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मत्स्यपालन, पशुपालन और डेयरी मंत्रालय
MINISTRY OF FISHERIES, ANIMAL HUSBANDRY AND DAIRYING

GROW MORE FISH
DEPT. OF FISHERIES ASSAM

Sustainable Aquaculture for Food and Livelihood
SAFAL

Training Manual for Trainers

(Grow out ponds)

Sustainable Aquaculture

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Sustainable Aquaculture for Food and Livelihood (SAFAL)
Sarbeswar Bhawan, 1st by Ln, Jaya Nagar, Guwahati, Assam, 781022, India
E: info@giz.de
I: www.giz.de/india

Responsible
Pratap Sinha, Project Leader, SAFAL, GIZ India
Email: pratap.sinha@giz.de

Author
Umakanth R., Independent Consultant (Aquaculture)

Co-authors
Dr. Jens Kahle, Advisor, Global Program Sustainable Fisheries and Aquaculture, GIZ
Dr. Jeherul Islam, Fisheries and Aquaculture Advisor, SAFAL, GIZ India
Sandeep Nayak, Junior Advisor for Fisheries and Aquaculture, SAFAL, GIZ India

Editors
Dr. Bhagaban Kalita, Marketing Officer, Fisheries, Guwahati
Apurba Kumar Das, Joint Director of Fisheries (FFDA), Nodal Officer (RKVY and RIDF) and Lecturer, RFTI, Amranga
Krishna Kanta Kalita, DFDO and Superintendent of Fisheries, TCPC, Guwahati
Dr. Dhruba Jyoti Sarma, Managing Director, FISHFED, DoF, Assam, Nodal Officer, OPIU, DoF, Assam and AFIO
R. C. Roul, Addl. Fisheries Officer, DoF, Government of Odisha
Dr. Ambika Prasad Nayak, Scientist (FY. Sc.), KVK Puri
Dr. A. K. Das, Principle Scientist and In-Charge, Training & extension unit, ICAR-CIFRI

Content Review
Department of Fisheries (DoF), Assam; Department of Fisheries (DoF), Odisha; Indian Council of Agricultural Research- Krishi Vigyan Kendra (ICAR-KVK), Puri; Indian Council of Agricultural Research - Central Inland Fisheries Research Institute (ICAR-CIFRI), West Bengal; APART (Fisheries), Government of Assam; Pratap Sinha, Project Leader, SAFAL, GIZ India; Dr. B. K Baliarsingh, Technical Advisor, SAFAL, GIZ India; Imran Syed, Junior Monitoring and Evaluation Specialist, SAFAL, GIZ India; Nijira Basumatary, Project Assistant, SAFAL, GIZ India; Dharamananda Bhoi, Project Assistant, SAFAL, GIZ India; Kimberly Sarlette, Intern, GIZ; Priyam Kakoti Bora, Communications Consultant; Kalong-Kapili; Seven Sisters Development Assistance (SeSTA); Innovative Change Collaborative Services Private Limited (ICCSPL); Gram Utthan (GU); Darbar Sahitya Sansada (DSS); College of Fisheries, Assam Agricultural University, Raha; Hushframe Ideas Pvt Ltd, Kolkata, Farmers.

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We are committed to creating a welcoming and inclusive environment for all users of this Training Manual for Trainers. We believe that this knowledge product would go a long way in helping the pond-based fish farmers in their effort to practise sustainable aquaculture in an environment-friendly and profitable manner. The knowledge products would also be helpful to academicians and researchers in understanding the problems of pond-based fish farmers and designing practical solutions. In conclusion, the efforts could allow fish farmers to optimise their practice of sustainable aquaculture for generations to come.

Pratap Sinha

Project Leader, SAFAL, GIZ India

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Module 1:
1.0 Introduction

The aquaculture, an allied agricultural activity is considered as a major sector in boosting social and economic development in terms of providing employment and livelihood in addition to food and nutritional security. Fish is an important nutritious and health food item. Fresh water aquaculture, is an integral part of farming activities in Eastern and North eastern states.

Fresh water aquaculture in India is dominated by carp species contributing over **85 %** of the total aquaculture production and hence focus is on carp aquaculture. Carps feed at the primary and secondary level in the food web and are efficient utilizers of plankton to meet their major protein and other requirements from natural food and require minimum additional supplementation to meet energy requirement. The preference to carps specially Indian Major Carps (IMC) and other carps is also attributed to availability of seed, availability of technology, know how on carp farming and most importantly consumer preference and steady demand for carps in the market. Aquaculture has to be a sustainable activity to face the challenges in the present and future. Sustainable aquaculture focuses on environmental, economic and social sustainability to improve capacity building and effective utilization of available land for aquaculture purpose.

Farming practices should be eco-friendly and not impose any serious threat to environment, biodiversity and ecosystem to make it environmentally sustainable. The aquaculture practices should result in long term sustained production resulting in a profitable activity to make it and to bring in economic sustainability and also contribute to the welfare of the society Aquaculture, to be a sustainable activity needs to be supported by technically sound and adaptable package of practices.

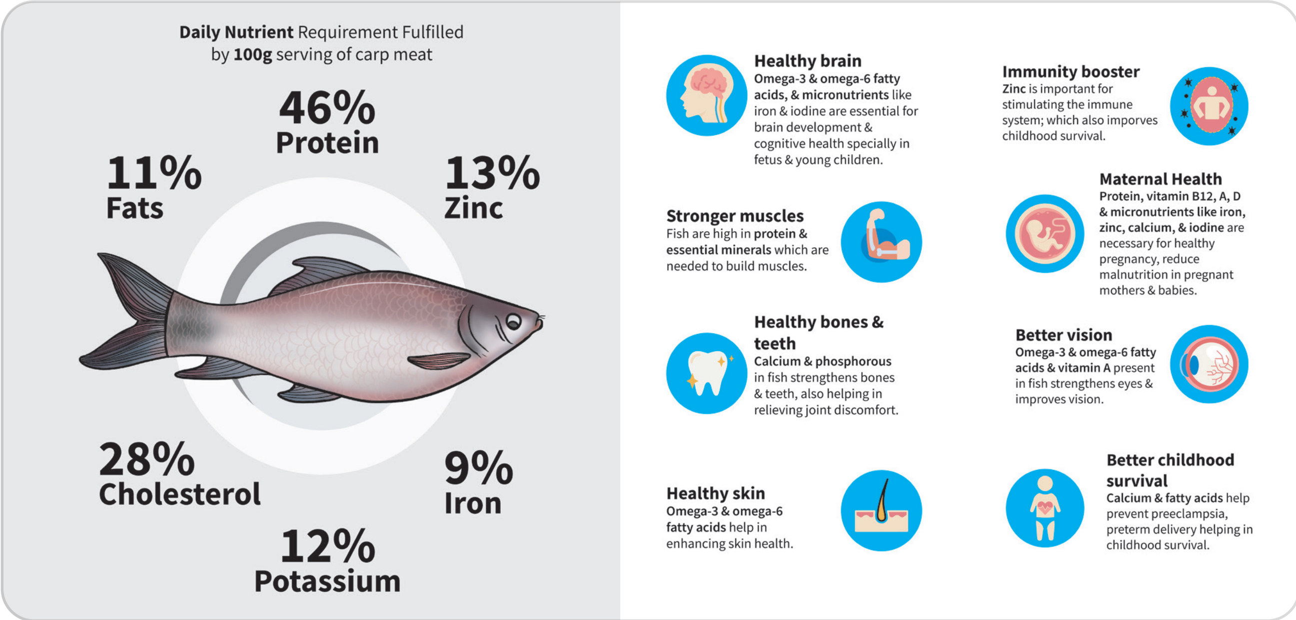
In this manner basic concepts include:
Pond site should be located in a suitable place and fish pond constructed in a more user friendly way for ease of operation and management. Use of fish species which are fast growing, efficiently converting natural fish food available in the pond into fish flesh in a reasonably short time .

Furthermore, they should be, compatible to each other and do not compete for food and space so that they can be grown together for rational and efficient utilization of available food and space in the pond. Also, they should have the ability to tolerate a wide range of environmental changes likely to happen.
Use of organic manures (Biological waste of animals) in appropriate quantity and no or minimal use of chemical fertilizers.
Use of supplementary feed made out of locally available feed ingredients (farm made feed) to make it chemical free product and also reduce the feeding costs.

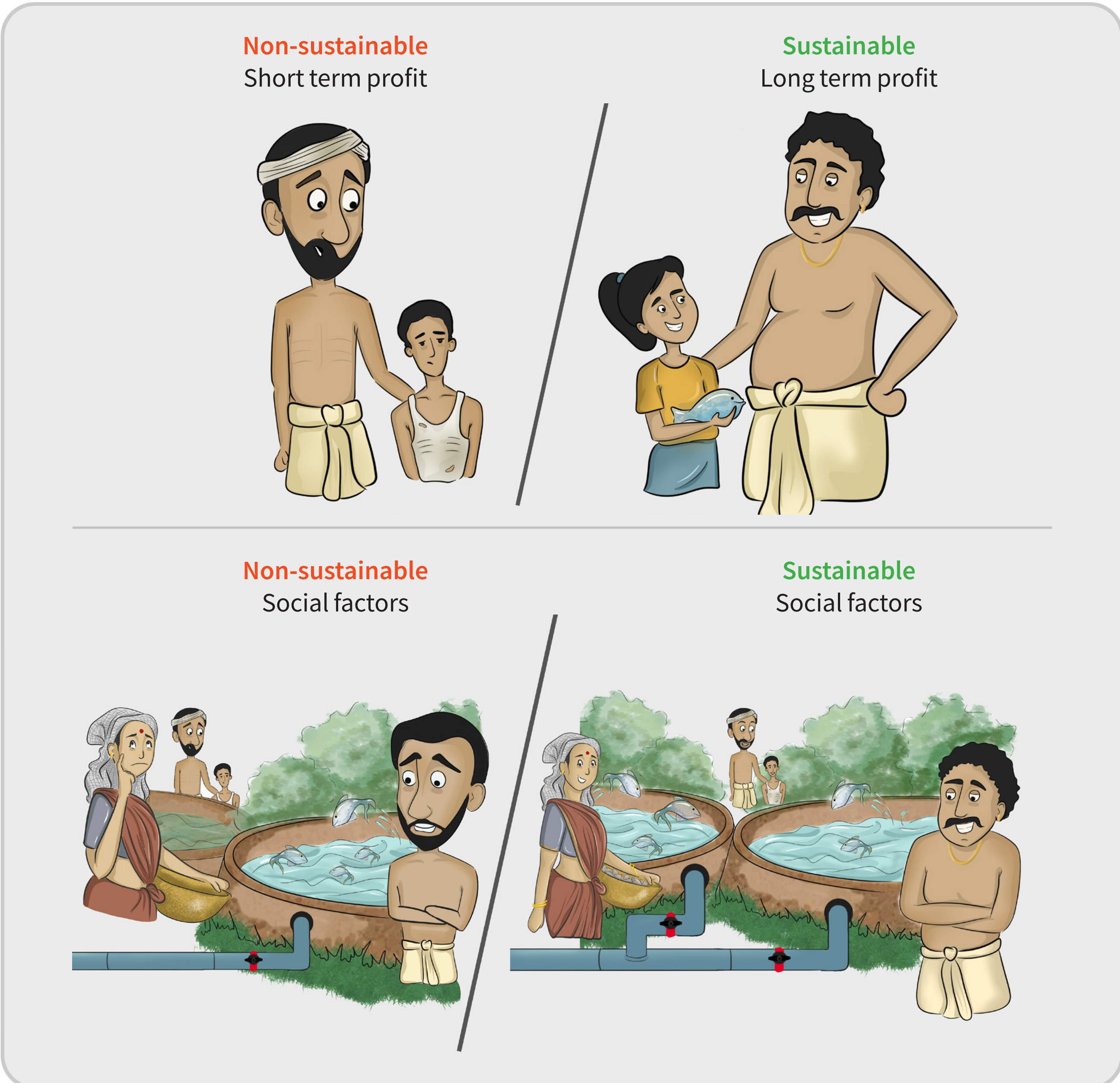
Good Management Practices(GMP) in post stocking management practices (water quality, feeding practices and fish health management) to have a sustained aquaculture production.
Reduce the cost of production to increase profitability in a sustained manner by following SOPs in reality and avoiding excess use of inputs.

This hand book is prepared keeping in mind the aquafarmers as the main target groups to use this hand book and hence the contents are focused primarily on what farmers have to know to decide what needs to be done to make their aquaculture business sustainable. The hand book also contains relevant illustrations and few frequently asked questions (FAQs) **that farmers might ask and these are also provided at the end of each task /chapter.**

The term 'Farmer/Aquaculture Service Provider (ASP)/Community Resource Person (CRP)' in this book describes all individuals involved in the aquaculture value chain, regardless of their gender identity.



Benefits of aquaculture: Fish nutrition & health benefits



Benefits of aquaculture: Sustainability & additional income

Risk Factors:

1. Defective pond site location:

If selected pond site is not suitable for aquaculture operations (Ref: Chapter 2.1.1. Site selection), construction cost, pumping cost, manuring cost and other operational costs are going to influence the final economic viability of the project. So, ideal site selection for pond construction is the most important factor to initiate the aquaculture operation.

2. Undependable source of quality water:

Water is the primary requisite to commence aquaculture operation. If the source of water is unreliable or the water availability of the selected source is inconsistent, entire aquaculture operation is going to be affected. So, careful selection of water source is another important factor of ideal pond construction site identification. (Ref: Chapter 2.1.1. Site selection).

3. Aged ponds:

Use of same pond more than 5 years continuously (without preparation between the production cycles) without gap and not cleaning the pond bottom may lead to increased incidence of diseases. The infectious disease incidence was 43% in farms of above 5 years of age as against 15% in farms less than 5 years age.

4. High intensive practices:

Farmer who wants to adapt high intensive fish farming needs to make sure that the infrastructure and resources should be ample to support the selected mode of fish farming operation. If not, it will affect the survival, growth, health and finally the profitability of the venture.

5. Lack of knowhow of technologies:

This risk factor is going to create havoc in the entire fish farming operation, having the basic knowledge about aquaculture operational methodology and minimal farm management skills are very much essential. Absolute objective of this knowledge material is to provide required knowledge to the end user.

FAQs:

Why should I grow fish?
What are the benefits of aquaculture?
How do I make an aquaculture system sustainable?
Are there any negative impacts of aquaculture on the environment?

Module 2: Pre-Stocking

Topics:

2.0– Pre-stocking
2.1– Construction of new pond
2.1.1– Site selection
2.1.2– Pond construction
2.1.3– Pond preparation & existing pond renovation
2.1.3.1– Ponds that can be drainable
2.1.3.2– Ponds that are not drainable
2.1.3.3– De-watering
2.1.3.4– Cleaning and repairing
2.1.3.5– Arrange Pond surrounding
2.2– Liming and Manuring
2.2.1– Liming
2.2.1.2– Types of lime
2.2.1.3– Usage and the quantity (Dosage)
2.2.1.4– Water filling
2.3– Manuring
2.3.1– Manuring for newly constructed pond or that can be completely drained
2.3.1.1– Types of fertilizers, Dosage and mode of application
2.3.1.1.1– Conventional method
2.3.1.1.2– Improved manuring technique
2.3.2– Manuring pond that cannot be completely drained
2.3.2.1– Type of herbal products, dosage, and toxicity period
2.4- Pre-Stocking Economics

Risk Factors
FAQs

2.0 Pre-Stocking:

Pre-stocking operations involves crucial steps that influences the success, profitability, and sustainability of your entire aquaculture operation. Strategic approach towards execution of this Pre – stocking operations will lead to a positive outcome by the end of your farming cycle. Pre-stocking operations involves following key phases, proper site selection approach, methods to develop and design a good cost optimized pond construction plan, proper execution of the construction plan, how to prepare the pond well for water culture and development of good planktonic density in the pond, methods to optimize the water pumping cost and predator eradication cost by implementing ideal water pumping principles and methods.

2.1 Construction of New Pond:

Building a new aquaculture pond consists of numerous influencing factors which needs to be understood and well planned before venturing into sustainable aquaculture operation. These factors are directly related to the productivity, profitability, and sustainability of your aquaculture operation. Core aspects involved in building a new aquaculture pond are listed and explained in detail below.

2.1.1 Site Selection:

Selection of appropriate culture site with ideal soil quality with ample water source will lead to a sustainable and financially viable aquaculture operation. But soil quality varies from place to place, so we need to know which soil quality suits the best for a sustainable and profitable aquaculture operation. The most important function of the pond soil is to hold the water, should be a stronger building material to build the pond dike. So, it is very much essential to understand the soil types, their compositions, textures, water retention efficiencies, and productivity efficiencies.

Criteria for selection of site suitable for pond construction:

• Land, less suitable for other agricultural activity can be used for constructing a fish pond.

• Use land with gentle slope for constructing the fish pond to make it easy to empty enabling easy netting and fish harvest and drain out the water.

• Do not use the land in a very low lying area, which is close to a river as it is likely to be flooded during rainy season and may dry up during winter/summer season.

• A steep hill is not suitable for building a pond as access to water may be difficult, more seepage and construction cost may also increase.

Types of Soil their pros and cons: For aquaculture purposes the soils can be classified into three major types:

A) Pervious soils: *(Sandy soils and mixed gravel & sand soils)* These soils have very little water retention capability, so the water pumping cost is very high in these types of soils.

B) Impervious soils: *(Silty soils, clay soils, mixture of both and mixture of both with a small percentage of sand and/or gravel.)* These soils have good water holding capabilities and are best suited for aquaculture operations.

C) Peaty soils: Soils with high organic soil might lead to high seepage and unstable dikes.

Most of the times the soil condition may be a mixture of pervious and impervious soils, then the selection will be based on permeability. So, permeability of the soil can be determined by the texture of the soil, soil texture reveals the relative content of different types of soil particles such as sand, silt and clay in the soil.

Following tables shows you the details of different types of soils and their textural class based on the relative composition of sand, silt, and clay in them. Types of soils and their textural classification:

Common names of soils *(General texture)*	**Sand %**	**Silt %**	**Clay %**	**Textural class**
Sandy soils *(Coarse texture)*	86-100	0-14	0-10	Sand
	70-86	0-30	0-15	Loamy Sand
Loamy soils *(Moderately coarse texture)*	50-70	0-50	0-20	Sandy Loam
Loamy soils *(Medium texture)*	23-52	28-50	7-27	Loam
	20-50	74-88	0-27	Silty Loam
	0-20	88-100	0-12	Silt
Loamy soils *(Moderately fine texture)*	20-45	15-52	27-40	Clay Loam
	45-80	0-28	20-35	Sandy Clay Loam
	0-20	40-73	27-40	Silty Clay Loam
Clayey soils *(Fine texture)*	45-65	0-20	35-55	Sandy Clay
	0-20	40-60	40-60	Silty Clay
	0-45	0-40	40-100	Clay

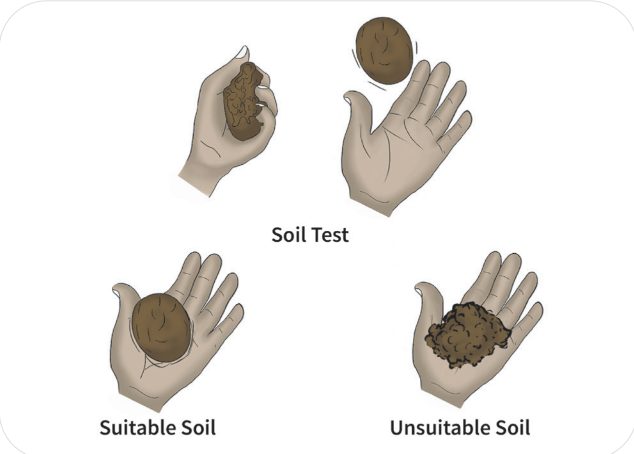
Table 1: Types of soils and their textural classification (*Based on the USDA particle-size classification)

How to Test Soil Texture to Determine the Soil Class:

To identify the Soil texture, fine earth sample needs to be collected from the pond, fine earth sample pertains to a soil sample with less than 2mm particle size. Collect multiple dry soil samples from the pond, ideally from a depth of 1 foot, mix them well, pass the sample through 2mm sieve, collect the fine earth sample.

Throw Ball Test:

Add sufficient water to the collected fine earth sample so that it can be rolled as a firm ball, throw the soil ball upwards for about 1.5 feet high and catch it back. If the soil ball shatters it is a poor soil with more sand component in it. If the soil ball is intact after you catch it back, it is probably good soil with sufficient clay particles in it.



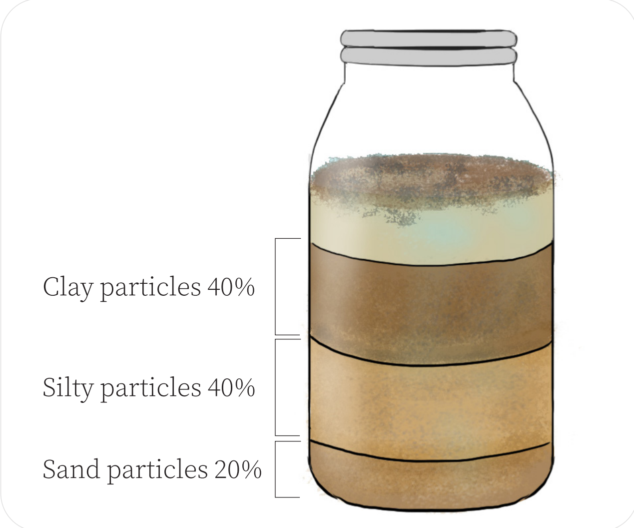
How to test soil texture (Throw ball test, Squeeze test)

Squeeze Test:

Add sufficient water to the collected fine earth sample, squeeze the sample hard, if the soil sample retains the shape of your hand, there is sufficient clay particle in the sample, if the soil sample shatters, it means that the sample contains more sand particles in it.

How to Check Proximate Composition of Different Soil Particles in the Soil Sample:

Take a measuring jar, add collected fine earth sample up to 10 cm level, fill it with water, stir the soil sample as well as the water well, keep it untouched for about an hour. After one hour you can observe that the soil particles have



Soil proximate composition check

settled, and water will be clear. Soil particle will settle in the jar based on their bulk density, Sandy soil particles settles at the bottom first due to its high bulk density (1.6 g/cc), silty soil particles, due to their lower bulk density (1.3 g/cc) than sandy soil, they settle next on top of sandy soil particles. Clay soil particles are with lower bulk density (1.1g/cc) than the other two type of soil particles so they settle on top of silty particles.

Measure of the depth of each particle type gives you an estimate of approximate proportion of each particle type. If sand particles are up to 2 cm level out of the total 10cms level, sand proportion will be 20%, if the silty particles settle up to 6 cm level out of 10 cm level, the silt particle proportion will be 40% and if the clay particle occupy the remaining 4 cms then clay particle proportion will be 40%.

For a sustainable Aquaculture operation soil types like silt and/or clay soils which can hold water well are best suited. Texture classification based on bulk density:

Textural class	Bulk density (g/cc)
Sandy soil	1.6
Loam	1.4
Silt loam	1.3
Clay	1.1

Table 2: Texture classification based on bulk density

Fish Farming Site Suitability Assessment

Key Steps:

1. Plan the entire process well in advance.
2. Take expert advice before action.
3.Site selection process & Sequential order should be as follows:

- Soil quality & suitability assessment
- Water source quality & proximity
- Drainage facility
- Road axis
- Proximity to power source
- Proximity to market

4. Prioritization of site based on soil type

- Silty
- Clay
- mixture of Silt and clay
- mixture of Silt and clay with little sand and/or gravel

5. Prioritization based on source of water

- Perennial River
- Perennial Creek
- Irrigation Canal
- Reservoir or dam
- Borewell
- Irrigation Drain

6. Drainage facility

- Pond bottom level should be above the drainage top level
- Should be in proximity

7. Power source

- Should be in the proximity
- 24X7 supply lines are preferable
- Standby power generator (*Based on intensity of culture operation)

8. Proximity to market – The closer the better

Water Source:

Another crucial factor in the process of site selection is identification of ideal source of water. This factor is very much crucial in the entire culture process. For fish farming operation perennial source of surface water is very much ideal, provided if it not polluted. The next priority goes to ground water, but it should be assessed for quality parameter assessment and suitability before finalising it as the major source of water for the culture operation. The last priority goes to irrigation drains.

Quality of water should be investigated by taking a number of water samples from the proposed water source for laboratory analyses of physical, chemical, biological and micro-biological properties, including health hazards.

From a production point of view, emphasis should be placed on the following parameter assessment:

(i) physical properties - temperature, colour, odour, turbidity, transparency, suspended solids.

(ii) chemical properties - pH, dissolved oxygen, biochemical oxygen demand, free carbon dioxide, alkalinity, salinity, dissolved solids, ammonia, all as regards both useful and toxic qualifies; also, whether pollutants of agricultural or industrial origin are present, and if so, to what extent.

(iii) biological properties - quality and density of plankton.

(iv) micro-biological properties - species and quantity of parasites.

Pro & Cons of Different Water Sources:

Water Source Type	Advantages	Disadvantages
Perennial River *(Water should be available throughout the year)*	**1.** Suitable water source **2.** Less pumping cost **3.** Can pump large volumes of water in less time **4.** Can do quick water exchange during emergency situations	**1.** Pollution threat **2.** Weed fish entry **3.** Organic loads during rainy season **4.** Flooding **5.** Bacterial & parasitic infection possibility
Perennial creek *(Water should be available throughout the year)*	**1.** Suitable water source **2.** Less pumping cost **3.** Can pump large volumes of water in less time **4.** Can do quick water exchange during emergency situations	**1.** Pollution threat **2.** Weed fish entry **3.** Organic loads during rainy season **4.** Flooding **5.** Bacterial & parasitic infection possibility
Agriculture canal *(Water should be available minimum during the culture cycle)*	**1.** Suitable water source **2.** Less pumping cost **3.** Can pump large volumes of water in less time **4.** Can do quick water exchange during emergency situations	**1.** Pollution threat **2.** Pesticide contaminations **3.** Bacterial & parasitic infection possibility **4.** Weed fish entry **5.** Organic loads during rainy season
Reservoirs or lakes or dams *(Water should be available minimum during the culture cycle)*	**1.** Suitable water source, **2.** Less pumping cost, **3.** Can pump large volumes of water in less time, **4.** Can do quick water exchange during emergency situations	**1.** Pollution threat **2.** Pesticide contaminations **3.** Bacterial & parasitic infection possibility **4.** Weed fish entry **5.** Organic loads during rainy season
Borewell *(Water should be available throughout the year)*	**1.** Sterile water **2.** No bacterial contaminations	**1.** More manuring and water culture cost **2.** More pumping cost **3.** Takes more time for pumping **4.** Quick water exchange is not possible
Agriculture drains *(Water should be available minimum during the culture cycle)*	**1.** Ample water availability **2.** Can do quick water exchange **3.** Lesser water culture and manuring cost **4.** Lesser pumping cost	**1.** More organic loads **2.** Pollution & pesticide threat **3.** Weed fish entry **4.** Flooding **5.** Bacterial & parasitic infection possibility

Table 3: Pro and cons of different water sources

Ideal Water Quality Standards for Freshwater Aquaculture:

Sr. No	Parameter	Acceptable Range	Desirable range	Stress level
1.	Temperature *(°C)*	15-35	20-30	<12, >35
2.	Transparency/ Visibility *(cm)*		30-80	<12, >80
3.	Water colour	Pale to light green	Light green to light brown	Clear water, Dark green & Dark brown
4.	Dissolved Oxygen *[mg L^{-1}]*	3-5	5	<5
5.	BOD *[mg L^{-1}]*	3-6	1-2	>10
6.	CO_2 *[mg L^{-1}]*	0-10	<5, 5-8	>12
7.	pH	7-9.5	6.5-9	<4, >11
8.	Alkalinity *[mg L^{-1}]*	50-200	25-100	<20, >300
9.	Hardness *[mg L^{-1}]*	>20	75-150	<20, >300

Sr. No	Parameter	Acceptable Range	Desirable range	Stress level
10.	Calcium *[mg L^{-1}]*	4-160	25-100	<10, >250
11.	Ammonia *[mg L^{-1}]*	0 – 0.05	0 – <0.025	>0.3
12.	Nitrite *[mg L^{-1}]*	0.02 – 2	<0.02	>0.2
13.	Nitrate *[mg L^{-1}]*	0 – 100	0.1 – 4.5	>100
14.	Phosphorus *[mg L^{-1}]*	0.03 – 2	0.01 – 3	>3
15.	H_2S *[mg L^{-1}]*	0 – 0.02	0.002	Any detectable level
16.	Primary productivity *[mg Chlorophyll/L/Day]*	1-15	1.6 – 9.14	<1.6, >20.3
17.	Plankton *[No. L^{-1}]*	2000 – 6000	3000 – 4500	<3000, >7000

Table 4: Ideal Water quality standards for freshwater Aquaculture

Drainage Facility:

Drainage facility is as important as soil suitability and water source. Any aquaculture facility without access to proper drainage facility it is going to be risky, expensive, and unsustainable proposition. Access to the drainage will be crucial at times when you need to do quick water exchange to replace deteriorated water from the pond or during emergency harvest situations or during floods. So, having proper access to a drainage is a must for an aquaculture pond.

It is very important to understand few key criteria about proper drainage facility while selecting a site for pond construction.

1. The level of the pond's outlet should always be above the peek water level of the drainage canal.
2. The closer the drainage canal to the pond's outlet the better.
3. Maintain sufficient gradient from your pond's outlet to the drainage canal so that the water discharge can be quick and easy.
4. If your pond's outlet is connected to the major drain through a sub drain canal, make sure that the sub drain canal is wide enough to allow quicker flow of water.

Power Source:

Proximity to Power source is another important factor in the process of ideal site selection. Preferably the power source should be a supply line which can supply power 24X7, if the power line is dedicated for aquaculture or industrial purpose that will be better. If the power line is very close to the proposed site, you can avoid lot of additional expenses for bringing the line up to your pond. Check with the electricity department about the process of availing subsidised power connection for aquaculture purpose because most of the state governments in India are facilitating aquaculture farmers with subsidised power supply. Estimate your power requirement based on your culture system and apply for the approval from the department of electricity accordingly.

2.1.2 Pond Construction:

Surveying is the first step in the selection and initiation of pond construction in the proposed site. Surveying is a science of measuring the Earth and its features, and of making maps and charts to show them. The type, number, and shape of the ponds to build depend on the topographical profile of a site.

To choose a good site for a fishpond, there is a need to measure several things, including:

1. The area of land available.
2. The slope of the land.
3. The elevation (height) of the land in relation to the source of water that will be used.
4. The distance between the source of water and the location of the ponds.
5. The best way to supply water to the ponds.
6. The easiest way of draining the ponds.

After selection of ideal site, a systematic approach towards building a pond is going to be the next crucial step in establishing an ideal fish farm with sustainability perspective. Before starting the demarcation of a pond, it is imperative to make a plan on paper, detailing the following:

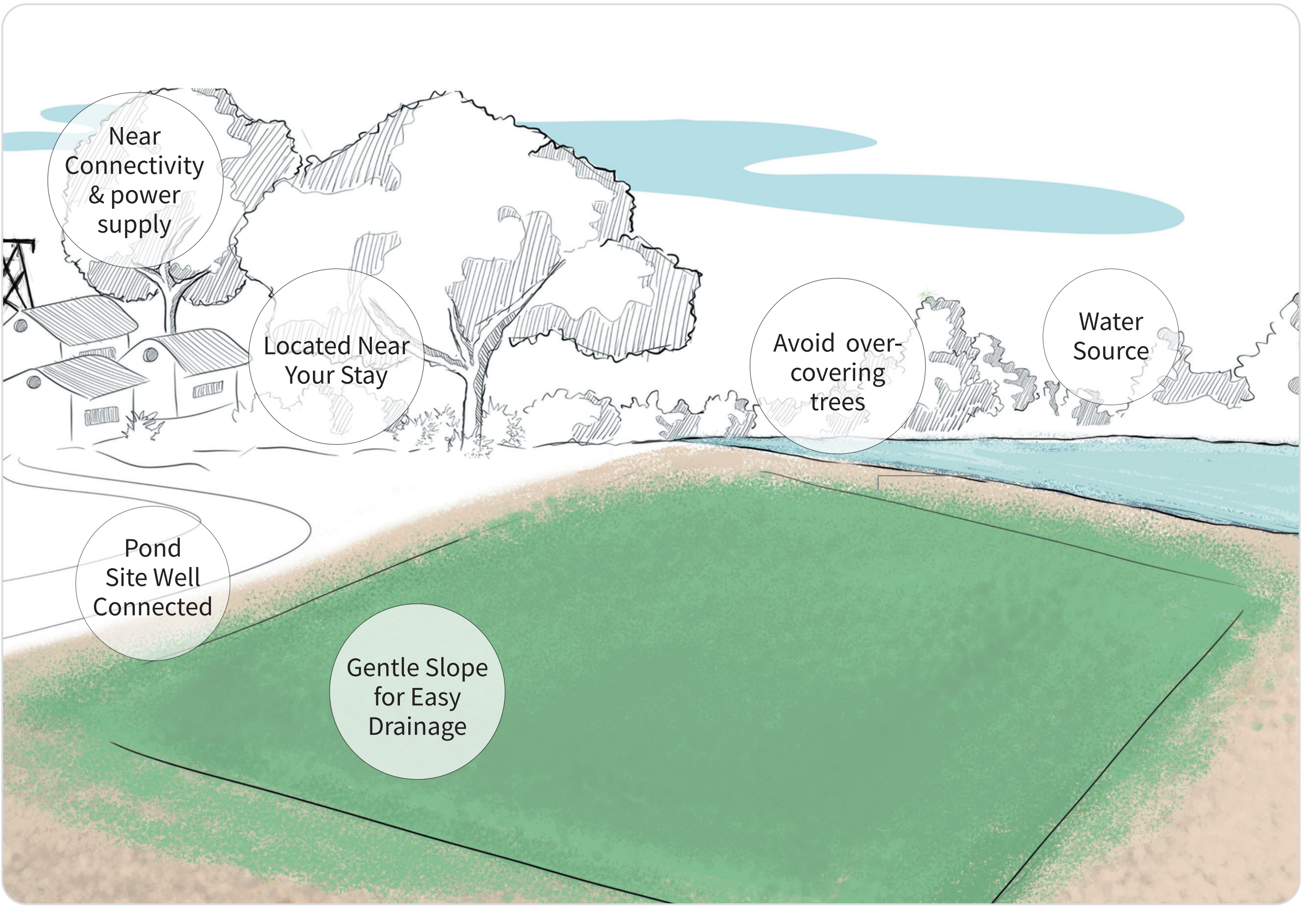
Physical Planning:

Deciding the layout and providing a detailed design and construction.
During the process of designing ponds layout, decisions on the following should be made:

1. Total area of the pond water surface (this is the actual pond size).
2. The length and the width of the pond water surface.
3. The water depth and the total pond depth at the deep end.
4. The slope of the dykes and the pond bottom
5. The size of the free board (height of dyke above water level)
6. The width of dykes

Administrative Planning:

Defining materials for construction, and how, where, and in which order the farm will be built.



Ideal Pond Site with all Infrastructure Needs & Resources. (An ideal pond site with nearby water source, power source, road axis, drainage etc)

Design & Construction of Ponds, Which Includes the Pond Size, Depth, & Shape:

A pond could have a surface area of between 1000 m^2 and 2000 m^2 (and no less than 300 m^2). In general, pond dimensions should not allow for a total production exceeding 100 tonnes per pond, for ease of management and to reduce potential risks. Ideally, it should take no more than 10 days to fill a pond. For intensive operations, complete drainage is essential for hassle-free harvesting at the minimum possible time.
The maximum depth should range between 1.2 and 2 m. In regions with elevated temperatures, ponds should be deeper, between 1.8 and 2 m. square or rectangular shapes are easiest to construct and manage. However, any shape can be chosen based on the layout of the land.

Concerning the farm layout design, the following factors should be considered when laying out the locations of the farm.

1. The distances to be covered when transporting feed from storage to ponds, and hauling harvested products to the holding facilities, should be as short as possible.
2. A farm shed is required to store equipment, feed, and other inputs, in addition to farm records.
3. The farm buildings should be accessible by road.
4. Areas that require attention or frequent attendance, such as hatcheries, should be close to the farm operating buildings.
5. Each pond should have its own filling and draining system, if possible, independent from other ponds.
6. The dyke crests used as unpaved roadways should be at least 3 m wide. Paved roadways on dyke crests should also have 1-m-wide unpaved shoulders.
7. The dimensions of the canals that carry water from the intake to the individual ponds should allow all ponds to be filled and drained within the recommended time.
8. The drain (outlet) ditches should be at least 0.3 m below the surrounding terrain, and not be allowed to overflow. Drain ditches serve as conduits for seepage and external runoff, as well as a mechanism to prevent this water from entering directly into surrounding waterbodies.

Building the Pond

Building a pond requires thoughtful planning and preparation. Some very practical insights and guidance for consideration based on the site and farm specific contexts are noted below.

The Number, Size & the Shape of Ponds will be Determined by:

1. Land size
2. Topography of the land
3. Intended use of the pond
4. The species to be produced
5. Frequency of harvest
6. Target quantity per harvest
7. Whether juvenile production is intended etc.

For these reasons it is not always possible to give general recommendations on the sizes and shapes of earthen ponds. However, rectangular ponds are easier to manage. Fingerling ponds should be smaller than grow out ponds.
Once this assessment is done, all other pond dimensions can be calculated.

Standard Commercial Fishpond

The recommended characteristics of a standard commercial fishpond are:

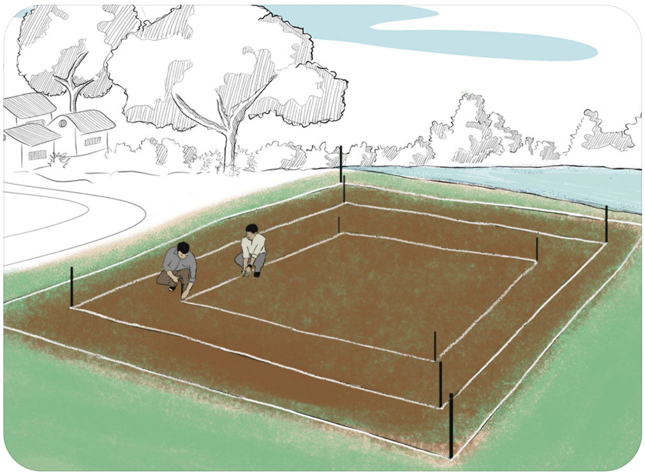
- **Size of Pond:** 500–1 500 m^2 or more.
- **Maximum suggested depth of the pond:** 1.5 m.
- **Suggested range of pond's shallow end depth:** 0.80–1.00 m.
- **Suggested range of pond's deep end depth:** 1–1.80 m.
- **Dyke width top:** 1–3 m.
- **Height of dyke:** 1.8–2.20 m.
- **Dyke bottom slope/ratio** of 2–3:1 **for inside dyke slopes** and 1.5–2:1 for **outside slopes.**
- One or several overflow facilities, which can facilitate arming.
- **Overflow pipe** placed near the top of the dyke (freeboard 0.5 m).
- **The outlet furrow:** 1 m wide at the bottom and 40 cm deep.
- The slope at the pond bottom from the outlet towards inlet should be between 1 and 2 percent.

Key Steps in New Pond Construction

The parts of an earthen pond are:

Dykes, pond bottom, inlet canal, outlet canal, inlet pipes, outlet pipes, the freeboard and capture area or the monk.

Step 1. Mark out the area that the pond will occupy using wooden pegs and strings and then remove all the vegetation.



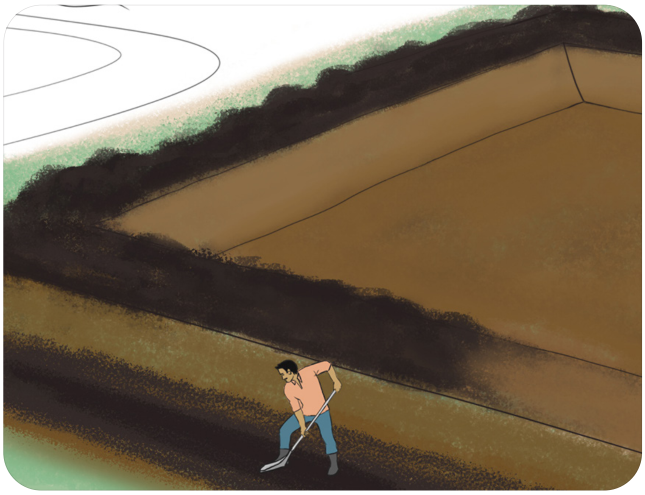
Marking the selected pond construction site

Step 2. Remove the topsoil and keep it in a good location close to the site. It will be used to cover the pond bottom and the dyke tops to enhance fertility.

Cleaning the vegetation, removal of topsoil and keeping it aside

Step 3. Clear the area within the pond limit of all vegetation including the area within 10 m of dikes and pond structures and any access, water supply or drainage area.

Step 4. Establish a Temporary Bench Mark, a mark on the ground that establishes the elevation of a place and is used as a reference point for all other elevation. This will allow you to determine and check by use of levelling equipment, the elevations of the dykes, canals and other structures. The Temporary Bench Mark should be set and permanently fixed in a protected location during the whole construction period.



Marking the dike area, digging trench next to dike area, placing the dugout soil on the marked dike area

Step 5. Using spirit level, measuring tape, pegs and strings, mark out:

- The dykes
- Dyke slopes
- Inner and outer toes
- The pond bottom.

Step 6. Using the determined pond depths and the actual elevations of the site, determine which areas need digging and which need filling. This is very important because it eliminates unnecessary movements of soil and thus keeps the construction cost at a minimum.

Step 7. Dig out the soil at the 'dig' areas and place it on the 'fill' areas. Most of the fill areas will be on the dyke position. Make sure to remove boulders and tree stumps from the pond area.

Step 8. Once the soil is placed on the fill area, make sure that this soil is properly compacted. To achieve good compaction, place soil in layers not exceeding 15 cm in height and compact back to at least 10 cm. When constructing dykes, soil layers are place 20 cm inside on top of each other to reduce amount of work during dyke cutting.

Dike compaction process with machine

Dike compaction process done manually

Good dykes should:

• Be able to resist water pressure resulting from the pond water depth
• Be impervious
• Be high enough to keep the pond water from overflowing

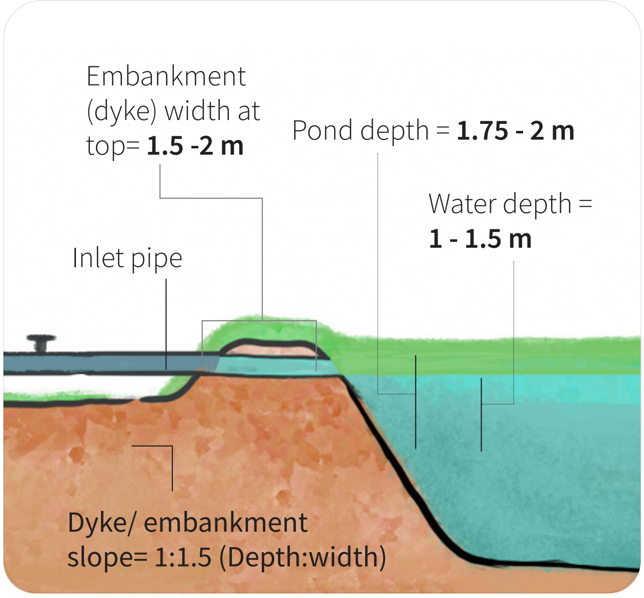
To determine the height of the dyke to be built, consider:

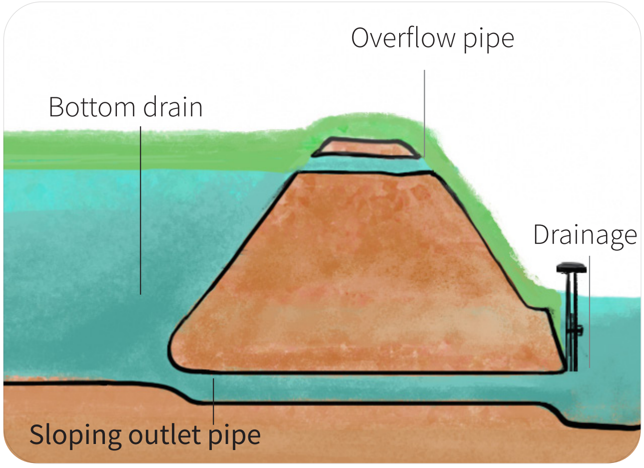
• The water depth you want in the pond
• The freeboard (upper part of a dyke that is never under water). It varies from 0.25 m for very small ponds to 1 m for very large ponds.
• Dyke height that will be lost during soil settlement. This varies from 5 to 20 percent of the construction height of the dyke.
• Dyke width depending on the water depth and the role the dyke will play for example transportation in the farm.
• It should be at least equal to the water depth, but not less than 0.60 m in clay soil or 1 m in somewhat sandy soil.
• It should be wider as the amount of sand in the soil increases.

Dyke slopes should be determined bearing in mind that:

• Steeper slopes erode easily.
• The more the soil becomes sandy, its strength decreases, and slopes should be more gentle.
• The bigger the pond size, the stronger is the erosive power of the water waves.
• As the slope ratio increases, the volume of earthwork increases, and the overall construction cost and the land area required for the ponds increases.

Note: that the gentler the slope, the more solid the pond, but very gentle slopes make ponds more expensive and make rooted weeds control difficult. A slope of 50% is the minimum recommended.

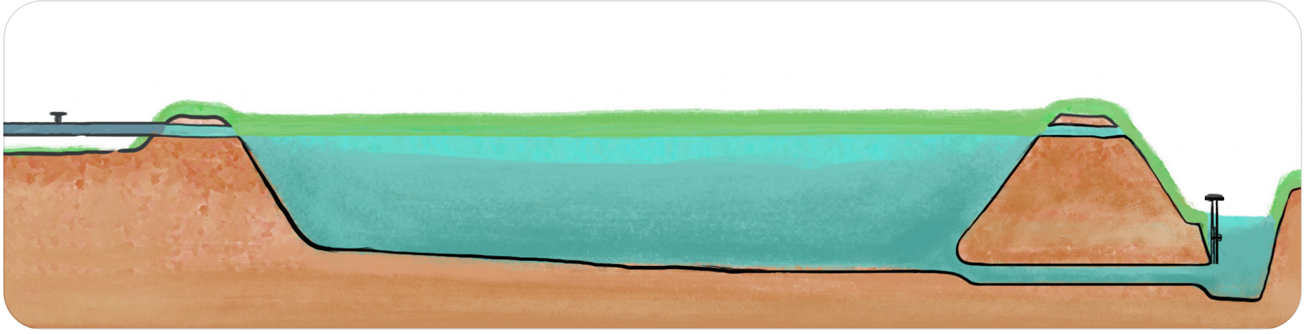




Dike slope, dike measurements on the top and at the bottom

The ability of the dykes to hold water can be enhanced by:

• Using good soil that contains enough clay (about 25% clay is best)
• Building a core trench (clayey core) within the dyke where the soil is pervious.
• Building a cut-off trench when the foundation is permeable.
• Proper compacting of the soil.
• Ensuring that the thickness of the dyke is appropriate.
• Newly built dykes should be protected against erosion by planting a grass cover on the crest of the dykes, on outer slope and on the free board.
• Compacting and shaving dykes are necessary processes to complete the construction of a pond.
• To reduce leaks and seepage, when you add



Pond bottom levelling with slope from inlet to outlet

soil to build a dyke or dyke slopes, you should compact each layer 30–40 cm.

• In areas where the water has been raised quite high above the natural water table, ponds will leak through the pond bottom. To reduce the amount of seepage, use clay soil.

• Uptake out all roots and other wooden material, and after each layer of 30–40 cm of soil, compact it with compactors.

• A very steep slope of pond bottom will lead to less depth of water in the pond and increase proliferation of aquatic vegetation.

• The dyke must be shaved to give it good shape and to avoid erosion.

Core Trench:

• In areas with sandy soil, you should begin pond construction with something called a "core trench".

• A core trench is a trench about 50 cm wide, which runs from one end of a dyke to the other.

• It should be dug as deep as necessary, until finding an impermeable clay layer, and then filling the entire trench with clay.

• The purpose of a core trench is to make the dike stronger and less permeable to water, and thus less likely to leak or seep.

Pond bottom construction:

• Replace the topsoil that was removed during the initial pond construction process back on the pond bottom and on the dike sloops

• Respect the pond bottom slope. Follow the maximum/ minimum of 2 percent for the pond bottom slope.

• The pond bottom should be constructed such that water drains towards a harvesting sump at the deepest part of the pond, in front of the outlet, where all the fish can be concentrated during complete draining of the pond.

Water Inlet & Outlet

Water Inlet System: Main water intakes are used for the overall regulation and transportation of water to the fish farm. They ensure constant supply of water and allow regulation of the amount of water to the farm allowing for diversion of what is not needed. The system includes a water source, supply water furrow and inlet pipes.

Demarcating the inlet system should follow this process:

• First identify the water capture point/River or canal or dam or barrage o`r borewell or Irrigation drain and demarcate the area. Demarcate/stake out the water supply furrow/ derivation canal from the water capture point (river/canal/barrage/dam/reservoir/borewell/ Irrigation drain).

• Staking out a water supply canal for construction involves creating a contouring or contour line, which means levelling points that are at the same level. If the water source is inconvenient for gravity fill, a pumping system needs to be installed at the point of water capture so that it can pump the water into the water supply channel or into the pond directly.

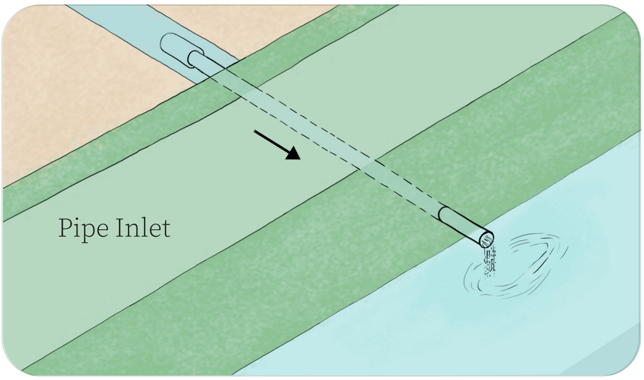
• If the water source is a borewell, instead of pumping it directly into the pond immediately, if it is possible to expose the water for atmospheric air either by running on the surface or by spreading it before it gets into the pond, oxygen level can be enhanced before entering the pond and toxic gases (CO_2, H_2SO_4)

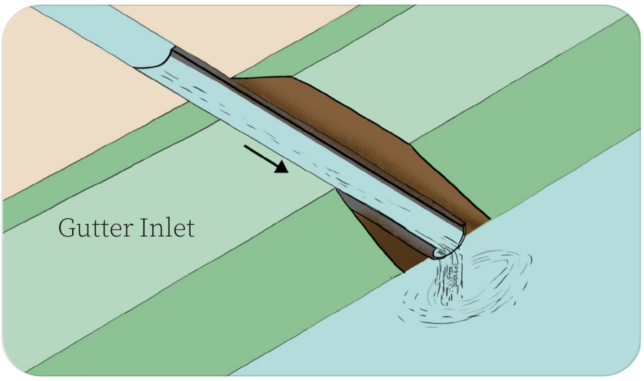
decreased.

Considerations when designing and constructing an inlet:

- Place the inlet at the shallow end of the pond
- Make sure that the bottom level of the inlet is at the same level as the bottom of the water feeder canal and at least 10 cm above the maximum level of the water in the pond
- Design the inlet structure to be horizontal, without a slope.
- Make it wide enough to fill the pond completely in reasonable time
- Make it such that water splashes and mixes as much as possible when entering the pond.
- Provide a screen to keep unwanted fish and other organisms out

Simple Inlets





Inlet models

- Flow control mechanism e.g. gate valves

1. Pipe Inlets

Inlet can be made from a piece of heavy bamboo or a pipe of plastic or metal. The inlet pipe should be about 10 centimetres in diameter. The inlet pipe should be long enough to reach through the top of the bank from one side to the other. You will need a pipe about 3 metres long to reach through the bank at the upper end of your pond. Dig a gap in the bank where you want the inlet to be. It should be a little above the water level on the inside of your pond and a little below the level of the water that flows from the source outside your pond. Put the inlet pipe in the gap in the bank and rebuild the bank over it.

2. Open Gutter Inlets

You can also make an inlet by cutting a shallow trench through the bank to let the water into the pond.

If you use a shallow trench to get water into your pond, you can improve it and keep it from washing away by using a trough of roofing metal to line the bottom of the trench.

3. Canal Inlets

A small open canal can be built to connect the water feeder canal to the pond, usually from a division box. There are several possibilities such as, digging a small earthen canal, building a small, lined canal, with a rectangular section and using either wood, bricks or concrete blocks. Small parallel walls are built on a light foundation along the sides of the canal.

A sluice can be built in the trench to control the flow of water into the pond. This sluice has a wall on each side of the trench and a floor set into the bottom of the trench. There are slots in the walls to hold wooden boards or a screen. Wooden boards are put into the slots to keep water out of the pond or taken out to let water in. When you are filling the pond, you can put in a screen to keep out wild fish. Sluice can be built from wood, or with bricks or blocks.

Water Outlet System:

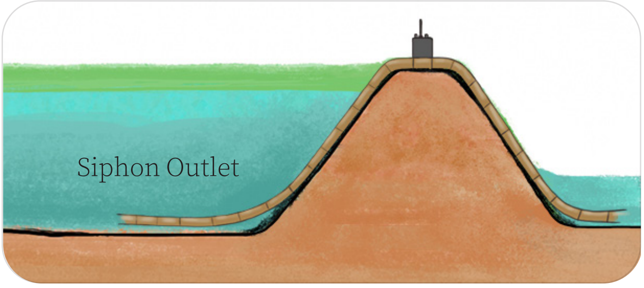
Keep the water in the pond at its optimum level, which should be the maximum water level designed for the pond. Allow for the complete draining of the pond in not more than 1 day for harvesting of the fish when necessary.

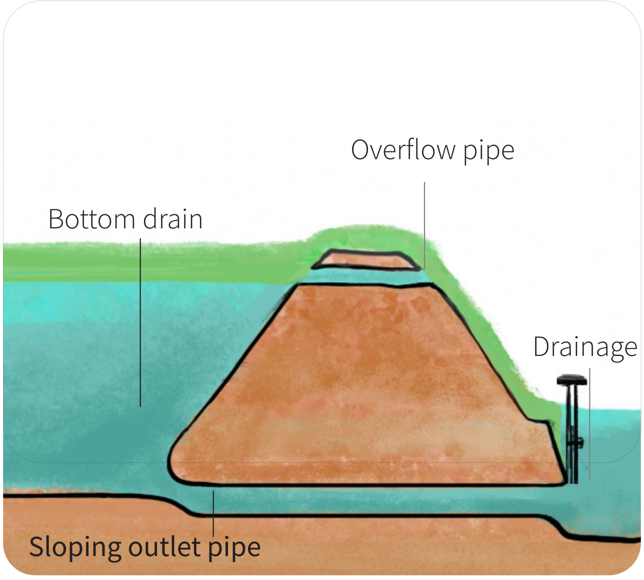
In most cases, outlets have the following main elements:

Water control plugs, valves, control boards, screens or gates, a collecting sump inside the pond, from which the water drains and into which the fish is harvested.

A good outlet should ensure that:

• The time needed to drain the pond completely is reasonable (less than 1 day)
• The flow of the draining water is as uniform as possible to avoid disturbing the fish excessively
• Fish are not lost even during the draining period
• Water can be drained from any pond levels
• Allow for overflow of excess water
• Can be cleaned and serviced easily
• Construction and maintenance costs are kept at a minimum





Outlet models

Construction of a drainage canal:

• Identify the drainage point of the pond at the outside deep end (this should at least show a difference in height with the inside deep end point at least 20 cm below the inside deep end of the pond).
• Determine the longitudinal profile of the drainage canal. The slope of this longitudinal profile should be at least 2 percent up to the drainage area. Ideally, the drainage areas should be a running water body and not a small swamp that can be filled up during harvesting.

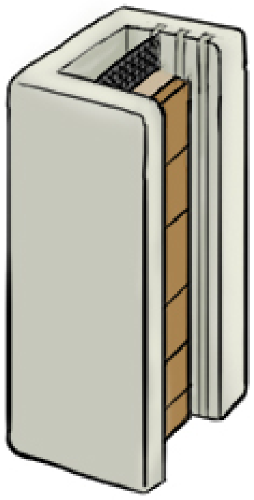
Simple Outlet:

The outlet can be made from a piece of heavy bamboo or a pipe of plastic or metal. The outlet pipe should be about 10 centimetres in diameter. The bank of your pond is much wider at the lower end than at the upper end, so the outlet pipe will have to be longer than the inlet pipe. The outlet pipe should be long enough to reach through the bottom of the bank from one side to the other. You will need a pipe about 6.5 metres long to reach through the bank at the lower end of your pond. If you cannot get a pipe that is long enough to go through the bank, you can join shorter pieces of pipe together using straight pieces of pipe. If you are using bamboo, you can join short pieces of bamboo together with pieces of smaller bamboo in the centre, but the smaller pieces should be at least 8 to 9 centimetres in diameter.

Wrap the bamboo joints with rope and close them with tar to keep water from seeping out. Now dig a gap in the bank where you want the outlet to be. It should reach from the deepest part on the inside of the pond through the bank to the outside of the pond. If the outlet pipe is below ground level on the outside of the pond, you will have to dig a ditch to take the water away from the outlet. Put the outlet pipe in the gap in the bank and rebuild the bank over it. If you use an outlet of about 10 centimetres in diameter, it will take about 10 hours to empty your 400 square metre pond. It is easier to place the outlet where you want it to be before you dig out the centre of the pond and build the banks. When you build another pond, you will understand this and you will be able to do it when you are building the banks. But now, when you are building your first pond, you should place the outlet in the way you have just learned because it is easier to understand.

The Monk Outlet:

Monk type outlet can be built to empty a bigger pond faster. It is built inside the bank at the deep end of the pond. When the pond is filled, the monk will be in the water. A monk is a tall box with two sides, a back, a front formed by wooden boards and a bottom. Each side has two slots to hold two rows of wooden boards. Boards are put into the slots to keep water in the pond or taken out to let water out.
A monk has a screen that fits on top of the first row of boards. It keeps your fish from getting out when the pond is too full or when you are emptying it. A monk also serves as an overflow, so you will not need to have an overflow pipe. You can build a monk from wood, or with bricks or blocks.



Monk outlet

2.1.3 Pond Preparation & Existing Pond Renovation:

Identify the problems of an existing ponds that need to be renovated in order to meet the technical requirements for adapting sustainable aquaculture practices. In this section we will discuss about appropriate techniques to renovate existing dykes, pond bottom, and the inlet and outlet systems of the pond. In most cases, renovating an existing fishpond is often difficult because the fact of its prior construction and design factors makes it necessary to try and reshape the pond to the required standard at that location.

Problems of most Existing Fishponds before Renovation:

- Existing dykes are often built with decomposable organic matter; therefore, it is usually wise to take the dykes apart and rebuild them.
- Most traditional old ponds have narrow dyke tops and no slopes, so abundant fill dirt (soil) is needed.
- Most traditional old ponds are shallow. You need to sink them to the required depth.
- A drainage canal needs to be constructed if it does not exist.
- Some ponds are too large or small or do not meet the standards of a commercial pond; it is necessary to rebuild them to a manageable size.

Based on the condition of these existing ponds renovation approach should be different.

2.1.3.1 Ponds that can be Drainable:

- **If the existing pond can be drained completely, they should be de watered either by gravity draining or by pumping out and empty the pond completely**
- **Remove slush (silt) from the pond bottom, raking or ploughing the pond bottom will help to eliminate the undesirable mats of filamentous algae, and also aerate the pond bottom to make it more productive.**
- **Allow it to sun drying for 3-4 days: Advantages are aerating surface sediments, oxidizing reduce compounds such as such as H_2S, NO_3, NH_3, Ferrous iron, Methane and decomposition and mineralization of organic matter**

Cleaning and Repairing:

- Free the pond from all aquatic /terrestrial plants grown on the dykes (both outside and inside) If trees are present surrounding the pond, trim all the branches extending over the pond if any, to avoid falling leaves and debris into water.

• Level the pond bottom with gentle slope towards outlet side (towards lower end)

• Repair any crevasses on the pond dykes and the sides are levelled to get proper slope

• Strengthen/repair the dykes by proper compacting to avoid seepage of water either manually or, apply sodium bentonite (Bentonite clay)

• Turf/grass pitching in the pond bank area will avoid erosion of dykes. During rainy days covering top of the pond bank with low cost polythene sheet or dry paddy hay will reduce soil erosion. Bentonite clay (Sodium bentonite), a natural clay which acts as natural sealant can be used for large ponds for control of seepage as it expands as soon it comes in touch with water. The dosage required ranges from 150-300 tons/ha depending the soil type. Sandy soils require more whereas soil with clay mix will require less quantity. The cost is around Rs 1600/ton.

• Ensure that inlet and outlet are working properly

• Fencing of pond to a height of 1 m using pegs and nylon netting around the pond to prevent entry of snakes, frogs, and other predators (bio security) into the pond

• Cover the pond with nylon net for initial 1-2 months for avoiding bird predation. Tying cassette tapes/lines at 50 cm to create sound due to wind effect will scare away the birds- comparatively low cost but they may tear away if the wind is very strong or manual bird scaring by beating drums/ tin cans during early morning and evening hours

• Follow the pond construction guidelines as mentioned in section "2.1.2 – Pond Construction".

2.1.3.2 Ponds that are not Drainable:

If the existing ponds are not drainable either due to various reasons like improper outlet and drain positioning, drain blockage or flooding, the following approach can be adapted for the renovation process.

2.1.3.3 De-Watering:

If the existing pond is not be drainable completely, they should be de watered as much as it can be either by gravity or by pumping out.

2.1.3.4 Cleaning and Repairing:

• Remove all the fish by repeated netting and manually remove all the aquatic plants in the pond.

• Disturb the pond bottom and allow escape of all the poisonous gas from the pond bottom.

• Restructure and restrengthen the dikes as much as you can

• Ensure that inlet and outlet are working properly

2.1.3.5 Arrange Pond Surrounding:

• Free the pond from all aquatic /terrestrial plants grown on the dyke sloop inside the pond (Pond water and dike soil intersection area) to avoid ectoparasitic harbouring. If trees are present surrounding the pond, trim all the branches extending over the pond if any, to avoid falling leaves and debris into water.

• Use recommended suitable herbal products to eradicate unwanted fish and other unwanted small animals from the pond (These herbal products are explained later in the document - 2.3.2.1. Type of herbal products, dosage, and toxicity period)

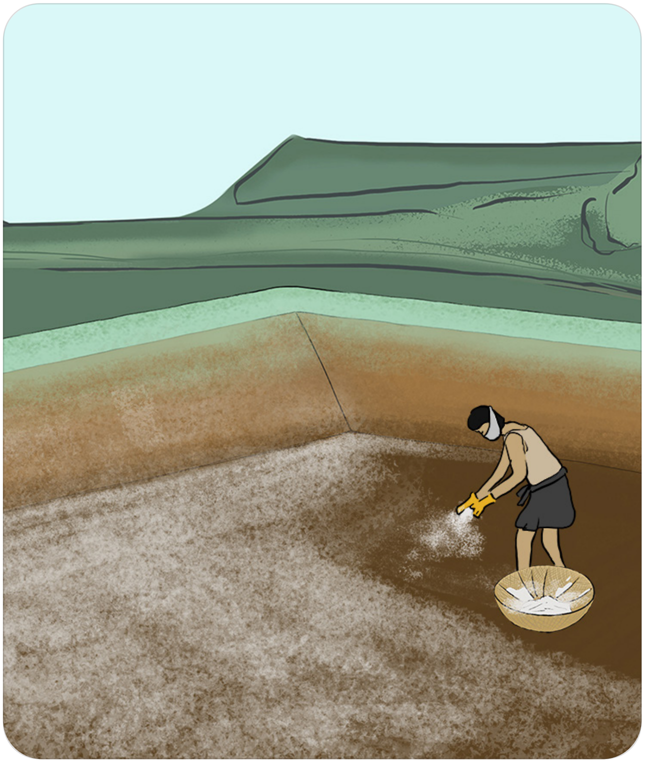
2.2 Liming and Manuring:

Liming and Manuring / fertilizing are the two important steps in pond preparation for a productive culture cycle. Zooplankton and phytoplankton are the main natural food of fish in the pond. Usage of lime and manuring will support this natural planktonic productivity and water quality management.

2.2.1 Liming:

Liming is an important step in preparation of ponds. Liming increases the total alkalinity, pH and total hardness of pond water by increasing the concentration of bicarbonate ion which is in equilibrium with carbon dioxide.

Phytoplankton growth in water is influenced by carbon dioxide and bicarbonate ion levels, lime application increases the availability of carbon for photosynthesis by raising the total alkalinity of the water. Lime neutralizes soil acidity and creates a buffer system to prevent marked diurnal fluctuations of the water from acidic to alkaline conditions. The addition of a lime increases the pH of bottom soil and makes phosphorus more available, but Ponds should not be fertilized at the same time that lime is applied, as the calcium in lime will remove phosphorus from the water, so Lime treatment for ponds should be done before initial manuring. Ponds with total alkalinity values less than 10 milligrams per liter seldom produce adequate plankton for good fish production unless they are limed. Responses to fertilization are variable in un-limed ponds with waters containing 10 to 20 milligrams per liter total alkalinity. Apart from other advantages, the buffering action of calcium is the most important. Lime serves both the prophylactic and therapeutic purposes.



Limed pond bottom

The basic objectives of liming in the pond are

- To maintain the pH of soil and water above 6
- To increase the function of fertilizer
- To remove the turbidity of water
- To control decrease any toxic gases.
- To make the pond environment clean
- To increase the productivity

Liming of a fishpond is highly recommended because of its following advantages.

- Destroys fish pathogens and their intermediate life stages.
- Converts unsuitable acidic condition of water to suitable alkaline condition.
- Neutralize iron compounds which are undesirable in fishponds.
- Promotes mineralization of soil which is desirable in fishponds.
- Settle excess dissolved organic matters and thereby reduces incidences of oxygen depletion
- Acts as determinants and improves hygienic

2.2.1.2 Types of Lime:

The term lime is applied to a variety of substances containing one or more active ingredients of calcium, or calcium and magnesium in combination with an anionic radical capable of neutralising acidity. Common liming materials include, agricultural limestone or calcium carbonate ($Ca\ CO_3$), calcium hydroxide or Slake lime or hydrated lime ($Ca\ (OH_2)$), calcium oxide or Quick lime or burnt lime (CaO) and Dolomite or calcium and magnesium carbonate ($Ca\ Mg\ (co_3)_2$.

Types of Lime:

Calcium Oxide or Quick Lime or Burnt Lime (CaO)

This lime produces heat when it mixes with water and very rapidly increases the PH of soil and water. This lime is very much effective in those ponds which are highly acidic. This lime is also very effective disinfectant and prevents occurrence of diseases.

Agricultural Limestone or Calcium Carbonate ($Ca\ CO_3$)

Acid neutralizing power is very much less than that of other lime. This lime does not produce heat when it mixes with water. As this lime does not increase the pH of the pond rapidly, so it is suitable to apply.

Calcium Hydroxide or Slake Lime or Hydrated Lime ($Ca\ (OH)_2$

Acidity neutralizing power is less than that of quick lime. This lime produces less heat than quick lime. Use of this lime in the pond is very less.

Dolomite or calcium and magnesium carbonate (Ca Mg $(co_3)_2$

Dolomite is used to treat water, increase the alkalinity of water, provide trace elements and macro nutrients and create an environment for algae to grow and hence normally used in pH management and plankton proliferation during post stocking operation.

Liming materials react with acidity as follows, for dolomite: Ca Mg $(CO_3)_2$ +4H+ = Ca_2+ + Mg_2+ + $2H_2O$ + $2CO_2$

This reaction neutralises acidity, increases pH and total hardness of water, and results in an increase in total alkalinity. The addition of lime can be used to increase these properties to levels favoured by culture species.

2.2.1.3 Usage and the Quantity (Dosage):

- Both quicklime and slaked lime dissolve rapidly in water. Quick lime is preferred during pond preparation for its quick action and caustic effect.
- Quicklime, in fact, reacts violently with water releasing a tremendous amount of heat in the process. Adequate precautions should be taken when handling quicklime to prevent inhalation or contact with skin, use hand gloves as it has caustic effect resulting in heat and vapours.
- Both quicklime and slaked lime can dramatically raise the pH of ponds to levels toxic to fish. Rapid pH changes, even within the range normally tolerated by a species, may also cause the death of fishes. Liming materials such as calcium oxide and calcium hydroxide can result in a pH increase above 11, which is considered to be the alkaline death point for pond fishes. Slaked lime should only be used in ponds when alkalinity must be raised quickly.
- Agricultural lime or dolomite is more preferred as this releases bicarbonate ions slowly and for longer period of time to maintain alkalinity at desired levels.

Apply the lime covering entire pond bottom, application once during pond preparation and subsequently during culture operation depending on the pH of water.

pH	Agricultural Lime *(in kg/ha)*	Quick Lime *(in kg/ha)*
6.5	250	230
6.0	550	460
5.5	750	690
5.0	1000	920
4.5	1250	1150
4.0	1500	1380

Table 5: Lime requirement for soil treatment during pond preparation for correcting the pH

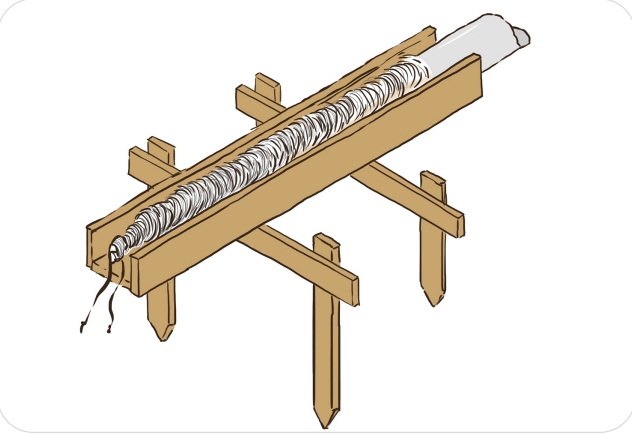
2.2.1.4 Water Filling:

Water of good quality is very critical for pond productivity, please follow water quality guidelines mentioned in chapter 2.1.1 Site selection, under water source. Check the water for very important critical parameters –Dissolved Oxygen, pH, Alkalinity and Hardness (Specially if bore well water is used)- **the optimal ranges are also provided under water quality management in Post stocking management chapter.**

If water from natural source (River, streams, reservoirs, rainwater) is directly used, build a silt trap before the entry point to avoid silting of pond and cover the inlet point with nylon mesh to avoid entry of unwanted fish or other material into pond.

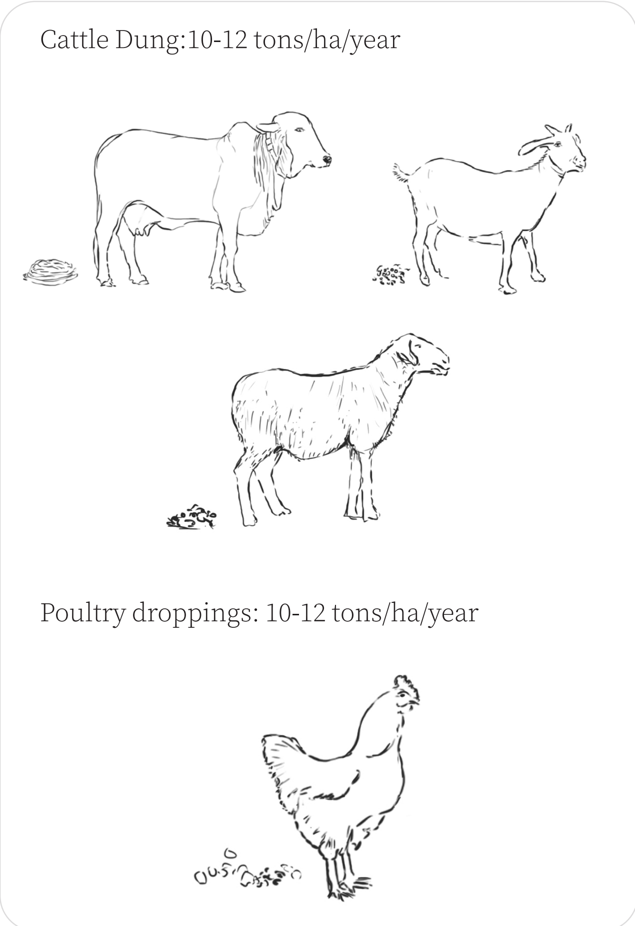
Controlling & Screening Trash & Fish:

Inlet should have a screen to keep out wild fish, dirt and trash when you fill the pond. You can make screens for your inlet, outlet and overflow from fine-mesh plastic or metal or from a tin with holes in the end. Screens should be placed outside the pond on the inlet pipe and inside the pond on the outlet and overflow pipes. This will keep the pipes from filling with trash which could stop the flow of water. Lash the screens tightly in place on the pipes, using heavy cord or light wire. If you fill your pond by cutting a trench through the bank, you can screen the opening using a fish trap, split and woven bamboo, a clay pot with holes in the bottom or a piece of metal roofing with holes. When you are filling or emptying your pond, clean the screens often. If you do not do this, dirt and leaves will cover them up and the water will not flow.



Controlling & screening trash and fish

2.3 Manuring:



Different manure dosage

The number of fish that can be produced in a pond greatly depends on water fertility, manuring / fertilization improves the quality of fish growth, if the area in which your pond is located is poor in natural nutrients. However, while fertilization can benefit your farm pond, improper management can lead to significant problems such as excessive aquatic vegetation or oxygen depletion. Fertilization of ponds has been done for centuries. Chinese fish farmers used fertilization techniques over 2,000 years ago in carp culture. Proper manuring/fertilization can greatly increase crop yields and fish will be in better condition.

The fish productivity of any farm pond begins with the base of the food chain, the phytoplankton population. Phytoplankton are microscopic plants that often give the pond's water a green or olive colour. Microscopic animals, which feed on the phytoplankton, form the next stair of the food chain and are known as zooplankton. A "plankton bloom" is the term used for the colour change produced when these microscopic plants and animals are in sufficient abundance. Because plankton are the base of the food chain, there is a close relationship between plankton abundance and fish production. The plankton are also the food source for aquatic insects and other aquatic invertebrates.

The "planktonic bloom "produced is usually in the upper three feet of the pond and if maintained properly during the complete culture cycle, will effectively shade out and prevent the establishment of rooted aquatic weeds. Manuring/Fertilization will not eliminate aquatic weeds that are already established or prevent the growth of such weeds in ponds that have shallow shoreline edges or control floating plants such as duckweed. Aquatic weeds that are already present, must first be eliminated (usually through the use of an approved aquatic herbicide or with biological control), before a fertilization program should be implemented.

Nutrients are the vital first step in the pond's food cycle, since they are used by phytoplankton in the production of food. The use of Manures/ fertilizers containing the nutrients, nitrogen, phosphate, potassium (N-P-K)**, is necessary to grow and sustain large populations of planktons.**

• Ponds with excessive water flow through are not supposed to be manured. As a general rule, if the total volume of water flowing out of a pond in 30 days exceeds the total pond volume, you should not fertilize. The added nutrients will probably not be in the pond long enough to develop adequate blooms.

• Ponds with water depth less than two feet should not be fertilized. The addition of nutrients will only worsen the problem with overgrowth of aquatic vegetation. Even with a good bloom, sufficient sunlight will reach the pond bottom and promote rooted vegetation growth.

• Ponds in which commercial feeds or supplementary feeds like agriculture biproducts are used for commercial fish culture should be fertilized judiciously. Added nutrients from fertilizers, coupled with wastes associated with feeding, could lead to excessive phytoplankton blooms and result in depletion of dissolved oxygen levels and fish kills.

• Ponds that have acidic soils should not be fertilized before proper liming. Application of phosphate fertilizers to ponds with acidic soils is a waste of time and money. Proper liming allows the phosphorus to be available to the phytoplankton and not become bound up on the soil.

• Ponds that are constantly muddy should not be fertilized. Phytoplankton require sunlight for growth and if the pond is constantly muddy, it is most likely that insufficient sunlight is penetrating the water to allow proper phytoplankton blooms to develop. Muddy fresh water can usually be cleared up with applications of gypsum.

2.3.1 Manuring for Newly Constructed Pond or that can be Completely Drained:

Manuring of ponds is very essential for carp culture to produce plankton- natural food of carps to meet most of its protein requirements Sustained phytoplankton production is essential to produce required zooplankton population in the pond as zooplankton is preferred food for carps.

Pond manuring (organic manures mixed with small quantity of chemical fertilizers) triggers the enhancement of autotrophic and heterotrophic production in pond ecosystem Once the pond is ready for filling water, fill the water to about 2 ft and manure the pond normally 5-7 days before stocking fingerlings

2.3.1.1 Types of Fertilizers, Dosage and Mode of Application:

Fertilizers may be organic or inorganic. They each contain varying amounts of nitrogen, phosphorus and potassium. A complete fertilizer usually is one that contains all three nutrients.

Inorganic Fertilizers:

These are chemical fertilizers which contain nutrients either alone or in combination to make a mixed fertilizer. The composition is always expressed in order of nitrogen, phosphorus and potassium. (For example, a 20-20-5 fertilizer will have 20 percent nitrogen, 20 percent phosphorus and 5 percent potassium.) Inorganic fertilizers come in either granular or liquid form. Granular fertilizers have different forms and vary in their effectiveness, cost and ease of application. Liquid fertilizers are easier to use. In contrast to granular forms, they are usually more available to the plant for uptake because the fertilizer is already in solution. Nitrogen is an element of basic protein and is a part of all living cells. Expressed as N, it may be present as nitrate, ammonium or urea. Nitrogen is usually not a limiting factor in the production of plankton in freshwater ponds, as it is almost always present in sufficient amounts through natural processes (e.g., animal wastes, decomposition). Phosphorus is present as phosphate, expressed as P2O5 or phosphoric pentoxide. It is considered the most essential element in freshwater fertilization program because it aids in plant respiration and helps to stimulate root production. It is usually the limiting nutrient in fishponds, which means it

Pond bottom with Manuring

is the one nutrient that inadequate quantities are available to maintain or maximize plant growth. Clay and organic matter in a pond may adsorb to phosphorus molecules, binding them up and making them unavailable as a pond nutrient. Potassium (K) is expressed as KO or potassium monoxide. Acting as a catalyst in plants, although needed at lesser levels than the other nutrients, potassium is used in the plant's manufacture of carbohydrates. It tends to move from the bottom mud to the water and plants readily.

Generally, nitrate and phosphate fertilizers are used in the pond. On the other side, fertilizers containing potassium are not used in the pond. Among nitrate fertilizers, urea and among phosphate fertilizer, single superphosphates are mostly utilized in the fishpond. Importance of phosphate-fertilizer application is more compared to other fertilizers in the pond because they contribute to the plant growth more prominently. Within a few minutes of application of phosphate-fertilizer in the water body, they are readily absorbed by plant-tissue for their growth. Uses of nitrate fertilizers along with phosphate fertilizers create a synergistic effect on the benefits of using these fertilizers.

The application procedure of inorganic fertilizers in the fishpond:

The main disadvantage of using phosphate fertilizer is their insolubility in water, but nitrogen fertilizers are very much soluble in water. So, phosphate fertilizers should not use in dry condition otherwise, they will be readily absorbed by bottom soil instead of being absorbed by plant tissue or phytoplankton. So, these fertilizers should be soaked in the water before 3-4 hours of their application. Then, the next day morning, it should be mixed with any nitrate-fertilizer in a large container and then should be spread in the pond.

Amount of inorganic fertilizer to be used in the pond:

How much inorganic fertilizer should be used in the pond, depends upon the nature of the water and soil of the pond. Before application of the inorganic fertilizer in the pond, the density of the plankton should be determined in the pond which in turn, should be determined by the transparency of the Secchi disk.

- If transparency of Secchi-disk is between 30-40 cm, then generally no need to apply any fertilizer in the fishpond.
- If transparency of Secchi-disk is above 40 cm, then fertilizer should be used in 15-day intervals.
- If transparency of Secchi-disk is above 60cm, then fertilizer should be used weekly, until Secchi disk transparency reduced to 30-40 cm.
- If transparency of Secchi-disk is below 30 cm, then application of fertilizer in the fishpond should be totally prohibited.

Some other factors which determine the amount of inorganic fertilizer to be applied

- In the case of turbid water, there is no benefit of the application of inorganic fertilizer, as due to turbidity of the water, sunlight cannot adequately enter into the water.
- Before the application of fertilizer in the pond, aquatic plants present in the waterbody should be eradicated otherwise, nutrient of the fertilizers will be absorbed by those plants present in the water body. As a result of that, the growth of the aquatic plants will create problems in the culture of the fish species.
- In the case of the algal dominated pond, inorganic fertilizers should not be used at all.
- In case of cloudy days or before sun-rise fertilizers should not be used in the pond, as plants cannot perform physiological functions adequately in the absence of sunlight.
- If total alkalinity of the pond below 20 mg/l, then no benefit will be extracted from the application of inorganic fertilizers.

Organic Fertilizers:

Organic fertilizers are animal and plant-derived fertilizers are known as organic fertilizer. These fertilizers tend to accelerate the production of zooplankton or other microscopic animals on which many fish feed more rapidly than inorganic fertilizers. Organic fertilizers contain low levels of nitrogen, phosphorus and potassium compared with inorganic fertilizers; thus, larger quantities must be added to effect the same level of nutrients as inorganic fertilizers. Ideal organic fertilizers should have a low carbon to nitrogen ratio (C:N) and a small particle size. Organic fertilizers with low C:N are better utilized by plants and animals in the pond. Manures, for example, have high C:N and do not decompose rapidly. Thus, concentrations of organic material build up on the pond bottom and can lead to water quality problems. For this reason, it is highly recommended to decompose organic matter outside of the pond in a normal compost pile and apply the decomposed compost to the pond. Once the material is decomposed, that C is gone (as CO_2) while N and P stay.

Classification of organic fertilizers:

Organic fertilizers can be divided into two groups.

1. Plant-derived fertilizer: These kinds of fertilizes are produced from plant or plant-derived materials. Ex- compost fertilizers, oil-cake fertilizers etc.
2. Animal-derived fertilizers: These kinds of fertilizers are produced from animal or animal-derived material. Ex- Dairy fertilizers, poultry fertilizers, swine-derived fertilizers.

Some important organic fertilizers used in fish culture and their application procedure

Green-fertilizers: This fertilizer is generally used in nursery pond. This fertilizer increases the amount of nitrogen in the pond, as a result of which productivity increases a lot.

Compost-fertilizers: Different types of aquatic plants, grasses and leaves are mixed with raw cow-dung and then compost-fertilizers are produced. This fertilizer helps to control the pH of the fishpond.

Oil-cake fertilizers: Among plant-derived fertilizers, most widely used fertilizer is oil-cake fertilizer. After extracting the oil from mustard, mohua, til and badam etc, the residue is known as oilcake. Oilcake contains different chemical components like nitrogen, phosphate and potash. Generally, mustard oil cake and mohua oil cake are widely used in the pond.

Use of mustard oil cake: Mustard oil cake is used as fertilizer in the fishpond and also serves as supplementary feed. It is used as fertilizer in the fishpond after mixing with cow-dung. When it is used as supplementary feed in the fish nursery pond, it should spread in the pond water directly after grinding it into small pieces. In grout ponds it will be used in bag feeding method.

Use of mohua oil cake: Initially mohua-oil cake act as a poison in the pond so, it kills unwanted fishes in the pond. Later it becomes converted into fertilizer so, it increases the productivity of the fishpond. This oil cake contains alkaloids, named saponin, which is water-soluble. It enters the blood of fish, snake and frog through gill and mouth and destroys red blood corpuscles of blood and death of these unwanted species occur. After some time, mohua oil cake degrades and increases the amount of nutrient components in the water. As a result, the growth of zooplankton enhances in the water body, and it serves the function of fertilizers.

Amount of mohua oil cake to be used in the fishpond: To kill the unwanted fish species, 250 ppm (2500 kg/ha/1 meter water depth) mohua oil cake should be used in the fishpond.

The procedure of application of mohua-oil cake in the fishpond: Most of the portion of mohua-oil cake is in cake form, so it does not dissolve directly in water of the fishpond. So, if we directly use it in the fishpond in cake form, the optimum result does not occur. So, an adequate amount of mohua oil cake should be soaked in the water three days, after three days it should be spread in the fishpond water.

Use of cow dung in the fishpond: In case of application of cow dung fertilizer in the pond, cow-dung will be disintegrated with the help of microbes. As a result, cow-dung will release nitrogen, phosphorus and potash components in the water, which makes water very much fertile.

Disadvantages of using organic fertilizers

- Organic fertilizers especially animal-derived organic fertilizers should not be used in a fishpond in excessive amount.
- Application of excessive amount of organic fertilizers can create the problem oxygen depletion in the fish pond.
- Application cow dung in raw condition can give birth to some harmful bacteria in the pond,
- Use of organic fertilizers in the fishpond in large amount can become the cause of fish death in the pond later.

2.3.1.1.1 Conventional Method:

Conventionally Fresh Cattle dung/Poultry manure in combination with nitrogen and phosphorous based inorganic fertilizers are used

Type of Manure/ fertilizer	Recommended quantity	Method of application
Cattle dung (alone)	10-12 tons/ha/ year	25-30% as initial dose at the time of pond preparation and the balance in equal instalments at fortnightly interval
Poultry droppings (alone)	4-6 tons/ha/year	
Combination of both	50% each	
Nitrogen based fertilizer (Urea)	100kg/ha/year	Once at the time of pond preparation
Phosphorous based (Single Super Phosphate)	50kg/h/year	Once at the time of pond preparation

Table 6: Conventional manuring practices

2.3.1.1.2 Improved Manuring Technique:

Phased manuring technique using only organic materials

Ingredient	Quantity in [kg/ha]
Jaggary	05.00
DORB	25.00
Oil cake	05.00
Yeast	00.25
CURD	1 ltr

Table 7: Improved manuring technique

Process of Preparation:

Mix all the ingredients. Anaerobic condition fermentation for 3-4 days and filter. Mix with water and spray all over the pond in slurry form

Application method

Apply in the morning hours and sunny days are preferred. Apply initially 3 days before stocking fish. Repeat once in 10-15 days depending on the plankton density in the pond

2.3.2. Manuring Pond that cannot be Completely Drained:

Use herbal products like mahua oil cake or Derris root powder to eradicate small unwanted fish and other aquatic animals including snails and large insects but will not kill phytoplankton.

These products are effective at low dosage, non- hazardous to human and livestock, shorter persistence of toxicity; no or minimal residual affect and dead fish suitable for human consumption.

Skip initial dose of organic manure as herbal products initially act as poison and later acts as organic manure after decomposition and will have no residual effect after two weeks.

Apply the herbal product 2 weeks before stocking fish at a water depth of 2-3 ft.

2.3.2.1. Type of Herbal Products, Dosage, and Toxicity Period:

Name of Product	Recommended dosage	Active component	Toxicity period
Mahua oil cake (Bassia latifolia)	200-250 ppm (Volume of water is very critical) -2000-2500 kg/ ha/1meter water depth	Saponin (4-6%)	2 weeks
Derris root powder	1.5-2.0ppm (15-20kg/ha-m)	Rotenone (5%)	Two weeks

Table 8: Type of herbal products, dosage, and toxicity period

2.4 Pre-Stocking Economics:

New Pond Construction Cost:

Note: There is a considerable difference in construction cost between exclusive manual labour usage and manual & mechanical hybrid mode. In this economics estimate we considered the hybrid mode. But for the convenience and knowledge of the user we provided both the details separately below. In some places the possibility to use mechanical devises might not be possible, in those places manual mode is the only way. **For example,** and calculations purpose the pond size and other dimensions are considered as follows. Area: 1 Acre (4080 M^2); Length:65 Meter; width: 62.77 Meter; Total dike hight 2 Meter; After compaction dike hight: 1.8 Meter; Dike crust width: 2 Meter; Wet side dike slope: 2:1; Dry side Dike slope: 1.5:1; Water filling depth: 1.5 Meter.

Adapt the approach as per your pond dimensions.

One Time Capital Investment Costs	Component	Units	Cost per Unit*	Cost*
Asset acquisition cost	Land purchase cost	1 Acre	Rs. 1,00,000.00	Rs. 1,00,000.00
	Lease cost	1 Acre	Rs. 15,000.00	Rs. 15,000.00
	Soil quality & suitability assessment test	1 Acre	Rs. 2,000.00	Rs. 2,000.00
	Survey, drawing & topographical work plan	1 Acre	Rs. 5,000.00	Rs. 5,000.00
		A	**Total if purchased the land**	**Rs. 1,07,000.00**
		B	**Total if it is a lease the land**	**Rs. 22,000.00**
Construction cost for new pond	Clear vegetation in the site with bulldozer	1 Acre	Rs. 2000.00/hour X 4 hours	Rs. 8000.00
	Remove topsoil with bulldozer	816 M^3	Rs. 2000.00/hour X 12 hours	Rs. 24,000.00
	Build inlet pipe manually	1 M	Rs. 600.00/M	Rs. 600.00
	Dig drainage canal	1.5 M^3	Rs. 600.00/M	Rs. 900.00
	Drainage pipeline installation	15 M	Rs. 300.00/M	Rs. 4500.00
	Build dikes	2500 m^3	Rs. 2000.00/hour X 30 hours	Rs. 60,000.00
		C	**Total**	**Rs. 98,000.00**
Infrastructure Development cost and others	Warehouse	100 M^2	Rs. 300.00/ M^2	Rs. 30,000.00

Pumping system	5 Hp submersible pump cost	1	Rs. 45,000.00	Rs. 45,000.00
Boat	1 M.T volume boat	1	Rs. 10,000.00	Rs. 10,000.00
Others	Drainage pipes, cement, gravel etc	---	Rs. 25,000.00	Rs. 25,000.00
		D	**Total**	**Rs. 1,10,000**
Value for farmer's time spent on the site	Farmer's time for planning and execution supervision	15 days	Rs. 1000.00	Rs. 15,000.00
		E	**Total**	**Rs. 15,000.00**
Total capital investment (For lease pond) B+C+D+E				**Rs. 2,45,000.00**
Total capital investment (For purchased pond) A+C+D+E				Rs. 3,30,000.00

* Indicative values, need to be verified and replaced with local cost. * For example, and calculations purpose the pond size and other dimensions are considered as follows. Area: 1 Acre (4080 M^2); Length:65 Meter; width: 62.77 Meter; Total dike hight 2 Meter; After compaction dike hight: 1.8 Meter; Dike crust width: 2 Meter; Wet side dike slope: 2:1; Dry side Dike slope: 1.5:1; Water filling depth: 1.5 Meter.

Cost Variation between Manual Labour and Machinery:

With manual work force:

Component	**Units**	**Cost per Unit**	**Workforce required**	**Time**	**Estimated units for calculation**	**Cost**
Clear vegetation in the site	M^2	Rs.2.00/M	4 people	4 people X 72 hours	4080 M^2	Rs. 8160.00
Topsoil removal/ storage (0.20 m)	M^3	Rs. 36 / M^3	12 people	12 people X 68 hours=816hours ($1M^3$/hour excavation & moving)	816 M^3 (for 4080 M^2 area)	Rs. 29,376.00
Build inlet pipe	M	Rs. 600.00/M	2 people	2 X 2 hours	1 M	Rs. 600.00
Dig drainage canal digging 15 M long &0.1 M2 deep	M^3	Rs. 600.00/M	2 people	2 people X 2 hours =4 hours (0.75M^3/ hour excavation & moving)	1.5 M^3	Rs. 900.00
Drainage pipeline installation	M	Rs. 300.00/M	4 people	4 people X 8 hours =32 hours	15 M	Rs. 4500.00
Build dikes (65 M length X 62.77 M width X 2-meter hight and 2-meter crust)	M^3	Rs. 36/M^3	36 people	36 people X 70 hours ($1M^3$/hour excavation & moving)	2500 M^3	Rs. 90,000.00
					Total	**Rs. 1,33,536.00**

With machinery & manual combination work:

Component	Units	Cost per Unit	Resources required	Time	Estimated units for calculation	Cost
Clear vegetation in the site	M^2	Rs.2000.00/ hour	1 Bulldozer	4 hours	4080 M^2	Rs. 8000.00
Topsoil removal/ storage (0.20 m)	M^3	Rs. 2000 / hour	1 Bulldozer	12 Hours (excavation & moving)	816 M^3 (for 4080 M^2 area)	Rs. 24,000.00
Build inlet pipe	M	Rs. 600.00/M	2 Bulldozer	2 X 2 hours	1 M	Rs. 600.00
Dig drainage canal digging 15 M long &0.1 M2 deep	M^3	Rs. 600.00/M	2 Bulldozer	2 people X 2 hours =4 hours (0.75M3/ hour excavation & moving)	1.5 M^3	Rs. 900.00
Drainage pipeline installation	M	Rs. 300.00/M	4 Bulldozer	4 people X 8 hours =32 hours	15 M	Rs. 4500.00
Build dikes (65 M length X 62.77 M width X 2-meter hight and 2-meter crust)	M^3	Rs. 2000/ hour	1 Bulldozer	30 hours (excavation & moving & compaction)	2500 M^3	Rs. 60,000.00
					Total	**Rs. 98,000.00**

Risk Factors:

1. Unsuitable soil selection for pond construction:

The soil selected for the pond construction needs to meet the criteria mentioned in the site selection chapter 2.1.1-Site selection. If the soil is too pervious it leads to more cost in strengthening the dikes, and more pumping cost due to the high rate of seepage. Even though selected, need to spend a lot of money to reduce the seepage by addition of cellulose and organic mater in the pond bottom for longer periods.

2. Lack of required facilities and infrastructure in the selected pond location:

After ideal site selection for aquaculture pond construction, the next important aspect is availability of minimum requirements to undertake aquaculture operation. These minimum facilities or infrastructure requisites are good quality water, road access and power supply etc. If you take the example of good quality water source, for any aquaculture operation the first and far most important requirement is availability of ample quantity of quality water throughout the year. If availability of sufficient quantity of water throughout the culture cycle is not there it leads to lot of issues like poor water quality, insufficient water depth, frequent planktonic crashes, increased stress on the culture species and the end result will be depletion in production.

3. Poor pond construction or unproper renovation planning:

Robust pond construction or renovation planning and implementation should be there as explained in chapter 2.1.2. Pond construction. If either planning or implementation is not appropriate farming will be a nightmare. For example, if the pond dikes are not designed and constructed properly, dike erosion can lead to insufficient water depth which in turn will lead to lot of water quality issues like poor plankton growth, growth of macrophytes in the pond bottom etc.

FAQs:

What are the characteristics of an ideal site for aquaculture pond construction?
How to assess the site soil suitability for aquaculture?
How to plan for a new pond construction?
What is the sequence of events in ideal pond construction operation?
How deep my pond should be?
Where to position inlet and outlet?
What should be the sloop from the inlet to outlet?
How to design and construct the pond dikes?
How to renovate existing pond?
Why it is necessary to remove bottom sludge from existing pond?
Why it is necessary to remove macrophytes and plants from existing pond and from the dikes?
How to avoid weed fish entry into the pond? How to irradicate them if they are there in the pond before stocking?
What are biosecurity measures? Why we need to adapt biosecurity measures?
Why we need to apply lime in the pond? What are the advantages?
Benefits of manure application?

Module 3: On-Stocking

Topics:

3.0 – On-stocking
3.0.1– Culture systems in aquaculture
3.0.2– Selection of fish species
3.0.3– Fish Seed selection criteria –sourcing
3.0.4– Identification of good quality seed
3.1– Species Stocking
3.1.1– Stocking size and density
3.2– Species composition
3.3– Transportation of fish seed
3.3.1– Preparations for transportation
3.3.2– Methods of transportation
3.3.2.1– Open system
3.3.2.2– Closed system
3.3.3– Timing of transport
3.4– Release of fish seed
3.5– On-Stocking Economics

Risk Factors
FAQs

3.0 On-Stocking:

In this module we will learn about the processes and administration aspects that are required for on stock management. Based on the available infrastructure and resources one need to select the mode of culture system they can adapt. Based on the market demand, suitability and seed availability Aqua culturist need to select the culture species, transport the seed safely to the culture site and introduce the seed into the culture pond.

This module will guide you in all these core aspects so that you can successfully complete the seed stocking into your pond by following these guidelines.

3.0.1 Culture Systems in Aquaculture:

Aquaculture practices can be classified in several ways, depending upon the different aspects and conditions involved in the culture practice. Some major and important classifications are given below based on the different aspects involved in aquaculture.

Basis			**Variant**		
Salinity	Freshwater farming	Brackish farming	Marine water farming		
Intensity	Extensive fish farming system	Semi-intensive fish farming system	Intensive fish farming system		
Fish species	Monoculture	Polyculture			
Enclosure	Pond culture	Cage culture	Pen culture	Race-way culture	Indoor farming
Integration	Agriculture cum fish farming	Animal husbandry cum fish farming			

Table 9: Culture system classification

In this manual we will be focussing on pond based freshwater fish farming. So, the classification pertaining to this segment will only be discussed on the basis of intensity of inputs and stocking density.

Fresh water aquaculture is primarily carp based with three Indian major carps Catla, Rohu and Mrigal are grown with three exotic carps, silver carp, grass carp and common carp as the six species mixed species farming, also known as poly culture or composite fish culture. Carp culture in most cases is undertaken in earthen ponds or ponds with soil bottom. Over the years culture practices are evolved utilizing variety of carp species, manures, fertilizers, feed, water quality management, health management etc., Based on the level of management and out put the culture systems are categorised into Low input, medium input and high input systems.

Extensive Fish Farming System (low input system):

Extensive fish farming system is the least managed method of fish farming, in which little care is taken. This system involves large ponds measuring less than 1ha to 5 ha in area with stocking density ranges between 2500 to 3000 fishes/ha (0.3 Fish/m^3). No supplemental feeding is provided, and only organic manuring is provided in minimal quantities to augment the natural productivity of the pond. Fish depends only on planktonic food for nutrition. Productivity per unit area is very low in this system, yield is limited to 500 Kg to 2000 Kg/ha and survival is also low. The labour and investment costs are low, Fish seed is the only major investment in this system.

Semi-Intensive Fish Farming System (Medium Input System):

Semi-intensive fish culture system is more prevalent and involves rather small ponds (0.5 to 1 hectare in area) with higher stocking density 5000 to 7500 fish/ha (0.5 to 0.75 Fish/m^3). In this system care is taken to develop natural foods by fertilization and supplemental feeding like Rice bran and oil cakes are provided. However, major food source is natural food. Yield is moderate, 3000 to 7000 kg/ha and survival are high. Proper pond preparation, appropriate stocking density, supplementary feeding water quality monitoring are implemented in this system.

Intensive Fish Farming System (High input system):

Intensive fish farming system is the well-managed form of fish farming, in which all attempts are made to achieve maximum production of fish from unit area. This system involves small ponds/tanks/raceways with very high stocking density ranging between 10,000 to 15,000 (10-15 fish/m^3 of water). Fish are fed completely formulated feed. Good management is undertaken to control water quality by use of aerators and nutrition by use of highly nutritious feed. The yield obtained ranges from 9500 to 14500 kg/ha or more. Although the cost of investment is high, the return from the yield of fish exceeds to ensure profit.

Once you narrowed down which farming system you are going to adapt the next step is selection of culture species.

3.0.2 Selection of Fish Species:

Criteria for Selection of Fish Species for Aquaculture

Profitable fish culture aims at production of maximum quantity of edible fish flesh form a given quantity of organic matter in the shortest possible time. Therefore, the species selected for culture should have certain essential qualities like

1. **Fast growth–** Fishes which grow to big size in a short period of time are the most suitable for cultivation. E.g., Indian major Carps. (Attain marketable stage in a reasonable time 6- 8months)

2. **Short food chain–** Fishes with short feeding chain are ideal. This will help to reduce the loss of energy from the passage of

one link of production to the next. Because at every tropic level, there is loss of 90% of the energy. Fishes feeding on detritus, plankton or vegetation have additional advantage of being tolerant of other species in a pond.

3. Efficient food conversion– The selected species should be able to assimilate the nutrients received through food to the maximum possible extent and should be able to convert them into biomass or fish protein.

4. Accept external feed- In order to obtain a high production rate from unit area, it is necessary to rear those fishes which accepts and efficiently utilises supplementary feeds or formulated artificial feeds.

5.Adaptation to climate- This is an essential condition which limits the use of both cold and warm water species. Salmonids which are cold water species cannot tolerate warm water. Similarly warm water species like Tilapia spp, Indian major carps etc., can't tolerate the cold climates of temperate countries.

6. Resistance to common fish diseases and parasites-

7. Consumer preference and market demand- It is absolutely essential to bear in mind the consumers liking, when a species is selected for culture, because the last step in a successful culture is to sell the fish at a profit. In some markets consumers prefer bony fishes based on their food tradition. Some markets prefer boneless fish meat. Some markets look at delicacy but not the price, but some markets consider price per volume of meet. You also need to consider which species fetches best farmgate price with least possible investment in your market and can it be grown in your farm with the available infrastructure and resources.

8. Low cost of production- Ultimate profitability of fish farming operation depends upon the production cost per kg fish production, it encompasses each and every cost component in the culture operation. The lesser the production cost per kg fish production the better the profit. Never assume that low cost of production can be attained only by resourcing cheaper inputs, value for money matters, make sure that you get right quality for right price.

Ok, now you selected the culture system and learned about the considerations that you need to make for the selection of culture species, now it is time to learn about the criteria for selection of quality seed that you planned to stock in your pond.

3.0.3 Fish Seed Selection Criteria – Sourcing:

Fish seed is the small sized fish which is stocked in ponds to make it in marketable size fish. Fish seed refers from hatchling life stage to fingerling stage.

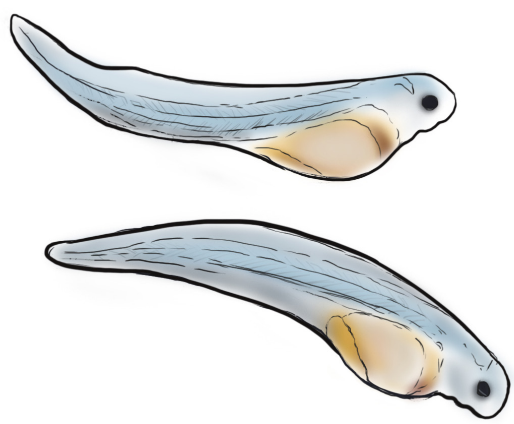
Hatchling – Spawn – Fry – Fingerling

Hatchling:

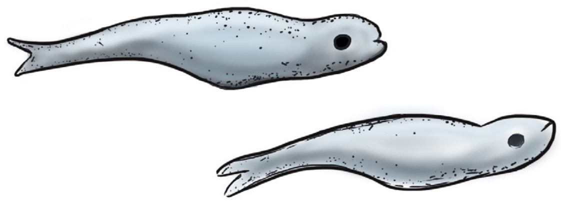
The larvae emerging from the fertilized eggs after hatching is called hatchling. It is characterized by the presence of yolk sac hanging below from where it draws its nutrition for 2-3 days. At this stage the mouth is not formed and hence it does not take food from outside.

Spawn:

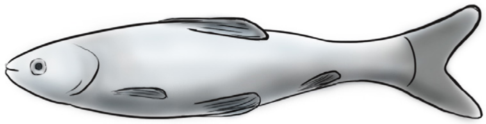
As soon as the yolk sac of the hatchling is absorbed it is known as spawn. At this stage the mouth is formed, and it starts taking small zooplankton like rotifers and supplementary feed like egg yolk, finely powdered oil cake, rice bran etc.



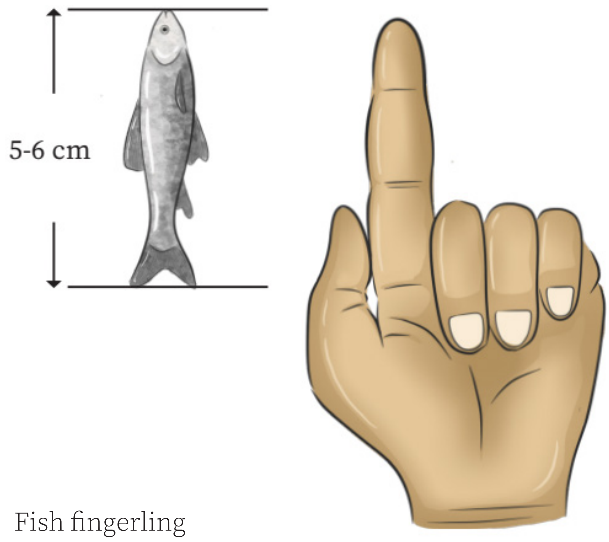
Fish hatchling



Fish Spawn



Fish fry



Fish fingerling

Fish hatchling, fish spawn, fish fry, fish fingerling (Indian major carp)

Fry:

As soon as the spawn assume the shape of the fish and grow to about 1-2cm it is known as fry. At this stage they are primarily smaller size zooplankton feeder. It takes about 7 to 10 days for spawn to grow up to fry stage.

Fingerling:

As soon as the fry grow up to 10-15 cm size or roughly equal the size of a finger it is known as fingerling. Fingerling is the proper size for stocking in table fish production ponds. It takes about 30-60 days for the fry to grow up to fingerling size.

- Fish seed sourcing from a good hatchery source is important as it is the key input determining production.
- Source the fish seed preferably from a certified hatchery (if available) or from a reputed hatchery using good breed, following good brood stock management, hatchery practices (no mixed species breeding) and seed rearing techniques.
- It is always preferable to visit seed supplying hatchery prior to seed selection, assess the quality standards, observe the management practices and tray to find out whether they are following ideal hatchery management SOP's.
- If your seed requirement is only in small quantities, it is preferable to get from nearby hatchery for easy transportation and reduce cost of transportation.
- Avoid seed from mixed breeding hatchery as this may be a mix of two different species.

3.0.4 Identification of Good Quality Seed:

What Do We Mean By Seed Quality?

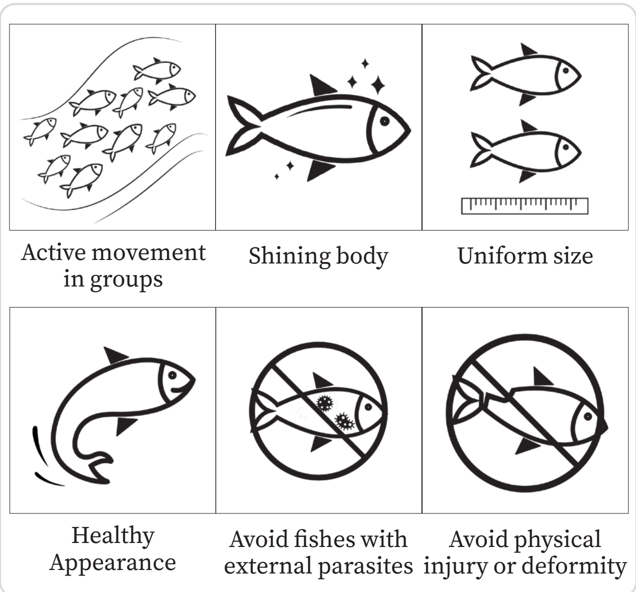
Seed quality is that which optimizes the potential for aquaculture production and is related to the quality of the brood stock used and the seed produced. "Seed" can mean eggs, milt fry, fingerlings or nursed animals. The quality considerations are those which meet the expectations and demands of the producer (grow-out operations) and the final consumer of the end product. There are marked differences in priority and importance of quality criteria according to the systems for which they are intended (e.g., intensive system of small-farmer, extensive systems).

The Parameters for Quality Assurance may include the following:

On field observations to identify good quality seed are mentioned in the following table.

Good quality	Poor quality
Body colour bright and glossy	Dull body colour
Slippery scales	Scales are rough
No marks on body and gills	Red marks on the body and gills
If tail is held in a pinched manner, then head moves quickly	If tail is held pinched, then moves head very slowly
Very agile in movement	Does not move and moves with current if water is stirred in container
Normal body structure, no deformities	Body structure is not normal, can observe body deformities
No physical injuries	Body with physical injuries
Free from external parasites	External parasites on the body or on the gills
uniformity of size and age	More size variation

Table 10: Seed quality identification



Identification of good quality seed

To identify a healthy fish, one should have minimum knowledge about the physical characteristics of Fish

The major body parts of all fish perform the same functions, and they are located in about the same places on any different fish's body. But the size, shape, and color are often different, and these differences help tell the fish apart. Knowing a healthy fish look is important. All fish have a tail consisting of the ***caudal peduncle*** and ***caudal fin***. The fins help the fish to steer through the water and hold it upright in the water. Often a sick fish cannot steer or flops over on its side.

Other fins on the body include:

- **Pectoral fins:** Usually located on the sides of the fish behind the head.
- **Pelvic fins:** Usually located towards the rear of the body where the hips would be if the fish were a four – legged animal.
- **Dorsal fin:** Runs along the top of the fish. May be single or double. The second dorsal fin is sometimes called the soft dorsal fin.
- **Anal fin:** Usually located right behind the anal vent (anus) on the rear bottom end of the fish.

All fish have **eyes** and **gills.** The gills are covered by a flap called the **operculum.** Fish can see, but they cannot see very well. The gills are extremely important. Fish take in water through their mouth. The water is then passed through the gills which remove the oxygen and nutrients from water. The water is then passed outside of the body of the fish through the gill slits.

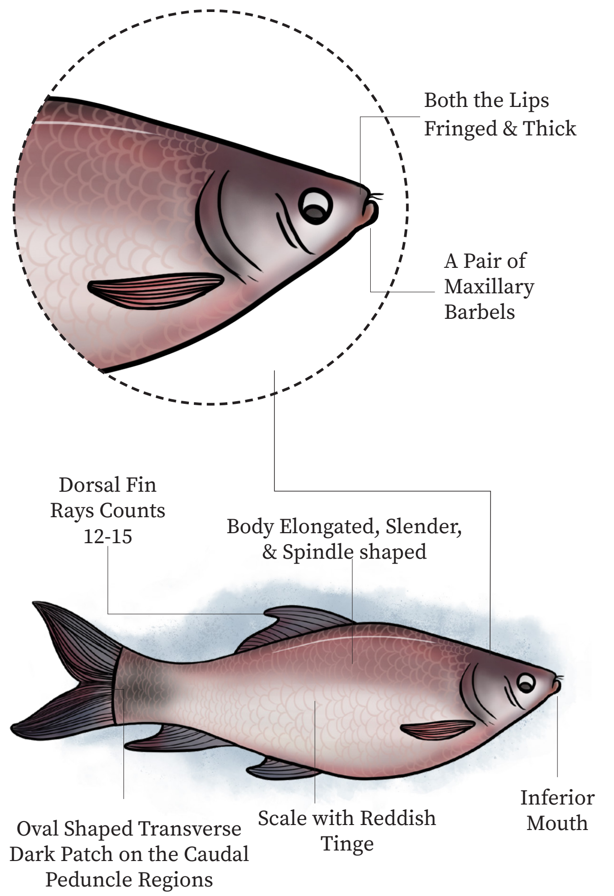
It is possible to tell a lot about a fish's health and eating habits by looking at its gills. Fish with many feathery gill rakers and few if any teeth eat the smaller foods in the pond. Fish with few and larger gill filaments eat the larger particles from the pond. **Healthy gills are bright red color.** If the farmer sees fish with gills that do not have this healthy red color, or have white spots all over, for example, they will know that fish is not healthy and should not be bought or placed in their pond. Or if the fish is already in their pond, they know they must take steps to get rid of the disease before it troubles more fish.

Other identifying parts that all fish have are the **mouth, the genital openings** (to reproductive organs), and **the lateral line.** The lateral line is a small line of nerve cells which runs along the length of the body. Sometimes it is a different color than the rest of the body. In any case, **the lateral line is an area of sensitivity that helps the fish feel pressure and temperature changes in the water around it.**

Some fish, like catfish, also have barbels, small projections that hang down from the sides of the mouth. **Barbels** help the catfish sense its surroundings, find food, and attract small fish to the catfish so that it can eat them.

When the farmer goes to buy fish, they must already know what healthy fish look like. It is very important that they be as familiar as possible with each of the fish they decide to raise. They must know the characteristics of that fish and its life cycle, its eating and breeding habits, etc.

The farmer who begins any fishpond enterprise without having this kind of information is inviting failure. And if it is a new venture, it is particularly important that the farmer's first effort be as successful as possible. Fish seed should be screened through 10% salt solution test.



Fish body parts

Recommended treatment dosage is 10 percent common salt. Take a plastic barrel containing 10 liter water; you will need 0.10 x 1000 x 10 l = 100 g salt.

Containers with measurements are available-500 ml/1 lir-we can say 10gm salt/ one lts jar/mug etc., -Yes, salt can be weighed once put it in spoon or small cups and show 10 gm is one spoon or two spoons or small cup etc- This can be trained by CRPs

3.1 Species Stocking:

It should be clear by now that much of the success of a fishpond depends upon careful planning. Before the farmer could build the pond, it was necessary for them to think through why they wanted the pond, for their own consumption, for profit or both, what kind of culture system they wants to adapt based on the available resources and funding, what kind or kinds of fish are best suited for their pond condition, climate, market and financial objectives.

When selecting a species to grow in an aquaculture system, there are a variety of factors to consider to ensure you are choosing a species that will do well in a controlled environment and is also marketable. Some of the more important characteristics to consider include nutritional needs, reproductive habits, disease resistance, stocking density, ability to succeed in polyculture, and marketability Species combination primarily depends on the consumer/market demand and availability of seed of required species at right time in required quantity.

Now with the pond constructed, fertilised and otherwise prepared for the fish growing, the farmer is ready to put the fish into the pond and get to the business of fish raising.

3.1.1 Stocking Size and Density:

• Stocking is the word used to describe the act of placing the fish into the pond. The stocking density is used here to refer to the total number of fish which can be put into the pond.

• Stocking ratio is the term used to refer to the ratio of different compatible fish species which are put together into the pond. Therefore, in monoculture pond the stocking ratio is the same as stocking density. In case of polyculture these two terms hold different meaning.

• Stocking ratioe and stocking density are important. There is only limited food and space is available in the pond to a certain number of fish in your pond. If supplementary food is not provided, proper stocking ratioe and stocking densities needs to be planned well.

Generally, fish production increases with the increase in the number of fish stocked per unit area to a maximum and then starts decreasing. There is always an optimum stocking ratio and stocking density in a particular situation, which gives the highest production and largest fish. Under crowded condition at a higher stocking density fish may compete severely for food and thus suffer stress due to aggressive interaction. Fishes under stress eat less and grow slowly. By increasing the stocking density beyond the optimum rate, the total demand for oxygen increases with obvious dangers, but no increase of the total yield of the fish is obtained. Stocking density and stocking ratio of fishes should be on the basis of the quantity of water, natural productivity of the pond, availability of natural food for fish and the amount of oxygen production.

Farmer also needs to understand how they can utilise the natural productivity of their pond completely and attain maximum productivity per unit area in a sustainable manner. For that they needs to understand what type of natural food sources for fish are available in their pond, what are they, how they are going to be utilised by different classes of fishes without competing with each other for food, space and resources.

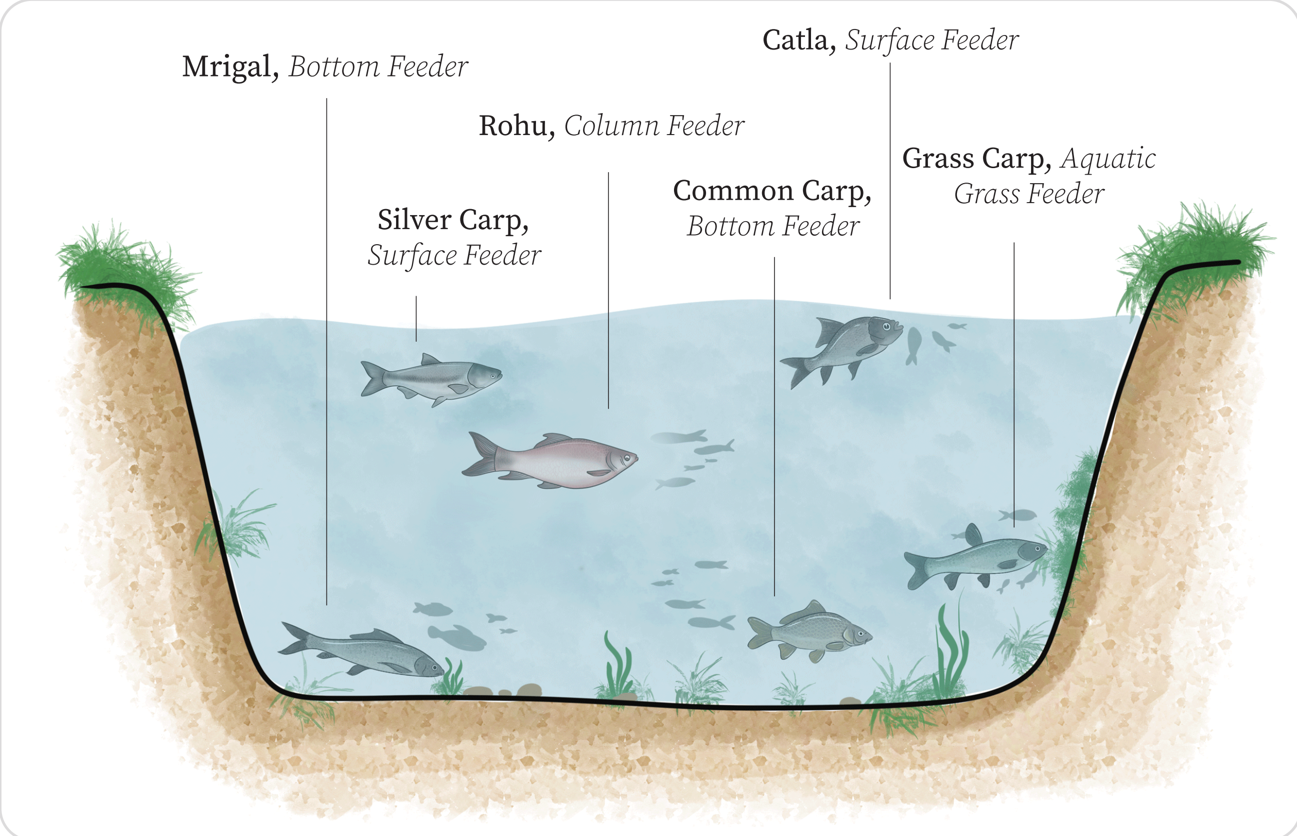
Regardless of their size and shape, all fishpond habitats have four main biotopes where different organisms can live and develop.
In ponds these organisms are, directly or indirectly, the natural food of the cultured fish. The biotopes of pond habitat are the water surface, the water column, the pond bottom and the periphyton. Pond water is connected to the atmosphere through the water surface. It offers limited quantity of natural fish food, discounting the invasive gradations of aquatic or terrestrial insects when they became abundant in this biotope of the pond. The bulk of the natural fish food organisms in the water column of fishponds are the plankton. The phytoplankton and zooplankton contribute directly to the diet of the different species of the polyculture. Besides phytoplankton and zooplankton, the role of the bacterioplankton is also important in fishponds. This group of living organisms participates in the processes of both composition and decomposition. The bacterioplankton has a significant role in nitrogen fixation, nitrification, denitrification, remineralization, etc. The bacterioplankton serves directly as a food source of other planktonic organisms and their colonies are consumed directly by some of the fish. The pond bottom is another important biotope in carp ponds, as different fish food organisms live and develop there. Moreover, the detritus and the bacteria, ciliate, etc., that develop in the detritus also serve as natural food for common carp, etc. Water weeds which grow on the pond bottom serve as natural fish food for grass carp. Periphyton or biological cover is the collective name of organisms which live on the surface of the submerged objects and macro-vegetation in a pond. These are bacteria, algae, moss and animals of different sizes. Though periphyton is less frequently mentioned as an important source of natural fish food, it may still provide a considerable quantity of food for some of the fish of pond polyculture.

	Habitat Biotopes	WATER SURFACE (Aquatic or terrestrial insects)	WATER COLUMN (Plankton, bacterioplankton)	
FEEDING PREFERENCES		Insects	Phytoplankton	Zooplankton
Herbivorous			Silver carp **	Silver carp *
Omnivorous		Rohu*, Nile tilapia* Mozambique tilapia*	Rohu* Catla* Nile tilapia** Mozambique tilapia** Common carp* Bighead carp* Mrigal*	Rohu* Catla** Nile tilapia** Mozambique tilapia* Common carp* Bighead carp**
Carnivorous		Pangasius spp** Rainbow trout**		Clarias spp*

		PERIPHYTON (bacteria, algae, moss, animal of different sizes)		
FEEDING PREFERENCES		Macrophytes	Biological covers	Filamentous algae
Herbivorous		Grass carp** Puntius javanicus** Silver carp [Dec]		Puntius javanicus*
Omnivorous		Nile tilapia* Mozambique tilapia* Common carp [Dec] Mrigal [Dec]	Rohu** Nile tilapia* Mozambique tilapia** Common carp*	Catla* Mrigal**
Carnivorous				

		POND BOTTOM (Detritus, bacteria, ciliate, water weeds)			
FEEDING PREFERENCES		Bottom fauna	Bottom detritus	Molluscs	Fish
Herbivorous			Silver carp *		
Omnivorous		Nile tilapia* Mozambique tilapia* Common carp**	Rohu** Catla Dec Nile tilapia* Mozambique tilapia* Common carp** Mrigal**		
Carnivorous		Clarias spp**	Clarias spp*	Clarias spp* Rainbow trout*	Clarias spp** Pangasius spp** Rainbow trout*

Table 11: Feeding zone and major feeding habits of different species in a pond
*: From relatively less important (*) to more important (**).
[Dec]: Decayed material from macrophytes.



Feeding zones of different species

Monoculture or Polyculture?

Farmers need to decide whether they prefer to culture one species or multiple species in their pond. For this purpose they need to understand about both the systems, their pro and cons.

Monoculture:

Monoculture is the culture of a single species of fish in a pond. If only one species is introduced into a pond, due to the same dietary habits, all the fish congregate at one place. Naturally, when monoculture is preferred, more number of fish of one species are introduced.

The advantage of this method of culture is that it enables the farmer to make the feed that will meet the requirement of a specific fish, especially in the intensive culture system. Fish of different ages can be stocked thereby enhancing selective harvesting. But this results in high competition for food and space. Due high density, water quality management, disease prevention, provision of proper nutrition must be well taken care otherwise heavy mortality of fish might occur. In monoculture systems other niches are vacant and in that area and the available food in these niches remains wasted.

Commonly cultured fish species under monoculture method:

Common carp
Tilapia
Pangasius
Rainbow trout
Channel catfish (Ictalurus punctatus)
Catfish (Clarias gariepinus)

Polyculture:

Polyculture is the practice of culturing more than one species of aquatic organism in the same pond. The motivating principle is that fish production in ponds can be maximised by raising a combination of species having different food habits. The mixture of fish gives better utilisation of available natural food produced in a pond.

Species of fish for polyculture and their practical classifications

One of the main characteristics of pond polyculture is rearing together fish species which have partly or entirely different food spectrums and feeding habits. This ensures that all kinds of natural fish food organisms which develop in different biotopes of a pond will be exploited properly.

Fish species can be classified according to many different aspects. Science uses the taxonomy of fishes, which arranges the species into genus, family, subfamily, order and class. Out of these, only the order, the family and the common and scientific names are widely quoted for the sake of exact identification of a fish.

Besides the scientific classification, there are other practical groupings of fish which can be classified as mentioned in the following table:

Practical grouping	Classification				
Proportion & position in the polyculture	**Main Fish**	**Additional Fish**	**Trash Fish**	**Fed Fish**	**Unfed fish**
Final use of Fish	Food Fish	Sport Fish	Ornamental fish	Bait Fish	
Economic Importance	Expensive Fish	Cheap Fish	High Value Fish	Low Value Fish	
Food Spectrum	Herbivorous	Carnivorous	Detrivorous	Omnivorous	
Biotype	Surface Feeder	Column Feeder	Bottom Feeder	Periphyton Feeder	
Feeding Habit	Filter-Feeding	Grazing	Predatory		
Temperature	Cold Water	Warm Water	Tropical		

Table 12: Practical groupings of fish

Farmers also needs to be aware of these classifications so that they can make right selection of species for their polyculture farming operation.

The economic importance is the most subjective aspect from the ones listed above as it varies considerably from region to region. The food spectrum, feeding habit or proportion and position in the polyculture are aspects of grouping which provide biological and/or technological information on the species.

Determination of Stocking Density

The number of fingerlings to be stocked depends on the type of farming practice, Monoculture or Polyculture, Extensive (low input), semi-intensive (medium input) and intensive (high input) culture systems. All the three types are in practice depending on the pond size, water depth, availability of external inputs like feed and also the investment and managerial capacity of the farmer.
The farmer must know how many fish they wants to put into their pond so that they can get the right number from the seed sourcing point. They should also remember that there is a possibility that some seed might not be able to survive until the end of culture cycle, which is called as mortality. They need to have an estimation of this mortality loss % so that based on their targeted production plan they need to decide the total number of seed that they need to stock in their pond. Stocking density of fish depends on type of water body, earth type, depth, culture method and management, culture species selected, target body weight of the fish, and carrying capacity limitations of the selected culture system.

Other criteria to take into consideration include:

- Stocking density also depends on what size of fish you wish to harvest. If of same size then if stocking density is low then the fish will grow faster than when stocked at high density.
- If it is a new pond, then fish inhabiting top layer should be more and in case of older ponds, fish that feed in the bottom layer of the water body should be more.
- In shallow ponds where water is present for only 5-6 months, it should be stocked with fast growing fish such as tilapia, silver carp, Cyprinus carpio fish etc.
- Within the same stocking density if different sizes of fish seed are released then at time of harvest different sizes of fish will be harvested.

Suggested stocking size and density for different aquaculture systems

Culture System	Preferred Size at Stocking	Water Depth	Stocking Density/ha	Anticipated Fish Production/ha
Low input system (Extensive)	Fingerlings(8-10cm)	1-1.5 m	2500-3000	2-3 tons/ha
Medium input system (Semi intensive)	Advanced (10-15 cm) fingerlings	1.5-2 m	5000-7500	5-8 tons/ha
High input system (Intensive)	Fish weighing 50-100g (stunted fish of 5-6 months old)	2-2.5 m	15000-20000	10-15 tons/ha

Table 13 : Suggested stocking size and density for different aquaculture systems

3.2 Species Composition:

When selecting a species to grow in an aquaculture system, there are a variety of factors to be considered to ensure that you are choosing a species that will do well in a controlled environment and is also marketable. Some of the more important characteristics to consider include nutritional needs, reproductive habits, disease resistance, stocking density, ability to succeed in polyculture, and marketability. Species combination primarily depends on the consumer/market demand and availability of seed of required species at right time in required quantity.

The technology of aquaculture has seen major changes over the years with incorporation of compatible medium and minor carps (Puntius gonionatus; fimbriatus) and small indigenous species (SIS) such as mola in small quantities in major carp based production systems and also number and varieties of species used in poly culture system. Recently two genetically improved strains of rohu (Jayanthi Rohu) and Amur common carp are finding place in carp polyculture system.

Select fish species that are compatible to each other and do not compete for space and food in the pond ecosystem and carps meet most of the requirements as good species for aquaculture. Manipulation of species combination and ratio to avoid competition for food and space at different trophic level will help in efficient utilization of pond food resources.

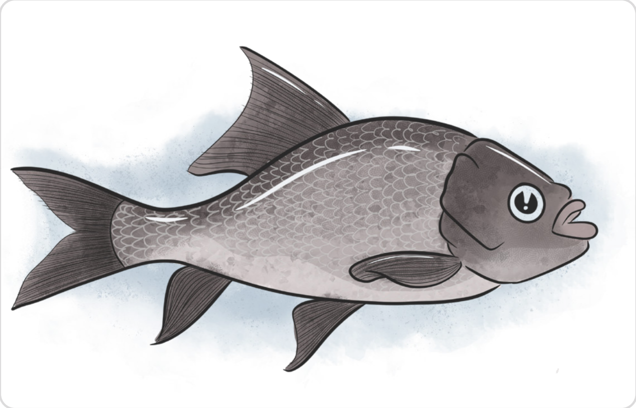
Suggested Species

Carps meet most of the criteria of suitable aquaculture species and hence carps are the most commonly grown species across all forms of farming systems using Indian major carps (IMC) are major species, either alone or in combination with exotic carps and a few selected locally available indigenous species for efficiently utilizing available food resources in the pond. A proportion of 30-40% surface feeders, 30-35 % column feeders and 30-40% bottom feeders is the ideal combination for rational utilization of pond food resources. A few different combinations are suggested below, and the former can decide the combination according to their choice based on the pond productivity, seed availability and managerial capacity.

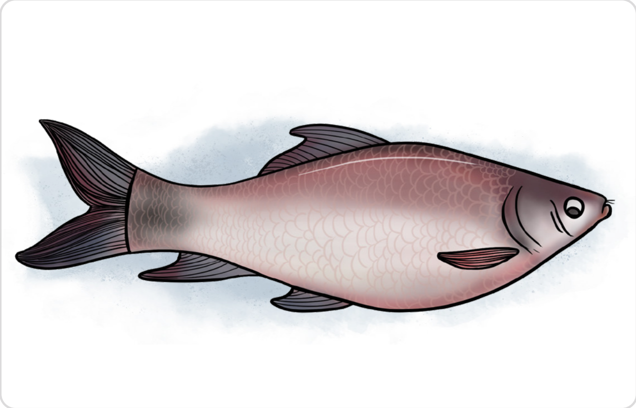
Options of different species combinations and proportions.

Species (Scientific name)	**Common English Name**	**Vernacular Name** (if any to be added)	**Feeding Zone**	**Feeding Habit**
Major species				
Catla catla *Latest- Labeo catla*	Catla		Pond Surface Area	Zooplankton Feeder
Labeo rohita	Rohu		Pond Column Zone	Feeds on algae and dead & Decaying Organic matter
Cirrhinus mrigala	Mrigal		Bottom Zone	Diatoms & algae; semi decayed vegetable matter
(Hypophthalmichthys molotrix)	Silver carp		Surface Area	Phytoplankton
Ctenopharyngodon idella)	Grass carp		Surface, Column and Marginal areas	Herbivorous-aquatic and terrestrial plants
Cyprinus carpio	Common carp		Bottom zone	Omnivorous
Labeo gonius	Silver barb??			
Cyprinus carpio Vr	Amur common carp (Genetically improved variety)		Bottom zone	Omnivore & accepts external Feeding
Additional species/varieties that can be used based on the need or specific requirements/demand based				
Labeo rohita	Jayanthi Rohu (Genetically improved species)		Column zone	Detritus feeder and plankton
Cyprinus carpio	Amur common carp (Genetically improved species)		Bottom zone	Omnivore
Amblypharyngodon mola	Mola		Column/ Bottom	Plankton Feeder
Labeo gonionatus	Silver Carp		Column Feeder	Detritus & Plankton

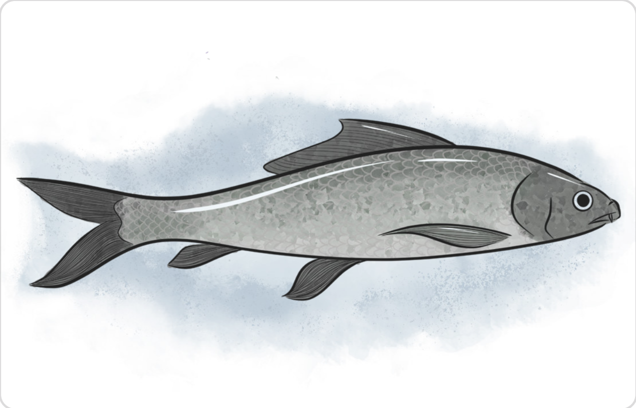
Table 14: Options of different species combinations and proportions



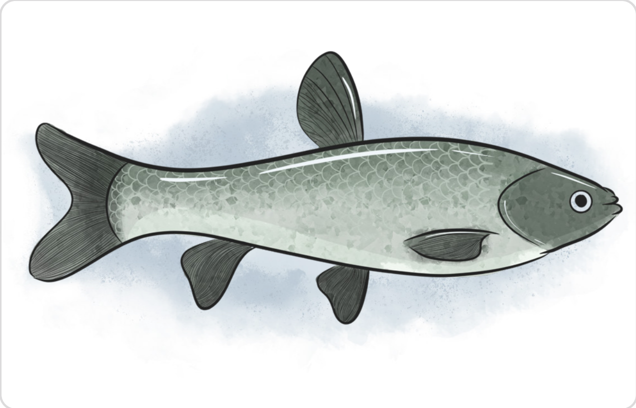
Catla *(Catla catla)*



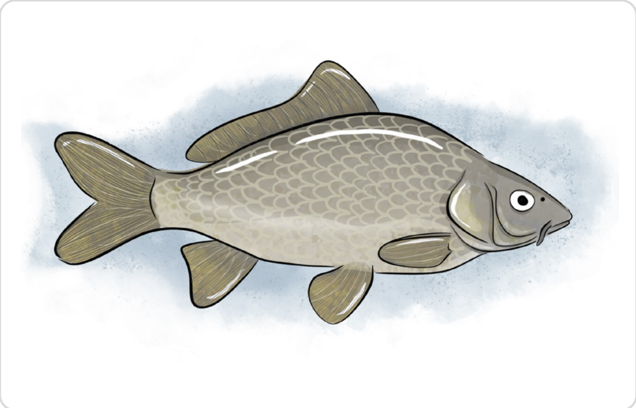
Rohu *(Labeo rohita)*



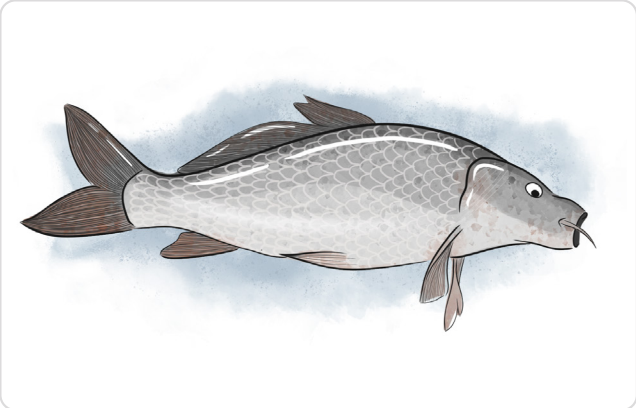
Mrigal *(Cirrhinus mrigala)*



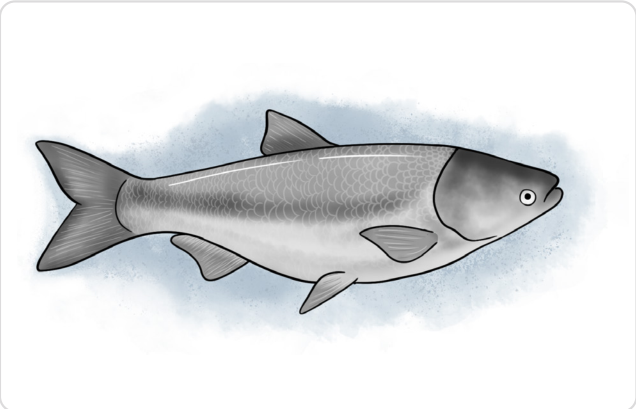
Grass Carp *(Ctenopharyngodon idella)*



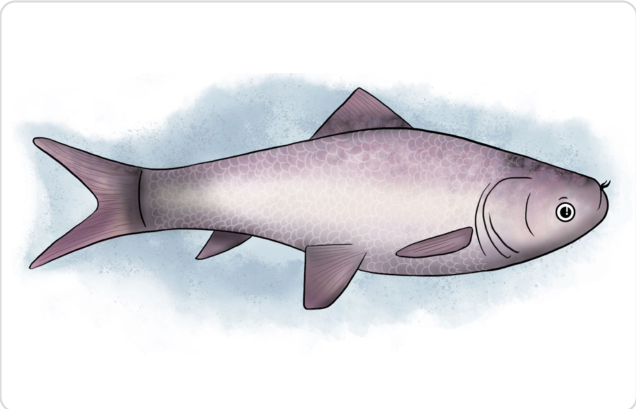
Common Carp *(Cyprinus carpio carpio)*



Amur Common Carp *(Cyprinus carpio)*



Silver Carp *(Hypoptholmichthys molitrix)*



Jayanthi Rohu *(Labeo rohita)*

Fish Species

Combination and stocking ratio options

Species Combination	Species	Stocking Ratio	Remarks
2 Species	Catla and Rohu	50 :50	They can utilize both phyto and zoo plankton efficiently
3 Species (Only IMC)	Catla, Rohu and Mrigal	30 :40: 30	This is the best combination for efficient utilization food resources in the pond
3 Species (Only Exotic Carps)	Silver Carp Grass Carp and Common Carp	40:30:30	In this combination there is no species that can utilize zooplankton
4 Species	Catla, Rohu, Mrigal and Common Carp	30:40:15:15	Use of bottom feeders need based
6 species (Most recommended subject to availability of seed of all the species and feed for grass carp)	Catla, Rohu, Mrigal, Silver Carp, Common Carp and Grass Carp	30: 40: 10: 5: 10:5	Grass carp will be a good choice if aquatic plants are present in the pond as it can control excessive growth of aquatic plants in the pond
Species like Jayanthi Rohu, Amur common carp, mola can also be included by replacing/reducing the proportion of species having similar feeding habit and have good consumer demand. Ex. Ex. Jayanthi Rohu and Amur common carp can be used along with normal strains at 50%. Mola can be used in small quanutites-5% along with major carps			

Table 15: Combination and stocking ratio options

3.3 Transportation of Fish Seed:

Transport of fingerling is a critical aspect for the survival of fish to be stock. Fingerlings require proper care during transportation to minimize transportation loss. If fish are roughly handled, they will lose their scales and/or mucus covering their body. Their organs also will be injured. These wounds can easily be infected and will cause slower growth, retardation, or later, even death. Finding good quality fingerlings, transporting and proper stocking procedures are necessary for ensuring good production. The farmer and hatchery/nursery operator must make all materials and equipment readily available on site prior to transport.

3.3.1 Preparations for Transportation:

Proper preparations are required for transportation both at the packing place (hatcheries/seed rearing farms) and receiving place (fishponds to be stocked) and these apply for both short distance and long-distance transportation of seed.

The Preparation at Packing Place:

• Fish seeds should not be fed for 24-48 hours before transportation as they survive better on empty stomach when in transit.

• Keep all the materials required ready for packing - Oxygen cylinder, packing bags/containers and other accessories

• Collect the fingerlings from the pond during cool hours (very early morning or late evening) condition them either in hapas or small cement tanks with clear well aerated water free of plankton.

• Condition the fingerlings minimum of two hours before packing to keep the stomach empty, minimize the metabolic rate and oxygen consumption during transportation.

• Observe the seed and remove any dead fish and week ones. ***(Refer 3.0. 4 Identification of good quality seed)***

• Pack during cool hours (very early morning or late evening)

• Count the fingerlings using premeasured scoops 3 or 4 and take the average numbers/weight per scoop and this will be base for calculating number or weight of the fingerling for packing purpose.

• Sanitize the vehicle/container and the materials used for transporting using $KMnO_4$

• Cover the top of the vehicle/container to avoid fish jumping out
• During long travel, exchange water partially for every 200 km is desired.

Conditioning of Fish before Transportation

Spawn, fry and older fish for long transportation have to be prepared or conditioned. The fish seed are kept starving usually in a cloth 'hapa' or other containers in a quiet corner of the fishpond or in relatively quiet water in a canal or river for a period of time before transferring them to the transport carrier.

The advantages of conditioning fish thus are:

• The fish become used to confined condition.
• The fish are less excited and thus restrained in expenditure of energy.
• The fish recover from the handling effect of capture - increased blood lactate level and decreased blood pH become normal - excited high metabolic rates (O_2 consumption, CO_2 production, N-excretion) become normal.
• The fish recover from minor injury - mucus loss etc - Ion-osmotic balance upset by handling becomes normal.
• Gut evacuation takes place and during the period of transport the medium is not further contaminated by faecal matter.
• Since the fish are starved there is exhaustion of available glycogen, and this considerably reduces the chance for accumulation of high amount of lactic acid in blood during transport and consequent acidosis and collapse.

Further knowledge about conditioning:

• It must also be mentioned that the recovery and well-being of the fish under conditioning would indeed help increased survival, but the rigours of transport are different, and these can again cause stress and strain on fish and cause mortality as already explained.
• The most common method of conditioning is to store fry in a cloth 'hapa' in ponds or in a still part of a river or canal. The period of conditioning depends on the size and health of the spawn (hatchling), fry and fingerlings.
• In general, a conditioning period of 6 – 24 hours would suffice for all species of fish - longer conditioning period should be given specially in cases where stress due to capture and subsequent handling is high.
• A point often ignored is that there is considerable ion-osmotic stress on all fish due to handling and in freshwater fish considerable amount of salt from the body is likely to be lost due to capture and handling. Addition of a little amount of NaCl in the ambient medium especially in the case of tilapias, might be of advantage, but the system has to be sufficiently modified since conditioning is often done in open waters.
• Various types of conditioning containers are used, namely boxes made of wire meshes, bamboo or cane wicker work; barrels or boats with perforated bottoms; temporary enclosures made of netting or bamboo matting, cloth 'hapa' etc - any of these materials available conveniently may be used.
• The temperature of the conditioning water should not be high - it should be preferably on the lower side of the optimal thermal range for the species.
•During conditioning and transportation fry and fingerlings should not be handled with bare hands - the slime over the fish body should remain intact. The loss of slime and scales would render the fish disadvantageous in maintaining osmotic balance and also fish are likely to get infected.

Materials and Equipment needed for Transport of fish:

• Polythene bags/ containers
• Ice cubes/chips in a coolant
• Water
• Equipment: buckets, bowls, scale, scoop nets, Oxygenated cylinder and accessories.
• Sheathed Fish Transport truck with O_2 cylinders (motor vehicle, boat etc.)
• Record book

Fish seed conditioning process

Grading and Pre-Packing

• Grade fish seedlings as per size and species, if possible, using suitable means of sieve or manual isolation to pack size and species wise separately so as to reduce disturbance due to inter-species and sizes during their transport and help their easy identification or categorical stocking in different ponds.

• Stocking fingerlings with wide size variations is often undesirable in order to achieve uniform growth and sizes of stocked fishes.

• Usually, common carp (Cyprinus carpio) and air breathing catfishes (Clarius spp.) are hardier and more flexible for transport in higher density or under minimum oxygen pressure.

• The hardiness of fish seeds of other species is in the order of catla (Catla catla) > mrigal (Cirrhinus mrigala) and rohu (Labeo rohita) > grass carp (Ctenopharyngodon idella) > silver carp (Hypophthalmichthis molitrix).

• Give more attention during the transport of less hardy species. Retain weak fishes in source itself or eliminate from the transport consignment since stressed fishes and seeds die quickly either during transport, stocking or soon after stocking and become source of microbial infection.

• Give a brief bath to fish seeds in diluted (1-2 parts per million) potassium permanganate (KMnO) before packing for disinfection. Addition of 0.3-0.5% sodium chloride (NaCl) or calcium chloride (CaCl) salt to transport water reduces handling stress and later-stage mortality in transported fishes.

Sampling And Quantification of Fish Seeds

• Take 3-4 random samples by volume using a small, perforated cup to count the number of seedlings per cup and to determine number of cups per bag or consignment required fort transport.

• Sometimes, random sampling of fish seedlings is done on weight basis to determine number of seeds per given weight, say 200 seeds counted in 100 gm weight and a total of 8 kg seeds packed or transported to get 16000 number of seeds.

• Weight based sampling gives a chance to account water and sampling error while weighing since it is done quickly before water drains out fully. Volume based sampling is preferred over the weight-based sampling since the latter is stressful to fishes as well.

Use of Chemicals in Live Fish Transport

Drugs and chemicals are either used as tranquilizers and sedatives or as antiseptics and antibiotics. Generally, anaesthetics are used for fish transport to reduce metabolic rates, mainly oxygen consumption and excretion of carbon dioxide and ammonia, for reducing excitability of fish and injury, and for convenience in handling fish. The sedatives and drugs have to be used very carefully, for slight increase in dosage and/or exposure time can cause irretrievable loss of fish.

If partial sedation is preferred to avoid jumping and stress during transportation- can use (Tricaine methane sulphonate) **Ms222 @ 5ppm or Sodium amatol @ 50-100 ppm.**

Please use any chemical with prior advise from your consulting Fisheries expert or fish diseases expert or your local fisheries department official.

Use of antiseptics and antibiotics

A prophylactic bath of fry and fingerlings in the following chemicals is recommended while handling the fish prior to transport, for prevention and spread of diseases - pathogens and parasites.

Commonly used chemicals and their doses are indicated below,

Sodium chloride- 3%
Potassium permanganate- 3 ppm

Please use any chemical with prior advice from your consulting Fisheries expert or fish diseases expert or your local fisheries department official.

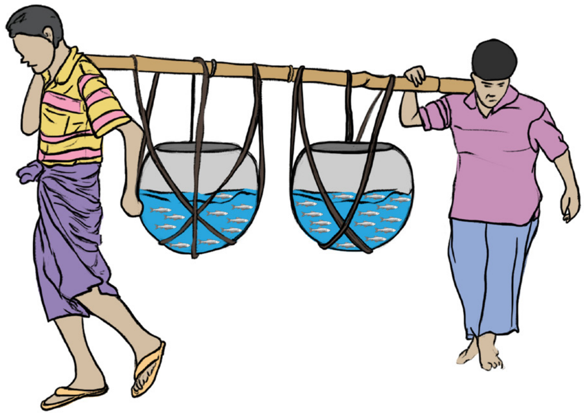
3.3.2 Methods of Transportation:

Transport Carriers are of Two Types:

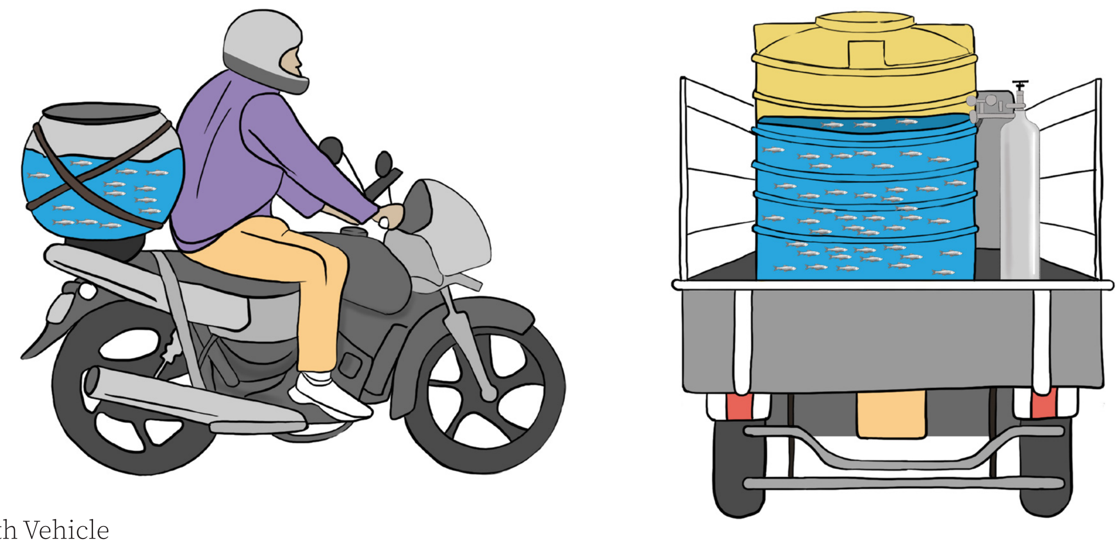
(1) open system comprising open carriers, with or without artificial aeration/ oxygenation/water circulation and (2) closed system having sealed airtight carriers with oxygen.

3.3.2.1 Open System:

Fish is transported in open vehicle or container fitted in a vehicle and provided with equipment for continuous oxygen supply during transport and normally used for short distance that can be covered in few hours and when large quantities of seed are to be transported.



On foot



With Vehicle

Open system of fish seed transportation

The simplest transport carrier is the earthern vessel, such as the traditional "Hundi" used in Bengal in India. The earthern hundi is now being replaced by aluminium vessels which are unbreakable, but the earthern hundies have the advantage that they keep the temperature of the water inside cool by means of evaporative cooling.

The earthern vessels are filled with water of the same source as that of the fry. In traditional transport in India, about 60 g of finely pulverized red soil is sprinkled over the water surface in the transport vessel and the vessels are shaken periodically during transport. The addition of red soil coagulates the suspended organic matter and keeps down the zone and extent of pollution. During transport, the bottom sediments are periodically removed by mopping them up with a rough cloth rope - the water is also partially renewed depending on the need. The addition of red soil and change of water permit transport of fry up to a duration of 30 hours. Besides pulverized earth other absorbent substances such as activated charcoal and 'Amberlit' resin can be also used as these absorb carbon dioxide, ammonia and other substances from the medium.

Aluminum Vessels or Metal Containers:

As already mentioned, the improved metal containers are better than the earthern carriers only because they are not breakable. The metal containers used are round vessels with a wide mouth, which can be closed with perforated pressed-in lids. To prevent denting and perhaps more to effect insulation, wooden covers are used on the metal containers. Larger containers mounted on motor vehicles have also been in use. In some of these a semi-rotatory pump has been added producing sprays of water over the water surface in the tank, through a delivering tube with two rows of holes at 45° to each other. Fish fry have been transported in such motor vans (semi-insulated) over a distance of 500 km with mortality less than 5%. Several other adaptations of open transport carriers mounted on motor vehicles are also in trend. Galvanized iron drums or polyethylene tanks of 1000 L capacity are also used for large sized fingerlings transportation. In these tank 1000-1500 fish of large fingerlings (50-100g) are transported for 12-18hr duration.

Open Canvas Containers:

Transport of fish seedlings in open carrier of trucks lined with plastic sheet and filled with transport water may be traditional in nature, it is preferable for the transport of bigger size fish seedlings or live fishes. Transportation of live fishes in open trucks is more suitable for ponds located in far-off and remote places. Cost of transport reduces with increasing size of truck carrier and consignment. Line the carrier with thick plastic sheet and fix it firmly to form a water pool as per requirement in the area starting from front to rear side of the carrier. The pool made in the transport carrier may be compartmented suitably using nets or plastic sheets to act as baffles to prevent water surges, permit separation of fish species or sizes and facilitate fish stocking at different sites on a single trip. Fill the lined carrier with required quantity of source water, check for any leakage and then introduce fish seedlings or live fishes to be transported into the pool. About 20,000-30,000 fish seedlings of 5-10 gm size per 1000 liter water can be transported for a distance of 4-12 hours duration.

Quantum of water and density of fishes maintained in the carrier varies as per size of fishes and duration of transport involved. If bigger size seeds are transported, transport density may be reduced, or quantum of water increased. Give care to avoid pile-up or smothering of seeds during transport due to higher density or limited water quantity, which may be disproportionate to the fish biomass. If problems due to oxygen depletion and surfacing of fishes occur during travel, change 10-20% or little more of transport water gradually with clean new water of the same temperature, if available. Temperature of water can be known using simple thermometer or by feeling. Sprinkle water over the pool and monitor condition of fish seedlings intermittently during the transport. Gently splash water with hands without causing stress to create mild wavy action, facilitate oxygen dissolution from atmosphere and help fish seeds remain inside water while transportation. Fast agitation may cause stress to fish seeds.

3.3.2.2 Closed System:

Most adapted method in this system is the use of Polythene Bags, fish fry and fingerling are now widely transport in this method. In this method the bag is filled up to ⅓ of its capacity (6–7 liters) with water and the required number of seed is put into it and the bag is inflated with oxygen in high pressure from a cylinder, up to ⅔ of the bag. The upper 10 – 15 cm of the bag is twisted, bent and tied securely airtight with a string or rubber band. These packed bags are kept in a container to insulate from heat during transport and used mainly for transporting to long distances. Carp hatchlings numbering 20,000 – 40,000, 300 – 600 fry (30 – 40 mm) and 40 – 70 fingerlings per bag depending on the distance are packed and transported in this manner. This method is safe for transporting fingerlings up to 24 hours in healthy condition with no or minimal death (< 5%)

Packing Method in Polythene Bags

Avoid both thicker and thinner polythene bags since the former poses difficulty to tie them tightly and the latter often bursts out during packing or transport.

Use plastic bags of 15-25 kg capacity with 65-75 cm length, 40-45 cm width and 30–50-micron (0.03-0.05 mm) thickness and have moderate softness, flexibility for better handling or knot making and tensile strength. Place a bag inside another one to provide safety and sufficient resistance to puncturing, if thinner bags are used unavoidably.

Constrict the bottom of the bag in a zigzag folding and tie the folded bottom end tightly to avoid leakage and give a cylindrical shape to the bag after packing for protection and easy stacking while transportation.

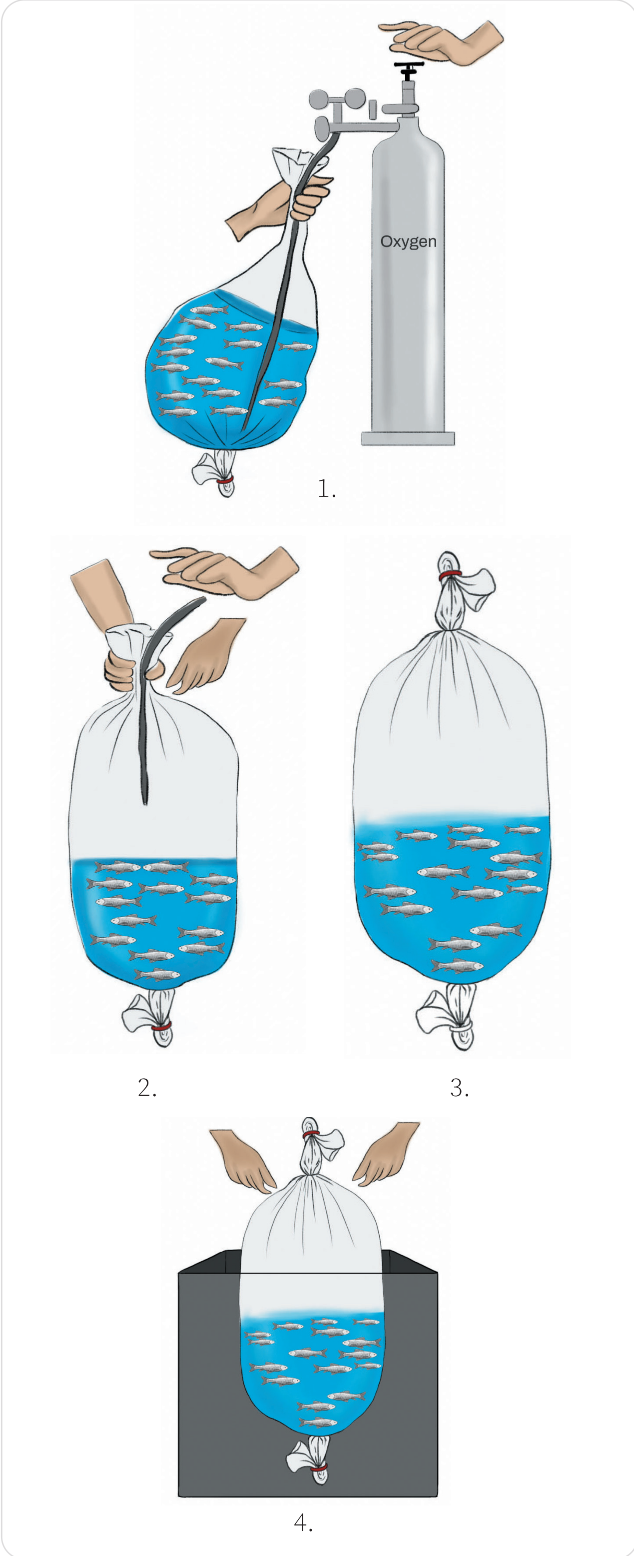
First, put the polythene bag with a closed bottom end in the outer transport case such as cardboard carton or Styrofoam box or tin case, if used. Pour transport (source) water taken from the water pool where fishes are maintained or conditioned to 20-30% capacity of the bag, check for leakage if any and place inside the pre decided number of fish seedlings.

Introduce the hose of an oxygen cylinder into the bag and hold tightly the upper end of the bag around the hose by hand after expelling air from the bag.

Release oxygen from the cylinder to blow the bag slowly. Stop the supply of oxygen when the bag is filled in 4-6 seconds to remaining 70-80% capacity, leaving little free space (3-5%) inside the bag.

Do not blow the bag fully and tightly with oxygen to avoid bursting during transportation, especially if sun stroke is expected in transit on sunny days.

Quickly draw out the hose from the bag and twist the upper end of the bag twice and fold it at its top end by holding tightly to prevent oxygen leakage or over-pressure and tie tightly using a small piece of thread or rubber band.



Fish seed packaging for closed system transportation

Suggested density of Fish seed per bag based on fish length

The number of fingerlings (range /bag) is given below and the actual number is to be determined based on the duration of transport.

Size of the Fish	Number per bag	Transport Duration
8-15 mm	1000-15000	Up to 24 hours and the number packed is determined by the size distance and also the number of travel hours
15-25mm	300- 500	
25-50mm	250-400	
50-100mm	100-250	

Table 16: Suggested density of Fish seed per bag based on fish length

Seedling weight in grams	Number per bag	Transport duration in hours
1-5	2000	12
1-5	1000	24
5-30	500	12
30-60	20-30	8 hours
60-100	8-10	8 hours

Table 17: Suggested density of fingerlings based on weight

3.3.3 Timing of Transport:

Best time for transportation during early morning or late evening hours for transportation around 5-6 hours. If it is more than 6 hours evening and night hours are most desirable timings.

3.4 Release of Fish Seed:

• Make sure pond is ready with good quality water and sufficient plankton for stocking fingerlings. Water quality to be checked on previous day of stocking and made corrections if required.

• Upon arrival to the destination, keep the closed bags with seeds on the surface of receiving water to balance the temperatures of transported seed pack water and pond water.

• Check the condition of seeds for their position, swimming, resting behaviour, agility or reaction to light & touch and dead individuals before releasing them into pond.

• Disinfect the seed by dipping in $KMnO_4$ solution @5 ppm and also treat with 2 to 5% salt solution for about 2 min before releasing into the pond.

• Open the bags to release after 5-15 minutes of acclimatization when the temperature of the water in bags reaches close to the level in the water in the receiving pond.

• Before releasing into pond water, fish seedlings can be initially introduced into a small hapa established inside pond for close monitoring of fish seeds, remove any dead or week fish before and finally release the seed into pond water after 2-5 hours.

• If you are transporting the seedlings by open truck, add water collected from receiving pond gradually to the water in the open truck used for transport and after 15-20 minutes of acclimatization to the new water, follow the disinfection process mention above and release fish seedlings from the transport truck slowly and carefully into the hapa established in the pond water using a small hapa or scoop net. Remove any dead or week fish before and finally release the seed into pond water after 2-5 hours.

• Best time releasing fish into ponds is cool hours (early morning or late evening hours).

Seed release into the pond

3.5 On-Stocking Economics:

Note: For example, and calculations purpose the pond size and other dimensions are considered as follows.

Area: 1 Acre (4080 M^2); Length:65 Meter; width: 62.77 Meter; Total dike hight 2 Meter; After compaction dike hight: 1.8 Meter; Dike crust width: 2 Meter; Wet side dike slope: 2:1; Dry side Dike slope: 1.5:1; Water filling depth: 1.5 Meter.
Adapt the approach as per your pond dimensions.

Recurring or operating costs	Component	Units	Cost per unit*	Cost
A. Pond Preparation Cost				
Liming	Agriculture Lime	100 kg	Rs. 7.00/kg	Rs. 700.00
	Ag lime application cost	1 X 1 hour time	Rs. 200.00/hour	Rs. 200.00
Pumping Cost	5 Hp pumping cost to fill the pond (8 days' time)	716 units	Rs. 3.00	Rs. 2,148.00
Manuring	Manure purchase cost	1200 Kg	Rs. 5.00/kg	Rs. 6,000.00
	Manure application cost	2 X 2 Hours	Rs. 200.00/hour	Rs. 800.00
		A	**Total**	**Rs. 9,848.00**

Recurring or operating costs	Component	Units	Cost per unit*	Cost
B. Seed stocking cost	Seed purchase cost	1500 fish	Rs. 2.00	Rs. 3,000.00
	Seed transportation cost	1 vehicle	Rs. 3000.00	Rs. 3,000.00
	Seed stocking cost (Resources)	2 vehicle	Rs. 300.00	Rs. 600.00
	Farmer's work-hours cost	6 hours	Rs. 200.00/hour	Rs. 1,200.00
B.	**Sum of all expenses incurred for the stocking of fish seed in the pond**			**Rs. 7,800.00**

On-Stocking recurring expenses total (A + B) = Rs. 9,848.00 + Rs. 7,800.00 = Rs. 17,648.00

Risk Factors:

1. Selection of unsuitable culture system and species and species composition:

Adaptation of ideal culture system for your farming operation needs to be based on the availability of farming related resources and financial resources also. If both the resources availability is low and if farmer adapts either semi-intensive or intensive farming operation, entire farming operation ends up in disaster. For example, if the water availability is very low and if the selected mode of farming is intensive where the need for water exchange will be more in order to manage the water quality, the culture ends up in trouble. In case of financial resources, if the farmer opts for semi-intensive or intensive operation, the need for supplementary feeding and installation of additional aeration devises is required to attain desired production for which they need to invest more money.

2. Poor quality seed selection & unproper handling during seed transportation and stocking of fish seed:

Selection of quality seed is the most important primary factor that drives your farming operation towards a successful production. Farmer must follow the guidelines provided **under chapter 3.0.4. Identification of good quality seed.** If the quality of the seed is not good, it effects your entire farming operation objective. The growth, resistance to diseases gets compromised, which results in financial loss. Unproper handling during transport or during stocking also leads to the same situations as explained in case of poor seed selection. Farmer needs to follow good management practices while transporting and stocking the seed as explained in chapter **3.3. Transportation of fish seed.**

3. Stocking seed in unprepared or poorly prepared pond water:

Making the pondwater ready with all physical, chemical and biological parameters maintained at optimal level so that the pond ecological system is ready for the selected fish species to thrive well in your pond. It is also very important to make sure that optimal planktonic levels are maintained so that the fish seed can kickstart their feeding properly, because optimal nutrition availability is very much important especially for younger fish for a healthy growth. If you stock the fish in an unprepared pond, the fish seed will undergo lot of stress and the growth and immunity gets compromised.

FAQs:

How to decide the best fish species for aquaculture?
How many fish can be put into a pond of one-acre water area?
What is the best species combination to be stocked in to aquaculture pond to get maximum production?
How to transport baby fish(fingerlings) from nursery to pond location?
What is the most suitable culture system for efficient utilization of resources?
How do you check whether the pond is ready to receive baby fish?
What are the precautions to be taken before releasing baby fish in to fish pond?

Module 4: Post-Stocking

Topics:

4.0– Post-stocking
4.1– Water quality management
4.1.1– Physical parameters
4.1.2– Biological parameters
4.1.3– Chemical parameters
4.2– Liming
4.2.1– Types of limes used
4.2.2– Liming Dosage and mode of application
4.3– Manuring
4.4– Feed management
4.4.1– Natural food
4.4.2– Supplementary feeding
4.4.3– Feeding rate, methods and feeding frequency schedule
4.5– Diseases
4.5.1– Causes
4.5.2– Types of diseases
4.5.3– Management of diseases
4.5.4– Management of pond hygiene
4.6– Sampling
4.7– Harvest
4.7.1– General comments
4.7.2– Types of harvest
4.8– Women in Aquaculture
4.9– Post-Stocking Economics

Risk Factors
FAQs

4.0 Post-Stocking:

This phase includes the activities to be undertaken from stocking of fingerlings up to the final harvesting of fish from the pond. The activities are pond hygiene, water quality monitoring & management, manuring and/or feeding, growth and health monitoring & management, and harvesting at right time are the key steps of post stocking management.

4.1 Water Quality Management:

Water Quality includes all physical, chemical, and biological factors that influence the beneficial use of water. Where fish culture is concerned, any characteristic of water that affects the survival, reproduction, growth, production, or management of fish in any way is a water quality variable. Obviously, there are many water quality variables in pond fish culture. Fortunately, only a few of these normally play an important role. These are the variables that fish culturists should concentrate on and attempt to control to some extent by management techniques.

A pond with "good" water quality will produce more and healthier fish than a pond with "poor" water quality. How to define "good" water quality for fish culture.

4.1.1 Physical Parameters:

Water Depth & Water 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 influence upon its productivity. The temperature in fishponds 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. Fish display great variability in their tolerance to temperature. Indian major carps usually tolerate wide range of temperature and are called eurythermal.

Fish grow best at temperatures between 25°C and 32°C (Celsius). Water temperatures are in this range the year around at low altitudes in the tropics, but in temperate regions water temperatures are too low in winter for rapid growth of fish and fish food organisms. For this reason, management procedures such as feeding, and fertilizing are halted or reduced in winter. Temperature has a pronounced effect on chemical and biological processes. In general, rates of chemical and biological reactions double for every 10°C increase in temperature. This means that aquatic organisms will use twice as much dissolved oxygen at 30°C as at 20°C, and chemical reactions will progress twice as fast at 30°C as at 20°C.

Therefore, dissolved oxygen requirements of fish are more critical in warm water than in cooler water. Chemical treatments of ponds also are affected by temperature. In warm water, fertilizers dissolve faster, chemicals act quicker, and the rate of oxygen consumption by decaying manure is greater.

In ponds, heat enters at the surface, so surface waters heat faster than lower waters. Since the density of water (weight per unit volume) decreases with increasing temperature above 4°C, the surface waters may become so warm and light that they do not mix with the cooler, heavier waters in lower layers. The separation of pond waters into distinct warm and cool layers is called **thermal stratification**. The upper warm layer is called the epilimnion and the lower, cooler layer is known as the hypolimnion. The layer of rapidly changing temperature between the epilimnion and the hypolimnion is termed the **thermocline**. In temperate regions large ponds may stratify in the spring and remain stratified until fall. In small, shallow ponds in temperate regions and in tropical ponds, stratification often exhibits a daily pattern. During the day, the surface waters warm and form a distinct layer. At night the surface waters cool to the same temperature as the lower waters and the two layers mix. In some ponds, the surface waters may reach temperatures of 35°C or more. This is above the optimum temperature for most warmwater fish, but the fish may seek haven from the high temperature in subsurface waters. Fish have poor tolerance to sudden changes in temperature. Therefore, one should not remove fish from water of one temperature and suddenly thrust them into a water of appreciably higher or lower temperature. Often, a sudden change in temperature of as little as 5°C will stress or even kill fish. The effect is usually worse when moving fish from cooler to warmer water. Since temperatures increase with decreasing altitude, one must allow for temperature adjustment when moving fish from high altitude to low altitude waters. Fish readily tolerate gradual changes in temperature. For example, one could raise the temperature from 25°C to 32°C over several hours without harming fish, but fish suddenly removed from 25°C water and placed in water of 32°C might die.

Watercolor

The term watercolor indicates that a water contains suspended material which interferes with the passage of light. In fishponds, watercolor which results from planktonic organisms is a desirable trait, whereas that caused by suspended clay particles is undesirable. Even with the latter condition, the clay particles are seldom abundant enough in water to directly harm fish. If the pond receives runoff which carries heavy loads of silt and clay, the silt settles over the pond bottom and the clay particles which remain in suspension restrict light penetration and limit the growth of phytoplankton. A persistent clay turbidity which restricts visibility into the water to 30 centimeters or less may prevent development of plankton blooms.
Some ponds receive large inputs of vegetative extracts often impart color to the water. Color from vegetative extracts often appears as a dark stain giving the water the appearance of tea. Pond water with high concentration of humates are typically quite acid and have a low total alkalinity.

Plankton is comprised of all the microscopic organisms which are suspended in water and includes small plants (phytoplankton), small animals (zooplankton), and bacteria. When there is enough plankton in the water to discolor it and make it appear turbid, the water is said to contain a plankton "bloom". In fish culture systems where fish are not provided supplemental feed, plankton forms the most abundant base of the food web. In addition to supporting fish growth, plankton makes water turbid and prevents the growth of undesirable aquatic weeds through shading. Despite the benefits of plankton blooms in fishponds, more plankton can sometimes be produced than can be utilized by the fish for growth. Heavy plankton blooms usually contain large numbers of blue-green algae which can form scums at the surface. These scums absorb heat during the day and cause shallow thermal stratification. During the night, heavy plankton blooms consume large amounts of dissolved oxygen and may cause oxygen depletion before the next morning. Scums of plankton may suddenly die, decompose, and cause oxygen depletion. In addition to causing dissolved oxygen problems, organisms in heavy plankton blooms often produce substances which impart a strong off-flavor to fish flesh.

Water Transparency

Water transparency is a trait that imparts the abundance of plankton in an aquaculture pond. By observing the water transparency level farmer can be able to assess the water quality, level of natural fish food availability in the pond. There are many techniques for measuring plankton abundance, but most are too tedious for use in practical fish culture. The most practical technique for use in ponds which do not contain appreciable clay turbidity is to measure the Secchi disk visibility. Secchi disk visibility is the depth at which a disk 20 centimeters in diameter with alternate black and white quadrants disappears from view. There is a high correlation between Secchi disk visibility and plankton abundance. It is impossible to establish an ideal plankton turbidity for fish culture. However, a Secchi disk visibility in the 30 to 60 centimeter range is generally adequate for good fish production and for shading underwater weeds. As Secchi disk visibilities decrease below 30 centimeters, there is an increase in the frequency of dissolved oxygen problems. At values above 60 centimeters, light penetrates to greater depths encouraging underwater macrophyte growth, and there is less plankton to serve as food for fish or fish food organisms. Plankton communities are constantly changing in species composition and in total abundance. This results in corresponding fluctuations in Secchi disk visibility and in the appearance of pond water. These changes in plankton communities may be disconcerting to the fish farmer. However, unless plankton becomes so dense that dissolved oxygen problems occur or so thin as to encourage underwater weeds, the changes do not affect fish production appreciably. By monitoring Secchi disk visibility on a regular schedule (once or twice weekly) and observing the appearance of the water, the fish farmer can obtain information on the continuing condition of the plankton community in a pond and on the supply of fish food organisms.

Measuring Transparency or Turbidity

Turbidity of pond water varies from almost zero to highly turbid, depending on the amount of suspended particles. The method used for its measurement varies according to the kind of turbidity present. If it is a mineral turbidity (brownish water), you will need the help of a laboratory to determine the weight of material suspended in a given volume of water. This figure is called the total suspended solids (TSS), which is usually expressed in milligrams per litre (mg/l). When taking samples, be careful not to disturb the water too much, as you can increase the TSS very easily. Also, do not take the water only from the surface, as it is often much less turbid.

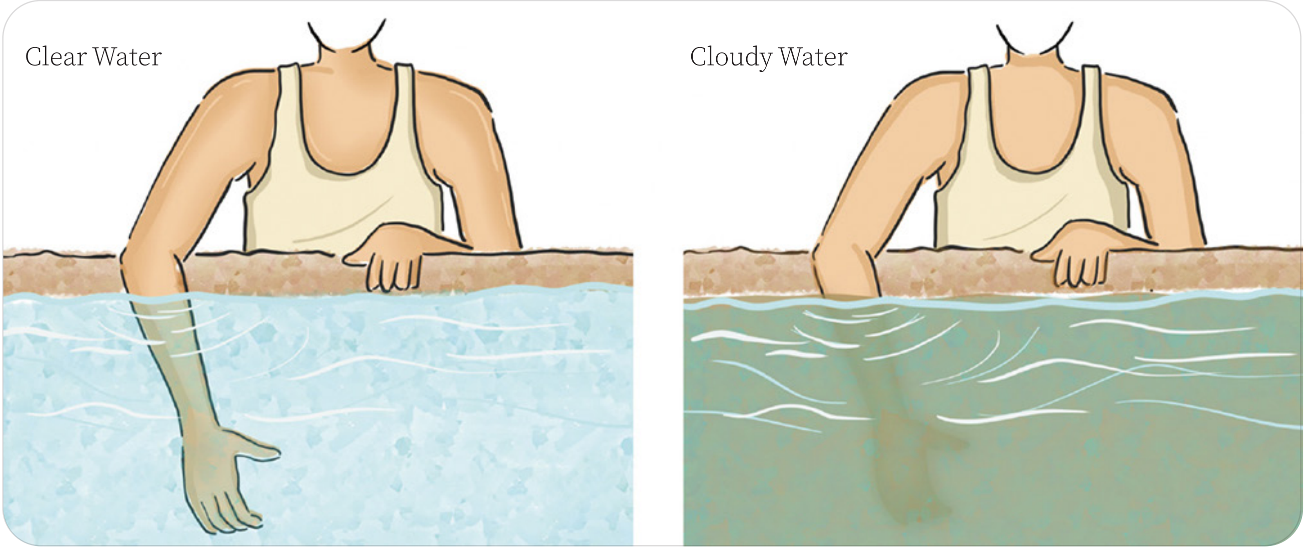
TSS (mg/l)	Mineral turbidity
Less than 25	Low
25-100	Medium
Over 100	High

Table 18: Amount of total suspended solids (TSS) range in aquaculture pond

Removal of Clay Turbidity

In some ponds, it is necessary to remove the turbidity caused by suspended clay particles so that light will penetrate deep enough into the pond for phytoplankton growth. A better method for removal of clay turbidity is treatment with filter alim (aluminum sulfate, $Al_2(SO_4)_3.14H_2O$). Allum will cause suspended clay particles to coagulate and precipitate from the water within a few hours. Application of 25 to 30 milligrams per liter will apparently precipitate the clay turbidity from most ponds. When applying alum, it should be dissolved in water and quickly distributed, preferably by spraying, over the entire pond surface. Application should be made during calm, dry weather because mixing by wind and rain will break up the floc and prevent it from settling out. Alum has an acid reaction in water, so it destroys total alkalinity and reduces pH. If the total alkalinity of water is below 20 milligrams per liter, alum treatment may depress the pH to the point that fish are adversely affected. lime ponds with waters of low alkalinity before treating with alum, Liming materials will often precipitate clay turbidity, but if turbidity persists after liming, alum treatment may be conducted without (danger of pH depression).

If it is a plankton turbidity (greenish water), you can estimate the level yourself using the two simple methods described below. They will also give you an estimate of the potential fertility of your pond, from which you can decide on the kind of management practice to be applied.



Measuring plankton turbidity with your arm

This is a very simple method which does not require any special equipment. Proceed as follows.

Stretch one arm and immerse it vertically into the water until your hand disappears from sight.

Note the water level along your arm:

- If it Is well below your elbow, plankton turbidity is very high.
- If it reaches to about your elbow, plankton turbidity is high.
- If it reaches well above your elbow, plankton turbidity is low.

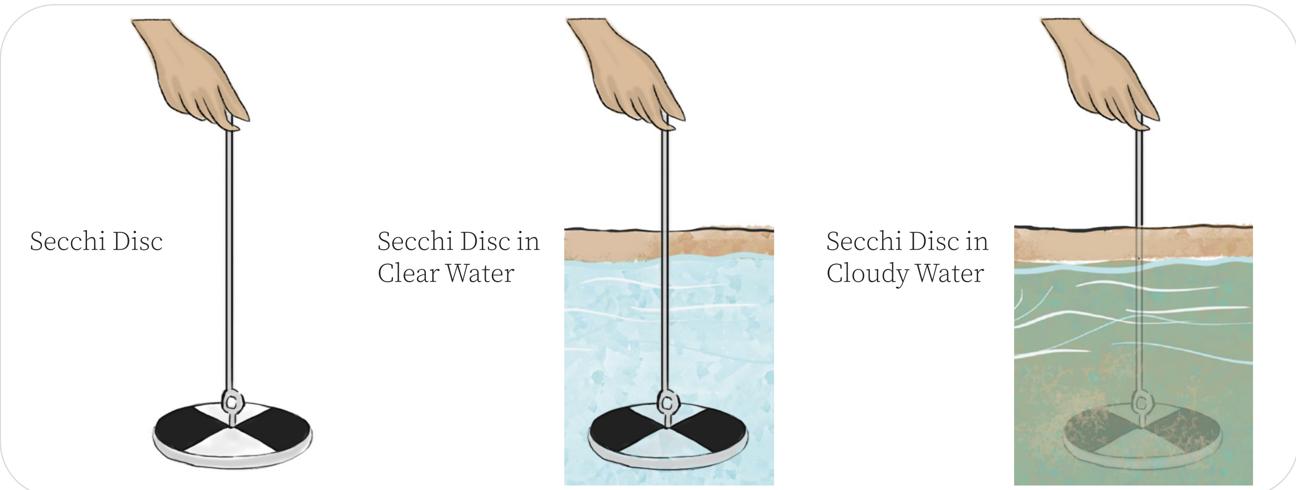
Measuring Turbidity with the Secchi Disc Transparency

The Secchi disc is a very simple tool which can be used to give a better estimate of turbidity. It is particularly useful in aquaculture ponds to estimate plankton turbidity. This measurement is then called the Secchi disc transparency. You can easily build a Secchi disc yourself.

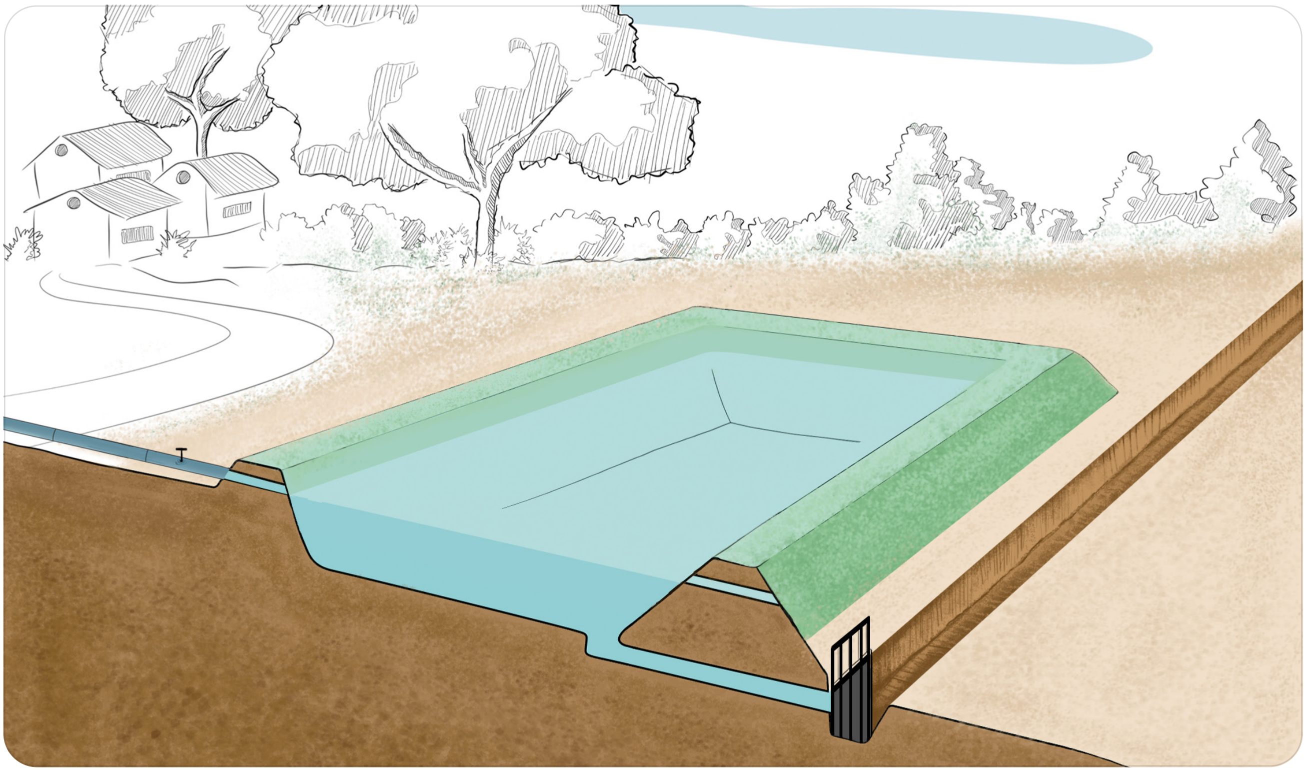
Proceed as follows:

- Cut a round disc about 25 cm in diameter from a piece of wood or metal, such as a crushed tin can for example.
- On its surface, mark two lines to make four quarters. Paint these black and white using matt paint to prevent glare.
- Drill a small hole at the centre of the disc. Through this hole pass a line or a piece of string about 1 to 1.5 m long.
- Below the disc, attach to the line a small weight such as a long bolt or a stone.
- Fix the disc at the bottom of the line, against the bottom weight, by knotting the line around a small piece of wood or metal, across the top of the disc.
- Mark the rest of the line with knots or tightly tied coloured thread at 10-cm intervals.

Note: instead of using a line, you may also attach the disc from its centre to a graduated vertical stick about 100 cm long.



Measuring transparency using secchi disk



Well managed pond (light green & brownish, good water quality)

To measure the Secchi disc transparency, proceed as follows:

(a) Slowly lower the disc into the water.
(b) Stop when it just disappears from sight.
(c) Note at which point the line breaks the water surface. Mark this point A.
(d) After noting at which point along the line the disc just disappears, lower the disc a little and then raise it until it just reappears. Mark this point B.
(e) Mark point C, midway between points A and B.
(f) Measure the transparency of the water as equal to the distance from the top of the disc to this point C, counting the knots along the line.

To obtain the best measurement, take note of the following points:

• Measure transparency between 09.00 hours and 15.00 hours on calm days.
• Whenever possible, make the readings when the sun is out, not behind a cloud.
• Look at the sinking disc from directly above, if possible, with the sun behind you.
• Keep the disc clean, particularly the two white quadrants. If necessary, repaint the disc black and white.

Light

Light is another physical factor of importance. Availability of light energy to a fishpond greatly influences its productivity. Light could affect fish feeding and other aspects, such as improved appetite, increased ratio consumption, and high food conversion efficiency, which influences the early stages of fish. 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. Light facilitates good photosynthesis stimulating good plankton production. Keep the pond surroundings clear of trees for light penetration to pond.

Odor

Heavy plankton blooms usually contain large numbers of blue-green algae which can form scums at the surface. Scums of plankton may suddenly die, decompose, cause bad odor and oxygen depletion. In addition to causing dissolved oxygen problems, organisms in heavy plankton blooms often produce substances which impart a strong off-flavor to fish flesh. Sudden change in physio-chemical parameters of water can also cause planktonic crash, decomposition and bad odor. Periodic application lime can be helpful in maintaining optimal Ph and alkalinity in the pond which will be helpful in managing consistent planktonic bloom in the pond, helps in decomposition process at the pond bottom.

Not managed pond (dark green/dark brown color for bad water quality)

Recommended physical parameters

Parameter	Suitable Range/ Conditions	Remarks
Water depth	1.5 m	This depth will help to grow healthy fish as sun light will penetrate and help in plankton production Shallow pond less than 1.5 m will get heated up during summer resulting in algal blooms and reduce the oxygen level causing fish death. Deeper pods >2.5m will reduce plankton production and productivity. Also increase water requirement and cost of production
Water Temperature	26 to 32°C	For good growth and health of fish. In case of high use shower, use orchid net, use water hyacinth or replenish with fresh water
Watercolor	Light green brown	Indicates a good mixture of phytoplankton and zooplankton Dark green- indicates algal blooms not good for production Dark brown indicates excess organic matter –not desirable
Water Transparency	30 cm from surface	Indicates good productivity
Light	Keep the surroundings clear of trees for light penetration to pond	Facilitate good photosynthesis stimulating good plankton production
Odor	No fouling smell from the pond	Any fouling smell indicates deterioration of water quality

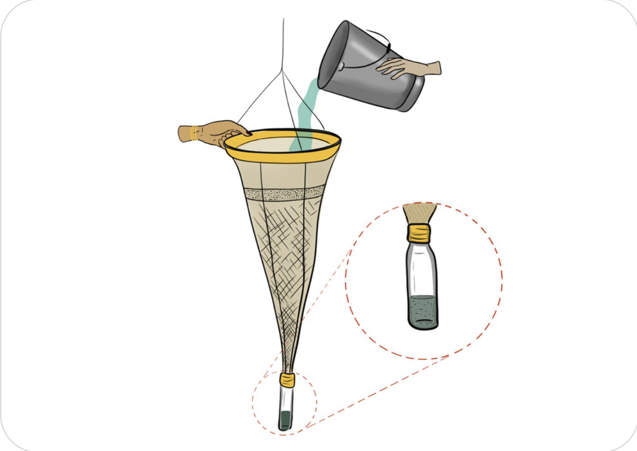
Table 19: Optimal range for key physical parameters of aquaculture pond

4.1.2 Biological Parameters:

The biological characteristics of an aquaculture pond pertains to all the aquatic organisms that exists in a pond ecological system. This includes macro and microphytes, zooplankton, bacteria, and all other organisms. All these organisms are dependent on each other for food, this relationship between these organisms is known as food chain or trophic levels. Bacteria is the base of the food chain, which breaks down organic matter into inorganic nutrients, inorganic nutrients get utilized by phytoplankton in the process of photosynthesis producing food(carbohydrates). These phytoplankton which are the primary producers in this food chain are then consumed by zooplankton, fish feeds on these phytoplankton, zooplankton, bacteria, other macrophytes and other small animals. Dead aquatic organisms and animal wastes will settle on the pond bottom. Bacteria will feed on this organic matter and the cycle will commence again.
The biomass of phytoplankton varies seasonally in general reaching its highest levels in spring and summer. The density is highest in superficial layers of water and decreases with depth. The appearance of different populations is linked in part to the characteristics of the surrounding water temperature, turbidity, and depletion of nutrients.

Maintaining good plankton density of phytoplankton and zooplankton is essential for good growth of Fish. Plankton type and density is to be checked once in two weeks to decide the manuring schedule. This can be done by using plankton net made of bolting silk cloth of 60-micron mesh (readily available in market) by filtering known quantity of water (50 ltr. using buckets with measurements).

Prevent excess growth of aquatic weeds, especially floating aquatic weeds. Weeds utilize the nutrients and compete with desirable organisms. Excess growth will form a mat preventing penetration of sunlight and affecting plankton production. Roots of these plants will harbor harmful insects.
Remove snails or other animals attached to the inner side of the pond by scraping or using net. Snails may act as hosts for pathogens.
The diseases in fish are caused by bacteria, virus, fungi, protozoa and crustacean parasites. These parasites enter into the pond along with water, through fish seed and nets from other infected ponds.



Plankton collection using a plankton net

4.1.3 Chemical Parameters:

pH:

The pH is a measure of the hydrogen ion concentration and indicates whether the water is acidic or basic in reaction. The pH scale ranges from 0 to 14, with pH 7 being the neutral point. Thus, a water of pH 7 is neither acidic nor basic, while a water with pH below 7 is acidic and one with a pH above 7 is basic. The greater the departure from pH 7, the more acidic or basic a water. The pH of natural waters is greatly influenced by the concentration of carbon dioxide, an acidic substance. Phytoplankton and other aquatic vegetation remove carbon dioxide from the water during photosynthesis, so the pH of a body of water rises during the day and decreases during the night. Waters with low total alkalinity often have pH values of 6 to 7.5 before daybreak, but when phytoplankton growth is heavy, afternoon pH values may rise to 10 or even higher. Fluctuations in pH are not as great in water with higher total alkalinity where pH values normally range from 7.5 or 8 at daybreak or 9 or 10 during the afternoon. In some water with extremely high total alkalinity, and particularly in waters with high total alkalinity and low total hardness, pH values may rise above 11 during periods of rapid photosynthesis. Obviously, pH measurements should be made in the early morning and again in the afternoon to assess the typical pH pattern for a pond. Waters with pH values of about 6.5 to 9 at daybreak are considered best for fish production. Some ponds which receive drainage from acid soils or swamps may be too acid for fish production. Waters with extremely high total alkalinity may have pH values too high for fish culture. The acid and alkaline death points for pond fish are approximately pH 4 and pH 11, respectively. Even though fish may survive, production will be poor in ponds with early morning pH values between 4 and 6 and between 9 and 10. The afternoon pH in many fish culture systems rises to 9 or 10 for short periods without adverse effect on fish.

Dissolved Oxygen (DO):

Dissolved oxygen is probably the most critical water quality variable in fish culture, so the fish culturist should be familiar with the dynamics of dissolved oxygen concentrations in ponds. The atmosphere is a vast reservoir of oxygen, but atmospheric oxygen is only slightly soluble in water. The solubility of oxygen in water decreases as the temperature increases. When water contains a dissolved oxygen concentration equal to the solubility of oxygen in water at the existing temperature, the water is said to be saturated with dissolved oxygen. If water contains more dissolved oxygen than it should for the particular temperature, it is supersaturated. Water may also contain less dissolved oxygen than the saturation value. The solubility of dissolved oxygen decreases with decreasing atmospheric pressure (barometric pressure).

The most important gas dissolved in water is oxygen (O_2). As you have already learned, dissolved oxygen (DO) is essential to most living organisms for their respiration. Oxygen is also necessary for dead organic matter to be broken down during the process called decomposition.

Sources of Dissolved Oxygen

The oxygen dissolved in water has two sources:

1. Atmospheric oxygen, 2. photosynthesis.

The atmospheric oxygen in contact with the water surface is an unlimited source of oxygen; unfortunately, its passage into water, its diffusion and its subsequent dissolving into water is a very slow process. You can improve this process by using mechanical aerators. The major source of dissolved oxygen in ponds is photosynthesis (see Section 2.0). This process depends on the amount of light available to the phytoplankton and therefore oxygen production decreases during cloudy days, it completely stops at night, it gradually decreases as water depth increases and light levels diminish, the rate of the decrease depending on the water turbidity.

Measuring DO content in water:

You can measure how much oxygen is dissolved in water either by chemical methods or by electrical methods.
Chemical methods usually rely on the use of simple kits, which can be bought from specialized suppliers. They contain all the chemicals and small equipment necessary to determine the DO content with sufficient accuracy for pond management purposes. Instructions should be closely followed. The measurement is taken on a small water sample obtained with the water sampler.
Electrical methods are based on the use of an oxygen meter, a rather expensive device which can be bought from specialized suppliers. It has the advantage that the DO content can be measured directly from the water, at any depth. The DO content is read from a scale. Instructions should be accurately followed. You should take particular care to calibrate (i.e., adjust) the meter regularly to make sure it remains accurate.

Note: when measuring DO content, you should always measure the water temperature simultaneously, so that you will be able to relate the DO measurement to this temperature.

Record the readings of DO level observations in the pond record book so that it will be helpful to observe the trends over a period of time and can take appropriate measures to manage optimal DO levels in the pond.

When to measure DO:

It depends on the purpose of the measurements. If you plan to measure DO routinely as part of the regular monitoring of the fish farm, it is best to measure it twice on a specific day, just after sunrise, when DO is at its minimum and a few hours later. In seasons when DO might be insufficient, if you want to predict low night-time DO content, you should also measure it twice, just before sundown and a few hours later.
If you suspect from observation that there might be a lack of DO, you could measure the DO content immediately to confirm and then take remedial action. Fish gasping for air is always a sign of low oxygen levels, which will lead to less uptake of feed and slow growth.

How to determine the average DO content of the water in a pond:

To estimate the average DO content of the water in a shallow pond at a certain time, you should obtain a series of water samples. The simplest (but less accurate) way is to obtain water samples from one station only but at different depths. Select the sampling station at the deep end of the pond and a little away from the dikes, for example in front of the monk outlet structure. Take a first sample from about 30 cm below the water surface and measure its DO content (Reading- A), take a second water sample from a depth 0.50-meter total depth and measure its DO content (Reading-B), take another water sample from a depth 0.80-meter total depth and measure its DO content (Reading- C). Average value of all the three samples gives you the average DO content of the water in the pond.
For more accurate results, proceed as just described above, but use two stations, one in the middle of the pond, to obtain a first average DO value, one at the deep end of the pond, to obtain a second average DO value. Average of these two values gives you the overall average DO content of the water in the pond.

Note: Do not take water samples near growing aquatic plants or beneath a heavy cover of algae blown against the shore, as these samples would not be typical of the conditions in the rest of the pond.

If the pond is large and deep, such as a barrage pond, you may need more water samples to obtain a better estimate of the average DO content of water in the pond. **You should, if needed:**

The concentration of DO in water is commonly expressed in parts per million (ppm), where 1 ppm = 1 mg/l.

Oxygen solubility in water, depends on three factors.

1. Temperature: the warmer the water, the less oxygen it can hold.
2. Atmospheric pressure: the lower the pressure, the less oxygen can be held.
3. Salinity: the more saline the water, the less oxygen it can hold.

The maximum quantity of oxygen which a particular body of water can normally hold is called the 100 percent saturation value. Under certain circumstances, it may happen that the pond water contains more than this 100-percent saturation value. It is then said that there is supersaturation of the water with oxygen, a phenomenon which may happen, for example, in the afternoon when photosynthesis has been very active.

Coldwater fish require higher oxygen levels than warmwater fish. Fish such as catfish, which are used to slow-moving water bodies, can tolerate lower levels than fish used to fast-moving water. For a particular species, younger fish require higher oxygen levels than adults. At higher water temperatures, the fish will consume more oxygen for their respiration. This factor can be very important, because when temperature rises, water holds less oxygen. When actively feeding and later, when digesting their food, fish will require much more oxygen than usual.

Types of oxygen fluctuations in Aquaculture ponds

Two types of fluctuation in oxygen level can be found in fishponds:

Daily fluctuations: It happens both in surface water and in deeper water. In surface water, the daily fluctuation of the DO content is related to the 24 hour cycle of day and night. From sunrise to sunset, photosynthesis increases the DO level. On clear days, DO production is higher than on cloudy days.

The higher the phytoplankton population, the higher the DO production. At night, photosynthesis does not take place, and therefore respiration reduces the DO content until sunrise. The higher the plankton population, the faster the DO will fall.
In ponds with very rich phytoplankton, surface water may become supersaturated by midday. However, as respiration is also high, there may be very little oxygen left by the end of the night. In this condition fish may die if you do not correct these conditions.
In deeper water, the daily fluctuation of the DO content is related to the plankton turbidity, the higher the turbidity, the smaller the amount of light penetrating deeper in the water, and the less the production of DO through photosynthesis in deeper water. The DO content therefore decreases as depth increases.

In ponds with very rich plankton, where there is a dense plankton population and high turbidity, the DO content of the lower depths of the water may become very low even during the day. The fish may have to concentrate at the surface of the pond to survive. Greater problems are to be expected after sunset.

Seasonal fluctuations: Mostly observed in deeper ponds. The seasonal fluctuation of the DO content is essentially related to the thermal stratification of the water. As the thermocline establishes itself and restricts exchanges between the upper and lower layers, the DO content of the bottom water decreases, mainly because of the decomposing organic matter. It is only after the pond water has turned over that DO is brought back from the pond surface to the bottom through the general mixing of the water.

In deep ponds rich in organic bottom mud, the bottom water may become totally devoid of oxygen (anoxic) within a few weeks, and fish will not be able to live there. Later, when the pond water turns over, this anoxic water may reach the surface, together with decomposed organic material, many fish may die if proper measure are not taken to mix the water to break the thermocline.

Sudden drops in the DO content of pond water

Apart from the fluctuations of the DO content described above which take place regularly, every day or seasonally, the DO content of pond water may also decrease suddenly for several other reasons. If this should happen, check on the following possible causes one by one:

1. The water supply:

- The incoming water may have a very low DO content, water from a well or deep water from a reservoir may be low in DO.
- Respiring or decomposing algae upstream in a surface water supply may reduce DO.
- DO may be lowered by organic pollution.
- If the water inflow is too small.

2. The weather:

- If the pond water was stratified and a cool rain or a strong wind has caused the pond water to turn over, bringing the deoxygenated bottom water to the surface.
- Several days of cloudy skies or rainy weather have reduced oxygen production through photosynthesis.
- A period of very hot days can increase the water temperature, reducing DO saturation and increasing fish requirements of oxygen.

3. The fishpond:

- If the plankton turbidity is too high, and too much oxygen is consumed at night for respiration.
- If there is too much decaying organic matter, and too much oxygen is used up for its decomposition.

4. Fish stock management:

- If there are too many fish in the pond.
- If the fish are overfed resulting in fish wastes (faeces), and/or unconsumed food is decaying on the bottom.

Generally, several factors combine to cause a sudden drop in the DO content. In most cases, good management can prevent this.

The signs of low DO content in fishponds
In the absence of a suitable chemical kit or oxygen meter, you can observe following signs in your pond which tell you that there is not enough oxygen in your pond water.
- Tadpoles assembling at the margin of the pond.
- Water snails crawling up emerging plants.
- An odor of rotten egg rising from the water.
- The fish not feeding well or even stopping feeding.

• The fish coming to the water surface in an effort to breathe from the thin, better oxygenated surface film - this behavior is called piping.

How to predict low DO content with a Secchi disc?

In Section 4.1. Physical parameters- Transparency or turbidity, you learned how to measure the Secchi disc transparency. If phytoplankton is the main source of turbidity in your pond, you can use this measurement together with other observations to predict low DO content. Proceed as detailed below.

Measure Secchi disc transparency (SD).

1. If SD is smaller than 25 cm, the risk of oxygen depletion is great, especially if:
• There is a heavy cloud cover for two to three consecutive days.
• There is a heavy fog cover in the morning.

2. If SD is between 25 cm and 60 cm, there is still a risk, although decreasing as SD increases, that oxygen depletion may take place. Check on the weather and look regularly for signs at the pond.

3. If SD is greater than 60 cm, the risk that oxygen depletion may suddenly take place is minimal, unless overcast weather persists for more than a week.

Note: when applying this method, you should remain aware of the other reasons that may cause a sudden DO drop.

How to increase the DO content of pond water:

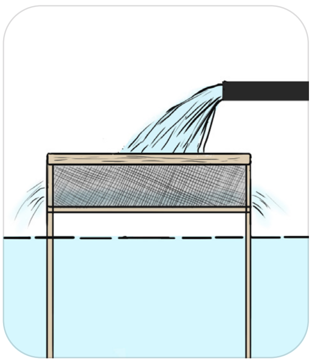
1. Direct improvement of DO content by:
• Increasing the inflow of well-oxygenated and/or cooler water.
• Removing the less oxygenated bottom water, by using the pond outlet, and replacing it with better oxygenated water.
• In smaller ponds, increasing the mixing of air and water by splashing the water with hands or with a broad stick or paddle.

2. Reduction of oxygen consumption from decomposition of organic matter by:
• Avoiding overfeeding if feeds are used.
• If possible, trying to drain away some of the loose organic matter on the bottom.

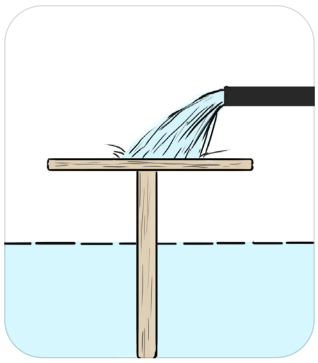
3. Increased production of oxygen through photosynthesis by:
• Increasing sunlight availability by keeping shady trees and aquatic vegetation growth under control.
• Improving sunlight penetration and reducing night-time respiration through the control of submerged plants and algae whenever necessary.
• Reducing the existing phytoplankton population slightly if it is causing oxygen levels to fluctuate too strongly, you can drain off some of the surface water and replace it with fresh water.
• Treating the pond water by liming and/or fertilization to increase phytoplankton only when it is necessary.
• If low phytoplankton levels are observed in the pond, can inoculate them by pumping water from other ponds with good planktonic bloom. While doing this make sure that the source pond is devoid of any disease.

4. Reduction of oxygen requirements of fish by:
• Reducing the number of fish present in the pond.
• Reducing or even stopping their supplementary feed.

Methods to improve water oxygenation at pond water inlets



Water from inlet falling on a bamboo mesh



Water from inlet falling on a wooden splashboard

It is relatively easy to improve the oxygenation of the water as it drops into the pond by allowing it to expose to atmospheric oxygen as much as it can be. Several simple ways to do this are described below. You should select the system best adapted to your needs.

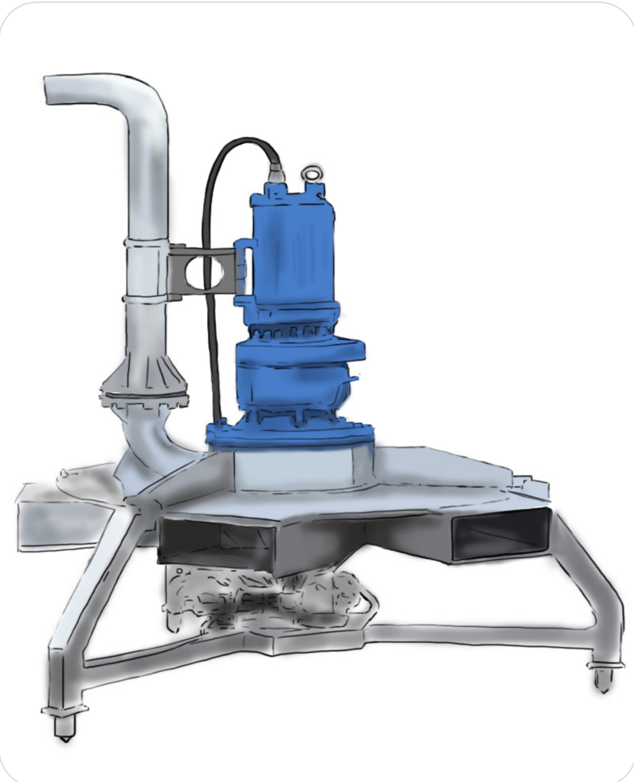
• If the height of the water dropping into the pond increases, the width of the water and area of contact with the air increases, splashing and breaking of the water into fine droplets increases.

• If the water supply is delivered to the pond through a pipe, adding a 900 bend at the end of the pipe and turning its opening up, fix a vertical perforated screen over the upturned pipe end which can increase the contact of incoming water with the air.

• If the water supply drops vertically into the pond through any type of overhanging inlet, such as a pipe or a wooden frame, by placing a horizontal splashboard or an inclined splashboard, improved by transversal strips, fixed to a wooden support above the maximum water level can improve oxygenation.

• If the water supply flows into the pond through a slanting piece of perforated corrugated iron or asbestos sheet above the dike side.

Mechanical aeration devices



Mechanical aeration device

Mechanical aeration devices are relatively expensive and require an external power source. They are consequently most commonly used for short-term and emergency aeration, such as converting extreme daytime oxygen depletion when ponds are particularly heavily stocked, or during extreme climatic periods. In more intensive fish farming, mechanical aerators may be used continuously, but this step is only practical for higher- value fish species under extremely well-managed and controlled conditions.

Alkalinity:

The term total alkalinity refers to the total concentration of bases in water expressed as milligrams per liter of equivalent calcium carbonate. In natural waters, these bases are primarily carbonate and bicarbonate ions. Another way to think of alkalinity is in terms of basicity and resistance to pH change. The amount of acid required to cause a specified change in pH in a given volume of water increases as a function of the total alkalinity levels of the waters. In general, early morning pH is greater in waters with moderate or high total alkalinity than in waters with low total alkalinity. The availability of carbon dioxide for phytoplankton growth is related to alkalinity. Waters with total alkalinities less than 15 or 20 milligrams per liter usually contain relatively little available carbon dioxide. Waters with total alkalinities of 20 to 150 milligrams per liter contain suitable quantities of carbon dioxide to permit plankton production for fish culture. Carbon dioxide is often in low supply in waters with more than 200 to 250 milligrams per liter of total alkalinity. The afternoon pH in waters with low total alkalinity may often be as great as in waters with moderate or high total alkalinity. Waters of low alkalinity are poorly buffered against pH change, and the removal of carbon dioxide results in rapidly rising pH. If total alkalinity and total hardness are too low, they may be raised by liming (refer chapter 2.2.1. Liming). However, there is generally no practical way of decreasing total alkalinity and total hardness when they are above the desirable level. As a general rule, the most productive waters for fish culture have total hardness and total alkalinity values of approximately the same magnitude.

Ammonia:

Ammonia reaches pond water as a product of fish metabolism and decomposition of organic matter by bacteria. In water, ammonia nitrogen occurs in two forms, un-ionized ammonia and ammonium ion. Un-ionized ammonia is toxic to fish, but the ammonium ion is harmless except at extremely high concentrations. The **toxic levels** for un-ionized ammonia for short-term exposure usually lie between **0.6 and 2.0 milligrams per liter** for pond fish, and **sublethal effects** may occur at **0.1 to 0.3 milligram per liter.** The pH and temperature of the water regulate the proportion of total ammonia which occurs in un-ionized form. A pH increase of 1 unit causes roughly a tenfold increase in the proportion of un-ionized ammonia. At 280C, the percentages of total ammonia in un-ionized form are; at pH 7, 0.70ppm; at pH 8, 6.55ppm; at pH 9, 41.23ppm; and at pH 10, 87.52ppm. Fortunately, ammonia concentrations are seldom high enough in fishponds to affect fish growth. The greatest concentrations of total ammonia nitrogen usually occur after phytoplankton die off, at which time pH is low because of high concentrations of carbon dioxide.

How to control ammonia:

Aeration and Flushing with freshwater: The un-ionized ammonia is in the form of dissolved gas. Increasing pond aeration or the process of removing dissolved gases is another way of decreasing ammonia concentration in a fishpond. In a small-scale pond, aerating will remove the dissolved toxic ammonia through diffusion from water into the air. Flushing the pond with fresh water can also dilute the concentration of ammonia which in turn could lessen water toxicity. Both ways (aeration and flushing with freshwater) of lessening the toxic concentration of ammonia can only be practical on a small scale than in larger aquaculture operations.

Aquatic Plants and Organisms: Aquatic plants play a vital role in aquaculture water treatment. Algae and other aquatic plants take and consume a huge amount of ammonia in a fishpond. Aside from producing oxygen, plants such as yucca reduce harmful and toxic substances. Algae, in contrast, uses ammonia to harness energy from sunlight. It acts like a sponge that absorbs ammonia in its process of photosynthesis. Thus, both produce a positive effect in the maintenance of the tolerable presence of ammonia in a fishpond. Research suggests that the presence of plants and other aquatic organisms such as algae acts as a natural process in the loss or transformation of ammonia. Oxygenating plant species are always a good recommendation unless for commercial scales, air pumps would mostly do the trick. Oxygen levels can be controlled by means of stocking fish at a reasonable density, this also aids in the calculated proportion of feed consumed by fish to help eliminate excess feed.

Reducing/Increasing Pond Depth*:* In shallow ponds, algae would usually thrive because of ample availability of light. Because of the high availability of light, algal growth will increase. This, in effect, will remove the ammonia more effectively. On the contrary, the increased depth of the pond is also another way to reduce or preserve the essential level of ammonia in ponds. Deeper ponds contain more water than in shallow ponds. They should have lower toxic ammonia concentrations because there is more water to dilute the ammonia excreted by fish.

Reduction of feeding: In case of supplementary or formulated fed fishponds, protein from the feed of fish is the major cause of ammonia build-up in water. In the process of metabolizing protein, ammonia is necessarily produced. When ammonia is found present, reduction or elimination of feeding is done. In winter, feeding is only done at higher temperatures of around 100C. Contrary to what most people believe, ammonia is low in summer due to the intense photosynthetic activity of algae in removing ammonia. Unmonitored feeding will most likely impose ammonia concentration in months without algal interventions. When feeding is regulated, fish are not likely to eat feed due to ammonia stress and the feed will only make the situation worse upon accumulation. In this case, changing 25 to 50% of total water volume is recommended to remove some for the ammonia in smaller ponds/tanks.

Parameters	Suitable Range
pH	7.5- 8.5
Dissolved oxygen (DO)	5-8 ppm (not less than 3ppm)
Alkalinity	40-80 ppm (critical 25ppm)
Ammonia	<0.2 ppm

Table 20: Optimal range for key chemical parameters of aquaculture pond

4.2 Liming:

Application of agricultural limestone and/ or dolomite to improve pH and alkalinity in aquaculture ponds is a widely used practice. However, there is considerable use of lime in aquaculture to disinfect pond bottoms and water, to attempt to control pH and various other reasons. (Refer chapter 2.2.1 – Liming)

The Effects of Liming on Pond Water are:

- pH will increase and become more stable.
- Total alkalinity will increase, providing more carbon dioxide for photosynthesis.
- Calcium content will increase, to be used by plants.
- Certain toxic substances such as iron compounds will be neutralized and precipitated as pH increases.
- Excess organic matter will precipitate, decreasing the demand for dissolved oxygen in the pond water.

4.2.1 Types of limes used:

Lime Type		Form	Safety & Use
Common Name	**Chemical Composition**		
Calcitic lime or agricultural limestone	calcium carbonate. $CaCO_3$	powdered, crushed, pelletized	Recommended for use in ponds containing fish.
Dolomitic lime	calcium carbonate + magnesium carbonate. $CaMg(CO_3)_2$	powdered, crushed, pelletized	Recommended for use in ponds containing fish.
Liquid lime	calcium carbonate + calcium hydroxide in aqueous solution. $CaCO_3 + Ca(OH)_2 + H2O$	liquid	Recommended for use in ponds containing fish; large applications may be split into two applications, 5 days apart to improve safety for fish.
Slaked or hydrated lime	calcium hydroxide. $Ca(OH)_2$	powdered, pelletized	Not recommended for use in ponds containing fish; may be used to adjust alkalinity and pH in new ponds before stocking fish.
Burnt or quick lime	Calcium oxide. CaO	powdered, granular	Not recommended for use in ponds containing fish. may be used to adjust alkalinity and pH in ponds before stocking fish.

Table 21: Types of limes, their safety level for application in ongoing culture ponds-

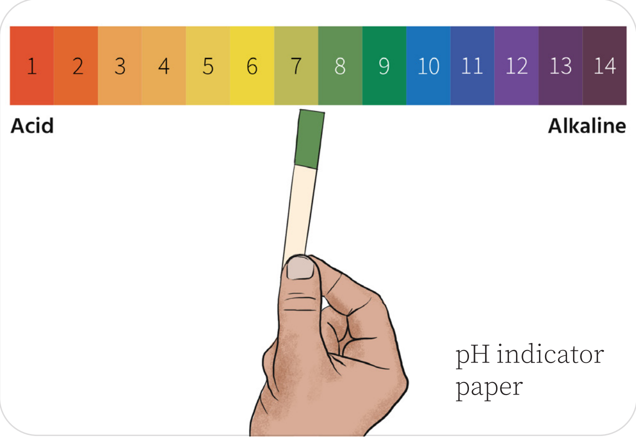
Measuring pH in Pond Water:

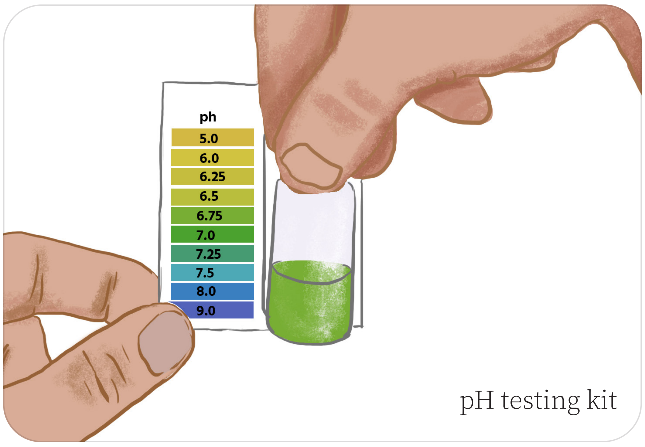
1. pH indicator paper: a thin strip of paper (such as chemically treated litmus paper) is partly dipped into the water to be tested. The colour of the paper changes, and this new colour is compared to a colour chart, which gives the pH value according to the colour obtained. You can buy litmus paper cheaply from some chemists.

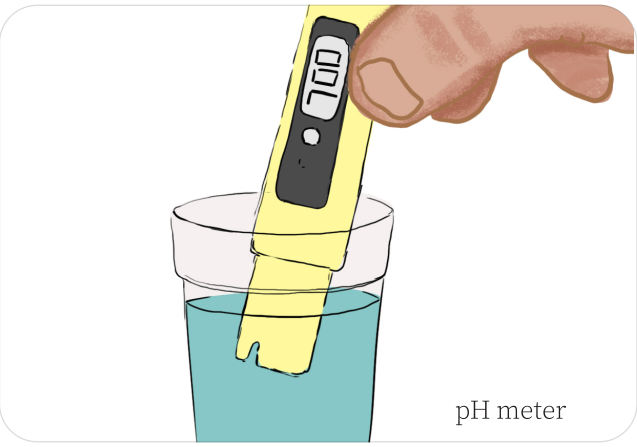
2. Colour comparator: cheap water-testing kits can be bought from special chemical suppliers. They usually include a number of liquid indicators. A few drops of one of these colour indicators are added to a small water sample, and the new colour of the solution is compared with a set of standard colours supplied with the testing kit.

3. pH meter: such equipment provides the easiest way for determining the water pH, even in the field, but it is relatively expensive. The pH value is directly read from the meter after placing the glass electrodes in a water sample. Such electrodes are very fragile and should be well protected when being transported. They should be accurately calibrated in buffer solutions of known pH, at regular intervals.

Note: because of the variation of the pH in fishponds during the day, you should measure pH at a regular time, preferably at sunrise. It is even better to measure the pH at regular intervals of two to three hours from sunrise to sunset, which will give you a good idea of the pH variations during daytime.







Measuring pH with pH indicator paper, with testing kit and pH meter.

Choosing the pH value of your water
Fish production can be greatly affected by excessively low or high pH. Extreme pH values can even kill your fish. The growth of natural food organisms may also be greatly reduced. The critical pH values vary according to the fish species, the size of individual fish and other environmental conditions. For example, fish are more susceptible to extreme pH during their reproductive seasons, and eggs and young fish are more sensitive than adults.
Waters ranging in pH from 6.5 to 8.5 (at sunrise) are generally the most suitable for pond fish production. Most cultured fish will die in waters with pH below 4.5, pH equal to or greater than 11. Fish reproduction can be greatly affected even at pH below 5.5, while a pH greater than 9 can already be detrimental to fish eggs and juveniles.

Fluctuation of pH throughout the day and night

The original pH of the water may be affected by the pH of the soil. However, the pH of pond water varies throughout the day mostly as a result of photosynthesis, and through the night through respiration.

(a) At sunrise, the pH is lowest.

(b) Photosynthesis increases as the light intensity increases. More and more carbon dioxide is removed from the water by the plants causing the pH to increase.

(c) A peak pH value is reached in late afternoon.

(d) Light intensity then starts decreasing, which reduces photosynthesis. Less and less carbon dioxide is removed from the water, as respiration adds more carbon dioxide to the water, pH starts to decrease.

(e) At sunset, photosynthesis stops, but respiration continues for the rest of the night. More and more carbon dioxide is produced, and pH keeps decreasing until sunrise, when it reaches its minimum.

(f) The next day, this cyclic fluctuation of pH starts again.

This pH fluctuation varies in intensity. The more productive the pond, the richer its water will be in minute plant organisms (phytoplankton), the plant and animal respiration will be greater, and the daily fluctuation in pH will be stronger. The pH value of 9.5 will be quite common in late afternoon. The alkalinity of the water is the buffering system to prevent too strong variations in pH. The level of pH variation during the day depends on the Alkalinity of the water (see next chapter 4.2.3 Liming Dosage and Mode of Application).

4.2.2 Liming Dosage and Mode of Application:

Routine treatment of the pond water: check the pH of the pond water in the morning and during mid-dayat the end of the day, and the acceptable levels of pH variation over the day are, from 6 to 8.5 from morning before sunrise to midday are acceptable. pH fluctuation between 5.5 to 9 require attention and $CaCO_3$ should be added:

• If the pH is less than 6.5, add 150 to 200 kg/ha $CaC0_3$, checking the pH one week later and repeating liming if the pH is still too low.

• If the pH is between 6.5 and 8.5, check the total alkalinity of the water and if it is less than 75 mg/l $CaC0_3$, you could use lime to increase its value by adding one or several doses of 150 to 200 kg/ha $CaC0_3$ at weekly intervals until the total alkalinity is improved.

• If the pH is greater than 8.5, no liming is required.

Note: Do not forget to correct the above quantities according to the percentage of $CaC0_3$ present in the particular liming material you are using. For example, if you are using a limestone containing 90 percent $CaC0_3$, multiply the amount of $CaC0_3$ suggested above by 100 ÷ 90 = 1.11.

Mode of application:

• It will be easier to distribute the liming material evenly if it is first diluted in some water before being thrown into the pond.

• Lime diluted in water can be applied using a large wooden spoon. In small ponds this can be done directly from the banks, but if the pond is large, it may be necessary to use a boat or a floating platform.

***Note:** Regular monitoring of pH every day, recording the readings in the pond record book will be helpful for the farmer to assess the water condition, plankton levels and overall fish health condition.

4.3 Manuring:

Manuring during post stocking operation is done to maintain sustained production of plankton during the entire culture period. The ability of water to produce plankton depends on many factors, but the most important is usually the availability of inorganic nutrients for phytoplankton growth. Essential elements for phytoplankton growth include carbon, oxygen, hydrogen, phosphorus, nitrogen, sulphur, potassium, sodium, calcium, magnesium, iron, manganese, copper, zinc, boron, cobalt, chloride, and possibly others. Phosphorus is most often the element regulating phytoplankton growth in ponds. The addition of phosphate fertilizer will cause an increase in plankton production and an increase in fish production in most ponds. Inadequate supplies of nitrogen, potassium, and carbon also limit phytoplankton in some ponds. In general, the level of plankton production in unmanaged ponds is related to the basic soil fertility of the surrounding watersheds. Therefore, the basic levels of plankton and fish production are greater in ponds located on watersheds with fertile soils than in ponds located on watersheds with poor soils. The management practices on watersheds also influence plankton production in ponds.

Fertilizers used for manuring are natural or synthetic substances that are used in ponds to increase the production of the natural food organisms to be eaten by the fish. These organisms include phytoplankton, zooplankton, bacteria and insects. They are all part of a complex food web converging toward fish production. By increasing the availability of major nutrients, fertilizers promote the development of planktonic algae, which provide food for many fish. Fertilization also leads to the development of animals which feed on algae.

When a fertilizer is added to a fishpond, the chemicals it contains dissolve in the water, where:

• A portion is usually rapidly taken up by the phytoplankton present, either to be stored, sometimes in quite large proportions, or to be assimilated and used for growth, reproduction, etc.

• Another portion is attracted by and becomes attached to the organic and mineral particles present, both in the pond water and in the upper layers of the bottom mud or soil.

• This second portion may also assist the development of bacteria, responsible for the decomposition of organic matter. The decomposition of organic matter may in turn release more nutrients back into the mud or water. The chemicals attached to soil particles may also later be released back into the water slowly, over a long period of time. They may also migrate deeper into mud and soil, where they will no longer affect the water body, unless the pond bottom is dried or ploughed.

• Most of these phenomena are linked with and controlled by water quality and in particular temperature, pH, alkalinity and dissolved oxygen level.

Different types of Manures or Fertilizers

Pond fertilizers form two distinct groups:

Mineral or inorganic fertilizers, which contain only mineral nutrients and no organic matter; they are manufactured industrially to be used in agriculture for improving crop production and they can be obtained from specialized suppliers.

Organic fertilizers, which contain a mixture of organic matter and mineral nutrients; they are produced locally, for example as wastes from farm animals or as agricultural wastes.
Both types of fertilizer have advantages and disadvantages, as listed **in Table-22.** Select the most appropriate type of fertilization for your own needs. Selection may depend not only on local availability but also on the size of the farm.

(a) Small-scale fish farms tend to rely on organic fertilizers as they are cheap and available locally.
(b) Large-scale fish farms most often adopt inorganic fertilizers, as they are more easily stored and distributed.

The best results can often be obtained with the combined use of both types of fertilizer.

Making the best use of fertilizers

When using fertilizers to increase fish production in your ponds, you should aim to establish and maintain a dense growth

Item	Organic Fertilizers	Inorganic Fertilizers
Storage	Difficult, only short time	Easy, possibly for long time
Distribution	Difficult, esp. on larger scale	Easy
Mineral content	Variable, low	Consistent, high to very high
Organic matter	Present	Absent
Effect on soil structure	Improvement	No
Direct food for fish	Yes	No
Decomposition Process	Yes, with oxygen consumption	No
Price	Low to medium	High to very high
Cost per Nutrient Unit	Higher	Lower
Availability	Possibly in neighbourhood or even on own farm	Commercial suppliers only; sometimes imported
Direct pond fertilization	Possible by raising animals on or near the pond	Not feasible

Table 22: Comparison of organic and inorganic fertilizers

of planktonic algae (phytoplankton) and zooplankton, which should colour the water a rich shade of green. Such dense planktonic growth is often called a plankton bloom.

To establish and maintain a good plankton bloom at minimum cost, watch for the following points.

(a) Pond water and bottom soil should be neutral or slightly alkaline. Lime them if necessary (Refer chapter 2.3.1 – Liming).
(b) If present, bottom mud should be good quality, not too thick and mostly made of fine detritus; too much cellulose slows down its decomposition. Control the emersed vegetation and the mud thickness, if possible, by draining and drying.
(c) Reduce the competition for nutrients and sunlight by controlling the floating and submersed vegetation.
(d) Reduce the water exchange rate as much as possible to avoid draining away water rich in nutrients and plankton.
(e) Fertilize each pond according to its particular characteristics; for example, use more fertilizer:

- If the pond is new, and good mud has not yet formed.
- If the water supply is poor in nutrients.
- If the bottom soil is sandy rather than clayey.

(f) Add more fertilizer as needed according to the plankton density, using small amounts regularly.

Do not fertilize a pond if:

- If your fish production system does not depend on the use of natural food.

• The exchange rate of the water is excessive, there is too much emersed or other aquatic vegetation.
• The water is too muddy or dark-coloured, and transparency is limited.
• The plankton density is too high and the secchi disk visibility range is very low (Less than 25 cm)

Deciding about the need for fertilizers

The Secchi disc transparency can be used as a simple method for judging plankton turbidity and the need for additional fertilization of a fishpond. Depending on the value observed, control and manage the pond as shown in the following chart.

Secchi Disc Transparency	Management/control
Less than 25 cm	**No Fertilization** Closely observe fish for signs of dissolved oxygen depletion, Increase water inflow, if necessary
25-40 cm	**No Fertilization** Regularly observe fish behaviour
40-60 cm	Routine fertilization necessary
More than 60 cm	Routine fertilization necessary, possibly with an increased dose

Table 23: Assessment of Fertilization Needs

Organic fertilizers:

In many instances, especially for small farmers, organic fertilizers are the most effective way of increasing natural food supply in ponds to improve fish production.

Different kinds of organic fertilizer

Several kinds of organic material, mostly waste materials, can be used as organic fertilizers. Most common are the following:
• Animal manures, mostly from farm animals
• Agro-industrial wastes
• Biogas slurry
• Cassava fermentation
• Natural vegetation
• Compost, a mixture of various kinds of organic matter.

Animal manures as organic fertilizers

• As pond fertilizers, animal manures have such great advantages that they should be preferred whenever' possible.
• As direct food, they can partly replace supplementary feeds. For example, on manuring days additional feeding may be cancelled. Some fish, such as the Nile tilapia, may even be produced in large quantities without any additional feeding.
• They are a source of additional carbon dioxide (CO_2), which is very important for the efficient utilization of the nutrients present in the water.
• They increase the abundance of bacteria in the water, which not only accelerate the decomposition of organic matter, but also serve as food for the zooplankton, which in turn also increases in abundance.
• They have beneficial effects not only on the bottom soil structure but also on the bottom fauna, such as the chironomid larvae.
• However, animal manures also have some disadvantages, mostly related to their low content in primary nutrients and their negative effect on dissolved oxygen content.

The composition of animal manures

• The chemical composition of organic manure varies greatly according to the animal from which it originates - namely the species, age, sex, the nature of its diet - and according to the way the manure is handled, namely its relative freshness, conditions of storage and rate of dilution with water. In some cases, total wastes made of dung and urine are available, while in others only solid wastes can be collected.
• Throughout the world, most animal manure is obtained from a limited number of species such as buffalo, cattle (bullock, dairy cows or fattening beef), horses or donkeys, sheep, goats, pigs, and poultry (chicken, ducks etc). Examples of solid manure composition in primary nutrients NPK, on a dry weight basis, are given in Table 24.
• Chicken droppings are the richest in nutrients. Pig dung is usually richer than sheep or goat dung. Manures from cattle and horses are poorer in nutrients, especially when the animals feed on grass only. Their fibre content is relatively high. Buffalo dung is the poorest manure of all.

Animal/ Poultry	Country	Nitrogen N	Phosphorous P	Potassium K
Buffalo dung	India	0.75	0.20	2.00
Horse dung	India	1.88	0.52	1.00
Cattle dung	India	1.65	0.44	0.83
Sheep dung	India	1.55	0.70	0.72
Goat dung	(Asia)	2.04	0.73	0.47
Pig dung	China	2.66	1.37	1.47
Chicken Droppings	India	2.87	1.28	1.95
Duck Droppings	Mean values	2.15	1.13	1.15

Table 24: Examples of the NPK composition of animal manures** (percent of oven-dry weight)

**Source: R.V. Misra and P.R. Hesse, Comparative analyses of organic manures, FAO/UNDP Regional Project RAS/75/004, Project Field Document 24, 97p.

Selecting the best animal manures for your fishpond

If several types of manure are available, choose the best for fertilizing your pond according to the following criteria.

(a) The manure should be easily soluble and dispersible in water. Liquid manure or solid poultry wastes are preferred, because cow or horse dung usually contains a lot of insoluble cellulose especially if mixed with stable litter.

(b) It should be in small particles rather than in lumps.

(c) Use it as fresh as possible. Large losses of nitrogen and carbon occur during storage, especially if the manure is left in the open air and in the rain.

(d) Make sure it has a high nutrient content, as discussed above (see also Table 24).

(e) Manure should be easy to collect. Housed or enclosed animals produce more concentrated manure than free- roaming ones.

Note: in new ponds with sandy soil, cattle manure with higher fibre content may be preferable to help form the bottom mud.

When to fertilize your ponds with animal manure

Fishponds are usually fertilized with animal manure at least ten to 15 days before stocking with fish. In drained ponds, the manure is applied to the pond floor just before refilling with water. In undrained ponds, the manure is applied to the water.

After the first application, the pond should be fertilized at regular Intervals throughout the fish production cycle. For best results,

- fertilize your ponds with manure frequently, at short intervals preferably not less than once a week. Daily applications are best.
- You should monitor your pond carefully during fertilization to avoid fish losses. This is especially important if you are using animal manure.

Continue to fertilize a pond only if:

The water quality remains acceptable (Refer table 19, 20 and 23) the behaviour of the fish remains normal (see Section 4.1.3 Chemical Parameters-Dissolved Oxygen).

Using animal manure safely

Because of the increased demand of dissolved oxygen caused by the addition of organic matter to the pond water, you should limit the amount of animal manure to be applied at any one time. This safe maximum amount is usually expressed in kilograms (kg) of dry matter (DM) per hectare (ha) per day (d) abbreviated as kg DM/ha/d.

The safe maximum amount of animal manure in cooler and temperate climates is 60 kg DM/ha/d or 0.6 kg DM/100 m^2 /d; in warmer and tropical climates, the safe maximum is 120 kg DM/ha/d or 1.2 kg DM/100 m^2 /d.

To determine how much dry matter (DM) a specific manure contains, you can measure it yourself. Take exactly 100 g of the manure you want to use and place it in a dry container such as a tin. Weigh the manure and the container (W1grams). Place the open container in an oven and heat it to about 1800C for four hours. Weigh the manure and container again (W2 grams). The difference (W1 - W2 = W3 grams) is the moisture content (in percent) of the manure. Obtain the dry matter weight DM (in g) = 100 g - W3. This is also the percentage of dry matter present in your manure.

Example
You weigh 100 g of cow manure collected from a farm and place it in a tin. The total weight W1 = 185 g. After drying the sample in an oven, you find W2 = 145 g. The moisture content of the manure is W3 = 185 g - 145 g = 40 g. The dry matter content of your manure is DM = 100 g - 40 g = 60 g or 60 percent.

Note: if you are using liquid manure, you should be even more careful because of its relatively high content in ammonia, a very toxic gas for fish. Do not apply more than 1000 litres/ha/d = 10 l/100 m^2 /d.

Maximum amount of fresh solid manure to be safely applied per day in 100 m^2 of tropical fishpond is shown in the table 25 below.
Note: Moister level in fresh solid manure varies widely, based on the animal source, number of days after collection and local atmospheric conditions it can vary from 90% to 30%.

The suggested application levels mentioned in the following table 25 are advised based on their respective dry matter value basis.

Solid Manure	Maximum amount (kg fresh/100 m^2 /d)
Buffalo	**6.3**
Cattle	**6.0**
Horse	5.2
Sheep/ Goat	3.4
Pig	6.0
Duck	2.8
Chicken	4.8

Table 25: Daily application limit of different solid manures

Beware: If you do not use manure every day but only once a week, it does not mean that you can safely place on one day seven times as much manure into your pond. The safe maximum amount remains the same. If you wish to use more manure, you should reduce the interval between two consecutive applications. Place the manure two or three times a week.

Controlling the amount of animal manure to apply

The amount of animal manure to be applied to a particular pond varies greatly, depending on factors such as climate, water and soil quality, characteristics of the manure and kind of cultural system (type of fish, rearing density, length of rearing period). For best results according to your particular case, you may apply one of the following procedures.

(a) As an approximate guide, in small tropical rural ponds generally from 100 m^2 to 300 m^2 in size, apply once or preferably twice a week, one of the following:

Note: Moister level in fresh solid manure varies widely, based on the animal source, number of days after collection and local atmospheric conditions it can vary from 90% to 30%. The suggested application levels mentioned in the following table 26 are advised based on their respective dry matter value basis.

Manure Type	Dose /100 m^2
poultry droppings	4.5 kg
Sheep or Goat Dung	3 kg
Pig Dung	6 kg
Cattle or Horse Dung	5 kg
Cattle or Horse Stable-Litter	15 kg

Table 26: Weekly or biweekly manuring schedule

(b) For more controlled application in a warm climate, at relatively low rearing densities of fish:
• About ten to 15 days before stocking the fish, apply fresh manure at the equivalent rate of 10 to 20 kg dry matter per 100 m^2, either to the dry bottom (drainable pond) or to the water (undrainable pond).

• About one week after stocking the fish, apply fresh manure to the full pond at the equivalent rate of 0.5 to 1 kg dry matter per 100 m^2.

• Every week thereafter, check on water quality, increasing or decreasing the preceding amount of dry matter accordingly (Refer table-19, 20 and 23).

(c) In a warm climate, at higher rearing densities of fish:

• About ten to 15 days before stocking the fish, apply fresh manure at the equivalent rate of 10 to 20 kg dry matter per 100 m^2.

• A few days after stocking, apply fresh manure at the equivalent dry matter rate per 100 m^2, equal to about one-tenth of the weight of fish stocked per 100 m^2.

• Every day thereafter, or at least twice a week, apply manure to the pond according to water quality and fish behaviour, increasing or decreasing the amount of dry matter applied. In general, you should gradually increase this amount as the total weight of fish present in the pond increases, until you reach the maximum amount of dry matter which can be safely applied on any one day, or about 1.2 kg/100 m^2.

Applying animal manures to water-filled ponds that have been stocked

• Once the pond has been stocked with fish, you may apply liquid manure directly over its entire water surface.

• However, solid manure should only be applied indirectly. Use one of the following methods:

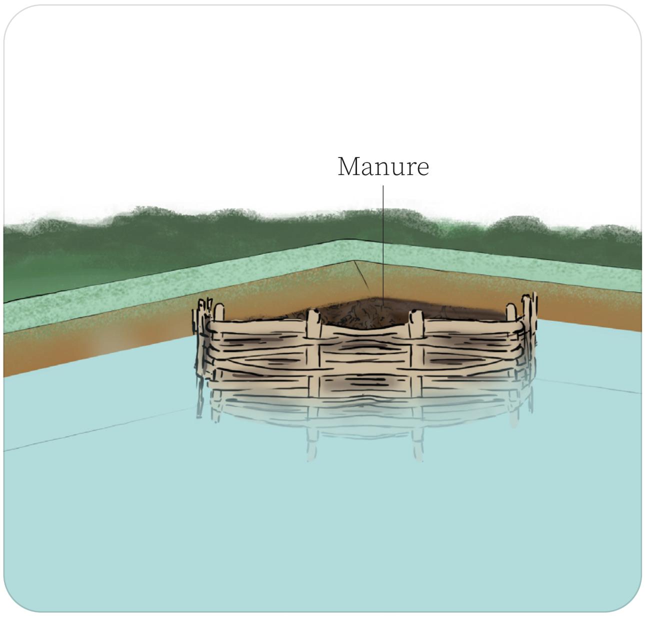
a) Floating Basket: A floating basket attached to the inside of a car tyre inner-tube. Prepare the amount of manure to be applied to the pond. Fill the basket with some of this manure, place it in the inner-tube and attach two long ropes. Pull the floating basket from bank to bank across the entire water surface. The manure will soften and gradually dissolve in the water. Refill the basket when necessary, until all the manure has been distributed.

b) Manure Heaps: Place the manure underwater in heaps at regular intervals along the pond banks.

c) Crib Method: A compost crib constructed using wooden sticks at one or more sides of the

a) Floating basket method

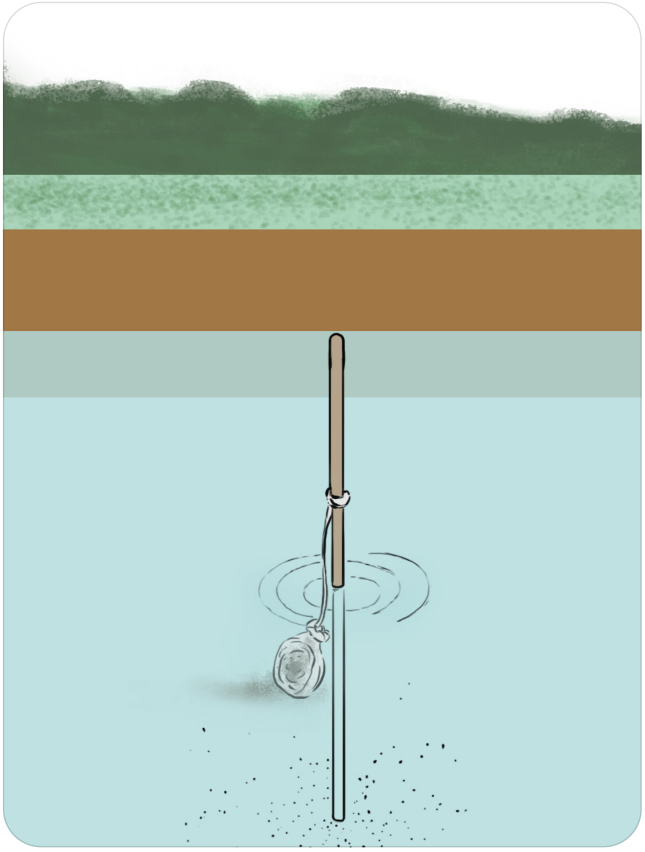
b) Manure heaps method



c) Crib method

pond. It helps fertilize the water gradually. If you are using this kind of crib, spread and mix the manure the full length of the crib, because the manure in the crib requires frequent turning to facilitate the release of nutrients. In smaller ponds, it is best to build a crib in each of the two shallow corners of the pond. Fertilize the cribs as you were told in item (c) above.

d) Bag method: A bag is filled with manure and tied to the corner of the pond. The bag is shaken weekly or daily to release nutrients.



d) Bag method

When planning the fertilization of your ponds, remember the following:

(a) It is preferable to use animal manure as fresh as possible. Check if it is available when you need it.
(b) There should be at least a 15-day interval between liming and manuring.
(c) Apply manure preferably in the early hours of the day, about two to three hours after sunrise.
(d) Best results are obtained by combining manuring with inorganic fertilization. Additional phosphorus and nitrogen are usually beneficial to maintain a good plankton bloom.
(e) Always maintain and adjust your fertilization by checking water quality and fish behaviour.

General Guidelines:

During pond preparation only 25-30% of the recommended dose is used (see pond preparation).

The balance is to be used in equal monthly instalments for the rest of the culture period to maintain continuous plankton production as a post stocking management practice.
High transparency (> 30 cm) indicates low productivity (low alkalinity <20 ppm) and requires one additional dose of manuring. Apply manure in the corners of pond in heaps for slow mixing and release of nutrients for phytoplankton.

Apply organic fertilizers regularly, avoiding overloading the pond with several weeks' supply. Check the water quality to control the quantities used.

Note: wastes such as rice hulls, sugar-cane stalks and sawdust are rich in cellulose, which decomposes very slowly in the pond. Do not use them too much, unless you are trying to establish a good pond bottom on sandy soils.

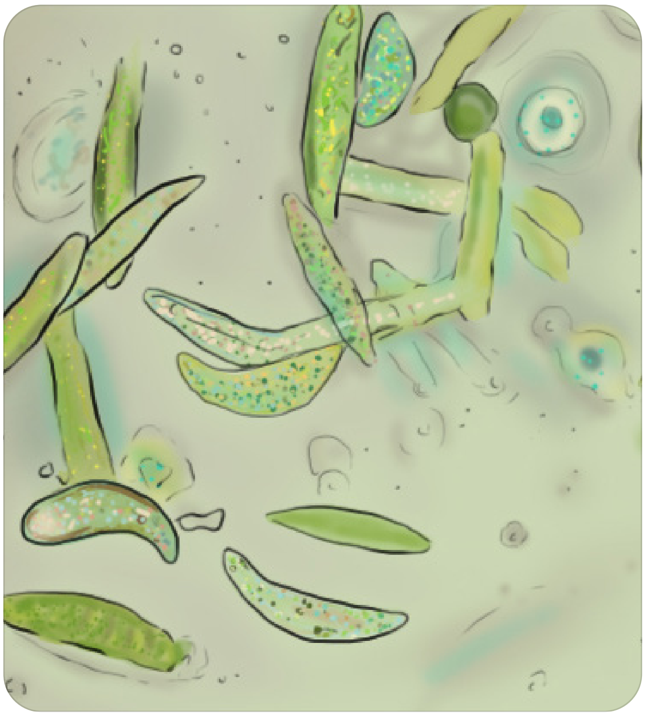
4.4 Feed Management:

Plants are able to produce new organic material, through photosynthesis, by utilizing sunlight and simple nutrients. On the contrary, animals, including fish, cannot. Thus, to survive, grow and reproduce, fish need to feed on organic materials such as plants, other animals, or prepared feeds containing plant and/or animal material. It is therefore most important for you to ensure that your fish get the food they require, both in quality and in quantity.

4.4.1 Natural Food:

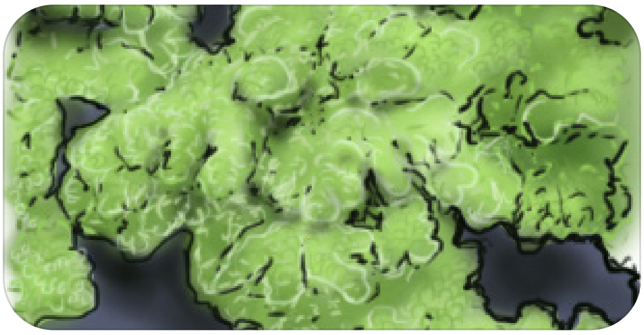
Biological Cycle And Food Chain in Fishponds

From a fish production point of view, fish is the final result of the complex biological cycle which takes place in a pond. This cycle in a fishpond includes production, consumption and decomposition of living or

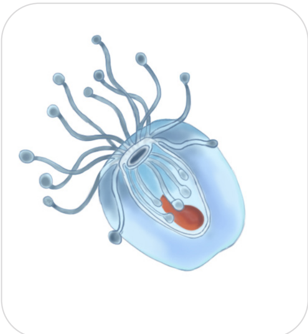


Phytoplankton

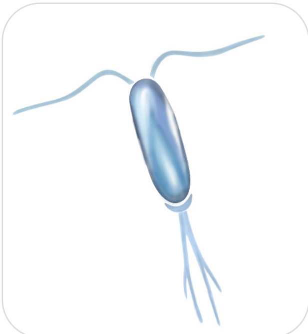
Napier grass



Azolla



Zooplankton



Copepod

Rotifer

Cladoceron

Lemna

organic materials. Primary production is the building of organic material from inorganic materials by autotrophic organisms when CO_2 is the single or main source of carbon. These organisms are the autotrophic bacteria and plants. In the case of plants, the production takes place in the course of photosynthesis. This is when plants (phytoplankton, algae and aquatic weeds) use mineral nutrients, CO_2 dissolved in the water and solar energy from which they build up their body.
Consumption is performed by both autotrophic and heterotrophic organisms.
In the dark period plants consume and break down organic compounds which were produced by them in the light period to release energy for maintenance and growth.
Heterotrophic organisms are mainly animals, fungi and bacteria. They cannot produce organic compounds from inorganic, but feed on living or dead organic materials which they break down to release energy or to use as building stones for growth, maintenance and reproduction.

According to the size of consumer organisms, macroconsumers and microconsumers are distinguished. Macroconsumers are mostly animals, both invertebrates (worms, insects, etc.) and vertebrates (fish, amphibians, reptiles, birds and mammals). On the basis of their typical food, they can be herbivorous, carnivorous, detritivorous or omnivorous. Microconsumers, mainly bacteria and fungi, break down complex organic compounds and release inorganic or relatively simple organic materials. Hence, microconsumers are decomposers and their performed process is the decomposition. The success of pond fish culture depends on how the biological cycle is influenced and controlled. In technical literature authors often describe and illustrate the natural food consumption of fish in the context of the food chain, which is the series of organisms that consume each other. The food chains of fish start with the primary production and finish with those organisms or organic materials on which they feed. Different fish species have partly or entirely different food chains. The food chains of fish which feed on phytoplankton or zooplankton are much shorter than the food chains of predator fish. The food web, which is the system of food chains, is a more scientific way to illustrate the complexity of how the different organisms feed on each other. (Refer-Feeding zone and major feeding habits of different species in a pond – Table 11).

Role of Natural Fish Food and Supplementary Feeds in Pond Fish Culture

In ponds, the detritus, the colonies of bacteria, the aquatic weeds, tahe plankton, the water and the terrestrial insects and their larvae are all-natural food for the different fish species. Phytoplankton and Zooplankton form the main food for carps. Continued production of plankton is required for good growth, survival and health of fish.

Plankton density need to be assessed once in two weeks by either by water colour or Secchi disc reading or more precisely by collecting plankton using net. (Collection method is explained under biological parameters) (Refer-4.1.1 Physical parameters- Transparency and Assessment of Fertilization Needs Table 23)

Accordingly, manure is to be applied as explained under manuring. (Refer-Conventional manuring practices: Table-6; Weekly or biweekly manuring schedule-Table-26 and Dailey application limit of different solid manures-Table -25)

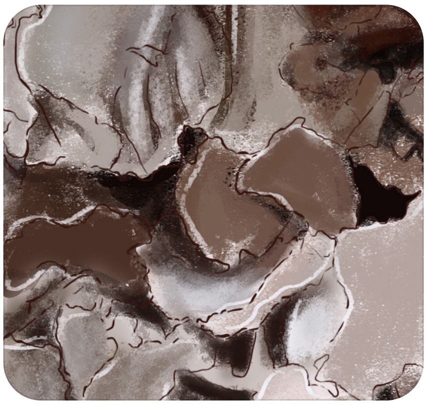
If grass carp is used as a component in culture, provision for providing its natural food (Floating aquatic plants- Lemna, Azolla or grass like Napier) should be made.

4.4.2 Supplementary Feeding:

In pond polyculture, the role of natural fish food is outstanding because it is the source of protein in the diet of fish which otherwise would only be supplied by expensive animal or plant protein meal. As the name indicates, feeding in pond fish culture is practiced mainly as a supplement to the natural fish food. Natural fish food organisms are rich in proteins but poor in carbohydrate. Widely applied supplementary feeds are the different cereals. They are relatively poor in protein but rich in energy. More protein-rich feeds, together with cereals, are also used to supplement the natural fish food when the standing stock of fish increases by the end of the production season. The consumption and utilization of supplementary feeds depend on the species and the age of fish, as well as on the quantity and quality of the available natural fish food. Consequently, the feed conversion ratio (FCR) of the supplementary feeds may vary within certain ranges. Conventionally Oil cakes like ground nut cake, mustard oil cake, cotton seed cake and cereal biproducts like De-oiled rice bran, Raw rice bran, wheat bran are used in combination of 80:20 or 90:10 (Rice bran/ wheat bran 80%or 90%+oil cakes 20%or 10%) to provide supplementary feed for fish. This will meet the protein requirement of fish but is devoid of vitamins and minerals. Oil cake is soaked for few hours and mixed with dry rice bran.

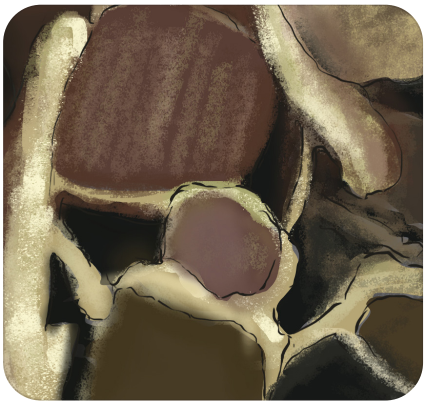
Farm made Supplementary feed can be prepared by the farmers using ingredients like Oil cakes/Fish meal/ soybean meal + pulses/ rice bran/ wheat bran and vitamin and mineral mixture to make it a balanced diet containing 32% protein and 6% fat with mineral and vitamins. Farmer can source locally available biproduct ingredients from oil cake processing and cereal processing biproducts, but farmer needs to check for the following characteristics supplementary feed ingredients.

Water stability
Easily available and cheap
Easily acceptable
Easily digestible
Causing less pollution



Ground nut cake

Mustard seed oil cake



Cotton seed cake

Raw rice bran

De-oiled rice bran

Wheat bran

Supplementary feed ingredients

On-farm storage of supplementary feed ingredients:

The feeds, either mash or pellets needs to be stored in well secured place to keep the quality of the ingredient intact and to prevent rain, heat, and animal damage. The farmer can adapt any one of the following three modalities of storage systems to store the feed ingredients based on the resources available and storage duration.

- Well protected permanent storage facilities constructed with bricks and mortar.
- Semi-permanent structures constructed with locally available construction material like bamboo, wood or mud.
- Feed storage on the pond embankments covered by polythene/plastic sheets or tarpaulins.

Please find below an indicative recipe for making on farm mash feed

Ingredient	% Composition	Feed preparation method
Oil cake (GNC or Mustard oil cake)	45	All the ingredients are mixed and powdered. Mix with in water and cook for about 20 min and make into dough/ balls
Rice Bran	25	
Broken Rice	15	
Pulses (Horse gram, black gram)	20	
Maize	15	

Table 27: Farm made feed

Commercial Feeds

A number of commercial fish feeds (floating and sinking) are available in the market, and these can also be used based on the availability, quality, accessibility and affordability of the farmer.

Compounded pelleted feed are classified into two types:

Sinking pellets: Sinking pellets are dense, heavier and sink in the water immediately after broadcasting. Usage of sinking feed pellet is followed in semi-intensive or intensive farming operations where the natural productivity of the pond is not sufficient to support the expected production outcome. The feeding rate and volume depends on the culture species, fish size, biomass and nutritional specifications of the diet that you are using. Please follow the feed supplier's guidelines.

Floating pellets: These pellets contain less moisture, are light in weight due to reduced bulk density and have air- pockets due to which feed floats on the water surface, which helps to observe the amount of feed consumed by the fish. Usage of floating feed pellet is also followed in semi-intensive or intensive farming operations where the natural productivity of the pond is not sufficient to support the expected production outcome. The feeding rate and volume depends on the culture species, fish size, biomass and nutritional specifications of the diet that you are using. Please follow the feed supplier's guidelines.

4.4.3 Feeding Rate, Methods and Feeding Frequency & Schedule:

The amount of feed given to carp depends upon several factors such as species, size, biomass (spawn, fry, fingerling, adult/brood), natural food present in pond, water quality parameters etc. To reduce feed wastage, feeding should be monitored regularly otherwise it will lead towards deterioration of water quality, which in turn causes stress, disease and/or mortality in fish. The proper feeding schedule should be followed throughout the carp culture. Feeding quantity is to be regulated based on the fish biomass in the pond. Biomass needs to be assessed preferably once in two weeks or at least once in four weeks by sample netting and weighing the fish. Supplementary feed to be given @5% of the fish biomass for initial 2 months and gradually reduced to 1.5-2% at the end of the growing period.

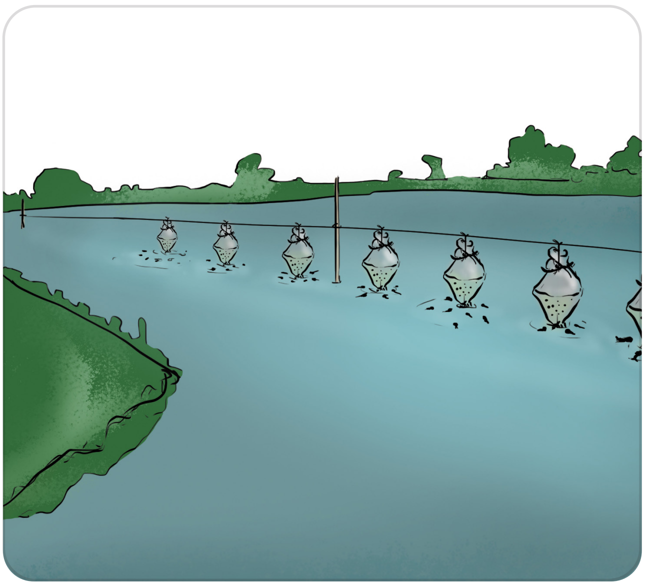
Feeding Methods of Supplementary Mash Feeds:

Bag feeding:

Selected feed ingredients are mixed well, and 3–8 kg of the mixture is placed in used perforated fertilizer bags. Standard (50 kg) fertilizer bags are used. Holes are made in the bags, usually in four rows, about 1 to 1.25 inches from the bottom of the bag. The bags are transported to the middle or bed areas of the pond and tied to fixed feeding poles or by ropes.

Farmers have reported a number of advantages of the bag feeding system. These include the ease with which large quantities of mash feed can be fed with minimum feed wastage and water quality deterioration. The system enables feeding behaviour to be easily observed and promotes the uniform distribution of the feed throughout the pond. In addition, the quantity of leftover feed can easily be estimated, and subsequent feed rations adjusted accordingly. Furthermore, feed wastage through consumption by nontarget species is minimized because smaller fish, such as the tilapias and Puntius spp. are unable to compete with the larger Indian major carps at the feed bags. Finally, the system is easy to maintain using cheap locally available materials.

Currently, Indian major carp farmers base their daily feeding regimes on a number of factors. These primarily include monthly growth parameters, the number of days that the fish have been cultured, the standing biomass, and the average fish weight. Some farmers base their feeding regimes on simple feed responses.



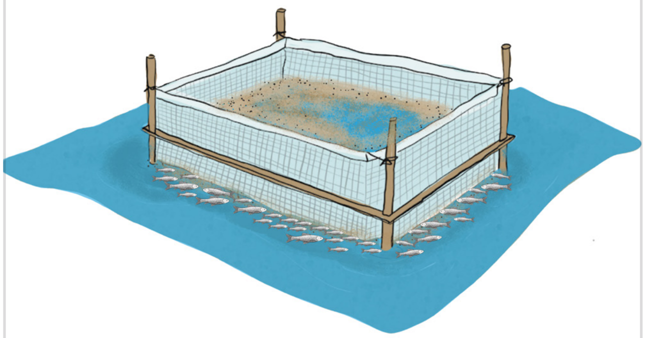
Bag feeding method

In general, the farmers use between 5 to 8 feeding points per hectare at the start of the production cycle when the feed requirements are low. As the feed requirements increase, they gradually increase the number of feed points in the pond; usually a maximum of 25 feed points per hectare are used

Hapa Feeding Technique:

In some regions, carp farmers use pole and simple hapa feeding techniques. The farmers rarely change the feed bags. Each day, mash feed is delivered to the feeding points, and the required quantity of mash is placed in the bag. Hapa feeding involves the use of different sizes of hapas that are made of discarded perforated fertilizer bags. The dimensions of the hapas are either 2 × 1 × 0.75 m or 4 × 4 × 0.75 m and accommodate 25 to 40 kg of mash feed. The fish access the feed through the perforations in the bottom of the hapas.

Feed may be given once (in the morning hours) or twice (morning and evening) in a day based on the consumption by fish, avoid very late evening feeding.



Hapa feeding method

Key Points to Remember

- During feeding, observe your fish carefully to see how actively they eat. A good appetite is a sign of good health and good water quality.
- Every 15 to 30 days, check the fish weight gain and adjust the daily feeding ration accordingly.
- Feed should be always given at a fixed amount and at a fixed place.
- Feed should be stored in cool, dry, well-ventilated room to avoid losses due to spoilage.
- Fingerlings/adults should be fed twice a day in two equal instalment, while spawn/fry should be fed 4-5 times/day.
- In case of disease problem in ponds, feeding should be stopped with immediate effect.
- Feeding should be stopped during overcast conditions, while in winters it should be reduced/stopped gradually.

4.5 Diseases:

Occurrence of diseases in carp farming is very scarce specially so in case of extensive and semi intensive culture systems. There are no reported incidences of fish diseases causing heavy economic loss. Diseases are often seen only in very high intensive culture systems but there are no reported high losses due to diseases. Estimated loss of fish production (as percentage of total production) and total economic loss (in INR) were estimated to be in the range of 5- 10% (14,900.00- per ha to 30,770.0 per ha)

Unlike Land animals it is difficult to isolate and treat infected fish in a pond hence entire water body is to be treated which may not only be effective but also not economical. prevention of occurrence and further spread of diseases through good biosecurity, pond preparation Good water quality and feed management practices are the key for successful aquaculture

4.5.1 Causes:

There are several causes of disease that may affect the fish directly or may continue to cause disease problems. Basically, any factor which causes stress or difficulty to the fish decreases its resistance to disease and increases the chance of disease problems occurring.

The Three Main Causes of Disease are

Improper nutrition and feeding:

- Nutritional diseases become more frequent as the culture system becomes more intensive and the fish obtain less of their nutrients from natural food organisms.

Stress through extreme or toxic condition:

In the previous chapters, you have already learned about such factors as,

- Rough and/or excessive handling, for example when harvesting or sorting/grading/sampling.
- Overcrowding and/or behavioural stresses, for example while stocking or transport.
- Unsuitable water temperature or any other physical parameter.
- Lack of dissolved oxygen or insufficient dissolved oxygen.
- Changes in pH towards extreme values.
- Presence of toxic gases such as ammonia or hydrogen sulphide.
- Toxic factors in artificial food such as particular chemicals in certain plant foodstuffs (saponin, gossypol, etc.), fungal toxins in stored foods, and pesticide residues in source water.
- Pollution of the water by agricultural or industrial chemicals, sewage effluents, heavy silt loads.

Attack by disease organisms:

Fish are attacked by successful disease organisms, either externally on the skin, gills or fins, or internally in the blood, digestive tract, nervous system, etc. (Refer: Common diseases, causative agent, symptoms and control measures-Table 27)

Some other causes for disease are:

- Fish seed with low genetic immunity
- External source through Infected fish seed, equipment, feed, birds and such other sources.

4.5.2 Types of Diseases:

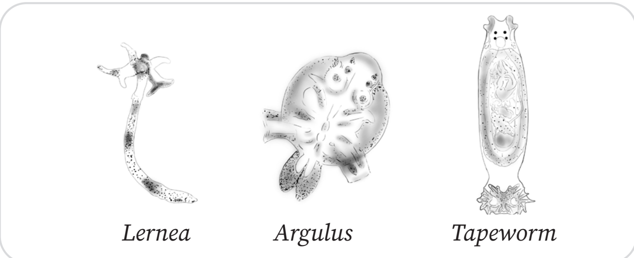
Common diseases, causative agent, symptoms and control measures in carps are as follows:

Name of the disease	Causative Agent	Symptoms	Stages of Infection	Treatment/ Management Protocols
Infectious Diseases				
Ichthyophthiriasis *(Itching disease)*	*Protozoa (Ichthypthiriasis multifilis)*	White nodular spots on skin, gills, fins and restlessness	Fingerlings and adults	Daily bath treatments in 2-3%salt solution for one hour for 7 days or 0.15 ppm of malachite green for pond treatment
Trchodiniasis	*Trichodina*	Attached to Gills	All stages	Improve water quality and bath treatment
Costiasis	*Parasites of Genus Costia*	Bluish –white shade on the body	All stages	Bath treatment with 2-3% NaCl or 50mg/litre of $KMn)_4$ or pond treatment with 5mg/ltr of $KMnO_4$
Whitespot Disease	*Myxobolus Species*	White creamish cysts on gill	All stages, more in fingerlings	Only prophylactic measures. Segregation of infected fish and disinfection of pond after drying
Dactylogyrosis & Gyrodactylosis	*Helminth*	Gills and body get faded	All stages	Bath treatment 25mg/l of formalin with 3-5%NaCl for 15 min or pond treatment with 5mg/ltr of $KMnO_4$
Block Spot Diseases	*Larvae of Diplostomum sp.*	Block spots on the body	Adults	Removal of intermediate(mollusks) and final hosts(birds)
Crustacean Diseases (External parasite)				
Fish lice	*Argulus sp*	Ulcers on the body and visible movement of the parasite	Adults	Bath treatment with 25mg/l of formalin 3-5%NaCl for 15 min or 100ppm $KMnO_4$ pond treatment with 5mg/ltr of $KMnO_4$ for 5-10 seconds or Pond treatment with 5mg/ltr of $KMnO_4$ and removal of parasites

Lernaeosis	*Lernaea sp.*	External attachment to body	Adult stage	Bath treatment with 25mg/l of formalin or 2-3%NaCl for 15 min or 100ppm $KMnO_4$ pond treatment with 5mg/ ltr of $KMnO_4$
Non-Infectious Diseases				
Gill Disease	*Water born irritants, low oxygen level*	Respiration Problems	All stages	No specific treatment. improve the water quality
Algal Toxicosis	*Algal Blooms*	Surfacing of fish with erratic movement	All stages	Sprinkling of cow dung @200kg/ha over surface and covering to reduce sunlight intensity

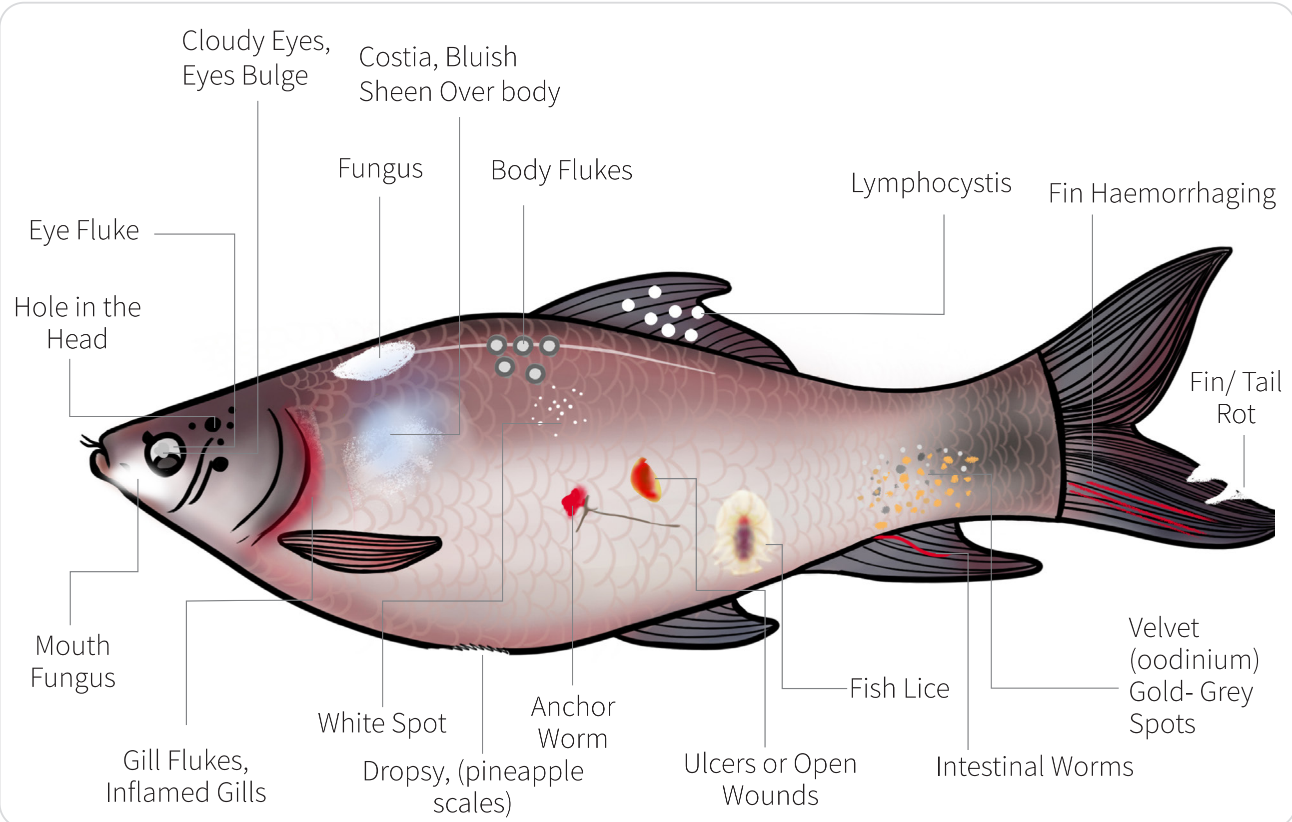
Nutritional Diseases/ Disorders				
Starvation	Complete deprivation of feed/not acceptance of feed	Enlarged head and slender body and retarded growth	All stages	Provide nutritionally balanced diet
Scoliosis	Irregular development of skeleton	Spinal deformity	All stages	Removal of deformed individuals

Table 28: Common diseases, causative agent, symptoms and control measures



Fish parasites

Deformed fish



Disease infected fish

4.5.3 Management of Diseases:

Treating a diseased fish is difficult when compared to land animals, as individual treatment is difficult/ not possible in aquaculture there by requiring mass treatment of the entire mass or the pond itself. Prevention, therefore, is always the best approach in aquaculture to control the disease outbreak than treating the disease.

Management practices like good pond preparation practices, optimum stocking density, water quality monitoring, proper feeding and periodic liming are some of the key factors to avoid occurrence of diseases in fish.

Prophylactic measures specially during winter months like maintaining proper water depth, avoiding over feeding will help in managing of fish health.

Preventing diseases through good management

Ensure good water quality: Sufficient supply, with adequate dissolved oxygen concentration and free of pollution.

Keep the pond environment healthy: Control silt, control plants, keep a healthy balance of phytoplankton and zooplankton, and exchange water if needed. If necessary, use mechanical aeration.

Keep the fish in good condition: Control stocking density. Keep different sizes or sexes separate if necessary to control fighting. Ensure good food supply. Handle the fish properly, especially during harvesting, sampling and sorting/grading. Care for your fish during storage and transport.

Prevent the entry of disease organisms from outside your farm:

• Control wild fish by using filters and screens and regularly eradicate them from canals and ponds.

• Disinfect all fish stocks imported from outside as eggs, juveniles or adults.

Increase vigilance:

• If you have to use water downstream from a neighbouring fish farm, use screens to control escaped fish. If possible, it is safest to use spring or well water, free of disease organisms.

• Use footbaths and protective clothing if necessary to limit contamination.

Prevent the spread of disease organisms within your farm:

• Control fish-eating predators, particularly birds and mammals.

• If a disease breaks out on your farm, remove dead or dying fish from the ponds as quickly as possible, at least daily, and do not disturb and stress remaining fish excessively.

• Bury diseased fish with quicklime away from the ponds, carefully treat infected ponds and disinfect all equipment that has come in contact with them.

• Use disinfectant bins for routine disinfection of equipment, and clearly mark the equipment accordingly.

4.5.4 Management of Pond Hygiene:

• Maintain required water quality and depth all through the growing period.

• Clear excess growth of aquatic weeds and plants on the margins (inside pond).

• Stop manuring or feeding during excessive rainfall and heavy wintertime.

• Clear or control algal blooms (brown algae) when starts appearing to avoid further spread and creating mat/bloom.

• Clear branches of big trees that covering the pond to avoid drooping of leaves into the pond.

4.6 Sampling:

If you are growing chickens, pigs, or cows it is easy to tell if they are healthy and growing or how many you have. They can be looked at, counted and weighed without much trouble. Fish live in a pond full of water these important tasks are not as easy. The only way to do these important tasks is to sample the pond.

A cast net is one of the easiest ways to take a sample. However, for larger ponds a seine net can be used to sample a corner of the pond.

A fish sample should be at least 15 fish. If one cast is not enough to catch this number of fish cast again until enough fish are caught.

If more than 15 fish are caught don't through the extra fish back. Collect all the fish caught, weigh them, and count them and record the information in the pond record book.

Use the following formula to calculate the average weight of fish from the sample.

Average Weight of Fish = (Total Weight of sample) / (Number of fish in sample)

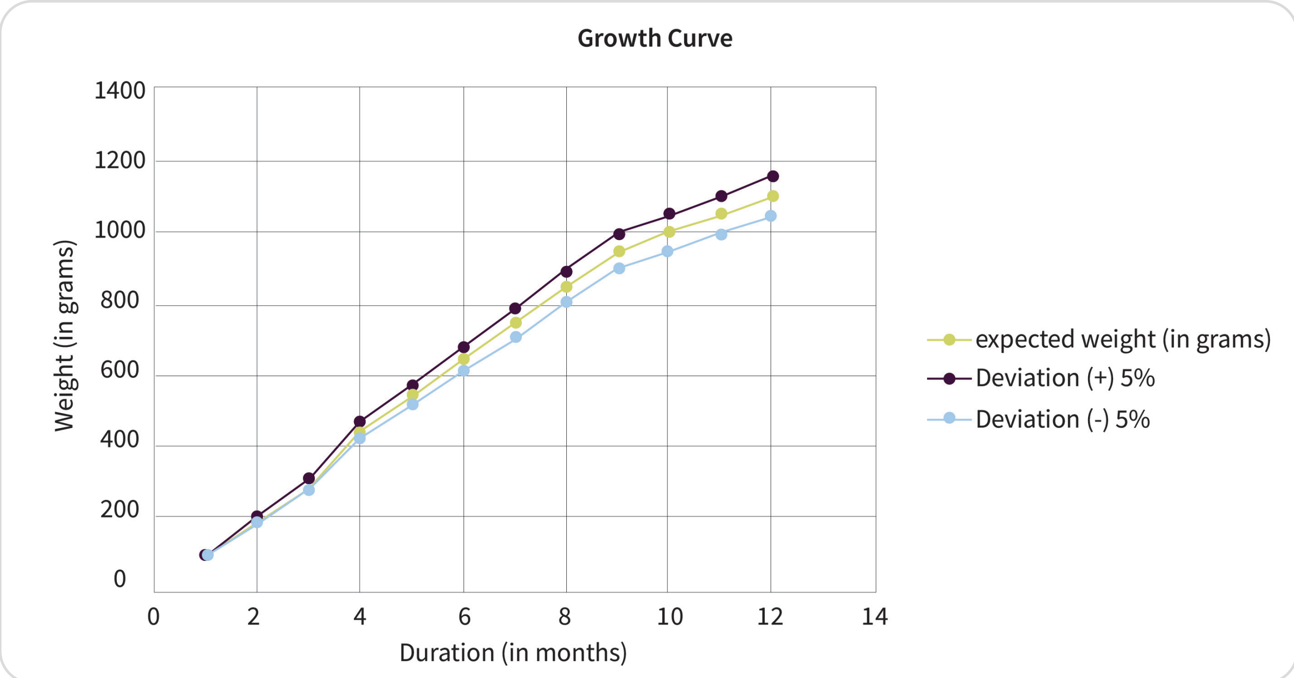
When weighing fish, the fastest and least stressful way to do it is to first place the freshly caught fish in a basket that is partially submerged in the pond as you extract the from the net. Second, pick the basket up and place it on the scale. Record the weight of the fish and the basket. Third, count the fish as they are released back into the pond and record the number. Fourth, place the empty basket back on the scale and record the empty weight. Fifth, subtract the empty weight of the basket from the full weight to determine the total weight of the fish. Finally, to calculate the average weight of the fish, divide the total fish weight by the number of fish in the sample using the formula above

• Sample netting of pond at regular intervals will help in assessing growth and health of fish and also in regulating feeding quantity.

• Sampling at two weeks' interval is preferred. Once in a month is a must.

• During sampling take out all unwanted weed fishes/predatory fishes if found entry unintentionally.

• After sampling disinfect the fish by dipping them in 5ppm $KMnO_4$ solution followed by 2% salt solution before releasing back to pond.



Fish growth curve

4.7 Harvest:

The Decision to Harvest the Fish from a Pond is made for Two Main Reasons:

A. The fish has attained the right size at which it gives maximum profit in the market and any further waiting may reduce the profit.

B. When the prevailing market opportunities offer the highest profit and the opportunity may be lost with delay.

In order for the farmer to decide that the fish has attained optimum size for harvest, the farmer must conduct regular sampling and weighing the fish and recording the data. If The data shows that the monthly increase in fish weigh rises until it attains marketable size. After attaining marketable size, it is advisable to harvest the fish.

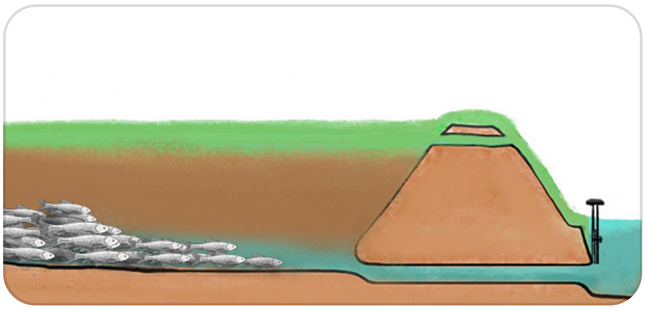
Methods and Gear for Harvesting Pond Fish:

Harvesting by draining

This method of harvesting is the simplest and most effective. Water is let out of the pond by opening the sluices or lowering drain pipes at the outlet. As the water level drops and the water moves towards the deeper end of the pond, the fish drift with it. Finally, all the fish collects at the outlet and is collected with a net. For this method the pond should have been constructed well with a good slope. Harvesting is made much easier if a depression is made at the point of outlet as a "harvesting bay". The fish is then scooped or picked from the ditch (harvesting bay). In this way the fish is picked clean and does not bury in the mud. This method of harvesting is suitable for both small and large pond. For the larger ponds it is used in combination with seining. Fish collected from the mud tends to be dirty and it dies quickly. Pond fish should be marketed clean. During harvesting, there should be two containers with clean water. The first bucket is for washing off mud from the fish. Then the clean fish is put in another container with clean water to keep it alive. The water for washing the fish should be replaced with clean water when it gets dirty.

Harvesting using a seine net:

The seine net is the conventional pond net. It is like an open curtain made of a net with small meshes. The top side of the net is tied to a rope on which plastic round spheres (floats) are attached at about 1 m interval. The seine net is a large curtain-like net. It has floats on one side that keeps the net above water surface. It has heavy cement balls on another side that keeps the net at the bottom of the pond. Therefore, the net remains open during fishing. One wing of the net Metal or wooden ring. 1 m long folded into a ring. The bottom side is tied to another rope on which small stones are attached at about 1 m interval. The length of the net should be longer than the width of the pond by an extra 3 to 5 m to make a curve when it is operated. Example: a pond with a width of 20 m requires a seine net 25 m long. The seine net at the end of the operation. It has trapped fish in the middle (need number of people to operate it).

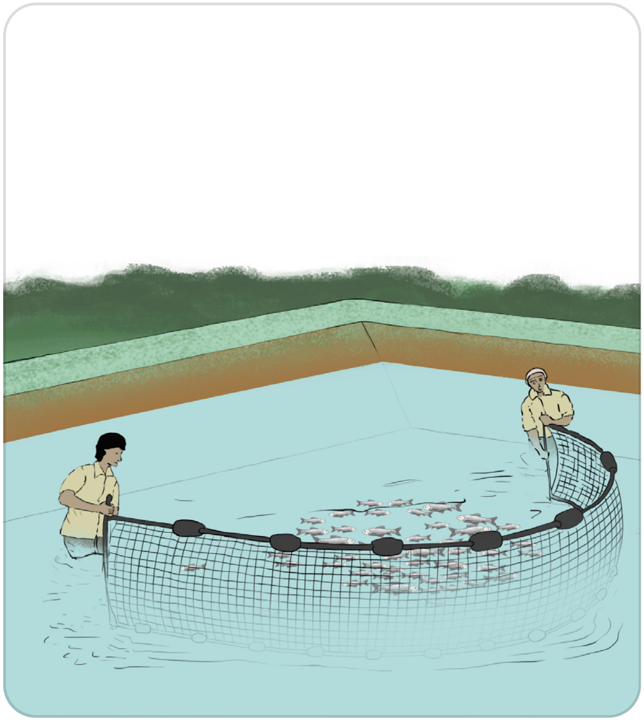


Drained harvest

Seine Net Attributes Are:

- It makes bulk harvests (harvesting up to 90 percent of the fish stock in the pond when fished four to six times repeatedly).
- It is expensive, but it lasts long (up to five years with minor repairs).
- It requires more labour to operate (ranging from 4 people for 10 mx 20 m pond to as many as 12 people for a 20 m x 50 m pond).
- It is most appropriate for large size ponds.
- If operated carefully, it does not injure fish much and fish can be returned into the pond.

A cast net is a net made like an umbrella. It is tied on a rope. It opens out when cast over the pond. As it sinks deep into the pond the mouth is closed, trapping whatever fish that will be in the water space enclosed. But its operation is limited to only small ponds and is time wasting for larger ponds. Catches by chance and the operator does not have much choice of the fish to catch.

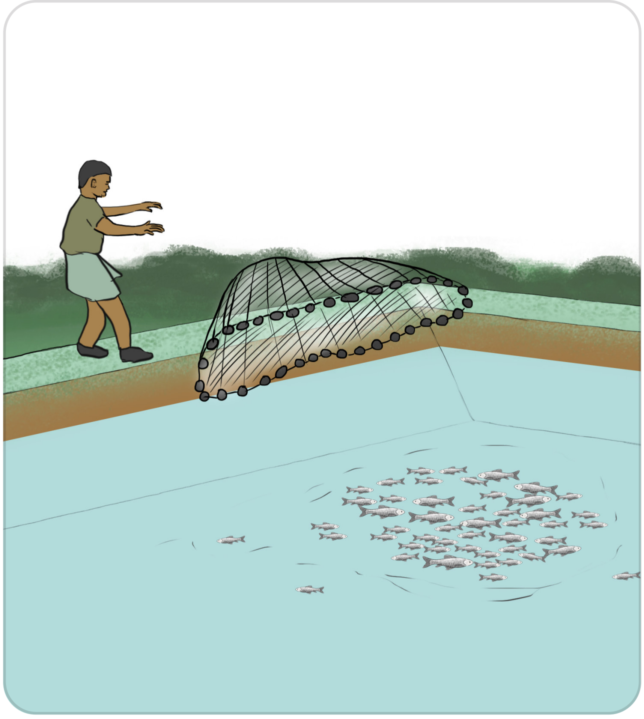


Harvesting using a seine net

Advantages of cast:

- The cast nets is cheap to operate in case if the pond are very small like 0.6 acre or lower than that.
- It is simple to operate but requires training in the skills.

• Does not require large labour force (only one person)
• It does not harm fish, the fish can be returned into the pond.



Harvesting using cast net

4.7.1 General Comments:

• **Stop feeding 2 days before harvest**
• **Early morning hours is the best time for harvesting, if the markets are far away from the farming site, harvesting can be done during late evening hours so that the harvested fish can be transported to the market by early morning hours.**
• **Harvesting using big, meshed size** (> 2 inches) **drag net is better to avoid smaller fish getting caught.**

4.7.2 Types of Harvest:

There are 2 type of harvest one is partial and other is complete harvesting

Partial harvesting

Partial harvesting can be done 4-5 months after stocking and fish of marketing size, around 750g (varies from place to place) and allowing the smaller fish to grow fast.
The number harvested may replenished with equal number of fresh from the rearing pond

Complete harvesting-

Full harvest may be done once all the fish attain marketable size (10 months after stocking).
It is preferable to harvest completely during summer months (May month) by repeated netting and dewatering the pond. Dewatering will also enable preparing the pond for the next crop.
Completing harvesting during summer months will also help in avoiding risk of flooding and fish loss during monsoon months

4.8 Women in Aquaculture:

Participation of women in aquaculture is limited due to several factors right from social taboo to lack of technical knowhow on aquaculture practices. However, women support their menfolk in pond cleaning, pond preparation and feeding fish. They also take part in decision making in sourcing inputs like fish seed, feed and other inputs required for aquaculture. It is more of a family activity in small scale aquaculture than men alone doing the job. Women with literacy help men in keeping record books.

Women groups are now more involved in managing aquaculture ponds as seen in Bangladesh and Nepal. In India also women have started in aquaculture activities as exemplified by WSHGs (Women Self-Help Groups) being allotted GP ponds on priority in Odisha state where complete operations are managed by women.

Women involvement in fish trade is very negligible as they are ill suited due to security and domestic responsibilities at the same time. Socio-cultural inhibitions in specific communities also debar women freely take marketing activities.

4.9 Post-Stocking Economics:

Note: For example, & calculations purpose the pond size and other dimensions are considered as follows- Area: 1 Acre (4080 M^2); Length: 65 Meter; width: 62.77 Meter; Total dike hight 2 Meter; After compaction dike hight: 1.8 Meter; Dike crust width: 2 Meter; Wet side dike slope: 2:1; Dry side Dike slope: 1.5:1; Water filling depth: 1.5 Meter. Adapt the approach as per your pond dimensions.

Recurring or operating costs	Component	Units	Cost per unit*	Cost
C. Water quality assessment kit cost	Water quality test kits (pH, Ammonia, Nitrite, nitrate, alkalinity)	1 (100 tests each)	Rs. 3500.00	Rs. 3500.00
D. Periodic Liming cost	Ag lime purchase cost	20 kg X 8=160 Kg*2	Rs. 7.00/kg	Rs.1120.00
	Ag lime application cost	8 X 1 hour time	Rs. 200.00/hour	Rs. 1600.00
E. Periodic manuring cost	Manure purchase cost	200 kg X 16 applications =3200 kg*3	Rs. 5.00/kg*3	Rs. 16,000.00
	Manure application cost	16 applications	Rs. 200.00/hour	Rs. 3200.00
F.Supplementary feed cost*4	DORB purchase cost	480 Kg (32% of target biomass)	Rs. 14.00/kg	Rs. 6720.00
	Oil cakes purchase cost	120 Kg (8% of target biomass)	Rs. 35.00 /kg	Rs. 4200.00
	Used bags cost	25	Rs. 10.00/bag	Rs. 250.00
	Feed application cost	60days*5	Rs. 200.00/hour	Rs. 12,000.00
G. Sampling cost	Monthly sampling cost	8 times	Rs. 500.00/hour	Rs. 4000.00
H. Expert advice &/or lab assessment cost	Consultation cost	4 times	Rs. 1500.00/visit	Rs. 6,000.00
I. Harvesting cost	harvesting gear rental	1 seine net	Rs. 1500.00/ Day	Rs. 1500.00
	Harvesting workforce	7 people	Rs. 600.00/ half day	Rs. 4200.00
J. Value for farmer's time	Work-hours spent by farmer on farm	@ 1 hour/day X 240 days =240 hours	Rs. 200.00/hour	Rs.48,000.00
i) Total post stocking expenses (Sum of C+D+E+F+G+H+I+J)			**Rs. 1,12,290.00**	
ii) Total On-Stocking expenses (A+B)			**Rs. 17,648.00**	
iii) Sum of all operating expenses (A+B+C+D+E+F+G+H+I+J)			**Rs. 1,37,738.00**	
iv) Land lease			**Rs. 15,000.00**	
v) Sum of all investments made for the complete culture cycle			**Rs. 1,52,738.00**	
vi) Harvested biomass value	@ 1kg body weight with 100% survival estimate	1500 X1 Kg= 1500 Kg	Rs. 120/ Kg farmgate price	Rs. 1,80,000.00
One culture cycle profit margin = (VI-V)				**Rs. 27,262.00**

*2 This is an estimation for demonstrating the economics part based on the need of your farm, application necessity and dosage needs to be decided. Estimated at the rate of 20 kg / Acre / month and an estimate of 8 months of culture period.
*3 Application volume, number of applications and unit price are indicative, considered for the purpose of calculation, actual manuring dose needs to be decided as per the individual pond requirement and price of the manure also needs to be amended as per your local cost.
*4 Total supplementary feed usage volume is estimated @ 40% of the total target biomass of 1500 kg and the DORB and Oil cake ratios are 80% and 20% respectively.
*5 While calculating the supplemental feed application cost, the total days of supplemental feed application was calculated only for 60 days considering its usage extensive farming system, in case of semi-intensive system it needs to be corrected as per the actual application days. If the productivity of the pond is good, there might be no need to use supplementary feeds and that cost component can be deducted from the expenses.
* In the case of leased ponds, land lease needs to be considered under recuring expenses.
* Expenses like disease treatment and other incidental expenses which are case specific are not mentioned in this estimate model, if such expenses are there, they need to be counted under recuring expenses.

Risk Factors:

1. Flood and heavy rain fall:

This type of risk is generally anticipated in fishponds located very closed to rivers/streams in flood prone areas. The simple mitigation measure is to stock the ponds after flood seasons (August) and harvest before Monsoon starts (May).

The dykes of ponds located in flood prone areas may be increased to avoid flooding and provide overflow pipe to drain out during excess rain fall.

2. Disease outbreak:

Occurrence of disease outbreak is not common in extensive and semi-intensive systems but often seen in intensive type of aquaculture. Major factors being unhygienic pond condition, polluted water source and eutrophication of pond bottom because of not cleaning for long time. One of the major sources of disease is infected or poor-quality seed.

Prophylactic measures like using good quality seed, clean pond, good water quality and feed management can prevent disease outbreak.

In case of any occurrence of disease control measures needs to be taken in the initial stage to avoid further spread and major disease outbreak.

3. Algal bloom-red algae:

Algal blooms commonly noticed are Euglena (Brown/Red algae) and Dark green bloom caused by blue green algae –microcystis (filamentous algae). Both these algae are harmful as they prevent penetration of sun light. Blue green algal bloom is more harmful as they release harmful material to water. The algal bloom can be controlled either by manual removal periodically or by sprinkling cow dung water over the pond.

4. Excessive use of commercial inputs:

Commercial inputs include, feed, growth promoters, probiotics, pond hygienic and health care products. However, use of these products is practiced only in high intensive aquaculture system. Only lime, manures and fertilizers and supplementary feeds are used in extensive and semi-intensive systems.

Commercial inputs if used, must be based on the necessity and at recommended doses and time. Any excess use of commercial inputs will result in water quality deterioration leading to disease outbreak.

5. Irregular water quality monitoring and poor water quality management:

Periodic water quality check is a crucial step for proper water quality management. Monitoring and recording the physical and chemical parameters of pond water is very much essential to take appropriate water quality management related decisions at right juncture. If a farmer doesn't practice this process of regular monitoring and recording the data related to the physical and chemical parameters of pond water will eventually fail in the maintenance of good water quality standards, which eventually leads to disturbed pond ecological system and unstable planktonic growth and poor health and growth of the fish.

6. Over nourishment or undernourishment:

Proper nutrition provision to the reared fish species is a key factor in attaining targeted biomass from the culture pond. Under nourishment might lead to slow growth and nutritional deficiency disorders. Periodic checking of planktonic levels in the pond, making appropriate manuring applications to maintain optimal planktonic levels in the pond is very much essential for attaining optimal and consistent growth of the fish. At the same time, application of excess manure or usage of excess supplementary feed might lead to eutrophication and deterioration of water quality. Judicious usage of nutrient inputs into the pond ecosystem should be strictly followed.

7. Not recording farm data in pond record book:

It is the major issue due to which most of the farmer fail in their aquaculture operation. In terrestrial animal rearing visual observation happens all the time, so problem can be identified immediately. In case of Aquaculture systems, only few conditions can be observed visually like, water colour, plankton level etc but most of the physical, chemical and biological conditions are not assessable visually, you need to measure those parameters regularly as explained in chapter 4.1 Water quality management. The measured data needs to be recorded in pond record book so that the current phenomena can assessed correctly by analysing the historic data trends and appropriate correction measures can be taken immediately. If you don't have the data, it all becomes a prediction or guess job which might lead you into deeper problems.

8. Lack of proper vigilance and Irregular sampling:

If you are growing fish in a confined and controlled pond environment for profit, regular sampling and recording the observed and measured data in the pond record book to assess the health and growth condition of the fish is very much essential. Failing to do so can trigger serious disease proliferation issues if the problem is not identified and cured during its early stages of emergence.

FAQs:

What are the important steps in post stocking management?
What are the major water quality parameters that require attention during post stock management practices?
How does the water quality affects growth, survival and health of fish?
Why should we apply lime and manure during culture period?
What type of supplementary feed is best growth of fish?
How do we calculate the feed quantity to be fed?
What time is the best for feeding fish and how do we feed the fish?
What are the common diseases of fish and how to control?
How to control the spread of fish disease?
What are the risks and mitigation measures?

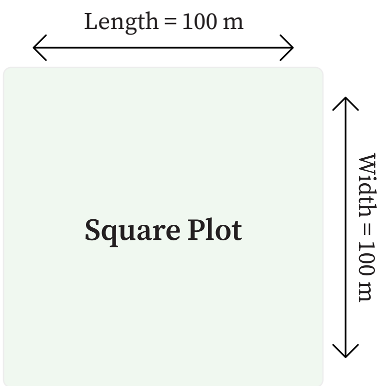
Know the Units – Lengths

1 m = 100 cm
1 m^2 = 0.00025 acre
1 Acre = 4,000 m^2
1 Bigha = 1,333 m^2
1 m^2 = 0.00039 Bigha
1 Bigha = 5 katha
1 Katha (Assamese Katha) **=** 2880 ft2
1 Katha (Bengali Katha) **=** 720 ft2
1 ha = 10,000 m^2
1 m^2 = 0.0001 ha

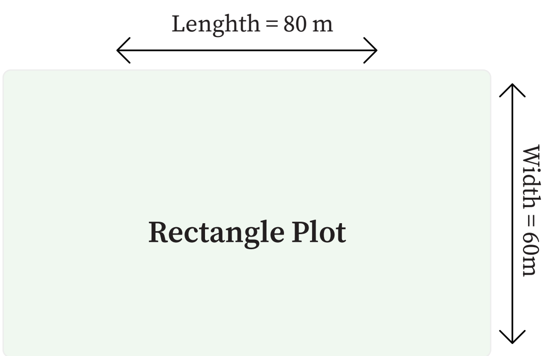
Before we start, let's get familiar with measuring an area.

The size or surface area of a field or pond is measured in square meters (m^2), square feet (ft^2), hectares (ha) or Bigha.

Measuring an Area using a Measuring Tape:



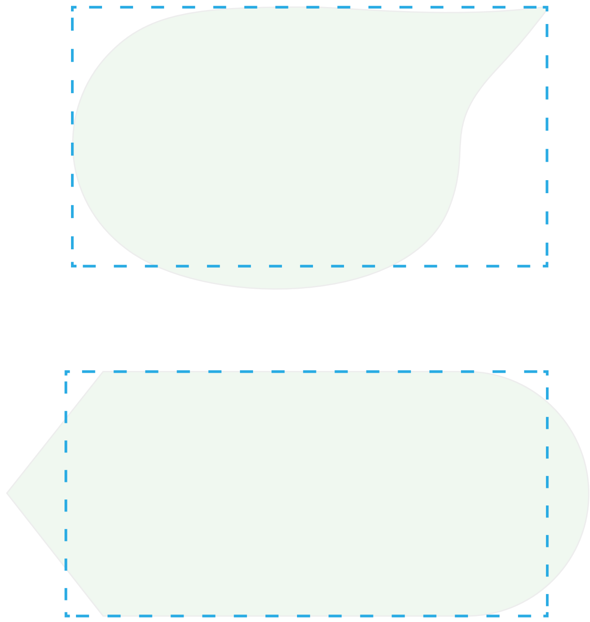
Surface Area Calculation
= 100 m x 100 m
= 10,000 m^2
= 1.0 ha = 2.5 acre

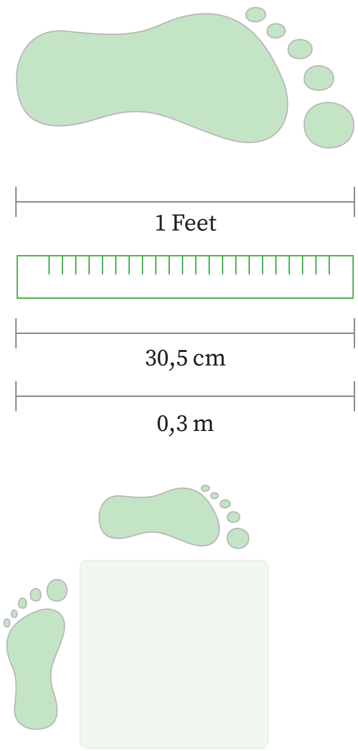


Surface Area Calculation
= 80 m x 60 m
= 4,800 m^2
= 0.48 ha = 1.2 acre

Measurement of an Area of a Irregular Shaped:

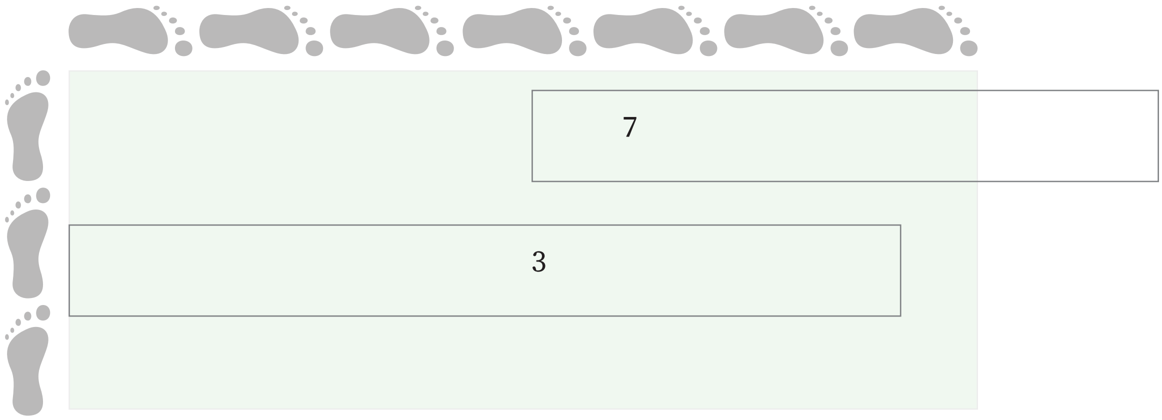
"Best fit" measurement: Measure the length and width of an approximated rectangle (dashed lines). Use the same calculation like above.





1 Sqaure-Feet (ft^2)
= 30.5 cm x 30.5 cm
= ca. 930 square-centrimetre (cm^2)
= 0.093 square-metre (m^2)

Measuring an Area Using Your Feet



3 ft x 7 ft = 21 ft2

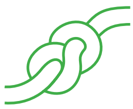
21 ft^2 x 930 cm^2 = 19530 cm^2

19530 cm^2 ÷ 10000 = 1.95 m^2

Measuring an Area Using Knots

Calculate the area:

Length x Width 10 m x 5 m = 50 m^2



Length:
- 21 Knots
- Distance between knots: 50 cm x 50 cm = 10 m

Width:
- 11 knots
- Distance between knots: 50 cm
- 10 x 50 cm = 5 m

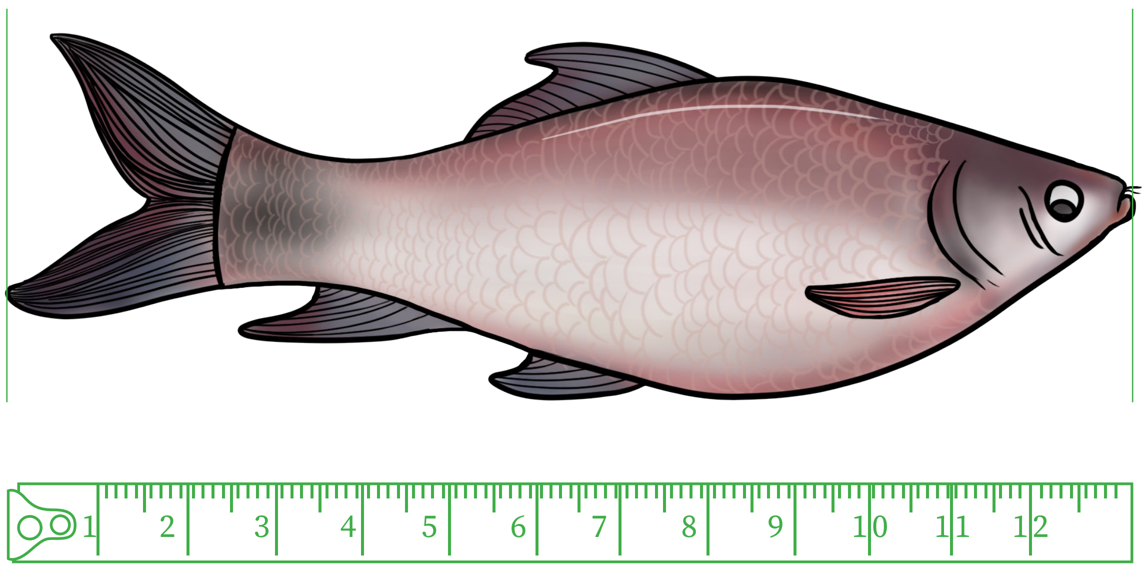
Know the Units – Weights

Before we start, let's get familiar with measuring the weight of fish.

The weight of a fish is measured using a scale

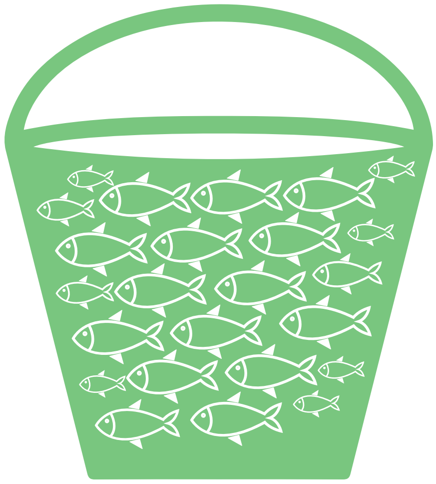
If you do not have access to a scale, it is possible to estimate the approximate weight by using a measuring tape or a bucket. (**But please note:** this is not 100% perfect method for measuring the fish, this is an alternative method for estimation)

Measuring the Weight of Fish Using a Measuring Tape



Measuring the Weight of Fish using a Bucket

5 Litres of Water



5 Kgs of Fish

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मत्स्यपालन, पशुपालन और डेयरी मंत्रालय
MINISTRY OF FISHERIES, ANIMAL HUSBANDRY AND DAIRYING

Sustainable Aquaculture for Food and Livelihood
SAFAL

Didactics: CRP Trainer-CRP

Sustainable Aquaculture

Module 1: Introduction

Session: 01
Time: 30 mins

Time to Complete Session:
30 minutes

Training Materials:
Whiteboard, Charts, Markers.

Introduction:
Farming practices should be eco-friendly and not impose any serious threat to the environment, biodiversity, and ecosystem to make it environmentally sustainable. The aquaculture practices should result in long-term sustained production resulting in a profitable activity to make and to bring in economic sustainability and also contribute to the welfare of the society

Aquaculture, to be a sustainable activity needs to be supported by a technically sound and adaptable package of practices.

Justification & Context:

Aquaculture, an allied agricultural activity is considered a major sector in boosting social and economic development in terms of providing employment and livelihood in addition to food and nutritional security. Fish is an important nutritious and healthy food item. Freshwater aquaculture is integral to farming activities in Eastern and North-eastern states.

Objectives:

At the end of this unit the participants will learn about the importance and impact of aquaculture on our socioeconomic status. It is helping the farmer community towards better and more sustainable financial development. How the aquaculture industry is helping to provide protein security to the nation. Farmers will be able to understand that sustainable fish farming operations are going to be the way forward.

Methodology:

Brainstorming & Group Discussion:

- What do you mean by sustainable aquaculture?
- How can you convert your existing fish farming operations into a sustainable farming mode?
- What are the advantages of sustainable fish farming operations?

Module 2: Pre-Stocking

Time to Complete Session:
355 minutes

Content:

2.0– Pre stocking
2.1– Construction of new pond
2.1.1– site selection
2.1.2– Pond construction
2.1.3– Existing Pond renovation
2.1.3.1– Ponds that can be drainable
2.1.3.2– Ponds that are not drainable
2.2– De-watering
2.2.1– Cleaning and repairing
2.2.2– Arrange surrounding
2.3– Liming and Manuring
2.3.1– Liming
2.3.1.2– Types of lime
2.3.1.3– Usage and the quantity (Dosage)
2.3– Water filling
2.4– Manuring
2.4.1– Manuring for newly constructed pond or that can be completely drained
2.4.1.1– Types of fertilizers, Dosage and mode of application
2.4.1.1.1– Conventional method
2.4.1.1.2– Improved manuring technique
2.4.2– Manuring pond that cannot be completely drained
2.4.2.1– Type of herbal products, dosage, and toxicity period

Justification & Context:

A sustainable Fish Farming approach requires a good understanding of the core aspects of Aquaculture operations. Pre-stocking operations are the building blocks for an efficient and sustainable aquaculture operation. Before starting the fish farming business, farmers have to understand important factors in the construction of a new pond such as identification of an ideal site with a good water source, basic amenities like road access, and power source in the vicinity, soil texture, judging the soil suitability, pond construction or existing pond renovation methodology and conditioning, water pumping and manuring the pond. The trainer will learn all these aspects step-by-step so that the knowledge can be transferred to the farmer effectively. how to construct the pond.

Objectives:

At the end of this unit the participants will have the knowledge to select a good site for the pond. Be able to check the soil texture for suitability to hold water. Have the skills to construct a pond.

Training Materials:

- Types of soils and their textural classification-Table-1
- Water source images, Pro and cons of different water sources Table-3 as flip chart, Ideal Water quality standards for freshwater Aquaculture Table-4 as flip chart
- Illustrative drawings 3. Ideal Pond site with all infrastructure needs and resources, Screening mesh samples
- The Lime requirement for soil treatment during pond preparation for correcting the pH: Table-5,
- Conventional manuring practices: Table-6, Drawings depicting a farm site with all required infrastructure in the vicinity, Water, Soil samples, Pictures of ponds with different types of soil types, Water source images, Whiteboard, white charts, markers, workbook, Measuring tape, Calculator, pond record book.

Session: 02. A
15 mins

Site selection:

Technical Manual Reference Chapters:
2.0; 2.1; 2.1.1

Introduction (7.5 mins):

There are different factors to consider when choosing the location for your pond construction. Most important is the source of water, soil type & suitability, location, topography, proximity to inputs and markets, and proximity of amenities like road and power source.

Training Material:

- Drawings depicting a farm site with all required infrastructure in the vicinity
- Whiteboard, and markers

Methodology:

Brainstorming & Group Discussion (7.5 mins):

- For the construction of a new pond, how did you choose the location? What factors did you consider? How will you access the soil suitability? Gather inputs from participants and sum-up factors.

Session: 02. B
30 mins

Soil Section & Texture Suitability Assessment:

Technical Manual Reference Chapters:
2.0; 2.1; 2.1.1

Introduction (15 mins):

Need to assess different types of soils and their texture for water retention ability. Check your soil with the different tests you learned to see if it's suitable to hold water.

Training Material:

- Types of soils and their textural classification (Table-1) as flip chart
- Water, Soil samples, and Pictures of ponds with different types of soil types

Methodology:

Brainstorming & Group Discussion (15 mins):

- What are the common types of soils? Their pros and cons with respect to sustainable aquaculture operations?
- How do you check different types of soil and their water-holding ability? How do you check the soil texture?

Practical session: Do different tests (e.g., soil squeezing method, ball soil testing), see reference chapter-2.1.1.-Site selection.

Session: 02. C
20 mins

Water Source:

Technical Manual Reference Chapters: **2.0; 2.1; 2.1.1**

Introduction (10 mins):

Source, quality, and availability are crucial factors for the success of aquaculture. There are different water sources that can be used with advantages and disadvantages. Streams/rivers: check for possible pollution and usage from others. Springs/wells: water temperature might be low and low oxygen.

Training Material:

- Water source images, pros and cons of different water sources Table-3 as flip chart
- Ideal Water quality standards for freshwater Aquaculture Table-4 as flip chart
- Whiteboard, & Markers

Methodology:

Brainstorming in Small Groups (10 mins):

- Which source of water do you use for your pond?
- What do you like and dislike about it?
- Which source is more advantageous for your aquaculture operation? Collect from participants and add advantages and disadvantages summary.

Session: 03. A
30 mins

Pond Construction:

Technical Manual
Reference Chapters:
2.1.2; 2.1.3; 2.1.3.1; 2.1.3.2; 2.2; 2.2.1; 2.2.2

Introduction (15 mins):

Physical & administrative planning is the prerequisite for the efficient execution of new pond construction. Based on the available resources and required pond size, a proper layout and construction plan should be prepared. All the elements required for the pond construction need to be decided and acquired before the initiation of construction.

Training Material:

- Illustrative drawings:
3. Ideal Pond site with all infrastructure needs and resources
- Construction process step-by-step method chart
- Whiteboard, & Markers

Methodology:

Brainstorming & Group Discussion (15 mins):

- What are the core components of an aquaculture pond?
- Where from you begin your pond construction plan?
- What is the most critical aspect of an aquaculture pond in your opinion?

Session: 03. B
45 mins

Building the Pond:

Technical Manual
Reference Chapters:
2.1.2; 2.1.3; 2.1.3.1; 2.1.3.2; 2.2; 2.2.1; 2.2.2

Introduction (22.5 mins):

Building a pond requires thoughtful planning and preparation. Based on the cultural objectives, the designing of the pond can be done. Based on the land dimensions and intended depth of the water in the pond, the dike dimensions, outlet, and inlet structure are decided.

Training Material:

- Step-by-step pond construction process drawings or Pictures, Construction process step-by-step method chart
- Markers, Measuring tape, Calculator, Workbook, Pond Record Book

Methodology:

Exercise (22.5 mins):

- Prepare a construction plan for your pond, and list out all the key elements required for the construction of an aquaculture pond. Design a plan incorporating all elements like a dike, outlet and inlet structure, drain canal, etc.
- Record the pond construction cost information in the pond record book.

Session: 03. C 30 mins

Renovation of Existing Drainable & Undrainable Ponds:

Technical Manual Reference Chapters: **2.1.2; 2.1.3; 2.1.3.1; 2.1.3.2; 2.2; 2.2.1; 2.2.2**

Introduction (15 mins):

Existing pond renovation in alignment with the specified standards of a sustainable fishpond is critical in achieving the production objective. Check for possible ways to renovate the existing ponds, and how the surroundings and pond infrastructure needs to be reorganized properly.

Training Materials:

- Existing non-removed pond and renovated pond Pictures
- Charts, Markers, Pond Record Book

Methodology:

Brainstorming (15 mins):

- How a drainable pond can be renovated? How are you going to restructure your pond dikes?
- How the pond surroundings can be organized?
- In what ways did you adapt to renovate and prepare the non-drainable ponds?
- What biosecurity measures do you take at your farming site?

Record the renovation method and renovation expenses information in the pond record book.

Module 2: Pre-Stocking

Session: 04. A
30 mins

Liming:

Technical Manual Reference Chapters:
2.3; 2.3.1; 2.3.1.2; 2.3.1.3; 2.3; 2.4; 2.4.1; 2.4.1.1; 2.4.1.1.1; 2.4.1.1.2.

Introduction (15 mins):

Liming is an important step in conditioning the pond soil. Knowledge about available lime types, and their efficacies, usage dosages and application methods need to be understood while preparing the pond for stocking the fish.

Training Material:

- Limed pond Pictures, Lime requirement for soil treatment during pond preparation for correcting the pH: Table-5
- Markers, Workbook, Calculator, Pond Record Book

Methodology:

Brainstorming (15 mins):

- Why liming is important in pond preparation?
- What types of limes are available in your region?
- How are you going to decide how much quantity of lime needs to be applied to your pond soil?

Exercise:

- Calculate the liming dose required for your pond based on the guidelines provided in the liming chapter.
- Record the liming dosage and subsequent expenses information in the pond record book.

Session: 04. B
20 mins

Water Filling:

Technical Manual Reference Chapters:
2.3; 2.3.1; 2.3.1.2; 2.3.1.3; 2.3; 2.4; 2.4.1; 2.4.1.1; 2.4.1.1.1; 2.4.1.1.2.

Introduction (10 mins):

Proper care needs to be taken while pumping the water into the pond, prayer assessment of water quality needs to be done before pumping and proper screening methods need to be adapted to avoid weed fish entry into the pond while pumping.

Training Material:

- Water pumping with different filter mesh Pictures
- Water quality standards Charts
- Whiteboard, Markers
- Screening mesh samples, Pond record book

Methodology:

Brainstorming & Group Discussion (10 mins):

- What water quality parameters do you check before pumping the water into the pond?
- Why it is necessary to use screening mesh while pumping water into the pond?
- What types of weed fish are predominant in your region?

Session: 04. C 45 mins

Manuring:

Technical Manual Reference Chapters:
2.3; 2.3.1; 2.3.1.2; 2.3.1.3; 2.3; 2.4; 2.4.1; 2.4.1.1; 2.4.1.1.1; 2.4.1.1.2.

Introduction (22.5 mins):

Manuring is the critical step in enhancing the productivity of the pond, by making available all essential nutrients required for the primary producers of the pond's ecological system. Understanding the available manuring products, and their efficiency levels are essential for the selection of the right manuring product. Based on the pond soil characteristics correct dosage of selected manure needs to be applied. Manuring the existing drainable and non-drainable ponds needs a different approach and methodology.

Training Materials:

- Different manure Pictures, Conventional manuring practices: Table-6
- Whiteboard, Markers, Calculator, Workbook, Pond Record Book

Methodology:

Brainstorming & Group Discussion (22.5 mins):

- Why manuring is important in pond preparation?
- What types of manures are available in your region?
- What are the pros and cons of those manures?
- How do you decide the manure dosage?
- What manuring method do you adapt for manuring the existing drainable and non-drainable ponds?
- Have you ever tried any advanced manuring technic?

Exercise: Calculate the manuring dose required for your pond based on the guidelines provided in the manuring chapter.

Record the manuring dose and subsequent expenses information in the pond record book.

Module 2: Pre-Stocking

Session: 05. A
30 mins

Risk Factor:

Technical Manual Reference Chapters:
Risk Factors

Introduction (15 mins):

Having the awareness about the risk factors that are associated with pre stocking operations is very much necessary for the farmers so that they can be able to take precautionary measures.

Training Material:

- Whiteboard, & Markers

Methodology:

Brainstorming & Group Discussion (15 mins):

- What risk facts do you think you can encounter in pre-stocking operations or due to improper execution of pro-stocking operations?

Session: 05. B
60 mins

Economics:

Technical Manual Reference Chapters:
Pre-Stocking Economics

Introduction (30 mins):

Economics is the most critical factor in the pre-stocking operations, it ultimately determines the financial viability and capital investment requirement of the culture operations.

Training Material:

- Whiteboard, Markers, Workbook, & Pond Record Book

Methodology:

Brainstorming & Group Discussion (30 mins):

- How are going to derive the investment estimate for the pre-stocking operation?
- How will you judge whether the investment you will be making for the pond construction is going to be viable?

Exercise: Prepare an investment estimate listing all cost implications and derive an ROI estimate, record these details in the pond record book for reference.

Module 3:
On-Stocking

Time to Complete Session:
260 minutes

Content:

3.0 – On-stocking
3.0.1– Culture systems in aquaculture
3.0.2– Selection of fish species
3.0.3– Fish Seed selection criteria –sourcing
3.0.4– Identification of good quality seed
3.1– Species Stocking
3.1.1– Stocking size and density
3.2– Species composition
3.3– Transportation of fish seed
3.3.1– Preparations for transportation
3.3.2– Methods of transportation
3.3.2.1– Open system
3.3.2.2– Closed system
3.3.3– Timing of transport
3.4– Release of fish seed

Justification & Context:

In this module, we will learn about the processes and administration aspects that are required for the Next step after successfully learning about Pre-stocking operations are on-stocking management. On-Stocking management involves the selection of an ideal culture system Based on the available infrastructure and resources. Based on the market demand, suitability and seed availability Aqua culturist also need to select the culture species suitable for their culture operation. The aquacultures also need to be aware of the methodology of identification of quality seed, methods of transporting the seed safely to the culture site and the process of introduction of the seed into the culture pond.

Objectives:

By the end of this module the audience should be able to:

- Identify suitable culture systems adaptable for their aquaculture operation.
- Should be able to identify apt culture species for their culture objective.
- Should be acquainted with the knowledge of the selection of good quality seeds for their culture.
- Should be aware of all the available transportation methods to transport fish seed, and select the appropriate method for them.
- Should be acquainted with the knowledge of ideal fish seed acclimatization methods while stocking the seed in the pond.

Training Materials:

- Culture system classification- Table -9, Illustrative drawings: 1. Pictures of Fish hatchling, Fish spawn, Fish fry, Fish fingerling (Indian Major carp)
- Seed quality identification-Table-10, Feeding zone and major feeding habits of different species in a pond – Table- 11, Charts, Options of different species combinations and proportions-Table-14 as flip chart
- Combination, and stocking ratio options-Table-15 as flip chart, Fish seed samples, Illustrative drawings- 6
- Fish seed conditioning process image or drawings/ images or drawings of tools required for fish seed packing and transportation, Picture of different fish seed transportation methods
- Whiteboard, Charts, Markers. Workbook, & Pond Record Book

Module 3: On-Stocking

Session: 06. A 30 mins

Culture Systems in Aquaculture:

Technical Manual Reference Chapters: **3.0; 3.0.1; 3.0.2; 3.0.3**

Introduction (15 mins):

Aquaculture farmers need to have the knowledge about different culture systems that are being practiced. They need to acquire the knowledge about each culture system infrastructure requirements. They should be able to select ideal culture system for their culture operation based on the resources available for them.

Training Material:

- Culture system classification- Table -9
- Charts, Markers, & Pond Record Book

Methodology:

Brainstorming & Group Discussion (15 mins):

- What methods of pond culture systems are practiced in your region?
- What methods of pond culture systems are practiced in your region?
- What are the core infrastructure requirements for each of these systems?

Assess available infrastructure with you and identify the suitable culture system for your culture operation and title your pond culture operation with the selected culture system method in the pond record book.

Session: 06. B
30 mins

Selection of Fish Species & Seed Selection Criteria:

Technical Manual Reference Chapters:
3.0; 3.0.1; 3.0.2; 3.0.3

Introduction (15 mins):

Knowledge about Ideal culture species selection is a must for each farmer to achieve the desired outcome. Market demand, efficiency in growth, immunity, genetical potential, its adaptability to the selected culture method are some of the key considerations that needs to be assessed while selecting a culture species.

Identification of proper source for the selected species seed is one other important factor about which the farmer need to emphasize.

Training Material:

- Illustrative drawings:
1.Pictures of Fish hatchling, Fish spawn, Fish fry, Fish fingerling (Indian Major carp),

- Charts, Markers, & Pond Record Book

Methodology:

Brainstorming & Group Discussion (15 mins):

- What are the fish species that fetches maximum price in your target market?
- Can you grow them in your selected culture system?
- What are fish species that can be grown quickly and easily in your culture system?
- Do they fetch good price in the market?
- In your opinion, what are the basic criteria of a good fish seed supplier?

Selected culture species, seed supplier details needs to be noted in the pond record book.

Session: 07. A 40 mins

Identification of Good Quality Seed:

Technical Manual Reference Chapters: **3.0.4; 3.1; 3.1.1**

Introduction (20 mins):

Skill to assess the quality of the fish seed is the most important criteria that each fish farmer needs to acquire. Knowledge about the physical characters of fish is prerequisite for acquiring the skill of seed quality assessment.

Training Material:

- Seed quality identification-Table-10,
- Quality seed Pictures,
- Charts, Markers, Fish seed samples.

Methodology:

Brainstorming & Group Discussion (20 mins):

- What are the physical characteristics that you check to assess the quality of fish seed?
- How should a heathy fish look like?

Exercise: Identify the physical characterises of healthy fish from the live fish seed samples.

Session: 07. B 40 mins

Species Stocking, Size & Density:

Technical Manual Reference Chapters: **3.0.4; 3.1; 3.1.1**

Introduction (20 mins):

Strategic approach towards the selection of culture species is very much critical for a successful farming operation, consistent market demand, faster growth, disease resistance and seed availability are some of the important criteria that needs to be considered while selecting the species.

Stocking size and stocking density depends on the culture duration, target body weight, productivity of the culture system and adapted mode of culture system.

Training Material:

- Feeding zone and major feeding habits of different species in a pond – Table- 11,
- Charts, & Markers.

Methodology:

Brainstorming & Group Discussion (20 mins):

- What considerations do you make while selecting a fish species for your farming operation?
- What size of the fish you prefer to stock in your pond? & Why it is so?
- How are you going to decide the stocking density?

Session: 8. A
30 mins

Species Composition:

Technical Manual Reference Chapters:
3.2; 3.3; 3.3.1; 3.3.2; 3.3.2.1; 3.3.2.2; 3.3.3; 3.4

Training Material:

- Feeding zone and major feeding habits of different species in a pond – Table- 11 as flipcharts
- Options of different species combinations and proportions- Table-14 as flip chart, Combination and stocking ratio options-Table-15 as flip chart
- Charts, Markers, & Pond Record Book

Introduction (15 mins):

Combining different fish species that utilises the natural productivity of the pond at different feeding zones with out competing with each other is the efficient way to utilize the pond productivity completely.

Knowledge about different feeding zones and fish that can grow in those specific zones is very much essential to select the ideal species combination to be grown in your pond.

Methodology:

Brainstorming & Group Discussion (15 mins):

- What are the feeding habits of different fish species that are grown in your region?
- How do you select different fish species and their combination? How will you set the combination ratio?

Exercise: Set the species composition and ratio, record the concluded information in the pond record book.

Session: 8. B
30 mins

Transportation & Stocking of Fish Seed:

Technical Manual Reference Chapters:
3.2; 3.3; 3.3.1; 3.3.2; 3.3.2.1; 3.3.2.2; 3.3.3; 3.4

Training Material:

- Illustrative drawings- 6. Fish seed conditioning process image or drawings/ images or drawings of tools required for fish seed packing and transportation,
- Pictures of different fish seed transportation methods,
- Charts, and Markers.

Introduction (15 mins):

Knowledge about different modes of transportation for shifting the seed from the source to the culture site very important for the farmer so that they can opt for ideal mode of transport which suits their requirement. Conditioning the seed, carful packing methods & appropriate acclimatization technics are other important topics upon which the farmer needs to acquire knowledge.

Methodology:

Brainstorming & Group Discussion (15 mins):

- What are the packing and transportation methods that are being followed in your region? List out their pros and cons?
- What do you know about conditioning of fish seed before packing? How is it practiced in your region?
- How do you do the seed acclimatisation process at your pond while stocking the seed?

Session: 9. A 30 mins

Risk Factors

Technical Manual Reference Chapters: **Risk Factors**

Introduction (15 mins):

Having the awareness about the risk factors that are associated with On-stocking operations is very much necessary for the farmers so that they can be able to take precautionary measures.

Training Material:

- Whiteboard, & Markers

Methodology:

Brainstorming & Group Discussion (15 mins):

- What risk facts do you think you can encounter in pre-stocking operations or due to improper execution of pro-stocking operations?

Session: 9. B 30 mins

Economics:

Technical Manual Reference Chapters: **On-Stocking Economics**

Introduction (15 mins):

Economics is the most critical factor in the On-stocking operations, it ultimately determines the financial components and operational cost factors involved in On-stocking operations.

Training Material:

- Whiteboard, Markers, Workbook, & Pond Record Book

Methodology:

Brainstorming & Group Discussion (15 mins):

- How are going to derive the investment estimate for the On-stocking operation?
- How will you judge whether the investment you will be making for the seed stocking operations is going to be viable?

Exercise: Prepare an investment estimate listing all cost implications involved in On-stocking operations, and record these details in the pond record book for reference.

Module 4:
Post-Stocking

Time to Complete Session:
505 minutes

Content:
4.0- Post-Stocking
4.1- Water Quality Management
4.1.1- Physical Parameters
4.1.2- Biological Parameters
4.1.3- Chemical Parameters
4.2, 4.2.1- Lime & Types of Limes
4.2.3- Liming Dosage & Mode of Application
4.3- Manuring
4.4, 4.4.1- Feed management & Natural Food
4.4.2, 4.4.3- Supplementary Feeding, Feeding Rate, Methods, & Feeding Schedule
4.4, 4.5.1- Diseases & Causes
4.5.2- Types of diseases
4.5.3- Management of diseases
4.6- Sampling
4.7, 4.5.4-Harvest & Types of Harvest
4.8- Risk factors
4.9- Women in Aquaculture
4.10- Economics

Justification & Context:

In this module, we will learn about the processes and administration aspects that are required for the next step after successfully learning about on-stocking operations i.e., post-stocking operations and management.

Post-Stocking operations and management involve the activities to be undertaken from the stocking fingerlings up to the final harvesting of fish from the pond. The activities are pond hygiene, water quality monitoring & management, manuring and/or feeding, growth and health monitoring & management, and harvesting at right time are the key steps of post-stocking management.

Objectives:

By the end of this module the audience should be able:

- To understand the physical, chemical, and biological parameters that govern water quality management aspects and their management methods.
- Use different liming and manuring methods for managing the water quality and to enhance primary productivity of the water.
- Understand feed management methods, both natural food material that gets produced in the pond as well as the other supplementary feeding methods.
- Be aware of common diseases in fish, their causative factors, and some of the control and prevention methods.
- Be acquainted with sampling, recording the data in the pond record book, and also about the harvesting methods which are very much important at the end of the culture cycle.

Training Materials:

- Ideal Water quality standards for freshwater Aquaculture: Table-4- & Optimal range for key Physical parameters of aquaculture pond – Table-19 flip chart
- Illustrative drawings: 4. Zonation of pond ecological system, depicting feeding zone and major feeding habits of different species in a pond image of Phytoplankton, zooplankton, periphyton, Filamentous algae, Bottom fauna etc., Plankton collection illustration flipchart
- Optimal range for key chemical parameters of aquaculture pond – Table-20- flip chart, Types of limes, their safety level for application in ongoing culture ponds-Table-21 flip chart, Comparison of organic and inorganic fertilizers -Table-22 & Assessment of Fertilization Needs-Table-23 & Dailey application limit of different solid manures-Table -25 & Weekly or biweekly manuring schedule-Table-26
- Feeding zone and major feeding habits of different species in a pond – Table- 11
- Illustrative drawing:4- Zonation of pond ecological system, depicting feeding zone and major feeding habits of different species in a pond image of Phytoplankton, zooplankton, periphyton, Filamentous algae, Bottom fauna etc.,
- Farm made feed-Table-26, Common diseases, causative agent, symptoms and control measures-Table-27 in flip chart, Illustrative drawings: 11. Images of infected fishes with infections and good quality photos/pictures of Lernea, arugulas, Tape worms, deformed fishes, and bacterial and fungal infected individuals in flip chart
- White board, Markers, Charts, Workbook, Calculator, Pond Record Book.

Session: 10. A
15 mins

Water Quality Management:

Technical Manual Reference Chapters:
4.0; 4.1; 4.1.1.; 4.1.2; 4.1.3.

Introduction (7.5 mins):

Water quality plays a major role in the fish farm success, all the physical, biological, and chemical parameters need to be checked regularly for maintaining them at optimal levels. Knowledge about their measurement and management technics and recording the data in the pond record book is very much essential.

Training Material:

- Whiteboard, Markers, Workbook, & Pond Record Book

Methodology:

Brainstorming & Group Discussion (7.5 mins):

- What are the different factors that influences the water quality in an aquaculture pond? List out.
- Why these factors are important in water quality management?
- Why it is important to record these data points in the pond record book?

Session: 10. B
45 mins

Physical Parameters:

Technical Manual Reference Chapters:
4.0; 4.1; 4.1.1.; 4.1.2; 4.1.3.

Introduction (22.5 mins):

Knowledge about the physical parameters of a pond ecological system like, depth, temperature, transparency, colour, light, odour etc is necessary to manage them properly. Farmer need to monitor these parameters regularly so that they can be able to mange them at optimal levels. All the data gathered needs to be recorded in the pond record book for review and monitoring purpose.

Training Material:

- Ideal Water quality standards for freshwater Aquaculture: Table-4- & Optimal range for key Physical parameters of aquaculture pond – Table-19 flip chart

- White board, Charts, Markers, Pond Record Book

Methodology:

Brainstorming & Group Discussion (22.5 mins):

- What are the different physical pond parameters that are crucial in your observation?
- How can you be able to manage them at optimal levels?
- Why it is important to record these monitored data points in the pond record book?

Exercise: Practice recording the physical parameters in the pond record book?

Session: 10. C 20 mins

Biological Parameters:

Technical Manual Reference Chapters:
4.0; 4.1; 4.1.1.; 4.1.2; 4.1.3.

Introduction (10 mins):

Different biotic factors of pond ecological system, their interactions, interdependence, and their position in the trophic level plays a major role on the productivity of the aquaculture pond. Major influencers of pond biological parameters are phytoplankton, zooplankton, bacteria, fungi etc. Observation and monitoring of these factors level, abundance, fluctuation in their levels will be helpful in maintaining them at optimal level to attain a sustainable growth.

Training Material:

- Illustrative drawings:
4. Zonation of pond ecological system, depicting feeding zone and major feeding habits of different species in a pond image of Phytoplankton, zooplankton, periphyton, Filamentous algae, Bottom fauna etc.

- Plankton collection illustration flipchart,

- White board, Charts, Markers, Pond Record Book, & Plankton net.

Methodology:

Brainstorming & Group Discussion (10 mins):

- How biological parameters like plankton level will be influential in deciding the pond productivity?
- Can you list out different tropic levels in your pond ecological system and which biotic component will be dwelling in that zone?
- How can you check the plankton level in your pond?
- What happens when the plankton level is too high or if it is too low?

Module 4: Post-Stocking

Session: 10. D
45 mins

Chemical Parameters:

Technical Manual Reference Chapters:
4.0; 4.1; 4.1.1.; 4.1.2; 4.1.3.

Introduction (22.5 mins):

pH, D.O, Alkalinity and Ammonia are some of the critical pond chemical parameters that influences not only the water quality but other biotic and abiotic factors of pond ecological system. Fish farmer should be acquainted with the knowledge about these chemical parameters, methods to observe them, their optimal levels and methods to manage them at optimal level.

Training Material:

- Ideal Water quality standards for freshwater Aquaculture: Table-4- & Optimal range for key chemical parameters of aquaculture pond – Table-20- flip chart,
- White board, Markers, & Charts.

Methodology:

Brainstorming & Group Discussion (22.5 mins):

- What are negative effects on the pond water quality and on the fish if critical chemical parameters are not managed properly?
- How frequently do you check the chemical parameters like pH, D.O, Alkalinity and Ammonia?
- What happens if the alkalinity level is lower, then required?
- What happens is the D.O level depletes to critical point?

Quiz:
- If you don't have D.O kit or D.O meter, what methods you can use to identify the D.O depletion problem?
- What are ways to improve the D.O levels in the pond?
- How can you improve the pond water pH if is lower than required level?
- What methods can be adapted to reduce the pH is it is higher than optimal level?

Through probing questions and group discussion, list out different methods of managing the key chemical parameters on the white board or chart.

Session: 11. A 45 mins

Lime, Types, Dosage, & Mode of Application:

Technical Manual Reference Chapters: **4.2; 4.2.1; 4.2.3; 4.3**

Introduction (22.5 mins):

The effects of lime application in the pond water are numerus, increase or stabilise the pH, improves alkalinity levels essential for plankton growth, helps in organic matter precipitation & decomposition, improves calcium availability. Farmer should be aware of what types of limes are available, their individual efficacy and level of adaptability for aquaculture operation, dosage levels, how to apply them and when to apply them.

Training Material:

- Types of limes, their safety level for application in ongoing culture ponds-Table-21 flip chart
- White board, Markers, Charts, Pond Record Book

Methodology:

Brainstorming & Group Discussion (22.5 mins):

- What are the benefits of lime application?
- How to check whether you need to apply lime or not to your pond water?
- What are the chemical parameters that you need to check to find out the need for lime application?
- How will you decide the dosage of selected lime product based on your need?
- How to apply lime in your pond water?

Quiz:
- What type of lime products are available in your region?
- What tools can be used to check the pond water pH?
- How important it is to measure the pH regularly and record it in the pond record book?

Module 4: Post-Stocking

Session: 11. B
45 mins

Manuring:

Technical Manual Reference Chapters:
4.0; 4.1; 4.1.1; 4.1.2; 4.1.3

Introduction (22.5 mins):

Manuring during post stocking operation is done to maintain sustained production of plankton during the entire culture period. The ability of water to produce plankton depends on many factors, but the most important is usually the availability of inorganic nutrients for phytoplankton growth. Application of manure will support the planktonic growth there by enhances the productivity of the pond. But manure application needs to be decided based on the need. Farmer should be aware of the methods to check the need for additional manure application. They also should be aware of which type of manure at what rate should be applied and method of application.

Training Material:

- Comparison of organic and inorganic fertilizers -Table-22 & Assessment of Fertilization Needs-Table-23 & Dailey application limit of different solid manures-Table -25 & Weekly or biweekly manuring schedule-Table-26
- White board, Markers, Charts, Pond Record Book

Methodology:

Brainstorming & Group Discussion (22.5 mins):

- How are you going to decide that you need a manuring dose to your pond?
- What are the organic manures that are available in your region?
- What happens when manure is applied beyond the need?
- How frequently do you apply manure to your pond?
- How to apply manure to your pond?

Quiz:
- How manuring will help for fish growth?
- What happens when you dump manure in large volumes at a time?
- Which type of manuring practice is more productive?

Session: 12. A 45 mins

Feed Management & Natural food:

Technical Manual Reference Chapters: **4.4; 4.4.1; 4.4.2; 4.4.3**

Introduction (22.5 mins):

To achieve optimal and desired production outcome from the pond aquaculture, consistent growth should be there. For the growth nutrition through food is vital. In pond ecological system natural food source is the major contributor. The art of growing natural food in the pond should be learned and practiced by every farmer so that with minimal investment one can achieve better economic returns. Before growing the natural food in the pond, one should know which fish prefers what varieties of natural food material, how to grow, balance and maintain these multiple food organisms at the same time in your pond. Each and every aspect of learning during this training program is aimed to teach you this art of growing natural food in your pond in a synchronised & harmonious manner.

Training Material:

- Feeding zone and major feeding habits of different species in a pond – Table- 11
- Illustrative drawing:4- Zonation of pond ecological system, depicting feeding zone and major feeding habits of different species in a pond image of Phytoplankton, zooplankton, periphyton, Filamentous algae, Bottom fauna etc.,
- White board, Markers, & Charts

Methodology:

Brainstorming & Group Discussion (22.5 mins):

- What methods do you follow to grow natural food material in your pond?
- How to maintain consistent natural food material availability in your pond?
- What are the causes for low natural food material availability in your pond?
- How can you check the level of natural food material in the pond water?

Quiz: • What natural food your fish likes to eat?
- How many types of living organisms grows in your pond water and soil?
- Of all the organisms that live in your pond, can you differentiate what are plant type, what are grazing animal type and what are meet eating type of organisms?

Session: 12. B 30 mins

Supplementary Feeding, Feeding Rate, Methods and Feeding Schedule:

Technical Manual Reference Chapters: **4.4; 4.4.1; 4.4.2; 4.4.3**

Introduction (15 mins):

In pond aquaculture based on the production target supplementary nutrition can be provided by using agriculture by products like different cereals and oil cakes in combination to provide additional protein and carbohydrate to the fish. The selection and usage of these supplementary feeds depends on their availability in your region, its cost advantage and nutritional benefits. But farmer needs to check the selected ingredient for some basic criterial like water stability, availability, and cost-effectiveness, acceptability & digestible by fish, and should cause less or no pollution to the pond water. The farmer should also learn about the method to use these supplemental diets, economic assessment, balanced and optimised combination of ponds natural productivity and supplemental nutrition.

Farmer also should be acquainted with the knowledge of method of using supplementary feed, setting its volume per meal, how to combine different ingredients, their ration and usage methods.

Training Material:

- Farm made feed-Table-26,
- White board, Markers, & Charts.

Methodology:

Brainstorming & Group Discussion (15 mins):

- Can you list some of the Agri process biproducts that are available in your region which can be used as supplemental diets for fish?
- What combination of these supplemental diet materials can give better benefit?
- How can you decide that you need to provide supplemental nutrition to your fish in addition to natural food material i.e., available in the pond?
- What happens if the supplemental diet is not used by the fish completely?
- What type of feeding methods are being practiced in your region to provide supplemental diets to your fish?
- How are you going to fix the feed volume that you wanted to feed your fish?
- When can you opt to use commercial feed to your fish?
- What are the Ideal culture criteria for commercial feed usage?

Session: 13. A 45 mins

Diseases, Causes, Types, Management, & Pond Hygiene:

Technical Manual Reference Chapters:
4.5; 4.5.1; 4.5.2; 4.5.3; 4.5.4; 4.6; 4.7; 4.7.1; 4.7.2.

Introduction (22.5 mins):

There are several causes for occurrence of disease in fish that may affect the fish directly or indirectly. Basically, any factor which causes stress or difficulty to the fish decreases its resistance to disease and increases the chance of disease problems occurring. Insufficient nutrition, reduced immunity, wide fluctuation in physical, chemical and biological components of water, taxic gases emission in the pond due to organic matter accumulation, bacterial and external parasites attack are some of the reasons for disease occurrence. Maintenance of ideal water quality by managing the physical, chemical and biological parameters at optimal range can reduce the chances of disease incidences.
Farmer should be acquainted with the knowledge of identification early disease symptoms and should be able to take preventive and prophylactic measures.

Training Material:

- Common diseases, causative agent, symptoms and control measures-Table-27 in flip chart, Illustrative drawings: 11
- Images of infected fishes with infections and good quality photos/ pictures of Lernea, arugulas, Tape worms, deformed fishes, and bacterial and fungal infected individuals in flip chart
- White board, Markers, Charts

Methodology:

Brainstorming, & Group Discussion (22.5 mins):

- What are the common disease incidents you encountered during your fish farming operations?
- Were you be able to narrow down the reason for the disease incidents?
- What preventive measures do you think can be implemented to avoid disease occurrence?
- How can you avoid cross contamination of diseases in fish farming operations?
- What processes do you adapt to maintain hygienic conditions at the pond?

Quiz: • Identification of diseased fish and causative agents from the flip chart.

Session: 13. B
30 mins

Sampling:

Technical Manual Reference Chapters:
4.5; 4.5.1; 4.5.2; 4.5.3; 4.5.4; 4.6; 4.7; 4.7.1; 4.7.2.

Training Material:

- Whiteboard, Markers, Charts, Workbook, Calculator, Pond Record Book.

Introduction (15 mins):

Periodic sampling is necessary to assess the heath, growth and wellbeing of the fish in your pond. Sampling should be done at least once in a month to observe the animal condition and growth. Farmer need to follow specified protocol to do the sampling as mentioned in the manual and record the observations in the pond record book.

Methodology:

Brainstorming, & Group Discussion (15 mins):

- Why it is necessary to do regular sampling?
- What needs to be observed and recorded during the sampling?

Quiz:
- How will you measure your fish weight?
- How to calculate the monthly growth rate of your fish?
- How to calculate monthly FCR?

Session: 13. C
30 mins

Harvest & Types of Harvest:

Technical Manual Reference Chapters:
4.5; 4.5.1; 4.5.2; 4.5.3; 4.5.4; 4.6; 4.7; 4.7.1; 4.7.2.

Training Material:

- Whiteboard, Markers, Charts, Workbook, Calculator, Pond Record Book.

Introduction (15 mins):

Harvesting decision is taken by the farmer when the fish attains desired and marketable size, and the market price fetches better margin for the farmer. The farmer needs to have ample knowledge about various harvesting methods so that proper harvesting method can be selected based on the pond dimensions, size and availability of infrastructure and skilled workforce.

Methodology:

Brainstorming, & Group Discussion (15 mins):

- What factors do you take into consideration while taking the harvest decision?
- What measures do you need to take before harvesting?
- What are the tools and infrastructure requirements for commencing the harvesting process?

Quiz:
- How to estimate total biomass harvested?
- How to estimate production per unit culture area?
- How to estimate the FCR?
- How to estimate profit per kg fish production?

Session: 14. A
30 mins

Risk Factors:

Technical Manual Reference Chapters:
Risk Factors

Introduction (15 mins):

Having the awareness about the risk factors that are associated with On-stocking operations is very much necessary for the farmers so that they are able to take precautionary measures.

Training Material:

- Whiteboard, & Markers

Methodology:

Brainstorming, & Group Discussion (15 mins):

- What risk facts do you think you can encounter in On-stocking operations or due to improper execution of On-stocking operations?

Session: 14. B
20 mins

Women in Aquaculture:

Technical Manual Reference Chapters:
Women in Aquaculture
4.8. 4.8.1; 4.8.2; 4.8.3; 4.8.4; 4.9

Introduction (10 mins):

Women can be able to handle most of the fish farming operation like men. They can handle tasks like, water quality monitoring, measuring physical, chemical, biological parameters, and recording the data in the pond record book. They can also handle recoding financial transaction data in the pond record books. In small village neighbourhood they can even do the sales and marketing job for on form sales. In small fish farming operations, companion assistance in day to day farming responsibilities will be of great help.

Training Material:

- Whiteboard, & Markers

Methodology:

Brainstorming, & Group Discussion (10 mins):

- In your opinion what are the fish farming activities in which women can be engaged?
- What are the fish farming activities in which your companion would like to engage?
- How would you like to engage your companion in your farming operations?

Module 4: Post-Stocking

Session: 14. C 60 mins

Economics:

Technical Manual Reference Chapters: **On-Stocking Economics**

Introduction (30 mins):

Economics is the most critical factor in the On-stocking operations, it ultimately determines the financial components and operational cost factors involved in On-stocking operations.

Training Material:

- Whiteboard, Markers, Workbook, & Pond Record Book

Methodology:

Brainstorming, & Group Discussion (30 mins):

- How are going to derive the investment estimate for the On-stocking operation?
- How will you judge whether the investment you will be making for the seed stocking operations is going to be viable?

Exercise: Prepare an investment estimate listing all cost implications involved in On-stocking operations, record these details in pond record book for reference.

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मत्स्यपालन, पशुपालन और डेयरी मंत्रालय
MINISTRY OF FISHERIES, ANIMAL HUSBANDRY AND DAIRYING

Sustainable Aquaculture for Food and Livelihood SAFAL

Didactics: CRP-Farmers

Sustainable Aquaculture

Module 1: Introduction

Session: 01
Time: 30 mins

Time to Complete Session:
30 minutes

Training Materials:
Whiteboard, Charts, Markers.

Introduction:

Farming practices should be eco-friendly and not impose any serious threat to the environment, biodiversity, and ecosystem to make it environmentally sustainable. The aquaculture practices should result in long-term sustained production resulting in a profitable activity to make and to bring in economic sustainability and also contribute to the welfare of the society

Aquaculture, to be a sustainable activity needs to be supported by a technically sound and adaptable package of practices.

Justification & Context:

Aquaculture, an allied agricultural activity is considered a major sector in boosting social and economic development in terms of providing employment and livelihood in addition to food and nutritional security. Fish is an important nutritious and healthy food item. Freshwater aquaculture is integral to farming activities in Eastern and North-eastern states.

Objectives:

At the end of this unit the participants will Learn about the importance and impact of aquaculture on our socioeconomic status. It is helping the farmer community towards better and more sustainable financial development. How the aquaculture industry is helping to provide protein security to the nation. Farmers will be able to understand that sustainable fish farming operations are going to be the way forward.

Methodology:

Brainstorming & Group Discussion:

- What do you mean by sustainable aquaculture?
- How can you convert your existing fish farming operations into a sustainable farming mode?
- What are the advantages of sustainable fish farming operations?

Module 2: Pre-Stocking

Time to Complete Session:
270 minutes

Content:

2.0– Pre stocking
2.1– Construction of new pond
2.1.1– site selection
2.1.2– Pond construction
2.1.3– Existing Pond renovation
2.1.3.1– Ponds that can be drainable
2.1.3.2– Ponds that are not drainable
2.2– De-watering
2.2.1– Cleaning and repairing
2.2.2– Arrange surrounding
2.3– Liming and Manuring
2.3.1– Liming
2.3.1.2– Types of lime
2.3.1.3– Usage and the quantity (Dosage)
2.3– Water filling
2.4– Manuring
2.4.1– Manuring for newly constructed pond or that can be completely drained
2.4.1.1– Types of fertilizers, Dosage and mode of application
2.4.1.1.1– Conventional method
2.4.1.1.2– Improved manuring technique
2.4.2– Manuring pond that cannot be completely drained
2.4.2.1– Type of herbal products, dosage, and toxicity period

Justification & Context:

A sustainable Fish Farming approach requires a good understanding of the core aspects of Aquaculture operations. Pre-stocking operations are the building blocks for an efficient and sustainable aquaculture operation. Before starting the fish farming business, farmers have to understand important factors in the construction of a new pond such as identification of an ideal site with a good water source, basic amenities like road access, and power source in the vicinity, soil texture, judging the soil suitability, pond construction or existing pond renovation methodology and conditioning, water pumping and manuring the pond. The trainer will learn all these aspects step-by-step so that the knowledge can be transferred to the farmer effectively. how to construct the pond.

Objectives:

At the end of this unit the participants will Have the knowledge to select a good site for the pond Be able to check the soil texture for suitability to hold water Have the skills to construct a pond.

Training Materials:

- Drawings depicting a farm site with all required infrastructure in the vicinity, Types of soils and their textural classification (Table-1) as flip chart, Soil samples, Water, Ideal Water quality standards for freshwater Aquaculture Table-4 as flip chart, Ideal Water quality standards for freshwater Aquaculture Table-4 as flip chart, Pro and cons of different water sources Table-3 as flip chart.
- Illustrative drawings: 3. Ideal Pond site with all infrastructure needs and resources, Step by step pond construction process drawings or Pictures, the Lime requirement for soil treatment during pond preparation for correcting the pH: Table-5, Ideal Water quality standards for freshwater Aquaculture Table-4 as flip chart, Conventional manuring practices: Table-6, Screening mesh samples, Whiteboard, white charts, markers, workbook, Measuring tape, Calculator, pond record book.

Module 2: Pre-Stocking

Session: 02
75 mins

Site with Suitable Soil, & Water Resources Identification & their Suitability Assessment:

Technical Manual Reference Chapters:
2.0; 2.1; 2.1.1

Introduction (22.5 mins):

Site selection depends on most important factors like a source of water, soil type & suitability, location, topography, proximity to inputs and markets, the proximity of amenities like road and power source. Farmers need to assess the soil for its water retention ability.

Training Material:

- Drawings depicting a farm site with all required infrastructure in the vicinity
- Types of soils and their textural classification (Table-1) as flip chart
- Soil samples, Water, Ideal Water quality standards for freshwater Aquaculture Table-4 as flip chart
- Pros and cons of different water sources Table-3 as flip chart
- Whiteboard, Markers

Methodology:

Brainstorming & Group Discussion (22.5 mins):

- What are the basic criteria for an ideal aquaculture pond site?
- How will you access the soil suitability?
- How to check soil water holding capacity?
- What type of water source is good for aquaculture?

Gather inputs from participants and sum-up factors

Practical Session (30 mins):

Do different tests (e.g., soil squeezing method, ball soil testing), see reference chapter-2.1.1.-Site selection.

Exercise: Practice recording the pond parameters in the pond record book.

Question, Answers & Breakout Sessions: Make farmer teams, give a task of site suitability assessment

Review & Discussion

Session: 03
75 mins

New Pond Construction & Existing Pond Renovation:

Technical Manual Reference Chapters:
2.1.2; 2.1.3; 2.1.3.1; 2.1.3.2; 2.2; 2.2.1; 2.2.2

Introduction (22.5 mins):

Physical & administrative planning is the prerequisite for efficient execution of new pond construction. All the elements required for the pond construction need to be decided and acquired before the initiation of construction. Based on the land dimensions and intended depth of the water in the pond, the dike dimensions, outlet, and inlet structure are decided. Existing ponds also need to be corrected as mentioned in the manual like, strengthening the dikes, correcting the pond slop and outlet structure, etc.

Training Materials:

- Illustrative drawings:
- 3. Ideal Pond site with all infrastructure needs and resources
- Step by step pond construction process drawings or Pictures
- Measuring tape, Calculator, Workbook, Pond Record Book

Methodology:

Brainstorming & Group Discussion (22.5 mins):

- What are the core components of an aquaculture pond?
- Where from you begin your pond construction plan?
- How are you going to restructure your existing pond dikes?

Exercise: Prepare a construction plan for your pond, and list out all the key elements required for the construction of an aquaculture pond. Design a plan incorporating all elements like a dike, outlet and inlet structure, drain canal, etc. Record the pond construction or renovation cost information in the pond record book

Question, Answers & Breakout Sessions (30 mins):

Make farmer teams, give a task of pond construction plan and renovation of the existing pond.

Review & Discussion

Module 2: Pre-Stocking

Session: 04 75 mins

Liming, Water Filling, & Manuring:

Technical Manual Reference Chapters:
2.3; 2.3.1; 2.3.1.2; 2.3.1.3; 2.3; 2.4; 2.4.1; 2.4.1.1; 2.4.1.1.1; 2.4.1.1.2.

Introduction (22.5 mins):

Knowledge about available lime types, their efficacies, usage dosages, and application methods needs to be understood while preparing the pond for stocking the fish. Before pumping water into the pond, a quality assessment needs to be done. Proper screening methods need to be adapted to avoid weed fish entry into the pond while pumping.

Manuring is the critical step in enhancing the productivity of the pond. Understanding the available manuring products, and their efficiency levels are essential for the selection of the right manuring product. Manuring the existing drainable and non-drainable ponds needs a different approach and methodology.

Training Material:

- Lime requirement for soil treatment during pond preparation for correcting the pH: Table-5
- Ideal Water quality standards for freshwater Aquaculture Table-4 as flip chart
- Conventional manuring practices: Table-6, Screening mesh samples
- Whiteboard, Markers, Workbook, Calculator, Pond Record Book

Methodology:

Brainstorming & Group Discussion (22.5 mins):

- Why liming is important in pond preparation?
- What types of limes are available in your region?
- How are you going to decide how much quantity of lime needs to be applied to your pond soil?
- What water quality parameters do you need to check before pumping the water into the pond?
- Why it is necessary to use screening mesh while pumping water into the pond?
- What types of manures are available in your region?
- What manuring method do you adapt for manuring the existing drainable and non-drainable ponds?

Exercise: Calculate the liming dose required for your pond based on the guidelines provided in the liming chapter. Record the liming dosage and subsequent expenses information in the pond record book.
calculate the manuring dose required for your pond based on the guidelines provided in the manuring chapter. Record the manuring dose and subsequent expenses information in the pond record book.

Question, Answers & Breakout Sessions (30 mins):

Make farmer teams, give a task of liming and manuring dosage calculation plan and manuring plan for the existing pond.

Review & Discussion

Session: 05. A
15 mins

Risk Factors:

Technical Manual Reference Chapters:
Risk Factors

Introduction (7.5 mins):

Having the awareness about the risk factors that are associated with pre-stocking operations is very much necessary for the farmers so that they are able to take precautionary measures.

Training Materials:

- Whiteboard, & Markers.

Methodology:

Brainstorming & Group Discussion (7.5 mins):

- What risk facts do you think you can encounter in pre-stocking operations or due to improper execution of pro-stocking operations?

Module 2: Pre-Stocking

Session: 05. B
30 mins

Economics:

Technical Manual Reference Chapters:
Pre-Stocking
Economics

Introduction (15 mins):

Economics is the most critical factor in the pre-stocking operations, it ultimately determines the financial viability and capital investment requirement of the culture operations.

Training Material:

• Whiteboard, Markers, Workbook, & Pond Record Book

Methodology:

Brainstorming & Group Discussion (15 mins):

- How are going to derive the investment estimate for the pre-stocking operation?
- How will you judge whether the investment you will be making for the pond construction is going to be viable?

Exercise: Prepare an investment estimate listing all cost implications and derive an ROI estimate, record these details in the pond record book for reference.

Module 3: On-Stocking

Time to Complete Session:
210 minutes

Content:

3.0 – On-stocking
3.0.1– Culture systems in aquaculture
3.0.2– Selection of fish species
3.0.3– Fish Seed selection criteria –sourcing
3.0.4– Identification of good quality seed
3.1– Species Stocking
3.1.1– Stocking size and density
3.2– Species composition
3.3– Transportation of fish seed
3.3.1– Preparations for transportation
3.3.2– Methods of transportation
3.3.2.1– Open system
3.3.2.2– Closed system
3.3.3– Timing of transport
3.4– Release of fish seed

Justification & Context:

In this module, we will learn about the processes and administration aspects that are required for the Next step after successfully learning about Pre-stocking operations are on-stocking management. On-Stocking management involves the selection of an ideal culture system Based on the available infrastructure and resources. Based on the market demand, suitability and seed availability Aqua culturist also need to select the culture species suitable for their culture operation. The aquacultures also need to be aware of the methodology of identification of quality seed, methods of transporting the seed safely to the culture site and the process of introduction of the seed into the culture pond.

Objectives:

By the end of this module the audience should be able to:

- Identify suitable culture systems adaptable for their aquaculture operation.
- Should be able to identify apt culture species for their culture objective.
- Should be acquainted with the knowledge of the selection of good quality seeds for their culture.
- Should be aware of all the available transportation methods to transport fish seed, and select the appropriate method for them.
- Should be acquainted with the knowledge of ideal fish seed acclimatization methods while stocking the seed in the pond.

Training Materials:

- Culture system classification- Table -9, Illustrative drawings: 1. Pictures of Fish hatchling, Fish spawn, Fish fry, Fish fingerling (Indian Major carp)
- Seed quality identification-Table-10, Feeding zone and major feeding habits of different species in a pond – Table- 11, Charts, Options of different species combinations and proportions-Table-14 as flip chart
- Combination, and stocking ratio options-Table-15 as flip chart, Fish seed samples, Illustrative drawings- 6
- Fish seed conditioning process image or drawings/ images or drawings of tools required for fish seed packing and transportation, Picture of different fish seed transportation methods
- Whiteboard, Charts, Markers. Workbook, & Pond Record Book

Module 3: On-Stocking

Session: 06
60 mins

Selection of Culture System, Species & Criteria for Seed Selection:

Technical Manual Reference Chapters:
3.0; 3.0.1; 3.0.2; 3.0.3

Introduction (20 mins):

Aquaculture farmers need to have the knowledge about different culture systems that are being practiced and should be able to select ideal culture system for their culture operation based on the resources available. Market demand, efficiency in growth, immunity, genetic potential, its adaptability to the selected culture method are some of the key considerations that need to be assessed while selecting a culture species.

Training Material:

- Culture system classification- Table -9

- Illustrative drawings:
1. Pictures of Fish hatchling, Fish spawn, Fish fry, Fish fingerling (Indian Major carp)

- Charts, Markers, & Pond Record Book

Methodology:

Brainstorming & Group Discussion (20 mins):

- What methods of pond culture systems are practiced in your region?
- What are the core infrastructure requirements for each of these systems?
- What are the fish species that fetch the maximum price in your target market?
- Can you grow them in your selected culture system?
- What are fish species that can be grown quickly and easily in your culture system?
- What are the basic criteria of a good fish seed supplier?

Exercise: Assess available infrastructure with you and identify the suitable culture system for your culture operation.

Question, Answers & Breakout Sessions (20 mins):

Make farmer teams, give a task of culture system and species selection and ask them to list out criteria for good seed selection.

Review & Discussion

Session: 07
80 mins

Identification of Good Quality Seed, Species Stocking, Size, Density & Composition:

Technical Manual Reference Chapters: **3.0.4.; 3.1. ; 3.1.1**

Introduction (30 mins):

Knowledge about the physical characteristics of fish is a prerequisite for acquiring the skill of seed quality assessment. Consistent market demand, faster growth, disease resistance, and seed availability are some of the important criteria that need to be considered while selecting the species. Stocking size and stocking density depend on the culture duration, target body weight, productivity of the culture system, and adapted mode of the culture system.

Knowledge about different feeding zones and fish that can grow in those specific zones is very much essential to select the ideal species combination to be grown in your pond.

Training Material:

- Seed quality identification-Table-10
- Feeding zone and major feeding habits of different species in a pond – Table- 11, Charts Options of different species combinations and proportions-Table-14 as flip chart
- Combination and stocking ratio options-Table-15 as flip chart
- Fish seed samples, flipcharts, Charts, Markers, workbooks, and Pond Record Books

Methodology:

Brainstorming & Group Discussion (30 mins):

- What are the physical characteristics that you check to assess the quality of fish seed?
- What should a healthy fish look like?
- Which species do you think suits well for your farming operation?
- What size of fish do you prefer to stock in your pond? & Why it is so?
- How are you going to decide on the stocking density?
- What are the feeding habits of different fish species that are grown in your region?
- How do you select different fish species and their combination? How will you set the combination ratio?

Exercise: Identify the physical characteristics of healthy fish from the live fish seed samples. Set the species composition, density, and ratio for your farming operation, and record the concluded information in the pond record book.

Question, Answers & Breakout Sessions (20 mins):

Make farmer teams, give a task of species combination selection, stocking size, and density estimations ask them to list out criteria of good quality seed.

Review & Discussion

Session: 08
20 mins

Transportation & Stocking of Fish Seed:

Technical Manual Reference Chapters:
3.2; 3.3; 3.3.1; 3.3.2; 3.3.2.1; 3.3.2.2; 3.3.3; 3.4.

Introduction (10 mins):

Knowledge about different modes of transportation for shifting the seed from the source to the culture site is very important for the farmer so that they can opt for the ideal mode of transport which suits their requirement. Conditioning the seed, careful packing methods, and appropriate acclimatization technics are the other important topics upon which the farmer needs to acquire knowledge

Training Material:

- Illustrative drawings-
6. Fish seed conditioning process images or drawings/ images or drawings of tools required for fish seed packing and transportation

- Pictures of different fish seed transportation methods, Charts, and Markers

Methodology:

Brainstorming & Group Discussion (10 mins):

- What are the packing and transportation methods that are being followed in your region?
- List out their pros and cons?
- What do you know about the conditioning of fish seed before packing? How is it practiced in your region?
- How do you do the seed acclimatization process at your pond while stocking the seed?

Session: 9. A
20 mins

Risk Factors:

Technical Manual Reference Chapters:
Risk Factors

Introduction (10 mins):

Having awareness about the risk factors that are associated with On-stocking operations is very much necessary for the farmers so that they can be able to take precautionary measures.

Training Material:

- Whiteboard, & Markers

Methodology:

Brainstorming & Group Discussion (10 mins):

- What risk facts do you think you can encounter in On-stocking operations or due to improper execution of On-stocking operations?

Module 3: On-Stocking

Session: 9. B 30 mins

Economics:

Technical Manual Reference Chapters:
On-Stocking Economics

Introduction (15 mins):

Economics is the most critical factor in the On-stocking operations, it ultimately determines the financial components and operational cost factors involved in On-stocking operations.

Training Material:

- Whiteboard, Markers, Workbook, & Pond Record Book

Methodology:

Brainstorming & Group Discussion (15 mins):

- How are going to derive the investment estimate for the On-stocking operation?
- How will you judge whether the investment you will be making for the seed stocking operations is going to be viable?

Exercise: Prepare an investment estimate listing all cost implications involved in On-stocking operations, and record these details in the pond record book for reference.

Module 4:
Post-Stocking

Time to Complete Session:
340 minutes

Content:

4.0- Post-Stocking
4.1- Water Quality Management
4.1.1- Physical Parameters
4.1.2- Biological Parameters
4.1.3- Chemical Parameters
4.2, 4.2.1- Lime & Types of Limes
4.2.3- Liming Dosage & Mode of Application
4.3- Manuring
4.4, 4.4.1- Feed management & Natural Food
4.4.2, 4.4.3- Supplementary Feeding, Feeding Rate, Methods, & Feeding Schedule
4.4, 4.5.1- Diseases & Causes
4.5.2- Types of diseases
4.5.3- Management of diseases
4.6- Sampling
4.7, 4.5.4- Harvest & Types of Harvest
4.8- Risk factors
4.9- Women in Aquaculture
4.10- Economics

Justification & Context:

In this module, we will learn about the processes and administration aspects that are required for the next step after successfully learning about on-stocking operations i.e., post-stocking operations and management.

Post-Stocking operations and management involve the activities to be undertaken from the stocking fingerlings up to the final harvesting of fish from the pond. The activities are pond hygiene, water quality monitoring & management, manuring and/or feeding, growth and health monitoring & management, and harvesting at right time are the key steps of post-stocking management.

Objectives:

By the end of this module the audience should be able:

- To understand the physical, chemical, and biological parameters that govern water quality management aspects and their management methods.
- Use different liming and manuring methods for managing the water quality and to enhance primary productivity of the water.
- Understand feed management methods, both natural food material that gets produced in the pond as well as the other supplementary feeding methods.
- Be aware of common diseases in fish, their causative factors, and some of the control and prevention methods.
- Be acquainted with sampling, recording the data in the pond record book, and also about the harvesting methods which are very much important at the end of the culture cycle.

Training Materials:

- Ideal Water quality standards for freshwater Aquaculture: Table-4- & Optimal range for key Physical parameters of aquaculture pond – Table-19 flip chart

- Illustrative drawings: 4. Zonation of pond ecological system, depicting feeding zone and major feeding habits of different species in a pond image of Phytoplankton, zooplankton, periphyton, Filamentous algae, Bottom fauna etc., Plankton collection illustration flipchart

- Optimal range for key chemical parameters of aquaculture pond – Table-20- flip chart, Types of limes, their safety level for application in ongoing culture ponds-Table-21 flip chart, Comparison of organic and inorganic fertilizers -Table-22 & Assessment of Fertilization Needs-Table-23 & Dailey application limit of different solid manures-Table -25 & Weekly or biweekly manuring schedule-Table-26

- Feeding zone and major feeding habits of different species in a pond – Table- 11

- Illustrative drawing:4- Zonation of pond ecological system, depicting feeding zone and major feeding habits of different species in a pond image of Phytoplankton, zooplankton, periphyton, Filamentous algae, Bottom fauna etc.,

- Farm made feed-Table-26, Common diseases, causative agent, symptoms and control measures-Table-27 in flip chart, Illustrative drawings: 11. Images of infected fishes with infections and good quality photos/pictures of Lernea, arugulas, Tape worms, deformed fishes, and bacterial and fungal infected individuals in flip chart

- White board, Markers, Charts, Workbook, Calculator, Pond Record Book.

Module 4: Post-Stocking

Session: 10 75 mins

Physical, Biological & Chemical Water Quality Parameters & their Management:

Technical Manual Reference Chapters:
4.0; 4.1; 4.1.1.; 4.1.2; 4.1.3.

Introduction (22.5 mins):

Water quality plays a major role in the fish farm's success, all the physical, biological, and chemical parameters need to be checked regularly for maintaining them at optimal levels.

Physical parameters like depth, temperature, transparency, color, light, and odor, biological parameters like phytoplankton, zooplankton, bacteria, fungi, pond chemical parameters like pH, D.O, Alkalinity, and Ammonia needs to be monitored regularly, should be recorded in the pond record book.

Fish farmers should be acquainted with knowledge about all these parameters, methods to observe them, their optimal levels, and methods to manage them at optimal levels.

Training Material:

- Ideal Water quality standards for freshwater Aquaculture: Table- 4 & Optimal range for key Physical parameters of aquaculture pond – Table-19 flip chart

- Illustrative drawings: 4. Zonation of pond ecological system, depicting feeding zone and major feeding habits of different species in a pond image of Phytoplankton, zooplankton, periphyton, Filamentous algae, Bottom fauna, etc

- Plankton collection illustration flipchart, Optimal range for key chemical parameters of aquaculture pond – Table-20- flip chart

- Whiteboard, Charts, Markers, Plankton Net, Pond Record Book

Methodology:

Brainstorming & Group Discussion (22.5 mins):

- List out different physical pond parameters that are crucial in your observation.
- How can you be able to manage pond physical parameters at optimal levels?
- How biological parameters like plankton level will be influential in deciding the pond's productivity?
- How can you check the plankton level in your pond?
- What happens when the plankton level is too high or if it is too low?
- How frequently do you check chemical parameters like pH, D.O., Alkalinity, and Ammonia?
- What happens if the alkalinity level is lower, than required?
- What happens if the D.O. level depletes to the critical point?

Quiz: If you don't have a D.O. kit or D.O. meter, what methods you can use to identify the D.O. depletion problem? What are ways to improve the D.O. levels in the pond? How can you improve the pond water pH if is lower than the required level? What methods can be adapted to reduce the pH if it is higher than the optimal level? Through probing questions and group discussion, list out different methods of managing the key chemical parameters on the whiteboard or chart.

Exercise: Practice recording the pond parameters in the pond record book.

Question, Answers & Breakout Sessions (30 mins):

Make farmer teams, give a task of troubleshooting different simulated pond parameter deviations from the optimal range like reduction in D.O level or pH raise, or high-water transparency, discussion and evaluation of the outcomes among themselves.

Review & Discussion

Session: 11
65 mins

Lime & Manuring, Types, Dosage, and Mode of Application:

Technical Manual Reference Chapters:
4.2; 4.2.1; 4.2.3; 4.3

Introduction (22.5 mins):

The effects of lime application in the pond water are numerous, the farmer should be aware of what types of limes are available, their individual efficacy, and the level of adaptability for aquaculture operation, dosage levels, how to apply them and when to apply them.

Manuring during post-stocking operation is done to maintain sustained production of plankton during the entire culture period. Farmers should be aware of the methods to check the need for additional manure application. They also should be aware of which type of manure at what rate should be applied and the method of application.

Training Material:

- Types of limes, their safety level for application in ongoing culture ponds-Table-21 flip chart
- Comparison of organic and inorganic fertilizers -Table-22 & Assessment of Fertilization Needs-Table-23 & Dailey application limit of different solid manures-Table -25 & Weekly or biweekly manuring schedule-Table-26
- Whiteboard, Markers, Charts, Workbook, Calculator, Pond Record Book

Methodology:

Brainstorming & Group Discussion (22.5 mins):

- What are the benefits of lime application?
- How to check whether you need to apply lime or not to your pond water?
- How to apply lime to your pond water?
- How are you going to decide that you need a manuring dose for your pond?
- What are the organic manures that are available in your region?
- What happens when manure is applied beyond the need?
- How frequently do you apply manure to your pond?
- How to apply manure to your pond?

Quiz:
- What type of lime products are available in your region?
- What tools can be used to check the pond water pH?
- How manuring will help fish growth?
- What happens when you dump manure in large volumes at a time?
- How important it is to measure the pH regularly and record it in the pond record book?

Question, Answers & Breakout Sessions (20 mins):

Make farmer teams, give a task of fixing lime and manuring dose to a simulated situation like low alkalinity pond water and a high-water transparency pond water, allow discussion and evaluation of the outcomes among themselves.

Review & Discussion

Module 4: Post-Stocking

Session: 12
65 mins

Natural Food, Supplementary Feeding, Feeding Rate, Methods, & Feeding schedule:

Technical Manual Reference Chapters:
4.4; 4.4.1; 4.4.2; 4.4.3

Training Material:

- Feeding zone and major feeding habits of different species in a pond – Table- 11
- Illustrative drawing:4- Zonation of pond ecological system, depicting feeding zone and major feeding habits of different species in a pond image of Phytoplankton, zooplankton, periphyton, Filamentous algae, Bottom fauna, etc
- Farm made feed-Table-26,
- Whiteboard, Markers, & Charts

Introduction (22.5 mins):

To achieve optimal and desired production outcomes from the pond aquaculture, consistent growth should be there. The art of growing natural food in the pond should be learned and practiced by every farmer so that with minimal investment one can achieve better economic returns. Before growing the natural food in the pond, one should know which fish prefers what varieties of natural food material, how to grow, balance, and maintain these multiple food organisms at the same time in your pond. In pond aquaculture based on the production target, supplementary nutrition can be provided by using agriculture by products like different cereals and oil cakes in combination to provide additional protein and carbohydrates to the fish.

The farmer should learn about the method to use these supplemental diets, economic assessment, balanced and optimised combination of pond's natural productivity, and supplemental nutrition.

Farmer also should be acquainted with the knowledge of method of using supplementary feed, setting its volume per meal, how to combine different ingredients, their ration, and usage methods.

Methodology:

Brainstorming & Group Discussion (22.5 mins):

- What methods do you follow to grow natural food material in your pond?
- How to maintain consistent natural food material available in your pond?
- How can you check the level of natural food material in the pond water?
- Can you list some of the Agri process bi-products that are available in your region which can be used as supplemental diets for fish?
- What type of feeding methods is being practiced in your region to provide supplemental diets to your fish?
- How are you going to fix the feed volume that you wanted to feed your fish?
- When can you opt to use commercial feed for your fish?
- What are the Ideal culture criteria for commercial feed usage?

Quiz: •What natural food your fish likes to eat?
- How many types of living organisms grow in your pond water and soil?
- How can you decide that you need to provide supplemental nutrition to your fish in addition to natural food material i.e., available in the pond?
- What happens if the supplemental diet is not used by the fish completely?

Question, Answers & Breakout Sessions (20 mins):

Make farmer teams, give a task of methods to check the natural plankton level in the pond water and fixing appropriate manuring dose to improve the level of natural food in the pond water. How to decide supplemental feed requirements and fix the feed volume with a given case study or a simulated situation, allow discussion and evaluation of the outcomes among themselves.

Review & Discussion

Session: 13. A 30 mins

Diseases, Causes, Types, Management, & Pond Hygiene:

Technical Manual Reference Chapters: **4.5; 4.5.1; 4.5.2; 4.5.3; 4.5.4; 4.6; 4.7; 4.7.1; 4.7.2.**

Introduction (15 mins):

There are several causes for the occurrence of disease in fish that may affect the fish directly or indirectly. Insufficient nutrition reduced immunity, wide fluctuation in physical, chemical, and biological components of water, toxic gases emission in the pond due to organic matter accumulation, and bacterial and external parasites attack are some of the reasons for disease occurrence. Farmers should be acquainted with the knowledge of identifying early disease symptoms and should be able to take preventive and prophylactic measures. Maintenance of ideal water quality by managing the physical, chemical, and biological parameters at optimal range can reduce the chances of disease incidences.

Training Material:

- Common diseases, causative agents, symptoms, and control measures-Table-27 in flip chart, Illustrative drawings: 11.

- Images of infected fishes with infections and good quality photos/ pictures of Lernea, arugulas, Tapeworms, deformed fishes, and bacterial and fungal infected individuals in flip chart,

- Whiteboard, Markers, & Charts

Methodology:

Brainstorming, & Group Discussion (15 mins):

- What are the common disease incidents you encountered during your fish farming operations?
- What preventive measures do you think can be implemented to avoid disease occurrence?
- How can you avoid cross-contamination of diseases in fish farming operations?
- What processes do you adapt to maintain hygienic conditions at the pond?

Quiz: • Identification of diseased fish and causative agents from the flip chart.

Module 4: Post-Stocking

Session: 13. B
20 mins

Sampling:

Technical Manual Reference Chapters:
4.5; 4.5.1; 4.5.2; 4.5.3; 4.5.4; 4.6; 4.7; 4.7.1; 4.7.2.

Training Material:

- Whiteboard, Markers, Charts, Workbook, Calculator, Pond Record Book.

Introduction (10 mins):

Periodic sampling is necessary to assess the heath, growth and wellbeing of the fish in your pond. Sampling should be done at least once in a month to observe the animal condition and growth. Farmer need to follow specified protocol to do the sampling as mentioned in the manual and record the observations in the pond record book.

Methodology:

Brainstorming, & Group Discussion (10 mins):

- Why it is necessary to do regular sampling?
- What needs to be observed and recorded during the sampling?

Quiz:
- How will you measure your fish weight?
- How to calculate the monthly growth rate of your fish?
- How to calculate monthly FCR?

Session: 13. C
20 mins

Harvest & Types of Harvest:

Technical Manual Reference Chapters:
4.5; 4.5.1; 4.5.2; 4.5.3; 4.5.4; 4.6; 4.7; 4.7.1; 4.7.2.

Training Material:

- Whiteboard, Markers, Charts, Workbook, Calculator, Pond Record Book.

Introduction (10 mins):

Harvesting decision is taken by the farmer when the fish attains desired and marketable size, and the market price fetches a better margin for the farmer. The farmer needs to have ample knowledge about various harvesting methods so that proper harvesting method can be selected.

Methodology:

Brainstorming, & Group Discussion (10 mins):

- What measures do you need to take before harvesting?
- What are the tools and infrastructure requirements for commencing the harvesting process?

Quiz:
- How to estimate total biomass harvested?
- How to estimate production per unit culture area?
- How to estimate the FCR?
- How to estimate profit per kg fish production?

Session: 14. A
20 mins

Risk Factors:

Technical Manual Reference Chapters:
Risk Factors

Training Material:

- Whiteboard, Markers, & Charts

Introduction (10 mins):

Having the awareness about the risk factors that are associated with On-stocking operations is very much necessary for the farmers so that they are able to take precautionary measures.

Methodology:

Brainstorming, & Group Discussion (10 mins):

- What risk facts do you think you can encounter in On-stocking operations or due to improper execution of On-stocking operations?

Session: 14. B
15 mins

Women in Aquaculture:

Technical Manual Reference Chapters:
Women in Aquaculture
4.8. 4.8.1; 4.8.2; 4.8.3; 4.8.4; 4.9

Training Material:

- Whiteboard, Markers, & Charts

Introduction (7.5 mins):

Women can handle tasks like, water quality monitoring, measuring physical, chemical, biological parameters, and recording the data in the pond record book. In small village neighbourhood they can even do the sales and marketing job for on form sales. In small fish farming operations, companion assistance in day-to-day farming responsibilities will be of great help.

Methodology:

Brainstorming, & Group Discussion (7.5 mins):

- In your opinion what are the fish farming activities in which women can be engaged?
- How would you like to engage your companion in your farming operations?

Module 4: Post-Stocking

Session: 14. C Economics:
30 mins

Technical Manual Reference Chapters:
On-Stocking Economics

Introduction (15 mins):

Economics is the most critical factor in the On-stocking operations, it ultimately determines the financial components and operational cost factors involved in On-stocking operations.

Training Material:

- Whiteboard, Markers, Workbook, & Pond Record Book

Methodology:

Brainstorming, & Group Discussion (15 mins):

- How are going to derive the investment estimate for the On-stocking operation?
- How will you judge whether the investment you will be making for the seed stocking operations is going to be viable?

Exercise: Prepare an investment estimate listing all cost implications involved in On-stocking operations, record these details in pond record book for reference.

Deutsche Gesellschaft für Internationale
Zusammenarbeit (GIZ) GmbH

Sustainable Aquaculture for Food and Livelihood (SAFAL)
Sarbeswar Bhawan, 1st by Ln, Jaya Nagar,
Guwahati, Assam, 781022, India

E: info@giz.de

www.giz.de/india