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Integrated Carp Farming in Asian Country

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SUMMARY

Asia has been the cradle of integrated crop-livestock-fish (mainly carp) farming systems, which evolved by themselves since the inception of human civilization particularly when the human settlements started moving more towards inland leaving the river banks. And to meet their water requirements they started constructing rain or flood fed water retention/detention structures which formed the nu'cleus of such intergration. Based on

empirical knowledge of the farmers, the systems have a history of over two millennia in parts of south and southeast Asia. However, the importance of the systems has been realized of late and scientific basis of which are being investigated to evolve proper technologies to get optimum productivity of the land, labour, waste and water. The systems help poor fishermen and small farmers having too small holding for crop production and a few heads of livestock to diversify their farm production, increase cash income, improve quality and quantity of food produced and exploitation of unutilized resources. The paper enumerates different carp integrated farming systems being prevalent in Asia along with certain successful case studies indicating potentiality and constraints of such systems. On the basis of which it is recommended that utmost emphasis is needed to integrate carp farming with agriculture and irrigation, livestock farming, sewage utilization and water pollution control not only to increase the productivity of land and water and improve the economic conditions of poor farmers but also to maintain health and hygiene of the rural poor and city dwellers alike.

INTRODUCTION

Asia has been the cradle of integrated carp-crop-livestock farming systems mainly based on empirical knowledge of the farmers. The systems help poor fishermen and small farmers who are having small holdings for crop production and a few heads of livestock to diversity their farm production, to increase cash income, improve quality and quantity of food produced and exploit unutilized resources particularly labour and waste. The systems are highly relevant to over 2000 million poor people and having limited size farm, for example, 60% of the farmers in Bangladesh have less than 0.8 ha size, 60% of Indian farmers have only 2–4 ha, 46% of land holding is less than 0.5 ha in Indonesia (Delmendo, 1983). These mixed farms in Asia possess about 500 million cattle and buffalo comprising about 90% of the ruminant animal of the world and about 400 million sheep and goat, which also constitute about 50% of the world population (Puri, 1983)

Though there are several successful practices of integrated fish farming in China and other South and South-east Asian countries, the system of farming using synergising scientific integration of agriculture, aquaculture and livestock farming are not yet wide-spread in the region. While planners and administrators have realized the importance of such farming system, it is essential that scientific research should be directed to upgrade the existing technology and evolve appropriate technology after examining the socio-economic and other production constraints under varying conditions. Further, large-scale integration of carp culture with irrigation and sewage utilization are to be viewed seriously both for economic and ecological reasons (Sinha, 1979). Certain successful case studies have been incorporated indicating potentiality as well as constraints of such system, the latter would throw light on the necessity of future backup of these farming systems both in terms of scientific as well as service support.

PRINCIPLES OF INTEGRATED FARMING

As it is well known that to utilize all the ecological niches available in the pond ecosystem a synergic combination of carps has been in vogue in Asia where normally polyculture of carp involving a surface feeder, column feeder and bottom feeder is undertaken successfully. This unique feature of associating and integrating more than two to three species of carps results in utilizing not only the water column at different depth but as well to utilize different types of food available in the pond water ranging from the algae to macrophyte and benthos to zootecton.

The wet land of paddy-field is congenial to many fish both for spawning and for pasture. Those breeding in paddy fields have adhesive eggs and are normally laid on green plants to facilitate more oxygen for developing embryo whereas shallow water spawners and the nest builders get favourable conditions of breeding in paddy fields. The flooded field has considerable quantities of putrifying plants giving rise to enormous amount of plankton and in fact serves as a richly laid table for fry and figerlings. The fish while controlling the excessive growth of plankton, which compete with the paddy, also control zootecton, insects, molluscs, the submerged and floating weeds harbouring the above and adversely affecting paddy. Fish fertilize through its fecal matter and acts as “swimming fertilizer factory” and also overturns the submerged soil normally under reduced stage making thus available more nutrient and oxygen to the root of paddy, acting like a biological plough (Sinha, 1985).

In fact, in integrated farming nothing is wasted, the byproduct of one system becomes the input for other. The pond embankment-used for terrestrial crop and raising of the livestock near the water bodies offer integration of such farming system with fish cultivation. The recent approach to feed the stocked fish with supplementary feeds and also to enrich the water with organic and inorganic fertilizers to augment fish production and utilization of the enriched pond mud and water for crop farming necessitates an integration of fish culture with other farming systems. In addition, irrigation system and sewage need to be profitably used in fish farming for optimal utilization of the water and waste.

INTEGRATION IN THE WATER BODY

Polyculture of different carp species, their cultivation in the rice fields and in the irrigation systems come under this system of integration. Since polyculture of carp is dealt separately by other scientist, this paper is dealing only with carp in the rice field and in the irrigation system.

1. Paddy-cum-carp culture

In order to facilitate fish culture in paddy-fields, the farmers make water retention or detention structures which help storage and conservation of water favouring paddy growth. These structures are either circular moat-like trench, pond or ditch type depending on the configuration/topography of the land. The use of such improvisations of paddy fields fall under three broad categories: (i) for harvesting the wild (natural occurring fish crop); (ii) for harvesting the fish crop after certain interval of time i.e. trapping and holding for growth; and (iii) for raising fry to fingerlings or to marketable size fish. Generally, fish culture in paddy fields is undertaken as second crop after the single annual crop of paddy or as an intermediate crop between the paddy harvest and the next transplantation or as concurrent crop with paddy. This system of farming is most prevalent in Japan, China, Indonesia, India, Thailand and Philippines involving mainly common carp, silver carp, bighead, Puntius, tilapia, snakehead, Trichogaster, Helostoma, Osteochilus, gourami in freshwater and shrimp and milk fish in brackishwater.

1.1 Japan

Carp (common carp) culture in rice fields is quite advanced in Japan (Hickling, 1962), however, it has got serious set back because of pesticide use in paddy cultivation. The depth of the water in the field is usually 12–15 cm in the spring and summer and about 18 cm in the autumn. The rice is transplanted in June and fish fry is stocked either before the transplantation or after the rice is rooted. Supplementary feeding consisting usually of silkworm pupae and bran at increasing rates is given till the harvest is done in Sept/ October. During this period, the rice fields are completely drained of water for the rice harvest. Though fish grow faster during this period, the rice crop is of main interest and hence, takes priority over the fish crop. The fry grows by this time to about 12 cm long weighing about 30 g. On being harvested, they are either sold or kept in the wintering pond where they are fed when the temperature rises about 12 °C. They are again stocked in the rice field in the spring. Prior to this, they are transferred from wintering pond to the recuperating small paddy field where they are given feed of boiled wheat and dried mysis. These yearlings are stocked in fact with the new crop of fry and the wild gold fish Carassius auratus, with the stocking proportion of 400 yearling per crop to 200–600 carp fry besides a few gold fish (Hickling, 1962). The rice fields are fertilized with inorganic and organic manures. Farmers also use some small paddy fields as temporary spawning pond for carp.

1.2 China

Originally, in China, common carp and golden carp were cultivated in the paddy-field but more recently silver carp (Hypophthalmichthys molitrix), bighead (Aristichthys nobilis), snakehead (Channa sp.), tilapia etc. are generally cultivated (Atkinson, 1977).

The deep water method of culture is undertaken in the northern provinces of Szechiwan, Kweichow, Kwansi and Hupeh where paddy-fields may have as much as 0.5 to 0.8 m water where the fish grow to about 250 to 500 g within 3 months and yield varies from 35 to 75 kg/100 m^2. The shallow water method is prevalent in the southern provinces where the depth of water in the paddy field may be 6 to 8 cm. However, to facilitate adequate space for fish to swim and hide, several ditches are dug in a criss-cross pattern in the field (Solecki, 1966).

Fingerlings of carps and tilapia are stocked into the fields about a week after the paddy transplantation and raised there until after the harvest. The rate of stocking varies from 3000–9000 fish/ha depending on the fertility of the soils. At certain places, fishes are fed intensively. In Kwangtong province, a brigade cultivates 2.7 ha of paddy field and gets about 4000 kg/ha and 5230 kg/ha of paddy from the first and second crops respectively along with 937 kg/ha of fish.

1.3 Indonesia

Common carp, Puntius, Osteochilus, Helostoma, Osphronemus are commonly cultivated in paddy fields in Indonesia. Common carp fry of about 7-day old is stocked at 30,000 fry/ha in July with flooding of cleared and repaired fields and harvested after 20 days in the month of July itself. The second batch of fry is stocked after 3 days of paddy transplantation and carp fingerlings are harvested in September after 37 days. Again, after the first weeding of paddy in September and 3 days of fertilization of field, 6000 fingerlings/ha are stocked and harvested in 60 days in October. Following this, the field is drained, weeded, fertilized and again flooded and stocked with advanced fingerlings i.e. smaller fish from third harvest at 100–2000/ha and harvested after 3–4 weeks in November as fourth crop of fish. The field is then drained and paddy harvested after which the field is left fallow for one month (Ruddle - personal communication).

Ardiwinata (1957) notes that mixed stocking of common carp and Puntius fry at 1000 fry/ha each are also undertaken in many places in Indonesia after 5 days of paddy plantation. The period of raising lasts for about 60 days. Mixed culture of common carp and tilapia is also undertaken in between two crops of paddy or along with paddy. Tilapia is stocked @ 1200/ha and carp @ 450/ha, both of about 8–12 cm in size. Manuring is done with night soil, farm yard manure and horse dung.

Raising 10-day old fry of P. gonionotus of about 1 cm length is undertaken when the field is ploughed and harrowed once over a period of about 1 to 1.5 month with the stocking density varying from 40,000 to 80,000/ha and with provision of feed varying from occasional to twice a day. The fry is also cultivated after the rice plantation. The rate of stocking varies from 120,000 to 150,000/ha and the rearing period is from about 4 weeks until the first weeding. Large size fry are obtained when raised between first and second weeding for 3 weeks at a stocking density of 10,000–15,000/ha of 3–5 cm length. For cultivation of large size fish, the large fry of 3–5 cm size is stocked at the rate of 2000–3500/ha. These fishes are made to stay in the moat during second weeding and reared for 80 days till flowering.

Production of fry of Osteochilus hasseltiis undertaken when the paddy is harvested and the depth of water in the field is about 30 cm. 7 days old fry are stocked @ 150,000/ha and raised for 30 days. During this period, 3 to 4 tonnes of farm manure is applied to the field. However, when it is reared along with paddy, the fry of 3–5 cm are stocked @ 25,000/ha after 1 month of rice plantation, raised for 9–11 months and harvested when the field needs to be tilled for the next planting period. The fry of goramy is raised in paddy field retaining

40–50 cm of water. They are stocked @ 200 fry/ha and are fed with pupae of white and red ants. The fry of 5–8 cm size are produced after 2 months.

1.4 India

Raising of carp seeds in paddy field and their culture during monsoon months in brackishwater and shrimps in brackishwater paddy fields has shown promising results. Trenching of paddy field and raising of Indian major carps has been successful with two crops of paddy from the same field by irrigating the field with water from the trench (Natarajan and Ghosh, 1980). Common carp has been cultivated in paddy field at an altitude of 5000 ft. in Apatani plateau in Arunachal Pradesh in spring. The high and wide bundh of paddy plots are utilized for ragi (Elevsine corona) cultivation (Manna - personal communication).

1.5 Philippines

Recently, rice-fish cultivation is under active investigation in different regions of Philippines. Stocking of rice-fish with tilapia (Tilapia nilotica), common carp and dalag is normally done with encouraging results (Delmendo, 1983).

2. Integration with Irrigation

Integration of fisheries in those water bodies created or developed for irrigation and drainage purpose holds great promise to small farmers. For example in Indonesia, fish cages of 4 × 2 × 0.5 m and 3 × 2 × 0.5 m and 5 × 2.5 × 0.5 m made of locally available wood or bamboo installed in a small and shallow irrigation canal produce about 40–110 kg of carp in 3 to 5 months without feeding the fish and much investment (Sinha, 1981). Cyprinus carpioin cages grow from 40–80 g to 400 g in about four months and has shown growth to about 800 g in 6–8 months in Indonesia and Japan (Coche, 1979). Pantulu (1979) while reviewing cage culture of fish in the lower Mekong Basin opined that since cage culture is not subjected to many inherent problems of pond culture, it is recommended to be given more emphasis in the region.

Flood land offers suitable location for lowland fish farm. In fact, in such flood land fish farm, melon and rice-fish rotation is being practiced very successfully in the Philippines (Delmendo - personal communication).

INTEGRATION ON THE WATER

Under this system of integration, two most important combinations such as pig-cum-fish and duck-cum-fish are undertaken where the livestock are either reared on top of the pond or at the edges where the wastes could flow directly into the pond.

1. Pig-cum-fish

1.1 China

In China, normally, the pigs are not reared directly on the pond itself. The wastes are collected and made into composts and applied to the farm land and fish ponds. The manure produced by 20–30 pig in a year produce the same fertilization effect as 1 tonne of ammonium sulphate applied to the soil. Collective as well as individual pig rearing is promoted where the pigs are largely fed on kitchen wastes, aquatic plants and crop wastes (Delmendo, 1983).

1.2 Vietnam

Similarly, in Vietnam, pig raising is done on large-scale and manure is composted and applied to vegetable plots and fish ponds. The washings from the pig-sties are channeled to the ponds.

1.3 Thailand, Malaysia, Hong Kong, Philippines and Indonesia

In Thailand, Malaysia, Hong Kong, Philippines and Indonesia, the pigs are reared on top of the pond or at the edges where the wastes could flow directly into the ponds. The feeds for the pig are mainly left over food from households, lettuce, rice bran, water hyacinth, peanut cake, corn meal and soybean meal. Delmendo (1983) has given detailed information on the economics of pig-fish farming in Thailand. Experimental trial in Philippines with pig and tilapia, common carp and snakehead has shown encouraging results (Cruz and Shehadeh, 1980). Highly encouraging results have been obtained in India where carps were reared in ponds and manured with pig dung (Sharma - personal communication).

2. Duck-cum-fish

Ducks, geese and chicken can be raised on ponds. In fact, a well managed fish pond provides much cleaner and healthier environment for ducks and pond-reared ducks are generally free from parasites and diseases. In Hungary, it is estimated that 4–6% of the duck manure added to a pond is converted into fish flesh and 3 to 4% of the required digestible protein of duck food comes by forage in the pond. The pond-reared ducks also produce excellent clean feathers, which are worth 13–15% of the value of their meat (Woynarovich, 1979).

2.1 Vietnam, Taiwan, Napal, Philippines, India.

In Vietnam, raising of these in and on pond increased fish production to an average of 5 t/ha/yr as against 1 t/ha/yr without ducks (Delmendo, 1983). Similarly, the average annual production of fish in a fish-cum-duck farm in Taiwan Province of China is about 3,500 kg/ha. Indonesia has also extensive duck-fish culture. Nepal has successfully introduced duck-cum-fish culture.

Delmendo (1983) notes that one of the factors that influences the high productivity of Laguna de Bay in Philippines is the commercial duck farming industry practised around its vicinity. The duck population in the area is more than 700,000 raised in about 4,000 duck farms. Demonstration trials in India have shown a production of over 4 t/ha/yr (Jhingran and Sharma, 1980) with about 100–150 duck for a pond having 2 ha-m water depth.

NEAR THE WATER

Cattles are raised near the pond. Cow urine and cow dung are two major sources of manuring pond in certain countries. In India, cowdung @ 10,000/ha/yr is supplied in ponds for high fish production.

Preliminary investigations carried out recently at the Freshwater Aquaculture Research and Training Centre (FARTC), Dhauli have clearly indicated that old rural ponds have at least 1 to 2 m depth of soft anaerobic sediment, the nutrient status of the sediment, both organic and inorganic is high. Certain ponds showed sediment organic-C ranging from 3.2 and 47.7 mg g^{-1} dry sediment. In fact, large amount of organic and inorganic nutrients are almost locked and unutilized for horticultural or other agricultural crop. On the other hand, irrigating terrestrial crop with pond water is much better than any running water since impounded water is more fertile and add nutrient for the growth of the plant (Sinha and Venkateswarlu, 1983). In fact, this is the basis of integration of agricultural or horticultural crop on the pond dyke.

1. China

The example of pond dyke system of integrated farming in the Pearl River Delta in China built up by several large rivers is an excellent one (Ruddle et al., 1983). Most of the production pond have rectangular or square shape, permitting more efficient natural or mechanical aeration of the water. The water depth ranges from 2 to 3 m. The single most important commodity produced by the dyke-pond system of Shunde Country is fish. On the basis of dominant crop grown, four different types of dykes production systems are recognized: mulberry, sugarcane, fruit and miscellaneous crop (Fig.1). Usually, dykes of 6–10 m wide and 0.5–0.7 m high above the level of the pond surface are considered ideal.

Under natural condition, the pond bottom is enriched by silt and organic matter through dyke erosion and organic load. This process is interrupted 2–3 times a year when the pond mud is used to fertilize the crop on dyke and to build up the upper surface of the dyke. Pond mud is also used to make mud-beds for mushroom cultivation on the floor of the silkworm shed in winter, when silkworms cannot be raised. Mulberry and sugarcane planted in alternate years are the main cropping system, wherein mulberry cutting planted on dykes are fertilized with pond mud and irrigated with nutrient-rich pond water. Mulberry provides leaves for silkworm, bark to make paper and pruned branches to use as stick for vegetable and also as fuel wood. The silkworm reared in sheds provide cocoons for yarn production, the cocoon waste and dead larvae provide feed to the fish and enrich the fish pond. The silkworm excrement is used in the ponds as fish feed. As has been indicated before, the mushrooms are cultivated on mudbed on the floor of the silkworm rearing bed during the off-season of silkworm production. After raising mushroom, the nutrient rich mudbed is used to fertilize those sections of the dyke used for vegetables, fruit trees and grasses. Small grooves of bamboo are also a fundamental part of the system. Sugarcane, some of which is either annually or biennially rotated with mulberry is another essential sub-system providing young leaves to feed fish and pig, old leaves for shading crops, roofing thatches and root for fuel. Besides sugar for human consumption, refinery wastes are used for animal and fish feed. Pig-sties constructed on the dykes provide faeces and urine which fertilize the pond (Ruddle et al., 1983)

2. India

Such integrated systems have not been systematically envolved so far. However, in many places, the pond mud is used for terrestrial crop and pond embankment for papaya, coconut, banana plantation and at times for growing vegetable.

FISH AND SEWAGE

Wastes, including sewage and waste water produced by human community hold high potentials for boosting fish production. The usual high density of plankton and consequent die-off in sewage water ponds is controlled and water quality improved by stocking with fish which graze upon and utilize the dense plankton population in such ponds. Thus, increasing importance is recently being given to enhance aquaculture production through sewage utilization. Very high production to the tune of 7–10 tonne/ha/yr have been obtained in many countries such as Taiwan and India. However, such fish may be used profitably for fish meal production to avoid public health hazard.

QUANTIFICATION OF BYPRODUCT UTILIZATION

Quantification of byproduct utilization through different farming system in integrated farming differs in different agroclimatic conditions as well as with the crop, livestock and fish species. However, certain gross relationships based mostly on experiences in China are enumerated below:

1. One tone of pond humus is equivalent to 6 kg of ammonium sulphate. Intensively cultured pond produces about 52.5 tonnes of humus and silt/ha/yr which is equivalent to 225 kg of urea.

2. Mulberry trees grown on pond embankments using pond humus and silt as manure can produce 30–75 tonnes of leaves/ha. The same pond dyke area in winter, when the mulberry trees are in dormant state, can produce vegetables @ 45–75 tonnes/ha.

3. About 30–75 tonnes of mulberry leaves can prodece 18–45 tonnes of sericulture wastes and excrement.

4. With 18–45 tonnes of excrement and wastes from sericulture, about 2 tonnes of fish can be produced without any additional feed or fertilizer.

5. 45–75 tonnes of vegetables produced by inter-cropping with mulberry, can yield additional of over 1 tonne fish and thus total production of fish of over 3 tonnes/ha without any investment over feed and fertilizer.

6. Sugarcane and vegetables on pond dykes in rotation yields 150–225 tonnes/ha of sugarcane with 150–225 tonnes of sugarcane leaves, using pond humus and silt. In addition, 45 tonnes of vegetables can be produced.

7. The total produce of sugarcane leaves and vegetables can yield about 2 tonnes of fish/ha without any additional investment on feed and fertilizer.

8. Fish in paddy-fields increases about 10% of paddy production.

9. It is also experienced in some countries that 60–70 kg of grass and vegetable tops produce about 1 kg of grass carp and its faecal matter provides adequate feed for three other fish.

10. 50 kg of molluscs produce 1 kg of black carp. 100 kg of fertile water (77% residues of bean curd and 23% residues of fermented products) produce 1 kg of silver carp.

11. Duck rearing with fish doubles the fish production in pond. Ducks raised in ponds have better feather quality than when they are reared in pens.

CASE STUDIES

Table-1 shows successful case studies made in different countries. However, as indicated before, isolated successful integrated farming systems have been analysed from different parts of India. Case studies in India involve the details of farm situation, household information, primary purpose of farming, farming inventory along with farm improvement if any, land use, labour use, cost and return, support services, like credit, marketing, technical service, rural organization, then the constraints and reasons for success and failure along with possible new approaches to improve the production, These need careful study (Sinha, 1985). However, the most important observations are-

i. In paddy fields which are used simulteneously for both rice and fish cultivation, or fish as the second crop, the income from fish is much higher than rice obviously because the price of fish is at least ten times more than rice. However, much scope exists for improvement if farmers adopt improved management practices - particularly eradicating/controlling trash fishes from paddy-fields and providing protection to the commercially important fishes and cultivating suitable variety of paddy. Presently, this system of production remains by and large traditional.

ii. The case studies clearly show that fish culture in about 30–80% of farm areas, gives 80–90% of total farm income in any system of integrated farming even if the fish culture component had not been successfully implemented.

iii. Horticulture is integrated excellently with fish culture since the former calls for uninterrupted irrigation and yields sizable soft-texture wastes which the fish utilized as feed.

iv. Integrated farming leads to higher labour engagement and better net income, Even when the farmers practised paddy cultivation in brackishwater along with the entrapped fish, the income from fish was 80% (primarily due to high price of prawn) and engaged 80% of labour time. The labour absorbing capacity of fish culture has been found to be remarkable in the case studies involving integration of fish-livestock-horticulture. The rate of fish production of 1500 kg to 3000 kg/ha depending on the degree of scientific practices adopted involving 200–300 man-days of labour/ha and giving high net cash income to the farmers, positively indicate the tremendous role fish culture has to play in ushering rural prosperity through integration of fish culture along with other agricultural crop or animal husbandry.

CONSTRAINTS AND RECOMMENDATIONS

The case studies indicate the potentiality of integrated farming system, however, also clearly show the constraints which are as follows:

1. While land preparation for paddy poses at times difficulty for fish culture, fields without proper water structures either suffer badly with flooding and

   consequently loss of fish or with water shortage restri cting the period of fish culture. High temperature and turbidity of the paddy fields adversely affect fish life.

2. Infestation through the water supply of undesirable species of fish become competitors with commercially important fishes for oxygen, space and food organism. There are numerous kinds of insects such as Corixa, Dysticus, Belostoma, Hydrometra, Gerris etc. in the paddy-field which predate on fish larvae and fry whereas leech, frog, birds, snakes and otters pray upon fish in paddy-fields.

3. Fish cultivation along with rice is affected by the use of pesticide. While the International Rice Research Institute (IRRI) is evolving certain strains of rice which are highly disease-resistant, biological control of pest and predators of paddy are also being vigrously investigated in many places. However, presently, the best way to apply the chemical is either to drive the fish before the application into the trenches or to increase the water level of the field and try to spray the chemicals on the leaves so that little amount of such chemicals drop into the water and their concentration get more diluted.

4. There is lack of suitable scientific technology available for crop and fish production systems. Fish culture in ponds have shown that it has great income generating capacity, however, its role in other watershed needs to be appreciated, investigated and extended. It is necessary that packages of practices may be developed from the existing knowledge and experience available in different countries and demonstration projects on these systems may be initiated.

5. While increased use of organic manures and crop residues (presently these are used more as fuel than for manuring), suitable seed, feed and breed - the three major input components for successful crop-fish-livestock production systems are by and large beyond the reach of poor farmers. This needs to be seriously viewed by all concerned.

6. Low investment capacity of the farmer, credit constraints, timely supply of inputs, non-availability of proper agricultural implements; leasing policy, multiple ownership, absentee landlordism, marketing facilities are socio-economic constraints for slow development of such systems. These need to be looked into by the developmental

agencies.

7. Strong expertise on various areas of agriculture, animal science and fisheries research and adequate number of institutions for agriculture, animal science, fisheries, water management, forestry, etc. have been set up in many countries of the region. Yet, research and expertise in integration for symbiosis and mutual coordination of various disciplines for efficient crop-livestock-fish farming system need to be developed and strengthened (Sinha and Venkateshwarlu, 1983.

However, the Indian Council of Agricultural Research has set up a number of Farm Science Centres which offer such scope of integrated farming with the help of subject matter specialists belonging to different farming systems.

At the global level, the Aquaculture Development and Coordination Programme (ADCP) of the FAO has set up the Network of Aquaculture Centres in Africa, Latin America and Asia. The Network of Aquaculture Centres in Asia (NACA) in particular has been designed to operate within the framework of Technic Cooperation among developing countries and is intended to serve the Asia-Pacific region. The immediate objectives are to establish four regional lead centres, which form the initial nucleus of the Asian Aquaculture Network for:

- conducting interdisciplinary research on selected aquafarming systems for adaptation or improvement of existing technologies and for the development of new technologies;
- training of core personnel needed for aquaculture development; and
- establishing and maintaining a regional information system for the provision of appropriate data and information for development planning, research and training.

Research activities are to be shared by the four regional lead centres in China (RLCC), India (RICI), the Philippines (RLCP) and Thailand (RLCT), and are to be focused on filling knowledge gaps of farming systems and on intensifying or improving the efficiency of the technologies involved. The Centre in the Philippines is, in addition to its research and information function, the headquarters for a one-year senior level nultidisciplinary training course in aquaculture, while the Centre in China is to provide training at a senior technician level in integrated fish farming. This is the most welcome step of FAR, through which it is expected a rapid transfer of technology of different fish farming systems including the integrated farming in this region.

However, scientific research is required to know the species of fish suitable for integrated farming; species and strain of pigs, ducks, chicken, cattle and their production/ integration efficiencies. Similarly, selection of crop for integration need investigation. Designing of farm for integrated farming along with utilization of animal and plant wastes, their decomposition, pathogenic organisms in wastes and their transmission to fish and through fish to human; plant as well as animal waste treatment, release of nutrients, common diseases and method of treatments all need extensive and intensive research investigations to evolve suitable models for efficient integrated farming systems relevant to the region.

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Table 1. Certain Successful Case Studies of Integrated Fish Farming in South East Asian Countries

Component of Integrated Fish Farming	Country and currency	Area (Ha)		Income		Percent (%) contribution of fish culture component
		Farm	Pond	Total farm	Fish culture	
* Fish/ Duck	Hong Kong (HK $)			19,472	9,899	50.83
* Fish/ Goose	Hong Kong (HK $)			26,580	9,109	34.27
** Fish/Horticulture/Livestock	India	0.903	0.75	26,526	24,178	91.14
	(Rupee)	0.8	0.7	14,500	13,750	94.82
	"	9.0	5.0	47,000	35,000	74.46
	"	0.2	0.4	21,950	20,150	91.79
	"	0.6	0.4	12,650	7,400	58,49
** Fish/ Livestock Crop/ Trapa	India (Rupee)	3.0	1.0	22,642	12,503	55.22
* Fish/ Chicken Farming	Indonesia	0.1	0.1	910,000	250,000	27.4
* Fish/Rice	Indonesia (Rupiah) (W. Java)	.337 Av. farm size	.337	169,109	129,000	76.28
* Fish/Pig	Thailand (Bht.)	.64	.64	69,139	18,500	26.75
		.96	.96	91,330	25,500	25.78
* Fish/Crop	Thailand (Bht.)	8.06	0.16	43,627	17,718	40.6
* Fish/ Vegetables	Thailand (Bht.)	8.8	2.4	46,995	19,995	42.54
* Fish/Crop/Vegetables/Livestock	Nepal (Rupee)	0.85	-	26,252	7,360	28.03

Source * Delmendo (1983)
** Sinha (1985)