ARTISANAL AQUACULTURE IN INDONESIA: THE NEED AND CONSTRAINTS FOR FURTHER DEVELOPMENT

by

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Abstract

The reason for the development of aquaculture in Indonesia was the same as in many Third World countries: the need to increase food production. Culture fisheries now produce both for the local and the export market.

Various types of aquaculture have been tried and are now common practice. Most types are used by farmers in conjunction with another occupation, i.e., fish plus crops. Inputs are low, and the returns are enough to raise the incomes of these farmers significantly. The technology involved is not complicated, and the resources of the farm are utilized efficiently, i.e., use of livestock waste.

Some types of aquaculture, such as culture in sewage fed canals, are being closely watched because of sanitation and health aspects. Fish diseases and insufficient seed supply are problems (there is no data on fish fry production). In rural areas, pesticides are becoming a problem, and there is a need for a pesticide which has low toxicity for fish while retaining its effectiveness against crop pests. More studies on these problems are needed to aid the development of fish culture in Indonesia.

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1. INTRODUCTION

The need to increase food production is the main reason why the development of aquaculture has been given great emphasis in many parts of the world, especially in the developing countries. Various programmes and projects in research as well as development have been launched and considerable amounts of budgets have been allocated and spent for the projects. Exchanges of information and ideas on aquaculture technology have also taken place among nations and some of the technology has been applied with success, but others still have to be modified to suit the local conditions.

In Indonesia as well, various levels of technology and practice in aquaculture have been applied. It ranges from very simple to intensive levels. It covers the indigenous practices and technologies as well as the introduced ones. The first technologies and practices are either developed by the farmers themselves through "trial and error" and long experience, or by Research Institutes.

The various types of aquaculture developed in the course of decades by the farmers and which now have become common rural practices in Indonesia are backyard family ponds, fish cum rice culture, the "sawah tambak" and cage culture in sewage fed canals. Those types of aquaculture are characterized by low input required, small-scale level, and product diversification; in some cases such as in various integrated farming systems, they may provide the farmers with a more or less continuous supply of fish and income. Furthermore, the ponds used are usually the small ones, ranging from a few square meters up to 2 000 m^2, irrigated or simply rainfed type.

This paper is highlighting the present state of small-scale fish farming in Indonesia, including the identification of the problems, needs and constraints for further improvements. Main stress is given to freshwater aquaculture.

2. BASIC FACTS

Aquaculture in Indonesia consists of brackishwater culture, freshwater pond culture, fish culture in paddy fields, cage culture and fish culture in barricade ditches. Mariculture is just started and still in the experimental stage.

The inland culture fisheries cover around 185 000 hectares of brackishwater ponds, 35 000 hectares of freshwater ponds, and 47 000 hectares of cage culture.

Around 59% of the existing brackishwater ponds, 62% of the freshwater ponds, 71% of cage culture and 46% of fish cum rice culture are available in Java where around 70% of the Indonesian population lives. Other brackishwater pond culture centers are South Sulawesi Province (46 851 hectares) and Aceh Province (20 086 hectares). Other centers of freshwater culture are West Sumatra Province (4 222 hectares) and North Sulawesi Province (1 266 hectares).

The culture fisheries engage around 609 671 fishermen, covering 89 439 brackishwater pond farmers, 398 179 freshwater pond farmers, 3 060 cage culture farmers and 118 893 rice cum fish culture farmers. It involves around 52 626 households of brackishwater pond farmers, 234 276 households of freshwater pond farmers, 1 800 households of cage culture farmers and 69 983 households of fish cum rice farmers.

Dividing the existing area by the respective household engaged indicates that the average land holding is small:

Culture	Average land holding (Ha/household)
Brackishwater pond	2.07
Freshwater pond	0.15
Cage culture	0.003
Fish cum rice culture	0.67

These culture fisheries in 1978 produced 176 000 metric tons of fish: 102 000 metric tons from brackishwater pond culture, 57 000 tons from freshwater pond culture, 16 500 tons from paddy fields and 500 tons from cage culture. Aside from producing fish for domestic consumption, the contribution from fish culture to the export of fisheries products is also quite substantial. This is especially true for the penaeid shrimp export.

3. SYSTEMS AND TECHNOLOGIES APPLIED

Based on the management applied, aquaculture in Indonesia may be classified into extensive, semi-intensive and intensive types. The latter, such as running water pond culture and floating net cage culture, where artificial feeding is practised and water quality is properly maintained, is only recent to this country. In the other two types may be included the brackishwater pond culture, freshwater pond culture, fish culture in paddy fields, cage culture in sewage fed canals and barricade culture in ditches. These types of aquaculture are natural productivity based aquaculture with or without fertilization.

Brackishwater pond culture

Species culture in brackishwater pond are milkfish and penaeid shrimps.

In the extensive type of shrimp culture, shrimp seeds of various species and size are taken into the ponds with incoming water and held for varying periods of time until they grow to a large size. This was done in every high tide during 4 to 5 successive periods of spring tides to ensure entry of the maximum number of young shrimp into the ponds.

Harvesting of the shrimp is done partially by using bamboo traps locally known as "perayang" and begun 3 to 3.5 months after the first day of hightide. The production varied from 100 to 300 kg per hectare per 6 months. The species harvested is usually dominated by P. merguiensis and P. indicus.

No fertilization or eradication of predators is done in this type of shrimp culture. Preliminary data obtained from field experiments conducted in the Aceh Province by the Inland Fisheries Research Institute showed that by improving the technology the production can be increased up to 1 200 kg/ha/year. In the experiment, the shrimp seeds were first collected in a collecting pond, caught, counted and stocked at 40 000 fry/ha into a prepared rearing pond and reared for 2 - 3 months period.

In the semi-intensive type, milkfish is reared in monoculture system or polyculture with P. monodon. The seeds of both species are collected from natural waters.

The species is grown mainly on natural productivity of the ponds with or without fertilization and with or without pest and predators control. Stocking rate applied in the monoculture of milkfish varied from 1 500 - 2 000 fingerling or 3 000 to 6 000 fry per hectare per season; in the case of polyculture 750 milkfish fingerlings and 10 000 P. monodon fry are stocked per season.

Production achieved varied from 300 to 1 000 kg of milkfish per hectare per year in the monoculture and around 600 kg of milkfish plus 100 to 300 kg of P. monodon per hectare per year.

Freshwater pond culture

Based on the water supply system applied, freshwater pond culture may be irrigated type ponds and rainfed type ponds. The latter is commonly found in low land area.

This type of aquaculture is operated basically at a traditional level, a natural based production system with low inputs. In the case of irrigated ponds, the ponds used are embankment ponds, while in rainfed type they are excavated ponds, or natural pools. The former are provided with water inlet and outlet, mostly made of a piece of bamboo. The latter have no such provision.

Actually the main purpose of the rainfed type ponds and the naturally occuring pools are to keep water for household purposes, crop plants and cattle rearing. Thus, fish culture is only a secondary activity. This is also true in fish culture in the paddy fields and some type of integration farmings. By contrast, most of the irrigated ponds are meant for fish culture, while their use for household purposes secondary. There may be commercial ponds and family ponds. The fish produced from the family ponds is merely for family consumption.

There are at least nine fish species that are commonly cultured in freshwater ponds, viz: C. carpio, O. gouramy, T. pectoralis, H. temmincki, O. hasselti, P. gonionotus, P. orphoides, T. nilotica and C. batrachus. Within the last few years freshwater giant prawn (M. rosenbergii) has also become a culture species in Indonesia.

Fish seeds are produced by the farmers themselves or by the local government hatcheries. The breeding technique applied varies according to the species. In certain cases a breeding pond may be used at the same time to breed 2 or 3 fish species.

Most of the species are cultured in polyculture system. There are various combinations, but the commonest are as follows:

(a) common carp, nile tilapia and java carp

(b) common carp, nile tilapia and gouramy

(c) kissing gouramy, O. hasselti, common carp and java carp

(d) tilapia, kissing gouramy, java carp, O. hasselti and common carp

(e) milkfish, java carp, tilapia and common carp.

The stocking rate of each component of the combinations is greatly varied. The percentage composition of combination (c) for example may be as follows: Kissing gouramy (50%); O. hasselti (20%); common carp (10%) and java carp (10%) or Kissing gouramy (37%); O. hasselti (12%); common carp (12%) and java carp (37%).

A typical characteristic of freshwater pond culture is also shown by the rapid culture rotation. Skimming or partial harvesting is the common practice. By doing so, fish growth can always be secured.

Inorganic fertilization is hardly practised in freshwater pond culture. The growth of natural food is stimulated by organic matters placed in the ponds, in forms of treated sewage, nightsoil kitchen wastes, remains of food industries and droppings of livestock. The nightsoil, kitchen wastes and remains of food industries may also be directly fed to the fish.

It is quite interesting that around 25% of the existing freshwater fish ponds in West Java Province have overhang latrines on them. An average of 25 latrines per hectare of fish ponds have been recorded in 4 districts in West Java by Djajadiredja et al. (1979). It was estimated that around 0.0625 ton of nightsoil was put into one hectare of fish pond per day.

Djajadiredja *et al*. (1979) also reported that fish production in latrine fish ponds may be six times greater than in ponds without latrines. Unfertilized ponds and organic fertilized freshwater ponds in Sukabumi produced an average 120 kg/ha/year and 894 kg/ha/year, respectively (Sutardjo, 1968). Vaas (1948) reported that a sewage fertilized pond in East Java province produced 3 tons of common carp and Java carp per hectare per year.

Integration farming systems

Another system applied in freshwater pond culture is the integration farming system. According to Djajadiredja and Jangkaru (1979), there are three major types of integration farming practised in Indonesia, viz. fish plus crops, fish plus livestock and fish plus home industry integration farmings.

Various fish species are cultured, either by monoculture or polyculture, integrated with the cultivation of vegetables or the rearing of livestock such as ducks, chickens, sheep and boats, and even horses, or connected with the disposal of home industrial wastes. In the last two types, the culture of fish has benefited by the excellent growth of natural food stimulated by the disposal of livestock remains and home industry wastes. The latter may also be directly consumed by the fish.

Fish culture in fish/crop integration farmings may be grouped into fish cum rice culture, fish cum vegetable culture and fish cum non-vegetable crop culture. The first culture will be discussed separately in the following paragraph.

Two kinds of vegetables growing in an aquatic environment which are popular in West Java are "kangkung" (*Ipomoea* sp.) and "genjer" (*Limnocharis flava*). The vegetables grow well in shallow waters with muddy bottoms.

The pond used in this type of integration farmings is provided with peripheral and central canals approximately 50 cm deep. The "kangkung" is planted at a distance of 25 x 25 cm when the water is 2 cm deep, while the fish is stocked as soon as the water has attained a depth of 50 cm. Fish species cultured is the common carp, and is stocked at fingerling size at the rate of 100 kg/ha.

Harvest of the fish is done one month after stocking and a production of 150 kg/ha can be obtained. A partial crop of young leafs or sprouts of "kangkung" is done every 15 to 20 days and produced 1 750 bunches of "kangkung" weighing 230 grams per bunch. The plantation of "kangkung" is totally renewed every three months.

The "genjer" is planted at a distance of 30 x 15 cm. Fish species cultured is also common carp, stocked at fingerling size at the rate of 60 kg/ha. The rearing period lasted for three months with a production of 240 kg fish and 32 400 bunches of "genjer" per hectare. Cropping of "genjer" is done everyday.

In both culture systems, the ponds are fertilized with urea at the rate of 130 to 150 kg and 75 kg in fish cum "kangkung" culture and fish cum "genjer" culture, respectively. Rice bran is also given to the fish as supplemental feed in both culture systems.

The non-vegetable crop cultured in the fish cum non-vegetable crop culture is the "mendong" scientifically known as Fimbrystylis globusa. It is a terrestrial weed used as raw material for plaiting mats, bags, hats, etc.

In this type of culture, the pond used is also provided with central and peripheral canals 30 to 50 cm deep. The water depth in the shallow portion of the pond where the "mendong" is planted is only 5 to 7 cm.

Common carp at the rate of 90 kg plus 30 kg of tilapia per hectare are stocked in the pond. The "mendong" is planted at a distance of 40 x 40 cm. The culture period of fish lasted for three months. About 180 kg of common carp and 90 kg of tilapia can be produced per hectare of pond.

The first harvest of "mendong" is done six months after planting. The following harvests are done every 4 months, which may be continued up to 10 times. Afterwards, the whole plantation has to be renewed. From a hectare pond 21 600 kg of "mendong" can be produced per year.

Urea is applied at the rate of 240 kg/ha/season. No supplemental feeding is given to the first during the culture.

Djajadiredja and Jangkaru (1979) reported that there are four types of integration farming between fish and livestock and three types between fish and home industries. The former consists of fish and chickens, fish and ducks, fish and sheep, fish and horses, while the latter consists of fish and soybean curd industry, fish and rice mill, and fish and coconut oil industry.

In all types, the fish is benefited by the presence or remains of livestock feed, droppings and wastes of the industries. The benefit is either direct or indirect, since all the items may be directly fed to the fish or act as fertilizers.

Fish produced in this type of integration farmings may be fish for consumption or fish fry. In case of the former, polyculture of two or more fish species is practised. Table 1 shows data compiled from Djajadiredja and Jangkaru (1979).

Fish cum rice culture

This type of fish culture is practised in irrigated and rainfed paddy fields. The latter, which are popularly known as "sawah tambak" have been developed since 1950 in East Java. They differ from the ordinary rice fields, by their physical appearance, resembling ponds rather than paddy fields. They have broad and deep canals and relatively wide, high and strong dykes. Such strong dykes are needed to hold great volume of water and to avoid flood.

The "sawah tambak" is a productive type of fish culture. Annual production of 1.5 to 2 tons rice and 1.1 to 1.6 tons of fish per hectare per year may be achieved. The application of inorganic fertilizers, the Urea and Tripple superphosphate, 175 kg and 300 kg/ha/year, respectively is commonly practised. In most cases, polyculture of milkfish and Java carp and sometimes also common carp is practised.

The methods of fish culture in ordinary rice field is a long history of endeavour by farmers. The old pattern of operation of rice cum fish culture was described by Hofstede and Ardiwinata (1950) and Ardiwinata (1957). The aims of cultivation were to harvest fry of particular size (2-3 cm or 3-5 cm) and consumption size of fish.

The pattern of fry production involved two periods of cultivation:

(a) Five days after planting until first weeding.
(b) Two days after first weeding up to second weeding.

Three periods of cultivation were encountered to gain consumption-sized fish:

(a) Some days after planting until second weeding.
(b) Some days after planting until flowering.
(c) Some days after second weeding up to flowering.

The species stocked for this system were mainly common carp as monoculture, or common carp with other species, e.g. tilapia, kissing gourami, nile and Java carp.

There is a wide range of production per unit area, depending on the stage of development, being as low as 23 kg/ha in Bengkulu province and as high as 1 200 kg/ha in East Java province. The national average production in 1978 was 350 kg/ha.

Cage culture in sewage fed canals

Cage culture in sewage-fed canals has been practised in Indonesia since 1940 (Vaas, 1955). It was started in city run-off canals in Bandung, the capital of West Java. At present, it has been developed in other cities of the same province and a total of 2 655 cages were recorded, contributing an annual production of 403 tons of fish.

This type of culture, operated on a waste recycling basis, is quite productive. The only inputs spent on the industry are expenditures for bamboo as the cage materials, cage construction and common carp seeds. No artificial feeding is given.

Fish culture in barricade ditches

In some parts of the country, during dry season the water flow rate of canals and small rivers in the villages is usually very small. The problem to get enough water for household purposes is common during such seasons. People living along the canals and rivers coordinated by the head of the village block the flow of the waters in the canals and rivers by constructing barricades made of stones and pebbles. By doing so, the water level of the canals and rivers is increased up to around 50 cm deep.

Aside from its use for household purposes, the barricaded canals and rivers are also used for fish culture. Into such a barricaded canals and rivers, a number of fish are stocked and reared for two to three months. The fish stocked are Java carp and tilapia. The stocking rate varied between 1 to 4 tilapia fingerling and 2 to 3 Java carp fingerlings per m^2.

The fish are fed with kitchen waste and sometimes with rice bran. Records show that production up to 75 kg of tilapia and 150 kg Java carp may be produced per season per a barricaded river of 1 200 m^2.

4. SOCIO-ECONOMICS

Marketing of freshwater fish

Unlike the marine and brackishwater fish, the fish produced from freshwater culture are sold alive. Well set-up markets are available in many important freshwater fish culture centres. The most well-known one is the fish market in Cisaat-Sukabumi in West Java.

Fry as well as fish for consumption are sold every day in the market. To facilitate the living fish, water flow through cemented tanks and fiberglass containers, and ground water is made available. Facilities to transport fish such as polyethylene bags and oxygen are also available. This market has a capacity to accommodate about 200 baskets of living fish per day. Data indicate that around 18 841 000 fingerlings, 85 653 bowls of fry, where one bowl may contain 1 000 to 3 000 fry of 1 to 3 cm long and 494 tons of consumption fish were marketed in the Cisaat market in 1978 (Djajadiredja et al., 1979).

Socio-economic status

It is believed that among the Indonesian society, the fish farmers and the fishermen are the poorest ones. Their social status, therefore, is the lowest. Djajadiredja et al (1979) have made a case study on integration fish and other product integration farming in West Java and reported that the respondents involved in the study have elementary education background. Sixty-seven percent of the farmers studied have farming experience of more than 10 years. Furthermore, it was also reported that the daily household expenditure of the farmers varies from \$1.2 to \$4.0 per day, while data on the income is presented in Table 2. The income per capita of a "sawah tambak" farmer in East Java is reported at Rp. 167 611 per farmer per year (Anon., 1976).

In all types of integration farming, the cost of fish seed/fingerling contributes 10 to 34 percent of the total input. Another bigger input is the labour cost which ranges from 17 to 73.3 percent of the total input.

5. THE NEED AND CONSTRAINTS FOR FURTHER DEVELOPMENT

Several points can be noted from the small-scale fish culture in Indonesia. First of all, it contributes to the protein food supply. According to Djajadiredja, Suyanto and Martono (1976), data collected from various parts of the country indicates that fish production of backyard ponds on per hectare basis may be as high as 8 000 kg to 12 000 kg per year. A rough estimate shows that around 94 to 98 percent of annual fish production in Indonesia is contributed by the small-scale fisheries.

Its contribution to foreign currency earnings, as mentioned in the introduction of this paper, is also substantial. This is especially true of the shrimp culture in the brackishwater ponds.

From the natural food utilization point of view, the system applied is quite economical. This is shown by the polyculture practised. High production may be achieved by applying this system.

Another characteristic of the small-scale fish culture practices in Indonesia is the high efficiency in resource utilization. The presence of latrine ponds is the prominent proof. A short nutrient cycle may be obtained by this practice. This also indicates the awareness of the farmers to the importance of fertilization to increase their pond productivity as well as their socio-economic status.

There is no doubt that fish cage culture in sewage fed canals is a productive industry. A level of production from 12.5 to 17.5 kg/m^2 per 2 to 3 months has been reported by Djajadiredja, Suyanto and Martono (1973).

Efficient utilization of resources is also shown by the integration farming systems. Out of a minimum area within a limited time unit, a diversified product can be obtained. It was also noted by Djajadiredja and Jangkaru (1979) that such systems provide better and more continuous income, employment and self-sufficient food supply to the farmers and community. This statement is also true for the fish culture in paddy fields.

The small-scale fish culture, therefore, suits the socio-economic status of the farmers, since less input is required; product diversification provides better and continuous earning and food supply, and the technology applied is rather simple. All the advantages justify the importance of developing the small-scale fish culture. Several constraints should first be overcome.

The general constraint in the development of aquaculture in Indonesia is the insufficient seed supply. This is reflected by the relatively high percentage of expenditure for seed as compared to the total input required as described in the previous chapter. No recent data is available regarding the fish fry production. According to Hardjamulia (1976), freshwater fish fry production in 1972 was only around 86.81 percent of fry needed to stock ponds and paddy fields in Indonesia.

Another constraint is fish diseases. It was reported that a disease outbreak caused by anchor worm in 1971 had caused a loss of 7 400 million rupiahs (Anon. 1978). Sanitation and health aspects as well as the aesthetical aspect are points to be considered for further development of latrine fish ponds. Djajadiredja et al. (1979) suggested that the further prospect of the use of nightsoil as fish feed in Indonesia should be considered more favourably by means of promoting its efficiency and eliminating its negative aspects on general aesthetics and human health, through appropriate research and development programmes. As in the case of latrine ponds, similar objections are encountered about fish culture in sewage fed canals. In addition, it is believed that the presence of the cages in canals causes bank erosion and flooding, since it blocks the water flow. Research regarding these aspects are necessary.

The original type of cage was the floating type. The recent type is the submerged one. It is usually installed in narrow canals and it covers the whole width of the canals. By this arrangement, it is believed that the blocking effect of the cage to the water flow will be minimal. Within the last ten years, the area of fish cum rice culture in the country has been greatly reduced. In 1967, it was recorded that in Indonesia there was 120 802 of fish cum rice culture, while in 1978 was only 47 000 hectares.

By contrast to the reduction of area, production per unit area is increasing. This is indicated by comparing the average production in 1967, 1972 and 1978 which were 0.170 tons/ha, 0.246 tons/ha, 0.289 tons/ha and 0.350 tons/ha, respectively.

Constraints encountered in the development of the fish culture in paddy fields, among others, is the use of pesticides. From the government, this problem is being alleviated by issuing pesticide regulations. Only pesticides of low and moderate toxicity are allowed to be used in rice fields. Highly toxic pesticides may be allowed with certain restrictions. On the other hand, the farmers themselves developed techniques to overcome the problem. They adopted a short period fish rearing scheme. Another method is to confine the fish in a special compartment and released them to the paddy fields after the killing effect of the pesticide has receded. The ideal solution would be to have pesticides which are of low toxicity to fish, but effective for crop pest eradication.

Other important constraints are the low bargaining position in the marketing of fish, and low financial capabilities. To overcome these problems, improvement in marketing facilities and credit schemes have been conducted by the government. Up to 1977, credit of Rp. 2 655 million rupiahs has been absorbed by small-scale fisheries in Indonesia (Anon., 1978).

Improvement in the technology is a matter of question. To increase the production, increase of input is required. Whether the increase of input will provide comparable output is still to be proved. Thus, thorough studies regarding this matter are urgently needed for further development of small-scale fish culture in the country.

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Table 1. Production data of typical integration farmings in West Java province

Farming type	Pond area (m^2)		Fish stocking rate (kg/year)	Production	
				Fish (kg/year)	Others
Fish cum chicken	1 000	Common carp) Tilapia) Chicken egg)	250	625	1.200 kg
Fish cum duck	1 000	Common carp Nile tilapia Duck egg Incubated egg Young duck Unfit duck	140 87.5	280 350	 33.600 pcs 13.400 pcs 1.000 pcs 40 pcs
Fish cum sheep	2 100	Common carp	-	300 bawls of fish fry	
		Sheep			4 pcs
Fish cum horse	900	Common carp Tilapia Kissing gourami	50 125 75	100 300 150	*)
Fish/soybean industry	5 000	Kissing gourami) Java carp) Tilapia) Nile tilapia)		1 000 cups of fish fry	**)
Fish/rice mill	15 000	Common carp) Tilapia) Kissing gourami)	400	2 400	***)
Fish/coconut oil industry	8 000	Common carp Tilapia Coconut oil	2 000	6 000 2 800	 7.200 kg

*) Income from renting dogcarts valued at $10 584/year.
**) Income from selling soybean curds valued at $4 000/year.
***) Income from selling rice bran valued at $84/year.

Table 2. Data on the net return earned by the fish and other product integration farmers

Farming type	Average (m^2)	Net return			
		Fish (Rp)	Other commodities (Rp)	Overall commodities (Rp)	Percent (%)
Fish cum "kangkung"	841	50 766	58 097	108 863	80
Fish cum "genjer"	4 100	28 820	150 534	179 374	177
Fish cum "mendong"	1 050	34 380	48 442	82 822	83
Fish cum chicken farm	1 203	392 891	636 861	1 029 752	69
Fish cum duck farm	2 625	295 825	235 500	531 325	90
Fish cum sheep farm	84	22 400	79 500	101 900	40
Fish cum rice culture	3 370	70 579	98 430	169 009	81

Source: Djajadiredja *et al.* (1979)

US$1 = Rp. 625.00