer in water and work against sudden change in pH. They can do this by absorbing hydrogen ions when the water is acidic and releasing them when water becomes basic. In general, calcareous water with alkalinities more than 50 ppm are most productive.

Sl	Alkalinity Range (mg/L)	Effect on fish
1	≤ 20	Stress to the fish, production will increase with increasing alkalinity
2	20-200	Ideal for fish culture
3	200-300	Low productivity
4	≥ 300	Stress to the fish, no reproduction

4. **Dissolved oxygen**: Among the chemical substances in natural water, O_2 is of primary importance both as a regulator of metabolic processes of plant and animal community and as an indicator of water condition. Success or failure in fish culture depends on the ability of farmers to manage the fluctuation in dissolved oxygen. Oxygen is major component of the atmospheric air comprising about 21%, but it is less soluble in water. The pond water receives oxygen mainly through (1) interaction of atmospheric

air on the surface water (2) by photosynthesis. Photosynthesis, respiration and slow rate of diffusion cause a fluctuation of dissolved oxygen in water and accordingly remain optimum during morning and gradually increase to attain maximum in the afternoon and declines thereafter during night to reach minimum before dawn.

In ponds, diffusion is done by wind & wave action and by mechanical aeration. Oxygen is lost from water through respiration (by fish, plankton and other organism) and aerobic decay of organic matter.

Sl	**Oxygen range (mg/L)**	**Effect on fish**
1	≤ 1	Lethal if exposure lasts longer than few hours
2	1-5	Fish survive, but slow growth, disease tolerance and reproduction if exposure is continuous
3	≥ 5	Fish grow and reproduce normally

It is possible that below 3.0 ppm of DO_2, asphyxia from low O_2 can be expected and to maintain a favourable condition for a varied warm water fish fauna, 5.5 ppm of DO_2 is required. Sometimes fishes congregate near the surface for respiration in such low DO_2 ponds. For average or good production ponds should have DO_2 concentration above 5.5 ppm.

5. **Hardness**: It is defined as the total of soluble Calcium and Magnesium salts present in the water medium. In most natural water, usually HCO_3 anions are associated with Ca, Mg, Na and K cations. Usually bicarbonates of Ca and Mg cause temporary hardness. Permanent hardness of water is due to soluble Ca and Mg carbonates and salts of inorganic acids ($CaSO_4$). The pond water having a hardness of 60 mg/L or above are satisfactory for growth of fish and do not require addition of lime, but water having hardness, less than 60 mg/L require liming for higher production of fish. Water having, hardness less than 20 mg/L, cause slow growth, distress and eventual death of fish. Water hardness also affects fish health as it influences osmoregulation. Owing to osmosis, freshwater fishes are subjected to continuous influx of water and marine fishes live with continuous outflow of water. Most productive waters for fish culture should not have high variation in hardness and alkalinity.

Sl	**Hardness range (mg/L)**	**Effect on pond and fish**
1	0-75	Soft water
2	75-150	Moderately hard
3	150-300	Hard
4	≥ 300	Very hard

5	≤ 60	Creates stress to the fish
6	≥ 60	Satisfactory for pond productivity, helps in protecting fish from pH fluctuation

6. **Ammonia**: Ammonia reaches fish pond water in form of fertilizer, faecal matter and microbial decomposition of nitrogenous compounds. Plants rapidly absorb ammonia, bacteria oxidize ammonia to nitrate and may be lost through other pathways. In certain ponds with high stocking density where fishes are given supplementary feed, ammonia concentration may reach undesirably high levels. Total ammonia concentration in water consists of two forms viz. NH3 free ammonia and NH4+= ionized ammonia. They maintain equilibrium as per the equation NH3 + H2O=NH4+ + OH-

   Free ammonia fraction is more toxic to fish and the its amount in this form depends on pH and temperature of water. Higher pH & temperature, more percentage of total ammonia present in toxic free form.

Table: Free ammonia concentration and its effect on fish biomass

Sl	**Free ammonia Concentration (mg/L)**	**Effect on fishes**
1	0.02-0.05	Safe concentration for tropical fishes
2	0.05-0.40	Sub-lethal, effects depend the species
3	0.40-2.50	Lethal to many fishes

Increase in ammonia in water- decrease in ammonia excretion by fish- ammonia level in blood and tissue increase- Elevation in blood pH- adverse effects on enzyme catalysed reactions and membrane stability- oxygen consumption increases, damage gills, reduces the ability of blood to transport oxygen

7. **Nitrite**: It is an intermediate product in the biological oxidation of ammonia to nitrate, a process called nitrification. It originates from the reduction of nitrate by bacteria in anaerobic mud or water. In most of the well-maintained pond and natural water bodies, nitrite concentration is under control but in case of high organic pollution and low oxygen, nitrite concentration may increase. When nitrite is absorbed by fish, it reacts with haemoglobin to form methaemoglobin. As methaemoglobin is not effective as an oxygen carrier, continued absorption of nitrite can lead to hypoxia and cyanosis. Blood containing methaemoglobin in appreciable amount is brown, so nitrite poisoning is often called “brown blood disease.

0.02-1.0 mg/L -Sub-lethal for many of the fishes
1.0-10 mg/L -Lethal for many of the warm water fish species
Addition of calcium and chloride reduced the toxicity of nitrite to fish

8. **Nitrate**: It is an important component in the fish pond. It is produced from nitrite by nitrifying bacteria (Nitrobacter) in the process nitrification. It is least toxic of nitrogenous compounds at lower concentration but can cause stress to the fish and water quality. It accumulates as a residue from feed, fish excreta and decomposed organic matter. It is major nutrient for algae and plants which enhances primary productivity.

Nitrate (mg/L)	Status	Recommendation
0-5	Safe	Normal culture operation
5-10	Moderate	Monitor and avoid increase in concentration
10-50	Elevated	Consider water exchange
≥ 50	High	Stressful, stop feeding & manuring

9. **Hydrogen Sulphide**: It is produced by chemical reduction of organic matter that accumulates and forms a thick layer of organic deposit at the bottom. Unionized hydrogen sulphide is toxic to fish, but ions resulting from its dissociation are not very toxic

Table: Percentage unionized hydrogen sulphide in aqueous solution 25° C and different pH values

pH	%	pH	%
5.0	99.0	7.5	24.4
5.5	97.0	8.0	9.3
6.0	91.1	8.5	3.1
6.5	76.4	9.0	1.0
7.0	50.6		

Any detectable concentration of hydrogen sulphide is detrimental to fish culture.

Estimation of water quality parameters

Sl	Parameters	Estimation methods
1	**Dissolved oxygen**	Winkler's titration method, Polarographic DO meter
2	**pH**	Glass electrode pH meter
3	**Carbon dioxide**	Phenolphthalein end point (pH 8.3) titration
4	**Total alkalinity**	Methyl orange end point (pH 4.5) titration

5	**Ammonia**	Nesslerization technique, Indophenol blue method, Phenate method, Ammonia sensitive electrodes
6	**Nitrate**	Phenoldisulfonic method, Cadmium reduction/diazotization, Nitrate test kit
7	**Plankton abundance**	Secchi disc visibility
8	**Phytoplankton abundance**	Chlorophyll a analysis, Light and dark bottle technique (APHA, 1975)
9	**Nitrite**	Griess reagent method using colorimeter, Nitrite test kit
10	**Hydrogen sulphide**	Mythelene blue (colorimetric method), Field kit method for routine monitoring in pond

Management of water quality parameters

Sl	**Parameters**	**Recommendations**
1	**Low DO less than 5 mg/L**	Aerators operation during early morning, Oxygen releasing chemicals like peroxides, perborates, Water exchange
2	**Low pH**	Lime application at recommended dose
3	**High pH**	Gypsum application
4	**Low hardness**	Liming
5	**Low alkalinity**	Liming
6	**High ammonia**	Aeration, Avoid overfeeding, Zeolite application, Yucca extract application
7	**High nitrite**	Aeration, Avoid over stocking, Biofilter application
8	**High nitrate**	Water exchange, Stop feeding and manuring
9	**Hydrogen sulphide**	Frequent water exchange, Increase pH by liming

Practical Exercises

Activity

Estimation of Dissolved Oxygen in Water Sample

Materials required:

BOD bottle (300 ml), Water sample, Rubber tube, Pipette, Manganous sulphate ($MnSO_4$) solution, Alkaline iodide-azide solution, Sulphuric acid (H_2SO_4), Starch solution (indicator), Sodium thiosulphate solution (0.01 N), Burette, Conical flask, Measuring cylinder, Wax, etc.

Procedure:

- **Collect the Sample:**
  - Use a rubber tube to slowly fill the BOD bottle with water sample till it overflows.
  - Make sure no air bubbles enter the bottle.
- **Add Chemicals:**
  - Add 1 ml of manganous sulphate solution just below the surface of water.
  - Add 1 ml of alkaline iodide solution the same way.
  - Close the bottle and gently shake or turn it upside down.
  - A brown color appears if oxygen is present.
- **Store the Sample (if needed):**
  - If titration is not done immediately, seal the bottle mouth with wax and keep it in a water bath at room temperature.
- **Titration:**
  - Add 1 ml of sulphuric acid to the bottle and close it.
  - Shake until the brown color mixes and the solution becomes clear brown.
  - Take 50 ml of this sample in a conical flask.
  - Titrate with 0.01N sodium thiosulphate till the color becomes pale yellow.
  - Add 1 ml starch. The color turns blue.
  - Continue titrating until the blue color disappears.
  - Note the reading and repeat for accurate result.
- **Calculation Formula:**
  - Use this formula to calculate dissolved oxygen in ml/l:

$$\mathrm{DO\ (ml/l)} = \frac{V \times 0.01 \times 8 \times 1000 \times 0.698 \times CF}{Vs}$$

- Where:
  - **V** = Reading from titration (ml)
  - **Vs** = Volume of sample used (usually 50 ml)
  - **CF** = Correction Factor = $\frac{\text{Total bottle volume}}{\text{Total bottle volume 2 ml}}$

Check Your Progress

Fill in the Blank

1. The ideal pond depth for fish productivity is about __________ meters.
2. Temperature affects metabolic rate, which doubles with every __________ °C rise.
3. Turbidity caused by __________ is generally desirable in fish ponds.
4. Secchi disc reading of ≤ 20 cm indicates a __________ pond condition.
5. The pH range suitable for good fish growth is between __________ and 9.0.
6. The main source of dissolved oxygen in ponds is photosynthesis and __________.

Multiple Choice Questions

1. Which of the following is a physical parameter of water quality?
   a) pH
   b) Depth
   c) Alkalinity
   d) Carbon dioxide
2. What causes turbidity in ponds that supports higher productivity?
   a) Clay particles
   b) Animal waste
   c) Plankton
   d) Rainwater
3. What does a Secchi disc reading of ≥ 40 cm indicate?
   a) Optimum productivity
   b) Bloom condition
   c) Less productive pond
   d) Alkaline water
4. Which gas, at high levels, makes pond water acidic?

a) Carbon dioxide
b) Methane
c) Oxygen
d) Nitrogen

5. Ideal total alkalinity for fish culture lies in the range of:
    a) 0-20 mg/L
    b) 20-200 mg/L
    c) 200-300 mg/L
    d) ≥ 300 mg/L
6. Which of the following indicates water is 'hard'?
    a) 0-75 mg/L
    b) 75-150 mg/L
    c) 150-300 mg/L
    d) ≥ 300 mg/L
7. In respiration, which gas is released into pond water?
    a) Oxygen
    b) Nitrogen
    c) Methane
    d) Carbon dioxide
8. Dissolved nitrogen above 0.2 ppm in a pond is considered:
    a) Harmful
    b) Average
    c) Favourable
    d) Negligible

Match the Following

Column A	Column B
A. Ideal pond depth	1. Indicates turbidity
B. Secchi disc	2. 1.5 - 2 meters
C. Free ammonia	3. Toxic gas in pond water

D. pH range for good fish growth 4. 6.5 - 9.0

Subjective Questions

1. Describe the major chemical parameters of water that influence fish culture.
2. Discuss the effects of turbidity on fish ponds.
3. What is alkalinity in pond water? what is its ideal range for fish culture?

Module 4
Fish Seed Production

Module Overview

Fish is a cheap source of protein for providing nutritional security for the Country. There should be regular and sustainable supply of fish seed to the fish farmers for a sustainable fish production. Most of the warm matter fishes are egg spawners and breeds in natural waters like rivers, lakes etc. They spawn once in a year mainly during the monsoon season in running waters excluding common carps and tilapia. Most of the fishes fail to spawn in stagnant waters like pond and tanks. Therefore, a specialized tanks made of cement or plastics is used for breeding of fish called the 'Fish hatchery'. In hatchery tanks, artificial rains, aeration with oxygen etc. to stimulate breeding.

This module provides students with a comprehensive introduction to fish breeding practices and hatchery systems, which are essential components of modern aquaculture. In Session 1, students will learn the fundamentals of fish breeding and gain insights into the different types of fish hatcheries, including their structure, function, and significance in seed production. Session 2 focuses on various fish breeding techniques, such as natural and induced breeding methods, highlighting their applications, procedures, and benefits in enhancing fish seed quality and availability.

Learning Outcomes

After completing this module, you will be able to:

- Explain the core principles of fish breeding, including the biological, genetic, and environmental factors that affect reproductive success in aquaculture.
- Differentiate between various types of fish hatcheries (e.g., flow-through, recirculating, and integrated systems), based on their structure, function, and suitability for different fish species.
- Describe commonly used fish breeding techniques, such as natural spawning, hormone-induced breeding, and artificial fertilization.

Module Structure

Session 1: Fish Breeding and Types of Fish Hatchery

Session 2: Fish Breeding Techniques

Session 1: Fish Breeding and Types of Fish Hatchery

History of Fish Breeding

Induced breeding of fish was first developed in Argentina in the 1930. Later Brazil was the first country to use Hypophysation technique to breed fish in the year 1934 followed by Russia in the year 1937. In this technique fish were breed in hatchery system in controlled condition ensuring desired quality and quantity of seed. Later induced breeding using different agents like GnRHa, HCG etc are developed. In India, Induced breeding of carps was first achieved by Dr. Hiralal Chaudhary using the pituitary Gland Extract. At present GnRH based agents are most commonly used for breeding.

In the 1950's, rivers were the main source of fish seed for the fish farmers. Fish seeds were collected using nets and others traditional gears. The seed collection gradually deceased due to environmental degradation of fish breeding ground in rivers and other natural water bodies. Other disadvantages were also associated in seed collection like-

a. There was no certainty for availability of fish seed from the natural spawning ground.
b. Pure seed of single variety is impossible to collect and mixed variety including predatory fish were caught.
c. Procurement of fish seed from riverine source is labour intensive.
d. High mortality rate occurs when seed were collected from wild source.

Techniques of Fish Breeding

1. Fish breeding by Pituitary Gland

The use of Pituitary gland for breeding of fishes is known as Hypophysation. Pituitary gland of different IMCs and Chinese carp are mainly used for Hypophysation. The gland is extracted from freshly killed mature fish or ice preserved mature fish by cutting the dorsal side of the skull. Then carefully the pituitary gland is taken out and preserved in alcohol or acetone till further use. During breeding operation, the pituitary extract is prepared freshly by Glycerine, Propylene Glycol or Trichloro Acetic Acid (TCA).

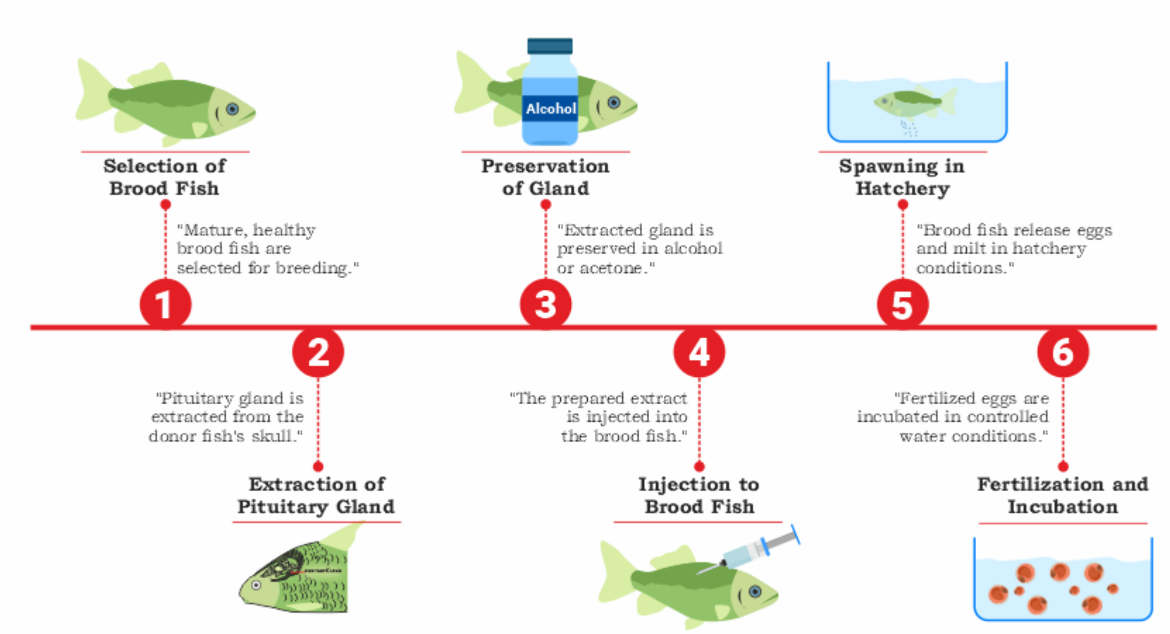


Fig. 4.1: Fish Breeding using Pitutary Gland

2. Fish Breeding by GnRH analogue

Gonadotropin Releasing Hormone (GnRH) analogue mainly extracted from salmon which is a synthetic peptide hormone is used as inducing agent for fish breeding. GnRH stimulate the gonadotropins like FSH and LH in fish which ultimate help in spawning. Different commercial products like Wova-FH, Gonopro, ovatide, etc. are used as the GnRH based hormone which is available in the market.

Fig. 4.2: GnRH based inducing agent

3. Fish Breeding by Other Agents

Human Chorionic Gonadotropins (HCG) is also used as inducing agent for breeding of fish. HCG stimulate the gonadotropins and trigger the release of eggs and milt by the fish brooders. The dose of HCG is 600 IU/Kg BW of the fish. Synahorin along with pituitary gland also used for breeding of fish.

Conventional Method of Fish Breeding

The Indian major carps(IMCs) is a seasonal spawner which spawn once in a year. Matured male and female fishes are called brooders. Indian major carps mature at 2 years and above. A mature female lay 1.5 to 2.5 lakhs of eggs per kg body weight. During monsoon water flows more from the upstream of rivers and fish migrate towards the upper stream for breeding in a particular breeding ground. But survival and purity of seed is not ensured due to the degrading water quality, species diversity and presence of predators. Also, collection of fish seed is more difficult in rivers due to current and isolated breeding ground. Therefore, breeding of fish in controlled condition i.e., in fish hatchery is required for increased fish seed production.

1. **Bundh breeding**
   Bundh are tanks made of cement or earthen in structure. During monsoon season the shallow water in the bundh is inundated with flowing water. The bundh may be seasonal or perennial in nature. The seasonal bundh is called the dry bundh where fish breeds during the monsoon season and perennial bundh is called the wet bundh where fish breeds during monsoon as well as fish can be reared later. Mature brooders are kept in such bundh during heavy rainfall and fishes breed naturally without any hormone. These types of fish breeding is popular in West Bengal and locally known as Bangla bundh.
2. **Hapa breeding**

   Fishes are breed in hapa which is a rectangular or box shaped enclosure made of nylon similar to mosquito net. It is a fine mesh size and covered from the bottom and top. The top portion have zip or opening which can be covered or closed during the breeding operation. Hapa breeding can be done in pond, tank and canals. It is kept fixed with the help of bamboo pole. Fish brooders are injected with inducing hormones and kept in hapa for breeding. Once the fish breed and eggs are released then the brooders are removed. Eggs are kept in the hapa for incubation and up to spawn size. Hapa breeding is less cost, easy to manage, protective from predators and insects, which can enhance the survival of fish seeds.

Fig. 4.3: Hapa based fish breeding

- **Double walled hatching hapa:** This type of outdoor hatching hapa is installed in a pond or in the river bank. There are 2 walls, the inner made of mosquito net and the outer wall with cloth material. The dimension of the hapa is 1.75 x 0.75 x 0.90 m. Once the eggs are hatched out, the spawn comes out of the inner hapa through the mesh and gets collected in the outer hapa made of cloth. The egg shells remain inside the inner hapa. This type of hapa is the most commonly used for breeding of carps in pond and rivers. The main advantage of this hapa is that there is high flow of water in river and canals hence increasing the survival of fish larvae.

3. **FRP based breeding tanks**

FRP tanks are made of fibre reinforced plastic material. It is circular in shape with capacity ranging from 2000 lit and above. CIFE D-85 hatchery with FRP tanks is an example of such breeding tanks. It is an indoor based fish hatchery with controlled environment. Oxygen supply and water showers are provided along with the tank. Fishes can be bred in off season with controlled environment.

Fig. 4.4: CIFE D-85 FRP based fish hatchery

Fish Hatchery

The demand of fish seed increased day by day due to the intensification of aquaculture system. There is a horizontal expansion of aquaculture across the country. This huge demand of seed can be fulfilled only by increasing the number of hatcheries across the country. Since the inception of fish breeding technology many hatcheries system have been developed based on different principle.

Different Types of Fish Hatchery

1. Circular eco carp hatchery

Circular eco carp hatchery is the most common used hatchery system in India. This type of hatchery was invented by the Chinese in the 1960s and earlier known as Chinese circular hatchery. The circular eco hatchery comprise:

a. **Overhead tank :** Overhead tank is a concrete RCC structure placed above the breeding pool. Water can be pumped from the canal or tube well. Water flows from the overhead tank to breeding or spawning pool by gravitational force.
b. **Breeding pool:** Breeding pool is concrete or fibre reinforced plastic based circular tank measuring 6-12 m in diameter and having a depth of 1.2 m. The base of the pool is sloped towards the centre where the outlet is located. The eggs are directly carried to the incubation chamber through a single connecting pipe. There should not be any T or L joint in between.
c. **Incubation pool:** The incubation pool is made of cement or FRP material tank, circular in shape. The tank is divided into two chambers, the outer and inner chamber. The diameter of the outer chamber is 3-6 m and inner chamber is 1-1.5 m. The depth of the pool is maintained at 1-1.5 m. The two chamber is separated by iron mesh with semi concrete wall. Nylon or muslin cloth of mesh size 1/80 inch is wrapped around the inner chamber during incubation of eggs to prevent escape of spawn. The outlet is placed at the centre of the inner chamber. Water flow is maintained by duck mouth shaped inlet pipe. The outlet pipe at the base of the outer chamber is connected to the spawn collection chamber. The capacity of the incubation pool is about 7.5-10 lakhs/ m^3.
d. **Egg collection chamber:** Egg collection chamber is a rectangular tank which is connected to the incubation pool. The dimension of the egg collection chamber is 3 x 2 x 1 m. The hatched-out egg after 72 hours of incubation is directly taken through the pipe.

Fig. 4.5: Circular Eco hatchery at ICAR-CIFE, Powarkheda

2. Glass jar hatchery

This type of hatchery consists of overhead tank, breeding tank, incubation and hatching jar and a spawnery to hold the hatched spawn. The design of Glass jar hatchery was conceived by Bhowmick and also known as Bhowmick's glass hatchery. The name of the hatchery suggest that the incubation jar is made up of glass. The capacity of the hatching jar is about 6 lit. Continuous water flow is required in the hatching jar to maintain the eggs with sufficient oxygen and prevent the eggs debris to accumulate. The water flow is maintained @ 600-800 ml/ min. Beside the hatching jar, spawnery tank are made to hold the spawn with a dimension of about 1.8 x 0.9 x 0.9 m which can hold a nylon hapa. Also, shower is provided to provide oxygen and also give cooling effect. In each cycle of operation, the glass jar can hold 50000 eggs. One of the advantages of this hatchery is that it is kept under controlled environmental condition. Breeding can be taken up pre and post monsoon season.

3. Transparent Polythene jar hatchery

Transparent polythene jar hatchery is a type of glass jar hatchery system where the incubation jar is made of plastics instead of glass. It is unbreakable in nature. The hatchery is design in such a manner that separate inlet and outlet were provided for continuous exchange of water. The inlet pipe supply water from top to bottom inside the jar producing an upward water current is created which is over flown on the top of the jar. This pattern of water movement gives more churning effect the eggs get better oxygenation and therefore better survival. Also, the incubation jar is cover with mosquito net on the inner side of the top portion to prevent escape of any eggs from the jar. This type of hatchery can be kept indoor under controlled environmental condition or it can be placed outside near to the breeding and eggs collection tank.

4. Galvanized iron jar hatchery

This type of hatchery is similar to the glass and plastic cylindrical hatchery. Here the incubation jar is made up of galvanized iron jars. The dimension of the cylindrical jar is 48.5 cm long and 23 cm in diameter and 19 cm top conical portion. Water flow of 1 lit/min is maintained for proper aeration of the eggs.

Practical Exercises

Activity

Visit a nearby fish hatchery and observe hatchery operations.

Materials required:
Pen, pencil, notebook, mobile camera (if permitted), species identification chart, etc.

Procedure:

1. Plan a visit to the nearest fish hatchery.
2. Observe and note down the following hatchery operations:
4. Types of fish species bred in the hatchery
5. Broodstock management practices
6. Induced breeding methods and spawning techniques
7. Incubation process and care of fertilized eggs
8. Water quality management (filtration, oxygenation, temperature control, etc.)
9. Feeding schedules and types of feed used
10. Larval and fry rearing techniques
3. Discuss with the hatchery manager or technician about:
   - Stocking densities and space management
   - Monitoring systems for growth and health
   - Disease management and prevention methods
   - • Processing and packing of fish seed for distribution

Check Your Progress

Fill in the Blank

1. Fish farming started around __________ B.C.
2. The Romans used __________ for fish rearing and breeding.
3. __________ is known as the Father of Induced Breeding.
4. The technique of breeding fish using the pituitary gland is called __________.
5. The use of __________ is common for fish breeding by GnRH analogue.

Multiple Choice Questions

1. What was the primary source of fish seed for farmers in the 1950s?
   a. Rivers
   b. Lakes
   c. Hatcheries
   d. Fish farms
2. Which country was the first to use the Hypophysation technique in fish breeding?
   a. Russia
   b. Argentina
   c. Brazil
   d. India
3. What is the common synthetic peptide hormone used for fish breeding?
   a. HCG
   b. GnRH
   c. FSH
   d. LH
4. What type of fish hatchery is commonly used in India for mass breeding?
   a. Glass jar hatchery
   b. Double-walled hatching hapa
   c. Circular eco carp hatchery
   d. FRP based tanks
5. The incubation pool in a Circular Eco Hatchery is usually made of?
   a. Glass
   b. Steel
   c. Cement or FRP
   d. Plastic
6. Which of the following is used to induce fish breeding in the GnRH analogue method?
   a. Pituitary gland

b. Human Chorionic Gonadotropin (HCG)
c. Propylene Glycol
d. Salmon

Match the Following

Column A	Column B
1. Dr. Hiralal Chaudhuri	a. Wova-FH, Ovatide, Gonopro
2. Hypophysation	b. Used for mass seed production
3. GnRH based inducing agent	c. Father of Induced Breeding
4. Circular Eco Carp Hatchery	d. Use of pituitary gland for breeding

Subjective Question

1. Describe types of fish breeding methods.
2. Explain Different Types of Fish Hatchery.

Session 2: Fish Breeding Techniques

Identification of Male and Female Fish Brooders

Most fishes sex can be determined by sexual dimorphism or secondary sexual character. In some fish sex characters are distinguishable throughout their life. But male and female fish of Indian major carp cannot be distinguished during fry, fingerling or juvenile stage. Once the brooder matures in 2 to 3 years, brooders can be physically identified. Indian major carp viz, Rohu, Catla and Mrigal mature in 2 to 3 years. The brooders can weigh up to 1 to 3 kg during the same period. Pond management like water quality, feed and health is important for production of good brooders. The morphology of brooders is different specially during the breeding season. With the onset of monsoon, the secondary sexual character becomes prominent. Some of the characteristic features of male and female fish are:

- **Pectoral fin:** The pectoral fins of male and female brooders are different during the breeding season. The pectoral fins of male have rough dorsal surface and slightly longer than the female. It feels sand touch when we rub the fins with our fingers. While the pectoral fins of the female are smooth which can be felt by our fingers.
- **Belly shape:** The belly or stomach of female fish is bulging, swollen and rounded in shape. In male it is slender.

- **Genital aperture:** The genital aperture of female fish is prominent during the breeding season. It is reddish to pinkish and swollen and eggs ooze out when gentle pressure is applied on the belly. Whereas male genital aperture is not much prominent with elongated slit and whitish in colour. When gentle pressure is applied on the belly milt ooze out.

Fig. 4.6: Female and male Catla brooders

Fig. 4.7: Rohu brooder

Induced breeding of fish

Artificial spawning of fish using inducing agent is called induced breeding. Fish breed naturally in rivers. Fish are unable to breed in confined waters like pond and tank. Although fish brooder matures in ponds, they are unable to release eggs and milt. Therefore, inducing agents like Ovatide, Wova-FH, Gonopro etc are used by hatchery owners to breed fish in confined waters. These inducing agents are made of GnRH analogue of Salmon fish. As we know GnRH trigger the gonadotropin hormones like FSH and LH and ultimately leads to spawning of fish.

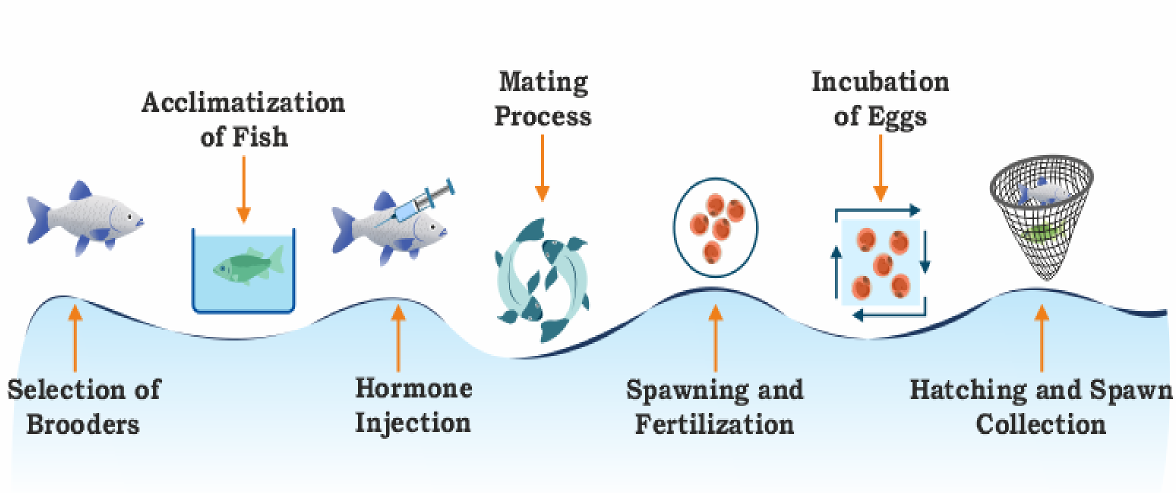


Fig. 4.8: Steps of Induced Fish Breeding

Water quality parameters

The water used for breeding of fish in hatchery should have optimum quality. The desired water quality parameter in the hatchery should be; Water temperature –

26-28 degree Celsius, dissolve oxygen - 5-6 ppm, Ammonia, nitrate, nitrite should be nil. Water pH-7.5-8.5. Water should be provided in the breeding tank by showers.

Fig. 4.9: Estimation of water quality parameter

Selection of breeders

Matured male and female fish are selected for breeding operation in hatchery. Brooders should be carefully chosen for successful spawning. Fish brooders should weigh more than 1 kg. When the fish belly is pressed ova and milt should be released. The brooders should be acclimatized for at least 2-3 hours before injecting hormones. The ratio of female to male should be 1:2 by numbers. Example if we keep one female for breeding at least two males should be taken. These will ensure successful breeding of the fishes.

Injecting with inducing hormones

Inducing hormones like Ovatide, Wova-FH, Gonopro etc are used for breeding of fish. The dose of the agent is given below-

Species	Inducing agent (GnRHa)	
	Male (ml/kg BW)	Female (ml/kg BW)
Catla	0.3	0.6
Rohu	0.2	0.4
Mrigal	0.2	0.4
Grass carp	0.3	0.6
Silver carp	0.3	0.6

Common carp	0.2	0.4

The dose may vary depending on the broodstock condition and environmental parameters. During the onset of monsoon (July-Aug) breeding season is peak and lesser amount of dose may be required.

Fig. 4.10: Injecting fish brooder for breeding in circular hatchery

Methods of injection

Syringe volume of 2-5 ml is mostly used for breeding IMCs. The needle size of 22-24 gauge is used for smaller fish. Needle size of 16-18 gauge is mostly used for the bigger fishes above 3 kgs. The different methods for injecting a brood fish are as follows-

- **Intramuscular injection:** It is the most common method of injecting a fish. The fish are injected in the muscle on the caudal peduncle or below the dorsal fin just above the lateral line. It is considered the safest method as the needle pierce only the muscle and no vital organ is situated on the caudal peduncle.
- **Intra peritoneal injection:** In this method of injection fishes are injected on the base of pectoral or pelvic fin. This method is effective but there is risk of injury to organs. Expert hatchery owners usually practice such type of method.
- **Intra cranial injection:** In this method the fishes are injected on the cranium in the head portion. This method is highly risky as it may damage the brain of the fish.

Fig. 4.11: Intramuscular injection of fish brooder

Mating of fish: After 6-8 hours of injection mating process of fish begin. The male starts to chase the females and during the climax both the fish twist and embrace together. This will exert pressure on the belly of the brooders.

Spawning of eggs: During this time female will start to release eggs from its belly and male will release its milt simultaneously. The number of eggs depend on the size of the brooders. The average fecundity of different fish species is given below-

Species	**Fecundity (lakhs/kg BW)**
Catla	1 -2
Rohu	1.5 - 3
Mrigal	1-2
Grass carp	0.8 - 1
Silver Carp	1-1.5
Common carp	1.5-2.5

Fertilization of eggs

During spawning eggs and milt are mixed and fertilization occurs immediately. The eggs are swollen and then eggs are water hardened. The diameter of the swollen eggs is about 1-1.5 mm in diameter. Carp fish eggs are semi pelagic and floating in nature therefore it remains suspended in the water. Fertilized and unfertilized eggs can be distinguished based on the appearance. The fertilized eggs are transparent in nature and a distinct nucleus will be visible. Whereas, unfertilized eggs are opaque or whitish in nature and disintegrated nucleus is observed.

Incubation of eggs

The fertilized eggs are kept in incubation pool for hatching into a young one called spawn. The eggs are kept in continuously in motion by water current. The movement of water is based on the hatchery system. In circular hatchery water is in circular motion. Water sprinkle and aeration can be provided for better survivability of spawn. The eggs hatch out in 16-24 hours in IMCs. The average length of spawn is 4-5 mm. Initially the spawn is transparent, non-pigmented and contain yolk sac on the ventral side of trunk. Just after hatching the spawn remains in the bottom and feed on the yolk for energy. After 12 hours vertical movement occur and slowly fins, stomach, mouth, intestine and other vital organs develop. The spawn will remain in the incubation pool for 72 hours. After the absorption of yolk sac, the spawns are ready to feed on natural food like zooplanktons and micro algae. Therefore, the spawns need to be transferred to the nursery pond.

Fig. 4.12: Collection of fish spawn from hatchery and fingerling from nursery pond

Induced breeding of fish has revolutionized the aquaculture industry around the Globe including India. With the invention of pituitary gland-based breeding known as Hypophysation the production of fish seed have increased. But there were certain drawbacks with use of pituitary gland. Some of the problem faced by the hatchery owners were like-

a. Pituitary gland from a mature fish was not available in good quantity in time.
b. The crude pituitary preparation of was time consuming and labour intensive.
c. Two dose of pituitary extract was necessary for breeding of fish.
d. The potency of pituitary extract is variable and also have short storage life.
e. Species specific pituitary gland may be required for breeding of certain fish.

Different inducing agent for fish breeding

Due to the various drawback of pituitary extract, other synthetic hormone based inducing agents were prepared. These hormones are easy to use and could be preserved as well. The hormones are categorized into-

1. Gonadotropins
2. Gonadotropin releasing hormones (GnRH) or Lutenizing hormone releasing hormone and their analogues
3. Steroids
4. Drugs

1. Gonadotropins

These are hormones secreted by pituitary gland. In fish there are two gonadotropins namely GTH I and GTH II. GTH I which resemble follicle stimulating hormone (FSH) in higher animals helps in follicle development and vitellogenesis in fishes. Whereas GTH II resemble luteinizing hormone (LH) in higher animals is involved in ovulation and spawning in fishes. Some of the gonadotropins used for fish breeding are- Mammalian luteinizing hormone (LH), Human chorionic gonadotropins (HCG) and Pregnant mare serum gonadotropins (PMSG)

Luteinizing Hormone is not a cost effective for breeding of fish. Though breeding is successful LH is rarely used for aquaculture purpose.

Human chorionic gonadotropins are similar to LH molecule, which stimulate gonads and helps in spawning. The HCG comes with various brand like Prolan, Antuitrin-s, APL etc. The effective dose for breeding is 100-2000 IU/Kg BW fish. Synahorin is a mixture of HCG and mammalian hypophysial extract is also one of the commercial products based on LH.

Pregnant mare serum gonadotropins are secreted in the uterus of a pregnant mare. The effective dose for breeding catfish Singhi was 500 IU.

Pubergen is a commercial product also used for breeding which comprise of FSH and LH. The effective dose is 50-200 IU/kg BW for female and 20-25 IU/Kg BW for male.

2. Gonadotropin Releasing Hormone/ Luteinising Hormone releasing hormone analogs

GnRH and LHRH is a decapeptide which regulate the secretion of gonadotropins (GtH) from the pituitary gland. Almost four GnRH molecule were synthesized from fishes. The analogues of this hormone was synthesized by substituting some of the amino acid of the decapeptide. The substitution of amino acid makes the peptide more potent by increasing the affinity of the molecule. It prevents from enzymatic degradation by serum and prolong the activity. The GnRH stimulate the release of GTH II which helps in spawning. Dopamine is an inhibitor of of gonadotropins. Various dopamine antagonist have been used along with Salmon GnRH to induce spawning. Some of the product based on GnRHa with different dopamine antagonist are as follows-

3. **Ovaprim**
   It is a combination of GnRHa of salmon and domperidone as dopamine antagonist. It was manufactured by Syndel Laboratory, Canada and marketed by Agri Vet farma of Glaxo India, Mumbai. Now the product is not available in the market but it has shown increase in fecundity of fish.
4. **Ovatide**
   It is made of GnRH analogue with dopamine antagonist called pimozide. It is widely used for breeding of carps and catfish. It is marketed by Hemmopharma, Mumbai.
5. **Ovapel**
   It is developed by University of Godollo, Hungary. It is made of mammalian GnRHa and dopamine receptor antagonist Metaclopramide. The recommended dose for fish is 1-2 pellet/ Kg BW of fish. It can be dissolved in water and injected into the fish body.
6. **Wova-FH**
   The product is marketed by Biostat Agriscience, Mumbai which is also GnRHa based inducing agent. It is found very much effective in breeding of carp. The dose recommended is 0.5 ml/Kg BW of fish.
7. **Steroid hormones**
   Steroid hormones like Cortico steroids and progestins have been used to breed fish. The hormones includes 11-deoxycortico sterone acetate (DOCA) and 17a-hydroxy-20b-dihydro progesterone. The effective was found at 1-5 mg for DOCA. Other steroid hormone like cortisol and cortisone are also found to have spawning effect at 25 mg per kg fish.
   Progesterone induces final maturation and ovulation when used together with gonadotropins. At present steroids are not used due to it side effect and high cost.
8. **Other drugs**
   Prostaglandin like F2 alpha is used at the rate of 10mg/Kg body weight in induce spawning in fish. This hormone need to be studied more for use in fish breeding.
9. **Antiestrogens**
   These are synthetic compounds that compete with estrogen for binding on estrogen receptors. There is negative feed back of estradiol during final maturation and ovulation. Therefore, antiestrogen lowers the effect of estradiol and increase the secretion of gonadotropins. Some of the compounds are Clomiphene citrate and tamoxifen. In spite of the breeding success by use of these compound, it is not used much in commercial aquaculture.

Practical Exercises

Activity 1

Demonstrate the Identification of Mature Male and Female Fishes

Materials required:
Notebook, pen/pencil, gloves, container with water, fish specimens, etc.

Procedure:

1. Visit a nearby fish farm or hatchery.
2. Select mature fish of a common species.
3. Observe the external body features of the fish.
4. Gently press the belly of the fish to check for milt or eggs.
5. Check if the female fish has a swollen belly.
6. Look for any colour difference.
7. Write down the differences between male and female fish.
8. Talk to the fish farm staff to confirm your observations.

Activity 2

Demonstrate to inject hormones to the brooders.

Materials required:
Syringe, hormone, gloves, disinfectant, container with water, brood fish (male and female), cloth or net for handling, notebook, etc.

Procedure:

1. Select healthy and mature male and female brooders.
2. Weigh each fish to calculate the hormone dose (dose is based on fish weight).
3. Prepare the hormone solution in a clean syringe.
4. Gently hold the fish using a wet cloth or net to avoid injury.

5. Inject the hormone at the base of the pectoral fin or below the dorsal fin.
6. Use the correct injection angle.
7. Keep the injected brooders in brooding tanks simulating the monsoon conditions.
8. Monitor their behaviour for spawning signs.
9. Clean all tools after use and record the details.

Check Your Progress

Fill in the Blank

1. Most fishes sex can be determined by___________.
2. The pectoral fin of male fish has a ______ texture during the breeding season.
3. In Indian Major Carps, brooders mature in ______ years.
4. The ideal pH range for hatchery water is ______.
5. After ______ hours of hormone injection, the mating process in fish begins.
6. ______ is a hormone product that combines GnRHa and domperidone.

Multiple Choice Questions

1. Which of the following is a secondary sexual character in male fish during breeding?
   a. Smooth pectoral fin
   b. Swollen belly
   c. Rough pectoral fin
   d. Pink genital aperture
2. What is the effective dose of Ovatide for female Rohu?
   a. 0.3 ml/kg
   b. 0.4 ml/kg
   c. 0.5 ml/kg
   d. 0.6 ml/kg
3. Which hormone is not commonly used due to side effects and high cost?
   a. GnRHa

b. Dopamine antagonist

c. Gonadotropins

d. Steroids

4. Which injection method is used on the base of pectoral or pelvic fin?

a. Intramuscular

b. Intracranial

c. Intra peritoneal

d. Subcutaneous

5. What is the function of FSH in fish reproduction?

a. Ovulation

b. Vitellogenesis

c. Egg hardening

d. Spawning

6. Which of the following is NOT a commonly used inducing agent?

a. Ovatide

b. Wova-FH

c. Synahorin

d. Ammonia

7. The size of swollen carp eggs after fertilization is:

a. 0.5 mm

b. 1-1.5 mm

c. 2-3 mm

d. 3-5 mm

8. What should be the female to male ratio in hatchery breeding?

a. 1:1

b. 1:3

c. 2:1

d. 1:2

Match the Following

Column A	Column B
A. Ovaprim	1. GnRHa based, marketed by Biostat Agriscience
B. Ovatide	2. GnRHa + Metaclopramide
C. Ovapel	3. GnRHa + Pimozide
D. Wova-FH	4. GnRHa + Domperidone

Subjective Question

1. Describe the importance of induced breeding in increasing fish production.
2. What are the differences between various commercial fish breeding hormones used in India?

Glossary

Ancillary Activities: Supportive operations related to the main activity of fisheries or aquaculture, such as boat building, net making, ice production, transportation, and packaging.

Biodiversity: The variety and variability of life forms, including different species of plants, animals, and microorganisms, in a particular ecosystem or on Earth.

Brood bank: A dedicated facility where mature, high-quality broodstock (parent fish) are maintained and managed for breeding purposes.

Broodstock: Sexually mature fish used for breeding purposes to produce offspring (eggs and sperm).

Conditioning (of fish): A process of acclimating fish to stress (e.g., transport) by fasting them and ensuring optimal water quality to reduce mortality.

Continental Shelf: The extended perimeter of each continent, submerged under shallow seas, which provides important fishing grounds.

Demersal Fishes: Fish species that live and feed near the bottom of seas or lakes (e.g., groupers, catfish).

Disinfection (in hatchery context): The process of cleaning and treating hatchery equipment and water to prevent the spread of disease.

Dykes: Raised barriers or embankments built around ponds or water bodies, often used in aquaculture for water management and land protection.

Ecosystem: A biological community of interacting organisms and their physical environment.

Exclusive Economic Zone (EEZ): A sea zone prescribed by the United Nations Convention on the Law of the Sea, extending up to 200 nautical miles from a country's coast, where the country has exclusive rights for fishing and resource extraction.

Fertilization (in aquaculture): The addition of nutrients to water bodies to enhance the natural productivity and increase food availability for fish.

Fingerling: A juvenile fish that has developed beyond the fry stage, typically 2.5 to 15 cm in length and ready to be stocked into grow-out systems.

Fry: The stage in fish development after hatching, when the young fish are still small and developing but begin to feed on their own.

GVA (Gross Value Added): A measure of economic output that indicates the contribution of a sector (like agriculture or fisheries) to the overall economy.

Integrated Farming: An approach where different types of farming (crop, livestock, aquaculture, etc.) are practiced together to improve efficiency, productivity, and sustainability.

Livelihood: The means by which a person earns a living, including employment or self-employment like fishing or farming.

Molluscs: Soft-bodied invertebrates, often with a shell, such as mussels, oysters, and clams.

Nutritional Requirement: The essential nutrients needed by humans for healthy living, such as proteins, vitamins, and minerals.

Omega-3 Fatty Acids: Essential polyunsaturated fats found in fish oil that are beneficial for heart and brain health.

Pelagic Fishes: Fish that live in the water column away from the bottom, typically in the open ocean (e.g., sardines, mackerel, tuna).

Salinity: The amount of dissolved salts in water, usually measured in parts per thousand (ppt). It defines whether water is freshwater, brackish, or marine.

Spawn: Fish eggs or the process of releasing eggs and sperm in aquatic animals for reproduction.

Specific Pathogen Free (SPF): Refers to animals, particularly aquaculture stock, that are certified free from particular pathogens of concern, improving survival and health.

Stocking Density: The number of fish or aquatic animals kept in a given area or volume of water, indicating intensity of aquaculture.

Sustainability: The practice of using natural resources in a way that they are not depleted, ensuring long-term environmental health and productivity.

Superfood: A nutrient-rich food considered especially beneficial for health and well-being; fish is often referred to as one due to its high-quality protein and healthy fats.

Trophic Levels: The hierarchical levels in an ecosystem based on how organisms obtain energy (e.g., producers, herbivores, carnivores). In aquaculture, this refers to species with different feeding roles.

Answer Keys

Unit 1- Session 1

Fill in the Blank

1. Fisheries
2. Natural
3. Controlled
4. 9
5. Mrigal

Multiple Choice Questions

1-c, 2-b, 3-b, 4-d, 5-b, 6-c, 7-c, 8-a

Match the Following

1 → a, 2 → b, 3 → c, 4 → d, 5 → e

Unit 1- Session 2

Fill in the Blank

1. Digital
2. 2018-19
3. 7
4. National Fisheries Development Board (NFDB)

Multiple Choice

1-b, 2-d, 3-a, 4-c, 5-b, 6-d

Unit 2- Session 1

Fill in the Blank

1. Clay loam
2. 6.5, 9.0
3. 3:1
4. 30
5. acidity

Multiple Choice Questions

1–b, 2-b, 3-c, 4-d, 5-a

Match the Following

1-c,2-d,3-a,4-b

Unit 3- Session 1

Fill in the Blank

1. sand, silt, clay
2. clay
3. 50–75
4. non-saline
5. Single super phosphate (SSP)

Multiple Choice Questions

1-b, 2-c, 3-b, 4-a, 5-d, 6-b

Match the Following

A -2, B -3, C -1, D -4

Unit 3- Session 2

Fill in the Blank

1. 1.5–2
2. 10
3. plankton
4. highly productive
5. 6.5
6. atmospheric diffusion

Multiple Choice Questions

1-b, 2-c, 3-c, 4-a, 5-b, 6-c, 7-d, 8-c

Match the Following

A – 2, B – 1, C – 3, D – 4

Unit 4- Session 1

Fill in the Blank

1. 2500
2. circular ponds
3. Dr. Hiralal Chaudhuri
4. Hypophysation
5. salmon

Multiple Choice Questions

1-a, 2-c, 3-b, 4-c, 5-c, 6-d

Match the Following

1 – c, 2 – d, 3 – a, 4 – b

Unit 4- Session 2

Fill in the Blank

1. Sexual Dimorphism
2. Rough
3. 2 to 3
4. 7.5 to 8.5
5. 6 to 8
6. Ovaprim

Multiple Choice Questions

1-c, 2-b, 3-d, 4-c, 5-b, 6-d, 7-b, 8-d

Match the Following

A-1, B-3, C-2, D-4

Further Reading

- Handbook of Fisheries and Aquaculture – Indian Council of Agricultural Research (ICAR)
- Broodstock Management and Quality Fish Seed Production in Freshwater Fishes- K. Karal Marx, J.K. Sundaray, A Rathipriya, M. Muthuabishzag, Narendra Publishing House.
- Textbook of Fish Biology and Fisheries – S. S. Khanna, H. R. Singh, Narendra Publishing House
- A Textbook of Fishery Science and Indian Fisheries – Dr. C. B. L. Srivastava

List of Credits

DAAH, PSSCIVE, Bhopal

Fig. 1.6
Figure 1.7
Fig: 2.1
Fig. 3.1
Fig. 4.1
Fig. 4.2
Fig. 4.8

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Fig.1.1
Figure 2.2
Figure 1.3
Figure 1.4
Figure 1.5
Fig 1.8
Fig 1.9
Fig 1.10
Fig 1.11
Fig 1.12
Fig 1.13
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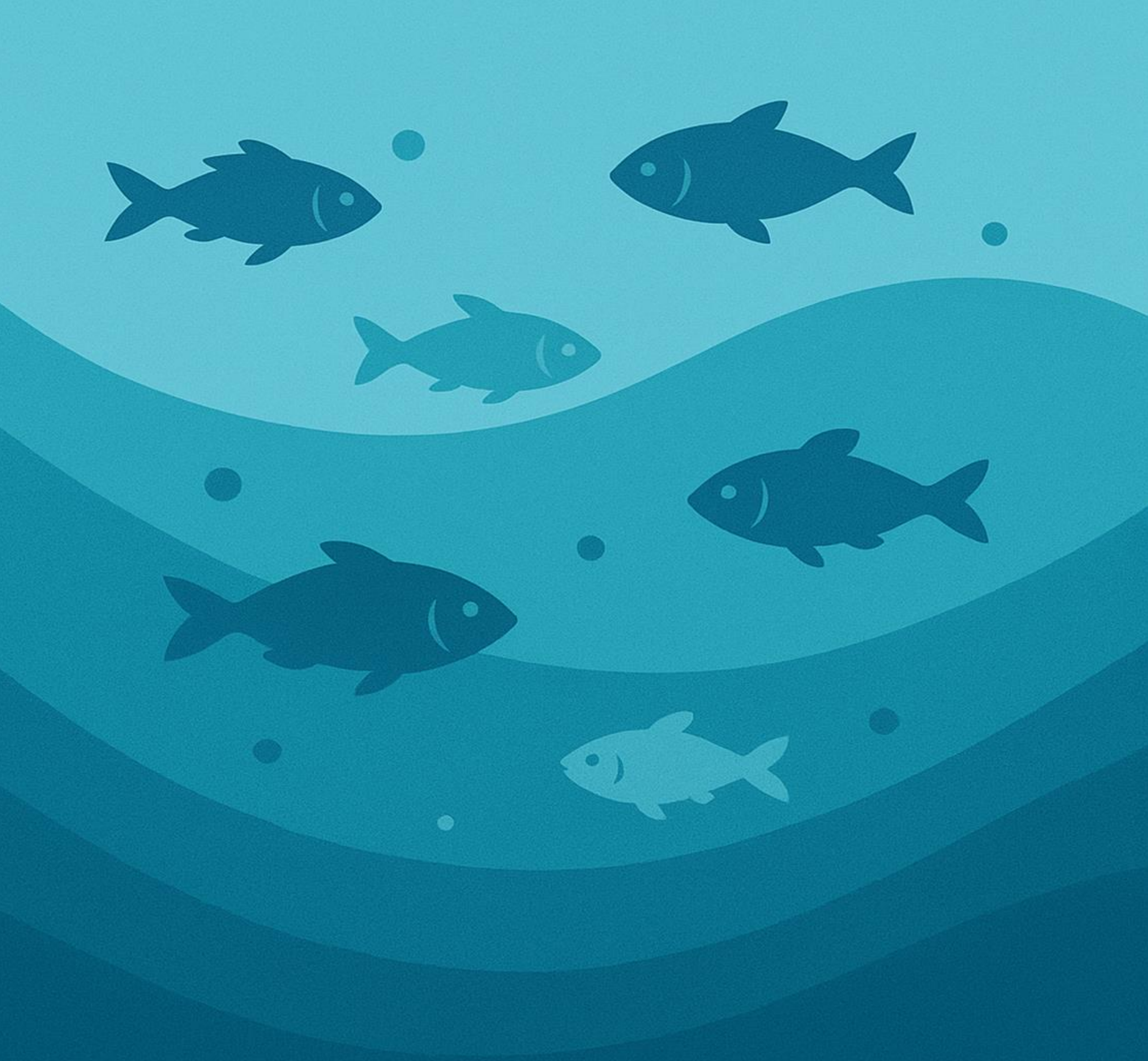
Fig 1.40
Fig 1.41
Fig 1.42

Dr. Dhalongsaih Reang, ICAR-CIFE, Powerkheda

Fig. 4.3
Fig. 4.4
Fig. 4.5
Fig. 4.6
Fig. 4.7
Fig. 4.9
Fig. 4.10
Fig. 4.11
Fig. 4.12



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