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UNIT II	Fish farm Maintenance – Farm management technique, water quality, temperatures and accessories in farm management viz Aerator, filter, paddler**.**
UNIT III	Fish culture technique: Monoculture, Polyculture and Monosex culture, Induced fish breeding,integrated fish farming

UNIT –II

Fish farm Maintenance – Farm management technique, water quality, temperatures and Accessories in farm management viz Aerator, filter, paddler.

FARM MANAGEMENT TECHNIQUE

Construction of a large pond can be very expensive if labor is hired, machines are used, and expensive equipment is rented. For example, in the Philippines, a one-hectare pond having two concrete gates and walls 3m high x 3m wide recently cost US$1,522.56. Another pond, about 100m x 25m, with only a Rivaldi valve cost about US$680.

An interesting fact about fish pond construction is that whether the pond is large or small, expensive or inexpensive, ponds are all very much the same. A larger, more expensive pond will not necessarily be a better pond.

Here is an example of a good beginning for a new and small fish farmer:

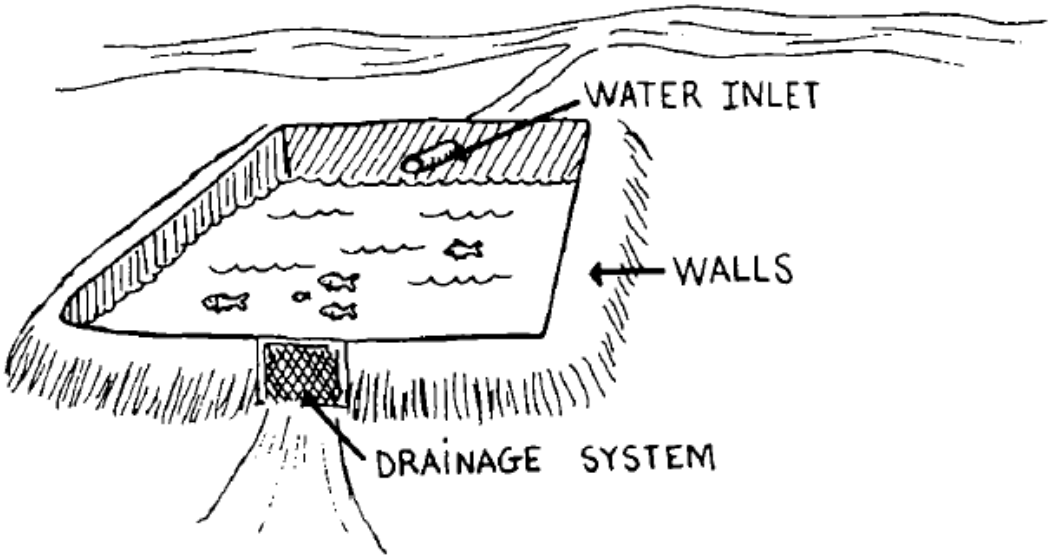
> A "backyard" fish pond was planned and sited very carefully by a farmer. The pond was dug by the farmer and constructed with bamboo pipes for water inlets and outlets. The construction itself cost no money. The farmer's only expense was a supply of fingerlings purchased from a nearby market. This fish pond, managed by the farmer and his family, produced enough fish for the family and some extra income from fish sold or bartered for goods needed by the farmer. The family ate well and suffered no major illnesses during the year.
>
> Next year, the farmer plans to add another pond and to produce more fish for market. He will add a Rivaldi valve or a wooden monk to this new pond, because either of these will make on-going management somewhat easier, now that there will be two ponds to manage (the bamboo pipe sometimes got clogged. This was no problem to correct when there was only one pond. But it would take up needed time in a two-pond operation). Whichever the farmer chooses, the valve or the monk, he will make it himself with materials found locally, using money from the sale of his fish:

The following section presents a range of ideas for constructing fish ponds. The farmer can pick a combination of construction possibilities which best fit his own needs and resources.

IMPORTANT: Stress that the "right" way in any situation is the way which:

- . the owner can afford
- . the owner can manage easily
- . fits the owner's needs most completely

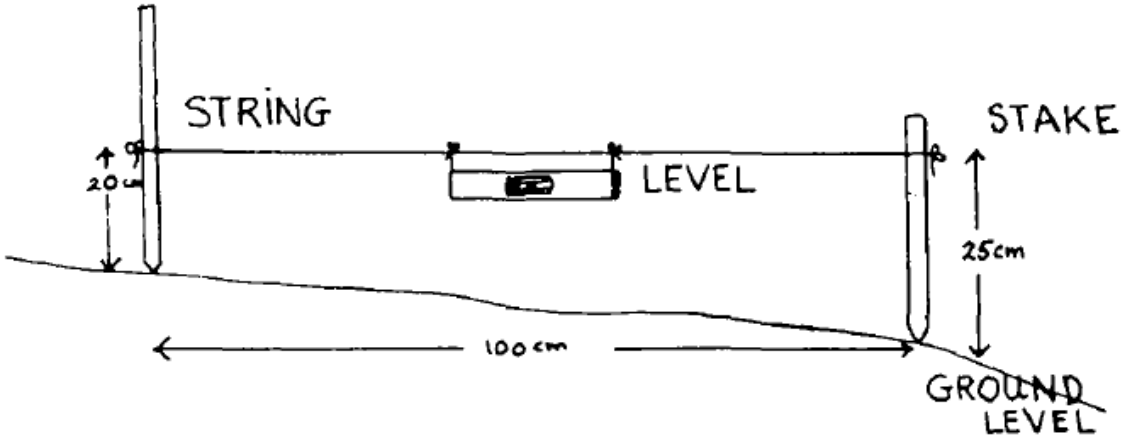
Construction should begin only after careful planning such as that outlined in the preceding sections on "Planning."



A fish pond has three main parts: the walls, the water inlet, and the drainage system. Walls are also called dams, dikes, levees, or bunds. This manual uses "walls." Whatever they are called, walls hold the water in the pond. They can be built using soil taken from inside the pond, or they can be built with soil taken from another place. They must be strong enough to withstand the pressure of all the water inside the pond: water constantly pushes against the walls. They must also be water tight (impermeable), so the pond does not leak.

. Tie string or fishline or vine (whatever is being used) between the two stakes. Attach the level to the string. Then move the string up and down on the stakes until the bubble is between the lines on the level, or the water level is even with the line marked on the container. This will mean the string is level between the stakes, even though the stakes are in the ground at different heights.

. Measure the height of each string by measuring from ground level to the place where the string is tied.



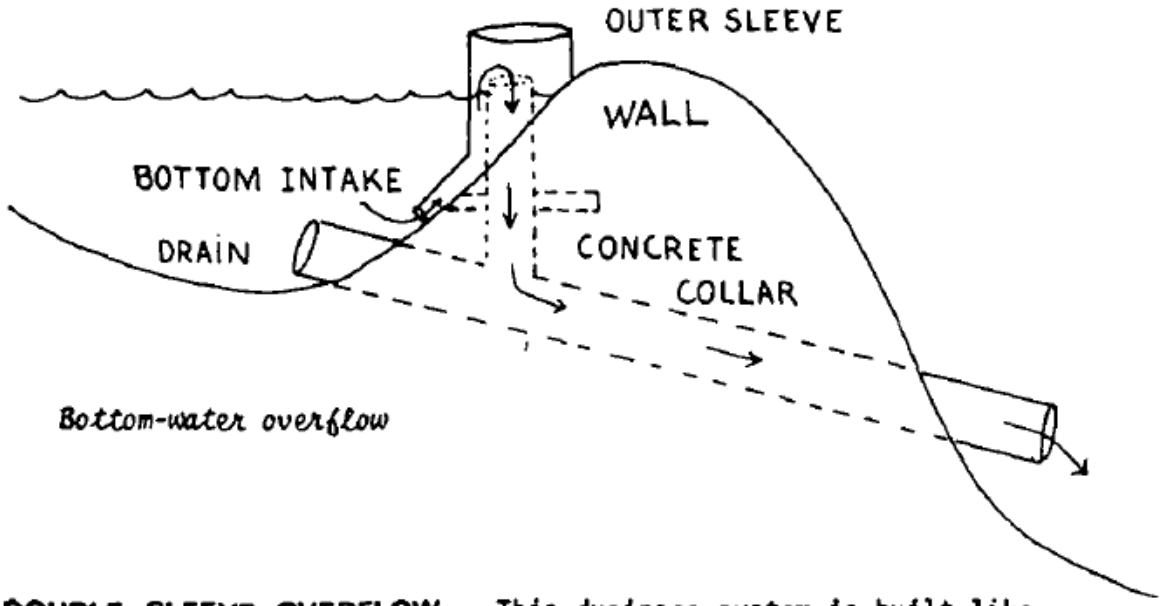
This drawing shows that one string is tied at 20cm; the other is tied at 25cm. Therefore, one end of the area is 5cm lower than the other. The distance covered by the string is 100cm, so the slope is 5% (over 100cm of ground, the elevation changed 5cm). Since a slope of 2-5% is good for a fish pond, this site has a satisfactory slope for a pond.

Other Ways of Determining Slope. As mentioned earlier, the above method of measuring slope is a good one, but it may be difficult for some people to do. It is possible to calculate slope roughly. A farmer, who realizes that what he is looking for is a way to place his pond so that the water can enter from the water source and drain away well, can figure the slope of his land by doing such things as rolling a ball or other round object and watching carefully to note where and how quickly the ball rolls. A good slope would mean a slow-rolling ball. A variation of this involves throwing a quantity of water, or a mixture of water and dye, on the ground and watching the path it takes and its speed as it moves along the ground.

It is important to consider slope carefully. A well-placed pond with good drainage is easier to care for and has more chance to be successful. It may be necessary for the pond owner to measure his land only once to find a good location. Or it may be necessary to repeat the measuring a number of times. This is probably a good thing to encourage since locations which look alike to the eye often have enough difference in slope to make a big difference to a fish pond. Also, determining slope

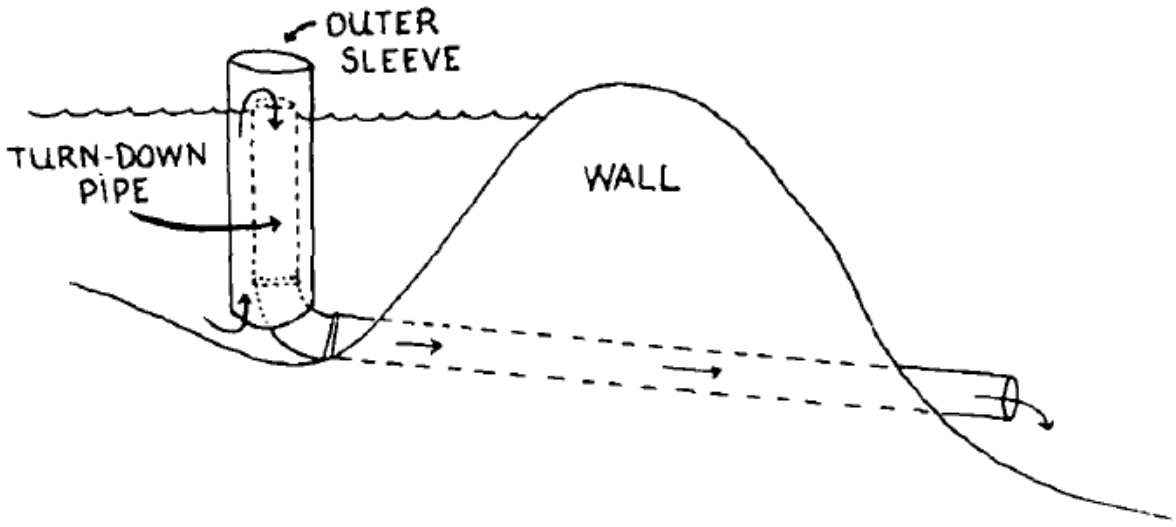
BOTTOM-WATER OVERFLOW This drain takes water directly from the bottom of the pond where oxygen levels are the lowest. The Rivaldi valve and elbow joint do this also, but each of these requires that the pipe be lowered so the pond can be drained. The bottom-water overflow regulates the depth of water without any need for moving the pipes. When new water is added to the pond, the less-oxygenated water at the bottom drains out automatically.

This type of drain is relatively complicated and usually difficult to build. For a small fish farm operation, it would probably not be worth the effort.



DOUBLE SLEEVE OVERFLOW This drainage system is built like the turn-down pipe, except a large pipe is placed over the section of pipe which extends above the pond's surface. This outer pipe should be longer and wider than the inner pipe, which is placed so that it is about equal in height to the depth of water desired in the pond.

When fresh water is required in the pond quickly because the water is too warm for the fish or because the oxygen levels are low, all the farmer has to do is to add water to the pond. The double-sleeve overflow automatically drains the stale water from the bottom of the pond.



TEMPERATURE

Fish are cold-blooded animals; that is, their body temperatures depend upon the temperature of the water in which they live. Every fish species has a temperature range within which it grows quickly. This is called the optimum temperature range, and it means that this fish grows best at temperatures within that range. In a fish pond, the fish should live at their optimum to grow well. However, since fish have different temperature requirements, the farmer must choose the fish which will grow best in the temperature range of his pond.

Here are some of the common pond fish and their temperature ranges:

Genus, species	*Common name*	*Temperature °C*
Tilapia mossambica	tilapia	25-35
Osphronemus goramy	gourami	24-28
Puntius javanicus	tawes	25-33
Cyprinus carpio	common carp	20-25
Ctenopharyngodon idellus	grass carp	25-30
Anguilla japonica	eel	20-28

This chart shows that all the fish on this list could live in water that is 25°C (77°F). The chart also shows that an eel can live and grow well at 20°C, but that the tilapia and the grass carp will not do well at 20°C because this temperature is below the range in which they are comfortable. When the temperature goes higher or lower than this optimum, fish will not grow. Eventually, if the temperature goes too high or too low, the fish will die.

The farmer must watch the temperature in the pond water carefully, especially if the weather becomes unusually hot or cold. If it is possible, it is a good idea for a farmer to use a thermometer to find the temperature of his pond water. This can be done by using a

thermometer which is used for taking temperatures when people are sick. The most important step is to guide the farmer to stock fish which will do well in the normal temperature ranges of his area. Then the temperature of the water will not generally be a problem, except in cases of unusual weather.

Some experienced fish growers can judge the water temperature by putting their arms in the water. Most people cannot tell temperature this way. But if the right kind of fish has been chosen for the pond, the farmer need only watch the fish to be able to judge the temperature of the pond water. If the water is becoming too hot, the fish will not eat and will move very slowly.

If the farmer sees this behavior in his fish pond, he can take out some of the pond water and put in new, cooler water. Another way of protecting the water from getting too hot is to find a way to shade the pond, so that the sun does not shine directly on the water. The shading should be temporary because sunlight is important to the success of the pond.

Aeration

Among various water quality parameters for a successful aquaculture practice, Dissolved oxygen content in the water is one of the most important parameters, as the oxygen is a vital for all the organisms living in the water and having an aerobic type of respiration. The purpose of aeration is to increase the concentration of oxygen in the water. In scientific aquaculture practices, this is more critical because, often the rate of consumption of oxygen is much higher than the natural rate of replenishment of oxygen in the water through diffusion from atmosphere and photosynthesis of aquatic plants. Oxygen is one environmental parameter that exerts a tremendous effect on growth and production through its direct effect on feed consumption and metabolism and its indirect effect on environmental conditions. Oxygen affects the solubility and availability of many nutrients. Low levels of dissolved oxygen can cause changes in oxidation state of substances from the oxidized to the reduced form. Lack of dissolved oxygen can be directly harmful to culture organisms or cause a substantial increase in the level of toxic metabolites. It is therefore important to continuously maintain dissolved oxygen at optimum levels of above 3.5 ppm.

Typically, dissolved oxygen is measured either in mg per litre (mgl-1) or parts per million (ppm) with 0 ppm representing total oxygen depletion and 15 ppm representing the maximum or saturation. The solubility of oxygen is influenced by several factors. The solubility of oxygen decreases as the temperature increases; decreases exponentially with increase in salinity; decreases with lower atmospheric pressure and higher humidity and increases with depth. Water temperature is the main limiting factor in aquaculture farms. Oxygen from atmosphere enters the water naturally through air/water interface. This process is enhanced by wind action which creates a mild turbulence at the water surface.

system

- Rise in atmospheric temperature causes an increase in the rate of biological degradation of organic matter and subsequent depletion of oxygen concentration in water.
- Prolonged cloudy conditions causes reduction in the photosynthetic activity by green plants in ponds results in reduction in oxygen concentration
- Increased stocking rate of animals in semi intensive and intensive farming practices requires greater amount of oxygen for respiration for all aquatic organisms results in depletion of oxygen concentration in water.
- Aeration in ponds helps in mixing and circulation of pond water. Mixing and circulation is more critical in scientific farming which also helps in feed distribution and waste disposal.

Aerators

Aerators are mechanical devices which increases the dissolved oxygen content of the water. Aerators utilizes the energy input to increases the surface area of water available for oxygen transfer and mix water with oxygen to ensure the liquid medium with of oxygen concentration is brought in contact with oxygen or air.

Oxygen Transfer Process

Three steps are involved in the transfer process of oxygen into water

a. Transfer of oxygen in the gas to gas liquid interface

b. Transfer across the gas liquid interface

c. Transfer of oxygen away from the interface into the liquid

Types of aerators

Different types of aerators used in aquaculture are

Filtration

Removal of particles from a water flow in important in aquaculture. Suspended solids, dissolved solids and organic matter were removed from water by filtration of water through suitable media.

Types of filtration

1. Mechanical filtration

In aquaculture, mechanical filtration is used primarily for the separation of solids and liquids. A mechanical filter is a filter that is set into the water flow to collect the particles and larger objects and allow water to pass through. Mechanical filters uses differences in particle size of the solution (or mixture) components to extract one part form the other. The simplest type comprises a static screen, a grating or perforated plate. They are usually simple in operation and relatively easy to maintain.

In Sand filters, water is allowed to flow through a layer of sand with particles of varying sizes and depth. The layer is not dense, but contains a number of channels and holes created between the particles that constitute filter medium. When water is passes through the filter medium, particles larger than a certain size will be trapped in the medium.

Various types of mechanical filters are (i) stationary screen (ii) rotary screen (iii) vibratory screen

2. Gravitational filtration

Gravitational filtration utilizes the force of gravity to separate particles from fluid. Density difference of the suspended particles and water is used in this type of filtration. A simple example of gravity filtration is sedimentation. Sedimentation is a process of allowing particulate materials having density greater than that of suspending liquid to settle out under gravitational forces. The settling process of the suspended particles can be increased by aggregating the suspended particles by addition of certain chemicals (coagulation) or by adding chemicals to produce insoluble compounds with suspended particles (precipitation).

3. Biological filtration

Concentration of ammonia in culture water is reduced by biological filtration process. Biological filters are devices to culture microorganism that will perform the given task of reducing the ammonia concentration when water with high ammonia level floes through them. In water both Ammonia (NH_3) and ammonium ion (NH_4^+) are present and their sum is known as Total Ammonia Nitrogen (TAN) and their proportions vary with pH. Ammonia (NH_3) is toxic to fish and their presence in water is important in aquaculture practices.

Biological filters (biofilters) are used to maintain water quality in recirculating or closed aquaculture systems. Biofilters are also used to improve water quality before water is discharged from a facility. Biological filers are formed as a component of the main filtration system which ensures water quality in an aquaculture farm. However it is very important in recirculating aquaculture or aquarium system.

In biological filters, bacteria are used to convert ammonia in various steps. (i) Conversion of ammonium to Nitrite (ii) conversion of Nitrite to Nitrate and (iii) Conversion of nitrate to molecular nitrogen. The first two steps, known as nitrification, are performed by specific bacteria which oxidize ammonia. The autotrophic bacteria, Nitrosomonas bacteria utilize ammonia as a food source and produce nitrite. This nitrite is further converted to nitrate by Nitrobacter. These bacteria grow and colonize on the filter medium of biological filter. Both nitrifying bacteria will grow and colonize the biofilter as long as there is food available. The efficiency of the nitrification process depends on the optimum growth of bacteria on the biofilter medium. One of the main factors affecting bacterial growth is the amount ammonia in the water. Other factors regulate are temperature, oxygen concentration, pH, salinity, organic substances and toxic substances.

Disinfection

Water drawn from coastal waters, estuaries and rivers used for various aquaculture activities often forms an efficient means for the introduction and spread of infectious diseases in the system. So it is very essential to have a pathogen-free water source for success in aquaculture. For aquaculture, the supply water to the farm or hatchery is disinfected by various methods. Disinfection of wastewater before discharging is necessary to avoid the pathogen contamination in the environment. Disinfection can be described as the reduction of microorganisms such as bacteria, viruses, fungi and parasites to a desired concentration. The aim of disinfection of water in fish farming is to reduce the risk of transfer of infectious dieses from water to the fish to an acceptable level.

There are several methods for disinfecting water. Disinfectants can be grouped as chemical and non chemical agents. A four group classification for disinfectants is (i) chemical agents (ii) physical agents (iii) mechanical agents and (iv) radiation. Even though various methods can be used for disinfecting water, the quality of the water to be disinfected is of major importance. Pure inlet water is much simpler to disinfect than the outlet water because latter contains more particles. Turbid water and water with a high content of organic substances such as re use water are also more difficult to disinfect and therefore not commonly disinfected. For disinfection of water supplies to aquaculture facilities, UV light and ozone are

UNIT – III

Fish culture technique: Monoculture, Polyculture and Monosex culture, Induced fish breeding, integrated fish farming.

MONOCULTURE

2. Introduction ωRecently researchers conducted by CIFRI (Center Inland fishery research institute) have revolutionized research institute in India for fishery and net production of about 85,000 kilogram per hectare per year has been achieved in fish production in India. ωMonoculture fish farming refers to the fish farming where only one type of fish species and breed is raised on a farm,

3. Indian Fisheries • Global position 3rd in Fisheries • 2nd in Aquaculture • Per capita fish availability (Kg.)9.0 • Annual Export earnings (Rs. In Crore)7,200 • Employment in sector (million)14.0

4. Fish culture There are two systems of fish culture in commercial fish farming Monoculture and Polyculture fish farming Monoculture fish farming : this refer to fish farming where only one types of fish species and breed is raised on a farm. ∂ Advantages of monoculture fish farming : easy to monitor individual fish breed performance , their is no undue competition for space and feed . ∂ Disadvantages of monoculture fish farming : these includes : regression in water quality , cannibalism among fish themselves , overstocking of pond with fish which may leads to diseases outbreak

5. Monoculture of aquatic animal ωIt is a branch of animal husbandry involving raising or breeding of animals such as Fin – Fish , shell – fish , oyster shell , clams , cockles , shrimps , crayfish , periwinkles , in a controlled water body to marketable size .

6. Fish culture is divided into many categories a) Fresh water fish monoculture , b) Marine water fish monoculture , c) Brackish water or salty water fish monoculture (these fishes are acclimatized to fresh water)

7. Terms used in monoculture fish farming ∂ Fishery : The study of fish or fishes, ∂ Pond : Artificial body of water where fish where reared , ∂ Fry : Newly hatched fish , ∂ Fingerling : Young fish or baby fish , ∂ Hatchery : This is a unit where fish eggs are been hatch artificially into fry, ∂Gears : Equipments for harvesting fish .

8. Objectives of monoculture in fish culture • To get maximum amount of production, and to prevent species extinction by over – exploitation , • High nutrient rich fish cultivation , • Supply high quality animal protein and vitamin rich oil e.g. – cod liver fish oil from cod fish which is

rich in vitamin A and D, • Fish oil used in medicines and in soap making industries for research purposes ,

9. Qualities of cultivable fish species in monoculture • Should have fast growth rate , • Should have ability to feed on natural and cheap artificial food , • Should be hardy and resistance to disease , • Should be able to tolerate adverse and physico – chemical conditions of pond water, • Should consume small quantity of food for development , • Should be of high nutritive value ,

10. • Should be gentle and non – poisonous , • Should be easily harvested , • Should be a proliferate breeder • Can reproduce under confined conditions , • Should support high population density in pond .

11. Factors to consider when siting fish farm 1. Availability of good quality water 2. Availability of good quality fish feed 3. Availability of suitable fingerling , fingerling that can grow rapidly and have good feed to flesh convertibility 4. Soil type must be the types that have good water retention ability and also rich in humus content therefore clay soil rich in humus content is the best soil for lining pond . 5. Do not site fish pond on soil rich in heavy metals like copper , mercury , arsenic , lead or in highly industrialized area because the sulphur fumes produced in industrial area are poisonous to fish when dissolve by rain water . 6. Avoid acidic soil or rocky soil 7. Vegetation of the soil must be easy to clear 8. Topography of the land must not be easily flooded

12. Types of cultivable fish species in Indian system I. Indigenous or Natural fresh water fishes : such as Mesocarps like Catla catla , Labeo rohita ,Cirrihinus mrigala, Labeo calbasu , Cirrihinus cirrhosa and few salt water species II. Exotic carps : such as , Hypothalmichthys molitrix (silver carp), Ctenopharyngodon idella (grass carp), Cyprinus carpio (common carp)

13. Indigenous Catla catla (catla) Labeo rohita (rohu) Cirrihinus mrigala (mrigal) Surface feeder zooplankton Column feeder omnivore Bottom feeder detritivorous

14. Exotic Hypothalmichthys molitrix (silver carp) Ctenopharyngodon idella (grass carp) Cyprinus carpio (common carp) Surface feeder Phytoplankton Herbivore Surface, column & marginal Bottom feeder Omnivore

15. Sea bass (Lates calcarifer) (brackish water species)

16. Oyster monoculture, Freshwater Mussels

17. Clams

18. Periwinkles Sitka Periwinkles (Littorina sitkana)

19. Crayfish

20. Cockle

21. Shrimps

22. Some examples of Prawn species used in monoculture technique (Penaeus is a genus of prawns, including the giant tiger prawn) Penaeus indicus

23. Penaeus monodon

24. Metapenaeus affinis (common prawn of paddy fields, west Bengal)

25. Metapenaeus dobsoni (dominant species of brackish water and is 11 cm in length)

26. Metapenaeus monocerose (17 cm)

27. Parapenaeopsis stylifera (2 year old specimen is of 11 cm)

28. Parapenaeopsis sculptlis (14 cm)

29. Macrobrachium carcinus (fresh water species 11cm in lenght)

30. Indigenous carps 1. Catla catla (catla) Characteristics : 1. Body is oblong and 4 sided view , 2. Eyes are situated on the lower halves of lateral line , 3. It does not breed in pond 4. Embryos hatch after 10 – 80 days of fertilization and adult character attain after 6 weeks of hatching , 5. It attains the length of 38 – 45 cm at the end of first year , with average weight 900 gm. , 6. At the end of second year the weight is about 4 – 5 kg ,

31. Fecundity • Egg laying capacity is 80 eggs per grams of body weight, Especially when it becomes two year old and the weight is about 5 kg

32. 2. Labeo rohita (rohu) Characteristics : 1. Dorsal profile of body is more complex than abdominal , 2. Dorsal fin originated mid – way of shout and base of caudal fin , 3. Body color is bluish or brownish and silvery on the sides and belly 4. It is a fresh water species but may live in brackish water as Catla , 5. The confined water is suitable for cultivation however it does not breed in confined waters . Fecundity : A 51 – 75 cm long specimen , lays about 2,25,500 – 27,94,000eggs, the average eggs per body weight is about 1258 eggs / gm body weight

33. 3. Labeo calbasu (calbasu) Characteristics : 1. It is a fresh water silver fish with reddish orange fins , 2. It spawn in India during monsoon from mid – May to July , 3. A female having a weight of 500 gm of 340 length can give 219450 eggs that is 430 eggs / gm body weight , 4. Eggs are deposited in flooded river margins and are oval in shape and measure about 5.3 – 6 mm in diameter .

34. 4. Cirrihinus mrigala (mrigal) Characteristics : 1. They are the fresh water river fishes which do not breed in confined waters but sometimes in reservoir , 2. The larvae are collected from river and able to transport over long distances , 3. It attains sexual maturity when only one year old , 4. Spawning period in India is from May to June , 5. After 6 months it becomes 24 cm in

length and 340 gm in weight , and at the end of first year the weight is about 1.1 – 1.8 kg and length 45 – 61 cm, 6. Ponds containing more than sufficient quantities of decaying organic matters are able to produce more than 1100 kg / hectare / year

35. II . Exotic carp 1. Hypothalmichthys molitrix (silver carp) Distribution It is found in south – central China , and transplanted to Japan, Taiwan, Malaysia and from Malaysia to Srilanka , It was introduced in India in 1959.

36. Characteristics : 1. They don't breed in ponds but sometimes in reservoirs , 2. It is able to live in slightly brackish water fry are collected from rivers and reared in nurseries , 3. Breeding takes place from April to June , 4. During first year growth is not very fast, however in second year the average length reached is 33mm and weight 900 gm, the length after third year become 450 mm and weight 1.8 kg .

37. 2.Ctenopharyngodon idella (grass carp) • It has been introduced in India in 1970 , Characteristics : 1. It is a fresh water river fish suitable for ponds , and does not breed in confined condition , 2. In china its spawning period is from May to June , 3. Eggs sre deposited in the middle of the river in the rapid current , they usually hatch in the 30 – 40 hr. at the temperature range between 24 - 30 º C 4. Larva aquries the adult shape in 15 – 20 days ,

38. 5. At end of the first year they attain a length of 120 – 300 mm , and weight about225 – 500 gm, 6. At the end of second year, length is about 600 mm and weight is about 1.8 - 2.3 kg , 7. At the end of fourth year, they become 4.5 kg in weight and can be grown alone in ponds , 8. Male may mature in 2 years while female a year later 9. Female fish weighing 3 – 4 kg, have been found to possess 1,80,000 – 4,92,750 eggs .

39. 3. Cyprinus carpio (common carp) • It was introduced to India from Srilanka in 1839 . Characteristics : 1. It is a major carp, attain a length of about 3 feet , 2. It is essentially a cold water fish but being hardy, it easily adapts itself to warm waters of the tropics, 3. It is world wide and most extensively cultivated 4. In India it was first stocked in Nilgiri hills, however it has now being distributed in other states also ,

40. Natural Fish Food Organisms (Phytoplankton)

41. Natural Fish Food Organisms (Zooplankton)

42. Natural food preferences of the Asiatic carps at different stages of their life cycle Species Stages of life cycle Larvae Fry Fingerlings Adult Catla (Catla catla) Protozoans, rotifers unicellular algae, etc. Protozoans, rotifers and crustaceans. Crustaceans, algae, rotifers and some vegetable debris Crustaceans, algae, rotifers, plant matters, etc. Rohu (Labeo rohita) - do - Protozoans, rotifers, crustaceans, unicellular algae. Vegetable debris, phytoplankton crustaceans, detritus, etc. Vegetable debris, microscopic plants, detritus and mud. Mrigal (Cirrhinus mrigal) - do - Crustaceans, rotifers, planktonic algae. Vegetable debris, unicellular algae detritus and mud.

Blue-green and filamentous algae, diatoms, pieces of macrophytes, decayed vegetable matters, mud & detritus.

INTRODUCTION

Polyculture is the practice of culturing more than one species of aquatic organism in the same pond. The motivating principle is that fish production in ponds may be maximized by raising a combination of species having different food habits. The mixture of fish gives better utilization of available natural food produced in a pond. Polyculture began in China more than 1000 years ago. The practice has spread throughout southeast Asia, and into other parts of the world.

HOW DOES POLYCULTURE WORK?

Ponds that have been enriched through chemical fertilization, manuring or feeding practices contain abundant natural fish food organisms living at different depths and locations in the water column. Most fish feed predominantly on selected groups of these organisms. Polyculture should combine fish having different feeding habits in proportions that effectively utilize these natural foods (Figure 1). As a result, higher yields are obtained. Efficient polyculture systems in tropical climates may produce up to 8,000 kg of fish per hectare per year.

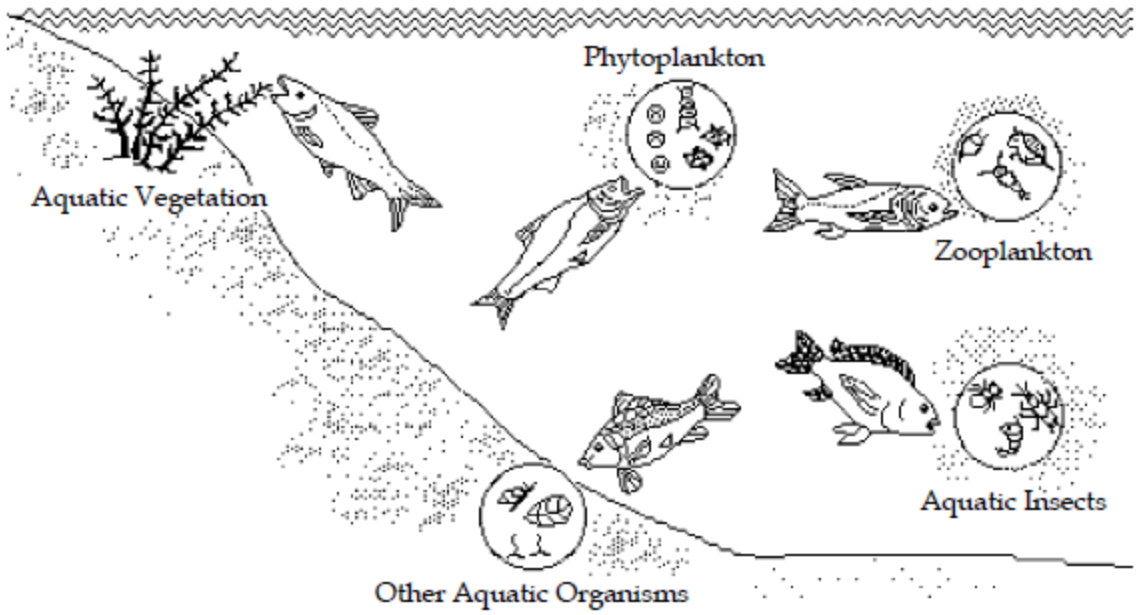


Figure 1: Polyculture utilizes natural foods efficiently.

FISH USED IN POLYCULTURE

Combinations of three Chinese carps (bighead, silver and grass carp) and the common carp are most common in polyculture. Other species may also be used. While fish may be grouped into broad categories based on their feeding habits, some overlap does occur. Descriptions of the feeding habit categories and examples of fish from each category follow.

Plankton Feeders

Plankton is normally the most plentiful food in a pond so it is very important to include a plankton feeding fish in a polyculture system. This group of fish feeds on the tiny, free floating plants (phytoplankton) and animals (zooplankton) which multiply abundantly in fertilized ponds. Two fish typical of this group are the silver carp, *Hypophthalmichthys molitrix* (Figure 2), and the bighead carp, *Aristichthys nobilis* (Figure 3). Other plankton feeders include:

Country/Region	Local Name	Scientific Name
China	ma lang yu	*Squaliobarbus curriculus*
	ca choi	*Labeo collaris*
	striped mullet	*Mugil cephalus*
India	catla	*Catla catla*
	fringe lipped carp	*Labeo fimbriatus*
	white carp	*Cirrhinus cirrhosa*
	Cauvery carp	*Labeo kontius*
	bata	*Labeo bata*
Indochina	sandkhol carp	*Thynnichthys sandkhol*
Vietnam	ca duong	*Hypophthalmichthys harmandi*
Worldwide	blue tilapia	*Oreochromis aureus*
	nile tilapia	*Oreochromis niloticus*

Mono Sex Culture

Mono-sex culture is based on the culture of fish by producing all males or all females depending upon the sex which have better food conversion ratio and growth rate. Sex of fish genetically is determined by the sex chromosomes (X, Y, Z, or W). The male determining gene M is present on any of the three X, Y and W. in XY mechanism, the females are XX and males are XO. Some species have ZZ female and ZW male. In platy fish there are 3 sex chromosomes – X, Y and W; XX, WX and WY are some combinations.

However for all male or female productions the flowing procedures are maintained –

The sex of fish is identified before maturity and male and females are separated. The process is laborious. Desired quantity of male or females are not produced by that process.

Experimental hybridization in Tilapia can produce monosex stock. Inter specific and intra

specific mating yields monosex male stocks as follows

♂ T, macrohir × ♀ T. nilotica
♂ T. hornorum × ♀ T. mossambica
♂ T. mossambica × ♀ T. nilotica
♂ T. mossambica (African) × ♀ T. mossambica (Malaysian)

Treatment with sex hormones: It is another easiest way, when male sex hormone methyl testosterone is administered through feeding in early developmental stages of female fish. The genotype female (XX) then transferred to phenotype male (XX). If such sex reversed male are crossed with normal female, the progeny will be 100% female. The gonads of fish (teleost) are undifferentiated at early stages of maturity and it can be triggered to produce male or female gonads by that process.

Sex reversed male (XX) × Normal female (XX)
↓
Female (XX) ……. F1

The hormone treated sex reversed male are generally not fit for human consumption. But F1 progeny is normal female and suitable for human consumption. But sometimes the culturist does not produce F1 progeny to produce only male population. In case of Tilapia the little amount of methyl testosterone (15-60mg/kg of food) is administered. The drug is given for 30-50 days of life, during which gonadal differentiation takes place. The uses of estrogenic steroids are not successful. However the production of all females has been attempted in salmon and trout. Oral administration of 17-ß estradiol at 20mg/kg of food is given to the juvenile trout & salmon up to 60 days resulted sex reversal of males to females. In pacific salmon (Onchorhynchus spp.), the immersion of young fish in drug as well as feeding appears to be necessary for sex reversal.

Necessity of Monosex Culture:

Some time one sex of certain species has better growth rate and food conversion efficiency. To culture that sex (male/female) monosex culture is essential. For example we can say that the male Tilapia grows faster than female, then the culture of male is beneficial in case Tilapia.

When the fecundity of certain species is very much high and if they can breed in captivity without any inducing agent, there is the possibility of overcrowding of fish, which leads to stunted growth (due to the prolific reproduction e.g. Tilapia).

The production of monosex fish is easier than the production of sterile fish, so in commercial purpose generally monosex cultured is mostly prefer.

Example of Monosex Production in Nature:

Induced fish breeding

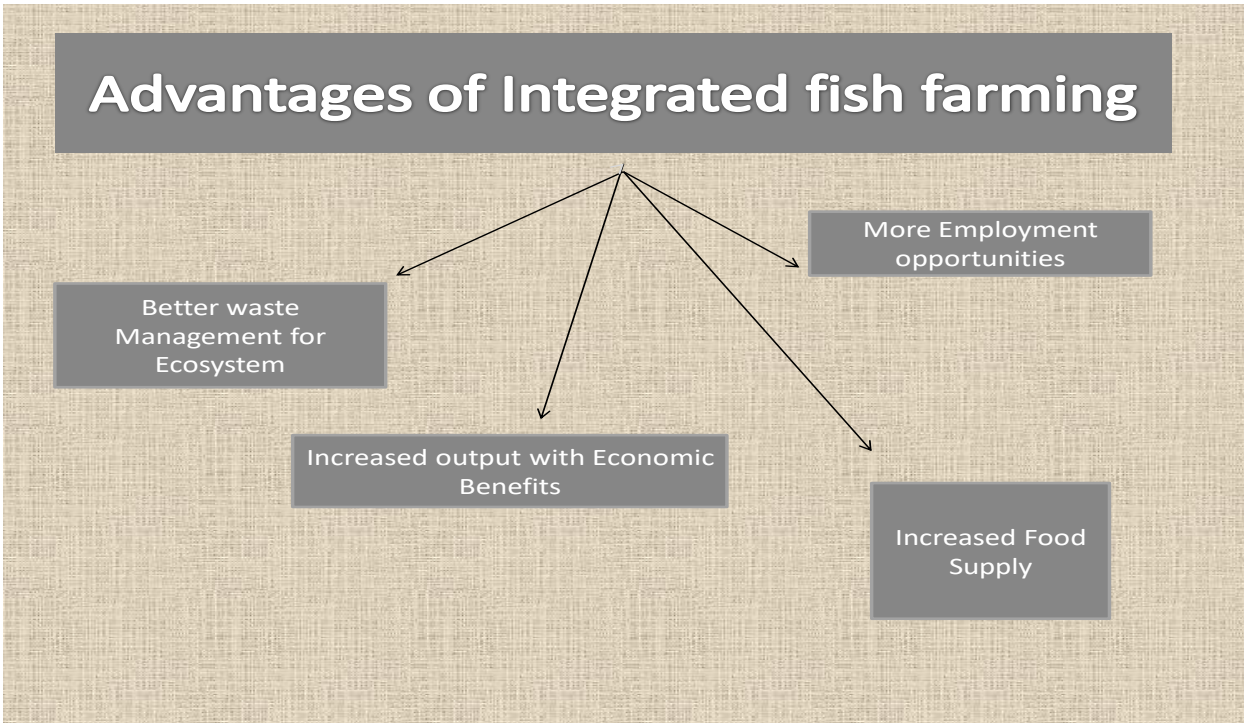
INTRODUCTION When the breeding is not allowed to occur naturally but is induced artificially in fishes such a process is called induced breeding. Availability of required quantity of fish seed of desired species is one of the most important pre-requisite for successful fish farming. The widely cultured Indian

major carps in inland waters like catla (Catla catla), rohu (Labeo rohita), mrigal (Cirrhinus mrigala) and calbasu (Labeo calbasu) and Chinese carps, silver carp (Hypophthalmichthys molitrix), big head (Aristichthys nobilis), grass carp (Ctenopharyngodon idella), black carp (Mylopharyngodon piceus) and mud carp (Cirrhina molitirella), normally do not breed in confined waters. They do mature there, but only breed in the flooded shallow areas along the course of the rivers during monsoon months which are their natural habitat. The Indian major carps do spawn in the specialised environments of bundhs, both wet and dry where lot of rain water is accumulated during monsoon period. Under such circumstances the fish culturists had to depend for the fish seed on collection from river systems and the collected fish seed consisted of not only of desired species, but also of uneconomic species including predators. The inability of Asiatic carps to breed in confined stagnant waters is owing to the lack of needed ecological stimuli to effect secretion of required quantity of gonadotrophic hormones and so extraneous hormones such as pituitary extract or synthetic hormones are injected to brood fish to induce them to breed. The first success in inducing the Indian major carps was achieved in 1957 (Chaudhuri and Alikunhi, 1957) and in silver carp and grass carp introduced in India in 1959, in the year 1962 (Alikunhi et al., 1963). Collection and Preservation of Pituitary Gland In India, generally, pituitary glands are used as an inducing agent to breed Indian major carps and Chinese carps. The glands are collected from fresh gravid fishes as well as fishes well preserved for a period of a week or so. Using a sharp butcher's knife the scalp is removed exposing the brain. The entire brain is lifted carefully, disconnecting the olfactory and optic nerves. On removal of the brain, the pituitary gland can be seen covered with a membrane, thin or thick and removed with a pair of forceps. Sufficient care has to be taken while removing the gland, so as to avoid any damage to the gland. Glands are also collected from the fish heads cut off from the body of the fish. While cutting the head, posterior part of the cranium also is cut, leaving sufficient space to remove the brain and collect the gland. After removal, the glands are immediately kept in absolute alcohol in phials or bottles for preservation. After 24 hours the glands are kept in fresh absolute alcohol. The glands of females and males can be preserved together and also the glands of Indian major carps and Chinese carps. The glands are kept under refrigeration for long duration but for short period may be kept in room temperature. Absolute alcohol dehydrates and defattens the glands. The glands may be weighed individually or in small lots before hand for use and their record kept. Common carp is a good donor of glands. Since in tropical countries they mature throughout the year, year round collection is possible. Glands from induced bred fishes, soon after spawning are also collected, as they are found potent, but glands from immature fishes are normally not used

INTEGRATED FISH FARMING (IFF)

Integrated farming may be defined as a sequential linkage between two or more farming activities. When the fish becomes a major commodity of this system it is known as integrated fish farming **(IFF).** Thus, the practice of Combining Fish Culture with Agriculture or livestock for full Utilization of resources and increased production is commonly known as Integrated Fish Farming.

PROSPECTS /Advantages of IFF: They include efficiency in resource utilization, efficient utilization of wastes from other culture practices, reduction in risks by diversifying crops, recycling of wastes/ by products of one farming system as input for another system, efficient utilization of available farming space for maximum production, additional source of food and income, a reduction in additional cost for supplementary feeding & fertilization. In fact, IFF is an artificial balanced ecosystem without any waste. It generates more avenues for employment, it reduces the input and increases output and economic efficiency. IFF provides fish, meat, milk, vegetables, fruits, fodder, eggs, grains, & mushroom etc. Altogether, IFF has enough potential for rural livelihood & socio-economic status.



SCOPE

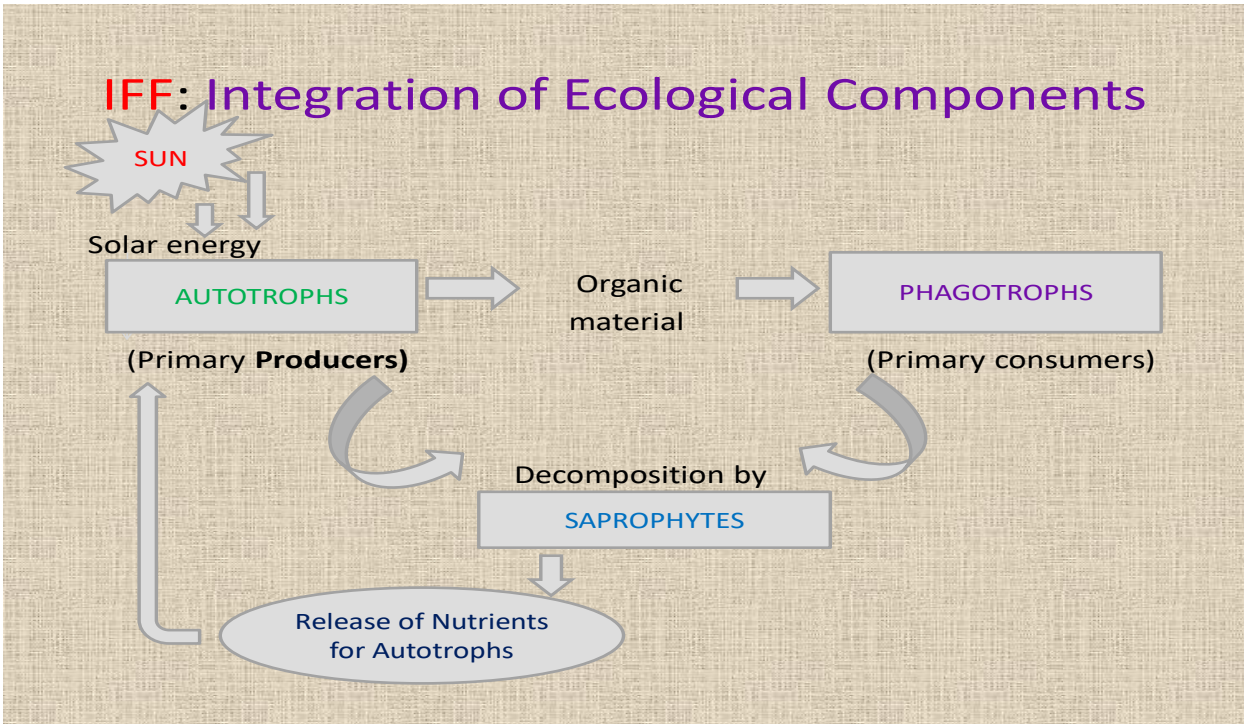
- Utilizes wastes from different components, livestock, poultry, & agriculture by products for fish production.
- Complete recycling of wastes: Organic wastes(40-50 kg) → Fish (1kg), pond silt utilized as fertilizer for fodder crop → livestock/poultry/fish feed
- Raising of ducks and geese

Pond dykes → horticulture , agriculture crop production & animal raising.

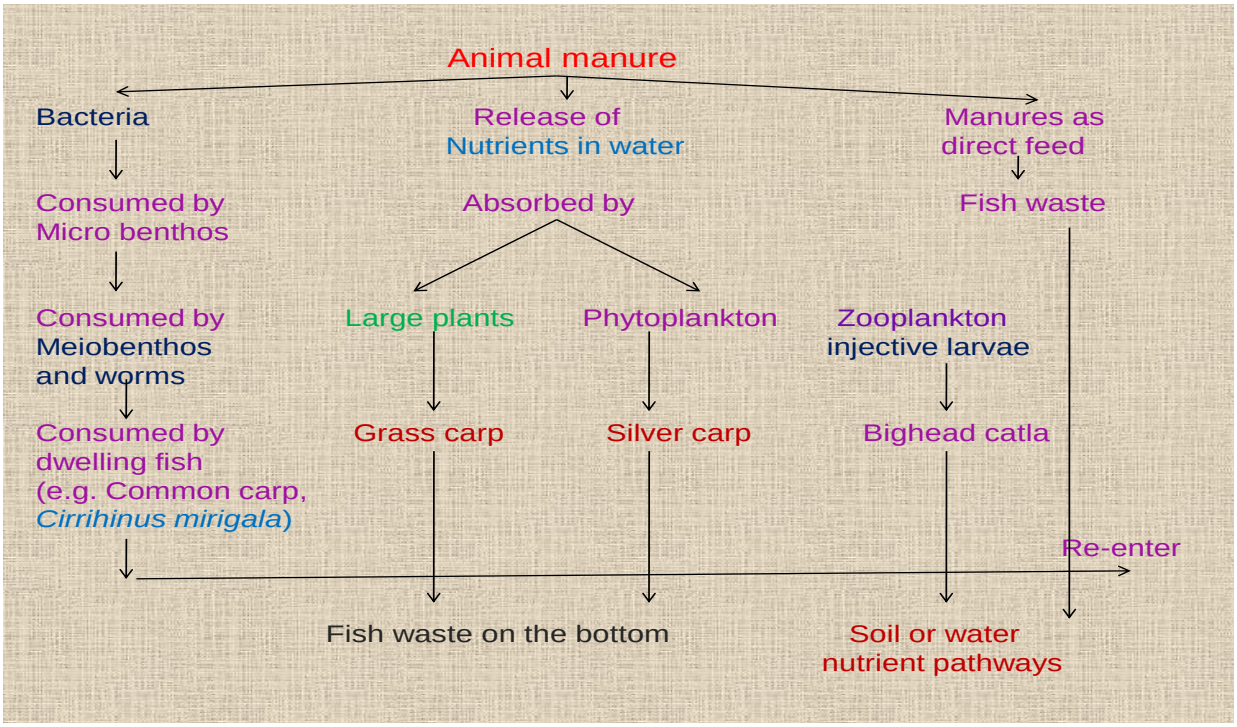
- The system provides meat, milk, eggs,fruits,vegetables,mushroom fodder & grains, in addition to fish.
- Utilizes water bodies, water surface, land , and pond silt for increased food production
- Holds great promise for augmenting production, betterment of rural economy, employment generation, and improving socio-economic status

IFF: Displays Integration of Ecological components- In IFF different ecological components displays a perfect integration. Sun is the ultimate source of energy. Solar energy is trapped by chlorophyll bearing autotrophs. They produce food (organic material) and thus, are designated as primary producers. The food is consumed by primary producers (Phagotrophs). Both

autotrophs and phagotrophs after their death are decomposed by saprophytes. Ultimately, the nutrients are made available in the pool for authotrophs.



IFF: A model for sustainable food production: IFF is an appropriate model for sustainable food production. Wastes (output) of one biological system serve as nutrients (in-put) for another system in IFF. For example in carp farming, animal manure can be efficiently employed as potential nutrients. Likewise, plants & fish integration results in a polyculture that enhances diversity and multiple yields. In IFF, water is re-used through biological filtration and re-circulation.IFF also involves local production of healthy foods and improvement in local economy.



SOURCE: Handbook of Fisheries and Auaculture, ICAR, New Dwlhi, (2006).

Justification of IFF for country like INDIA: India being an agrarian economy produces large quantities of animal & plant residues, to the tune of over 322 & 1,000 million metric tones, respectively, on annual basis. Our country provides larges bovine population of over 307 million cattle heads, along with 181 million sheep & goats, 16 million pigs, & over 150 million poultry and other livestock. Apart from activities like mushroom cultivation, rabbit rearing, Sericulture, Laculture and Apiculture, which provide huge quantities of organic material for aquaculture, different agro-based industries also produce effluents which could be effectively used after proper recycing for aquaculture in addition to the domestic sewage to the extent of over 4,000 million liters on daily basis.

Integrated Fish Farming: Types A. Fish farming with Agriculture (Agri-based fish farming);

1. Paddy-cum Fish culture, 2. Horticulture-cum Fish culture: Vegetable-cum Fish culture, Fruits-cum Fish culture, Flowers-cum Fish Culture, Mushroom-cum Fish Culture, Sericulture-Fish Culture, Fodder crops-fish Culture

B. Fish farming with Livestock (Live-stock fish farming): Fish cum pig Culture, Fish cum duck culture, Fish cum Poultry culture, Fish cum cattle culture.

A. Agri-based fish farming
1. Paddy – cum Fish Culture

- It is commonly practiced in countries like Japan, Malaysia, China and India (Southern and North eastern states: Assam, Bengal, Bihar Orissa, AP).
- Paddy fields remain flooded with water for considerable duration (3-8 months) hence fish can be grown along with rice at low additional cost.
- Traditional varieties of rice that require little inputs of harmful pesticides and fertilizers are more suited.

Advantages of fish- cum paddy culture

- Fish production is done at no additional cost.
- Rice production is increased by 10-15% due to increase in fertilization by fish excreta.
- Unwanted aquatic weeds and algae are eliminated by fish.
- Insect pests of rice like stem borers are eaten by fish.
- Mosquito larvae are eliminated by fish, thus controlling malaria.
- Fingerlings produced can also be sold in market.

Paddy-cum Fish Culture: Types of paddy plots

- (i) Perimeter type: paddy is grown in the middle
- (ii) Central Pond type: paddy is grown on the perimeter of paddy fields.
- (iii) Lateral trench system: Paddy is grown in the trenches provided on on either one or both the sides of the moderately slopping field.
- NOTE: Interest in paddy-cum fish culture is declining, CPC, High Yielding Rice Varieties

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2. Horticulture-cum Fish Culture

- ICMR recommends 85g of fruits and 300g of vegetables for every human being on daily basis.
- Fruits and vegetables are rich in vitamins & minerals.
- Crops of fruits, vegetables & flowers can be cultivated on inner and outer dykes and adjoining areas of the fish pond.
- Crop plants should be seasonal, evergreen, dwarf, remunerative and less shady.

Horticulture-cum Fish Culture

(i) Fish cum aquatic herb culture

- *Euryale ferox (Makhana)* and *Trapa indica (Singhara)*, two aquatic herbs, can be integrated along with air-breathing or carnivorous fishes.
- These cash crops are cultivated in many states as they have both nutritional & medicinal values.
- This acts as additional income with little input and care.

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Horticulture-cum Fish Culture :

Makhana cum fish culture

- It is a common practice in Bihar to grow air breathing fishes with Makhana plants.
- Fish species suitable for culture are *Heteropneustes fossilis*, *Clarius Batracus* and *Anabas testudenius*.

Trapa cum fish culture

The common chestnut, *Trapa indica* is another herb cultured in Tropical water bodies. It can also be coupled with Fish farming .

(ii) Horticulture-cum Fish Culture

Fruits- Fish Culture

- Banana, mango, papaya, lime and coconut plants can be cultivated on the pond embakements in rows, by making ditches between the rows, ditches have continuous supply of water.
- Air breathing and larvivorous fishes such as *Channa marulius, C. striatus and Tilapia* can be cultured in these ditches, which have a rich population of insects larvae.

(iii) Horticulture-cum Fish Culture: Vegetable-cum fish culture

- Vegetables are rich in a variety of nutritive elements.
- Selection of the suitable crop is the main criterion.
- Seasonal, fast growing and market ready crops should be preferred.
- Brinjal, tomato, gourds, cucumber, chili, carrot, radish, turnip, spinach, cabbage, cauliflower, ladies finger etc may be the choice.

(iv) Horticulture-cum Fish Culture: Flowers-cum fish culture

- Flowering plants like Rose, jasmine, Marigold, Gladiolus, Chrysanthimum and poppy etc. can be successfully cultivated along the pond embankment.
- Flowers provide fragrance and beuty.
- They have ready market.
- Flowers-cum fish culture provides 20-25% more returns in comparison to aquaculture alone.

(B) Live-stock fish farming

- Live-stock resources can be successfully cultured along with a variety of fishes having good food value.
- Both indigenous and exotic breeds of live-stock can be accommodated.
- Pigs, Poultry, Ducks, Cattles, Goats and Rabbits are good reference of live-stock.
- Major carps are the suitable choice.

(i) Fish cum pig culture

- Fish culture is linked with pig husbandry by providing pig houses on the pond embankment.
- wastes and excreta is directly drained into pond.
- Pig dung is a good fertilizer.
- Fish feeds directly on the excreta which contains 70% digestible food for fish.
- This system of integration is very common in China, Taiwan, Vietnam, Thailand, Malaysia, Hungry and some European countries.

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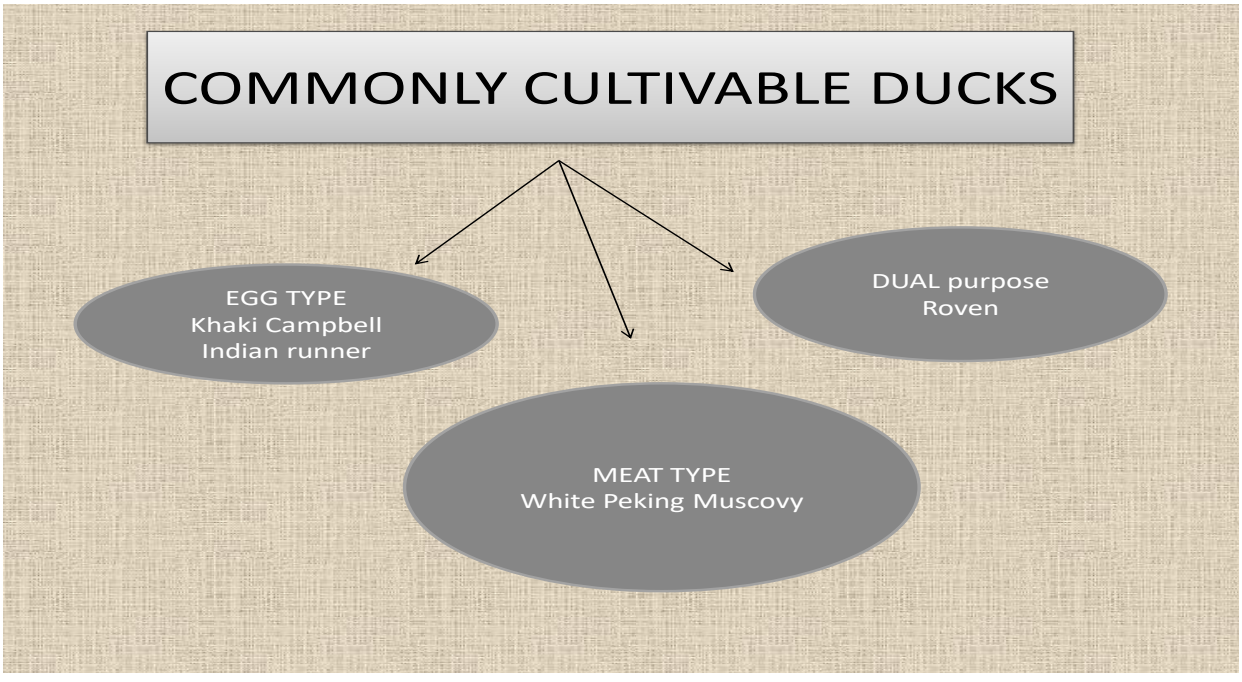
Advantages of fish cum pig culture

- Pig meal is very cheap. The pigs are fed on pig mash which is largely composed of agricultural wastes, viz. rice bran, rice polish, wheat bran, broken maize, ground-nut oil-cake, fish meal mineral mixture, salt, spoiled vegetables etc.
- Annual yield: 3000-4000kg/ha/fish; 4500kg pig meat; 800 piglets.
- Popular breeds of pigs for integration with fish: The white Yorkshire, Hampshire, & Landrace.

(ii) Fish -cum duck culture

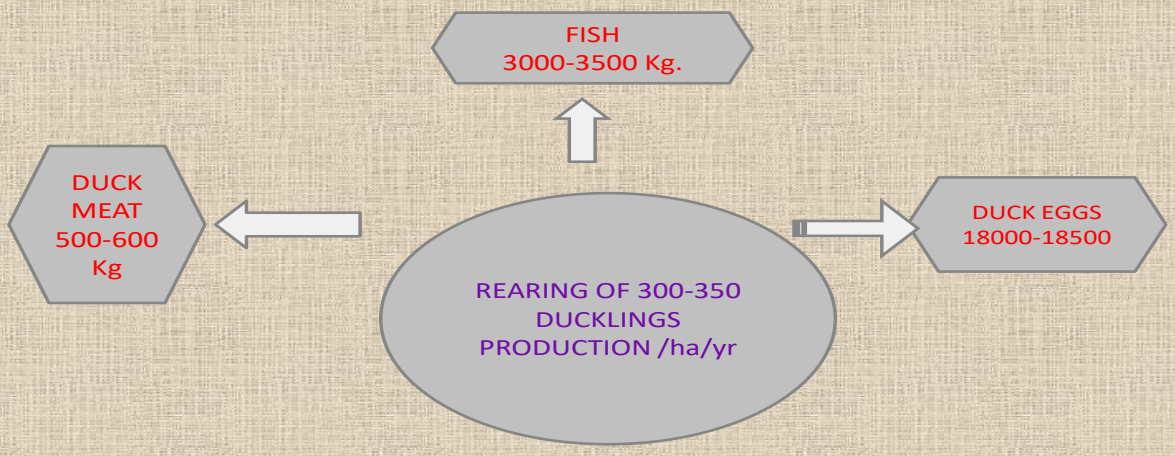
- The raising of ducks along with composite fish culture is a profitable practice in terms of flesh produced per unit area.
- The ducks feed on aquatic insect larvae and enrich the water with their droppings which act as fish feed and also proliferate growth of planktons.
- Duck droppings contain 25% inorganic substances including carbon, phosphorus potassium, nitrogen, calcium etc., which acts as fertilizers in fish ponds.
- Fish-cum duck culture is plasticized in Assam, A.P., Tripura, Bihar, Tamilnadu, Orissa, Kerala, U.P. etc.



Advantages of fish cum duck culture

- **Enhanced production coupled with decreased expenditure on fertilizers for the pond.**
- **Duck droppings cause enhanced production of planktons which serve as fish food.**
- **Ducks help in eradication of aquatic weeds (*Lemna, Azolla* etc.), auqatic insects, other like mollusks, tadpoles etc.**
- **Ducks act as 'biological aerators' by splashing water with their webbed feet.**
- **Rearing of 300-350 of ducklings is sufficient to fertilize 1 ha of pond by their droppings.**

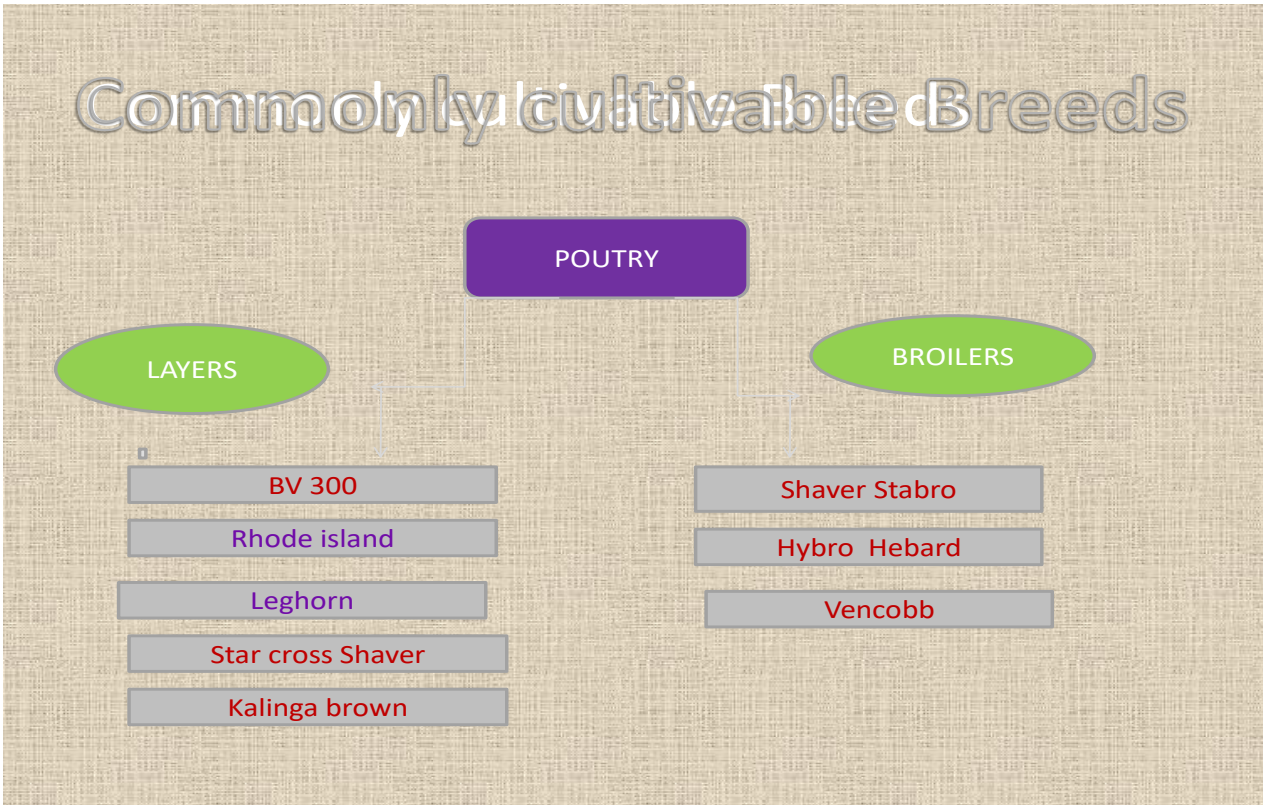
Fish- cum Duck Culture



(III) Fish -cum poultry farming

- This practice utilizes poultry droppings of fully built-up poultry litter for fish culture.
- The droppings of poultry are rich in nitrogen and phosphorus and are used as fertilizer for fish ponds.
- Poultry houses (0.3-0.4 sq. m. space /bird) are constructed above the pond with bamboo sticks so that droppings may directly fertilize the water.
- The enhancement in meat and egg production is accompanied by decreased use of fish food in combined cultures.
- Under the integrated fish cum poultry farming chemical fertilizers and supplementary feed for fishes are not required.

- Approximately 500-600 no. of birds are reared in 1ha pond.
- The annual yield includes: 4500-5000 kg/ha fish, 1250 kg. chicken meat, and 70,000 no. of eggs.
- The poultry birds (layers) are fed with starter, grower and brooder feed according to their age. Hoopers are used to feed them and to minimize the feed wastage.
- In India, this practice is prevalent in A.P., Bihar,Haryana, Kerala, Ms., UP, WB, TN, & Orissa.



(iv) Cattle- cum fish culture

- In this system of integration where the cattle dung, oxidized in biogas plants is transferred to fish pond through small channels to act as manure.
- It is advantageous to construct cowsheds near the ponds as the cow dung acts as fertilizer for propagation of natural fish food in water like planktons.
- 5-6 cows can provide adequate manure for 1 ha pond in addition to 9000 lt. milk & 3000-4000 kg. fish annually.

Species suitable for cattle- cum fish culture

Fish species	Breeds of cattle
• *Cyprinus carpio*	Holstein-Frisian.
• *Cirrhinus mrigala*	Brown Swiss
• *Catla catla*	Jersey
• *Hypothalmichys molitrix*	

Advantages of cattle -cum fish farming

- It is common practice all over the world.
- The cow excreta is most abundant in terms of availability. A health cow may excrete over 4000-50000 kg of dung and 3500-4000 lt. of urine.
- The BOD of cow manure is lower than other livestock manure.
- It provides higher source of income to farmers with small land holdings.
- This practices realizes the full potential of aquaculture.
- The fish survival rate in cow-manured ponds was found around 98 per cent.

(v) Goat-cum fish integration

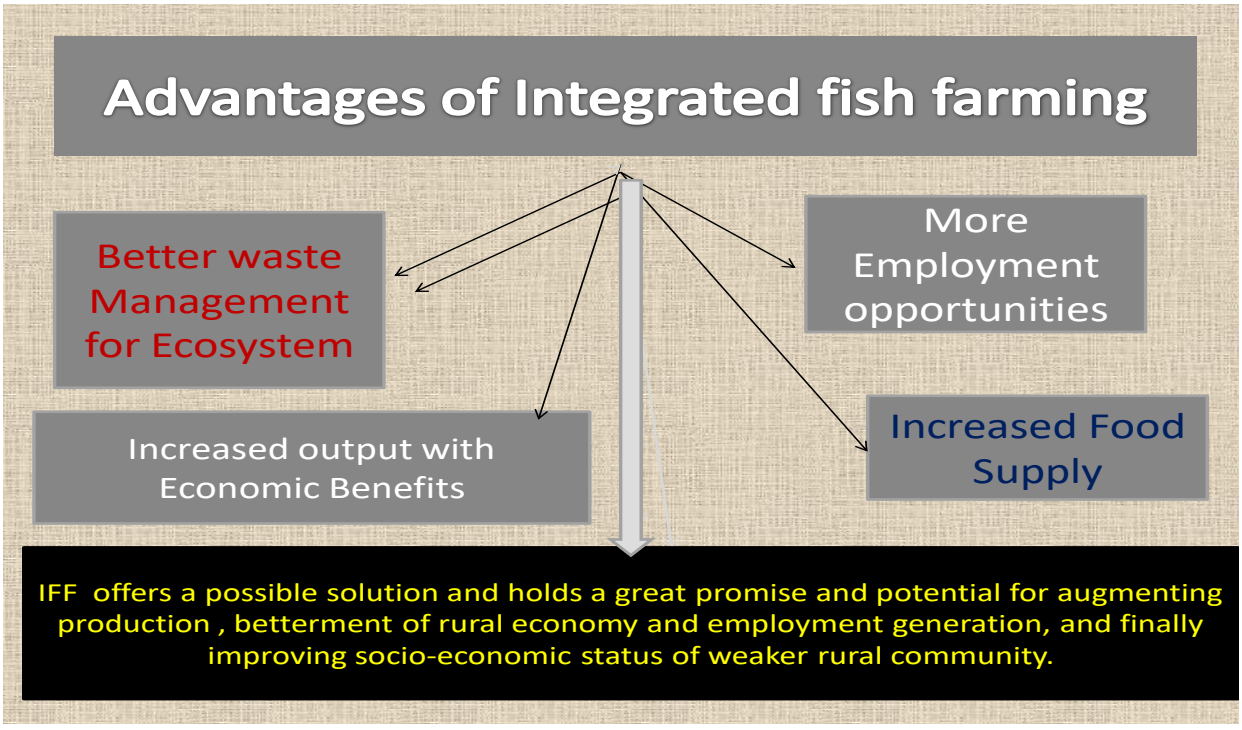
- Goat's excreta is considered as a very good organic fertilizer. (organic carbon-60%, N-2.7%, P-1.78%, k-2.88%) and its urine is also equally rich in both N & P.
- 50-60 goats are required to fertilize 1 ha pond.
- The goats should be provided with dry, safe, comfortable house protected from excessive heat.
- Goats are selective feeders and consume Berseem, Napier grass, Cowpea Soybean, Mulberry etc.
- The suitable goat breeds are Jamanapari, Beetal, Barbari, Barbari for milk and Bengal, Sirihi, Deccani are used for meat.
- This integration can provide 3500-400 kg fish/ha/year without supplementary feeding and fertilizer.

(VI) Rabbit-cum fish integration

- Rabbit meat is preferred due its low fat content.
- Rabbit excreta (carbon-50%, N-2%, P-1.33%, and K1.33%) is high in nitrogen content and low in moisture, thus forms quality manure for sustained plankton production.
- The excreta of about 300 rabbits would be enough for 1 ha pond's fertilization.
- Important meat breeds of Rabbit: Gray Giant SovietChinchilla,, & White Giant.

Constraints of IFF: Aqua farms in Asian countries are still operated by traditional ways without proper planning, application of latest technologies and management techniques, farmers largely depend on personal experience., Marketing of farm produce is not certain for reasonable price, lack of knowledge and inadequate experience may bring losses to farmers due to disease outbreaks, lack of working capital, middleman, low price, non-availability of extension services.

CONCLUSION: Fish culture integrated with agriculture and livestock provides a higher source of income to the farmer having a small land holding. These practices help in improving production with little additional expenditure. It is expected that IFF practices will increase in the near future in suitable agro-climatic regions of the country as they are dependent on eco-friendly measures and ensure higher returns as well as sustained production levels of fish and other bio-resources.



Reference:
*Online materials