Part IV

SUGGESTED AQUACULTURE HANDOUTS FOR TOT/FFS

THE FOLLOWING HANDOUTS HAVE BEEN DEVELOPED FOR TOT/FFS BY THE PROJECT FAO/TCP/RLA/3003 (D) "INTRODUCTION OF AQUACULTURE AND OTHER INTEGRATED PRODUCTION MANAGEMENT PRACTICES TO RICE FARMERS IN GUYANA AND SURINAME".

1st Week Session

INTRODUCTION

Fish culture in rice paddies has long been practiced worldwide, particularly in the irrigated rice producing areas in tropical countries. In South-East Asia, varying methods of rice-fish culture are being practiced, applying different approaches to the technical problems encountered, with the aim of ensuring economic benefits derived from the system. Although rice-fish culture is known to have existed in many countries centuries ago, not much has been known about it in Guyana and Suriname.

Rice in combination with fish forms an ideal food for both the Guyanese and Surinamese people. While rice is the main dietary source of carbohydrates, the fish supplements protein, since it is an important source of cheap and easily digestible animal protein.

Rice-fish culture is one component of aquaculture which has great potential for development in Guyana and Suriname, due to the vast areas of irrigated rice fields present in both countries. If properly implemented, it could increase the rice farmer's production and income, since two crops, rice and fish, will be grown. Adoption of proper techniques in rice-fish culture is expected to help improve food security in the Caribbean Region and increase the profit of rice farmers in Guyana and Suriname.

It is envisioned that close cooperation between farmers and government technicians will remove the present constraints for the introduction of rice-fish culture and the production of both commodities would be enhanced considerably. Improved techniques developed in one area could be extended into another with similar physical and environmental conditions.

1. Rice-fish culture practices in Asia

Rice-fish culture is the simultaneous or alternate production of fish in a rice field. It consists of stocking the rice fields with fish of selected size and species to obtain a fish crop, in addition to rice, which is the main crop.

a. Two types of rice-fish culture

i. Simultaneous rice-fish culture: Rice and fish are concurrently cultured in the same field, rice being the main crop and fish as the secondary crop. Since rice is the primary crop, the fish culture activities have to be adapted to the requirements of the rice farming activities.
ii. Alternate or rotation of rice and fish: Rice and fish are cultured, one after the other. This is known as rotational cropping of rice and fish.

b. Advantages of simultaneous rice-fish culture

i. Grain output of rice is increased in the presence of fish;
ii. Fishes help in controlling the weeds;
iii. Fishes help in the control of insect pests;
iv. Fishes help in the biological control of mosquitoes, the carriers of many human diseases, particularly malaria;
v. Fishes help in the control of snails, which are harmful to rice plants and also act as

a secondary host for many diseases of human beings;

vi. Rice field tillering caused by the grazing of fish results in higher yields of rice;
vii. Fish excreta also fertilizes the rice fields;
viii. Farmers usually pay more attention in the raising double crop, and chances of better returns are increased;
ix. Fish is also a source of animal protein and gives an additional income to the farmers;
x. Concurrent culture of rice and fish achieves increased economical utilization of land.

c. Advantages of rotational/alternate rice-fish culture

i. It allows better care and better cultural techniques for both rice and fish (for both can be undertaken without any detrimental effect on each other);
ii. Pesticides can be used in this system, for a higher yield of rice;
iii. The system permits greater water depth for fish production, since fishes are cultured after harvesting of rice. The higher water level will give better survival and growth of fishes.
iv. The digging of trenches and canals is not essential;
v. Better control of insect pests is possible, because their life cycles are disrupted;
vi. The residues from fish culture can act as fertilizer for rice plants
vii. Rice stubbles/stalks rot after being submerged and promote growth of fish food organisms.

d. Basic considerations

i. Site Selection:
    a. Good soil type: Must contain high percentage of clay to be able to hold water for a long time.
    b. Good Water Supply: Must be clean, free from pollution and poisonous substances, wild fish and excess silt. Must be capable of supplying the recommended depth at all times.
    c. Must be free from floods.
ii. Design and Size of Plots: Each plot should be capable of being filled or drained independently of any other plot, for easier water manipulation, and to prevent the spread of insects or diseases. The recommended size of rice-fish plot is from 500 square meters to 2,500 square meters, for easy management.
iii. Construction of Trenches: Trenches are dug to provide a retreat for fish during periods of temperature extremes, or when fertilizers and selected pesticides are being applied. They also serves as a refuge in case of unexpected drop in water level, as passageways for easy movement of the fish around the plot, as a regular site for fish feeding, and as catch basins during harvest time. Trenches should not occupy more than 10% of the total paddy area.
iv. Construction of Dikes/Meres: Dikes of plots intended for rice-fish culture must be larger than those used for rice culture alone. They must be sturdy enough to hold more water for a longer period of time.

v. Installation of Water Inlets/Outlets and Screens: All water inlets and outlets should be equipped with fine mesh screen to prevent entrance of unwanted fish and/or escape of cultured fish. During the rice-fish culture period, screens should be cleaned regularly to prevent clogging and the resulting poor water flow.

e. General considerations for management

i. Selection of Fish Stock: The species of fish to be used in rice-fish culture should be able to withstand rice paddy conditions, such as shallow water, high and variable water temperature, low dissolved oxygen content and a high degree of turbidity. They should be fast growing as well.

ii. Fish Stocking Rate:
   a. Simultaneous rice-fish culture: 5,000 to 10,000 fingerlings per hectare, to be stocked two weeks after rice transplanting or three weeks after sowing.
   b. Alternate rice-fish culture: 10,000 to 20,000 fingerlings per hectare for paddy fields having a water depth of 20 centimeters, or 20,000 to 30,000 fingerlings per hectare if water is more than 50 centimeters deep.

iii. Rice Variety: The rice varieties should be locally available, high yielding, tolerant to high water depth and resistant to insects and diseases.

iv. Insect Pest Control: Pesticides are toxic to fish and their use to control rice pests can adversely affect rice-fish culture. Pesticide applications should be avoided as much as possible in rice-fish culture. Application of IPM technology is the best option for controlling pests harmful to the rice.

v. Fertilization: Part of the fertilizer applied to the rice plants goes to the production of planktons and other organisms which are the natural food of the fish.

vi. Water Management: The plot should be flooded deeper, if possible at all times, to make it more conducive to fish growth. In simultaneous rice-fish culture, the water should be kept to the maximum depth which rice can tolerate.

vii. Supplemental Feeding: This is required to maintain the normal growth rate of stocked fish until harvest.

viii. Harvesting: In simultaneous rice-fish culture, the fish are harvested 5-7 days ahead of the rice. In alternate rice-fish culture, fishes are harvested by totally draining the plot after four or more months of culture, depending on the availability of water or the onset of the next rice cropping season.

2nd Week Session

2. Modified rice-fish culture for Guyana and Suriname

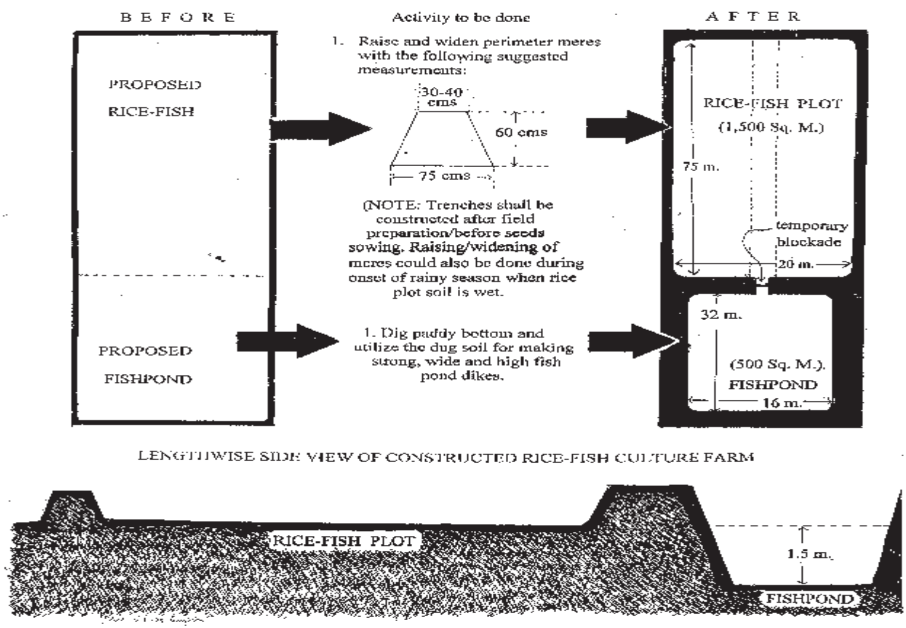
Conventional rice-fish farming systems successfully practiced in Asia may not do well in either the Guyana or Suriname situation, unless the existing physical rice field conditions in both countries is modified, taking into consideration the constraints raised by farmers, especially their dependence on chemicals for rice production. For the purpose of trial and demonstration, the Project utilizes small areas from whole rice field plots belonging to collaborating farmers. The area utilized is 2,000 square meters (less than half of an acre) for easy management, where one-fourth of it is developed into a fish pond. The fish pond is located at the lowest part of the rice plot.

A rice field comprising ¾ of the total plot area is modified by raising and widening the bunds to hold enough water during the culture period of the fish. A center trench is constructed lengthwise in the rice field, with one end connecting directly into the opening in-between the rice field and the pond. The trench does not occupy more than 10% of the total rice field area.

a. Advantages of this modified system are as followings:

i. Fish can be held in the pond when there is a compelling need for the farmer to apply chemicals in his rice.
ii. Undersize fish can be grown longer in the pond if the culture period of fish in the rice field is too short.
iii. Fingerlings produced inside the rice field could be kept in the pond for further growing, while waiting to be released back into the rice field come next rice cropping season.
iv. Fish can seek refuge in the pond if water in the rice field trench suddenly drops to an unsuitable level.
v. The system will give farmers optimum fish production as a dual system of fish farming in the rice plot and pond is applicable.
vi. Fish seed production is continuous even after the rice harvest, which helps solve a problem of fingerlings supply for the next rice-fish cropping season.
vii. Selective harvesting of fish is possible inside the pond, especially during the peak of the dry season, where draining of pond water is not possible.

FIGURE 1.CONSTRUCTION OF A MODIFIED RICE-FISH CULTURE FARM



b. Fishpond Management

Poor yields in fish culture are usually attributed to poor management. Good pond management includes the application of the right amount of fertilizer, use of appropriate fish stocking density, elimination and control of aquatic weeds, prevention of entry and control of predatory animals and competitors of fish, proper water management, use of supplemental feeds and correct harvesting technique.

c. Pond/Rice Field Preparation

Pond Preparation: For an old fish pond, dry the pond bottom by exposing it to sunlight, to kill fish predators and organisms that may cause fish diseases. In a new pond, apply lime to pond bottom and dikes, at a rate of 5 kg/100 m². This will neutralize the soil, making it suitable for the production of natural food for the fish, and kill bacteria harmful to the fish.

Apply animal manure to the pond at the rate of 50 kg/100 m². Let water in gradually to allow production of natural food for the fish until desired water level is attained.

Cropping calendar of activities for modified rice-fish culture farm

	ACTIVITES TO BE UNDERTAKEN	
Farming Day	RICEFIELD	FISHPOND
Pre-Sowing Activites	• Rice field preparation (harrowing/chipping/ raking/hengering)	• Fish pond construction for new pond • Pond preparation for old/constructed pond (sun-drying for 1 week, liming if available at 5 kg/100 m²; application of animal manure at 50 kg/100 m²) • Block opening in-between rice field and pond to prevent chemicals applied in the rice field from contaminating the prepared pond. • Gradually let in water into the pond and maintain at level with the rice field bed.
0	• Sowing of pre-germinated rice seeds	• Irrigate water into the pond at 3” higher than the water level in the rice field.
14 to 20	• Irrigate water and maintain at 3” to 4” level	• Maintain pond water level at 3” higher than the water in the rice field.
21	• Maintain water level at 3” to 4”level • Fertilize rice	• Stock fish fingerlings into the pond at a rate of 2 fish per square meter.
25	• Remove blockade in-between the rice field and the pond. Allow fishes inside the pond to enter the rice field through the center trench.	
45	• Raise water level 5” to 8” deep	• Pond water rises at same level with the rice field • Feed fishes regularly
48	• Fertilize rice	• Continue regular feeding of fishes • Check & repair any leaks found around meres/ bunds/dikes
60	• Raise water level from 8” to 12” deep	• Pond water rises to same level with the rice field • Continue regular feeding of fish
80 to 85	• Drain water gradually and let fishes from the rice field find their way back into the fishpond through the center trench • Close the blockade in-between rice field and fishpond	
95	• Service equipment	• Continue regular feeding of fish inside the fishpond
96	• Check empty sacks • Find rice buyers	
110	• Harvest rice	
		• Harvest large size of fish and allow small sizes to grow in the pond

NOTE: THIS CROPPING CALENDAR OF ACTIVITIES WILL VARY DEPENDING ON THE RICE VARIETY TO BE PLANTED AND ON THE AGRO-CLIMATIC CONDITIONS PREVAILING IN THE LOCALITY.

3rd Week Session

3. Transporting and stocking of live fish

The transport of live fish from the hatchery to any unit of water plays an important role in aquaculture management. Transporting fish involves the hauling of a large number of fish in a small quantity of water. Unless this is done properly, the length of time involved can quickly deteriorate the water quality, which can cause fish mortality.

There are many ways of transporting live fish. Some farmers use boats, others use the suspension net method, oil barrels, plastic tub method, and the plastic bag with oxygen method. Another method uses a hauling box with aerators. The objective of having a good transport system for live fish is to minimize stress to the fish and ensure a high rate of survival.

a. Handling Prior to Transport

Most hatcheries consist of numerous earthen ponds where fish are collected through combined seining and draining. These methods of capture cause stress to the fish. Proper techniques in harvesting should be applied to lessen stress and mortality during the hauling operation. Improper handling may result in immediate or delayed mortality.

b. Holding Process

Fish captured from ponds should be held in happa nets or aerated tanks for about three days prior to transporting. This process is called “conditioning”. Conditioning allows the fish to recover from handling stress after capture. During conditioning, fingerlings should be fed, except for the last 24 hours prior to transporting. The holding net should not be overcrowded with fish during conditioning. If fish are held in tanks, sufficient aeration should be supplied. If fish are seen at the surface gasping for air, increase aeration or decrease the holding rate.

The holding happa net should be tied to poles in the pond to keep it from being blown by the wind. Fine meshed nylon screen happa nets are preferred. Happa nets with large mesh are used for bigger fishes. Tanks used for holding fish should be clean, leak-proof, glazed or painted with epoxy paint to cover rough surfaces. Smooth surfaces will reduce physical injuries to fish.

Overcrowding should be avoided in holding happa nets or tanks especially in the early morning, when the dissolved oxygen (DO) level is low. Well-aerated water can hold more fish than less-aerated water. Approximately 4.4 kilograms of fish could be held in one cubic meter pond water, or 30 kilograms of fish in a happa net measuring 3 meters by 3 meters by 0.75 meters.

c. Transporting Fish Fingerlings by the Plastic Bag Method

This method uses plastic bags of various sizes. But the most common size which can hold a large quantity is 20” x 30” of a 0.003 gauge thickness. Standard size woven bags are used to support the plastic bags. Each woven bag has an approximate capacity of eight liters of water and 1.5 liters of pure oxygen. Four hundred grams of fish can be transported for 24 hours for more than 6 hours; 1,500 grams of fish for not more than 6 hours, for short distances. The loading capacity per bag depends largely on the transport time involved, distance covered and handling techniques used. Likewise, the rate of survival is affected by the water temperature in the bag. The temperature should be maintained at 28°C to 30°C. To reduce fish mortality and stress during the trip, about 500 grams of cracked ice should be placed in between the two plastic bags. This technique increases the survival rate of the fish. Although this method requires a lot of space, it facilitates the transport of fish from one place to another.

The following are some pointers to be followed in using plastic bags for fish transport:

i. One set should consist of one woven bag (pandan bag) and two plastic bags.
ii. Carefully check the plastic bags for punctures; put one bag inside the other.
iii. Place eight liters of water inside the plastic bag.
iv. Water temperature in the holding happa net or tank should be the same as that of the bag.
v. For small deliveries, count fish individually.
vi. For big deliveries, use the average weight method.
vii. Use the recommended loading capacity to reduce mortality due to overcrowding.
viii. Fill the remainder of the bag with oxygen immediately after the fingerlings are placed inside it.
ix. Tie the oxygenated bag with rubber bands immediately to avoid oxygen leakage.
x. Icing is advisable only when transporting fish for more than six hours and if the water temperature is 30°C.

d. Handling after Transport

Stocking the delivered fish seems easy, but it is one of the difficult tasks in fish handling. Before the fish are released into the stocking pond, the water temperature should be checked first to prevent shock to the fish. Abrupt changes in temperature will cause thermal shock to the fish. This should be considered when fish are unloaded at the stocking or delivery sites.

e. Causes and Preventions of Stress

Fish stress may be caused by one or a combination of the following:

i. Harvesting by seining;
ii. Scooping the fish from the seine net to graders, from graders to holding happa nets, from happa nets to hauling units;
iii. Grading fish according to size;
iv. Hauling or transporting.

Fish handling is one of the inevitable aspects of fish culture. Fish stress can be minimized by proper handling and hauling procedures. Stress from handling during hauling in a distribution tank may be severe and can result in immediate or delayed mortality.

Aeration during transport provides oxygen which supplies at least half of the requirement of the fish; it reduces the concentration of carbon dioxide to a satisfactorily low level. In transporting tilapia, the fish have ample oxygen as long as they do not gasp at the water surface. However, if the carbon dioxide level increases, more oxygen is required by the fish. Loading the fish in tanks causes stress; overloading the scoop net also causes stress.

Water temperature in the hauling unit should not differ by more than 5 degrees centigrade from that of the holding water. A difference of 5 degrees centigrade or more requires acclimation. Acclimatization is also needed when stocking fish from freshwater to water with higher salinity. The water temperature should not go beyond 30 degrees centigrade, if hauling units are to be loaded to the maximum, to avoid severe stress. Knowing the loading capacity of the hauling unit will help much in the handling of fish. Undoubtedly, many improperly handled fish are stocked in ponds and eventually die unnoticed.

4th Week Session

4. Construction of nets for use in rice-fish culture

Nets are among the basic gears and equipment in fish culture, and are indispensable in rice-fish culture operations. For ease of use, without harming the fish, it is important for a fish farmer to have knowledge on how to make the right net and its proper use. The types of nets most commonly used in rice fish culture are: happa net, lift net, and scoop nets.

A happa net, which looks like an inverted mosquito net, is used to nurse fry until fingerling size (fine mesh happa net) or used to hold or keep large sized fish alive before stocking or marketing (larger mesh size happa net).

A lift net is an assembly consisting of a plain net cut in a square shape measuring 2 meters by 2 meters seamed with a rope along the edges of its four sides. It is made ready for lift netting operation by stretching it, through the use of two bamboo splits measuring 3 cm width by 8 meters long, tied at the net's opposing corners forming a crossed arc position. It is very effective in catching fishes with no injuries sustained.

A scoop net is a device made of a fine netting material with all openings at the sides and bottom stitched together forming a purse and the upper opening stitched into a round or square shaped iron rod.

5th Week

5. Fish feeds and feeding

a. Supplemental Feeds

Supplemental feeds are prepared diets formulated to provide protein and other nutrients, besides those obtained from natural food organisms in the water. As the fish grow, the natural food in the pond will not be sufficient to sustain the growth of the fish population. Hence, the growth rate will be less than the maximum potential. As the food deficit increases, growth rate decreases.

It is difficult to recommend nutrients for supplemental rations because the nutrient contribution of pond organisms can not be predicted with accuracy. In practice, however, it is unnecessary and uneconomical to balance the supplemental diet for fish ponds according to the absolute nutrient requirements of the fish.

Aside from formulated feeds found in the market, which are costly, there are some natural supplementary feeds good for the cultured fish which are available locally.

6th Week Session

6. Water management

Availability of good quality water is a basic and very important consideration in culturing fish. The water should be free from toxic chemical contamination and of unwanted predatory or wild fishes, and must be available when needed. Oftentimes, however, such ideal conditions are rare, if not absent in most fishpond and rice-fish culture operations.

a. Source

Sources of water for freshwater fishponds and rice-fish farms are deep wells, irrigation canals, free-flowing wells, springs, rivers, dams, rainwater, and streams.

Precautionary measures should be employed when using water from rivers, streams and communal irrigation systems. A simple bioassay can be done using two simple techniques: two or three fish are placed in a bucket full of water from the source to be tested and observed for at least one-half day; or a happa or scoop net with three to five fish situated 25 to 50 meters upstream of the water source, can be used as well. The water is safe for use when the fish remain alive after the test period. Just looking at, or smelling the water, to determine the presence of toxic substances is generally ineffective.

b. Depth

The definite water depth for any specific culture unit or species of fish is not well defined. Nevertheless, deeper water impedes high fluctuation levels of water temperature. Breeding of tilapia is enhanced when water temperature highly fluctuates as in the case of rice-fish fields where tilapia are observed to breed earlier. Tilapia nests are built at an average depth of about 45 centimeters.

To help discourage reproduction and in order to increase the growth of tilapia, water depth in a grow-out pond is maintained at a depth of about 80 to 100 centimeters as much as possible. Sufficient water volume will enhance the production of plankton. In fish paddies where dikes are relatively smaller, a water depth of 50 centimeters was found to be sufficient to grow fish to marketable size when properly fertilized.

Some management modifications are employed when water supply is seasonal. When using rainwater or irrigation water with limited flow, it is necessary to increase the pond volume by increasing water depth. Enough water should be accommodated in the pond during rainy days, if possible.

In rice-fish culture, the paddy field should be flooded deeper, at all times if possible, to make it conducive to fish growth. In simultaneous rice and fish cropping, the water should be kept to the maximum depth which rice can tolerate. When the rice plants are still young, the water is kept at 5 to 8 centimeters deep. As the rice grow taller, the water depth is gradually increased to about 20 centimeters or more, depending on the rice variety planted.

Wind action increases the water evaporation rate in rice-fish fields while high organic content in its dyking materials likewise aggravates water leakage. Water change or leakage causes loss of fertility and fish food organisms.

7th Week Session

7. Pond and rice field fertilization

Fertilizers stimulate the growth of plankton, which is the natural food of the fish. Hence, fertilizers can increase fish yields three to four times. Pond fertilization may be appropriate if the following indicators are observed: measurement indicates low levels of nitrates and phosphates; water is transparent and may contain abundant growth of submerged plants; water is turbid with suspended soil particles or stained with humic substances. However, fertilization may not be recommended in soils containing high levels of nutrients sufficient to support plankton bloom.

a. Use of Organic Fertilizer

In Israel, Tilapia responds better with the application of animal manure than with artificial feeds. The nutrients and organic matter content of manure increase the water-holding capacity of soil, decrease the rate of evaporation and increase enzymatic activity, all of which increase fertility and crop yield. Animal manures contain the major inorganic nutrient components: nitrogen (N): 72% to 79%; phosphorous (P): 87%; potassium (K): 82 to 92%, in addition to such trace elements as calcium (Ca), copper (Cu), iron (Fe) and magnesium (Mg). Urine which comprises about 40% by weight of the total daily excreta has higher nitrogen and potassium levels than feces.

The chemical composition of manure also varies depending upon the animal species, age and condition of animals, nature and amount of manure, and the handling and storage of the manure before use.

b. Inorganic or Chemical Fertilizer

Chemical fertilizers are readily soluble and have high nutrient contents. The problem, however, arises when too much dependence is placed on them, neglecting the soil's organic matter. Likewise, the price of chemical fertilizers may become prohibitive in view of the cost required in processing.

8th Week Session

8. Fish predators and other pests

Fish production in ponds and rice fields is commonly affected by some pests and predators. Predators are organisms which prey on the fish being cultured; the animals that compete for food or space are called competitors.

a. Birds

Herons, kingfishers and other birds should be discouraged from frequenting the ponds. They devour fish and fingerlings. Birds are also carriers of parasites. They are kept away by shooting or trapping. Ponds and rice-fish plots constructed without a shallow area are not attractive to birds.

b. Snakes

Snakes prey on small fish. But, they are not a serious problem. Slopes and top of dikes must be kept clean to prevent harbouring snakes near the ponds/rice-fish plots.

c. Frogs

Fry and fingerlings are eaten by frogs. Tadpoles also compete with the fish for space. Frogs are seldom found in well-fertilized and well stocked ponds/rice-fish plots. Their presence can be controlled by removing their egg sacks from the water.

d. Piscivorous or Predatory Fish and Other Competitors

Huri, Perai, Silver Fish, Sunfish and other species may enter tilapia ponds and rice-fish plots during floods or by accidental stocking with the cultured fish. These predators devour fry and fingerlings during or after stocking. To avoid them, the pond should be drained totally after harvest or before stocking. Huri, which tends to burrow into the mud, can be totally eliminated by sun-drying. If possible, only clean water should be used. Water inlets and outlets should be equipped with the finest screen available. Fingerlings should be properly checked for possible contamination by predatory fish prior to stocking them.

Oftentimes, competitors are associated with predators. They enter the ponds and rice-fish plots the same way predatory fishes do. Silver Fish, Patwa and other species can compete with the stocked fish for space and food.

e. Poachers

Poaching is rampant in most grow-out ponds. There is always the danger of losing fish to thieves. Poaching may be prevented by employing a watchman in the area. Only trustworthy workers should be hired. In addition, access to the pond area should be restricted. Small areas can be fenced and/or lighted. Dogs are excellent guards. They create noise when unusual activities occur.

Dikes should be cleaned of unnecessary vegetation, bushes or trees. Un-kept dikes are excellent covers for poachers and other types of predators. Poaching of stocked fish by netting is greatly prevented by installing stakes or barbed wire underwater.

9th Week Session

9. Pond/rice field fish culture systems

a. Monoculture

The very common and widely adopted culture practice in the production of food fish is monoculture. It is the rearing of a single species of fish in a pond or rice field.

The most economical stocking rate in monoculture is not necessarily that which results in the highest growth rate of per fish per day, but rather that which results in the highest yield per unit area. Performance of the selected strains of tilapia for monoculture should also be considered. Some strains of T. nilotica were found to be inferior. The inferior strains do not respond well to fertilization, reproduce prolifically and cease to grow earlier.

In many tilapia ponds, wild spawning may reduce fish yields to uneconomical levels. The competition by the great number of small fry and fingerlings can result in stunted fish population and growth. The great number of fish below the desired market size reduces the profit of the producer.

b. Polyculture

Polyculture is the rearing of two or more non-competitive species in the same pond. In combining two species, it is ensured that the production of the target species will remain the same or be enhanced by the system. Furthermore, the stocking density of the target species in a polyculture operation must be generally similar to the density of the fish in monoculture. The species of fish to be used in a polyculture system must have different feeding habits and occupy different niches in the pond.

Non-availability of fingerlings recommended for polyculture hinders the wide adoption of polyculture.

10th Week Session

10. Fish stocking density

The growth of fish depends on the number of fish stocked and the number of fishes present in the pond or rice field. This is due to several factors that include density and competition.

Fish stocking ratio is one of several factors that affect fish growth. At a low stocking density, the amount of natural food in the pond is higher for each individual fish and the excess food is not utilized. As long as other factors are not limiting, the daily growth of fish will be better. However, the growth of fish will be slow at a higher stocking density because the capacity of the natural food to support the fish population will be limited to a certain extent. The maximum physiological growth of tilapia is attained at low stocking density.

a. Factors that Influence the Selection of Stocking Densities in Ponds

A common mistake in grow-out production of tilapia in ponds is the selection of proper stocking densities. The failure to select the most appropriate stocking density will result in poor growth and low market value of the fish produced. To insure profit, the stocking densities in ponds must be selected based on the following factors:

i. Market Demand

Market size preferences vary, depending on the place. In some rural areas, smaller fish (less than 100 grams) are highly saleable. Nevertheless, in commercial fishpond operations that require middlemen in the marketing of the produce, large fish command higher prices than small ones.

ii. Productivity of the Pond

The productivity of a pond may be related to its age. Generally, old ponds are more fertile than newly constructed ones. The mud present in old ponds contain organic nutrients that may readily initiate the growth and support the population of plankton that will serve as the natural food of the fish. On the other hand, because of the absence of mud, it will take longer time before plankton growth is initiated in new ponds.

Even with the use of organic and/or inorganic fertilizers in both old and new ponds, old ponds will still be more productive than new ones because of the organic nutrient and plankton seeds contained in the former.

Generally, old ponds can accommodate higher stocking densities than new ponds.

iii. Quality and Quantity of Feeds Used

The stocking density of a pond or rice field can be increased beyond what has been recommended when supplementary feeds are given to the fish. The extent of increase must be based upon the quality and quantity of feeds to be given. A supplementary diet with high protein content is best to use in ponds with a very high fish population. For example, rice bran when mixed with fish meal will produce a better feed than rice bran alone. This is because fish meal has a high protein content. However, the price of fish meal may not warrant its intensive use.

A supplementary diet must be given to the fish at a sufficient level to be more effective. The quantity of feeds to be given to the fish must, however, be complementary to its quality. Feeding the fish at the rate of three to five percent of its body weight is appropriate. The feeds given in excess of this rate may not be consumed and will just adversely affect the water quality of the pond.

iv. Quality and Quantity of Fertilizer and Method of Application

Animal manures with higher phosphorous and nitrogen content are the best for intensive fish farming. Chicken dropping is the most widely used manure by fish farmers in Asia. Its use insures much higher yield than when cow of buffalo manure is used. The capacity of the pond to accommodate fish can be further escalated when inorganic fertilizer like 16-20-0 is added with the manure into the pond.

Fertilizers are more effective in supporting higher fish population when they are applied in short and regular intervals, i.e., daily or weekly application.

v. Fish Farmer's Resources

Low-density stocking may be recommended for the fish farmers belonging to the low-income group. The high production inputs required in higher stocking density may prohibit its adoption by the farmer. The recommended stocking ratio must conform with the ability of the fish farmer to supply the needed inputs.

11th Week Session

11. Production of tilapia fry and fingerlings

a. Sex Identification

Sex identification of tilapia is relatively simple. The male has two openings just in front of the anal fin. The large opening is the anus and the smaller opening at the tip is the urogenital pore. The female has three openings: the anus, the genital pore, and the urinary pore. The genital papilla is usually smaller in the female. Tilapia can be sexed when it has attained the weight of 15 grams. Application of ink or dyes to the papillae may increase the accuracy of sexing and may allow sexing of smaller fish.

b. Spawning

The Nile tilapia is a mouth-brooder. The male establishes a territory and builds a round nest at the bottom of the pond. Usually the diameter of a nest is 30 to 60 centimeters. The size of the nest is correlated to the size of the male. The female enters the nest and lays the eggs. The eggs are fertilized by the male. The female then collects and incubates the eggs in her mouth. The eggs are yellow in color. Eggs hatch in about five to seven days. After hatching the fry remain in the mouth of the female for another four to seven days. The fry begin to swim freely in schools, but may return to the mouth of the mother when threatened. Females do not feed during incubation or the brooding period. Females spawn every four to six weeks, but may spawn sooner if the eggs are removed. The number of eggs per spawning is related to the size of the female. A female of about 100 grams may produce approximately 100 eggs per spawning while a female weighing 100 to 600 grams can produce 1 000 to 1 500 or more eggs per spawning.
The male may mate with more than one female.

12th Week Session

12. Fry nursing

After the fry have hatched they are transferred to a nursery area. There are many forms of nursery used to successfully rear fish fry. The decision which nursery system to use depends upon the species of fish, materials available and the amount of money that can be invested.

a. Earth pond nursery

Earthen pond nurseries are effective for the production of many species of fish. The natural feed that occurs in a well-prepared nursery pond assists survival and compensates for poor quality supplemental feed. Growth rates are high in earth ponds, but survival rates can vary greatly. This is due to problems of controlling earth ponds because they are difficult to feed and predators of the fish enter easily. One of the principal problems in earthen ponds is the entry of predatory dragon fly larvae nymphs, tadpoles and carnivorous fish. These prey on the larval fish and can reduce the survival greatly. Correct preparation of the earth pond is essential for good survival of the fish fry. This is often poorly done due to difficulty in draining ponds, lack of fertilizers or rainfall to fill ponds at the required time. Good preparation requires the following steps to be observed:

i. Empty the water out of the pond (drain or use a pump) and dry the pond.
ii. If water can not de drained, predators in the pond can be killed by the addition of rotenone (derris powder) at a rate of 1.5 grams per cubic meter of pond water. If derris is difficult to obtain, draining and drying the pond is the most effective method of eliminating predators.
iii. Add lime at a rate of 1 kg for every 25 meter of pond area. Lime can usually be purchased from building supplies shops. Lime assists soil fertility and reduces the amount of fertilizer required to produce green water in the nursery pond.
iv. Add fertilizer to the pond at the rate of 1.5 kilos per 10 square meters. This is equivalent to one full bucket per 20 square meters of pond area. Fertilizers that can be used include buffalo, cow, chicken, goat, sheep and pig manures. After the manure is applied the pond can be filled to a depth of 5 to 10 centimeters to allow the breakdown of the manure. After 3 to 5 days, the pond should be filled to a depth of 30 to 50 centimeters and is then ready for stocking.
v. Fry are stocked to the nursery pond at a rate of 125 to 500 individuals per m^2.
vi. After stocking the fry to the pond (usually done in the early evening) the water level is maintained for one week. One week after stocking the water level is then increased to 80 centimeters.

b. Net cages

Once fry are large enough not to escape through blue netting (about 2 to 3 weeks after hatching), they can be cultured in cages made of this material. The advantage of fry culture in cages is that they do not suffer from predation from larger fish, frogs or large water insects. The fish need to be fed more than if they were cultured in the pond, but the high survival will compensate for the extra cost of the feed.

If water can be supplied to the cage this will increase aeration and remove waste products. This will allow higher densities of fry to be cultured than is otherwise possible without water flow.

- Blue net cage (4 x 5 m) without water supply – stock 2 000 fry (>2 weeks old)
- Blue net cage (4 x 5 m) with water supply – stock 5 000 to 10 000 fry (>2 weeks old)

The fish should be fed with pig or chicken starter feed mixed with soft rice bran to ensure they obtain sufficient food and grow well.

13th Week Session

13. Pond / rice-fish field maintenance

To be able to do effective maintenance of a rice-fish farm, it is a must for a farmer to regularly visit his farm site. By having the farmer's regular presence in his farm he can immediately take remedial actions to whatever problems he could see, before the problem gets serious.

Among the major maintenance and operation activities to be done by farmers are the following:

a. Daily feeding of fish at 5% of its total body weight. Adjust daily feeding ration monthly to be based on the latest sampling of the fish stock, conducted after every thirty days.
b. To maintain the growth of planktons and other natural food of the fish present in the water, apply fertilization into the pond at a rate of 0.5 kg of animal manure per square meter every two weeks, or 0.6 kg of inorganic fertilizer per 100 m^2 per week.
c. To prevent poaching of cultured fish, stakes or barbed wire can be installed underwater inside the pond.
d. Grow and maintain crawling grass on top and slope of the dikes to help in maintaining compaction and preventing soil erosion.
e. Always repair any damaged dike, leakages or seepages seen before it becomes big and causes serious damage to the pond.
f. Check for any foreign objects in the screens of the pond pipes and clean regularly to avoid clogging and the resultant restriction of water flow.
g. Remove floating and submerged weeds growing inside the pond, as they compete with the stocked fish for space and nutrients necessary for production of natural food in the water.

14th Week Session

14. Fish harvesting

For better regulation of fish density in ponds, harvesting methods that efficiently remove most of the fish should be employed. A small number of fish left in the pond after harvest will probably be caught during the following harvest. However, if they are too numerous, the growth rate of the fish stocked in the following production cycle may be affected.

a. Thinning

Partial harvest can begin in the latter part of the growing season. Wild spawning normally occurs in this part of the culture period when the fish reach sexual maturity. The population should be thinned out to allow further growth of the remaining fish. Either fingerlings or marketable size fish are partially removed. If thinning is done for marketing only, a net with a mesh size that can catch the desired size of fish should be used. This will allow small fish to escape and grow bigger, faster.

The principle of thinning or selective harvesting should not be abused. In tilapia culture thinning is effective only if done once. Total harvest of tilapia must be done one to two months after thinning.

b. Seining

Although seining is often recommended in harvesting fish in pond, it is not an effective method to insure total harvesting of the stock. tilapia often burrow into the mud to escape from the net.

c. Draining

After seining, which is the fastest method of harvesting, the pond should be drained so as to eliminate all the predatory species, competitors and fish which may have escaped from the net.

If needed, the pond should be poisoned to insure the total elimination of any species left in the pond. Draining is necessary as exposure of the pond bottom to sunlight will increase its fertility.

15th Week Session

15. Post harvest technology

a. Why Fish Spoils?

Spoilage of fish begins as soon as the fish dies. It is the result of a series of deteriorative changes which are broadly classified into: autolytic, bacterial and chemical.

i. Autolysis or self-digestion

This is the breakdown of tissues caused by enzymes. Enzymes are chemical substances naturally present in fish muscles which are primarily responsible for the digestion of food. They act as biological catalysts in chemically breaking down the food taken in by the fish and are very powerful in their action. In the live tissues, their action is controlled. As soon as the fish dies, however, the control is lost but the enzymes remain active. Instead of acting on the food, the enzymes now act on the fish muscles resulting in the softening of fish flesh. In addition to the naturally occurring enzymes in fish, bacteria which are introduced into the fish muscles, and those present in the gills and intestines secrete enzymes which also act on the fish flesh.

ii. Bacterial decomposition.

While autolysis is in progress, bacterial decomposition sets in. Bacteria are not present in the flesh of living fish. However, shortly after capture they enter the flesh by way of the gills, kidney (which usually remains after gutting), the blood vessels, and eventually through the skin. Soon after death, the body's defense mechanism against this invasion ceases to operate, and bacterial activity is enhanced. Two important characteristics of bacterial activity are enhanced: they grow rapidly and increase in number so fast that, unless checked, they continue to their spoiling action. They have been found to be the most active spoilers of fish. Since spoilage starts from the surface, we can prevent contamination of fish muscles by proper washing, gutting and chilling.

iii. Chemical change

In addition to bacterial and enzymatic action, chemical changes involving oxygen from the air and the fat in the flesh of fish can produce rancid odors and flavors. These changes overlap with enzymatic and bacterial activities. Rancidity develops more in fatty species than in lean ones.

b. Characteristics of Fresh and Spoiled Fish

	Fresh fish	Spoiled fish
Eyes	• bright, bulging • Pupil, velvet black; • Cornea, transparent	• dull, wrinkled, sunken; • pupil, dull black; • cornea, opaque
Gills	• bright red, covered with Slime; • odor under gill covers fresh	• dull brown or gray; slime cloudy; • odor under gill covers sour and offensive
Flesh	• firm; body is stiff; impression made by fingers does not remain • Slime present is clear	• soft and flabby; impression made by fingers remains
Body	• stiff	• limp
Belly walls	• intact	• often ruptured, with viscera protruding
Muscle tissue	• whitish	• pinkish, especially around backbone
Vent	• pink not protruding	• brown, protruding
Odor	• fresh, fishy odor	• stale, sour or putrid
Color	• bright	• faded

c. Handling of Fish

The three important ways of preventing fish from spoiling too quickly are: care, cleanliness and cooling.

Care in handling is essential because unnecessary damage can provide access, through cuts and wounds, for the spoiling bacteria, thus hastening their effect on the flesh. Fish is soft and fragile and is easily bruised or torn by rough handling. Therefore, prompt and proper care of the fish must be taken from the time it is caught until it reaches the consumer. It should always be remembered that fish is food and should therefore be handled as such.

Cleanliness should be observed throughout the fish handling chain. All surfaces with which the fish may come into contact should be scrubbed clean and kept as free as possible from bacteria-laden materials. Fish will keep longer in a fresh condition if they are kept as free as possible from contamination with bacteria. Natural sources of bacteria can be removed soon after the fish is captured/harvested by taking out the guts and washing off the slime from the surface of the fish.

Temperature is the most important factor in controlling the speed at which fish spoils. The higher the temperature, the faster the bacteria multiply; the lower the temperature, the slower the bacterial and enzymatic activities. Therefore, the most important step to slow down these activities is to lower the temperature of the fish as quickly as possible.

d. Transporting Fish from Source to Market

The prime objective in the transport of fish is to take the fish from one place to another in a manner that will ensure as little change in its quality as possible. Fish have to be moved through great distances until they eventually reach the consumers. This is done because most consumers are far from where the fish are caught or harvested.

One of the greatest problems encountered in the transport of fish is how to preserve its freshness until it reaches the consumer. Since fish spoilage is controlled largely by temperature, enzymatic and bacterial activity, the control of temperature during transport, through icing or chilling, must always be observed.

e. Forms of Fish Sold in the Markets

Fish are generally sold in the market in the whole or round form. Other forms of marketing fish are the following:

1. whole or round	• fish is sold just as it comes from the water and must be dressed before cooking;
2. drawn	• fish have had their entrails removed to slow down spoilage process and be kept longer
3. headed and gutted	• head, tail fins, and viscera removed before sale;
4. dressed or "pan ready"	• fish are completely cleaned and ready to cook when purchased;
5. steaks	• these are larger sizes of cross-sections pf dressed fish where edible portion is about 86 to 92 %;
6. fillets	• sides of the fish cut away from the backbone; ready for cooking and 100% edible without any waste;
7. chunks	• these are cross-sections of large dressed fish, having a cross-section of the backbone;
8. fish sticks	• these are pieces of fish flesh cut into uniform width and length, and usually breaded before cooking;
9. fish portions	• larger than fish sticks but uniform in size and weight, usually, one portion is enough for a single serving;
10. deboned fish	• the whole fish is split, butterfly-fillet style, and all spines are removed with the use of a forceps.

16th Week

16. Cost and return analysis of rice-fish culture

a. Assumptions

Area of pond:	………………………………………	m^2
Stocking Density in pond:	………………………………………	fish/m^2
Area of rice field:	………………………………………	m^2
Stocking density in rice field:	………………………………………	fish/m^2
Total # of stocks:	………………………………………	fingerlings
Quantity of rice seeds:	………………………………………	lbs.
Average Body weight at Harvest:	………………………………………	grams
Survival Rate:	………………………………………	%
Harvest Volume:	…………………………… kg. (fish)	………………………… kg (rice)
Price/kg:	…………………………… G$ (fish)	………………………… G$ (rice)
No. of Croppings/year:	……………… croppings for fish	………… croppings for rice

b. Fixed Asset Investment

Qty	Unit	Item Description	Unit Cost	Total Cost
…	Square meters	Pond construction	G$ …………	G$ …………
…	Square meters	Rice field construction	G$ …………	G$ …………
…	…………………	………………………………………………	G$ …………	G$ …………
				G$ …………

c. Operating Expenses

Qty	Unit	Item Description	Unit Cost	Total Cost
…	Pcs	Fingerlings	G$ …………	G$ …………
…	lbs	Rice seeds	G$ …………	G$ …………
		Land preparation (field and pond)	G$ …………	G$ …………
…	Kgs.	Fertilizer (cow manure)	G$ …………	G$ …………
…	Kgs	Feeds (artificial/local feeds)	G$ …………	G$ …………
…	Pc.	Spade	G$ …………	G$ …………
2	Pcs.	Buckets	G$ …………	G$ …………
5	meters	Fine mesh twine net	G$ …………	G$ …………
…	meters	Barbed wire	G$ …………	G$ …………
1	pc	#3 PVC elbow	G$ …………	G$ …………
5	feet	# 3 PVC pipe	G$ …………	G$ …………
Add: contingencies (10%)				G$ …………
TOTAL				G$ …………

d. Depreciation Expenses

Item Description	Life years	Total Cost	Annual Cost
Pond	10	G$	G$ ....
Rice field	15 years	G$	G$ ....
....	....	G$	G$ ....
TOTAL DEPRECIATION EXPENSE			G$ ....

e. Income

GROSS SALES (harvest volume x price / kg x 2 croppings) :	G$ ....
Less: Operating Expenses	– G$ ....
GROSS INCOME:	G$ ....
Less: Marketing Cost (5% of Gross Sales)	– G$ ....
Less: Depreciation Expenses	– G$ ....
NET INCOME	G$ ....

f. Financial Analysis

$$\text{ROI} = \frac{\text{Net Income}}{\text{Operating Expenses} + \text{Depreciation Expense / Year}} \times 100\%$$

$$= \frac{\ldots\ldots\ldots\ldots}{\ldots\ldots\ldots\ldots + \ldots\ldots\ldots\ldots} \times 100\%$$

$$= \ldots\ldots\ldots\ldots\ \%$$

$$\text{Payback Period} = \frac{\text{Operating Expenses} + \text{Depreciation Expense / Year}}{\text{Net Income}}$$

$$= \frac{\ldots\ldots\ldots\ldots + \ldots\ldots\ldots\ldots}{\ldots\ldots\ldots\ldots}$$

$$= \ldots\ldots\ldots\ldots\ \text{years}$$

NOTE: tilapia fry and fingerlings produced during the culture period is not included here

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