TRAINING MANUAL

FISHERIES DEVELOPMENT IN RAINFED AREAS

WASSAN

Revitalising Rainfed Agriculture
The RRA Network

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CHAPTER - 1
Scope of Fisheries in Rainfed areas

1.1. Introduction

Realization of potential of fish production is untapped in rain fed areas across the country. Promotion activity of fisheries has not been outreach by the NGOs, government departments, and other concerned institutions in different parts of the country. The reason behind it may be lack of educational, technical institutions, research activity, policy makers; Lack of proper governance etc. 80 % area in India has been realized as rain fed areas.

The poor inland fishers and rural community depended for their livelihood and food security on these indigenous species. India has vast inland fishery resources in the form of rivers and canals (195210 km), reservoirs (2-94 million ha), tanks and ponds (2.41 million ha), floodplain, lakes and derelict waters (0.79 million ha), offering tremendous scope for fish production. (DAHD&F, Ministry of agriculture Govt. of India, 2009). The capture fisheries in the rivers, lakes, channels, flood plain water bodies, tanks and ponds, were always the rural livelihoods and food security base. Carps constitute 87% of the inland aquaculture production.

In different parts of the country small water bodies has been neglected by the state, only large water body has been taken into consideration for pisciculture which we can say that lack of proper data base.

After a long period of time some state has realized the fisheries as revenue source. State like Jharkhand, Bihar, Andhra Pradesh, West Bengal, and Orissa are providing different schemes to their state people. But the trend of scaling up the fisheries seems to be slow as governments programs are not able to reach to the beneficiary.

Rain fed rural areas has number of water bodies from small to large size water bodies with both seasonality and perennial type.

1.2. Weakness

The practices have been not being adopted. The weakness in this reasons are:

- ✓ Farmers have never realized the fisheries potential. Traditional indigenous fishes catches are only done.
- ✓ There is no sufficient money / lack of money during the seed availability results in no stocking and unutilization of the water body.

- ✓ Farmers could not identify the fish seed. Quality and quantity of seed is a major issue for farmers.
- ✓ Lack of technical resources person, institutions and service support also affects the production of the fish in the community tanks.

1.3. Our Opportunity

- ✓ We can tapped a maximum number of water body.
- ✓ Number of local institution can be formed and strengthened by conducting meeting and linkages with the other institutions.
- ✓ Collaboration with the technical institutions provides better practices and understanding and skill development of the farmers.
- ✓ Linkages with the local NGOs partners, Panchayati institutions and government departments help to form better policy.
- ✓ Capacity building in the mode of awareness campaign, trainings at proper time and at community level in local language may bring good quality of understanding.
- ✓ Skilled man power may be developed in the community,
- ✓ It saves time and dependency on others. Mutual understanding will be developed.
- ✓ Generates job opportunity
- ✓ Optimum production can be gained
- ✓ Proper marketing with good income source can be maintained.

1.4. Conclusion

Establishing fisheries resource center in rainfed areas to provide technical support in inland fisheries sector. Convergence with MGNREGs for repairing and renovation of tanks or new construction reduces extra expenditure for farmers. Hence better management practices can be done.

CHAPTER - 2
Fish Classification, intensification and their characteristic

2.1. *Catla - Catla catla* (Hamilton, 1822)

2.1.1. Classification

Kingdom	*Animalia*
Phylum	*Chordate*
Class	*Teleostomi*
Order	*Cypriniformis*
Family	*Cyprinidae*
Genu	*Catla*
Species	*Catla*

2.1.2. Characteristics

- Catla is a fish with large and broad head, a large **protruding** lower jaw and upturned mouth.
- It has large, greyish scales on dorsal side and whitish on belly.
- Catla is a surface feeder.
- Adults feed on **zooplankton** but young ones on both zooplankton and **phytoplankton**.
- Catla attains sexual maturity at an average age of two years and an average weight of 2 kg.
- Egg laying capacity of per kg of catla is 1-1.50 lak h
- Breeding season is June- July
- Commonly called as catla in most part of the country. Some state it is called as Bhakur.

2.2. *Rohu - Labeo Rohita* (Hamilton, 1822)

2.2.1. Classification

Kingdom	*Animalia*
Phylum	*Chordate*
Class	*Teleostomi*
Order	*Cypriniformis*
Family	*Cyprinidae*
Genu	*Labeo*
Species	*Rohita*

2.2.2. Characteristics

- Body is moderately elongated, mouth inferior and mouth thick
- Scales cycloids
- Body brownish on back and silvery on the belly sides
- Three day old **hatchlings**, measuring about 6 mm
- Rohu are column feeder. They feed on algae and zooplankton.
- **Juveniles** feed more than adult one.
- Sexual maturity attains 1-1.5 kg
- Egg laying capacity of per kg rohu is 1.5 to 2 lakh
- Breeding season is June – July
- Commonly called as rohu in all parts

2.3. *Mrigal Cirrihinus Mrigala* (Block 1795)

2.3.1. Classification

Kingdom	*Animalia*
Phylum	*Chordate*
Class	*Teleostomi*
Order	*Cypriniformis*
Family	*Cyprinidae*
Genu	*Cirrihinus*
Species	*Mrigala*

2.3.2. Characteristics

- Body is elongated, depressed with rounded snout. mouth inferior and mouth thick,
- Upper lips not continuous with lower lip.
- Large **cycloids** scales presents
- Body dark grey on back and silvery on the belly sides
- One pair of short **barbles** present on the mouth.
- Three day old hatchlings, measuring about 6 mm
- They are bottom feeder. They feeds on decomposed vegetation's
- Sexual maturity attains 1-2 kg
- Egg laying capacity of per kg mrigal is 2 to 2.5 lakh
- Breeding season is June – July
- Commonly called as mrigal or nain or naini

2.4. *Silver carp Hypophthalmichthys molitrix (Valenciennes in Cuvier and Valenciennes, 1844)*

2.4.1. Classification

Kingdom	*Animalia*
Phylum	*Chordate*
Class	*Teleostomi*
Order	*Cypriniformis*
Family	*Cyprinidae*
Genu	*Hypophthalmichthys*
Species	*Molitrix*

2.4.2. Characteristics

- The silver carp is a deep-bodied fish that is laterally compressed.
- They are a very silvery in color when young.
- In older they get older they fade from a greenish color on the back to silver on the belly.
- They have very tiny scales on their body but the head and the opercles are scaleless.
- They have a large mouth without any teeth in the jaw, but they have pharyngeal teeth.
- Its eyes are situated far forward on the midline of the body and are slightly turned down.
- Silver carp are unlikely to be confused with native cyprinids due to size and unusual position of the eye.
- They are most similar to bighead carp (*H. nobilis*) but have a smaller head and upturned mouth without teeth, a keel that extends forward past pelvic fin base, lack the dark blotches characteristic of bighead carp and have highly branched gill rakers.
- Juvenile fish lack spines in fins.
- **Metalarvae** and early juvenile are similar to bighead carp (*Hypophthalmichthys nobilis*) but pectoral fin extends only to base of pelvic fin (as opposed to beyond in the pelvic fin in bighead)
- Sliver carp are filter feeders that eat phytoplankton, zooplankton, bacteria, **detritus** and they graze aquatic vegetation.
- Sexual maturity attains at 3 yrs
- Egg laying capacity is 1.5- 2 lakh per kg.

2.5. *Big Head - Hypophythalmichtys nobilis (Richardson, 1845)*

2.5.1. Classification

Kingdom	*Animalia*
Phylum	*Chordate*
Class	*Teleostomi*
Order	*Cypriniformis*
Family	*Cyprinidae*
Genu	*Hypophthalmichthys*
Species	*Nobilis*

2.5.2. Characteristics

- The bighead carp is a large, narrow fish with eyes that project downward.
- Coloration of the body is dark gray, fading to white toward the underside, and with dark **blotches** on the sides.
- Its head has no scales, a large mouth with no teeth, and a protruding lower jaw.
- Its eyes are located far forward and low on its head.
- It is very similar to the silver carp, and can be distinguished by the dark coloration on its sides.
- The bighead carp can be identified by a smooth **keel** between the anal and pelvic fins that does not extend anterior of the base of the pelvic fins.
- The bighead carp has a very fast growth rate.
- Feeds on zooplankton

2.6. Grass Carp (*Ctenopharyngodon idella* (Valenciennes in Cuvier and Valenciennes, 1844)

2.6.1. Classification

Kingdom	*Animalia*
Phylum	*Chordate*
Class	*Teleostomi*
Order	*Cypriniformis*
Family	*Cyprinidae*
Genu	*Ctenopharyngodon*
Species	*Idella*

2.6.2. Characteristics

- Light yellow body, grey-green back, grey abdomen.
- Dark green dorsal and pectoral fins, other fins light grey.
- Body of adult fish elongate and sub-cylindrical (length 3.5-4.8 times body height)
- Abdomen round with no ridge.
- Head is compressed and slightly pointed and mouth terminal.
- Eyes small. **Snout** blunt and the mouth is terminal, lower jaw shorter than upper jaw.
- Lateral line is straight with 37-42 large scales.
- Egg laying capacity of grass carp is 1-1.50 lakh per kg
- Sexual maturity at 3-4 yrs.
- Feeds on aquatic plants.

2.7. Common Carp - *Cyprinus carpio*

2.7.1. Classification

Kingdom	*Animalia*
Phylum	*Chordate*
Class	*Teleostomi*
Order	*Cypriniformis*
Family	*Cyprinidae*
Genu	*Cyprinus*
Species	*Carpio*

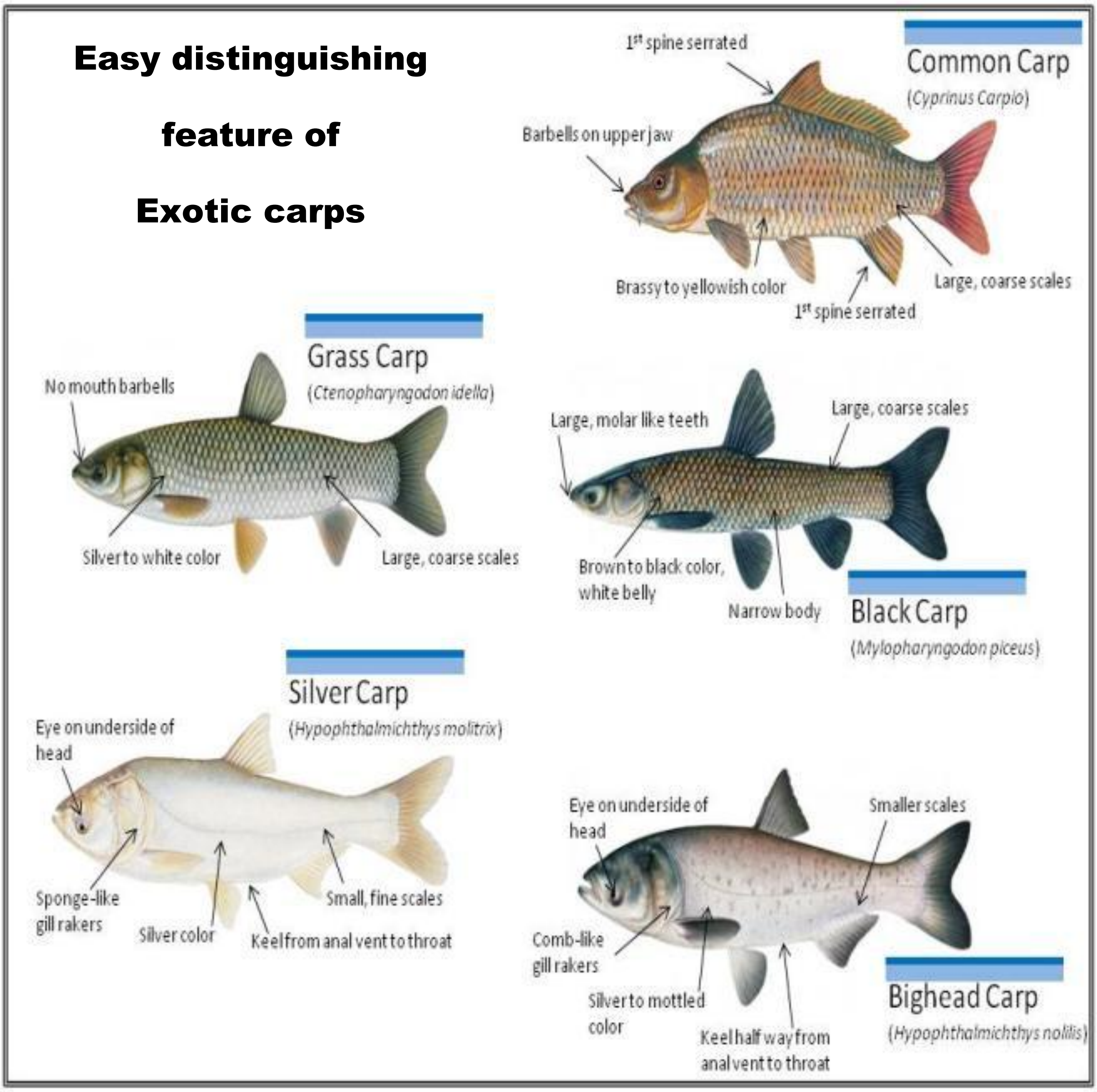
2.7.2. Characteristics

- The body of common carp is flat.
- Head is comparatively smaller than their body.
- The body of carpio fish is covered with slight reddish scales.
- The backside is slightly brown colored.
- Belly is golden colored.
- The scales large sized.
- A common carp lengths about 100-120 cm.
- Adult fish weights highest 40 kg.
- They survive for long time.
- Common carp fishes are omnivorous.
- They live in the lower water level. Eat water plants, various types of insects, benthic worms, **crawfish**, **crustaceans**, zooplankton etc.
- Breeding is two times a year
- Once at summer or rainy season and another time in winter season.
- They lay eggs about 1-1.5 lakh eggs per kg

Table - 1 : Species Common Name in different state

Scientific name	Common name	Hindi	Bengali	Odiya	Telugu	Tamil
Catla catla	*Catla*	*Bhakur, katla*	*catla*		*botchee*	*Thoppu*
Labeo rohita	*Rohu*	*Rohu*	*Rohu*	*Rohi*	*Bocha-gandumeenu*	*Kannadi kendai*
Cirrhinus mrigala	*Mrigal*	*mrigal*	*mrigal*		*Ven kendai*	*Arju*
Hypophthalmichthys molitrix	*Silver carp*					
hypophthalmichthys nobilis	*Big head*					
Ctenopharyngodon idella	*Grass carp*					
Cyprinous carpio	*Common carp*					

Box 1: Easy distinguishing feature of different fishes



CHAPTER - 3
Water Quality and Bottom Soil Management

3.1. Water Quality Management

Fish is an aquatic animals possess with special feature like gills and fins. These distinguishing characters made a fish different from other aquatic animals. Good aquatic environment produces healthy fish. Its aquatic environment affects growth rate, feeding efficiency, fish health and survival. Stress free environment have good impact on production system.

3.1.1. Dissolve Oxygen

Optimum level of oxygen should be 5 mg/l for fish productions. Oxygen depletion in water is rectified by following aeration method.

- **Manual -** in this method, water surface is splashed by bamboo sticks. This helps in dissolving the oxygen in water
- **Mechanical -** a diesel water pump is operated. Water is pumped out and spread into the water body results in dissolution of atmospheric oxygen.
- **Aerators -** this are floating device. These mechanical rotating blades churn the water and helps in dissolving the oxygen.

3.1.2. Temperature

Temperature plays important role in the aquatic environment. Optimum temperature ranges from 14-18 degrees Celsius in cold water and 24- 30 degree Celsius in warm water. Planting of trees on pond banks benefits as providing the shade results into reduce in **stratification**. A simultaneously beneficial effect of wind mixing and photosynthesis process is affected.

3.1.3. Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of **turbidity** is a key test of water quality. Turbidity is measured by secchi disk. Optimum visibility of turbidity ranges from 40-60cm. turbidity can be controlled by application of organic manure 500-1000 kg/ ha, 250-500 kg gypsum or 25-50kg alum.

3.1.4. Ammonia

In general, ammonia is toxic to fish. More ammonia depends upon the more pH and temperature. On ionized ammonia- 0.02-0.05 mg/ l is a safe concentration for fish. Following methods can be used to reduce the concentration of ammonia

- Avoid over feeding.
- Avoid excess liming
- Formalin can be used to remove the ammonia from the fish pond.
- Water exchange can reduce the concentration of ammonia in pond.
- Aeration increases DO concentration and decreases Ph resulting in reduces in toxicity.

3.1.5. Nitrite

Following are the measures to maintain nitrite level in water.

- Correct stocking, feeding and fertilization practices should be done.
- Bio filtration is done by special filters.
- Ponds should keep well oxygenated.

3.1.6. Hydrogen sulphide

Thick layer of organic deposit at the bottom. It is toxic to fish. It creates stress to fish. Following are the measures to control.

- Frequent water exchange is needed.
- Liming should be applied to reduce the toxicity of Hydrogen sulphide.

3.1.7. pH

pH is a concentration of the hydrogen ion concentration in water and indicates how much acidic or basic the water. Following are the guidelines.

Table - 2: pH scale range for water quality

pH	Effects
4	Acid death point
4-6	Slow growth
6-9	Best for growth
9-11	Slow growth
>11	Alkaline death point

3.1.8. Total alkalinity

It refers to the concentration of bases in water and capacity to accept the acidity. Carbonates and bicarbonates are predominant bases. 75-300 mg/l is ideal for fish. Low alkalinity rectified by lime treatment.

3.1.9. Total hardness

- Mainly calcium and magnesium constitutes hardness of water
- 60 mg/l helps in pond productivity and <60 mg/ l creates stress to fish. Low harness treatment can be done by use of lime.

3.2. Bottom Soil Management

Fish is an aquatic animals possess with special feature like gills and fins. These distinguishing characters made a fish different from other aquatic animals. Good aquatic environment produces healthy fish. Its aquatic environment affects growth rate, feeding efficiency, fish health and survival. Stress free environment have good impact on production system.

3.2.1. Texture

Soil texture should not be too sandy nor too clayey

3.2.2. Soil Acidity

- Ideal range for soil pH is 6 - 8
- Lime is used based upon soil pH

3.2.3. Bottom soil oxidation

Aeration and water circulation is useful

3.2.4. Drying pond bottom

Drying period is 2 - 3 weeks

3.2.5. Other treatments

3.2.5.1. Nutrient removal

Gypsum (calcium sulphate)-100-200mg/l and 20-30mg/l alum have lower phosphorus con in pond water

3.2.5.2. Phytoplankton removal

- **Algicides** are used to reduce abundance of phytoplankton in intensive culture.
- Copper sulphate is used to reduce - dose 1/100 cuso4 of total alkanity

3.2.5.3. Chlorination

3.2.5.4. Water exchange

CHAPTER - 4
Types of Culture Practices

4.1. Traditional pisciculture

Traditional pisciculture can be done in all types of water bodies where production is low. The culture depends upon the utilizing the naturally available food

4.2. Intensive culture

To enhance more production, fish feed and organic fertilizer are essential. Perennial water body is taken into consideration. This water is not used for any people uses like cleaning, bathing and irrigation purpose.

4.3. Composite culture/ polyculture

It is the composition of rearing the fish of different variety depends upon the demand and profit margins. Generally Indian major carp (3 variety) and exotic carp (3 varieties) species are considered. In farming system six types of species commonly known as catla, rohu, mrigal, silver carp, grass carp, common carp are used. Here full utilization of feed is consumed by the fish as different level of feeder fish exits in the pond. Hence enhance more production. Composite fish culture can be done to produce fry, fingerlings and table size fishes.

4.4. Integrated culture

Fish along with rice, vegetables, duckery, cattle, and poultry is known as integrated pisiculture. Practices can be done with locally available resources. See chapter 10 for details.

4.5. Mono species culture

Generally catfishes or single IMC or exotic species are culture.

Table - 3: Showing advantage and advantage in different input / culture system

Types of culture	Advantage	Disadvantage
Monoculture	• Raise Single species • harvest easily • less energy • Time saving	• Non utilization of all water level • Low productions as compared to polyculture • Species fights for food on sort.

Polyculture	• Raising multiple species from single area • Full water body utilization • Production could be optimum • More income	• More time and labor requirement • Multiple harvesting needed
Integrated	• Mixing two types of farming in one area. • Utilization of land and water • More productions • More extra source of income	

Table - 4: Showing features of culture system

Features	Extensive	Semi Intensive	Intensive
Where done	Reservoirs, lakes, rivers	Ponds , Check dams	Raised in artificial tanks, Small to large manageable ponds
Food dependency	Natural resources	Natural resources	Natural resources
Space	High, large area		Limited space
Water exchange	Low		Is needed
Feeding	no external feeding	Periodic feeding	Supplementary feed
Fertilizer use	No	Partially	Yes, High input
Risk	Algal blooms		Water quality decline, stress on fish, diseases
Stocking density	Low-1000 kg/ ha	Moderate high density	High
Harvesting	Difficult, more labor needed and harvesting skill	Not very difficult	Easy, save time, few labor required
Av productions	2-3 tons /ha	4 ton/ha	10-15tonn/ha

CHAPTER - 5
Criteria for site selection of pond

5.1. Pre-requisites for site selection for construction of fish farm

- Different types of pond are required for rearing various stages of fish.
- Good quality water retentive soil base and assured adequate water supply throughout the year is required for constructing various kinds of ponds.
- Topography should facilitate self- drainage of ponds.

5.2. Topography

- Topography / layout of land are the surface feature of water shed.
- Topography influences the type of farm.
- In a valley, basin is surrounded on three sides with high lands and a narrow outlet on the forth.
- In gently sloping land, self-drainable ponds can be constructed on higher elevation.
- In swampy and marshy areas, bunds constructed by depositing earth, to cordon off ponds of required sizes.
- Barrage type ponds are made by building a series of dams in a narrow flowing stream.

5.3 Soil type

- The soil should be free from vertical and lateral seepage
- Impervious soils store water for long periods and loss of water mainly from evaporation.
- Impervious soils are poor in heavy clay, clay loam, salty clay, etc.
- Bottoms of porous soil can be treated with **bentonite**, clay or other sealants. Even cow dung acts as a sealant.


Soil Quality for Fish Culture

- The degree of **porosity** determines the r required level.
- Sites with rocky out-crops, shale ledges, sand, gravel and limestone areas are not suitable.

- Sprayed on asphalt liners and plastic film liners can also be used and covered with layer of soil in permeable soils.
- The sealing material should be sprayed uniformly over the pond bottom in two or three layers, spreading in different direction ensure uniformity of coverage. Then it is disked into the soil and compacted by roller.
- Embankment base should be well scarified in preparation for fills. This will allow the embankment to knit in to the ground.
- A simple way to test the water retention soil at the field level is by squeezing a moist chunk of soil into a tight ball. If it does not crumble after some handling or squeezing, it may be regarded as satisfactory.

5.4. Water supply

- Fish depend on water for all their needs.
- Adequate quantity of good quality water must be available throughout the year.
- A dependable source of water supply must be available near the site.
- Usual sources of water supply are: reservoirs, streams, canals, surface run offs, wells, **artesian** wells, tube wells, etc.
- Water from any sources is suitable for fish culture, provided it is free from contamination.

5.4.1. Streams and Canals

Are satisfactory source of water for ponds, if the following requirements are met.

1. The flow is enough to fill the tanks.
2. It maintains a fairly constant water level.
3. Stream is not subjected to excessive flooding.
4. Watershed is well vegetated.
5. Small streams which are subjected to floods during heavy rains should be avoided as they usually carry a considerable amount of silt reducing the fertility of the ponds.

5.4.2. Springs

1. Spring water is obtained from underground.
2. It is a very good source for fish culture.
3. It is usually uncontaminated, and does not contain undesirable fishes, fish eggs and pathogens.
4. If the water from a spring has travelled very far, it may need to be filtered before it is used for a fish pond.

5.4.3. Rainfall

1. "Sky ponds" rely only on rainfall to fulfill their need for water.
2. For stock ponds, rain water run- off from land is one of the chief sources of water.
3. The size of watershed determines the availability of water throughout the year.

5.4.4. Wells

1. The best source of water for a fish pond is well water.
2. Continuous water supply can be obtained from wells.
3. Well and spring waters are often low in oxygen content and fish need more oxygen in the water.
4. The oxygen can be added to the water by agitating the water in the pond, stirring the water in the pond, by beating the water with bamboo sticks, by running small motors in the pond and by using sprinklers.
5. Artesian wells are used for water supply in areas where they confirm to certain geological contours.
6. Underground seepage is often used as the water supply for ponds formed in abandoned mining pools, rock quarries, burrow fits, etc.

Table - 5: Requirement of a normal fish farm site under Indian conditions

Particulars	Requirements of a normal fish farm site
Nature of terrain	Non rocky with at least 2m deep soil
Slope of the terrain	Land should be gently sloping or level
Physical quality of soil	Soil fraction should be above 90% of the whole soil, stone and gravel not exceeding 10%
Chemical quality of soil	• Neutral pH, total nitrogen >0.1%, • total phosphorous >0.1%, • Organic carbon >1.0%, Free CaCO3>5%.
Rate of fall in water level in ponds	Should be less than1 m per annum
Water table	Should not be far below the pond bottom when the soil is not water retentive
Water supply	There should be a source of perennial water- supply nearby, sufficient to meet the requirement of the farm
Biological productivity	Average plankton production per m^3 should range between 10 ml and 20 ml.

Other factor to be considered for site selection is as follows.

5.5. Economical factor

- Proximity to all-weather road connections
- Availability of construction materials
- Availability of electricity, telephone or radio connections
- Location of markets for the produce and determination of demand
- Availability of supplementary feeds
- Availability of suitable transport facilities

- Availability of ice for marketing
- Availability of organic and artificial fertilizers, drugs and chemical materials

5.6. Social Factor

- Ownership, availability of land and land values, land regulations and rights,
- Availability of local staff with adequate experience of pond management
- Availability of skilled and semi-skilled labourers
- Availability of equipment, services and supplies needed

CHAPTER - 6
Nursery Pond Management

6.1. About nursery ponds

- Spawn is produced in hatchery and nurtured in 72-96 hours called as hatchlings. Fish Carp hatchlings are very delicate. It requires very cautions handling. It is just 3-4 days old. They are stocked in a well prepared nursery pond. They are reared in nursery pond.
- Nursery ponds are the small water bodies of 0.02-0.10 ha with depth of 1.0-1.5 m. The hatchlings are properly released in these nurseries up to the fry stage for a period of 15-20 days. During the period it grows up to 25 to 30 mm size.
- These fry are further reared in another pond for a period of 2-3 months to raise the fingerlings of about 100 mm in size.

6.2. Site selections

WHY and **WHERE** to select area for nursery pond

- **WHY?**
  - To make better use of land and water.
  - To generate a regular source of income (self-employment) and therefore profit.
  - To ensure food security and nutrients.
  - For better livelihood
  - Proper time, hard work and skills, knowledge, trainings, practices and monitoring is needed to raise fry.

- **WHERE?**
  - Choose a good place with gentle slope so that too much digging is not required.
  - Drainage is also easier at slope side
  - Too low land place have risk of flooding.
  - Do not build pond on land which have good agricultural productions.
  - Build pond close to home for care and maintenance
  - Choose tree/ plants free area so that proper wind flows and water is oxygenated.
  - Place should be facilitated with good water channel such as streams, river, check dams.
  - Muddy water allows is not recommended in your pond.
  - Water holding capacity of quality Soil is must. Sand and gravel containing places are not recommended for good culture. Clay soil is good.

Box - 2: To check water holding capacity of soil

To check your soil quality

☞ Take a handful of soil from the surface and squeeze it into a ball. Throw the ball of soil into the air and catch it. Bad soil with too much sand or gravel in it will not stick together and the ball will fall apart. If the ball sticks together well the soil may be good, but you cannot be sure

☞ Now second test is done to be sure that the soil is good. Dig a hole as deep as your waist. Early in the morning fill it with water. Fill it to the top. By evening some of the water will have sunk into the soil. Then fill the hole with water again. Fill it to the top. Cover the hole with boards or leafy branches. The next morning if most of the water is still in the hole, the soil will hold enough water to build a fish pond there.

6.3. Physio - Chemical properties

- Good nursery ponds should possess good physio chemical environment. Wide fluctuation of water level causes mortality. Proper temperature ranging from 25 to 30 degree is essential for fry productions.
- High turbidity either due to suspended slit or due to profuse growth of phytoplankton is also harmful in nursery tanks. Following are the basic conditions needed for nursery management.
- Normally nursery with alkaline water and fair level of phosphate and nitrate can yield satisfactory growth and survival of fry.

Table - 6: Showing Parameter of Water Quality

Parameters	Preferable range
Colour of water	Turbid brown, Dark green, Red
Turbidity	40-60
pH	6.5-9
Dissolved O2	>5-10 ppm
Free CO2	Nil-<12 ppm
Total alkalinity	50 - 280 m

6.4. Pre-stocking management

a. <u>Preparation of strong pond dykes</u>

i. Pond slope should be in 2:1 ratio or 3:1.

ii. Dyke should be elevated from the surrounding level for preventing entry of outside water and fishes during rainy season

iii. Mud from pond bottom should not be used to construct elevation as it may wash down during heavy shower.

b. <u>Eradication of aquatic plants and weeds</u>

i. Eradication can be done by physical method
ii. By chemical method-glyphosphate 3kg/ha
iii. By biological method- grass carp

c. <u>Removal of predatory fishes</u>

i. By physical method- drying, repeated netting
ii. By using plant derivatives method - **moc (saponin)** - 2500kg/ha
iii. By using chemicals method - **bleaching powder** - 350kg/ha

d. <u>Drying and ploughing the bottom soil</u>

i. Drying by dewatering or partial removal by pump
ii. Bottom raking done
iii. Shells, stone, bricks, plastic etc. must removed
iv. Either moc - 2500kg / ha or bleaching powder - 350 kg ha or mixture of urea-100kg/ha+ bleaching powder - 175 kg / ha used

e. <u>Soil correction(pH)</u>

i. By adding lime, depending upon soil type

f. <u>Raising water level</u>

i. Water filled up to 1m to 1.5 meter
ii. If mahua + lime used- water kept for 2-3 weeks
iii. Bleaching powder- 1 week
iv. **Urea** + bleaching powder- 1 week

g. <u>Fertilization</u>

i. **GNOC**- method-dusted GNOC is spread over pond
ii. MOC-method- MOC mixed with water , kept overnight and spread over pond
iii. Cow dung and other organic fertilizer- cow dung stacked in all corner
iv. **SSP**- SSP diluted in water as much as possible and spread over pond
v. <u>Two types of fertilization</u>
    - Basal fertilization
        - Gnoc / moc-175kg/ha
        - Cow dung - 50 kg/ha
        - SSP - 12.5 kg/ha

- Intermittent fertilization
    - Gnoc / moc - 350 kg / ha
    - Cow dung - 100 kg / ha
    - SSP - 25 kg / ha

h. <u>Eradication of aquatic insects</u>

i. Preparation of soap oil emulsion(veg. oil -56l/ha and soap- 18 kg/ha)
ii. Application 1- 2 days before stocking

6.5. Stocking Management

- Stocking – stock hatchlings @ 50 lakh/ ha
- Duration of stocking (timing)- Stocking down early morning or in evening
- Transportation and Handling of seed- polythene bag, container are used for packing and transportations, proper road and less jerk should be maintained.
- Release of seed

Box - 3: Plankton testing

Check the plankton availability before release

☞ 1-2 ml zooplankton requires in about 50 ml of water. The qualitative and quantitative nature of the standing crop of plankton following fertilization of nurseries is to be ascertained at short intervals by filtering 45 litres of pond water through a plankton collection net made of No.21 bolting silk.

☞ A rich production and dominance of phyto-planktonic organisms in the nursery at the time of stocking suggests its immediate unsuitability for stocking and a sediment volume of about 1.0 ml. Of **zoo-plankers**, consisting of **rotifers, copepod nauplii** and **cladocera** is to regarded as a good food reserve for the hatchlings

☞ Take pond water in a transparent glass and observe

☞ If found actively moving small organism, it is sure pond is ready for stocking

☞ Fish seed poly bags are kept in water for 15 minutes, splash water, slowly released spawn

6.6. Post stocking management

- Monitoring **-Proper monitoring of pond should be done.**
- Supplementary feeding practices-
- Proper feeding practices should be adopted**.** Two times in a day in the morning and late afternoon when the water temp. is cool and the dissolved oxygen is high. For better survival

and growth feeding frequency should be increased more than two times. Feed are broadcasted on the pond surface along the pond periphery in powered form. Supplementary Feeding as

i. Ground Nut Oil Cake + Rice bran = 1:1
ii. Mahua Oil Cake + Rice bran = 1:1

- Repeated netting and harvestings techniques-Repeated trail netting should be done to check mortality and growth. After attaining a size 1- 1.5 inches after 21 days fry are harvested. Fry net is used and repeated netting is done.

6.7. Transportation and Packing of Fish Seed

Transportation in local area can be done by using large container. For distance area oxygen packing can be done.

Table - 7: Economics of Nursery Ponds

Sl.No.	Items	Amount (in Rupees)
I.	**Expenditure**	
A.	**Variable Cost**	
1.	Pond lease value	5,000
2.	Bleaching powder (10 ppm chloride)/other toxicants	2,500
3.	Manures and fertilizers	8,000
4.	Spawn (5 million @ Rs. 5,000/million)	25,000
5.	Supplementary feed (750 kg @ Rs. 10/kg)	7,500
6.	Labours for management and harvesting (100 man-days @ Rs. 50/man-day)	5,000
7.	Miscellaneous expenditure	5,000
	Sub-total	**58,000**
B.	**Total Cost**	
1.	Variable cost	58,000
2.	Interest on variable cost (@ 15% yearly for one month)	0.725
	Grand Total	**58,725**
II.	Gross Income	
	From sale of fry (15 lakhs fry @ Rs 7,000/ lakh fry)	1,05,000
III.	Net Income (Gross Return - Total Cost)	46,275

CHAPTER - 7
Rearing Pond Management

7.1. Introduction to Rearing Pond Management

- **What is rearing ponds?** Ponds of comparatively bigger in size than that of nurseries and preferably up to 0.2 ha area is used for rearing pond, i.e., for rearing fry to fingerlings. Rearing process is followed for 3 months upto fingerlings stage (8-12 cm)

- **Why it is necessary to builds rearing ponds?**

  - To make better use of land and water.
  - To generate a regular source of income (self-employment) and therefore profit.
  - To ensure food security and nutrients.
  - For better livelihood
  - Proper time, hard work and skills, knowledge, trainings, practices and monitoring is needed to raise fry.

- **Where to build the rearing ponds?** Good water supply, soil quality and some basic precautions is necessary to build the ponds.

  - **Water supply:** The most common sources of water used for aquaculture are surface waters (streams, springs, lakes) and groundwater (wells, aquifers). Wells and springs are generally preferred for their consistently high quality water. The quantity and quality of water should be adequate to support production. A good water source will be relatively free of silt, aquatic insects, potential predators, and toxic substances, and it will have high concentration of dissolved oxygen.

  - **Soil quality:** Land should be comprised of good quality soil, with little or no gravel or rocks either on the surface or mixed in. Farmers should consider importing clay soil for compacting in the fish bottom, sides and core trench to minimize seepage. Soil that will be used to build the dykes must contain at least 20% clay so the finished pond will hold water throughout the growing period. Some soil with higher clay content—preferably between 30 and 40%—should be available nearby. It will be used to pack the core trenches in the dykes. To check soil quality type refer *BOX NO 2*.

- **Recommendation to be followed:**
  - Choose a good place with gentle slope so that too much digging is not required.
  - Drainage is also easier at slope side
  - Too low land place have risk of flooding. Avoid such place
  - Do not build pond on land which have good agricultural productions.

- Build pond close to home for care and maintenance
- Choose tree/ plants free area so that proper wind flows and water is oxygenated.
- Place should be facilitated with good water channel such as streams, river, check dams.
- Muddy water allows is not recommended in your pond.
- Water holding capacity of quality Soil is must. Sand and gravel containing places are not recommended for good culture. Clay soil is good.

7.2. Pre-stocking Rearing Pond Management

- Preparation of strong pond **dykes**
  - Pond slope should be in 2:1 ratio or 3:1.(30- 50 cm above water level)
  - Dyke should be elevated from the surrounding level for preventing entry of outside water and fishes during rainy season
  - Mud from pond bottom should not be used to construct elevation as it may wash down during heavy shower.

- Eradication of aquatic plants and weeds
  - Eradication can be done by physical method
  - By chemical method-glyphosphate 3kg/ha
  - By biological method- grass carp

Table - 8: Commonly occurring aquatic plants and weeds

Groups	Scientific name	Common name
Floating	*Eichhornia crassipes*	Water hyacinth
	Pistia stratiotes	Water lettuce
	Salvinia cucullata	Water fern
	Spirodela polyrrhiza	Duck weed
	Lemna minor	Duck weed
Emergent	*Nymphea Mexicana*	Banana water lily
	Nymphea tuberosa	Fragrant water lily
	Nelumbo spp.	Lotus
	Nymphoides spp.	Floating heart
Submerged	*Hydrilla verticillata*	Hydrilla
	Najas marina/minor	Najas
	Potamogeton crispus	Curly leaf pondweed
	Vallisneria spiralis	Eel grass
	Ottelia spp.	
Marginal	*Ipomea aquatic*	Ipomea
	Jussiaea spp.	Water primrose
	Typha angustata	Cat-tails
	Cyperus spp.	Cyperus
Algal blooms	*Microcystis aeruginosa*	Microcystis
	Anabaena	Blue green algae
Algal mats	*Pithophora*	Horse hair clump
	Spirogyra	Filamentous algae

- Removal of predatory fishes
  - By physical method- drying, repeated netting
  - By using plant derivatives method- moc(saponin)-2500kg/ha
  - By using chemicals method- bleaching powder-350kg/ha

Table - 9: Common predatory and weed fishes of undrainable ponds

Predatory fish	Weed fish
Channa spp.	*Puntius spp.*
Clarias batrachus	*Oxygaster spp.*
Heteropneustes fossilis	*Gudusia chapra*
Pangasius pangasius	*Amblypharyngodon mola*
Mystus spp.	*Laubuca spp.*
Ompok spp.	*Esomus danricus*
Wallago attu	*Osteobrama cotio*
Glossogobius giuris	
Mastocembelus spp.	

- Drying and ploughing the bottom soil
  - Drying by dewatering or partial removal by pump
  - Bottom raking done
  - Shells, stone, bricks, plastic etc must removed
  - Either moc-2500kg/ha or bleaching powder-350kgha or mixture of urea-100kg/ha+ bleaching powder -175 kg/ha used

- Soil correction(pH)
  - By adding lime, depending upon soil type

- Raising water level.
  - Water filled upto 1m to 1.5 meter
  - If mahua + lime used- water kept for 2-3 weeks
  - Bleaching poweder- 1 week
  - Urea+bleaching powder- 1 week

- Fertilization
  - To increase availability of plankton- basal fertilization
  - Cowdung-4 tonn/ha
  - SSP-30-40kg/ha

- Intermittent fertilization
  - Cow dung - 500 kg/ha
  - SSP - 15 kg/ha
  - Urea-10 kg/ha

- Eradication of aquatic insects
    - Preparation of soap oil emulsion(veg. oil -56l/ha and soap- 18 kg/ha)
    - Application 1- 2 days before stocking

7.3. Stocking Management

Table - 10: Showing the Recommendation depending upon the pond conditions

Pond conditions	Recommendations
If pond is eutrophicated (nutrient rich) and weed infested	Stock more grass carp
If pond is more deeper	Stock more column feeder fish like rohu and grass carp
If pond is under manageable	Stock more fast growing demanded species like catla
If the region is colder	Stock more exotic carps
If the region is warmer	Stock all carp species in a proportion
If the area is turbid and water availability is less	Stock more common carp

- Stocking guideline
- Stocking – stock fry @ 2-3 lakh/ ha
- Stocking ratio:
    - For IMC - Catla: Rohu : Mirgal – 1:1:1 or 1:2:2
    - For IMC + EXOTIC - stocking ratio – C : R : M : S : G : CC :: 1 : 1 : 1 : 1 : 1 : 1

- Duration of stocking(timing)- Stocking down early morning or in evening
- Transportation and Handling of seed- polythene bag, container are used for packing and transportations, proper road and less jerk should be maintained.
- Release of seed- To check the plankton availability refer *BOX NO 3*

7.4. Post stocking management practices and monitoring

7.4.1. Supplementary Feeding Practices

- Abundance of natural fish food organism is essential.
- In case of grass carp stock- weeds like wolfia, lemna should be provided.
- GNOC/MOC and Rice bran/wheat bran in 1:1 is used.
- Feeding time-50% morning and 50 % evening
- Feeding method- broadcasting

Table - 11: Feed for grass carp during fry stages of life cycle

Stage	Feed
Fry (1.7 – 3.9 cm)	Soft **macrophytes** such as Azolla, Wolffia, Lemna and Spirodella, etc.

7.4.2. Repeated Netting and Harvesting Techniques

7.4.3. Transportation and Packing of Fish fingerlings

Box - 4: CIFRI Experiment

- The experiments conducted (during 1965-1967) at Pond Culture Division of CIFRI on rearing of carp fry to fingerling stage in various combinations of IMC and exotic carps, showed average survival of 76.6% (range 53.5 to 97.4%).
- The species combination consists of catla, rohu, mrigal and common carp; silver carp and grass carp; silver carp, grass carp and common carp.
- While the rate of stocking varied between 62,500 and 1,25,000 fry/ha, the number of fingerlings harvested ranges between 33,425 and 95,900/ha. The production values were in the range of 1,505-3,486 kg/ha (av. 2,204 kg/ha) per 3 months.
- The CIFRI later conducted 6-month rearing experiments during 1967-1971 and obtained survival rates of 62.1- 98.0% (av. 78.2%) and gross production values 755-2,462 kg (av. 1,712 kg/ha/6 months).
- In these experiments, fry of grass carp, silver carp and common carp were stocked at 0.1-0.25 million/ha in the ratio of 4:3:3.
- The survival of silver carp was 99%, while that of grass carp was 80-98%. Zooplankton is the most preferred food of catla fry.
- The fry of rohu and mrigal accept other feeds, with silk worm pupae resulting in better growth and survival than other feeds such as mustard/groundnut oil cake/rice bran/wheat bran/soybean/prawn waste.
- A recirculatory system was developed at CIFRI, Barrackpore for carp fry rearing wherein ponds arranged in series were supplied with water passed through a biological filter by means of a pump.
- Advanced fry of catla (35mm/2.2g) and rohu (45mm/2.9g) recorded high survival of 84.4 and 96.6% and a growth of 90mm (7.0g) and 117mm (14.7g), respectively, in 32 days.

Table - 12: Economics for rearing ponds in 1 ha

Sl. No.	Items	Amount (in Rupees)
I.	**Expenditure**	
A.	**Variable Cost**	
1.	Pond lease value	10,000
2.	Bleaching powder (10 ppm chloride)/other toxicants	5,000
3.	Manures and fertilizers	3,500
4.	Fry (3 lakhs fry @ Rs.7,000/lakh)	21,000
5.	Supplementary feed (5 tonnes @ Rs. 7,000 / tonne)	35,000
6.	Wages (100 man-days @ Rs. 50/man-day for management and harvesting)	5,000
7.	Miscellaneous expenditure	5,000
	Sub-total	**82,000**
B.	**Total Cost**	
1.	Variable cost	82,000
2.	Interest on recurring expenditure 15% per year for three months	3,000
	Grand Total	**85,000**
II.	**Gross Income**	
	From sale of 2.1 lakh fingerlings @ 500/1000 fingerlings	1,05,000
III.	**Net Income (Gross income - Total cost)**	**20,000**

CHAPTER - 8
Grow Out Pond

8.1. What is Grow Out Pond?

- The ponds where fingerlings/ advanced fingerlings of 80-120mm or weighing 10-40 gm is grown upto table size fish (> 500 gm) for 8- 9 months or in perennial ponds with the average depth of 1.5 to 2m is referred as grow out pond.
- Ideal size of pond could be 0.4 to 1 ha.

8.2. Why Grow Out Pond is essentials?

- To enhance more production
- Improving living standard
- Health improvement, protein availability, food security
- Better use of land and water
- Better use of aquatic environment
- Generates self-engagement and employment opportunity for others
- Contributes in economic development of country

8.3. Required conditions of grow out ponds

Two major concern with some recommendation as stated below

8.3.1. Water quality supply

- The most common sources of water used for aquaculture are surface waters (streams, springs, lakes) and groundwater (wells, aquifers).
- Wells and springs are generally preferred for their consistently high quality water.
- The quantity and quality of water should be adequate to support production.
- A good water source will be relatively free of silt, aquatic insects, potential predators, and toxic substances, and it will have high concentration of dissolved oxygen.

8.3.2. Soil quality availability

- Land should be comprised of good quality soil, with little or no gravel or rocks either on the surface or mixed in.
- Farmers should consider importing clay soil for compacting in the fish bottom, sides and core trench to minimize seepage.

- Soil that will be used to build the dykes must contain at least 20% clay so the finished pond will hold water throughout the growing period.
- Some soil with higher clay content — preferably between 30 and 40% — should be available nearby. It will be used to pack the core trenches in the dykes

8.3.3. Recommendations

- Choose a good place with gentle slope so that too much digging is not required.
- Drainage is also easier at slope side
- Too low land place have risk of flooding. Avoid such place
- Do not build pond on land which have good agricultural productions.
- Build pond close to home for care and maintenance
- Choose tree/ plants free area so that proper wind flows and water is oxygenated.
- Place should be facilitated with good water channel such as streams, river, check dams.
- Muddy water allows is not recommended in your pond.
- Water holding capacity of quality Soil is must. Sand and gravel containing places are not recommended for good culture. Clay soil is good.

8.4. Selection of suitable culture species

- The species need to be decided based upon the aquatic environment.
- Warmer region- Select IMC- catla, rohu, mrigal
- In colder region- select Exotic carp- silver, grass, common carp
- In weed infested area- select Exotic weed fish-grass carp
- In turbid water- select exotic fish- common carp

8.5. Required parameters for water quality management

8.5.1. Water Temperature

- Plays a vital role in the production of fish food and ultimately in the production of fish.
- Cold water is less productive -due to its low temperature--essential to supply more supplementary feed - cost of production high- turns beyond the reach of the people.
- In warm water - less efforts, natural fish food source- plants and animal origin - water is productive. Increased fish production- the cost of the product is reduced- fishes are available to the mass of the people.
- Temp above 20°C to 30°C is considered most suitable for fish culture.

8.5.2. Alkalinity of Water

- pH. 7-10 is most preferred in fish culture.
- pH. value below 6 is not at all preferred- acidic nature -water remains unproductive.

- pH. value 6 or so is manipulated to alkaline by the use of lime,
- pH. value 7.5- 8.5 considered as suitable water for fish culture.

8.5.2. Dissolved Oxygen

- In fish culture the water quality is defined by the quantity of oxygen dissolved in the water.
- The purity of water is defined with the higher dissolved oxygen.
- Ex-The rivers and stream's water are naturally aerated -contains higher oxygen.
- The water having below 4 mg./l dissolved oxygen
- Suitable range of D.O 5-10ppm

Box - 5: Rectification of Oxygen depletion

Oxygen depletion in water is rectified by following aeration method

☞ Manual- in this method, water surface is splashed by bamboo sticks. This helps in dissolving the oxygen in water

☞ Mechanical- a diesel water pump is operated. Water is pumped out and spread into the water body results in dissolution of atmospheric oxygen.

☞ **Aerators**- this are floating device. This mechanical **rotating blades** churn the water and helps in dissolving the oxygen.

8.5.3. Ammonia

In general, ammonia is toxic to fish. More ammonia depends upon the more **pH** and temperature. On ionized ammonia- 0.02-0.05 mg/ l is a safe concentration for fish. Following methods can be used to reduce the concentration of ammonia

- Avoid over feeding.
- Avoid excess liming
- Formalin can be used to remove the ammonia from the fish pond.
- Water exchange can reduce the concentration of ammonia in pond.
- Aeration increases DO concentration and decreases Ph resulting in reduces in toxicity.

8.5.4. Turbidity

There are two types of turbidity present in the water.

- **Mineral turbidity:** 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.

Table - 13: Amount of total suspended solids (TSS) present in pond water

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

- **Plankton turbidity:** If it is 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

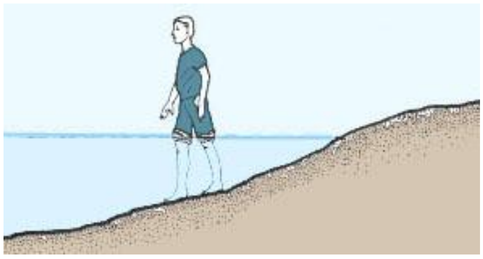
Box - 6: Measuring plankton turbidity

Measuring plankton turbidity with your arm

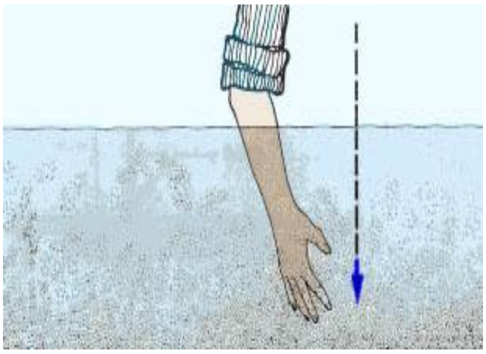
This is a very simple method which does not require any special equipment.

Proceed as follows,

☞ Slowly wade into the shallow part of your pond, trying not to disturb the pond bottom too much. ***Wade into the pond without disturbing the bottom***



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



Immerse your arm in the water until your hand disappears

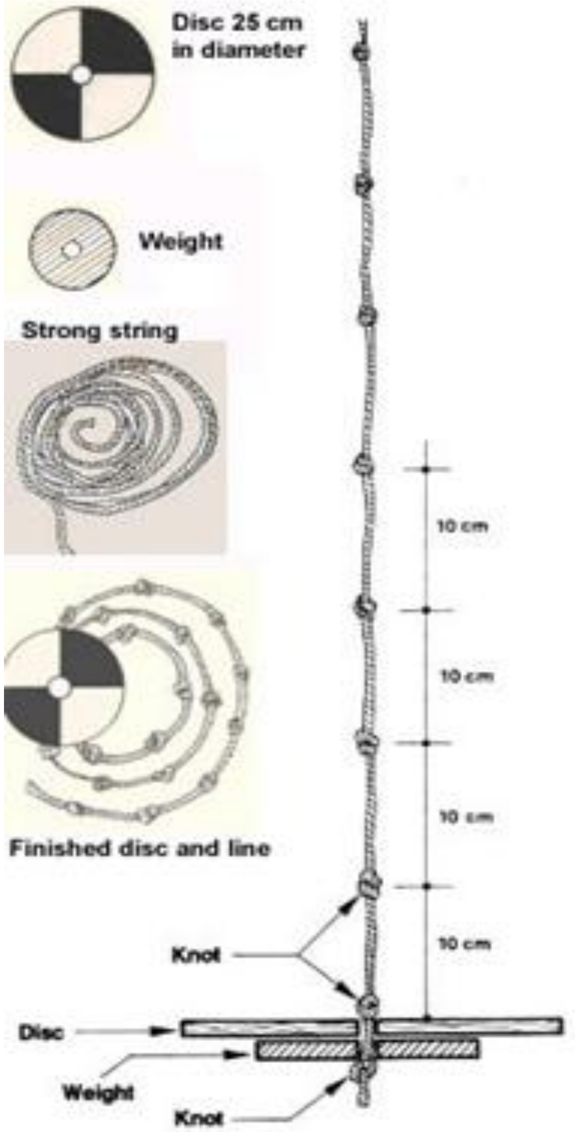
Note the water level along your arm:

☞ **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.

You can easily build a Secchi disc yourself. Proceed as follows.

Box - 7: Making Secchi disc - procedure

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 green-coloured ponds to estimate plankton turbidity. This measurement is then called the ***Secchi disc transparency***

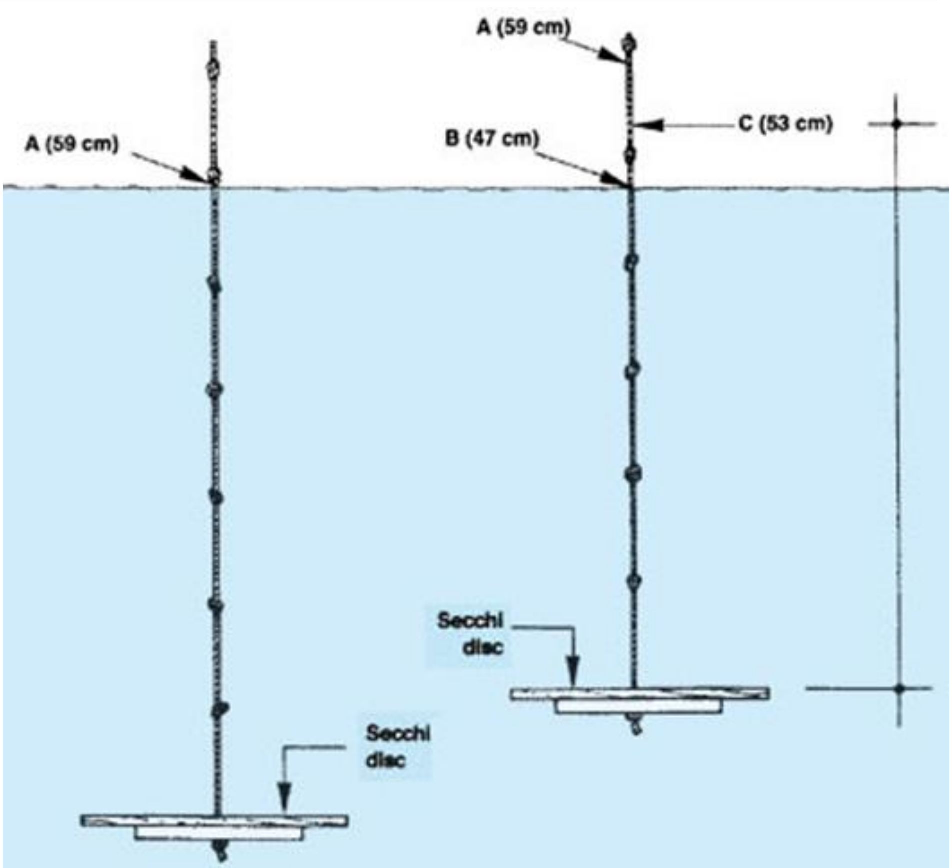
1. Cut ***a round disc about 25 cm in diameter*** from a piece of wood or metal, such as a pounded tin can for example.
2. On its surface, mark ***two lines*** to make four quarters. Paint these black and white using matt paint to prevent glare.
3. Drill a small hole at the centre of the disc. Through this hole ***pass a line*** or a piece of string about 1 to 1.5 m long.
4. Below the disc, attach to the line a small ***weight*** such as a long bolt or a stone.
5. ***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.
6. ***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

Box - 8: Measuring the Secchi disc transparency

Measuring the Secchi disc transparency

To measure the Secchi disc transparency, proceed as follows.



- Slowly lower the disc into the water.
- Stop when it just disappears from sight.
- Note at which point the line breaks the water surface. Mark this point A.
- 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.
- Mark point C, midway between points A and B.
- 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. This figure is the Secchi disc transparency.

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

Best practice of secchi disk

- 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.

Example If **the Secchi disc transparency** is:

- **less than 40 cm**, there is too much plankton and your fish are in danger during the night when oxygen is not produced by photosynthesis and when too much oxygen is consumed by the respiration of this plankton;
- **40 to 60 cm**, the fish production will be the best;
- **over 60 cm**, there is too little plankton, and your fish do not have enough natural food to eat.

Table - 14: Other factors to be considered for water quality parameters are as in table given below

Sl. No.	Parameters	Preferred range	Limiting level	Possible correction measures
1	Colour	Light green/ Greenish yellow	Dark brownish intense greenish	• add water or exchange water • remove plankton
			Colourless	• add fertilizer and lime
2	Transparency (cm)	20-40	<15	• harvest plankton, • add or exchange water
			>120	• apply lime and fertilizer
3	pH	7.5-8.5	< 6.5	• apply lime
			> 9	• apply gypsum or water exchange
4	Dissolved oxygen (ppm)	5-10	< 3	• Exchange or add water • Reduce fish density
5	Free carbon dioxide (ppm)	<3	> 20	• Exchange or add water • Do **raking**
6	Temperature (degree)	25-30	15 or > 40	• Reduce stress factor • Minimum feed • Fish harvest
7	Total hardness (ppm) (mg $CaCo_3$/l)	30-180	< 20	• apply lime
			> 500	• exchange or add water

8.6. Pre-stocking management

The practices and steps are similar to that of rearing ponds. Major concern in grow-out ponds are as follows.

8.6.1. Process of Eradication of Aquatic Plants and Weeds

Weed infested ponds can be control in biological ways by stocking grass carp as its feeding habit is on aquatic plants and weeds.

Table - 15: Feed for Grass Carp during different stages of life cycle

Stage	Feed
Fingerlings (4.0 – 15.0 cm)	*Hydrilla, Ceratophyllum, Vallisneria, Najas, Chara,* etc., in addition to those mentioned above.
Juveniles / Adults (above 15.0 cm)	In addition to above, green animal fodder such as barseem, napier, hybrid napier, elephant grass, tender leaves of vegetables and trees such as soobabul, drumstick, etc.

8.6.2. Removal of predatory fishes

- **Fish toxicants:** Although a number of chemicals and plant derivatives are available in the market which are poisonous for fish, only a limited number of such toxicants are safe and suitable for fish culture purposes. Based upon the following criteria a suitable fish poison is selected.
  - Poisoned fish should be safe for human consumption
  - Least adverse effect on the pond biota
  - Toxicity period should be of short duration
  - Should not have residual effect
  - Easy commercial availability
  - Simplicity of application
  - Cost considerations.

  - ❑ **Application of toxicants in ponds**: Mohua oil cake, bleachng powder and ammonia are considered suitable.

- **Mohua oilcake:**
  - Of all the fish poisons of plant origin, the most extensively used fish toxicant in undrainable ponds is oil cake of Mohua (Basia latifolia).
  - It kills all the fish species within a few hours when applied at the rate of 250 ppm (CIFRI, 1968). It contains about 4–6% of active ingredient, the saponia, which on dissolving in water haemolyses the red blood cells and thus kills the fish (Bhatia, 1970).
  - The required quantity of mohua oilcake should be soaked in water and uniformly broadcast over the entire pond surface.
  - Following this operation, repeated netting should be done to ensure proper mixing of the poison and removing the affected fishes which are suitable for human consumption.
  - The toxicity of doses up to 250 ppm lasts for about 96 hours (Jhingran and Pullin, 1985) and subsequently it serves as organic manure in the pond. It should be applied at least two weeks before stocking the ponds.

- **Bleaching powder**
  - Bleaching powder or Calcium hypochlorite (CaOCl2) is another practical and safe fish toxicant. It kills all the predatory and weed fish of the pond when applied at the rate of 25–30 ppm (Tripathy et al., 1980).

- However, during storage, significant chlorine content is lost and hence it is always safer to use the commercially available bleaching powder at the rate of 35–50 ppm or 350–500 kg/ha/m of water.
- Fish kill occurs within 1–3 hours and the toxicity lasts for 3–5 days.
- Plankton and benthic fauna start developing from the 7th or 8th day after treatment.
- Chlorine content of the bleaching powder thoroughly disinfects the pond which is essential in undrainable ponds where disinfection by sun drying is not at all possible.
- Disinfection of the pond is one of the essential measures for maintaining proper health condition of the fish. Besides, it also satisfies the lime requirement of the pond soil.

The method of application is also relatively simple. The powder is mixed with water and uniformly spread over the entire water surface. Distressed and dead fish are removed by netting. Chlorine killed fish are safe for human consumption.

- **Ammonia**
  - Anhydrous ammonia when applied at the rate of 20–25 ppm kills the predatory and weed fishes. Besides, it also controls the aquatic weeds and later acts as nitrogenous fertilizer.
  - Toxicity of ammonia lasts for 4–6 weeks.

Table - 16: Details of doses for commonly used fish toxicants are summarized in the following table

Recommended doses of fish poison	
Poison	**Dose (kg/ha/m)**
Bleaching powder	350 – 500
Mohua oil cake	2 500
Anhydrous ammonia	20 – 30
Powdered seed of *Croton tiqlium*	30 – 50
Root powder of *Milletia pachycarpa*	40 – 50
Seed powder of *Milletia piecidia*	40 – 50
Seed powder of *Barrinqtonia acutanqula*	150
Seed meal of tamarind (*Tamarindus indica*)	1 750 –2 000
Tea seed cake (*Camellia sinensis*)*	750

8.6.3. Liming

- Lime is used to bring the pH to the desired level.
- Lime application has the following effects.
  - Increases the pH.
  - Acts as buffer and avoids fluctuations of pH.
  - It increases the resistance of soil to parasites.
  - Its toxic effect kills the parasites
  - It hastens organic decomposition.

- The normal doses of the lime desired ranges from 200 to 250 Kg/ha. However, the actual dose has to be calculated based on pH of the soil and water as follows

Table - 17: Recommendation of Lime based upon soil pH

Soil pH	Lime (kg/ha)
4.5 - 5.0	2,000
5.1 - 6.5	1,000
6.6 - 7.5	500
7.6 - 8.5	200
8.6 - 9.5	Nil

8.6.4. Fertilization

Table - 18: Fertilizer application varies in different medium

Fertilizer needed /ha	Low input	Medium input	High input
Raw cow dung (tonnes)	20	15	10
Urea (46% N) Kg	350	250	150
SSP (16%) Kg	500	300	200

In grow-out system the two types of culture followed.

1. One year culture (single stocking and final harvesting)
2. Multiple stocking and partial harvesting

Fertilization process is different in grow out system

1. Fertilization for **one year culture period**
    - SSP - 300 - 400 kg / ha
    - Urea - 200- 250 kg / ha
    - Cow dung - 10,000 to 12000 kg / ha

Dose of fertilization:

1. Basal fertilization
    - Cow dung - 2000 kg / ha
    - Lime based upon soil type

On 7th day after stocking, lime application 2/3rd of first month dose

On 8th day after stocking, bottom raking by bamboo racker. Chain. Rope tied brick

1. Intermittent fertilization - (on 15th day after stocking)
    - SSP - 16kg / ha
    - Urea - 20 kg / ha

From 2nd month onward, repeat fertilization as given below:

- 3rd day - cow dung - 660 - 750kg/ha
- 7th day-lime according to soil type
- 8th day netting and bottom raking
- 15th day urea-20kg/ha and SSP 16kg/ha
- 22nd day- SSP - 16kg/ha

For multiple stocking and partial harvesting

- Fertilization done fortnightly (after every 15 days)
- Basal fertilization-7 days before stocking- cowdung@2000kg/ha
- Intermittent fertilization
- On 3rd day

  Cow dung @ 500 kg / ha
  SSP @ 16 kg / ha
  Urea @10 kg / ha

on 10th day- liming done depend upon soil type
on 11th day- bottom raking
on 18th day- fertilizer used is repeated on 3rd day
onwards

8.7. Stocking

- The pond will be ready for stocking after 15 days of application of fertilizers.
- Stocking density : 5,000-10,000/ha fingerlings
- In seasonal pond stocking density : 2,000-3,000/ha fingerlings
- Stocking propotion:30-40% surface feeder (Catla and Silver carp), 30-35% mid water feeders (Rohu), 30-40% bottom feeder (Common carp and Mirgal)

8.7.1. Guidelines for stocking fish from bags

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

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

- Set the bags right next to the pond (keep bags in basket or box to support the bag) or just in the pond. You are going to add water to the bag, so it may be too heavy to move after that. If you have the equipment, check the water quality parameters of the pond before opening the bags and the water quality within the bags as well as during the course of acclimation, especially for temperature and oxygen.

- Open one bag at a time. Begin with the bag that is least inflated. If you have no tools for checking water quality, use your fingers to detect for any obvious temperature differences between the pond water and water in the bag.

- Add water from the pond into the bag. While doing this, you can allow the other un-opened bags to float on the pond. This will allow the other bags to adjust to the pond temperature. Cover these bags to shade and prevent excessive sunlight.

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

- Add small amounts of water from the pond into the bag over 10 to 20 minutes to allow the temperature and water quality (e.g., pH) of the transported water to slowly become similar to that of the pond water.

- The total amount of water added should be double or triple the amount already in the bag.

- Then lower the bag in the pond and tip it so that the fish can swim out on their own. Observe how they swim out.

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

8.7.2. Guidelines for stocking from transport tanks / containers

- Drive down as close as possible to the pond.

- Check the water quality in the pond and in the tank.

- With a bucket, remove about a third of the water in the tank. Then add pond water

- Scoop out a few fish at a time into a bucket with adequate water using a scoop net.

- Gently lower bucket in water and let fish swim out on their own.

NOTE: 1. Keep the aeration going in the tank right through the process until all the fish have been stocked.
2. It is important to stay around and observe how the fish swim out of the bag or container. Any fish that lie immediately on the pond bottom will likely die within a day or two. Fish that swim erratically or have any discoloration on their bodies or fins may die within 2 to 4 days. If the fish swim back into the container, it is probably due to the fact that the water current has reversed (fish swim against the current). Be around to ensure no birds take the fish during stocking or soon after.

8.8. Post Stocking

8.8.1. Supplementary Feeding

- Fishes can be feed with a mixture of rice-bran and groundnut/mustard oilcake in 1:1 ratio.
- 4-3% of body weight initial followed by 1-2%
- The feed requirement in the pond is calculated by the formula

  i.e. Feed requirement = Estimated fish biomass in pond x % feeding rate

  Where,

  Biomass = Average body weight of fish x total no of fish stocked x % survival (70-80%)

- The feed should be placed on a bamboo tray and lowered to the pond bottom or it can be sprayed at the corners.

Table - 19: Supplementary Feeding Dose

Month	% of body weight
1st and 2nd	4-3%
3rd and 4th	3-2%
5th and 6th	2%
After 6 month	1%

8.8.2. Repeated Netting and Harvesting

- The trail netting is done for proper oxygen dissolve and to check the growth of the fish size.
- Large sized nets are used for growth check and harvesting .after 9-10 months fish are ready for table size.
- Proper monitoring and care is needed from being theft which is one of the major problems in fisheries sector in most rural areas.
- Timely feeding, fertilizer is important to enhance better productions.

CHAPTER - 9
Fish Health Management

9.1. Types of Treatment

Dip- In the **dip treatment,** fish are kept in a relatively strong solution of the chemical for a very short time, usually less than one minute. Proceed as follows:

I. Prepare the chemical solution in a bucket, half-drum or trough;
II. Place the fish or a batch of fish in a dip net;
III. Dip the fish for the prescribed duration into the solution;
IV. Immediately after the treatment, replace the fish in well-aerated water.

Bath treatment: In the bath treatment, fish are kept in a weaker standing solution of the chemical for a longer period of time, which may last from a few minutes to one hour (short bath) in a medium concentration, and up to 24 to 48 h (long bath) in a very low concentration. Proceed as follows.

(a) For a short bath, mix with water in a plastic watering can the amount of chemical required for the water volume to be treated. Lower the water level in the trough or circular tank by one-third to one-half. Let the water flow in again while spreading the previously mixed chemical over the entire surface area. If necessary, mix the water with a clean broom, an agitator or an aerator to evenly disperse the chemical within the whole water mass. Stop the water inflow once the water reaches its normal level. Treat for the required duration. Then drain two-thirds of the water while starting the water flow again.

(b) For a long bath, stop the water flowing into the tank or pond. Drain some water and reduce water volume to the acceptable minimum for the stock density and water temperature conditions. Determine water volume and required amount of chemical. Dilute this chemical amount at least 100 times, for example in several plastic buckets before application. Add this diluted solution to the tank or pond, spreading it as much as possible over the entire surface area and mixing it well with the pond water. Treat for the required duration. Then open the water flow and raise the water level back to normal. It necessary, drain again and refill.

Feeding - Anticipated feed is used such like tetramycin composition.

9.2. Types of Diseases

9.2.1. Bacterial disease

- **Aeromoniasis / ulcer:**
  - Mainly found in freshwater fish,
  - When infected with *A. hydrophila*, fish develop ulcers, tail rot, fin rot, and hemorrhagic septicemia. (Hemorrhagic septicaemia causes lesions that lead to scale shedding, hemorrhages in the gills and anal area, ulcers, exophthalmia, and abdominal swelling.)
  - Using a 1% sodium hypochlorite solution or 2% calcium hypochlorite solution

- **Dropsy** is the buildup of fluid inside the body cavity or tissues of a fish.

- **Columnaris**
  - The disease is highly contagious and the outcome is often fatal
  - Also referred to as cottonmouth

- **Bacterial gill disease**
  - Caused by a number of different bacteria that infect the gills of fish.
  - This reduces the ability of the gills to supply oxygen to the blood and results in mortality if left unchecked.

- **Finrot diseases**
  - Rotting and decaying fins, black/brown fin edges, fray fins, inflamed base of fins, white dots on fins. Milky white areas appear in the fins or tail, particularly around the edges that results in fish laying on the bottom of the tank.
  - Generally affects fins parts, fins will be cut off from the body

- Treatment general is salty water.

- Feed the fish 25mg tetracycline by mixing with per kg food for 7 days.
  - Reduce the density of fish in the pond.
  - Apply lime in the pond at the rate of 100kg per acre.

- 20mg tetracycline can be used as injection to the fish for each kg body weight.

- Stop serving organic fertilizer for few days to stop this fish diseases.

9.2.2. Parasitic diseases

- **Icthyophthiriasis**
  - Commonly called as white spot disease
  - White spot disease is one of the devastating protozoa infections affecting freshwater fish.
  - Diseases mostly found in pangasius and golden fish

- **Trichodinisis**
  - Causative agent is *Trichodina reticulata; T. negre*
  - Invasion of parasites in skin & gill region
  - 2-3 per cent NaCl bath for 5-10 minutes or 4 ppm $KMnO_4$ batch for 5-10 minutes; treat affected ponds with 25 ppm formalin

- **Argulosis**
  - The common fish louse lives in marine, brackish, and fresh water environments
  - When it is dark the louse is more active, swimming about to encounter a host.
  - A short bath in a sodium chloride solution can reduce the parasite load on a fish, but this treatment must be done carefully, because too short a duration or too dilute a solution is ineffective, while too long or too concentrated a bath can harm the fish.

- **Gill and skin fluke**
  - Flukes are small worm-like parasites up to 2mm in length. Technically they are monogenean trematodes, which describes their biological classification (trematodes) and the fact they only need one host to complete their life cycle (monogenean) whereas many parasitic trematodes need two or more hosts and are thus digeneans!
  - Flukes can cause lesions and tissue damage as well as producing side effects such as hyperplasia of both skin and gill epithelium and creating entry sites for secondary infections.

9.2.3. Fungal disease

- Cotton wool disease
- Gill rot diseases

9.2.4. Non infectious diseases

- EUS (epizotic ulcerative syndrome)

Box - 9: Different body parts of fish

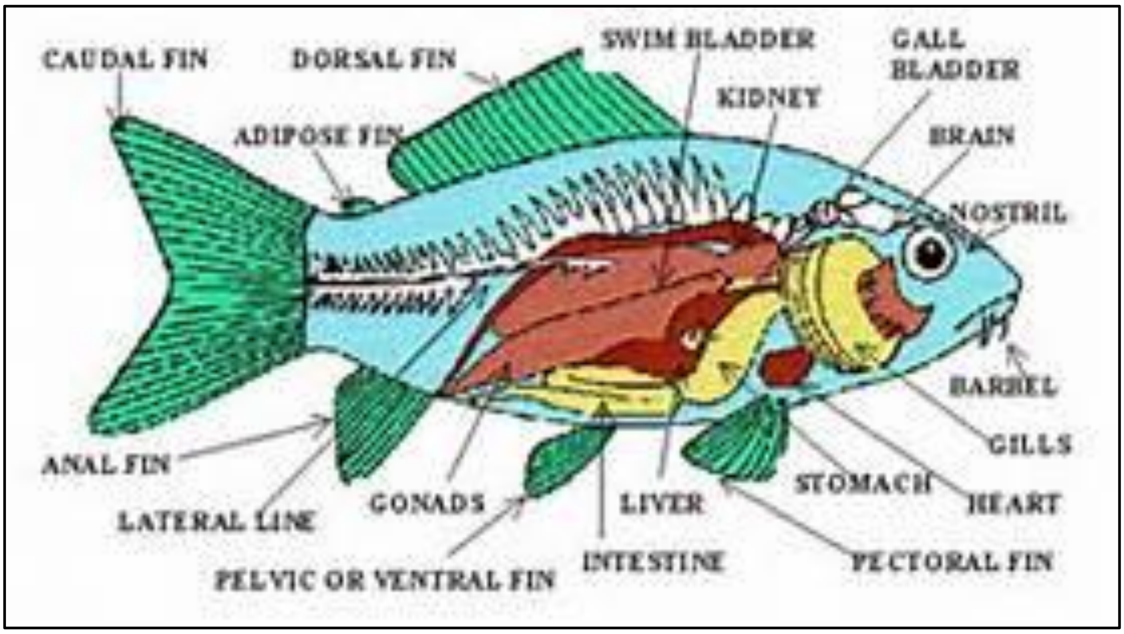


Table - 20: Common disease their symptoms and preventive measures

Type of disease	Bacterial Disease
Name of disease	Aeromoniasis / ulcer
Causative agent	Aeromonas hydrophila
Symptoms	• Site of infection- body surface or internal organs • Skin **lesion** with blood, **sluggishness**, • shallow open **sores**, **eroded fins** and mouth
Preventive measures	• **Terramycin** in feed @75 mg/kg fish for 7- 21 days • Sulfonamide in feed at 3g/kg fish feed for 12-20 days • Pond treatment-5 mg/l • **CIFAX**-1 l/ha-m of water depth

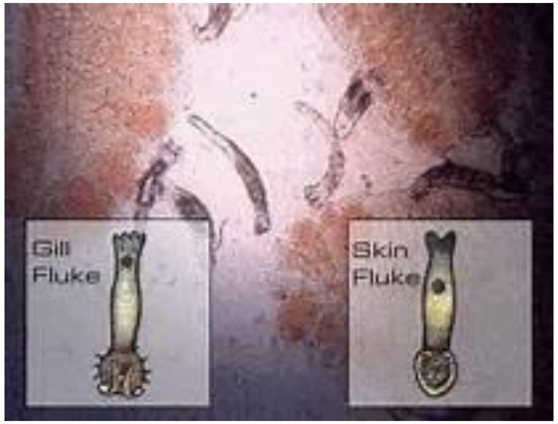
Type of disease	Bacterial Disease
Name of disease	Abdominal Dropsy
Causative agent	Aeromonas hydrophila
Symptoms	• Scale looses, • scale protrusion, • distend abdomen, • mild ulceration
Preventive measures	• **Potassium permanganate**-5mg/l in ponds

Type of disease	Bacterial Disease
Name of disease	Columnaris
Causative agent	Flavobacterium columnare
Symptoms	• Greyish patches over head and dorsal surface • Greyish white discoloration on outer margin of fins
Preventive measures	• Dip treatment500mg/l potassium permanganate

Type of disease	Bacterial Disease
Name of disease	Bacterial gill disease
Causative agent	Myxobacteria pathogens
Symptoms	• Fusion of gill filaments
Preventive measures	• Bath treatment with alkyl benzalkonium -2 mg/l conc for 1 hrs.

Type of disease	Bacterial disease
Name of disease	Finrot diseases
Causative agent	Bacterial gill disease
Symptoms	• Site of infection: body surface, fins and tails • Body reddening skin, • protruding scales, • sunken or protruding eyes, • fraying of the tails and fins, • disintegration of tails and fins tissues
Preventive measures	• Calcium hypochlorite 2 mg/l for 2 min

Type of disease	Parasitic diseases
Name of disease	Anchor worm infection
Causative agent	Lernaea sp.
Symptoms	
Preventive measures	• **Furazolidone** in fish feed @152-194mg fish • **Formalin -** 15ppm



Type of disease	Parasitic diseases
Name of disease	Gill and skin fluke
Causative agent	• dactylogyrus sp. (gill infecting) • gyrodactylus (skin infecting)
Symptoms	• appear **anemic**, • colors of gills fade • Fishes gasp for air, • gills covered with thick mucus layer,
Preventive measures	• Bath treatment in 0.25-0.50ppm Dipterex • Formalin - 100 ppm • Dip treatment 1% trichlorphon for 2-3 min.

Type of disease	Parasitic diseases
Name of disease	Icthyophthiriasis
Causative agent	Icthyophthirius multifilis
Symptoms	• Infection site gill and skin • Mucus secretion, parasite visible on skin, • gill and fins, • erratic swimming
Preventive measures	•

Type of disease	Parasitic diseases
Name of disease	Trichodiniasis
Causative agent	Trichodina sp
Symptoms	• Darkening of skin, • Excessive mucus production, • Gill turn pale in colour
Preventive measures	• Formalin-15-25 ppm conc. • Pot. Permanganate- 4mg/l in pond

Type of disease	Parasitic diseases
Name of disease	Argulosis
Causative agent	Argulus sp. (fish lice infection)
Symptoms	• Tiny red spot, • Erratic swimming behaviour, • Loss of appetite
Preventive measures	• Trichlorphon @ 0.2mg/l for 24 hrs

Type of disease	Fungal disease
Name of disease	Cotton wool disease
Causative agent	saprolegnia parasitica
Symptoms	• Skin and gills lesions, • Grey white patches on skin
Preventive measures	• Bath treatment in formalin@150-300ml/cubic meter water for 30-40 min • Ponds treated with formalin@20mg/l • Potassium permanganate@160mg/l

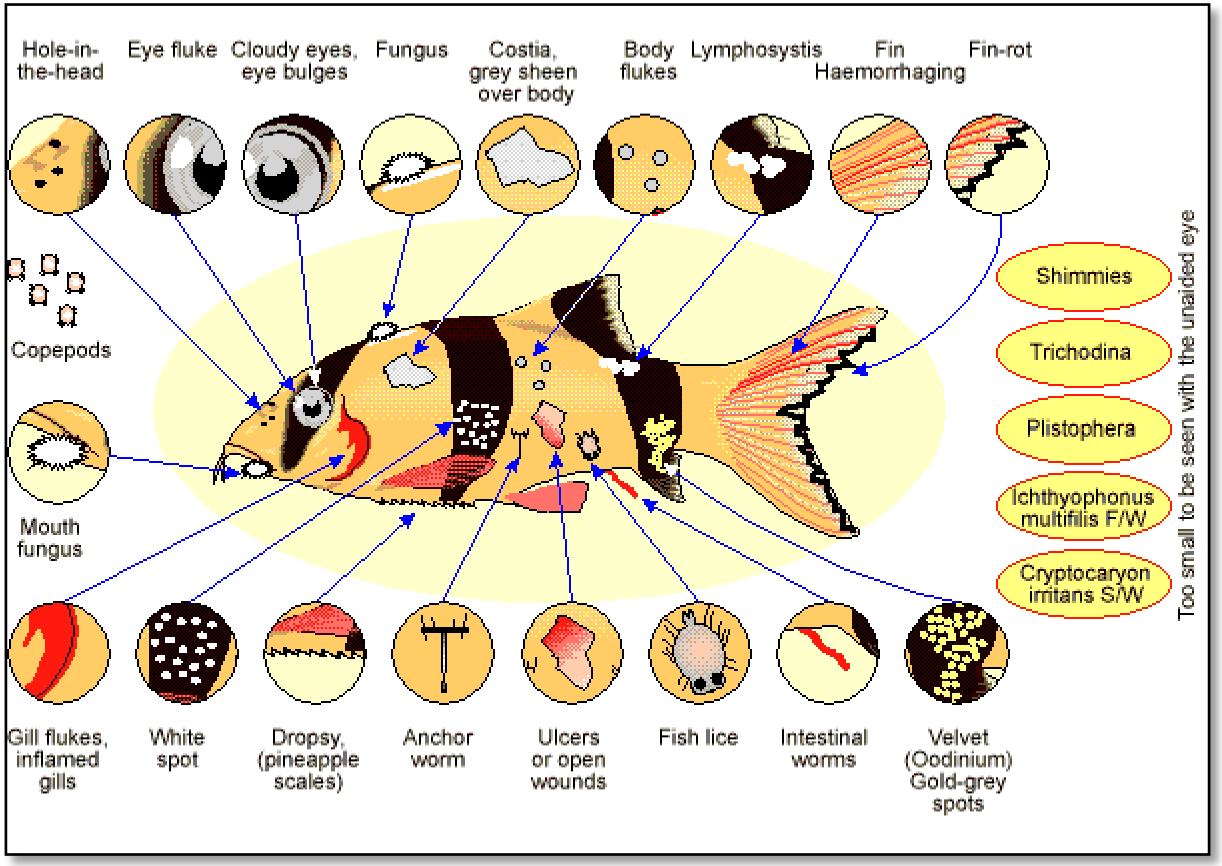
Type of disease	Fungal disease
Name of disease	Gill rot diseases
Causative agent	Banchiomyces sp
Symptoms	• Appearance of **white necrotic tip** of primary gill lamella, • fusion of gill lamella, • gills turns yellowish brown
Preventive measures	• Liming -50 kg / ha • Bath treatment- Sod. chloride @ 3 - 5% conc. Prevents infections

Type of disease	Non infectious diseases
Name of disease	EUS (epizotic ulcerative)
Causative agent	Aeromonas hydrophila
Symptoms	• **Haemorrhages** and ulcer
Preventive measures	• CIFAX-1l/ha m

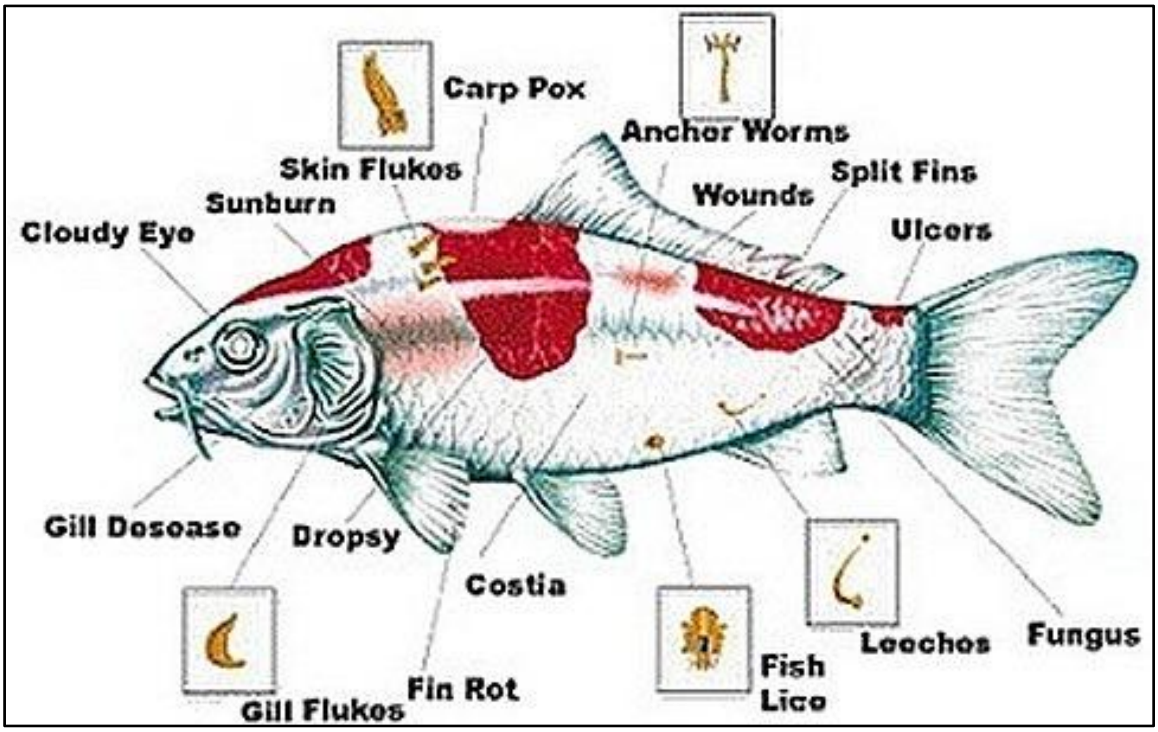
Type of disease	Non infectious diseases
Name of disease	Gas bubble disease
Causative agent	
Symptoms	• Site of infection- skin, eyes, scales gills • Tiny bubbles appear in above parts
Preventive measures	•

	Type of disease	Non infectious diseases
	Name of disease	Algal blooms problems
	Causative agent	
	Symptoms	• Site of infection- gills • Gasping for air
	Preventive measures	• Ammonium sulphate - 10 mg / 1 conc.

Box - 10: Disease affected in different parts of body



Box - 11: Disease affected in different parts of body



9.2.5. Environmental Factor

- **Sudden changes in pH**. pH will always fluctuate to some degree, but we want to have a pH that is as stable as possible. Ensuring that the **buffering capacity** (KH) will help keep a stable pH level. pH that is too high or too low can also cause stress, but stability is what is most important.

- **Sudden changes in water temperature**. Goldfish and koi are cold-blooded and can tolerate a wide range of temperatures, but a sudden change in that temperature can cause undue stress. Proper acclimation when adding new fish is critical. Small, shallow ponds are more apt to have the water temperature change quickly. Providing good surface coverage will help keep the temperature changes slow.

- **Insecurity**. Fish can be stressed if they are not comfortable in their surroundings. Clear water with little surface coverage will cause a fish to feel insecure. The fish are more susceptible to predator attack in clear water and the fish is aware of this risk. Providing surface coverage or an underwater hiding place can help. Extra stress will be caused if the fish have actually been visited by a potential predator.

- **Poor diet**. Fish need a regular balanced diet. This is not as complicated as it may sound. While some packaged foods may have advantages over other, as long as they are getting a regular feeding of a seasonally-appropriate food labeled for koi or goldfish they should be getting the nutrient they need.

- **Poor water quality**. Water quality is a broad term but is often referring mainly to the nitrogen compounds found in the water. Ammonia, Nitrite, and Nitrate are always going to be present to a degree in a pond with fish, but the levels need to be kept as low as possible. Good filtration is the key to breaking down ammonia and nitite. Nitrate is used up by plants or should be removed with regular, partial water-changes.

- **Water toxin**. There can be many, many possible toxins coming from many sources that can stress or directly kill fish. Chlorine and chloramines are common additives to tap water that if not removed can cause severe stress or death. Other common sources for toxins are lawn fertilizers or pesticides that may blow into the water or be washed in along with rain. If this type of toxin is suspected an immediate water change would be called for.

- **Lack of sufficient oxygen**. Fish rely on dissolved oxygen in the water for respiration. Common causes of a low dissolved oxygen level are too many fish, not enough aeration, or large algae kill.

- **Overcrowding**. Keeping too many fish leads to many of the other issues addressed here including poor oxygen levels and buildup of nitrogen compounds.

- **Physical stress**. Physical stress can be caused by an actual wound. A fish can be wounded by a predator or scrape against a sharp rock in the pond. Handling a fish also will cause stress. Avoid catching fish unnecessarily.

- **Infection**. Stress may lead to an infection from some sort of pathogen, but an infection will also increase the stress level thereby making the fish more susceptible to further infection and limiting their ability to fight it off.

9.3. Suppliers of Pathology Expertise

The following are examples of locations where expertise can be accessed:

- CIFA - Central Institute of Freshwater Aquaculture, India.
- CIFE - Central Institute of Fisheries Education, Mumbai, India.
- College of Fisheries, Mangalore, India

CHAPTER - 10
Integrated Fish Farming System

10.1. Benefits / Advantages of Integrated Fish Farming

- Efficient waste utilisation from different culture practice for fish production.
- It reduces the additional cost for supplementary feeding as well as fertilisation.
- It is an artificial balanced ecosystem where there is no waste.
- It provides more employment avenues.
- It reduces the input and increases output and economic efficiency.
- The integrated fish farming provides fish along with meat (chicken, duck, beef, pork etc.), milk, vegetables, fruits, eggs, grains, fodder, mushroom etc.
- This practice has potential to increase the production and socio-economic status of weaker section of our society.

10.2. Possibilities of /types of integration with the fish farming

10.2.1. Fish cum Duck farming

Duck raising in pond plays important role to maintain the pond ecosystem. Both fish and duck are benefited. Fish gets benefitted in different ways as essential nutrients are obtained from duck **droppings** (20-30gm/duck dropping distributed **homogenously** resulting into high yields). Water gets well aerated. It helps to increase natural food production or plankton productions. Finally kills the parasites and allows fingerlings to grow. No additional land is required for duckery activities. Its houses can be built near the embankment of ponds. It results in high production of fish, duck eggs and duck meat in unit time and water area. It ensures high profit through less investment.

(a) Know the benefits of duck cum fish farming

- Water surface of ponds can be put into full utilization by duck raising.
- Fish ponds provide an excellent environment to ducks which prevent them from infection of parasites.
- Ducks feed on predators and help the fingerlings to grow.
- Duck raising in fish ponds reduces the demand for protein to 2 – 3 % in duck feeds.
- Duck droppings go directly into water providing essential nutrients to increase the **biomass** of natural food organisms.
- The daily waste of duck feed (about 20 - 30 gm/duck) serves as fish feed in ponds or as manure, resulting in higher fish yield.

- **Manuring** is conducted by ducks and homogeneously distributed without any heaping of duck droppings.
- By virtue of the digging action of ducks in search of benthos, the nutritional elements of soil get diffused in water and promote plankton production.
- Ducks serve as bio aerators as they swim, play and chase in the pond. This disturbance to the surface of the pond facilitates aeration.
- The feed efficiency and body weight of ducks increase and the spilt feeds could be utilized by fish.
- Survival of ducks raised in fish ponds increases by 3.5 % due to the clean environment of fish ponds.
- Duck droppings and the left over feed of each duck can increase the output of fish to 37.5 Kg/ha.
- Ducks keep aquatic plants in check.
- No additional land is required for duckery activities.
- It results in high production of fish, duck eggs and duck meat in unit time and water area.
- It ensures high profit through less investment.

(b) Stocking density of fish

- The pond is stocked after the pond water gets properly detoxified.
- The stocking rates vary from 6000 fingerlings/ha and a species ratio of 40 % surface feeders, 20 % of column feeders, 30 % bottom feeders and 10-20 % weedy feeders are preferred for high fish yields.
- Mixed culture of only Indian major carps can be taken up with a species ratio of 40 % surface, 30 % column and 30 % bottom feeders.
- In the northern and north - western states of India, the ponds should be stocked in the month of March and harvested in the month of October - November, due to severe winter, which affect the growth of fishes.
- In the south, coastal and north - eastern states of India, where the winter season is mild, the ponds should be stocked in June - September months and harvested after rearing the fish for 12 months.

(c) Know about Use of duck dropping as manure:

- The ducks are given a free range over the pond surface from 9 to 5 PM, when they distribute their droppings in the whole pond, automatically manuring the pond.
- The droppings voided at night are collected from the duck house and applied to the pond every morning.
- Each duck voids between 125 - 150 gm of dropping per day.
- The stocking density of 200-300 ducks/ha gives 10,000 - 15,000 kg of droppings and is recycled in one hectare ponds every year.
- The droppings contain 81% moisture, 0.91% nitrogen and 0.38% phosphate on dry matter basis.

(d) How to Raise ducks in different water body structure

i. Large group of ducks in open water

- This is the grazing type of duck raising.
- The average number of a group of ducks in the grazing method is about 1000 ducks.
- The ducks are allowed to graze in large bodies of water like lakes and reservoirs during the day time, but are kept in pens at night.
- This method is advantageous in large water bodies for promoting fish production.

ii. Raising ducks in centralized enclosures near the fish pond

- A centralized duck shed is constructed in the vicinity of fish ponds with a cemented area of dry and wet runs out side.
- The average stocking density of duck is about 4 - 6 ducks/sq.m. area.
- The dry and wet runs are cleaned once a day. After cleaning the duck shed, the waste water is allowed to enter in to the pond.

iii. Raising ducks in fish pond

- This is the common method of practice.
- The embankments of the ponds are partly fenced with net to form a wet run.
- The fenced net is installed 40-50 cm above and below the water surface, so as to enable the fish to enter into the wet run while ducks cannot escape under the net.

(e) Knows about Selection of ducks and stocking

- The kind of duck to be raised must be chosen with care since all the domesticated races are not productive.
- The important breeds of Indian ducks are Sylhet Mete and Nageswari.
- The improved breed, Indian runner, being hardy has been found to be most suitable for this purpose, although they are not as good layers as exotic Khaki Campbell.
- The number of ducks required for proper manuring of one hectare fish pond is also a matter of consideration.
- It has been found that 200 – 300 ducks are sufficient to produce manure adequate enough to fertilize a hectare of water area under fish culture.
- 2 - 4 months old ducklings are kept on the pond after providing them necessary prophylactic medicines as a safeguard against epidemics

(f) Feeding

- Ducks in the open water are able to find natural food from the pond but that is not sufficient for their proper growth.
- A mixture of any standard balanced poultry feed and rice bran in the ratio of 1:2 by weight can be fed to the ducks as supplementary feed at the rate of 100 gm/ bird/day.

- The feed is given twice in a day, first in the morning and second in the evening.
- The feed is given either on the pond embankment or in the duck house and the spilled feed is then drained into the pond.
- Water must be provided in the containers deep enough for the ducks to submerge their bills, along with feed.
- The ducks are not able to eat without water. Ducks are quite susceptible to afflatoxin contamination, therefore, mouldy feeds kept for a long time should be avoided.
- The ground nut oil cake and maize are more susceptible to *Aspergilus flavus* which causes aflotoxin contamination and may be eliminated from the feed.

(g) Egg laying

- The ducks start laying the eggs after attaining the age of 24 weeks and continue to lay eggs for two years.
- The ducks lay eggs only at night. It is always better to keep some straw or hay in the corners of the duck house for egg laying.
- The eggs are collected every morning after the ducks are let out of the duck house.

(f) Health care

- Ducks are subjected to relatively few diseases when compared to poultry.
- The local variety of ducks is more resistant to diseases than other varieties.
- Proper sanitation and health care are as important for ducks as for poultry.
- The transmissible diseases of ducks are duck virus, hepatitis, duck cholera, keel disease, etc.
- Ducks should be vaccinated for diseases like duck plague. Sick birds can be isolated by listening to the sounds of the birds and by observing any reduction in the daily feed consumption, watery discharges from the eyes and nostrils, sneezing and coughing.
- The sick birds should be immediately isolated, not allowed to go to the pond and treated with medicines.

(g) Harvesting

- Keeping in view the demand of the fish in the local market, partial harvesting of the table size fish is done.
- After harvesting partially, the pond should be restocked with the same species and the same number of fingerlings.
- Final harvesting is done after 12 months of rearing.
- Fish yield ranging from 3500 - 4000 Kg/ha/yr and 2000 - 3000 Kg/ha/yr are generally obtained with 6 - species and 3 - species stocking respectively.
- The eggs are collected every morning. After two years, ducks can be sold out for flesh in the market. About 18,000 - 18,500 eggs and 500 - 600 Kg duck meat are obtained.

10.2.2. Integrated Fish cum Poultry Farming

- Much attention is being given for the development of poultry farming in India and with improved scientific management practices; poultry has now become a popular rural enterprise in different states of the country.
- Apart from eggs and chicken, poultry also yields manure, which has high fertilizer value.
- The production of poultry dropping in India is estimated to be about 1,300 thousand tons, which is about 390 metric tones of protein.
- Utilization of this huge resource as manure in aquaculture will definitely afford better conversion than agriculture.
- Poultry farming in India and with improved scientific management practices has now become a popular rural enterprise in different states of the country. Apart from eggs and chicken, poultry also yields manure, which has high fertilizer value.In this system, the fish crop is integrated using only poultry droppings or dip litter by rearing the poultry either directly over the pond or on the pond embankment. By adopting this technology, production of 3500 to 4000 kg fish, more than 20000 eggs and about 1250 kg (live weight) chicken meat can be obtained from a hectare of pond area in one year.

(a) Stocking Density of Fish

- The application of poultry manuring in the pond provides a nutrient base for dense bloom of phytoplankton, particularly nano plankton which helps in intense zooplankton development.
- The zooplankton has an additional food source in the form of bacteria which thrive on the organic fraction of the added poultry dung. Thus, indicates the need for stocking **phytoplanktophagous** and **zoo planktophagous** fishes in the pond.
- In addition to phytoplankton and zooplankton, there is a high production of detritus at the pond bottom, which provides the substrate for colonization of micro-organisms and other **benthic fauna** especially the **chironomid larvae.**
- Another addition will be macro-vegetation feeder grass carp, which, in the absence of macrophytes, can be fed on green cattle fodder grown on the pond embankments.
- The semi digested excreta of this fish forms the food of bottom feeders.
- For exploitation of the above food resources, polyculture of three Indian major carps and three exotic carps is taken up in fish cum poultry ponds.
- The pond is stocked after the pond water gets properly detoxified.
- The stocking rates vary from 8000 - 8500 fingerlings/ha and a species ratio of 40 % surface feeders, 20 % of column feeders, 30 % bottom feeders and 10-20 % weedy feeders are preferred for high fish yields.
- Mixed culture of only Indian major carps can be taken up with a species ratio of 40 % surface, 30 % column and 30 % bottom feeders.
- In the northern and north - western states of India, the ponds should be stocked in the month of March and harvested in the month of October - November, due to severe winter, which affect the growth of fishes.

- In the south, coastal and north - eastern states of India, where the winter season is mild, the ponds should be stocked in June - September months and harvested after rearing the fish for 12 months.

(b) Use of poultry litter as manure

- The fully built up deep litter removed from the poultry farm is added to fish pond as manure.

Two methods are adopted in recycling the poultry manure for fish farming.

1. **The poultry droppings from the poultry farms is collected, stored it in suitable places and is applied in the ponds at regular installments.**

   - Applied to the pond at the rate of 50 Kg/ha/ day every morning after sunrise.
   - The application of litter is differed on the days when algal bloom appears in the pond. This method of manurial application is controlled.

2. **Constructing the poultry housing structure partially covering the fish tank and directly recycling the dropping for fish culture.**

   - Direct recycling and excess manure however, cause decomposition and depletion of oxygen leading to fish mortality. It has been estimated that one ton of deep litter fertilizer is produced by 30-40 birds in a year.
   - As such 500 birds with 450 kg as total live weight may produce wet manure of about 25 Kg/day, which is adequate for a hectare of water area under polyculture.
   - The fully built up deep litter contain 3% nitrogen, 2% phosphate and 2% potash. The built up deep litter is also available in large poultry farms.
   - The farmers who do not have the facilities for keeping poultry birds can purchase poultry litter and apply it in their farms.
   - Aquatic weeds are provided for the grass carp.
   - Periodical netting is done to check the growth of fish. If the algal blooms are found, those should be controlled in the ponds.
   - Fish health should be checked and treat the diseased fishes.

(c) Poultry Husbandry Practices

- The egg and chicken production in poultry rising depends upon multifarious factors such as breed, variety and strain of birds, good housing arrangement, blanched feeding, proper health care

C1. Housing of birds

- In integrated fish-cum-poultry farming the birds are kept under intensive system. The birds are confined to the house entirely.
- The intensive system is further of two types - cage and deep litter system.
- The deep litter system is preferred over the cage system due to higher manurial values of the built up deep litter.
- In deep litter system 250 birds are kept and the floor is covered with litter. Dry organic material like chopped straw, dry leaves, hay, groundnut shells, broken maize stalk, saw dust, etc. is used to cover the floor up to a depth of about 6 inches.
- The birds are then kept over this litter and a space of about 0.3 - 0.4 square meters per bird is provided.
- The litter is regularly stirred for aeration and lime used to keep it dry and hygienic.
- In about 2 month's time it becomes deep litter, and in about 10 months time it becomes fully built up litter. This can be used as fertilizer in the fish pond.
- The fowls which are proven for their ability to produce more and large eggs as in the case of layers, or rapid body weight gains is in the case of broilers are selected along with fish.
- The poultry birds under deep litter system should be fed regularly with balanced feed according to their age.
- Grower mash is provided to the birds during the age of 9-20 weeks at a rate of 50-70 gm/bird/day, whereas layer mash is provided to the birds above 20 weeks at a rate of 80-120 gm/bird/day.
- The feed is provided to the birds in feed hoppers to avoid wastage and keeping the house in proper hygienic conditions.

C2. Egg laying

- Each pen of laying birds is provided with nest boxes for laying eggs.
- Empty kerosene tins make excellent nest boxes.
- One nest should be provided for 5-6 birds.
- Egg production commences at the age of weeks and then gradually decline.
- The birds are usually kept as layers up to the age of 18 months. Each bird lays about 200 eggs/yr.

C3. Harvesting

- Some fish attain marketable size within a few months.
- Keeping in view the size of the fish, prevailing rate and demand of the fish in the local markets, partial harvesting of table size fish is done.
- After harvesting partially, the pond should be restocked with the same species and the same number of fingerlings depending upon the availability of the fish seed.

- Final harvesting is done after 12 months of rearing. Fish yield ranging from 3500-4000 Kg/ha/yr. and 2000-2600 Kg/ha/yr are generally obtained with 6 species and 3 species stocking respectively.
- Eggs are collected daily in the morning and evening. Every bird lays about 200 eggs/year.
- The birds are sold after 18 months of rearing as the egg laying capacity of these birds decreases after that period.
- Pigs can be used along with fish and poultry in integrated culture in a two-tier system. Chick droppings form direct food source for the pigs, which finally fertilise the fish pond.
- Depending on the size of the fish ponds and their manure requirements, such a system can either be built on the bund dividing two fish ponds or on the dry-side of the bund.
- The upper panel is occupied by chicks and the lower by pigs.

10.2.3. Fish cum Horticulture

- Considerable area of an aquaculture farm is available in the form of dykes some of which is used for normal farm activities, the rest remaining fallow round the year infested with deep-rooted terrestrial weeds.
- The menacing growth of these weeds causes inconvenience in routine farm activities besides necessitating recurring expenditure on weed control.
- This adversely affects the economy of aqua-farming which could be considerably improved through judicious use of dykes for production of vegetables and fish feed.
- An integrated horti-agri-aquaculture farming approach leads to better management of resources with higher returns.
- Several varieties of winter vegetables (cabbage, cauliflower, tomato, brinjal, coriander, turnip, radish, beans, spinach, fenugreek, bottle gourd, potato and onion) and summer vegetables (amaranth, water bind weed, papaya, okra, bitter gourd, sponge gourd, sweet gourd, ridge gourd, chilly, ginger and turmeric) can be cultivated depending upon the size, shape and condition of the dykes.

(a) Suitable farming practices on Pond dykes

- Intensive vegetable cultivation may be carried out on broad dykes (4m and above) on which frequent ploughing and irrigation can be done without damaging the dykes.
- Ideal dyke management involves utilisation of the middle portion of the dyke covering about 2/3rd of the total area for intensive vegetable cultivation and the rest 1/3rd area along the length of the periphery through papaya cultivation keeping sufficient space on either side for netting operations.
- Intensive cultivation of water bind weed, Indian spinach, radish, amaranth, okra, sweet gourd, cauliflower, cabbage, spinach, potato, coriander and papaya on pond dyke adopting the practice of multiple cropping with single or mixed crops round the year can yield 65 to 75 that year.

- Semi-intensive farming can be done on pond dykes (2 to 4 m wide) where frequent ploughing, regular irrigation and **deweeding** are not possible.
- Crops of longer duration like beans, ridge gourd, okra, papaya, tomato, brinjal, mustard and chilli are found suitable for such dykes.
- Extensive cultivation may be practised on pond dykes (up to 2 m wide) where ploughing and irrigation by mechanical means are not at all possible. Such dykes can be used for cultivation of sponge gourd, sweet gourd, bottle gourd, citrus and papaya after initial cleaning, deweeding and digging small pits along the length of the dykes.
- Extensive cultivation of ginger and turmeric is suitable for shaded dykes.

(b) Carp production using leafy vegetables and vegetable wastes

- A huge quantity of cabbage, cauliflower, turnip and radish leaves are thrown away during harvest.
- These can be profitably utilised as supplementary feed for grass carp.
- During winter, grass carp can be fed with turnip, cabbage and cauliflower leaves, while in summer, amaranth and water-bind weed through fortnightly clipping may be fed as supplementary feed for rearing of grass carp.
- Monoculture of grass carp, at stocking density of 1000 fish/ha, fed on vegetable leaves alone fetches an average production of about 2 t/ha/yr.
- While mixed culture of grass carp along with rohu, catla and mrigal (50:15:20:15) at a density 5000 fish/ha yields an average production of 3 t/ha/yr.

CHAPTER - 11
Cage Culture

11.1. What is Cage Culture?

Cage culture is an aquaculture production system where fish are held in floating net pens. Cage culture of fish utilizes existing water resources but encloses the fish in a cage or basket which allows water to pass freely between the fish and the pond permitting water exchange and waste removal into the surrounding water.

The first cages which were used for producing fish were developed in Southeast Asia around the end of the 19th century. Wood or bamboos were used to construct these ancient cages and the fish were fed by trash fish and food scraps. In 1950s modern cage culture began with the initiation of production of synthetic materials for cage construction.

11.2. Cage Culture in India

The trends of establishing the cage culture has been improving. **NFDB** has provided guidelines on cage culture. Most of the state associated with marine water, brackish water and fresh water resources like lake , reservoirs, check dams has been taken up for fish productions.

11.2.1. Advantages

Cage culture has advantages which include:

- Many types of water resources can be used, including lakes, reservoirs, ponds, strip pits, streams and rivers which could otherwise not be harvested.
- A relatively low initial investment is required in an existing body of water.
- Harvesting is simplified.
- Observation and sampling of fish is simplified.
- Allows the use of the pond for sport fishing or the culture of other species.
- Less manpower requirement.
- Generation of job opportunities for unemployed youth and women.
- Additional income to fishers during closed seasons.

11.2.2. Disadvantages

Cage culture also has some distinct disadvantages. These include:

- Feed must be nutritionally complete and kept fresh.
- Low Dissolved Oxygen Syndrome **(LODOS**) is an ever present problem and may require mechanical aeration.
- Fouling of net cage.
- The incidence of disease can be high and diseases may spread rapidly.
- Vandalism or poaching is a potential problem.
- Navigation issues.

- Accumulation of unused feed and excreta will lead to water pollution as well as **eutrophication**.
- Change in water quality parameters.
- Conflicts within the local community.
- Predation by aquatic mammals and birds.
- Escapement.
- Overcrowding of aquatic organisms in cages.

11.3. Site Selection

Different criteria must be addressed before site selection for cage culture.

- The Average depth of the water column should be at least 5-10 metres.
- Water quality and circulation should be good, free from local and industrial pollution.
- In large and medium-sized reservoirs, sites should be in sheltered bays for protection from strong winds.
- In small reservoirs, the cage should be anchored in the deeper lentic sector to avoid the current flow through sluice gates and irrigation channel.
- They should be safe from frequent disturbance from local people and grazing animals.
- There should be access to land and water transportation.
- They should be devoid of algal blooms to avoid fouling.
- They should be free of aquatic macrophytes and high populations of wildfish, which can cause oxygen stress. Cages should be placed where they will not hinder navigation.
- They should be at a distance from bathing and burning ghats.
- Sites should be secure.
- Avoid Areas of fish nursery and breeding grounds, sensitive areas like wildlife habitat including birds nesting, socio-culturally important areas like pilgrimage centres, water bodies for public use like drinking water, cleaning, navigation, etc, and protected aquatic reserves, sanctuaries, etc. are also to be avoided.
- *Cage culture shall be allowed in reservoirs with an average depth of 10 m (Average depth is calculated as: Area in hectares divided by water holding capacity in m3*

11.4. Selection of Shape of Cage to be adopted

Four types of cage are used in cage aquaculture:

1. **Fixed -** The fixed cage is the most basic and widely used in shallow water with a depth of 1-3 metres. It consists of net bag fitted to posts and is normally placed in the flow of streams, canals, rivers, rivulets, shallow lakes and reservoirs, not touching the bottom. Fixed cages are comparatively inexpensive and simple, but their use is restricted.

2. **Floating -** Floating cages, on the other hand, are supported by a floating frame such that the net bags hang in water without touching the bottom. Floating cages are generally used in water bodies with a depth of more than 5 metres. Enormous diversity in size, shape and design has been developed for floating cages to suit the wide range of conditions of fish culture in open waters.

3. **Submersible -** The net bags of **submersible** cages are suspended from the surface, have adjustable buoyancy, and may be rigid or flexible.

4. **Submerged -** Submerged net bags are fitted in a solid and rugged frame and submerged under the water. Their use is very limited

11.5. Cage Materials to be used

Followings are the guidelines from NFDB.

- Size of a cage for fish culture in reservoirs can vary, but often multiple units are installed as a battery of cages with **catwalks** for easy access to the fish stock and floating huts.
- However, from operational and planning purposes, a cage with the dimensions: 6m (length) x 4m (width) x 4m(height) is considered as a standard unit and a battery comprises 6, 12 or 24 such cages, as per requirement.
- The cages in a battery are arranged in caterpillar design for better exchange of water thereby facilitating relatively high dissolved oxygen.
- Durable and stable cage materials are essential for achieving better results.
- A cage comprises hard frames as support and nylon nettings as cage body.
- It is desirable to have environmentfriendly, **HACCP** (Hazard Analysis and Critical Control Points) protocol compliant, rust-free materials for cage fabrication. Commonly used materials for cage frames are bamboos, mild steel (**MS**), galvanized iron (**GI**), poly-vinyl chloride (**PVC**) and virgin-grade **HDPE** (High Density5 Polyethylene) (for runner-based & pontoon-based frames). The bamboo based frames are not recommended for commercial cage fish farming due to their poor longevity and strength to withstand turbulence.
- Knotless nylon nets are recommended for cage fabrication.
- The net mesh size recommended for rearing fry of *Pangasianodon hypophthalmus* is 10 to 12 mm and that for fingerling to marketable size is 20 to 30 mm. (In case of IMC, the mesh size should be 5 mm for fry and 10 mm for fingerling).
- Protective net may be put above the cage to avoid crop loss due to predation by birds. Separate cages are needed for nursery rearing and grow-outs.
- Normally, 30% of the cages in a battery are earmarked for *in situ* rearing of fingerlings (stocking materials); the rest being grow-out cages.
- Special care is needed on **mooring**/anchoring of the cage structure to avoid displacement or damage to the structure.
- Anchoring needs to be done diagonally opposite at the four corners of the cage structure by providing heavy sinkers such as anchors or black stones having a dimension of 0.5 m x 1.0 m (not less than 40 kg in weight) tied with strong nylon rope.

11.6. Selection of Species

- Considering the consistent demand for species of high economic and nutritive
- value, coupled with the regional preference (for some species), the following indigenous
- species need to be inducted into the cage culture domain:
- *Labeo bata*,
- *L. rohita* (Jayantirohu),
- *Osteobrama belangeri* (*pengba*),
- *Ompok bimaculatus* (*pabda*),
- *Anabas testudineus(koi)*,
- *Pangasius pangasius*,
- *Puntius sarana*,
- *Lates calcarifer (bhetki)*,
- *Chanos chanos (*milkfish*)*,

- *Etroplus suratensis*,
- *Chitala chitala* (featherback),
- Murrels (*Channa striata, C. marulius*),
- *Wallago attu* and shellfish *Macrobrachium rosenbergii*

11.7. Stocking and Management Practices

11.7.1. Stock Management of *Pangasianodan hypophthalmus*

- Proper records on seed sourcing shall be maintained and the seed should be quarantined and acclimatized and bathed in 3 mg/L KMnO4 (as prophylactic treatment on need basis) before stocking. The size at stocking and optimum stocking density vary according to requirements, depending on growth and survival.
- However, stocking density for *P. hypophthalmus* range from 500 to 700 nos./m3 of 20 mm size fry for rearing to fingerlings.
- For grow-out, the stocking density is in the range of 60 to 100 nos./m3 of fingerlings (50-60 mm
- size).
- The stocking material is better transported to the cage site in water loaded open tank with frequent stirring.
- Stock maintenance involves periodic sampling to assess the growth and general health condition.
- The culture period of *P. hypophthalmus* is generally 7-8 months.

Table - 21: Feeding of *Pangasianodon*

Stage	Feed	Protein Requirement	Feeding Rate (% of Fish Body Weight)
Fry to Fingerling	Crumble Floating Feed (0.5 -1.0 mm)	30 to 35%	• Less than 10% body wt., 4-5 times a day
Fingerling to Table Fish	Pellet Floating Feed (Above 1.0 mm)	25 to 30%	• First 2 months 5% body wt., twice a day. • From 3rd to 5th month 3% body wt., twice a day or as required. • From 6th month onward 2% body wt., twice a day or as required.

11.7.2. Stock management for raising fingerlings of Indian major carps

- Fry measuring above 25 mm length are suitablefor rearing in cages.
- The size at stocking and stocking density of Indian major carps and other indigenous species shall be need-based as these have not been standardized yet.
- To raise fingerlings for culture of Indian major carps, it is always better to stock 50 mm fry as these will grow faster and survival rate would be higher.
- Harvesting can be done after rearing for 60 days.
- However, this depends on natural productivity and supplementary feeding. It is helpful if land based nurseries are available near a reservoir or a cluster of them for rearing fry to fingerlings.
- Pen culture is ideal for raising stocking material of IMC, but all reservoirs do not have the ideal
- Conditions for taking up pen culture.)

11.7.3. Stock management of tilapia

Table - 22: Cage features

Items	Items Details
Cage Size	Cage Size 5m x 5m x 4m
Mesh Sizes	Mesh Sizes 16 mm, 20 mm, 24 mm
Body weight, Feed Pellet Size & Protein Content	50-150 grams – 2 mm (28% protein) 150-500 grams – 3 mm (28% protein) 500-600 grams – 4 mm (25% protein) 600 grams and above – 5 mm (22% protein)
Stocking Density	40/m3
Cage Changing	Fortnightly
Nursery	Not permitted in Reservoirs; minimum stockable size is 50 grams

**Mesh Bar (knot to knot) is half the length of mesh size (stretched mesh size)*

Table - 23: Feeding management of tilapia

S.No	ABW (G)	Feeding rate (% of body wt)	Culture phase
1	1-5	8	Nursery rearing
2	6-10	6	
3	10-15	5.5	
4	15-20	4	
5	20-25	4-2.5	
6	50-100	2.5-1.7	Grow-out rearing
7	100-200	1.7-1.3	
8	200-300	1.3-1	
9	300-500	1-0.9	
10	500-700	0.9-0.8	
11	>700	1.8-0.6	

11.8. Cage Maintenance

- **Anti-corrosive** paint should be applied to GI/MS cages to prevent rusting and to increase the durability.

- Cage should be cleaned at 15-days interval to avoid net clogging.

- After shifting the stock to another cage, each cage is taken out, sun-dried and cleaned thoroughly by scrubbing/water-jet wash to remove debris and fowling organisms.

- *In situ* cleaning using water jets is not advised as it will dislodge the pathogenic organisms throwing them into cages to infect the fish.

- Additional *hapas*/nets may be maintained for this purpose or to meet other emergency
    - situation.

- The physico-chemical parameters of water should be recorded regularly as a part of
    - water quality monitoring.

11.9. Fish Health management

Table - 24: Fish health management in cage culture system

Drugs/ chemicals	Recommended dose	Indications	Administration
Chlor-amine- T	20 mg/l static bath once per day for 60 min on consecutive or alternate days fr 3 days	Columnaris disease associated with Flavobacterium colmnare	Immersion
Formalin	External parasite 250micron /l for 1 hr	Control of external protozoa and mono genatic trematode parasites	Immersion
Oxytetra cycline dehydrate	Catfish- 2.5 to 3.75 g oxytetracyclin/50kg of fishfor 10 days through feed	Control of hemphylum piscicum, furunculosis, bacterial hemorrhagic septicemia.	Medicated feed
Florfenicol	10 mg florfenicol/kg of fish/ day for 10 consecutive days through feed ingredients	Control of F. psychrophyilum and Aeromonas salmonicida,F.columnare	Medicated feed

11.10. Safety Measures

Cage culture involves working in a risky environment and therefore, all security measures should be taken to avoid injury and loss of life while installing cages and working in cages to manage the stock (rearing the fishes).

Adequate number of lifebuoys/ other life-saving equipment should be provided at the cages and in vessels used for approaching (managing) the cages.

Similarly, the workers should wear life-jackets all the time while working in water and cages.

Emergency life-saving kits and first-aid boxes should be provided at the cages/boats/floating huts or field camps.

The international conventions related to 'safety at sea' and procedures prescribed in the FAO-Code of Conduct for Responsible Fisheries (FAO-CCRF) will be the guiding principles for safety measures (http://www.fao.org/docrep /005/v9878e/v9878e00.HTM).

The cage stock needs to be protected from poaching/ trespassing by keeping efficient watch and ward.

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Glossary

Aerators - *are the equipments used to control the algae, low oxygen*

Algicides - *used for killing and preventing the growth of algae.*

Anemic- *lacking in color, spirit, or vitality*

Anticorrosive-something *that prevents or counteracts corrosion.*

Barbles- *sensory organ near the mouth*

Bath treatment- *external treatment*

Benthic *The benthic zone is the ecological region at the lowest level of a body of water such as an ocean or a lake, including the sediment surface and some sub-surface layers.*

Bentonite-Bentonite *is defined as a naturally occurring material that is composed predominantly of the clay mineral*

Biomass-Biomass *is organic matter derived from living*

Bleaching powder-Bleaching powder *is any of various mixtures of calcium hypochlorite, lime (calcium hydroxide), and calcium chloride. Also known as "chlorinated lime",*

Blotches *an irregular patch or unsightly mark on a surface, typically the skin*

Buffering capacity- Buffer capacity *is a measure of the efficiency of a* ***buffer*** *in resisting changes in pH. Conventionally, the* ***buffer capacity*** *( ) is expressed as the amount of strong acid or base, in gram-equivalents, that must be added to 1 liter of the solution to change its pH by one unit.*

Catwalks-*a narrow walkway, especially one high above the surrounding area, used to provide access or allow workers to stand or move, as over thestage in a theater, outside th e roadway of a bridge, along the top of arailroad car, etc.*

CIFAX- *chemical formulation,first commercialized technology of CIFA. It prevents and cures ulcerative diseases of freshwater fishes.*

Cladocera- *The* ***Cladocera*** *is an order of small crustaceans commonly called water fleas.*

Copepods-Copepods *are a group of small crustaceans found in the sea and nearly every freshwater habitat*

Crawfish-*freshwater crustaceans resembling small lobsters*

Crustaceans *mostly aquatic mandibulate arthropods that have a chitinous or calcareous and chitinous exoskeleton, a pair of often much modified appendages on each segment, and two pairs of antennae and that include the lobsters, shrimps, crabs, wood lice, water fleas, and barnacles.*

Cycloids *A thin, acellular structure which is composed of a bonelike substance and shows annual growth rings; found in the skin of soft-rayed fishes.*

Cyprinidae- *are the family of freshwater fishes, collectively called cyprinids, that includes the carps, the true minnows*

Cypriniformis- *an enormously successful group of freshwater fishes*

Detritus *organic matter produced by the decomposition of organisms.*

Deweeding- *removal of weeds*

Droppings- *the excrement of certain animals, such as rodents, sheep, birds, and insects*

Dykes- *a long wall or embankment built to prevent flooding*

Eroded fins-*affected with external abnormalities or signs of disease*

Erratic- *not even or regular in pattern or movement; unpredictable.*

Eutrophication's*rich in organic and mineral nutrients andsupporting an abundant plant life, which in the process of decayingdepletes the oxygen supply for animal life*

Fauna*collective name for animals of a certain region or time* ***Chironomid larvae-*** *diverse large group of small flies whose larvae inhabit just about every niche possible in most freshwater aquatic ecosystems - not to mention marine and terrestrial forms.*

Flurazolidone-Furazolidone *is a nitrofuran antibacterial agent, It works by killing bacteria and protozoa (tiny, one-celled animals)*

GI-(*Galvanized iron) is the process of applying a protective zinc coating to steel or* ***iron****, to prevent rusting.*

GNOC-*(****Ground Nut Oil Cake) - used as fertilizer***

HACCP- (*Hazard analysis and critical control points)- is a systematic preventive approach to food safety from biological, chemical, and physical hazards in production processes that can cause the finished product to be unsafe, and designs measurements to reduce these risks to a safe level.*

Hemorrhages-*and escape of blood from a ruptured blood vessel, especially when profuse.*

Hatchlings- *a young animal that has recently emerged from its egg.*

HDPE-(High Density Polyethylene) - is a *sheet that is extremely strong against impact, abrasion resistant, and exhibits a low coefficient of friction.*

Homogeneously-*Consisting of parts that are the same; uniform in structure or composition*

Juveniles- fish *go through various stages between birth and adulthood. They start as <u>eggs</u> which hatch into <u>larvae</u>. The larvae are not able to feed themselves, and carry a yolk-sac which provides their nutrition. Before the yolk-sac completely disappears, the tiny fish must become capable of feeding themselves. The juvenile stage lasts until the fish is fully grown, sexually mature and interacting with other adult fish*

Keel- *Prominent ridge along the side of the body*

Macrophytes-*It is an aquatic plant that grows in or near water and is either emergent, submergent, or floating,*

***Manuring-Manure** is organic matter, mostly derived from animal feces, contribute to the fertility of the soil by adding organic matter and nutrients, such as nitrogen, that are trapped by bacteria in the soil.*

***Metalarvae**- stage just before developing into adult*

***MOC-**Mahua oil cake- it is derivatives of mahua tree found in the central and north Indian plains and forests. The seed cakes obtained after extraction of oil constitute very good fertilizer.*

***Mooring:** to fix firmly; secure (a ship, boat, dirigible, etc.) in a particular place, as bycables and anchors or by lines.*

***MS– (mild steel) -**steel containing a small percentage of carbon, strong and tough but not readily tempered.*

***Nauplii-** the first larval stage of many crustaceans, having an unsegmented body and a single eye.*

Necrotic tip- pertaining to the death of the cells at the point or attachments

NFDB- (National Fisheries Development Boards), Government of India.

***Pathology-** is a medical specialty that is concerned with the diagnosis of disease based on the laboratory analysis of bodily fluids such as blood and urine, as well as tissues, using the tools of chemistry, clinical microbiology, hematology and molecular **pathology**.*

***pH- pH (**solution potential of hydrogen**)** is a numeric scale used to specify the acidity or basicity of aqueous solutions*

***Phytoplankton-Phytoplankton** are microscopic plants*

***Phytoplanktonphagus- eaters of** flora of freely floating, often minute organisms that drift with water currents*

Porosity- is a measure of space or cavity

Potassium permanganate-** an inorganic chemical compound with the chemical formula KMnO4., it is a purplish colored crystalline solid , is an oxidant, is cheap and used extensively in the **water treatment

***Protruding-** to thrust forward*

***PVC-**(Polyvinyl Chloride) -piping is the most widely used plastic piping material; they areenvironmentally sound, Easy to install and handle.*

***Raking -** make (a stretch of ground) tidy or smooth with a rake. Smooth, smooth out, level, even out, flatten, comb*

***Rotating blades-Rotating Blades** is a large, two-bladed Protosteel weapon used to cut and remove the material such as aquatic plants weeds.*

***RotiferRotifers** are microscopic aquatic animals, commonly called wheel animals, found in many freshwater environments and in moist soil*

Saponin-Saponins *are a class of chemical compounds found in particular abundance in various plant species.*

Skin lesion- skin lesion *is a part of the* ***skin*** *that has an abnormal growth or appearance compared to the* ***skin*** *around it.*

Sluggishness- *Slow to perform or respond to stimulation. inactive, Lacking alertness, vigor, or energy*

Snout*- is the anterior most part of the* ***fish*** *(forward end of head)*

Sores-*oozing pus, blood, or other fluid from the body, caused by the diseases*

SSP-Single superphosphate *(SSP) was the first commercial mineral fertilizer*

Stratifications: *changes in the water or separation of water layer. Ex by temperature called as thermal stratifications*

Submersible:*capable of operating under water*

Supplementary feed- *feed that is cheaper and have nutrient rich components, utilizedto enhance the growth and productions*

Teleostomi- *is an obsolete clade of jawed vertebrates that supposedly includes the tetrapod's, bony fish*

Terramycin-*is a broad-spectrum anti-infective that has been proven effective against a wide variety of infectious diseases*

Toxicants*- is any chemical that can injure or kill humans, animals or plants; a poison.*

Toxicity -Toxicity *is the degree to which a substance can damage an organism.*

Urea-Urea*, also known as carbamide, is an organic compound, used as fertilizer*

Zooplankers- *micro and macro animal organisms*

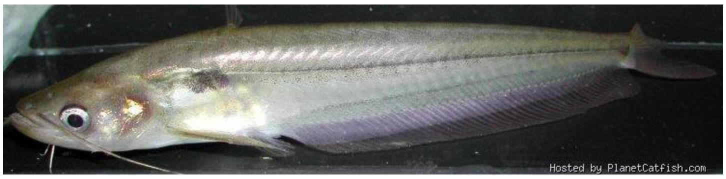
Zooplankton- zooplankton *are microscopic organism*

Zooplanktonphagus- *eaters of (eaters may be fish or any living organisms) tiny animals found near the surface in aquatic environments, usually weak swimmers and usually just drift along with the currents*

Photos

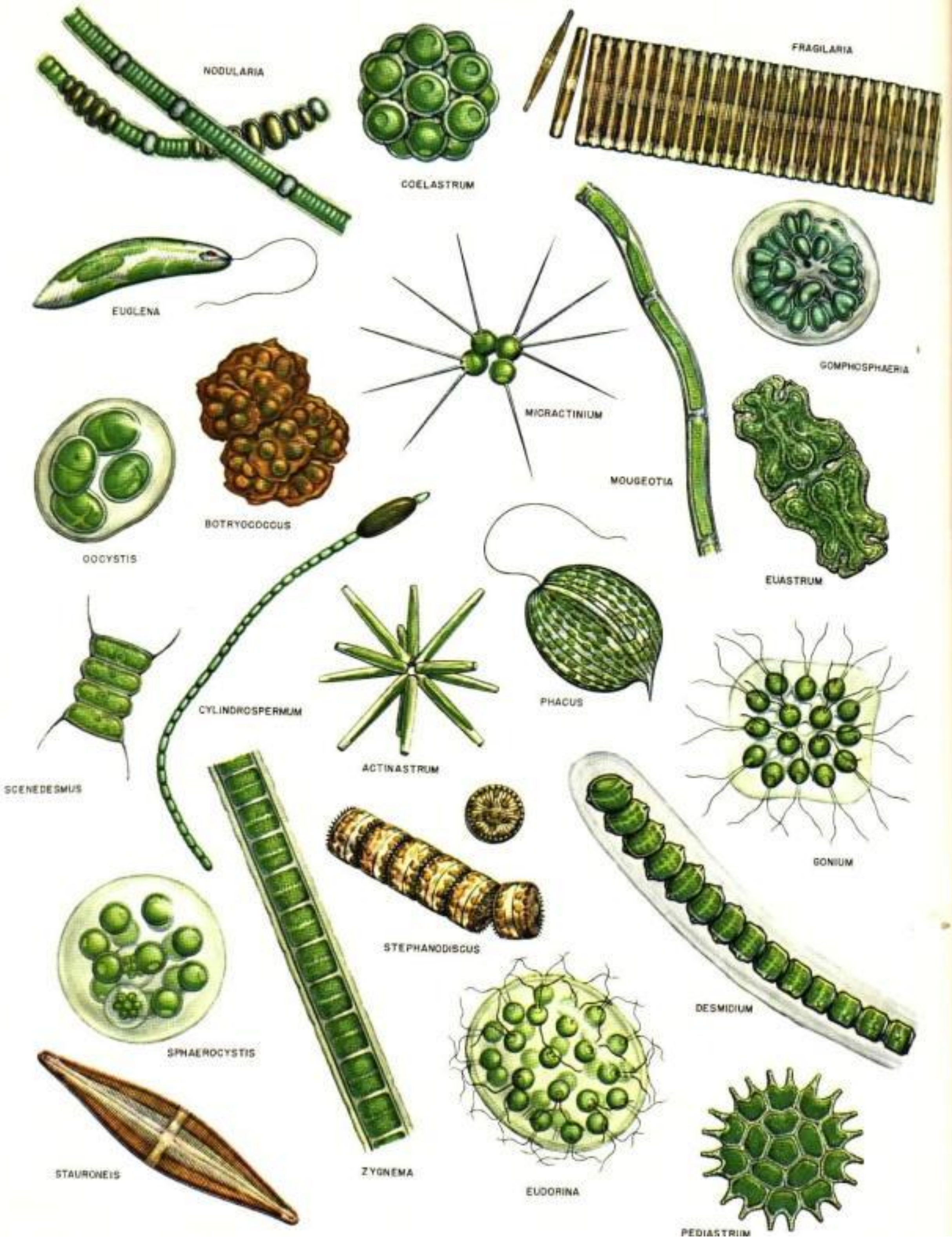
Emergent plants	Floating plants
 Nelumbo spp.	 Lemna sps.
 Nymphoid sps.	 Pistia sps.
 Nymphea sps.	 Salvenia sps.

Marginal Plants	**Submerged Plants**
 Typhea sps.(Lesser Indian reed)	 Hydrilla sps.
 Jusea sps.	 Najas sps.
 Cyperus Sps.	 Vallesneria sps.
 Ipomea sps.	 Potamogton sps.

Predatory Fishes	
Clariusbatrachus (Mangur)	
Glosogobiussps.	
Heteropneustesfossilis (Singhi)	
Mystustengra	
Ompaksps.	

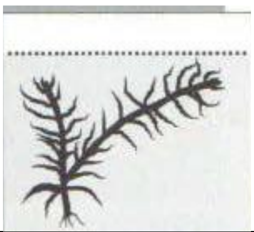
Pangasiussps.	
Wallaguattu (Bauwali)	
Weed fish	
Puntiussps.	
Osteobramasps.	
Molasps.	

PLANKTON AND OTHER SURFACE WATER ALGAE



Annexures

1. Identification Key of Aquatic Plants

Emergent, narrow leave		Plants are rooted in the substrate with modified leaves, reed like
Emergent, broad leaved		Plants are rooted in the substrate with stems, flowers and most mature leaves projecting above or floating on the water surface
Submerged		Plants rooted in the substrate. Leaves can be feathery or linear, mostly submerged. Flowers usually above the water.
Floating leave attached		Plants rooted in the substrata with mature leaves floating on the surface of water
Free Floating		Plants unattached and float on the surface of the water. May become rooted in mud when water level drops.

2. Estimation for 1 Acre Pond

Pond size	No. of fingerlings required	No. of fry required	Spawn required
1	20	1200	20000
2	40	2400	40000
3	60	3600	60000
4	80	4800	80000
5	100	6000	100000
6	120	7200	120000
7	140	8400	140000
8	160	9600	160000
9	180	10800	180000
10	200	12000	200000
11	220	13200	220000
12	240	14400	240000
13	260	15600	260000
14	280	16800	280000
15	300	18000	300000
16	320	19200	320000
17	340	20400	340000
18	360	21600	360000
19	380	22800	380000
20	400	24000	400000
21	420	25200	420000
22	440	26400	440000
23	460	27600	460000
24	480	28800	480000
25	500	30000	500000
26	520	31200	520000
27	540	32400	540000
28	560	33600	560000
29	580	34800	580000
30	600	36000	600000
31	620	37200	620000
32	640	38400	640000
33	660	39600	660000

Pond size	No. of fingerlings required	No. of fry required	Spawn required
34	680	40800	680000
35	700	42000	700000
36	720	43200	720000
37	740	44400	740000
38	760	45600	760000
39	780	46800	780000
40	800	48000	800000
41	820	49200	820000
42	840	50400	840000
43	860	51600	860000
44	880	52800	880000
45	900	54000	900000
46	920	55200	920000
47	940	56400	940000
48	960	57600	960000
49	980	58800	980000
50	1000	60000	1000000
51	1020	61200	1020000
52	1040	62400	1040000
53	1060	63600	1060000
54	1080	64800	1080000
55	1100	66000	1100000
56	1120	67200	1120000
57	1140	68400	1140000
58	1160	69600	1160000
59	1180	70800	1180000
60	1200	72000	1200000
61	1220	73200	1220000
62	1240	74400	1240000
63	1260	75600	1260000
64	1280	76800	1280000
65	1300	78000	1300000
66	1320	79200	1320000
67	1340	80400	1340000
68	1360	81600	1360000
69	1380	82800	1380000

Pond size	No. of fingerlings required	No. of fry required	Spawn required
70	1400	84000	1400000
71	1420	85200	1420000
72	1440	86400	1440000
73	1460	87600	1460000
74	1480	88800	1480000
75	1500	90000	1500000
76	1520	91200	1520000
77	1540	92400	1540000
78	1560	93600	1560000
79	1580	94800	1580000
80	1600	96000	1600000
81	1620	97200	1620000
82	1640	98400	1640000
83	1660	99600	1660000
84	1680	100800	1680000
85	1700	102000	1700000
86	1720	103200	1720000
87	1740	104400	1740000
88	1760	105600	1760000
89	1780	106800	1780000
90	1800	108000	1800000
91	1820	109200	1820000
92	1840	110400	1840000
93	1860	111600	1860000
94	1880	112800	1880000
95	1900	114000	1900000
96	1920	115200	1920000
97	1940	116400	1940000
98	1960	117600	1960000
99	1980	118800	1980000
100	2000	120000	2,000,000