AQUACULTURE SYSTEM

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INTRODUCTION

It remains uncertain as to the precise time or indeed location that aquaculture emerged. The archaeological record nevertheless illustrates that fish and shellfish have always been important sources of food to humankind. Early Neanderthal (500,000 years before present {BP}) and Cro-Magnon (25-10,000 BP) man are both known to have used fish hooks and nets and some sites suggest that both groups may have constructed primitive ponds that held fish. It is doubtful however, that these early hominids provided any direct care for their captives. Nonetheless, the intentional impoundment of aquatic organisms for later use as food or otherwise, symbolizes the first stage in the development of controlled farming of the aquatic environment. This protoaquaculture was developed further by the Egyptians of Dynastic times, some 4000 years ago.

A defining moment in the development of aquaculture was the demonstration that fish could be induced to spawn artificially. This finding, elaborated in Brazil in 1934, drove aquaculture forward by eliminating the need to collect wild seed or broodstock. This freedom brought about the revolution that was needed to support the rapid growth of the industry on a global scale. The development of methods for rearing larvae and controlling the reproductive cycle of aquatic species in general has created a hugely diverse industry of significant economic value. As researchers have discovered more about the life cycles of cultured aquatic organisms and the stimuli that encourage their development, aquaculturists have adapted their systems to gain greater control over production-related factors: growth, sexual maturation, reproduction, disease control and immunology. More recent has been the trend towards ensuring the safety and quality of the final product as well as developments in the culture of novel, non-food organisms. Today, aquaculture is practiced in fresh, brackish, and marine waters, in tropical through arctic conditions, in inland lakes and ponds through to large offshore cage operations.

An characterization of aquaculture is that proposed by the Food and Agricultural Organization of the United Nations: “The farming of aquatic organisms including fish, mollusks, crustaceans and aquatic plants with some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated.”

CATEGORIES OF AQUACULTURE

In general, aquaculture production can be categorized as extensive, semi-intensive and intensive in form. Extensive aquaculture is characterized by low to no inputs (food, fertilizer, etc.) and low stocking densities. Extensive aquaculture is practiced in lakes, reservoirs and lagoons. Often, extensive aquaculture incorporates the culture of two or more species in the same water body (polyculture). Good examples of extensive aquaculture are seen in East and South-East Asia, as illustrated by the Ganges baor or ox-bow lake systems of Bangladesh. Semi-intensive aquaculture, which is often integrated with agricultural production, is distinguished by increased stocking rates and the requirement for some level of input, such as food, fertilizer, chemicals, etc. Integrated systems, as seen in China, incorporate fish production with the rearing of pigs and chickens (the feces of which is used to fertilize ponds), ducks (that churn sediment and assist in nutrient turnover), plants (which may be used as food), etc.

In marked contrast to other forms of aquaculture, intensive production systems are typified by the need for total control over the production cycle. Examples of intensive aquaculture include the cage cultivation of tilapia, pond production of hybrid catfish. Intensive aquaculture generally demands total provision of feeds, chemicals, fertilizers, etc. and may also incorporate more sophisticated levels of intervention: control of reproduction, larval rearing, vaccination and so forth.

Intensification of aquaculture operations is constrained by a variety of factors, which include competition for water with other resource users (agriculture, fishermen, recreationists, etc.) and an increased demand for high quality water. The cost associated with the construction of new aquaculture facilities is generally high, today often exceeding a million dollars or more. With this increased level of investment, vulnerability to catastrophe is enhanced and hence the business becomes more risky. Many of the species reared under intensive conditions are fed with feeds that incorporate a high level of fishmeal as the protein source. The decline in the availability of fishmeal (and fish oils) and competition for its use (chicken, pig and other animal feed industries) has become problematic in economic terms. More expensive feed and chemical inputs demanded by intensive aquaculture has impacted the industry's profitability. Together with these economic factors, the level of stress experienced by animals held under intensive conditions increases and this elevates the chances of serious disease outbreaks occurring. Associated with an increased biomass in a production system is an enhancement in sophistication of the technological production environment. This in turn provides a higher demand for a skilled labor force with good management skills. The latter are expensive and indeed, often unavailable in the workforce. Accompanying aquaculture intensification are amplified problems with effluent outputs. In many countries, legislation has been enacted in efforts to reduce the potential environmental impact of aquaculture and this, in some instances, has forced closure of operations or reduced their production potential.

TYPES OF AQUACULTURE

Within intensive, semi-intensive and intensive aquaculture methods there are numerous specific types of aquaculture systems, each has benefits and applications unique to its design.

POND CULTURE

Pond aquaculture is the use of purpose-built earthen ponds, generally with water supply and drainage infrastructure incorporated, to grow fish and crustaceans. Ponds are the most widely used structure for commercial aquaculture production and are most commonly used in fresh and brackish water aquaculture. In general, ponds for aquaculture production are static (i.e. no regular water exchange) however, intensive systems with high stocking and feed rates and regular water exchange are utilised to produce some specie such as catfish and tilapia.

Advantages of Pond Culture

- Can be relatively cost effective, particularly if gravity fed and drained
- Some control over growing conditions (e.g. nutrient inputs)
- Minimize loss of stock through escapement or predation compared to more extensive operations

Disadvantages of Pond Culture

- Moderate to high land requirement and construction costs
- Little control over ambient environmental conditions (e.g. temperature)
- Stock management may be difficult
- May have some water consumption where evaporation is high

Pond System

There are several types of pond currently used in aquaculture. Some of these, such as barrage ponds (i.e. ponds filled by rainwater or springwater), diversion ponds and sunken ponds, use the natural topography of the land. Tidal ponds are typically used in brackish water areas with flat land and moderate to high (1-2m) tidal ranges.

Pumped ponds can be set up in a variety of configurations with pumps used as primary or supplementary water supplier. Pumps increase availability and versatility of sites and may be utilised in perpetual flow or static ponds.

Static ponds may vary greatly in size and depth, depending on site characteristics, culture species and the intensity of the operation. As a general rule, static ponds are 0.1-2.0 ha in area and 1.0-2.0 m deep. Purpose-built aquaculture ponds may have a sloping bottom from 1.0 m draining to a harvesting sump 1.5-2.0 m deep. Such ponds may be filled and drained at the sump.

Pond preparation

Eradication of predators, weed fishes and parasites*:* Predators in fish ponds such zooplanktons, insects, fishes, amphibians, reptiles, birds and mammals must be eradicated.

Eradication of aquatic vegetation and algae: Microphytes and macrophytes, submerged, floating or emergent can deplete nutrients and decreased production of plankton in fish pond.

Liming*:* Liming is a common practice in pond culture. There are three main purposes for liming ponds: 1) to increase the availability of nutrients, 2) to increase pH and to buffer against daily pH fluctuations. and 3) to sterilize ponds prior to stocking. While these practices use lime, they involve different compounds. The application of limestone (calcite or dolomite) to fish ponds with acid soils will increase the availability of nutrients, primarily phosphorous, to aquatic plants, specifically phytoplankton. Phytoplankton (microscopic free-floating plants) are the base of the food chain in fish ponds, and are essential for rapid fish growth and survival in recreational fish ponds and in commercial ponds in which small fish are being reared. Calcite and dolomite increase the total hardness, total alkalinity, pH, and act as a buffer to keep the pH constant. The rise in pH is primarily responsible for increasing the availability of phosphorous from the pond muds.

Identifying liming needs can be accomplished by taking either a water or soil sample from the pond. Measuring the total alkalinity of water in the pond is the most effective, and easiest way to determine if liming is necessary. Common application rates for limestone are 1 to 2 tons per surface acre. However, a more accurate rate can be calculated by taking a soil sample from the pond bottom and having a laboratory make a recommendation.

Limestone can be added anytime during the production cycle. Limestone will take several weeks to complete its impact on the water quality, so application should be at least one month prior to the initiation of a fertilization program. Limestone is best applied directly to the pond bottom prior to filling the pond with water. It should be spread evenly over the entire bottom. A disk harrow can be used to further incorporate the lime into the soil. Applying limestone to ponds which are full of water is more difficult, but can be done without fear of harming the fish. The material should be broadcast evenly over the entire pond surface.

Fertilization: fertilizers are used to stimulate beneficial phytoplankton production that acts as the basis of the food chain. By increasing the phytoplankton in a pond, more food items are available for smaller fish. This increases productivity, thereby increasing the amount of harvestable fish. The harvest of a fertilized pond can be triple that of an unfertilized pond. There are two types of fertilizer used in aquaculture.

Organic fertilizer: A fertilizer that is derived from animals, vegetable matters or minerals occurring in nature such as manure, compost or bonemeal.

The table lists nutrient content of a variety of organic matters as sources of organic fertilizers. As the C:N:P ratios in organic fertilizers often provide imbalanced nutrient ratio (N:P), it is recommended to supplement with inorganic fertilizer to make up desirable ratio.

Average elemental composition of organic manures (values are expressed as % by weight)

Manure	C:N ratio	% Moisture-free basis		
		N	P	K
ANIMAL MANURES				
Faeces/dung				
Buffalo	19	1.23	0.55	0.69
Cattle	19	1.91	0.56	1.40
Sheep	29	1.87	0.79	0.92
Goat & sheep (mixed)	-	1.50	0.72	1.38
Horse	24	2.33	0.83	1.31
Pig	13	2.80	1.36	1.18
Camel	-	1.51	0.15	1.30
Elephant	43	1.29	0.33	0.14
Tiger	10	2.82	3.19	0.03
Lion	9	3.60	3.21	0.04
Human	8	7.24	1.72	2.41
Poultry manure	9	3.77	1.39	1.76
Duck manure	10	2.15	1.13	1.15
Rabbit manure	-	1.72	1.30	1.08
Urine				
Buffalo	-	2.05	0.01	3.78
Cattle	-	9.74	0.05	7.78
Sheep	-	9.90	0.10	12.31
Goat & sheep (mixed)	-	9.64	0.14	-
Pig	-	10.88	1.25	17.86
Horse	-	13.20	0.02	10.90
Human	0.8	17.14	1.57	4.86
Meals				
Blood meal	3.5	11.12	0.66	-
Horn and hoof meal	-	12.37	1.60	-
Bone meal	8	3.36	10.81	-
Fish manure	4.5	7.50	2.82	0.80
MANURES				
Crop residues				
Wheat straw	105	0.49	0.11	1.06
Barley straw	110	0.47	0.13	1.01
Rice straw	105	0.58	0.10	1.38
Oats straw	-	0.46	0.11	0.97
Maize straw	55	0.59	0.31	1.31
Soybean straw	32	1.30	-	-
Cotton stalks and leaves	-	0.88	0.15	1.45
Cottonseed meal	-	7.05	0.90	1.16
Groundnut straw	19	0.59	-	-
Groundnut hulls	-	1.75	0.20	1.24
Groundnut shells	-	1.00	0.06	0.90
Bean straw	-	1.57	0.32	1.34
Cowpea stems	-	1.07	1.14	2.54
Cowpea roots	-	1.06	0.12	1.50

Coffee pulp	-	1.79	0.12	1.80
G Sugarcane trash	116	0.35	0.04	0.50
Grass	20	0.41	0.03	0.26
Green weeds	13	2.45	-	-
Oil palm bunch ash	-	-	1.71	32.50
Oil palm pressed fiber	-	1.24	0.10	0.36

Fertilizer Value of Farm Animal Manure

Animal	Unit weight of animal,lb,	Pounds/animal/year		
		N	P_2O_5	K
Dairy Cattle	1,000	131.4	36.1	55.8
Beef Cattle	1,000	170.8	26.3	39.4
Poultry	5	1.81	1.46	0.67
Swine	100	14.7	6.6	8.7
Sheep	100	12.3	4.3	8.9

Approximate conversion factors: P x 2.3 = P_2O_5, K x 1.2 = K_2O

Mineral Analysis (Percent of Total Solids)

Mineral	Hog feed	Hog manure	Beef cattle manure
Ca	.917	2.47	1.16
Mg	.194	1.20	0.47
Zn	.122	.05	0.01
Cu	.00218	.05	0.035
Fe..	.0161	.05	0.08
Mn	.00398	.02	0.01
Na	.312	.63	0.09
K	.682	3.49	2.28
P	.741	3.7	1.7
S	.455	…	…
N	2.839	…	…

Representative nitrogen (N) and phosphorus (P) concentrations (as dry wt) of different manures used for pond fertilization.

Manure	% N	% P	N : P ratio	Source
Chicken	2.8	1.4	2.0 : 1	AIT
Cow	1.5	0.6	2.5 : 1	GREEN et al. 1989
Duck	4.4	1.1	4.0 : 1	A.I.T. 1986
Buffalo	1.4	0.2	7.0 : 1	A.I.T. 1986

Chicken manure rate and Fish Production

Chicken manure (Kg/rai/wk)	Fish Production (Kg/5 month)
20	381
40	365
80	594
100	506

Inorganic fertilizer: A synthetic fertilizer containing a mixture of chemical compounds that are added to the soil to improve its fertility. Table below list a variety of fertilizer sources for N, P, K.

Approximate Grades of Common Commercial Fertilizers

Fertilizers	Percentage		
	N	P_2O_5	K_2O
Urea	45	0	0
Calcium nitrate	15	0	0
Sodium nitrate	16	0	0
Ammonium nitrate	33-35	0	0
Ammonium sulfate	20-21	0	0
Superphosphate	0	18-20	0
Triple superphosphate	0	44-54	0
Monoammonium phosphate	11	48	0
Diamrnonium phosphate	18	48	0
Calciummetaphosphate	0	62-64	0
Potassium nitrate	13	0	44
Potassium sulfate	0	0	50

Percentage dissolution of phosphorus and nitrogen from selected fertilizers after settling through a 2- meter water column at 29˚C

Fertilizers	Nutrient solubility (%)	
	Phosphorus	Nitrogen
Superphosphate	4.6	-
Triple superphosphate	5.1	-
Monoammonim phosphate	7.1	5.1
Diammonium phosphate	16.8	11.7
Sodium nitrate	-	61.7
Ammonium sulfate	-	85.9
Ammonium nitrate	-	98.8
Calcium nitrate	-	98.7

Factors affecting the action of fertilizers

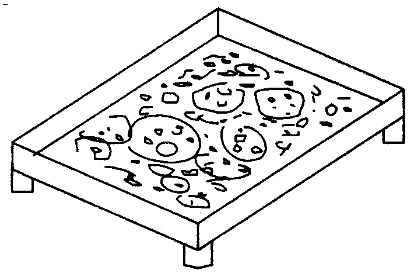
1. Light and temperature: incident light level, water depth, turbidity.
2. Water exchange.
3. Water quality.
4. Substrate conditions and pond history.
5. Aquatic weed.
6. Phytoplankton composition.
7. Fertilizer solubility.
8. Fertilizer application method and frequency.
9. Zooplankton

Inorganic fertilizer supplement to organic fertilizer: As animal wastes often contain nitrogen and phosphorus concentrations that are not in balance as required for optimal phytoplankton production, it is necessary to supplement the manures with inorganic fertilizer source (N/P) to make the more desirable ingredients.

Mechanical fertilizer application methods

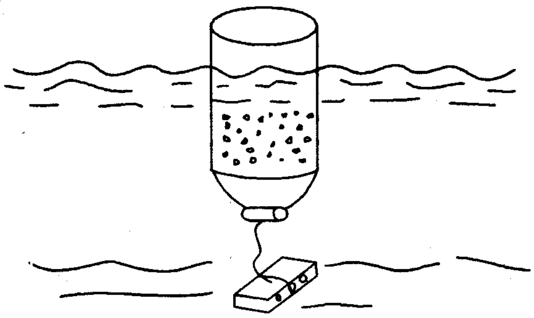
a) Underwater platform

The base of the platform should be 15-20 cm below the water surface, and located near the pond water inlet or at the end of the pond from which the prevailing wind comes. A single platform is sufficient for ponds up to 7 ha when plankton is grown. Suggested platform top sizes for ponds of different sizes are in the following table :

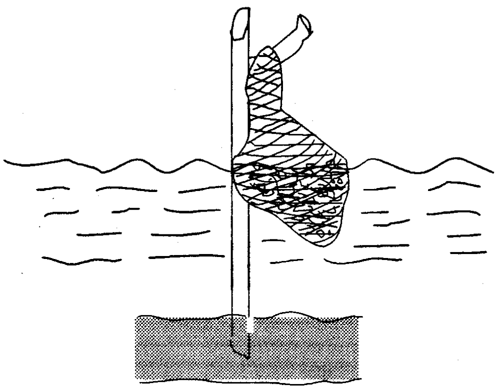


Pond area (ha)	Platform top dimensions (m)
1	0.85 X 0.85
2	1.25 x 1.25
3	1. 50 X 1. 50
4	1.70 x 1.70
5	1.90 X 1.90
6	2.10 x 2.10
7	2.25 x 2.25

b) Perforated floating can basket



c) Suspended perforated sack

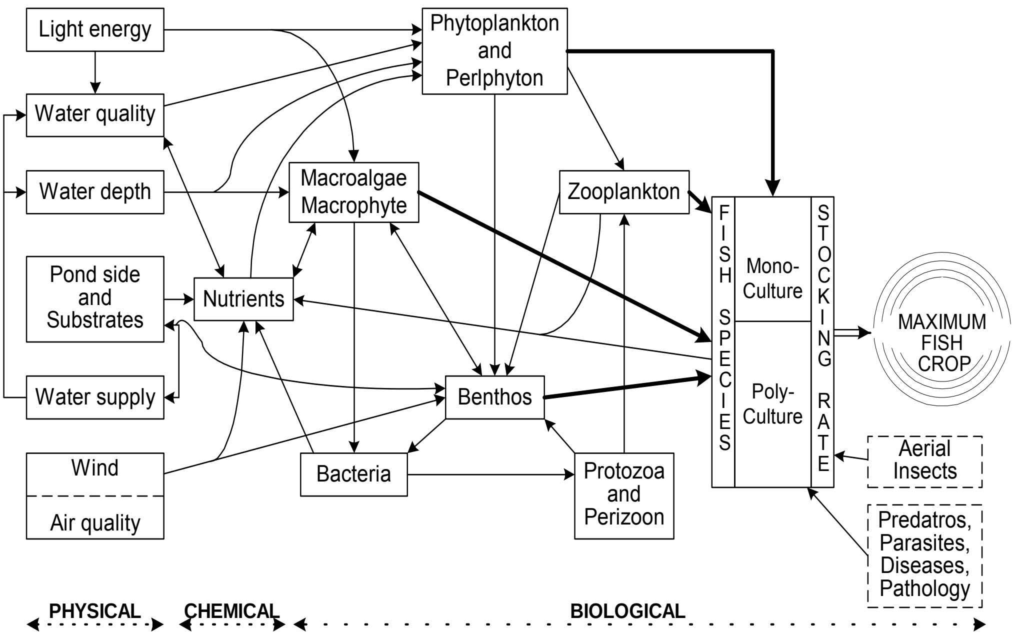


Fertilizer application rate and frequency:

As the complication relating to the effectiveness of fertilization discussed above, it is difficult to offer a set of quantitative formula for fertilization rate applicable to all situations. In general, to maintain a level of phytoplankton production at 20-40 cm. Secchi disc depth (80-300 mg chl-a / m^3), the total P and N concentrations in the water column should be kept at a range of 0.2-0.5 mg P/L and 1-3 mg N/L, with a N:P ration of 5-10:1.

In principle, greater frequency of fertilization give greater stability of nutrient concentration level in water thus maintain even stable biological productivity.

In practice: twice a week to weekly application are adequate frequency.



Pond Dynamic Model

Species selection

Although a large number of freshwater fish and crustacean species grow successfully in ponds, only a restricted number of species are usually cultivated on commercial scale. Reasons for this restricted choice is obvious. Commercial pond culture basically aims at achieving maximum possible rate of fish production and profit through optimum utilization of the natural food and the supplementary feed which drastically limits the choice of fish species for pond cultivation. Some of the basic criteria for selection are discussed below.

Criteria for selection of suitable fish species
1. Adaptability to pond environment
2. Faster growth rate
3. Efficient utilizers of natural food resources of the pond
4. Efficient converter of artificial feed
5. Hardy and not easily susceptible to disease
6. Non-predaceous, planktophagous and preferably herbivorous and detritus feeder
7. Compatability with other cultivable species of fish
8. Palatable with high nutritive value
9. High market demand and high price.

Many species of fish are suitable for pond culture. Species which have been researched and successfully reared in earthen ponds are in following table:

Common name	Scientific name
Catfish	*Pangasius hypophthamus, Pangasius conchophilus*
Striped catfish	*Pangasius sutchii*
Yellow catfish	*Pangasius bocourti*
River catfish	*Pangasius pangasius*
Sharp tooth catfish	*Clarias gariepinus*
Walking catfish	*Clarias macrocephalus*
Hybrid catfish	*C. gariepinus x C. macrocephalus*
Green catfish	*Mystus nemerus*
Nile tilapia	*Orechromis niloticus*
Giant gourami	*Osphronemus gourami*
Striped snakehead	*Channa striatus*
Giant snakehead	*Channa micropeltes*
Climbing perch	*Anabas testudineus*
Sand goby	*Oxyleotris mamoratus*
Giant freshwater prawn	*Macrobrachium rosenbergii*
Common carp	*Cyprinus carpio*
Silver carp	*Hypophthalmichthys molitrix*
Grass carp	*Ctenopharyngodon idella*
Bighead carp	*Aristichthys nobilis*
Mud carp	*Cirrhinus molitorella*
Black carp	*Mylopharyngodon piceus*
Catla	*Catla catla*
Rohu	*Labeo rohita*
Mrigal	*Cirrhinus mrigala*

Stocking density

Rates of stocking fry, fingerlings and yearlings is relation to food resources and condition of water body, carrying capacity of fish ponds and management practices.

The productivity of ponds in extensive pond culture depends upon the soil and water chemistry, location and water exchange. These factors limit the degree of primary productivity in the pond, and therefore the carrying capacity. In extensive systems, The stocking densities are low and yields are typically low and economics dictate that extensive pond culture is often not commercially viable.

In semi-intensive pond culture, production is increased through higher stocking densities, supplementary feeding and improved feed quality. In ponds, fish culture and primary production are correlated, so the fertilisation of ponds will increase fish production, particularly at the nursery stage. Fertilised ponds are commonly used for the nursery rearing of native warmwater fish. Organic and inorganic fertilisers may be used to increase the productivity in semi-intensive pond systems.

Intensive pond culture generally applies to pond systems where supplementary feeds, such as pelleted diets, are the primary source of feed for the growout of various species such as tilapia and catfish. Stocking densities in such systems are much greater than for semi-intensive systems, and often require additional energy input, such as mechanical aeration and/or high water exchange rates. Some examples of stocking density for pond culture are in the following table:

Species	Stocking density (fish/m^2)	Remark
Nile tilapia (*Orechromis niloticus*)	250 (1-2 cm.) 3-5 (3-5 cm.)	Nursing (Earthen pond) Rearing (Earthen pond) (8-12 months)
Climbing perch (*Anabas testudineus*)	20-50 (2-3 cm.)	Rearing (Earth pond) (3-4 months)
Hybrid catfish (*C. gariepinus x C. macrocephalus*)	3,000-5,000 (3 days old) 300-500 (1 cm.) 40-100 (2-3 cm.)	Nursing (Concrete pond) Nursing (Earthen pond) Rearing (Earthen pond) (3-4 months)
Green catfish (*Mytus nemurus*)	1,000-2,000 (3 days old) 60-90 (1.-1.5cm.) 1 (15-17 cm.)	Nursing (Concrete pond) Nursing (Earthen pond) Rearing (Earthen pond) (7 months)
Sand goby (*Oxyleotris mamoratus*)	3,300 (3 days old) 100-160 (1 cm.) 60 (2.5 cm.)	Nursing (Concrete pond) Nursing (Concrete pond) Nursing (Earthen pond)
Giant freshwater prawn (*Macrobrachium rosenbergii*)	30 (1-2 cm.) 10 (1-2 cm.)	Nursing (Earthen pond) Rearing (Earthen pond) (6 month-partial harvest)

Types of fish-pond culture

(a) Monoculture: culture of single species of: (i) same age and size; (ii) same sex (mono-sex culture), and; (iii) different size/age groups.
(b) Polyculture: culturing of: (i) compatible combinations of different species of fishes, fishes and shrimps, fishes and crustaceans, fishes and molluscs; (ii) predator-forage combinations; determination of percentage of different species used in polyculture in relation to food resources of the pond and supplementary feeding facilities; possible polyculture combinations for Africa and combinations presently practised.

CAGE CULTURE

Cage culture of fish utilizes existing water resources by encloses the fish in the cage or basket which allows water to pass freely. Today cage culture is receiving more attention by commercial producers. Factors such as increasing consumption of fish, some declining wild fish stocks have produced a strong interest in fish production in cages. Cage culture also offers the farmer a chance to utilize existing water resources which in most cases have only limited use for other purposes. Cage production can be more intensive in many ways than pond culture and should probably be considered as a commercial alternative only where open pond culture is not practical.

As with any production scheme cage culture of fish has advantages and disadvantages that should be considered carefully before cage production becomes the chosen method.

Advantages	Disadvantages
1. Many types of water resources can be used, including lakes, reservoirs, ponds, strip pits, streams, and rivers which could otherwise not be harvested. (Specific state laws may restrict the use of public waters for fish production) 2. A relatively low investment is all that is required in an existing water body 3. Observation and sampling of fish is simplified. 4. Allows the use of the pond for culture of other species. 5. Harvesting is simplified.	1. Feed must be nutritionally complete and kept fresh 2. Low dissolved oxygen syndrome is and ever present problem and may require mechanical aeration. 3. The incidence of disease can be high and diseases may spread rapidly. 4. Vandalism or poaching is a potential problem.

Interest in cage culture has been revived as an alternative crop for farmers outside traditional fish farming areas and in areas with topography not conducive to levee ponds. As this interest continues to increase, more research into cage culture techniques and alternate species will no doubt occur. A great deal of variability exists in the research and commercial literature about suitable pond sizes, growing season, stocking densities, and size of fingerlings to stock. Stocking rates or densities are dependent on species, cage volume and mesh size, pond surface area, availability of aeration, and desired market size. In general, stocking densities are calculated on the number of kilograms of fish which can be reared per surface area of pond and per cubic meter of cage.

Species selection

Many species of fish are suitable for cage culture. Species which have been researched and successfully reared in cages in Southeast asia are in following table:

Common name	Scientific name
Catfish	*Pangasius hypophthamus, Pangasius conchophilus*
Striped catfish	*Pangasius sutchii*
Yellow catfish	*Pangasius bocourti*
River catfish	*Pangasius pangasius*
Sharp tooth catfish	*Clarias gariepinus*
Walking catfish	*Clarias macrocephalus*
Hybrid catfish	*C. gariepinus x C. macrocephalus*
Green catfish	*Mystus nemerus*
Nile tilapia	*Orechromis niloticus*
Giant gourami	*Osphronemus gourami*
Common carps	*Cyprinus carpio*
Striped snakehead	*Channa striatus*
Giant snakehead	*Channa micropeltes*
Sand goby	*Oxyleotris mamoratus*

Some examples of stocking density for cage culture are in following table:

Species	Stocking density (fish/m^3)	Remark
Nile tilapia (*Orechromis niloticus*)	3,000 (1gm.) 2,500 (10 gm.) 1,500 (25-30 gm.) 1,000 (50-60 gm.)	Nursing (7-8 wks) Nursing (5-6 wks) Nursing (5-6 wks) Rearing
Green catfish (*Mytus nemurus*)	50 (3 gm.) 50-70 (200-250 gm.)	Nursing (6 months) Rearing (4 months)
Sand goby (*Oxyleotris mamoratus*)	70-100 (100-300 gm.)	Rearing (10-12 months)
Striped catfish (*Pangasius sutchii*)	100-150 (100 gm.)	Rearing (10-12 months)
Yellow catfish (*Pangasius bocourti*)	100-150 (100 gm.)	Rearing (10-12 months)
Striped snakehead (*Channa striatus*)	30-40 (100 gm.)	Rearing (9-10 months)
Giant snakehead (*Channa micropeltes*)	30-40 (100 gm.)	Rearing (9-10 months)
Giant gourami (*Osphronemus gourami*)	1-2 (3 inches)	Rearing (8-12 months)

Feeding practices for pond and cage culture

Fish must be fed with quality feed and adequate quantity for growth. Pond fish can be added by natural food in the pond while caged fish in most cases will receive no natural food and, therefore, must have a nutritionally complete diet which has adequate protein and energy levels, is balanced in amino acids and in essential fatty acids, and is supplemented with a complete array of vitamins and minerals. Many commercial feed mills manufacture both supplemental and complete diets. Fish should be fed a floating pelleted feed that allow the fish farmer the opportunity to observe the fish. In general, herbivorous and omnivorous species such as silver barb,carp and tilapia can be successfully reared from large-sized fingerlings on 16-25 percent protein complete diets. Catfish can be reared with 30-32 percent protein. Striped snakehead and carnivorous fish need diets with 38 to 42 percent protein. In semi-intensive systems, supplementary feed such as rice bran, broken rice can be applied.

Pellet sizes normally available include 1/8, 3/16, and 1/4-inch diameters. Usually large fingerlings can accept 1/4-inch pellets. Small fingerlings and species with small mouths may need to be started on 1/8-inch pellets. Fish will feed most aggressively near their preferred or optimum temperature and when oxygen levels are high. Oxygen is usually at acceptable levels (unless heavily overcast) between mid morning and late afternoon. From a temperature standpoint, warmwater fish such as catfish will feed better as the temperature rises in late afternoon in the spring, but prefer mid morning during the heat of the summer. Generally fish will adapt to any feeding time as long as it is consistent. Changes in the feeding schedule should be made gradually (e.g., not changing more than 30 minutes per day). Fish will grow faster and have better feed conversion if their daily feed ration is divided into two feedings given at least 6 hours apart. This is particularly true of small catfish, tilapia. For catfish, dusk feeding can increase growth and improve feed efficiency. Dusk is the natural feeding time for many species of fish. Dusk feeding cannot be practiced without a means of nighttime aeration. Dusk feeding can begin within 1 hour of sunset and can continue for an hour or more after sunset. The key to dusk feeding is not to overfeed. If mechanical aeration is not available, do not consider dusk feeding. Correctly feeding the proper amount of feed is extremely important. Overfeeding wastes feed and money, and can cause water quality deterioration leading to stress and increased incidence of disease. Underfeeding reduces the growth rate, total production and profit. A general rule of thumb for most warmwater fish is to feed fish all they will eat in 10 to 30 minutes when the water temperature is above 22^{o}C. Caged fish, particularly catfish, are sometimes shy and may not start feeding immediately. Also, when fish are first stocked into a cage they usually adjust slowly to feeding. Keeping good feeding records is essential to becoming a successful fish producer. It is a good practice to offer caged fish one-half of the amount of feed they consumed the previous day, so as not to overfeed if there is a weather, water quality or disease problem that reduces consumption. After adding feed observe the feeding response, adding more feed as needed at 20- to 30-minute intervals. If the fish have not consumed the feed after 20 to 30 minutes, do not add more feed. Many producers and researchers have found that catfish will continue to consume feed for several hours if fed at dusk. The key is to get as much feed into the fish as they want to eat (satiation) without leaving or wasting feed.

Feeding rate

Feeding rates for fish are calculated on a percent of body weight per day basis, based on the fish size and water temperature. Small fish consume a larger percentage of their body weight than larger fish, and all fish increase consumption as water temperatures approach optimum temperature range. Small fingerlings will usually eat 4 to 5 percent of their consumed each day for the first week. A new estimate should be recalculated each week, based on estimated growth. Estimated growth is calculated by multiplying the total amount of feed fed during the week by the estimated feed conversion ratio (FCR) of 1.0/1.8. This estimated growth weight is added to the total weight at the beginning of the week. This new total weight is divided by the number of fish (less any deaths) to get a new weight of individual fish. After they reach advanced fingerling size the rate will decrease to 3 percent and nearing harvest size will drop to only 2 percent or less.

Guideline on feeds and feeding

1. Observation of the fish at feeding time is vital. Feeding behavior is the best index of overall health. Actively feeding fish indicate everything is all right, for the moment. Poor feeding behavior should always be viewed with suspicion.
2. Reduce feeding levels when water temperatures drop below 20^{o} or above 32^{o}C.
3. Reduce or stop feeding on heavily overcast and windless days. These weather conditions reduce oxygen production and diffusion, particularly if sequential, and can lead to low dissolved oxygen. Feeding will only complicate the problem. Run aeration if available.
4. Feed quality must be excellent. Purchase feed which is known to be complete and keep it stored in a very dry, cool place. Feed should be fed within 90 days of the manufacture date.
5. Never feed moldy or discolored feed.
6. Keep accurate records on the amount of feed fed.

INTEGRATED AGRICULTURE-AQUACULTURE SYSTEM

Integrated agriculture-aquaculture system is an combination of cultivation between fish with plants and/or terrestrial animals. The system diversification comes from integrating crops, vegetables, livestock, trees and fish imparts stability in production, efficiency in resource use and conservation of the environment. Uncertainty in markets and climate is countered by a wide array of enterprises. In integrated farming, wastes of one enterprise become inputs to another and, thus, optimize the use of resources and lessen pollution. Stability in many contrasting habitats permits diversity of genetic resources and survival of beneficial insects and other wildlife. Integrated agriculture-aquaculture offers special advantages over and above its role in waste recycling and its importance in encouraging better water management for agriculture and forestry. Fish are efficient converters of low-grade feed and wastes into high-value protein. Fish are the greatest sources of animal protein in rural Asia. For rural households, fish are small units of cash or food which can be harvested more or less at will without loss of weight or condition. For sustainable development in farming, small-scale integrated agriculture-aquaculture is one option.

Rice-fish culture

The rice-fish farming system is an old tradition practiced extensively in Southeast Asia in areas where is an floodplain and receives irrigated water.

Advantages

- Provides additional food and income
- No additional expenses except when system is modified such as building trenches, strengthening dikes, etc.
- Optimises disused and under-utilized existing resources
- Maintains gene pool for locally valuable species

Constraints

- Short growing season due to double dropping of rice
- Improper and excessive pesticide and herbicide use
- Uncontrolled flooding may result to fish loss
- Improper management/lack of human resources
- Low productivity and low-carrying capacity when no regular supplementary feed is provided
- Distance of sump pond from house

Preparation of field for rice-fish culture

Good preparation is very important in order to succeed in rice-fish culture. Every farmer must be able to: hold enough water over a large enough area for enough time to produce enough fish; and prevent serious flooding of the dikes and other boundaries of his rice field.

Having a satisfactory water situation in the field is a key factor in the technology; this cannot be achieved if preparation is poor.

Field size and shape

There are many factors that should be considered:

1. How much land does the farmer own? If the farmer does not own the land and the landlord is agreeable, how big an area does the landlord want to try?
2. Topography and slope will greatly affect field size and shape. It may be possible to construct a large, square field on very flat land, but not quite so in sloping areas.
3. What area does the farmer think is suitable? This can limit field size and affect field shape.
4. How large an area does the family feel comfortable with trying out (especially for beginners)?
5. How large an area does the family think it can prepare and manage ?

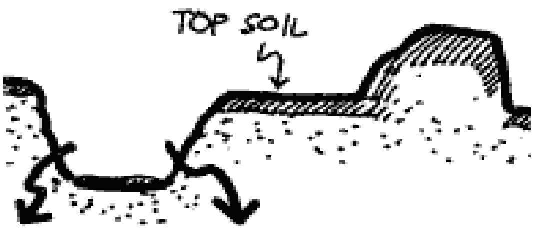
Some people say that a square field of 0.5-1 ha is the best size for rice fish culture. However, operations larger or smaller than this size can also be very successful. Good preparation and good management are the keys to success, whatever the size.

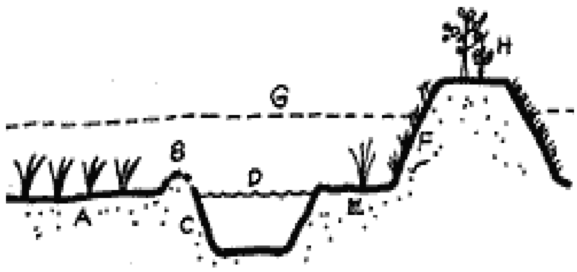
Dikes

All dikes must be built safely higher than maximum flood levels. During construction, the dike should be raised high enough to allow for compaction and erosion.

In raising the dikes, an excavation usually results. This may as well occur inside the field, all other factors being equal. This way, a small pond or trench is formed, which serves as a refuge for the fish.

Refuges



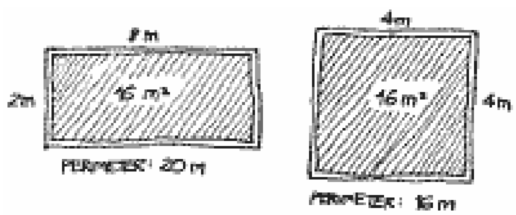


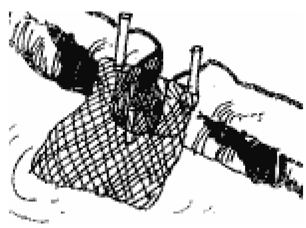
A refuge is a pond, trench or low point in the rice-fish field. When the rest of the field is dry, fish can be held here. Under some conditions (see paper on fry nursing in rice-fish systems, this volume), the refuge may be stocked before rice is transplanted.

Having a refuge is usually advisable and may be necessary for success. Without it, fish have to be harvested before the field dries out or moved to a pond in a flooded area. A refuge of at least 50 cm depth is desirable. If the farmer wants to hold fish all year around, the refuge will probably have to be much deeper than this. A refuge, when dug, is usually made at the lowest part of the field so that water and fish can easily collect there.
Some other factors governing size and arrangement of refuges:

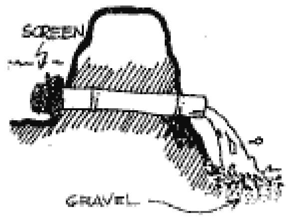
1. How much rice-growing area is the family willing to sacrifice for the refuge? This may depend on their total rice-growing area or on the relative importance they give to rice and fish.
2. How much money or time and labor can the family invests? As with field size, this can be an important limit.
3. What kind of soil is involved? A narrow trench (say 1 m wide x 1 m deep) will fill in quickly in sandy soil, but may last well in clay. The refuge in sandy soil should be three or more times wider than its depth.
4. Topography will affect trench or pond configuration. Extensive peripheral trenches on sloping areas will occupy too much space since such a field will be narrow.

Drains
Usually, the field will need a drain so that excess water can be removed rapidly without eroding the dike. Inflow and especially outflow drains are advisable. Drains should be screened to prevent fish from escaping.





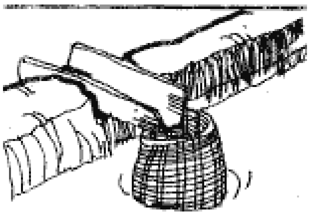
A bamboo, hollow log or pipe can be used, depending on availability. A screen should be placed at the point where the water enters. The screen can be a piece of fine netting or of flat metal full of nail holes. A little gravel scattered under the pipe will reduce dike erosion.



Such a drain is best for small fields (less than 1 000 m²) with limited flow (especially fields used to nurse hatchlings or small fry). Screens need to be checked every few hours for clogging any time water rises to pipe level and this can be a nuisance.

In most fields, the drain consists of a simple breach in the dike. This is screened by thin splints of bamboo or similar material, bound or nailed together.

Farmers in the rainier parts of northeast Thailand often use a bamboo chute or PVC pipe, set at a breach in the dike at the lowest part of the ricefield.

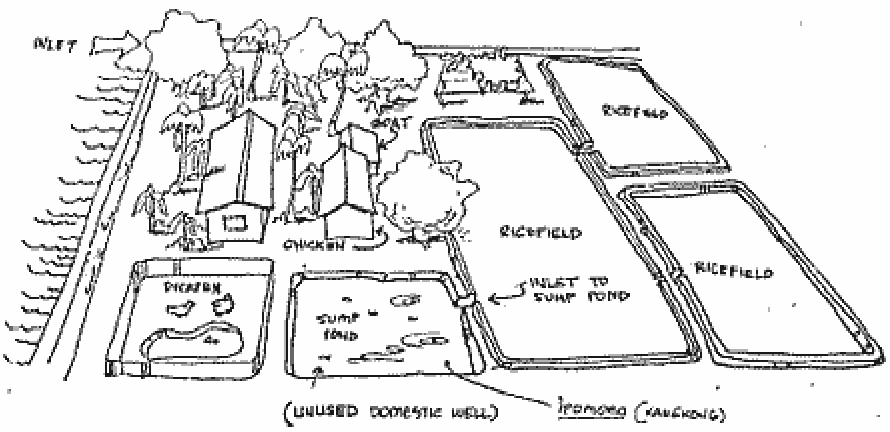


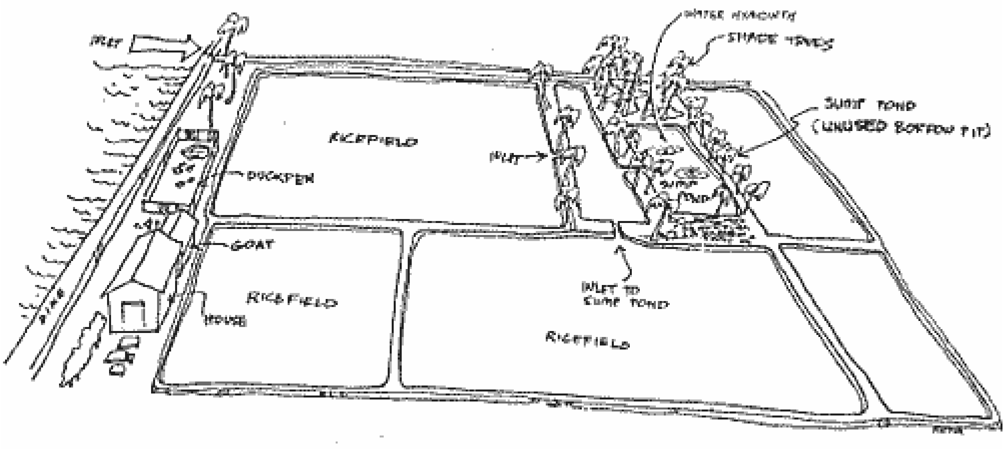
The bamboo or pipe slopes up slightly and narrows. Below the narrow end, a jug-shaped basket or net bag is set. Hence, water runs out along the length at the li, but ultimately falls into a bag or basket which holds any fish washed out of the field. These can be eaten, sold or returned to the field for further growth.

Some farmers use a simpler version, by setting a net bag supported by sticks next to the outlet drain.

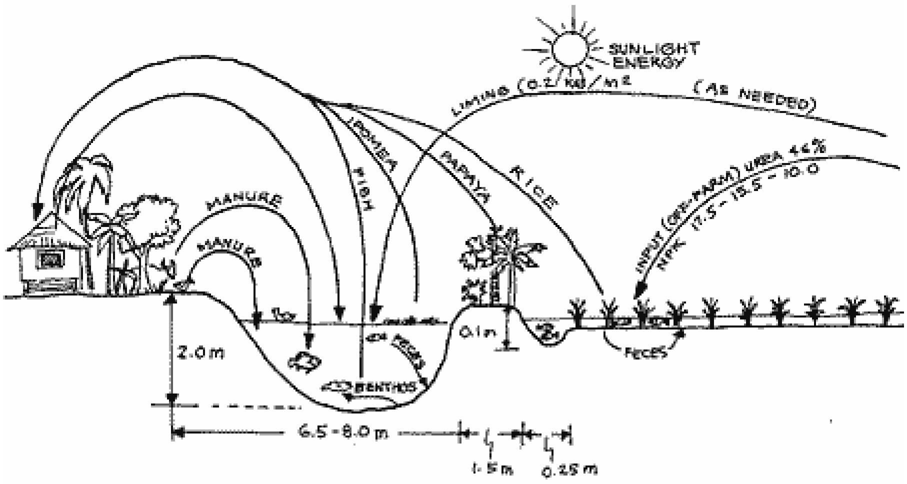
The drain should be set in the dike somewhere between depth of water that is best for the rice in the field and the depth that it will tolerate. A small pipe does not drain a large field effectively. The farmer will have to make a guess as to how wide the drain should be, based on experience. It is better to have the drain a little too wide than too narrow.

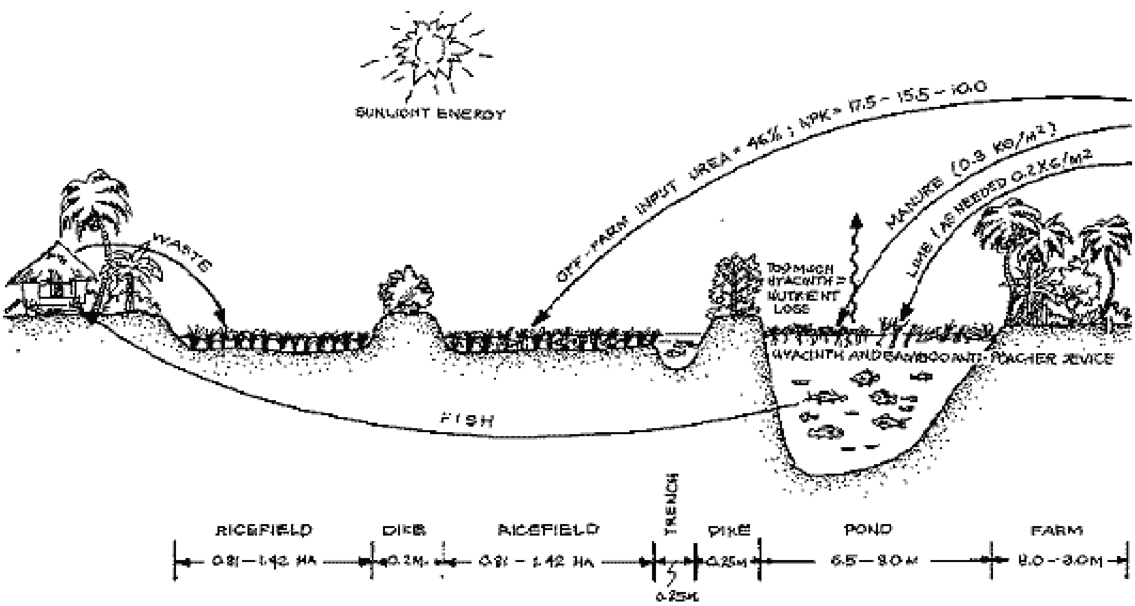
Farm layout of rice-fish farming





Material flow on a rice-fish farm system





Species for rice-fish culture

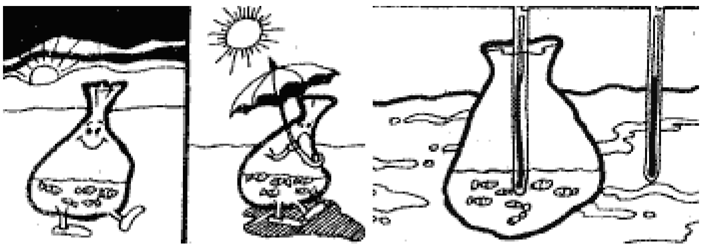
Local species and some exotic species can grow well in ricefields. They have adapted to shallow water, high turbidity and temperature, and low dissolved oxygen conditions of the fields.

- The snakeskin gourami (*Trichogaster pectoralis*) is numerically the most important. This species and the three-spot gourami (*T. trichopterus*) are herbivore/planktivore and occupy the lower rung in the food chain.
- Climbing perch (*Anabas testudineus*) is an insectivore.
- The catfish (*Clarias macrocephalus*), an omnivore, and the mudfish or snakehead (*Channa striatus*), a carnivore, are also important species.
- Tilapia (*Oreochromis spp.*), a herbivore/planktivore/insectivore, is ecologically suitable and economically important.
- Another species to be considered is the freshwater prawn (*Macrobrachium rosenbergii*).

Fish stocking

The following guidelines apply in any case where seed fish are transported and stocked:

- Transport and stocking are best done early in the morning or failing this, late in the day when temperatures are lower.
- Fish, once purchased, should be transported promptly and kept out of direct sunlight.
- They should not be shaken up or unduly disturbed.
- On arrival at the pond or ricefield, bags should be set in the water (where the fish will be released) for several minutes until temperatures become the same inside and outside the bags.
- Bags should only then be opened and fish immediately allowed to swim into their new home of their own accord.



Timing

The earlier in the season that fish can be stocked, the longer the growing period. Also, the earlier in the rainy season, the fewer the predators. However, fish cannot be stocked before there is water available and the farmer should be reasonably sure that the field will hold water for several months before he stocks. Rice should also be well-established with 2-3 tillers out before fingerlings or large fish are allowed into the field. Finally, the farmer may be ready to stock but seedfish may not be available. Therefore, the family may have to wait until fish can be found.

The wide scale of rice-fish is still constrained by continued application of pesticides in rice-based farming. The use of pesticide is not recommended in rice-fish farming. In rice-fish culture, there are ways of controlling rice pests that do not need pesticide, such as:

- Quick submergence (for three hours) of rice plants in water. This makes the insects vulnerable to fish predation. Limitation: suitable only before plants are taller than the dikes.
- Two persons can drag a stretched rope (50-100 m) across the rice fields to knock off the insects into floodwater, after which they can be eaten by the fish. Limitation: suitable only before rice plants reach booting stage.

However, should a farmer insist on using pesticides, here are some helpful tips:
1. Considerations in applying pesticides:
    - Choose and apply properly pesticides that have low toxicity to fish.
    - Minimize the amount of pesticide getting mixed with water.
    - Apply at suitable time.
2. Considerations in preventing fish poisoning:
    - Drive the fish into the sump, draining the field slowly before spraying. Keep the fish in the sump until the toxicity in the sprayed field is gone.
    - Increase water depth (+10 cm) to dilute the concentration of pesticides in the water.
    - Flush water through the ricefield. Open the inlet and outlet of the field, and allow irrigation water to flow freely during spraying. Begin spraying from the outlet end of the field. When one-half of the field is already sprayed, stop for a while and allow the pesticides to flow out of the field. Then, continue spraying towards the inlet end of the field until it is finished.

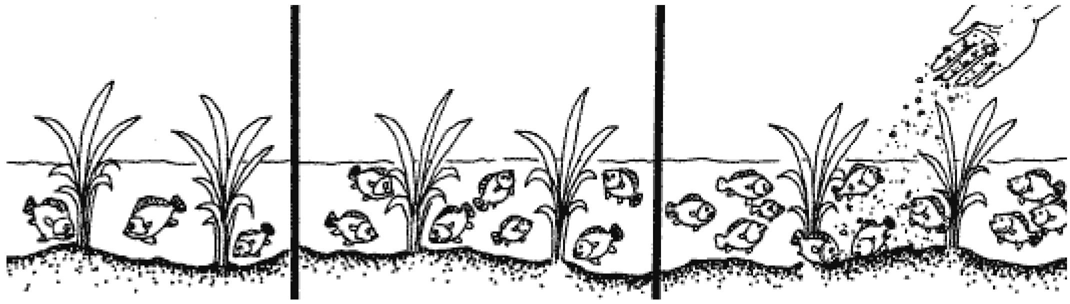
It is best to wait until the rice is well established before releasing seed fish, particularly if the fish are large. Fish can be stocked once two or three tillers have appeared for which the usual waiting period is 1-3 weeks after transplanting or 4-6 weeks after direct seeding depending on the state of the rice and the size of the fish. Small fry (about 2.5 cm long) can be stocked immediately after transplanting, without harm to the rice. The authors have never seen a rice variety that does not work with fish, but some varieties are better than others. Deepwater-tolerant varieties are preferable to those which thrive in only very shallow water. In some areas where rainfalls are highly unpredictable, farmers prefer to wait until very late in the rainy season to stock fish. At this time, surface water accumulation will be at its yearly peak and the chance of flooding from later rains is very slim. In such cases, long-lived, late-maturing rice varieties are best. Rice varieties which tiller (i.e. produce new plant stems) rapidly or under a wide range of water conditions will allow farmers to stock earlier in many cases.

Yields seem the most enhanced on farms with poor soil where fish are fed intensively. Possible mechanisms include:
- increasing availability of nutrients for increased floodwater productivity and uptake by rice; and
- reducing loss of ammonia through volatilization after fertilizer application by preventing floodwater pH to rise over 8.5.

Stocking density
- Stocking can be done before or during land preparation in the pond refuge; or 7-10 days after transplanting, if fish are released directly to the fields. If stocked in the pond refuge, animal manure should be applied into the refuge 4-5 days before fish stocking. About 15 kg may be applied in a 100 m^2 pond refuge.
- The stocking rate, using either monoculture of Nile tilapla or polyculture of Nile tilapia and common carp (5 cm.) is 400-800 fish/1,600 m^2. For polyculture, the stocking ratio of Nile tilapia to common carp is 1:1, or common carp (*Cyprinus carpio*), silver barb (*Barbodes gonionotus*) and tilapia (*Oreochromis niloticus*) at 2:1:1. or common carp (*Cyprinus carpio*), silver barb (*Barbodes gonionotus*) and tilapia (*Oreochromis niloticus*) 500 and Chinese and Indian major carp 30-50 fish/1,600 m^2.
- Ten days after transplanting, fish stocked in the pond refuge may be released to the field by making openings in the dividing dike. Fish will graze on natural food available in the ricefield.

Supplemental feeding

- This feeding is recommended at the middle culture period of rice, during which production of natural food in the fieldwater declines due to shading of rice leaves.
- Feeds: rice bran, kitchen refuse, termite, etc. Animal manure may also be applied in the pond refuge.
- Feeding rate: 3-5 percent of fish biomass



If stocking density is low, there is often sufficient natural food in the paddy and no feeding is necessary.	If stocking density is increased, natural food in the paddy is not enough and production is low.	If stocking density is increased, maximum production can still be obtained with supplementary feeding.

Harvesting

- Harvest fish by draining the water very slowly 1 week before rice harvest to avoid trapping the fish in the middle of the field.
- Select large fish for consumption or disposal and confine the small fish (50 g) for next culture.
- After harvesting rice, the field is immediately reflooded to about 30 cm deep, and the small fish in the refuge are released to allow them to grow for another 60 days before the dry season crop.

Pig-fish culture

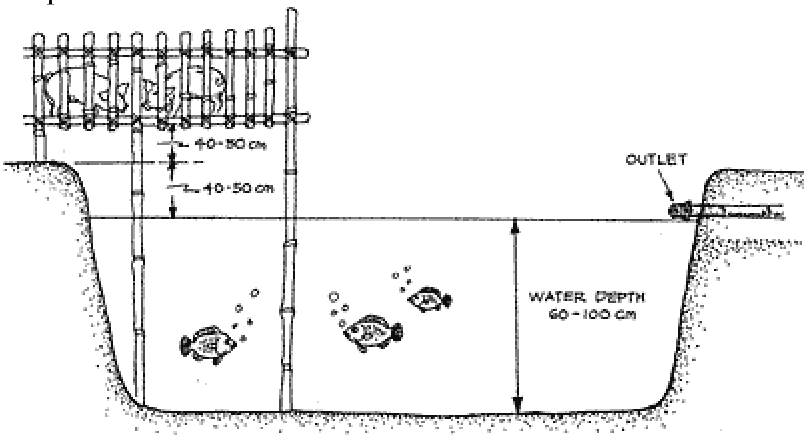
Integrated pig-fish culture is not a new concept; it has been practiced for many years in many parts of Asia. Raising pigs and fish at the same time has several advantages:

- Fish farmers can produce fish without feeding and hauling manure to fertilize the pond.
- Pig-fish culture maximizes land use by integrating two farm enterprises in the same area.
- The fishpond serves as a sanitary disposal place for animal wastes.
- Backyard integrated pig-fish culture provides additional income and a cheap source of animal protein for the family.

Location of the pig pen

- There are two optional designs for locating the pig pen. It can be constructed on the dikes near the fishpond. Preferably, the floor should be made of concrete (or other impermeable material to catch pig manure and urine) and should slope toward the pond. A pipe is necessary to convey the manure and urine into the pond. An alternative design is to construct the pig pen over the pond. In this case, the floor can be made of bamboo slats spaced just enough to allow manure and urine to fall directly into the pond but not too wide for the feet of the pigs to slip into (thus, causing injuries). The pen should have a floor area of 1 m x 1.5 m for each pig. Establish the pond near a water source. However, the site should be free from flooding. Inlet and outlet pipes should be installed and screened.
- The water depth should be maintained at 60-100 cm. With this recommended pond area and water depth together with the right stocking density, problems of organic pollution are avoided.
- A diversion canal can be constructed to channel excess manure into a compost pit or when manure loading needs to be stopped.

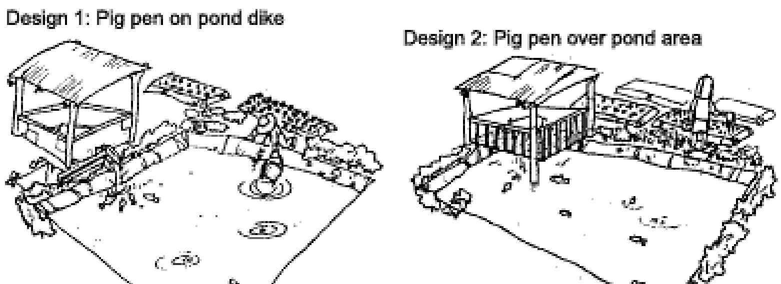
- Nutrient-rich water from the pond can be used for vegetables grown on the pond dike or adjacent to the pond.

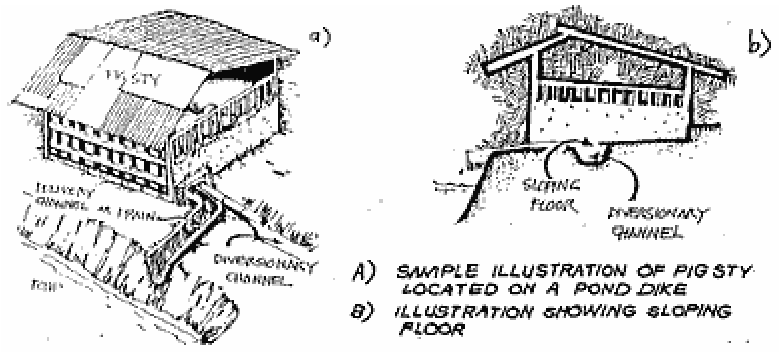


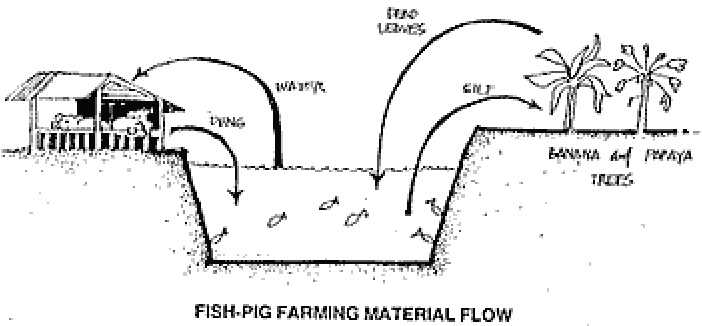
Stocking
- One pig can sufficiently fertilize a 100-150 m² pond with its manure.
- Stock the pond with tilapia or catfish fingerlings (3-5 cm.) at stocking density 200 fish/100 m²
- Stock the pig pen with one weanling (8-10 kg or 1.5 month old).
- Fish and piglets can be stocked at the same time.

Pig feeding
- Feed the pigs twice a day by mixed rice bran, broken rice, fish meal and pellet feed. Supplemental feeds such as Ipomoea (*Ipomoea aquatica*) may be given.

The raising of pigs can fruit-fully be combined with fish culture by constructing animal housing units on the pond embankment or over the pond in such a way that the wastes are directly drained into the pond. The system has obvious advantages:
- The pig dung acts as excellent pond fertilizer and raises the biological productivity of the pond and consequently increases fish production.
- Some of the fishes feed directly on the pig excrete which contains 70 percent digestible food for the fish.
- No supplementary feed is required for the fish culture, which normally accounts for 60 percent of the total input cost in conventional fish culture.
- The pond dikes provide space for erection of animal housing units.
- Pond water is used for cleaning the pigsties and for bathing the pigs.
- The system cannot be adopted in all parts of India due to religious consideration but it has special significance in certain areas as it can improve the socioeconomic status of weaker rural communities, especially the tribals who traditionally raise pigs and can take up fish-pig farming easily.







Fish-pig farming material flow

Harvesting

- Harvest the fish after 4-5 months. Collect fingerlings (if present) for the next growing season; sell the surplus. Partial harvesting for family consumption can also be done as needed.
- Sell the pig after 4-5 months.
- If possible, scrape out the organic waste or mud on the pond floor and use as fertilizer for the vegetable crop.

Limitations

- High cost of inputs for pig growing (feeds and weanlings)
- Consumers may be reluctant to eat fish produced in manure- loaded ponds, creating potential marketing problems.
- Farmers want their animals close to their homes (because of theft problems) and this may not be always possible.

Possible solutions to overcome some of the limitations

1. Raise crossbred/native pigs to reduce feed cost.
2. Occasionally, fish from ponds, which were overloaded with manure, can have a «muddy» or off-flavour taste which can be removed through the following measures:

- Stop loading manure to the pond a few days before harvesting fish.
- Transfer harvested fish to a net enclosure installed in a clear pond at least 4-6 hours (better several days) prior to selling or eating them.

Chicken-fish culture

Chicken raising for meat (broilers) or eggs (layers) can be integrated with fish culture to reduce costs on fertilizers and feeds in fish culture and maximize benefits. Chicken can be raised over or adjacent to the ponds and the poultry excreta recycled to fertilize the fishponds. Raising chickens over the pond has certain advantages: it maximizes the use of space; saves labour in transporting manure to the ponds and the poultry house is more hygienic. No significant differences have been observed on the chickens' growth or egg laying when they are raised over the ponds or on land. In case of the former, the pond embankment could still be utilized for raising vegetables.

Stocking

- Stock broilers 1000 or chickens layers at density of 200 chickens/1,600 m^2 and fingerlings of Indian carps, catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) and Chinese carps, silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*). Species stocking rate could be 40 percent surface feeders (catla and silver carp), 20 percent rohu, 30 percent bottom feeders (mrigal and common carp) and 10 percent grass carp or Nile tilapia at density of 3,000 fish/1,600 m^2.

Feeding

- No feeds need to be given, as the feed spilled by chicken (which could be as much as 10 percent) fall into ponds.

Fertilization

- No fertilizer is needed, except for excreta of chicken falling into ponds.

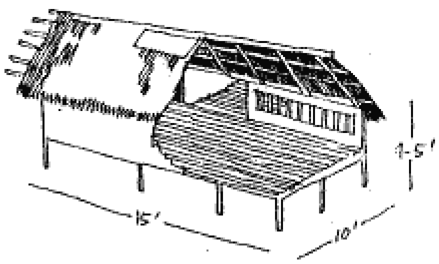
Harvesting

- Harvesting of fish could start 6-7 months after stocking when some fish reach table size.

Oxygen depletion

- When water becomes deep green due to plankton blooms, oxygen in the water may get depleted and fish may die. In such cases, put mats or plastic sheets below the poultry house to catch the chicken excreta and suspend nutrient inputs for 1 to 3 weeks. If possible, immediately irrigate the pond with freshwater.

Vaccinate your chickens



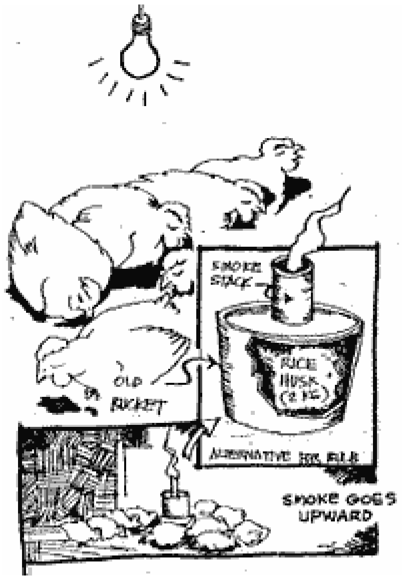
In some countries, vaccines can be obtained from the nearest livestock office, free of cost. The following are some reminders when collecting vaccines:

- Bring a good thermoflask and a little cotton wool.
- Do not waste vaccine. Obtain only the exact amount needed. Vaccine production costs a lot to the government.
- Store vaccines at low temperature, preferably in a refrigerator, to maintain their effectiveness.

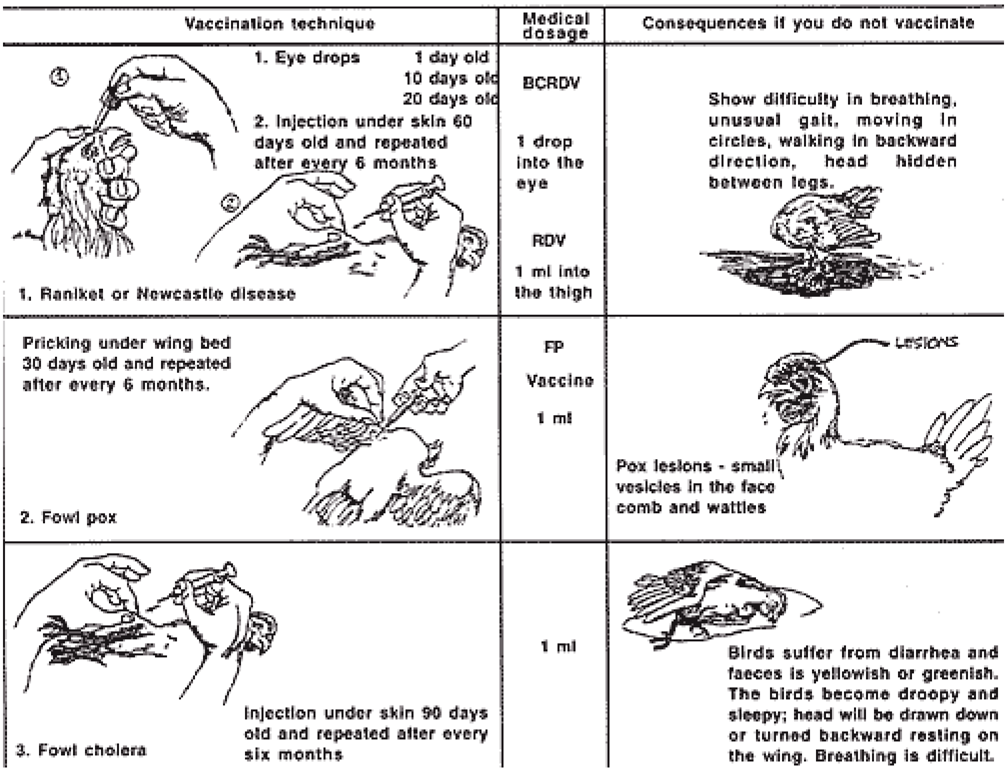
Equipment necessary in vaccination

- Thermoflask of sufficient capacity to carry the vaccines.
- Nylon syringe - one or two, graduated at 1 ml intervals. Smaller-capacity syringe is preferable.
- Needles of gauge 20 or 21 and 14 or 15. Shorter needles of 1-2 cm length are preferable for poultry vaccination. A few large sewing needles are suitably modified for fowl pox vaccination.
- Measuring cylinder
- Two wide-mouth bottles: one to carry distilled water and another to dilute vaccines, when necessary. These items preferably should be of nylon or polypropylene which could be sterilized by boiling when necessary.

Reminders when vaccinating chickens

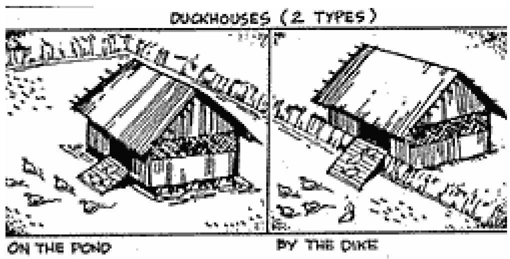


- Sterilize syringes, needles and all other equipment before using.
- Put ice cubes at the bottom of the thermoflask and a layer of cotton wool before placing the vaccine vial. Close the flask.
- Check vaccine if it looks all right. Do not use discolored or unusual-looking vaccines.
- Use distilled water purchased from a pharmacy when diluting vaccines, or boil clean water for 10-15 minutes. Cool down, then strain into a clean bottle.
- When only a small amount of distilled water has to be added, draw the required amount into the sterile syringe and inject into the vial. Dissolve by vigorously shaking the vial.
- Pour the balanced amount of distilled water into the mixing bottle. Draw the dissolved vaccine into the syringe. Pour into the mixing bottle containing the balanced quantity of distilled water. Thoroughly mix with a sterilized rod.
- In case of fowl pox, remove the required amount into a sterilized empty vial and use for vaccination. This prevents contamination and subsequent waste of surplus vaccine.
- Do not spill vaccines. This could be fatal to chickens.
- Hold the needle with the knob. Do not touch the tip when assembling the syringe for vaccination. Contaminated needles should not be used until sterilized.
- Before vaccination, confine the birds, picking up one by one and releasing after vaccination. This makes vaccination easy and no bird is missed.
- Do not vaccinate birds suffering from disease or in a state of stress. Vaccinate them only when they are back to normal.
- Two vaccines should not be given the same day. A 10-day gap is needed between two successive vaccinations.
- Record data so that the next vaccination will be known.
- If leftover diluted vaccine can be used within a short period, it should be put in a clean polythene bag and placed in the flask containing ice.
- Wash all equipment used with soap and clean water, then sterilize in boiling water.
- Thoroughly clean empty vaccine vials. Return them to the Livestock Officer when collecting the next requirement of vaccines.
- Vaccinate birds on time.



Vaccination technique	Medical dosage	Consequences if you do not vaccinate
1. Raniket or Newcastle disease 1. Eye drops 1 day old, 10 days old, 20 days old 2. Injection under skin 60 days old and repeated after every 6 months	BCRDV 1 drop into the eye RDV 1 ml into the thigh	Show difficulty in breathing, unusual gait, moving in circles, walking in backward direction, head hidden between legs.
2. Fowl pox Pricking under wing bed 30 days old and repeated after every 6 months.	FP Vaccine 1 ml	Lesions Pox lesions - small vesicles in the face comb and wattles
3. Fowl cholera Injection under skin 90 days old and repeated after every six months	1 ml	Birds suffer from diarrhea and faeces is yellowish or greenish. The birds become droopy and sleepy; head will be drawn down or turned backward resting on the wing. Breathing is difficult.

Duck-fish culture



Raising ducks over fishponds fits very well with the fish polyculture system, as the ducks are highly compatible with cultivated fishes. The system is advantageous to farmers in many ways:

1. Ducks fertilize the pond by their droppings when given free range over the pond surface. Ducks have been termed as manuring machines for their efficient and labour-saving method of pond manuring, resulting in complete savings on pond fertilizer and supplementary fish feed which accounts for 60 percent of the total cost in conventional fish culture.
2. Ducks keep water plants in check.
3. Ducks loosen the pond bottom with their dabbling and help in release of nutrients from the soil, which increase pond productivity.
4. Ducks aerate the water while swimming; thus, they have been called «biological aerators.»
5. Duck houses are constructed on pond dikes; hence, no additional land is required for duckery activities.
6. Ducks get most of their total feed requirements from the pond in the form of aquatic weeds, insects, larvae, earthworms, etc. They need very little feed, and farmers normally give kitchen wastes, molasses and rice bran, for the purpose.

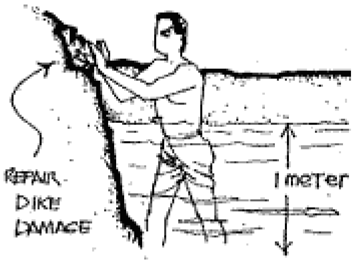
Cultural practices

Successful pond management is the basis of profitable fish culture. Build the pond (about 1 000 m²) near your house to enable you to take proper care of your ducks and fish and to discourage poaching.

Check the pond dikes and repair the damages, if any. Deepen the pond so that it retains more than 1 m depth during the dry season.

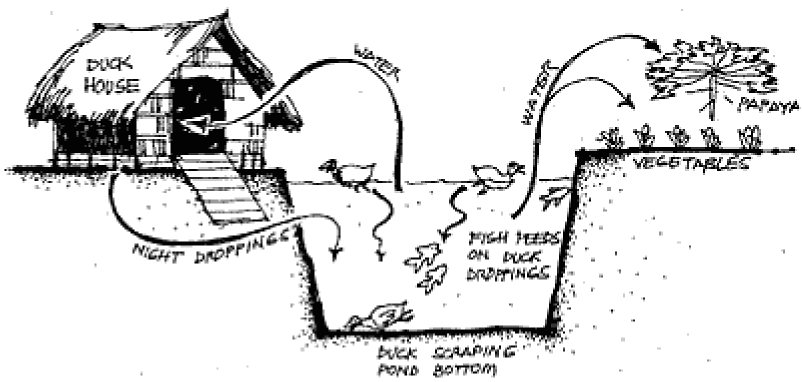
Drain or dry the pond and remove or kill all the remaining fish stock from the pond by applying 15 kg bleaching powder and 15 kg urea/1 000 m².

Urea and bleaching powder may be applied one after the other and the dead fish netted out. Alternatively, 250 kg of Mahua oil cake (Basia latifolia) may be applied which not only kills fish but also acts as pond fertilizer.



Apply 20-25 kg of lime about a week before manuring the pond. In case a mixture of bleaching powder and urea is applied to eradicate the predatory and weed fishes, apply only 5-10 kg of lime (reducing the amount of bleaching powder applied).Manure the pond with a basal dose of cattle dung at 500 kg/1 000 m².

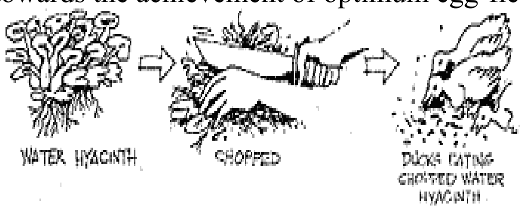
Stocking density
Stock the pond with fingerlings (5-7 cm. or large enough escaping from duck) 7 days after poisoning as the toxicity of bleaching powder lasts for about 1 week. The stocking density is 3,000 fish/1,600 m^2. Some alterations can be made on the stocking density and species ratio depending upon the pond conditions and availability of fish seed.



Fish-duck farming material flow

Harvesting
Fish which attain marketable size should be harvested and the rest allowed to grow further. Final harvesting may be done 10-12 months after stocking.

Duck farming
Egg laying by ducks depends upon many factors, including breed and strain, but good management contributes considerably towards the achievement of optimum egg-flesh production.



The ducks do not need elaborate housing since they remain in the pond most of the day. A low-cost night shaker made of bamboo or any other cheap material should be available in the area either on the pond embankment or on the water surface. The house should be well-ventilated and so designed that the washings are drained into the pond.

The ducks can find natural food from the pond. They will need very little supplementary feed which can come from household wastes, such as kitchen leftovers, rice bran, broken rice and spoiled cereals, if any. Alternatively, a balanced feed may be purchased and given at 50 g/bird/day. Moldy feed, or feed kept for long time, should be avoided as molds contain toxins which may cause poisoning.

The ducks start laying at the age of 24 weeks. Laying boxes with straw may be kept in the duck house.

Proper sanitation and health care are very important to maintain a healthy stock. A sick bird is easy to detect: it becomes restless, its eyes lack brightness, and watery discharge comes out of the eyes and nostrils. The sick bird should immediately be isolated and treated.

The eggs are collected every morning as the ducks lay eggs only at night. The ducks lay eggs for two years, after which they should be culled.