INTEGRATED FRESH WATER CULTURE SYSTEMS

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INTRODUCTION

Historically, fish farming has been a part time activity of peasant farmers, who developed it as an efficient means of utilising farm sources to the maximum extent.

Integrated fish farming combines fish, swine, poultry and vegetable production. The concept, of the integrated fish culture is theoretically brilliant since fish can be virtually free by-product of integrated arable and livestock farming. Chicken coops and pens for pigs and ducks can be constructed on the dikes or above the ponds. Fresh animal manure thus enters the pond directly, hastening the growth of natural food organisms for the fish being cultured in the pond. Moreover, livestock feeds that fall in the pond can be directly utilised by fish. In areas where rice fields retain water for 3-8 months in a year, paddy-cum-fish culture can provide an additional crop : fish. Animal manure can also be used to grow fodder crops on the sides of dikes such as squash for its chopped-up leaves to feed herbivorous fish, and adjacent vegetable plots can be fertilised by the nutrient-rich pond water. Because of the role which such integrated farming can play in increasing the employment opportunities, nutrition and income of rural populations, it has received considerable attention in recent years.

Integrated farming thus brings aquaculture to resource-poor, small scale farmers who cannot afford expensive farm inputs. Recycling by-products of animal husbandry greatly lowers the cost of fish production.

The present paper aims to review the information available on the integrated fresh water systems.

II- BASIC PRINCIPLES

The basic principles involved in integrated farming are the utilisation of synergetic effects of interrelated farm activities, and the conservation including the full utilisation of farm wastes. It is based on the concept that there is no waste, and waste is only a misplaced resource which can become a valuable material for another product (FAO, 1977).

The quantity-composition and value of animal manure vary according to species, weight, kind and amount of feed, and kind and amount of pedding. The data in Table 1 and Fig 1 are based on animals confined the year around. Actually, the manure recovered and available to spread where desired is considerably less than indicated because :

1) animals are kept on pasture and along roads and lanes much of the year, where the manure is dropped, and

2) losses in weight often run as high as 60 percent when manure is exposed to weather for a considerable time.

In China, USSR and other countries, animal manure is often composted with plant materials before application. Fig (2) show the concrete pits used for a manure composting in China. The pits are usually circular, measuring 2.5 m in bottom diameter, 1.5 m deep and 3.0 m in top diameter. Each pit is filled with a layer of a mixture of river silt and rice straw (7.5 tons and 0.15 tons respectively), pig or cow manure (1 ton) and aquatic plants or green manure crops (0.75 tons) in 15 cm layers. The top is covered with mud and a water column 3-4 cm deep is kept at the allowed surface to create anaerobic conditions and thus minimise losses. The compost is turned over in six to ten weeks, after which it is ready for use. In the 1st turning over, 20 kg superphosphate are added and thoroughly mixed with the organic material, adding water to ensure moist conditions. The chemical composition of the compost as a percentage of wet weight is 0.3 N. 0.3 P, 0.25 K and the organic matter 7.8 to 10.3. The carbon nitrogen ratio is 15-20 :1. Compost is applied at the rate of 5-10 tons/ha in three applications (the first being the largest) in 6 to 8 months of the fish rearing period.

Human sewage is also used for fertilising aquaculture ponds in some countries and the use of treated sewage for fish farms is expanding, particularly in areas near urban centres where the disposal of sewage is an ever increasing problem. Treatment generally consists of sedimentation, dilution and storage. Sedimentation may be done in two stages : a primary stage to settle most of the heavier solids and a 2nd stage to increase mixing and homogenisation as well as improve natural purification processes.

Green manuring is another method of pond fertilisation particularly where the pond soils are of poor quality. Some farmers grow such plants as and alternative crop on dried pond bottoms. After they are fully grown, the plants are cut and ploughed into the soil before the ponds are filled with water. This improves the fertility of soil and water very considerably. Green manuring is also sometimes done to increase the nitrogen content of water in ponds, using different types of plant matter.

Farm wastes can be used for fertilising and feeding the fish and accumulations of silt in the ponds can be used for fertilising agricultural crops, vegetables and fruit tree grown around the pond farms. Livestock animals (pigs, ducks, geese, chicken, cattle, sheep, rabbits etc...) are farmed in association with fish, although the association is not as close as with ducks and pigs, In many farms of china, mulberry plants are grown on fish farm dikes and in neighbouring fields for silkworm production. The mulberry wastes and silkworm pupae (after removal of silk) are used to feed the fish directly, and also serve partly as fertilisers for the ponds.

There are three types of animal farm system with fish :-

1) around the ponds

2) in the pond on the steep, and

3) above the pond on wooden platform.

The later system is the least expensive and most sensible. Initial interest in rice-fish culture was stimulated by the fact that rice is the stable food of 90% of the Filipinos, and fish is their second most important food. Recent publications in this respect showed that rice-fish culture is a profitable and more productive farming system than rice monoculture.

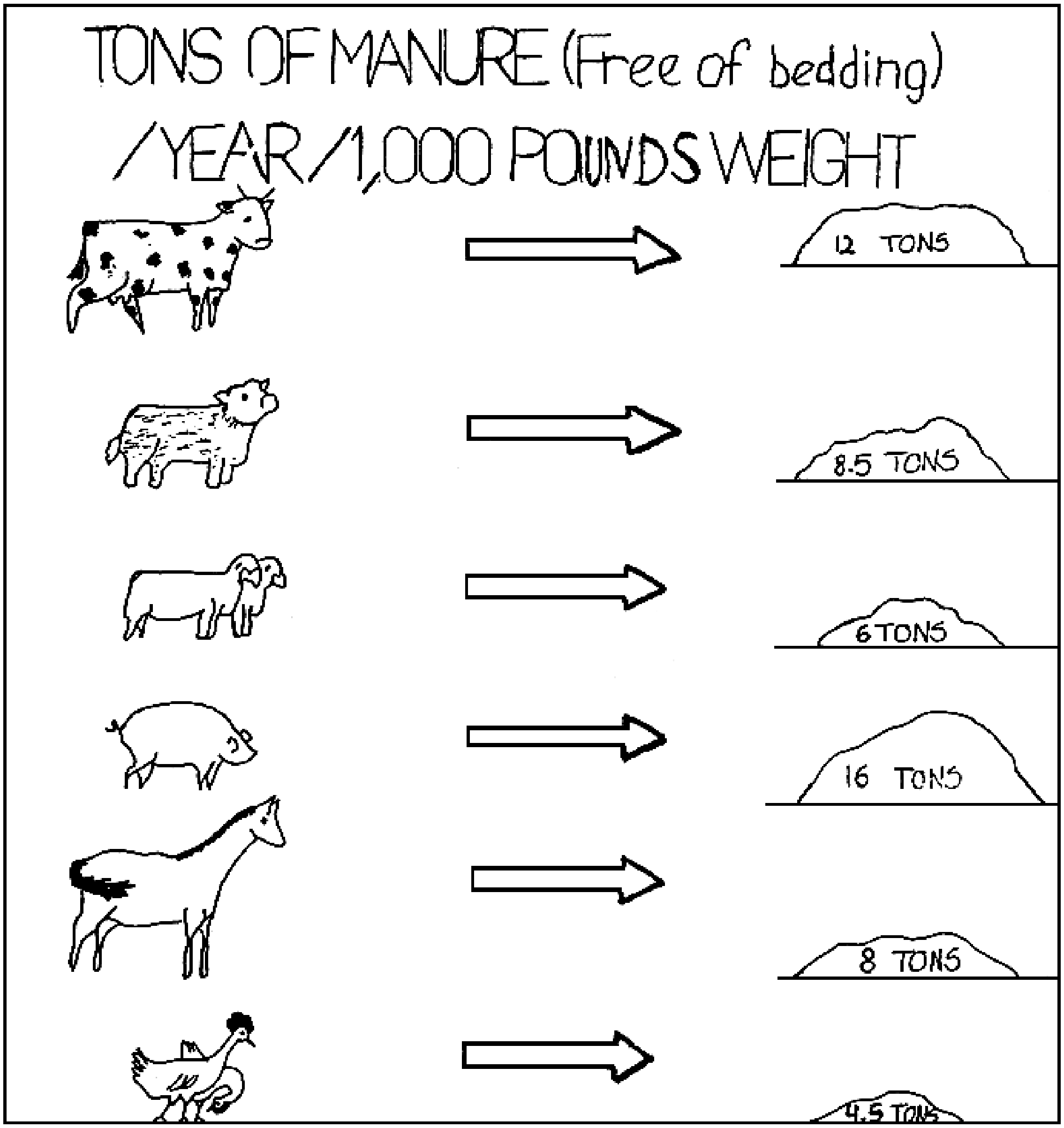
TONS OF MANURE (Free of bedding)
/YEAR/1,000 POUNDS WEIGHT
12 TONS
8.5 TONS
6 TONS
16 TONS
8 TONS
4.5 TONS

Table (1) : Quantity, composition and value of fresh manure excreted by 1000 pounds live-weight of different kinds of livestocks.

Animal	Excreted ton/1000/year	Excrement Lb/ton	Composition and value			
			Water %	N (Lb/ton)	POKO	value/ton
Cow	12	L 600				
		S 1400				
		T 2000	79	11	12	5.0
Streer	8.5	1,600				
		S 1400				
		T 2000	80	14	11	6.4
Sheep	6	L 660				
		S 1340				
		T 2000	65	28	24	11.3
Swine	16	L 800				
		S 1200				
		T 2000	75	10	9	4.7
Horse	8	L 400				
		S 1600				
		T 2000	60	14	14	5.8
Poultry	4.5	T 2000	54	31	8	12.3

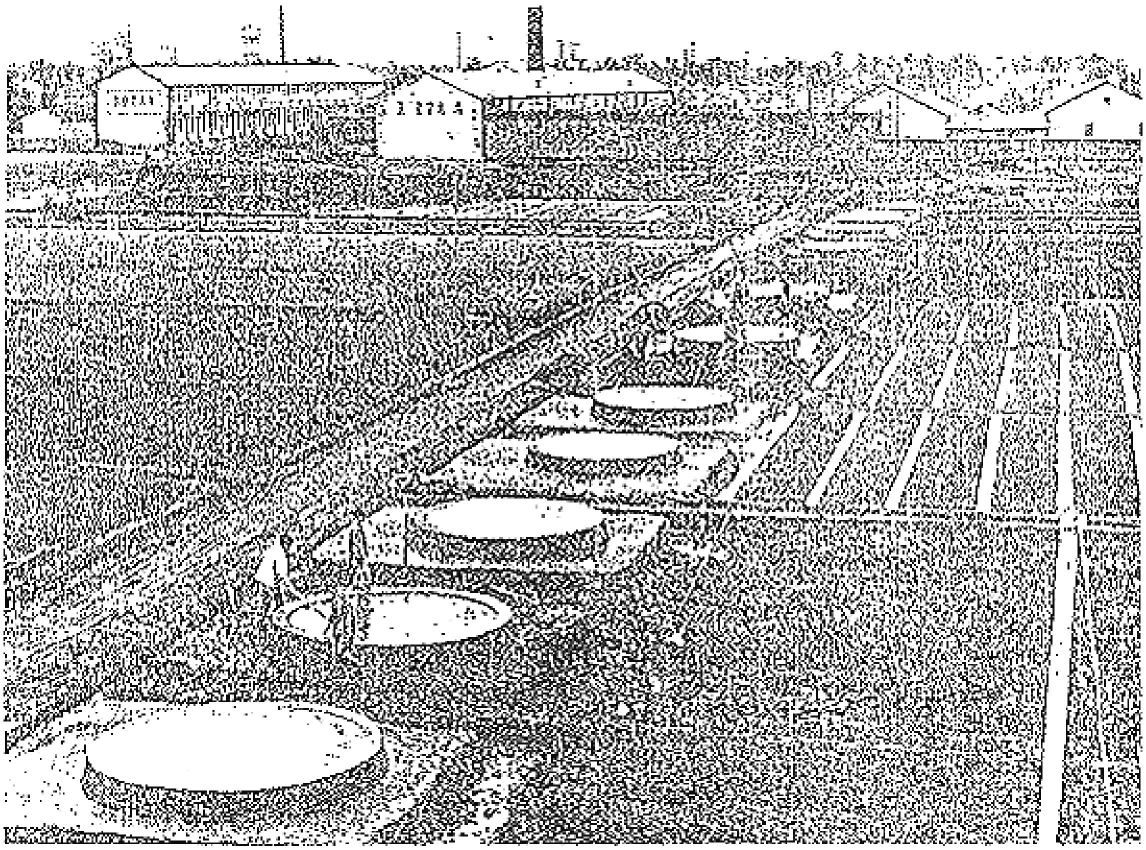

Fig. 2 : Coment concrete pits used for composting silt, rice straw and animal manure.

III. LIVESTOCK-CUM-FISH CULTURE

Cattle, sheep, goats, ducks, geese, poultry and pigs can be easily integrated with aquaculture. The most integrated systems at present are duck and pig framing. The dung and urine are either discharged directly into the pond or added after collection. These metabolites maintain a high level of nitrogen and phosphorus in the pond water, and thus help in sustaining a heavy crop of planktonic organisms which provide food for the fish. The dung also serve as fish food to a very limited extent but their main role is to enrich the pond ecosystem with nutrients and to contribute to the productivity of the water body. One recommended formula of animal numbers whose catabolic products may suffice to annually manure and fertilise one hectare of water pond with an expected productivity as the following:

Livestock	NO/ha	Expected Harvest (Kg/ha) year
Cattle	2	3000
Sheep	40	3000
Goats	50	3000
Chickens	200	3500
Ducks	100	3500
Pigs	40	6000

III- 1- DUCK AND FISH FARMING

Ducks have been raised on fish ponds in Eastern Europe and parts of China for several centuries. Though the compatibility of ducks and fish have long been recognised. The combination of duck and fish farming is seen as a means of reducing the cost of feed for ducks and convenient and inexpensive way of fertilising ponds for the production of fish food. Obviously more animal protein can be produced per unit area by such a combination. The ducks search for and feed on a variety of organisms, including tadpoles, frogs, insects, insect larvae, snails and water weeds, which need to be eradicated from ponds. The protein content of supplementary feeds which are necessary to achieve high production rates for ducks can be reduced to 10 or 15%. When the ducks are raised in ponds. In additions, the pond provides a clean and healthy environment for the ducks.

Special strains of ducks suited for pond raising have been developed. If a suitable strain is used, approximately 50-60% of their droppings will fail into the pond and act as fertilizer to the fish food organisms. Timely and reliable supplies of good quality ducklings of the required strain are of critical importance in successful farming.

These are two basic ways of keeping ducks on fish ponds :-

1) to allow them free access to the whole pond area (Fig.3).

2) to confine them to enclosures (Fig.4).

The 1st option of free range system has the following advantages:-

a) ducks are allowed to swim around freely on the pond surface

b) good proportion of droppings fall directly to the pond.

c) ducks are able to forage around the whole pond for organisms.

d) small duck houses are built and the disadvantage of the system is a considerable of the sys em is a considerable energy used up by ducks in swimming around and this is believed to ffect the growth rate and feed conversion.

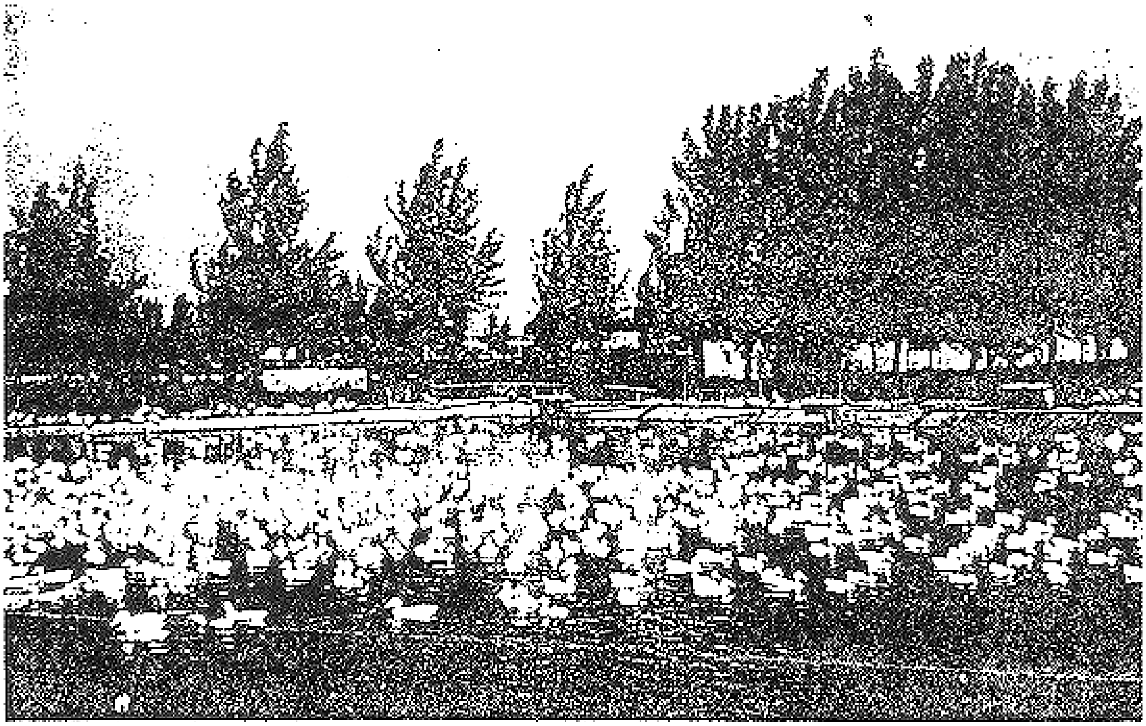

Fig. 3 : A fish pond in Hungary, where ducks have access to The whole pond.

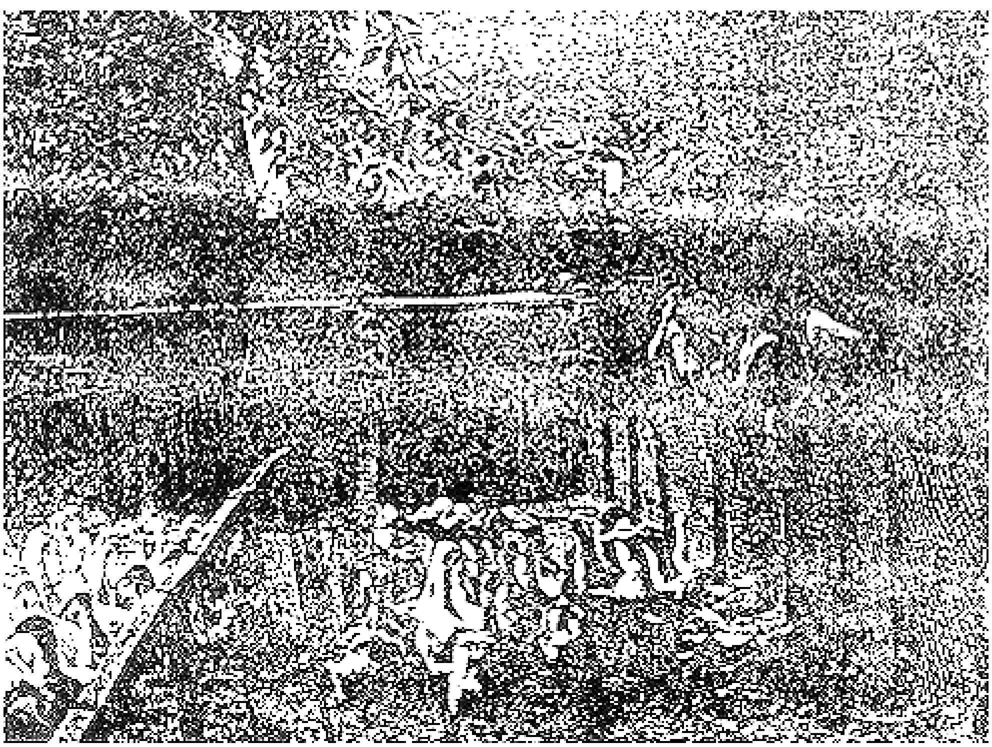

Fig. 4 : Ducks confined to enclosures on the banks of a fish pond.

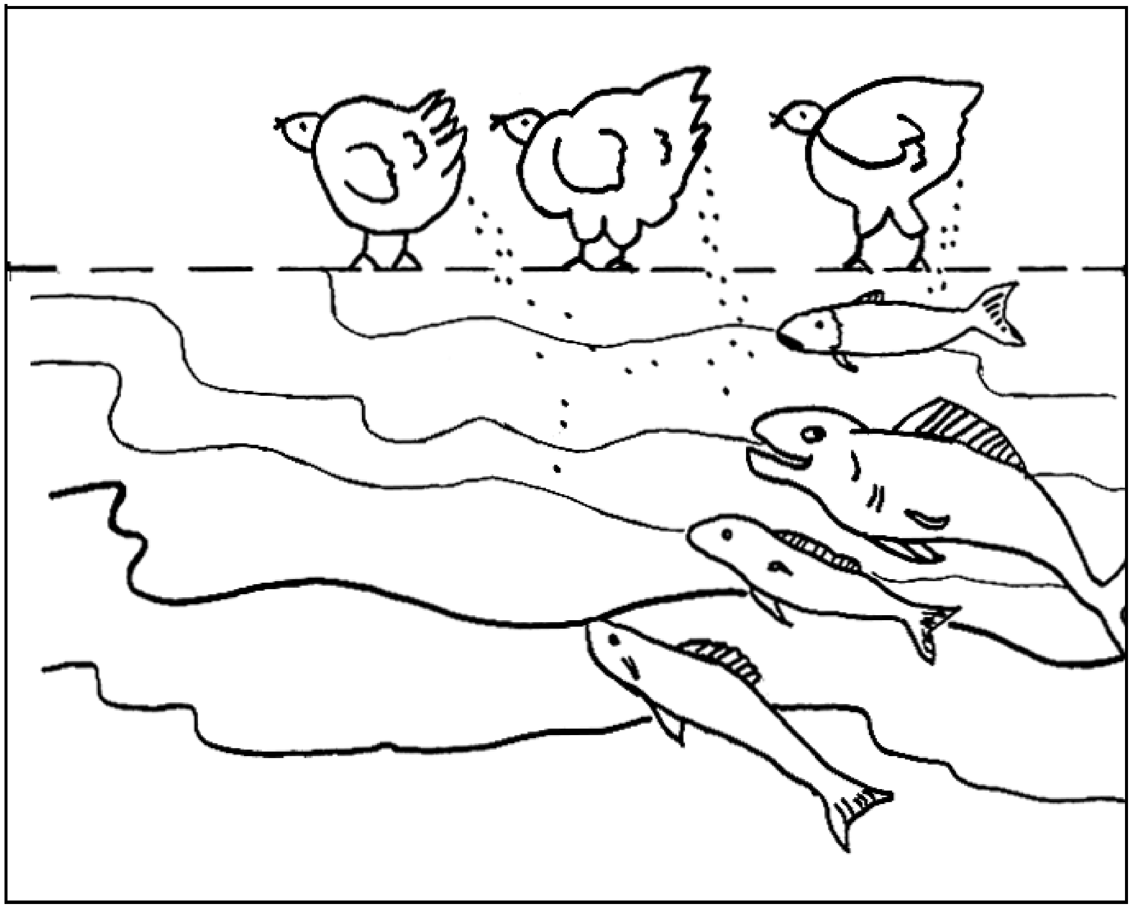

Fig. 5

In the 2nd option of confining them in enclosures which is preferred by many farmers, used selected strains of ducks for maximum growth. Wire fences are built, enclosing part of the pond area and adjacent banks, and suitable feeding and resting areas are provided. About one-quarter of the enclosure will be on land and the rest in water some of he droppings fall directly into the pond, and the rest have to be washed into it. it is reported that fish production under this system is nearly equivalent to the free range system.

The first egg laying from ducks at about 6-7 months old. They fed at the rate of 9-10% of body weight, i.e. about 240-300g per day. About 120-140 eggs are produced by a female every year. The incubation time for the eggs is about 28 days, and a survival rate of 75% of one-day-old ducklings can be expected. The one-day-old ducklings require special care and have to be reared in controlled environment to the age of 10-14 days, a temperature of 30-32°C is maintained in the rearing room, which can hold 50-55 duckling per m2. A screen floor is provided to allow manure to fall through. After the third of fourth day the ducklings are released to shallow splashing pools to become accustomed to water. During the 2nd week they are allowed to swim in small indoor conditioning ponds and are fed on prepared feeds. The ducklings are ready to release into fish ponds in 14-20 days, depending on weather conditions. The rapid growing strains reach a marketable size when about 42-58 days.

Stocking of ducks depends on the following :

a) quantity of excreta per duck, which in turns depends *on* species, quality of feed and method f raising.

b) climate condition.

c) stocking density and ratio of fish species.

In East European Countries, about 300-500 ducks are raised per ha of pond during the summer season. However, in tropical and sub-tropical countries, the stocking rates reached 2250/ha. if number of ducks exceeds 3000/ha, filter-feeding fish and omnivorous fish should be increased and herbivorous fish should be reduced. Values of excreta (kg/duck) are :

7 for fattening Beijing

42.5-47.5 for egg-laying Shaoxin

50 for hibrids of Shaoxin

and khaki - Combel.

Duck production is about 1000-1200 kg (each weighing 2- 2.4 kg).

The most common species of fish used in duck/fish culture are herbivores and omnivores. In East European Countries the common carp was traditionally the main species, but now the Chinese carps are also included to make full use of the food resources in integrated polyculture systems. A fish yield per ha of :

500 - 600 kg sliver carp,

150 - 200 kg bighead carp,

and 1000 - 1200 kg common carp, were achieved with supplementary feeding and high stocking density in Hungary. The same production can be achieved without supplementary feeding, if the proportions of Chinese ca ps were increased. However, since consumers prefer the common carp, it continues to be the main species.

In Taiwan, as well as in East european Countries, Chines carps (grass carp, silver carp and bighead carp) and common carp, other important species used in Taiwan are the hybrid tilapia (O. niloticus and O. mossbica) and the grey mullet. Small numbers, of eel, Asian catfish and sea perch are also added in poly culture. Some farmers stock male tilapia.

III- 2- PIG AND FISH FARMING

Pig sites are built on the pond embankments or on neighbouring land. In China, embankments in integrated farms may be over 10 m wide and planted with groundnut, vegetables, colza, corn, sugar cane, mulberry, bananas, castor etc... and about 45-75 pigs per ha are generally raised , but some farms have up to 90 pigs per ha. The average production of manure (faeces and urine) per pig is around 7.8-8 tons per annum. This amounts to 351-600 tons of manure/ha per year. In Taiwan higher rates of 150-300 pigs/ha of pond area are maintained. Considerable care and water management skills are required to prevent pollution of the water and mortality of the fish stock due to the very high loading of organic matter in ponds. Under Hungarian conditions, the maximum loading possible is reported to be 600 kg/day, when manure is placed localised heaps in the ponds. The manure output from pigs depends on its size and age (piglet gives about 3.4 kg/day and one year old produce 12.5 kg/day) and also on the quality and quantity of food consumed by pigs. The wastes are conveyed to a specially built tank, where sedimentation and fermentation of manure take place. At regular intervals, the supernatant liquid from the tank is allowed to flow into the ponds. The sludge that remains is removed for fertilising agricultural crops.

Traditionally, the pigs in integrated farms depend on foodstuffs produced on the farm. Several aquatic plants such as water hyacinth, Ipomoea, Pistia, Wolffia, Lemna and Azollal are grown in canals and associated water bodies near the farm. These as well as the foliage of several terrestrial plants, such as vegetable, rice and leguminous plants are utilized as feedstuffs for pigs. These plant materials are generally mixed with rice plant, bananas, coconut meal, soybean wastes, fish meal etc... for feeding the pigs. The pigs are generally sold when about 90-100 kg in weight. The duration of the culture of fish and pigs varies, but generally it is about year.

High rates of fish stocking density are practised as the productivity is generally high (2 to 18 tons/annum.) Because of the variety of food materials which become available in the ponds about 60 000 fingerlings (20-30 g) of polyculture fish species are stocked per ha of ponds. The most common species are :

(1) Common carp

(2) Chinese carps

(3) Catfish (Pangasius)

(4) Indian carps

(5) Tilapia species.

Integrated pig and fish farming increase the productivity per area and input, and it is also increases the farmers income by a factor of two or more (Table 2).

Table (2) : The annual operating costs and income for a pig/fish farm in Malaysia.

Item	US$
Operating costs:	
Pig food	29 612
Labour	1748
Maintenance and operation of equipments	874
Subtotal for pits	32 234
Fish fingerlings	3 083
Total	**35 317**
Cross income	
Sale of 480 pigs	39 611
Sale of bighead carp	7 282
Total	**46 893**
Net income	
Pig production	7 379
Fish production	5 510
Total	**12 889**

Source : Adapted from Tan and Khoo, 1980.

III-3 CHICKENS AND FISH AND SHRIMP

In the Philippines (1990), milkfish and shrimps are commonly cultured extensively in brackishwa-ter ponds. In pond operation, fertilisation with the use of chicken manure and inorganic fertilizers is indispensable. However, with increasing cost of fertilisers, the farmers in developing countries have tried integration of aquaculture with animal husbandry with promising results. The advantages of this integrated approach include :

(1) maximum utilisation of land space,

(2) use of excreted poultry wastes as feed to the cultured organisms or as fertilizer to the pond, and

(3) economic viability.

A study was conducted in twelve 1000 sqm ponds. Four treatments, composed of the various densities of chicken layers at 0, 25, 50 and 75 heads with the fixed density of 1100 P. indices and 225 C. chanos per pond, were allocated and replicated thrice. Poultry houses measuring 2x3m and made of nipa and bamboo were constructed at the middle of each pond designated with poultry (Fig.5) prior

to stocking, the ponds were prepared by drying and limning at 100 kg/pond. Chicken manure and inorganic fertiliser were applied only to the ponds without poultry at 100 kg/pond; The ponds with poultry were fully dependent on the poultry wastes that dropped directly from the poultry house. The ponds without poultry were properly applied with fertilizers (1:1 mixture of 16-20-0 and 46-0-0) at 2.5 kg/ pond every two weeks. Pond water replenishment was through tidal fluctuation and the depth maintained at 40-50 cm. Pond water dissolved oxygen, Ph, salinity and temperature were monitored twice a day results of the 1st and 2nd experimental (120 day each) periods are summarised in Table 3. The results clearly showed that the higher production of shrimps and milkfish in ponds with poultry was mainly attributed to the chicken manure that stimulated plankton growth. Milkfish was observed to eat the chicken manure directly. No off flavour or any micro-organism that could render the fish or shrimp unsuitable for human consumption was detected during pathological examination. The optimum number of chicken layers that could be integrated with 1100 shrimp and 225 milkfish proved to be between 50 and 75 heads. Dissolved oxygen deficiency due to the decomposition of plankton occurred frequently in ponds with 50 layers. Total ammonia-N (0.3 to 1.3 ppm), nitrate (0.1 to 0.2 ppm), and phosphate (0.2 to 0.6 ppm) appeared to be higher in ponds with higher poultry density. Salinity (15 to 48 ppt), Ph (6.2 to 9.0), and water temperature (21 to 36°C) did not vary much among treatments.

Based on the results of this experiment, production could be improved further by increasing the stocking density of shrimp and introducing another species such as tilapia (0.nilotica) that can efficiently utilise the plankton.

Further research showed that a 4m x 8m poultry house was right for a 1000 m2 fish pond. A bamboo catwalk connected the poultry house to the dike. Stocking in the pond consisted of 200 milkfish fingerlings, 1500 tilapia fingerlings, and 5000 shrimp juveniles and above it, 90 3-wk old chicks were put in the poultry house. This mix was found to give the best productivity. The chickens were harvested after 45 days (half the period for fish). Two chicken crops were harvested for one fish crop. Farmers have both fish and chickens for household food and for sale. For sanitation, it suggested that chickens be harvested a week before the fish and the pond water immediately changed. When the fish are harvested after another week, the ponds has the healthy smell and fresh fish.

Table (3) Growth and Survival of Prawn (Penaeus indicus) and Milkfish (Chanos chanos)

	Shrimp			Milkfish		
No of layers 1000 m	Final weight g	Yield kg/pond	Survival rate %	Final weight g	Yield kg/pond	Survival rate %
A) April – August (or 120 days)						
0	5.3	4.3	77	248	40.1	85
25	10.1	8.0	75	260	44.4	88
50	13.9	9.5	66	335	54.9	82
75	9.8	8.1	78	274	46.4	87
B/September - January						
0	9.4	7.4	79	253	54	100
25	14.6	12.9	85	222	45	96
50	13.5	11.4	83	260	53	96
75	11.9	8.7	72	255	52	96

Source : Adapted from Apua, F.D. and J. Pudadora, Jr.. Integrated farming of prawn and milkfish with poultry in brackishwater ponds. SEAFDEC Asian Aquaculture, Vo. XII No. 1 March 1990

IV. RICE-FISH CULTURE

Depending on the intensity of cultural practices used, fish culture in rice fields can be categorized as:-

a) a secondary crop of fish after the rice;

b) a crop grown along with the rice during cultivation;

c) a crop grown in continuous ditches or channels during the harvesting periods or when the fields are drained, which ensures a prolonged period of fish culture.

Species of fish (Table 4) suited for culture in ice fields are those which can:-

a) live in very shallow waters;

b) withstand fairly high turbidity

c) tolerate relatively high temperature;

d) grow to marketable size in short period.

Results in Table 5 summarise the stocking density and size of initial fishes used in rice fields in some countries.

In rice/fish farming the main crop is rice and therefore fish farming techniques have to be modified to make them compatible with rice farming. The construction of ditches and canals will reduce the area available for rice planting, as they may occupy 5-10 % of the land. Higher levels of water have to be maintained (10-25 cm) for growing fish together with rice. In areas where the water supply is limited, this may prove to be a major handicap. Also the short-stemmed, high yielding varieties presently used by farmers may tolerate only moderate water depths even when the water supply is not a constraint. The duration of cultivation of such varieties is shorter (105-125 days) and may not be long enough to grow fish to marketable size.

Table (4). Fish species cultured with rice in different continents of the world.

Species	Asia	Africa	Europe	North America	South
Anabas testudineus	*				
Carassius auraus	*	*	*		
Catl 1 catla	*				
Chanos chonos	*				
Cirrhina mrigala	*				
Clarias batrachus	*				
C. lazera		*			
Cyprinus carpio	*	*	*	*	
Eleotris legendrei		*			
Haplochromis mellandi		*			
Helostoma temmincki	*				*
Heteroits niloticus	*				
Ictalurus punctotus					
Ictiobus cyprinellus					*
Labeo rohita	*	*			
Lates calcarifer					
Lepomis macrochirus					
Micropteras salmoides					*
Mugil corsula		*			*
Mugil parsia		*			
Mugil tade		*			
Mystus gulio		*			
Odontesthes bonariensis					*
Ophiocephalus striatus					
Osteocheilus hasseltii					*
Paratilapia polleni		*			
Puntius javasnicus	*				
Tilapia macrochir		*			
T. mossambica		*			
T. nilotica		*			
T. rendalli		*			
T. zillii		*			
Tinca tinca	*		*		
Trichogaster pectoralis	*				
T. trichoperus		*			

Table (5). Stocking density and size of initial fishes used in rice field cultures in some countries.

Country	Fish Spacies	Stocking density cm/100 m2	Lengh
Taiwan	Tilapia mossambica	70–80	
Cotedevour	Heteroitis niloticus	20–60	
	Tilapia macrochir	20–80	
	T.nilotica	30–80	
Indonesia	T. massambica	10–100	1–3
	Cyprinus carpio	600–1000	1
	Cyprinus carpio	40	2–3
	Cyprinus carpio	10–20	8–12
Japan	Cyprinus carpio	2	5–7.5
	Cyprinus carpio	125 (Artificial feeding)	
	Cyprinus carpio	12–16	
	Cyprinus carpio	40	
Liberia	Tilapia macrochi	50	
Madagascar	Cyprinus carpio	10	5–6
	Cyprinus carpio	25	4–5
	Tilapia macrochi	25	4–5
	T. massambica	25–40	8–10
	T. nilotica	25	4–5
	T. renhalli	25–50	3–5
	T. zillii	25–50	3–8
Vietnam	Cyprinus carpio	200	
	Cyprinus carpio	12	

Deep water (floating) rice will be more suited for combined farming with fish. The fertility of the soil is equally important to rice farming and to fish culture. The water quality in the fields has to be maintained at a level which is suitable for the fish and its food organisms. The intensive use of pesticides which create lethal conditions for fish life caused a serious problem for the combined culture of rice and fish. Therefore, the use of pest-resistance rice varieties will reduce the need for insecticide application.

Through proper water management, a suitable water temperature and oxygen content have to be maintained. Depending on the period available for fish farming, the stocking rate and size can be determined. The duration of culture is generally three to four months. Some farmers use the rice fields to grow fry to late fingerling stage, or from late fingerling stage to marketable size. In well managed fields a yield of up to 700 kg/ha can be expected. Results in Table (6) summarised the results of costs and returns for a rotational crop of tilapia and common carp in the Philippines, for a culture period of about 116 days and the stocking rate of 10 000 Nile tilapia and 5000 common carp. The results showed that application of fish farming in rice fields adds to the income of the farmer and is a more efficient use of land and farm resources.

Table (6) : Costs and returns of polyculture of Nile tilapia and common carp with supplemental feeding in 1 ha rice field.

Item	Value US$
Returns	
470 kg marketable Tilapia	481
222 kg carp	197
Total return	**678**
Costs	
10 000 Nile tilapia	109
5 000 Common carp	34
Feed 1270 kg rice bran	130
Fertilizer 386 kg 16:20:0	90
Labour 18.7 man days	28
Total costs	**391**
Net returns	**287**
Net returns % of total cost	73.4%

Source : Adapted from De la Cruz, 1980.

In Philippines* from late 1970 S to 1987, a study based on three costs and returns (rice/drt, rice fish, rice/wet) on rice production systems. The fish used throughout were tilapias : *Oreochromis niloticus* and *O. mossambicus.* It was found that rice-fish culture is a profitable and more productive farming system than rice monoculture. The shift from rice monoculture to rice-fish culture improved *net profit, profit margin,* and *return on* operating cost by an average of 40, 10 and 14% respectively total productivity indices showed that resources are used more productively in rice-fish culture than in rice monoculture. The specific productivity and net productivity indices of major inputs that are common to both rice-fish culture and rice monoculture show that labour, fertiliser, and pesticides contributed more to total revenue in rice-fish culture. On the average, specific productivity indices for labour, fertilisers, and pesticides were higher by 25, 27 and 36% while net productivity indices were higher by 21,33 and 40% for these inputs, respectively.

The cost structure in rice-fish culture shows that labour, fingerlings, fertiliser, and pesticides are major production inputs. The revenue structure shows that the contribution of rice and fish to total revenue is the same in both the wet and dry seasons, i.e. rice contributes an average of 175%, while fish contributes 25%. Table (7) summarised cost and return data (average) of seven rice/fish farms in Indonesia.

Table (7) : Summary of annual inputs and returns from average of 7 rice / fish farms (2970 m / farms) in Indonesia.

Item	US$	%
Fish Inputs:		
Labour	24	25.8
Finger lings/fry	59	63.4
Fertilizers	-	-
Feed	10	10.8
Feed	-	-
Total	**93**	**100**
Fish Output:	171	-
Net Fish Returns	77	-
%	83	-
Rice Inputs:		
Field Construction	115	48.117
Buildings & Equipments	4	0.016
Labour	90	37.657
Seedlings	4	0.016
Fertilizers	20	8.360
Pesticides	1	0.004
Taxes	5	2.004
Total	239	100
Rice Output	369	
Net Rice Returns	157	
%	66	
Fish and Rice:		
Total Inputs	332	
Total returns	567	-
Total Net Return	235	-
%	71	-

Source : Adapted from Djajadiredja et al., 1980.

V- FISH AND AQUATIC PLANT INTEGRATION

The principal aquatic plants cultured are the water hyacinth (Eichhornia crassipes), water lettuce (Pistia stratistes) and water peanut or alligator weed (Alternanthera philexeroides). Water hyacinth is known as the king of aquatic plants. Per unit area, it produces 6-10 times more protein than soybean. Aquatic macrophytes are easy to manage with less labour and lower costs.

The three aquatic plants are especially good for rearing, fingerlings of silver and bighead carps. The plants should be mashed into a paste but the residue could not be removed. To ear adult fish, with herbivorous fish as the major species, these plants are often pulverised with a green fodder-crop pulveriser and fed to the fish.

Aquatic plants have a high nutrient content as shown below :

Item	**DM** *%*	**CP** %	**EE** %	**NFE** %	**CF** %	**Ash** %	**Ca** %	**P** %	**Yield ton**/ **mu**
Alligator weed	9.2	2.18	0.18	2.49	1.19	1.25	0.23	0.03	15-25
Water lettuce	4.6	1.07	0.26	1.63	1.10	1.30	---	---	10-20
Water hyacinth	7.3	1.90	0.25	2.21	1.11	1.33	0.11	0.03	10-26

VI- THE USE OF WASTEWATER IN FISH PONDS

The use of domestic wastewater in fish ponds may be considered one of the best ways of manuring. Indeed, almost all experiments and commercial scale culture were wastewater has been introduced into ponds report higher fish yields than those normally obtained in the same area. The following yield were recorded in different countries:-

Country	**Yield (ton/ha)**
Germany	0.50
Poland	1.32
Indonesia	3.00
India	3.20–9.50

Results of two examples on utilisation of waste water in fish production are the following :

1) Waste water increased both fish yield (by 75%) and feed efficiency (a decrease of feed conversion ratio by 53%) when compared with ponds (2.7 ha each) without waste water (Table 8)

2) Two larger reservoirs of 4 ha each (depth = 4 m) constructed in series in order to accumulate water during the winter. The primary treated (settled only) waste water of a nearly town of 5000 inhabitants flowed into the first pond and spilled over into the second. The total amount of waste water was 700 - 1000 m3/day. Results in Table 9 show the figures of harvesting. It can be seen that most of organic matter of the waste water was utilised in the first reservoir.

Three methods are employed to regulate the organic load of wastewater introduced into fish ponds :

Table (8), Fish Production and Feed Conversion for Fishponds with and without Wastewater.

	Regular ponds	Wastewater ponds	Manured ponds
Pond area (ha)	1.4 – 2.2	0.7 – 1.0	1.0 – 2.0
Fish yield (ton/ha/8 months)	4.7 – 4.7	8.0 – 8.6	8.1 – 7.5
Feed conversion ratio	1.8 – 1.6	0.6 – 1.0	0.8 – 1.1

Table (9). Fish Production in Two Production Reservoirs* supplied (in series) with Municipal wastewater (700-1000 m^3 / day).

Reservoir	Species	Stocking Date /ha	Rate (g)	Average weight	Harvest Date	Fish No /ha.	Ave	Yield (kg/ha)	Feed (kg/ha)	Conversion
1	common carp	March 10	2750	25	July	2632	748	1899		
	Silver carp	March 14	875	120	-Aug.	616	1286	<u>687</u>		
								2586	2465	1.05
					<u>Yield/day</u>		<u>17.1</u>			
2	common carp	march 10	1500	25	July	1321	280	332		
	Silver carp	March 14	900	120	July	875	750	<u>547</u>		
								879	803	1.47
					<u>Yield/day</u>			<u>5.8</u>		

* Each reservoir covers 4 ha and is 4m deep (about 16000m^3)

- **Direct Application** : The wastewater is added to the fish pond after only short primary treatment in settling tanks. The BOD is relatively high.

- **Dilution** : Prior to introducing wastewater into a pond. It is diluted with 3-4 volumes of fresh water.

- **Pretreatment** :- Pretreatment to reduce BOD and removes many of the pathogens. Treatment can be done by either conventional methods (trickling filter, activated pass through a series of lagoons. Fish are cultured in the last pond of series.

The following constraints may limit the utilisation of wastewater in fish ponds :

Public health aspects : unlike warmblooded animals, fish normally do not suffer from infections of Salmonella, Shigella and other interobacteria. Also processing the fish at high temperatures so as to eradicate pathogens entirely may be another way of avoiding hazards to the consumer.

Toxicant and havy metals.

Public attitudes : although suitable methods are available to overcome most objections. The best way to overcome public opposition seems to be to remove direct contact between fish and sewage by having some intermediate stage between the raw sewage and the fish culture pond, such as pretreat-ment plants or an oxidation lagon. The effluent then becomes "treated" or "reclaimed" water rather than "Sewage".

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