A Preliminary Survey of Fish Cultivation in Ricefields, with Special Reference to West Java, Indonesia

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Rice, the oldest domesticated cereal crop, is believed to have first been cultivated in Asia some 6,000 years BP, when *Oryza sativa* was grown along the foothills of the Himalayas in Northern Indochina and Southern China. Gradually, rice cultivation spread throughout the humid tropics and subtropics from the Asian center(s).[2)] Although techniques of flooded-field rice cultivation vary considerably throughout Asia, all such systems create aquatic conditions during periods of the cultivation cycle. Aquatic conditions may last for only a few weeks, or may involve continuous flooding for many months during which marsh-like habitats may develop, especially during the fallow season.

Such conditions permit the development of an aquatic fauna in the ricefields and their associated irrigation and drainage canals and ditches. This ricefield fauna, the richness, diversity and stability of which is correlated closely with the duration of permanent flooding, is derived from the original marsh, pond and stream fauna of the area surrounding the ricefields. Thus large-scale reclamation of the proximate marshes can seriously affect ricefield fauna by the elimination of dry season refuge habitats [FERNANDO *et al.* 1979: 3].

The human exploitation of the rich, naturally occurring ricefield fauna, which includes, *inter alia*, aquatic birds, frogs, snails, fish and shrimp, is probably as ancient as rice cultivation itself. At that time in human prehistory the exploitation of aquatic fauna would, of course, have been limited to collection, trapping and hunting techniques. It is noteworthy that such techniques remain those mainly employed at present.

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1) The field research on which this article is partially based was done in Java during May and June, 1980, and was supported financially by the United Nations University's Programme in the Use and Management of Natural Resources (NRP). This article is a contribution to the "Water-Land Interactive Systems Project" of the NRP. I acknowledge with gratitude the assistance of Mr. Koesobiono, Mr. Chairol Mulluk and Mr. Supomo Wardoyo, of Bogor Agricultural University. An abridged version of this paper was presented orally at the 24th Congress of the International Geographical Union, Section 8, held in Tokyo on September 2, 1980.

2) In addition, there was a West African center from which rice cultivation also diffused.

SCIENTIFIC NAME	COMMON NAME	China	India	Indonesia	Kampuchea	Malaysia	Philippines	Thailand	Vietnam
Anabas testudineus	Climbing perch	■	■	■	■	■	■	■	■
Anguilla spp.	Eel		■	■					
Barbus carnaticus	Carnatic carp		■						
B. gonionotus	Tawes		■	■					■
Botia spp.	Loach				■				■
Catla catla	Catla		■						
Chanos chanos	Milkfish		■	■					
Cirrhinus spp.	White carp (etc)		■						
Clarias spp.	Catfish		■	■		■			
Cyprinus carpio	Common carp		■	■					
Esomus spp.	Carp Family		■		■				■
Helostoma temmincki	Kissing gourami			■		■	■	■	■
Labeo spp.	Indian carps		■						
Lates calcarifer	Cock-up		■	■	■				■
Mastacembelus spp.	Spiny eels				■				■
Mugil spp.	Grey mullet		■						
Mystus gulio	Tengra		■						
Ophicephalus marulius	Snakehead fish		■						
O. punctatus	Snakehead fish		■						
O. striatus	Mud fish	■	■	■	■	■	■	■	■
Osphronemus goramy	Gourami	■	■	■			■		
Osteochilus hasselti	Nilem			■					■
Pristolepis spp.	?				■				■
Rasbora spp.	Carp Family		■		■				■
Thynnichthys sandkhol	Sandkhol carp		■						
Tilapia mossambica	Java tilapia		■	■	■	■	■	■	■
T. nilotica	Nile tilapia			■					
Trichogaster pectoralis	Sepat siam			■	■	■	■	■	■
T. trichopterus	Three-spot gourami			■		■			

■ Indicates present

Figure 1. Principal Fish Species Cultured or Captured in Southeast Asian Ricefields

The center(s) of the earliest development of fish cultivation in ricefields remains obscure, but it may have been in the Indian sub-continent, from which the practise appears to have been introduced to Southeast Asia some 1,500 years BP. If ricefield fish cultivation was introduced to Southeast Asia that long ago, then its diffusion within the region has been particularly slow, perhaps because of the persistent preference for captural rather than cultural techniques. In Java, for example, the practice seems to have started in the nineteenth century (mid-century according to Ardiwinata [1957: 121] and in the 1890s according to Satari [1962: 102]), whence it was spread to other parts of Indonesia by former students of religious schools, merchants and extension agents [*ibid.*].

Despite its long history and importance in many local economies of rural Asia, notwithstanding the urgent need to complement the rice staple with animal protein produced by cheap and technologically simple means, and in spite of the wide availability of suitable habitats, only an estimated 0.65 percent, or 136,000 ha of 21 million ha, of the irrigated ricefields in Southeast Asia are also exploited for the cultivation of fish [COCHE 1957]. But virtually everywhere that irrigated rice is grown fish are captured in flooded fields. However, the spread of high yielding varieties of rice and their associated technologies has introduced a major constraint to this traditional economic complement to rice production.

Where fish cultivation is well-integrated into local rice economies it plays a major role in augmenting household incomes. In West Java, Indonesia, for example, the value of fish produced in ricefields often equals and not infrequently exceeds that of the rice harvested (*vide infra*). Incomes derived from paddy field fish culture in Central Thailand are similar [HUAT and TAN 1979: 2], and in Peninsular Malaysia the value of ricefield fisheries is sometimes as much as 50 percent that of the rice [*ibid.*].

The joint cultivation of fish and rice is a rational form of land use, particularly among impoverished tenant farmers when land holdings are small, rents extremely high and lease conditions onerous; the prevailing conditions throughout much of Southeast Asia. A wide range of fish species is cultivated in Asian ricefields (Fig. 1).

RICEFIELD FISHERIES IN INDONESIA

In Indonesia, reported fish cultivation in ricefields is confined to the islands of Java, Sumatra, Sulawesi, Bali and Nusa Tenggara, which produce, respectively, 45.73, 21.16, 20.31 and 12.79 percent (by weight) of the total national fish production under this type of system (Table 1). It should be noted, however, that paddy-fish cultivation systems are possibly more widespread than the published data reveal, partly as a consequence of the spontaneous migration of Javanese to the Outer Islands. But since the fish are consumed mostly by the producing household or enter into only limited market transactions, no data have been recorded. In general it can be assumed that all the Indonesian data fall short of the actual

Table 1. Fish Culture in Paddy Fields: Area, Households, Fishermen and Productivity in Indonesia, 1977

PROVINCE[1]	Area (ha)[2]	HOUSEHOLDS	FISHERMEN	PRODUCTIVITY	
				VALUE[3]	QUANTITY[4]
JAWA	22, 371	30, 767	52, 303	720	0. 50
DKI Jakarta	183	272	462	640	0. 32
Jawa Barat	14, 045	21, 092	35, 856	1, 090	0. 71
Jawa Tengah	3, 637	770	1, 309	50	0. 04
DI Yogyakarta	1, 410	3, 766	6, 402	50	0. 07
Jawa Timur	3, 096	4, 867	8, 274	107	0. 24
SUMATERA	10, 351	18, 961	32, 233	420	0. 35
DI Aceh	686	150	255	110	1. 00[5]
S. Utara	6, 892	13, 250	22, 525	450	0. 29
S. Barat	179	919	1, 562	720	0. 65
S. Selatan	237	484	823	700	0. 51
Bengkulu	1, 700	3, 556	6, 045	540	0. 32
Lampung	657	602	1, 023	110	0. 11
BALI NUSA TENGGARA	9, 934	11, 350	19, 295	30	0. 05
Bali	7, 095	6, 149	10, 453	40	0. 05
NT Barat	1, 942	4, 863	8, 267	30	0. 10
NT Timur	87	338	575	70	0. 17
SULAWESI	6, 255	8, 890	15, 062	590	0. 37
S. Utara	1, 902	2, 523	4, 289	1, 550	0. 68
S. Tengah	13	33	56	110	0. 15
S. Selatan	4, 244	6, 190	10, 523	170	0. 24
S. Tenggara	96	114	194	30	0. 20

SOURCE: *Fisheries Statistics of Indonesia, 1977*, Tables 3.1, 3.2, 3.3.

NOTES: 1) Indicates only provinces where systems present.
2) Net area of surface water
3) U.S. $/ha (converted from rupiah at Rp 415=US $1, and rounded).
4) Ton/ha.
5) This figure should be treated with caution since the data source appears to have confused area and production figures.

production figures in that subsistence use of paddy-fish is not recorded. Within the areas reported, paddy-fish cultivation systems are concentrated mainly in particular provinces, all of which contain large population centers. Thus Jawa Barat (Java) accounts for 45.75%, Sumatera Utara (Sumatra) for 66.58%, Bali (Bali-Nusa Tenggara) for 79.57% and Sulawesi Selatan (Sulawesi) for 67.85% of the respective island totals.

The principal fish species raised in Indonesian paddy fields and their relative importance at the national level are shown in Table 2. With few exceptions,

Table 2. Principal Fish Species Raised in Indonesian Paddy Fields

VERNACULAR	ENGLISH	BINOMIAL	IMPORTANCE[1)]
Ikan mas	Common carp	*Cyprinus carpio*	87.7
Mujair	Java Tilapia	*Tilapia mossambica*	2.6
Tawes	Tawes	*Barbus gonionotus*	1.9
Ikan Nilem	Nilem	*Osteochilus hasselti*	1.2
Sepat siam	Sepat siam	*Trichogaster pectoralis*	0.7
Ikan lele	Catfish	*Clarias sp.*	0.7
Ikan nila	Nile Tilapia	*Tilapia nilotica*	0.5
Gurame	(Giant) Gourami	*Osphornemus goramy*	—
Tambakan	Kissing Gourami	*Helostoma temmincki*	—
Sidat	Eel	*Anguilla sp.*	—

SOURCE: *Fisheries Statistics of Indonesia, 1977,* Table 3.4.4a
NOTE: 1) Percentage distribution at the national level

Common carp (*Cyprinus carpio*) is the main fish cultivated throughout the country, and it accounts for 87.7 percent of the national production of fish from rice paddies (Table 3). However, in the provinces of Bengkulu, Sumatera Utara and Jawa Barat it accounts for 99.45, 97.43 and 97.82 percent, respectively. Although still the main species raised in D.I. Yogyakarta, Common carp accounts for only 41.17 percent of total production, whereas in Jawa Timur it comprises only 20.30 percent of total production, and is third in importance after miscellaneous species not intentionally stocked in the field, which account for 54.20 percent, and Tawes, which accounts for 24.73 percent of paddy fish production. Tawes is also relatively more important in D. I. Yogyakarta, accounting for 32.35 percent of paddy fish production. With few exceptions, both species of Tilapia are relatively unimportant in Indonesian paddy fields, but *T. mossambica* accounts for 12.6 percent of the fish produced in Sulawesi Utara province and 7.8 percent of that in D. I. Yogyakarta. In the latter province, also, *T. nilotica* is relatively more important, and accounts for 10.78 percent of total production. The other species are almost universally of minor importance. Sepat siam is more widely cultivated in Sulawesi Selatan, with 7.3 percent of the total production, and Nilem accounts for 8.79 percent of the total in Sulawesi Utara province [Indonesia 1977: 68].

As can be seen from Table 4, the importance of the fresh water fish pond (*kolam*) in the national inland fisheries sector exceeds that of the paddy field (*sawah*), which in turn is vastly more important than cage culture (*karamba*). Only in the provinces of Sumatera Utara, Bengkulu, Bali, Sulawesi Utara and Sulawesi Selatan is paddy field fish production the most important system.

RICEFIELD FISHERY SYSTEMS

Ricefield fishery techniques, although varying widely in detail among the countries of Southeast Asia, may be grouped broadly into *Capture Systems* and

Table 3. Production of Paddy Fish Culture by Province and Species, Indonesia, 1977

SPECIES / PROVINCE		Total	Common Carp	Puntius	Java Tilapia	Nilem	Nile Tilapia	Giant Gourami	Sepat Siam	Kissing Gourami	Catfish	Eels	Others
JAWA	a	11, 139	10, 210	299	50	57	34	1	—	20	5	—	463
	b	16, 246	15, 569	190	35	33	33	2	—	14	5	—	362
DKI Jakarta	a	59	55	4	—	—	—	—	—	—	0	—	0
	b	118	112	5	—	—	—	—	—	—	0	—	0
Jawa Barat	a	10, 072	9, 856	67	29	55	22	1	—	20	—	—	25
	b	15, 320	15, 145	65	23	31	25	2	—	14	—	—	16
Jawa Tengah	a	162	109	11	8	1	1	—	—	—	5	—	27
	b	192	154	10	5	1	—	—	—	—	5	—	14
DI Yogyakarta	a	102	42	33	8	—	11	—	—	—	—	—	8
	b	80	42	22	4	—	6	—	—	—	—	—	4
Jawa Timur	a	744	151	184	5	1	—	—	—	0	—	—	403
	b	535	118	88	2	1	—	—	—	0	—	—	85
SUMATERA	a	3, 609	3, 198	11	186	42	13	3	40	8	37	1	70
	b	4, 443	426	10	51	40	13	4	5	9	24	0	39
DI Aceh	a	686	486	—	132	—	—	—	40	—	12	1	15
	b	77	57	—	11	—	—	—	5	—	2	0	1
S. Utara	a	2, 062	2, 009	—	1	—	—	—	—	—	12	—	40
	b	3, 078	3, 035	—	0	—	—	—	—	—	12	—	31
S. Barat	a	118	76	4	4	34	—	—	—	—	—	—	—
	b	129	90	4	3	32	—	—	—	—	—	—	—
S. Selatan	a	121	48	6	35	—	12	3	—	8	9	—	—
	b	166	103	5	24	—	12	4	—	9	6	—	—
Bengkulu	a	549	546	—	3	—	0	—	—	—	—	—	—
	b	915	911	—	3	—	0	—	—	—	—	—	—
Lampung	a	73	33	1	11	8	1	0	—	—	4	—	15
	b	76	48	0	8	8	—	0	—	—	3	—	8

SULAWESI	a	2, 365	1, 689	20	197	116	40	—	83	2	69	—	149
	b	3, 703	3, 275	11	132	75	29	—	38	0	38	—	403
S. Utara	a	1, 285	924	1	162	113	40	—	83	2	69	—	45
	b	2, 957	2, 688	0	116	74	29	—	38	0	38	—	48
S. Tengah	a	2	2	—	—	—	—	—	—	—	—	—	—
	b	1	1	—	—	—	—	—	—	—	—	—	—
S. Selatan	a	1, 058	760	15	35	3	—	—	77	2	69	—	97
	b	741	585	9	15	1	—	—	37	0	38	—	53
S. Tenggara	a	20	3	4	—	—	—	—	6	0	—	—	7
	b	3	—	0	—	—	—	—	1	0	—	—	1
BALI-NUSA TENGGARA	a	588	430	15	44	—	3	0	4	—	14	2	76
	b	381	318	4	15	—	1	0	1	—	3	0	37
Bali	a	379	332	—	18	—	—	—	—	—	—	—	29
	b	308	273	—	10	—	—	—	—	—	—	—	25
NT Barat	a	194	91	15	22	—	—	—	4	—	14	2	46
	b	67	41	4	3	—	—	—	1	—	3	0	0
NT Timur	a	15	7	—	4	—	3	0	—	—	—	—	1
	b	0	4	—	0	—	1	0	—	—	—	—	0

SOURCE: *Fisheries Statistics of Indonesia, 1977,* Tables 3.4.4a and 3.4.4b.

NOTE: 1) [a] indicates total production in Tons and [b] indicates value in $ US 1,000.
Value data were converted from rupiah at Rp 415=$ 1, and rounded to nearest thousand.

2) — indicates not applicable, and 0 indicates less than 1 ton or 1,000$, as applicable.

3) Original data source contains probable discrepancy for the value and quantity of catfish produced in Sumatera Utara province.

Table 4. Comparison among Pond, Cage and Paddy Fish Production, Indonesia, 1977

	PADDY	POND	CAGE
Area (ha)[1]	48,911	29,902	7
Production (tons)	17,701	54,341	272
Value (1,000$ US)	24,774	56,507	531
No. of Households	18,961	72,949	330
No. of Fishermen	118,893	398,179	3,060

SOURCE: *Fisheries Statistics of Indonesia, 1977*, Tables 0.1, 0.2, 0.3, 3.1 and 3.2.
NOTE: 1) Net area of water.

Culture Systems (Fig. 2). Capture systems use a wide variety of techniques and tools to take naturally occurring fish from ricefields and their associated irrigation and drainage channels. There is little or no modification of the field under this type of system. As the term implies, culture systems involve the deliberate modification of ricefields and their stocking with one or several species that are cultivated to produce a desired product. Other species, not deliberately stocked, usually enter the field through the water supply network and are raised along with the principal fish crop(s). Culture systems may be further differentiated into *Concurrent* types, in which fish and rice are raised together, and *Rotational* types, where fish and rice are not cultivated concurrently. Two types of rotational system occur: *Alternate Cropping*, under which a single crop of fish is stocked in the paddy after a single annual crop of rice has been harvested, and, under double rice-planting systems, *Intermediate Cropping*, in which fish are cultivated during the period between the harvest of the first rice crop and field preparation for the second.

Capture Systems

These are the simplest type of ricefield fishery system, with few if any inputs. There is no deliberate stocking of fish, the harvest being derived from species that occur naturally in the flooded field (Photo 1). Although usually the ricefield is not specifically modified to retain the fish, in some instances small sumps are dug to concentrate them in the lower portion of a group of fields. Usually, predatory fish are predominant in the harvest of capture systems, and in Southeast Asia consist of such common species as Ophiocephalidae (snakeheads) and other air-

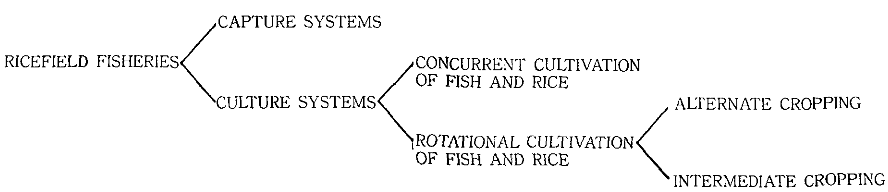

Figure 2. Principal Ricefield Fishery Systems

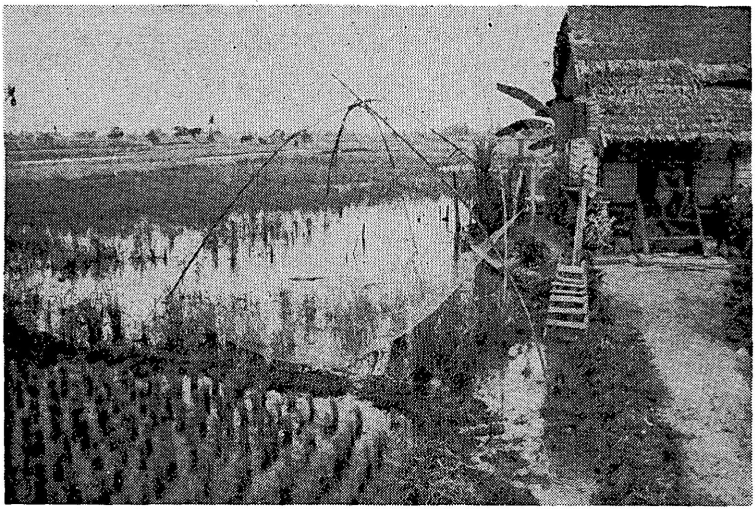

Photo 1. A small lift net is used to capture fish naturally occurring in the ricefields around Tj. Karang, Selangor State, Peninsular Malaysia.

breathing species like Anabantidae (Labyrinth fish), Clariidae (air-breathing catfish) and Heteropneustidae (Stinging catfish) [FERNANDO *et al.* 1979: 7].

In Malaysia, the success of capture systems improved with the introduction of *Trichogaster pectoralis* from Thailand, which gradually became the main fish cropped. The other main species taken in Peninsular Malaysia are *Clarias macrocephalus*, *Ophiocephalus striatus* and *Anabas testudineus* [KHOO and TAN 1979]. Although yields vary according to soil type and fertility and water pH, they average 135 kg/ha after 6–10 months, and range from 10 kg/ha to 400 kg/ha [HUAT and TAN 1979: 4].

Capture systems in ricefields around the Great Lake and along the Tonle Sap of Kampuchea are a minor but locally important method of exploiting aquatic ricefield fauna. The system is used to harvest various species of small fish, several centimeters in length, (which are used to make high grade *nam* [fish sauce]), for some 10–15 days in December and January as flood waters drain from the ricefields, carrying with them the fish. A crude barrage, 30–40 cm high and made of small sticks and branches, is erected at right angles to the direction of water flow. On the downstream side of the barrage a strip of mosquito netting (3 m$\times$0.5 m) is staked out to trap the fish, which are swept into it by the gentle current. A group of 5–6 men fish this way in a single ricefield. In the example observed, 5 men together caught 750 kg of fish in a 15 day period in the waters that drained from a group of several fields. Their catch consisted of three species of *Rasbora* (60%), *Danio* spp. (5%), *Trichogaster* spp. (5%), *Mastacembelus* spp. (3%), *Botia* (2%), *Esomus* (10%), *Pristolepis* (5%) and others (10%) [FILY n.d.: 455–457].

Table 5. Sequence of Operations in Concurrent Rice-Fish (Common Carp) Cultivation; Sukabumi Regency, West Java, Indonesia

Month	Activity	Inputs	Outputs	Remarks
July	Clean, till and prepare field for next rice crop. Repair dykes, maintain irrigation and drainage system. Prepare ditches for fish culture.	10 man-days labor		5 adult males working for 2 days
July	Field flooded. Carp fry stocked for 20 days.	7-day-old fry (1–1.5cm long)		Stocking rate 30,000 fry/ha.
July	*First Fingerling Harvest*		Fingerlings 27-days-old (3–5 cm long).	Mortality/loss rate unknown
August	Transplant rice to field. Raise water level in field. Stock fry 3 days after transplanting.	7-day-old fry		Stocking rate as above.
Sept.	*Second Fingerling Harvest*		Fingerlings 37-days-old (5–7 cm long)	Mortality/loss rate unknown
Sept.	First weeding of rice. Maintenance of fish culture ditches. Fertilize rice. Stock field with fingerlings.	Stocking rate 6,000/ha		Stock derived from Second Harvest.
Oct.	*Third Fish Harvest*		Fish 2 months old (8–12 cm long)	Mortality/loss rate unknown.
	Field drained, weeded and fertilized.			Rice flowering
	Field flooded			
	Field stocked with fingerlings	Smaller fish from Third Harvest (5–8 cm long) stocked at rate or 1,000–2,000/ha.		Larger fish stocked in ponds or sold to other pond owners.
Nov.	*Fourth Fish Harvest*		80–100 kg/ha (total wt) harvest 3–4 wks after stocking.	Mortality/loss rate unknown.
	Field drained *Rice Harvest* Field fallowed for one month.			
Dec.	Field preparation begins for second rice crop and concurrent fish cultivation (as above).			

Culture Systems: (1) The Minapadi of West Java

The monocultural system described below was studied in the Cisaat District of Sukabumi Regency, in June, 1980. The *minapadi* system, the principal objective of which is rice production, involves the concurrent cultivation of rice and fish (*Cyprinus carpio*). The cultivation of the fish is carefully synchronised with the sequence of activities and operations needed to produce a crop of rice. In the system practised at Sukabumi, two crops of rice (traditional varieties) are produced each year, together with 8 harvests of fish. This system is closely linked with fish pond production; 6 of the harvests being for fry or fingerlings for pond stocking and only 2 producing table fish for both household consumption and sale (Table 5).

In July, following the previous rice harvest, the paddy field is tilled, cleaned and prepared for the next rice crop. The dykes and irrigation and drainage ditches are maintained and repaired, and ditches for fish cultivation, 50 cm wide and 25–40 cm deep, are dug around the periphery of the field and across its center. The screens and water inlet and outlet pipes required for fish cultivation are also checked at this time (Photo 2). In the middle of the field, where the two fish cultivation ditches meet, a sump, 1 m^2, is excavated (Photo 3). Together, these field preparation activities require 10 man-days of labor. Seven-day-old fry, from the farmer's hatching pond, near the house, are released into the ditches, at a rate of 30,000/ha (Photo 4). They remain in the field for 20 days, and grow from 1–1.5 cm to 3–5 cm. After 20 days they are removed from the field (some are sold and others are stocked in rearing ponds near the house), in order that rice may be transplanted to the field, in August.

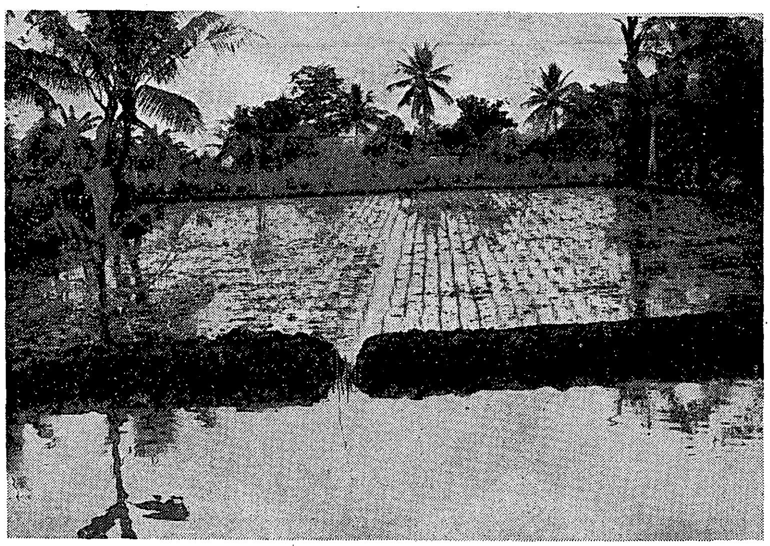

Photo 2. Rice newly transplanted into a *minapadi* for concurrent cultivation with Common carp; Sukabumi, Indonesia.

Photo 3. Sump to facilitate fish removal dug off-center in a *minapadi*; Sukabumi, Indonesia.

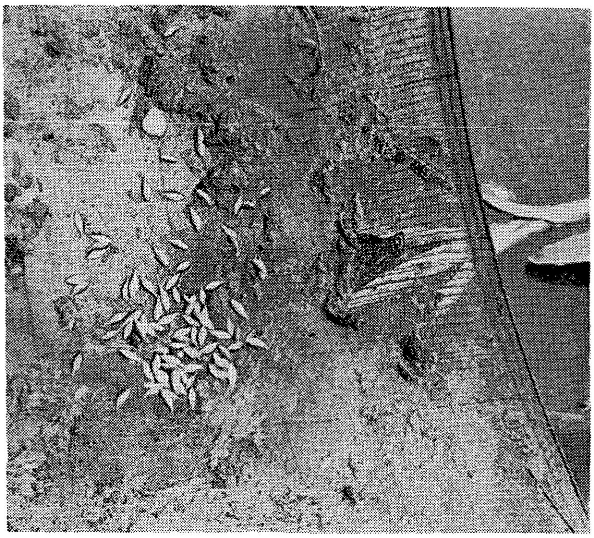

Photo 4. 7-day-old Common carp fry for stocking in a flooded paddy prior to the transplanting of rice; Bogor, Indonesia.

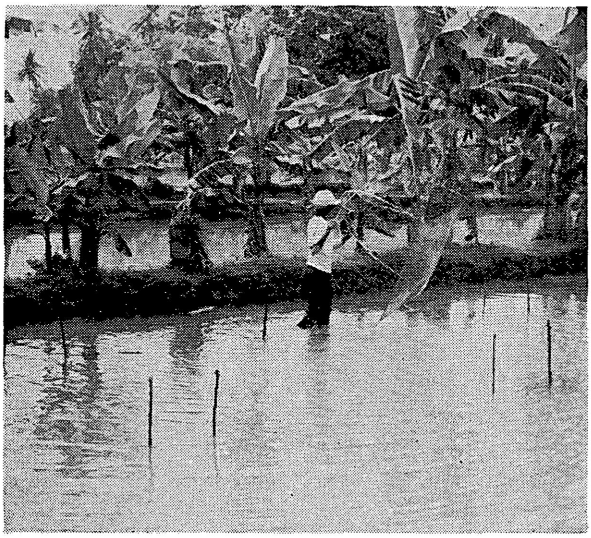

Photo 5. Using a simple scoop net (*serok*) to remove Common carp fingerlings from paddy prior to transplanting rice; Bogor, Indonesia.

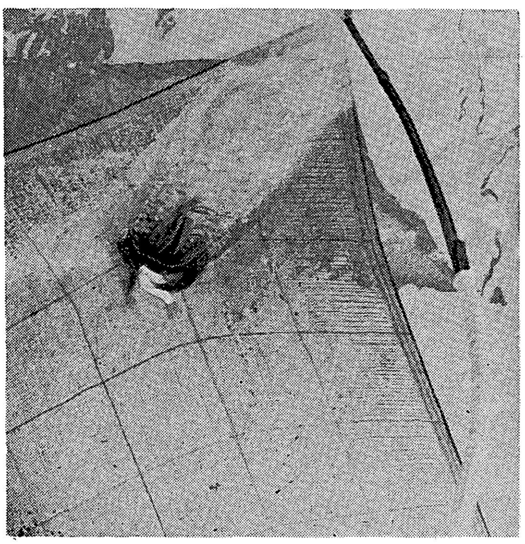

Photo 6. Common carp fingerlings ca. 37-days-old removed during the second fish harvest; Bogor, Indonesia.

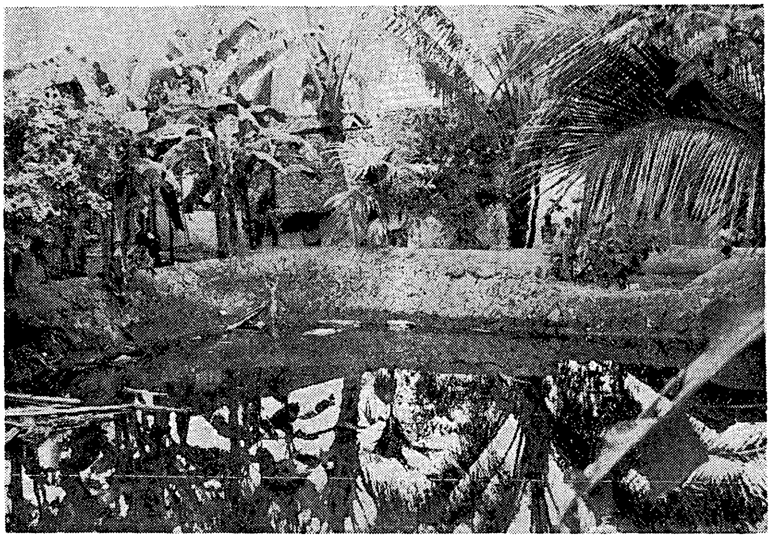

Photo 7. Dooryard pond for specialized fish cultivation; Sukabumi, Indonesia.

When rice transplanting is complete the water level is raised in the paddy, and 7-day-old fry are again stocked in the field, at the same rate. The first weeding of the rice takes place 30 days after transplanting, in September. At that time the fingerlings are removed from the field and either sold to other pond owners or stocked in the farmer's rearing pond (Photo 5, 6, 7). Concurrent with the first weeding, sediment and detritus is removed from the fish rearing ditches, and the dykes are checked and repaired if necessary. The rice is then fertilized.

Three days after rice fertilization fingerlings from the previous harvest are reintroduced into the paddy field, where they are cultivated for one month, until they attain an average size of 8–12 cm. In October, when the rice is at the "hamil" stage, just prior to flowering, the fish are removed from the field. As flowering begins the field is drained, weeded and fertilized. This takes one week. The field is then flooded and restocked with carp fingerlings. This time fingerlings 5–8 cm in length, are stocked at the rate of 1,000–2,000/ha. Three to four weeks later they are harvested and yield 80–100 kg/ha.

Once the fish have been removed, the field is drained and the rice harvest

Table 6. Rate of Return on the Fish Component of *Minapadi* Systems, Karawang Regency

Species	Stocking		Harvesting		Market	Total
	No. Stocked	Cost ($)	No. Harvested	Total Wt (kg)	Price ($/kg)	Income ($)
Carp	1,200	22,91	692	371	1.13	419.09
Tawes	3,000	29,12	1,215	360	0.64	233.01
Tilapia	30(kg)	—	—	370	0.48	179.61
TOTAL	—	—	—	1,101	—	831.71

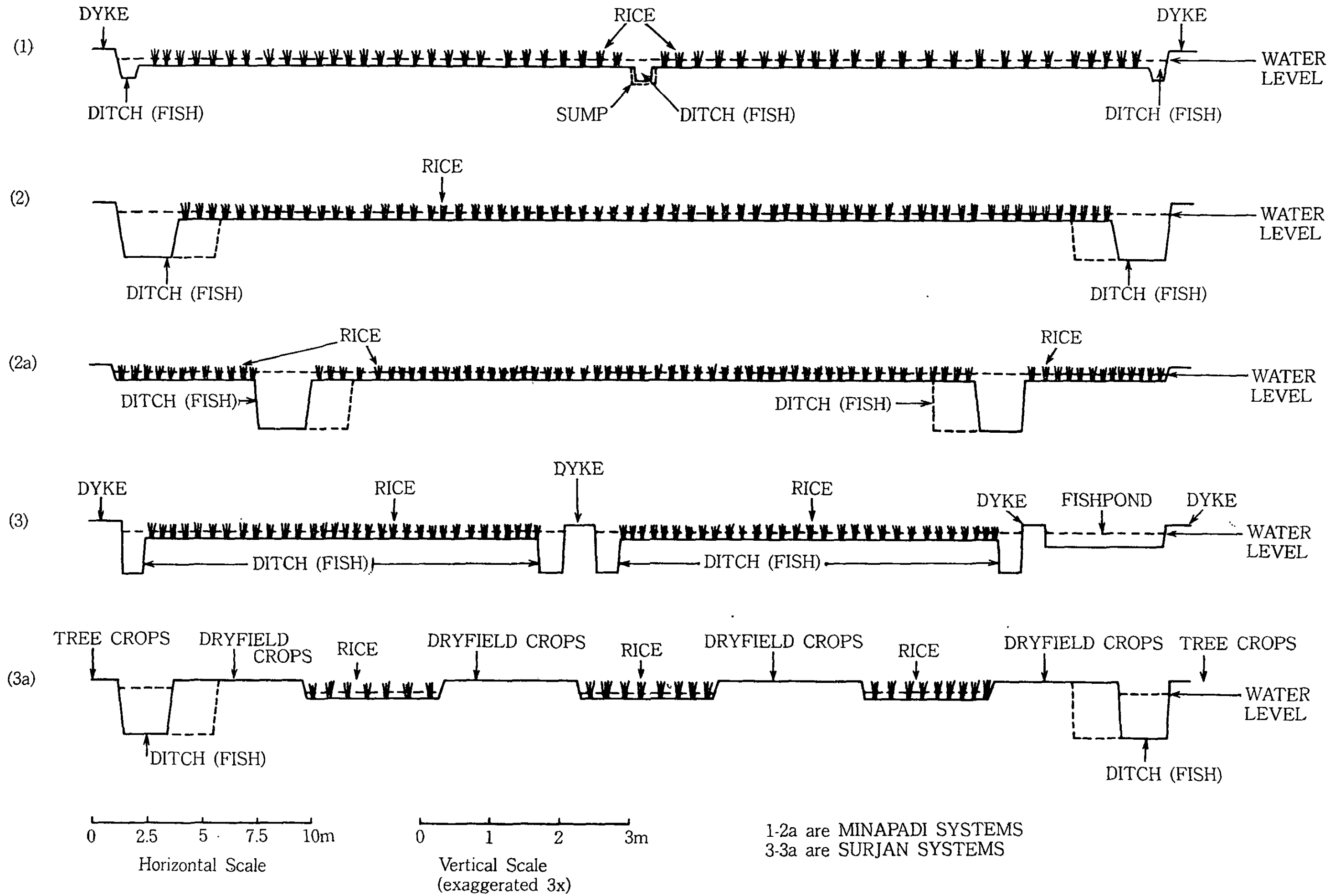

Figure 3. Adaptation of the Paddy Field for Concurrent Rice-fish Cultivation

begins. After completion of the harvest the field is left in dry fallow for one month. Then, in December, field preparation for the second rice crop starts, and the rice-fish cultivation cycle is repeated.

The rate of return under *minapadi* is illustrated by the example of a 0.4 ha farm located in Kertamukti Village, Pedes District, in the coastal lowlands of Karawang Regency (Table 6). This farm cultivates Common carp, Tawes and Java tilapia under a polycultural system, in ditches around the perimeter of the ricefield. Fingerlings were stocked in January, 1979. Some fish were harvested in June, and the remainder in September, 1979. Despite loss rates of 42.3% for carp and 59.5% for Tawes, the profits realized were high, just over 18 and 8 times the investment in fingerlings, respectively (costs of supplementary feed, ditch construction and maintenance labor not yet available). The high loss rates were attributed to predation by birds, snakehead fish, watersnakes, water lizards, eels (which are valued if caught) and otters.

The decision to convert a simple ricefield to rice-fish cultivation proved amply justified in this case. Hitherto, the farm was yielding rice at the rate of 2.4 MT/ha (field dry weight). With the addition of fish, the rate of rice yield declined to 2.44 MT/ha (actual yield was 1.4 MT) owing to reduction in the area devoted to rice, but the fish produced, at current market prices, the field dry rice equivalent of 10.97 MT/ha, with an actual padi equivalent of 6.862 MT.

Culture Systems: (2) The Surjan of West Java

In the *surjan* system the farmer seeks to optimize the production of rice, fish and dryland crops within a single farm unit. In the coastal zone of Karawang

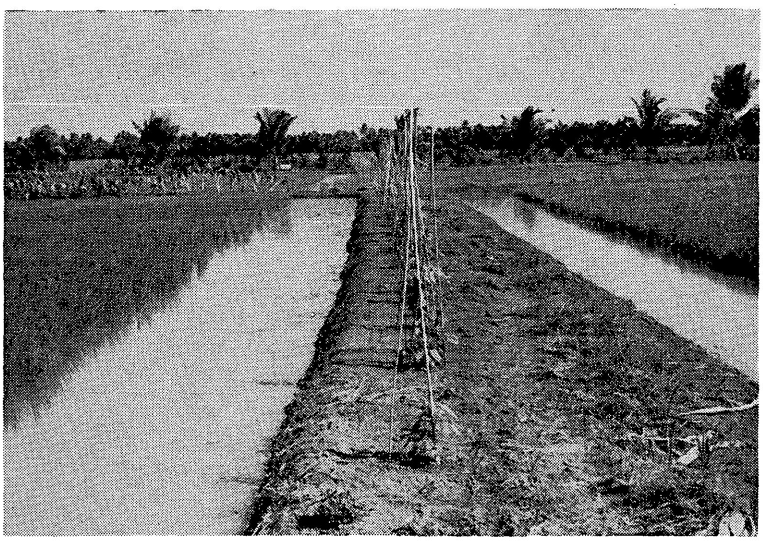

Photo 8. Dryfield crops, ditches for fish cultivation, rice and tree crops integrated in a *surjan* system at Kertamukti Village, Karawang, Indonesia.

Table 7. Rate of Return on the Fish Component of *Surjan* Systems, Karawang Regency

Species	Stocking		Harvesting		Market	Total
	No. Stocked	Cost ($)	No. Harvested	Total Wt (kg)	Price ($/kg)	Income ($)
Carp	5, 490	104. 53	3, 349	219	2. 10	462. 15
Tawes	400	3. 88	500	65	0. 80	52. 59
Tilapia	600	1. 21	—	7[a)]	0. 40	2. 75
Catfish[b)]	—	—	—	10[a)]	1. 29	16. 18
TOTAL	6, 470	203. 46[c)]	—	301	—	533. 67

NOTES: a) Weighed for marketing, not counted.
b) Enters with irrigation waters.
c) Includes $ 29.12 for supplementary feeding for 3 months, and $ 64.72 as labor costs for digging 1,200 m^2 of ditches for fish cultivation.
* All prices have been converted to U.S. from Rupiah at Rp. 618=$1.00
* No data for dryland crop production available yet for this farm.

Regency, where this field study of *surjan* systems was made, the *surjan* most commonly represents an adaptation in flood-prone areas. Fig. 3.3 illustrates the commonest type and 3.3a depicts an experimental type not yet widely adopted.

Field preparation is similar to that for *minapadi*, with the exception that the dykes are wider, to support dryland crops (beans, chili peppers, cucurbits and papaya, and around the borders of the farm, coconut, ipil-ipil and bananas [the latter group is never planted on the interior dykes since they cast too much shade]) (Photo 8). Commonly, polycultural fish production is practised in the *surjan*. In the example studied at Kutagandok Village, Common carp (*Cyprinus carpio*), tawes (*Barbus gonionotus*) and Java tilapia (*T. mossambica*) are intentionally stocked and cultivated together, along with catfish (*Clarias batrachus*) that enter the fields with the irrigation waters.

The example studied is a farm of 0.9 ha, developed into a *surjan* in 1979. Because the average rice production per harvest on this farm was exceptionally low for the area (2 MT/ha compared with the regional average of 3–4 MT/ha), the farmer decided to adapt his fields for *minapadi* production, rather than to use them solely for rice cultivation (Table 7).

ADVANTAGES OF AND CONSTRAINTS ON RICEFIELD FISHERIES

In addition to providing economic and dietary benefits to the farm household and utilizing more fully available ecological niches, and despite the higher cost of inputs, the joint cultivation of rice and fish in paddy fields enhances the yield of both rice and fish. But on the other hand certain aspects of rice technology are inimical to fish raising, and *vice versa* some facets of fish cultivation are detrimental to the rice crop.

Although the precise reasons are not clear, it is well-established that in Southeast Asia the cultivation of fish in paddies increases rice yields by as much as 15%

Table 8. Principal Constraints on Rice-Fish Cultivation Systems

(1) LAND PREPARATION	Poor and/or badly timed land preparation may harm fish exposed to the release of harmful substances by decaying organic material in the soil.
(2) RICE VARIETIES	HYVs mature in 105–125 days compared with some 160 days for traditional varieties. This may present problems in growing fish to harvestable size although it does not inhibit the cultivation of fingerlings for later stocking in fish ponds.
(3) FERTILIZERS	Fish cultivation in ricefields requires that N application be increased by some 50%. Incorrect application leading to high N concentrations in water may harm fish growth [Colt and Tchobanoglous 1978]
(4) RICE PEST AND DISEASE MANAGEMENT AND WEED CONTROL	Pest infestation, a major hazard in rice production, is combatted increasingly by the application of chemical pesticides, some of which may be toxic to fish and/or their consumers. Moreover, the persistence of pesticides in the ricefield environment may be a long-term constraint on paddy fish cultivation. But when insecticides such as Thiodan, Sevin or Malathion, which degrade rapidly, are used, a system that shifts fish back and forth between pond and paddy could prove suitable. Pest management by chemicals is a major constraint on ricefield fish cultivation. Combined cultivation, when this type of rice technology is used, will only be effective if insecticides are used sparingly, applied at rootzone depth or incorporated in the soil, and if the fish can be removed from the field until the toxicity hazard has diminished. Similarly, chemicals used to control rice diseases and weeds may be hazardous to fish, but in the absence of data, this remains speculative.
(5) IRRIGATION WATER	Successful cultivation in ricefields requires a standing water depth of 15–20 cm in the paddy and 50–60 cm in the ditches. Thus, a reliable supply of water beyond that required for rice-growing must be ensured throughout the season(s) of fish cultivation. This can be a major constraint; in parts of West Java, for example, centrally controlled water supply is geared to the needs of rice, *not* fish production, and it is cut-off completely during the fallow month. Although water may be stored in ditches for use during this period, the best system is one that involves a close ricefield-fishpond symbiosis, as illustrated by the Sukabumi *minapadi* example. Competing demands for water from other agricultural users as well as from industrial and domestic consumers are also increasingly problematical. Clearly, under these constraints, soils that suffer from high percolation rates are not suitable for ricefield fish cultivation.

[SATARI 1962: 105ff]. Rice yields improve even more under the polyculture of fish species [*ibid.*]. This may result from the increased aeration of the water caused by movements of the fish, which also appears to increase the rate of tillering of rice plants [*ibid.*]. And certainly, soil fertility is enhanced by the decomposition of fish excrement and the remains of supplementary feed fed to the fish, together with the increased amount of fertilizer required when fish are cultured in the ricefield. Moreover, when herbivorous fish, such as Common carp, Tawes and Java tilapia, are stocked in the field, weed control is enhanced, thus improving rice yields and reducing labor inputs. In field experiments in West Java, Common carp were found to reduce weed growth by 30% during the period between transplanting of the rice and the first weeding. Polyculture of fish appears to reduce weed infestation even more [*ibid.*]. In some instances fish present in ricefields consume insects and their larvae that damage rice plants as well as contributing to the control of diseases harmful to humans [HUAT and TAN 1979: 20]. But fish sometimes damage young rice plants. However, certain disadvantages are inherent in rice-fish cultivation systems, as a consequence of the management requirements of rice (Table 8). Throughout Southeast Asia, agricultural policies emphasise rice production, thus paddy-fish cultivation must be adapted to the needs of the rice crop. Certain techniques of rice husbandry, especially the application of fertilizers and water supply, could be modified to increase fish production without lowering rice yields, thus bringing the complementarities of both crops into full play [SINGH *et al.* 1979: 36]. The principal constraints are the toxicity of agricultural chemicals and the provision of a regular water supply. These, however, can be overcome by integrating ricefield-fishpond fish culture into a symbiotic production system, as illustrated by the example described from Sukabumi, Indonesia.

CONCLUSION

As a consequence of the two main constraints, water supply and the use of agricultural chemicals, a decline in the area and productivity of ricefield fisheries is observable throughout Southeast Asia. In response, and despite the greater investment required, the importance of freshwater fishponds has been increasing. This is clearly evident in Indonesia (Fig. 4–6). However, it is inaccurate to depict pond and paddy field culture of fish as two systems apart since in many cases their roles are complementary.

These complementarities appear to chart the course for the future when the respective roles of the ricefield and the fishpond will probably become more fully integrated for the production of fish (Fig. 7). Apart from the remaining pioneer zones and in areas where the greater investments required for the construction and maintenance of fishponds are not forthcoming, ricefield fisheries, in the strict sense, seem bound to continue their decline.

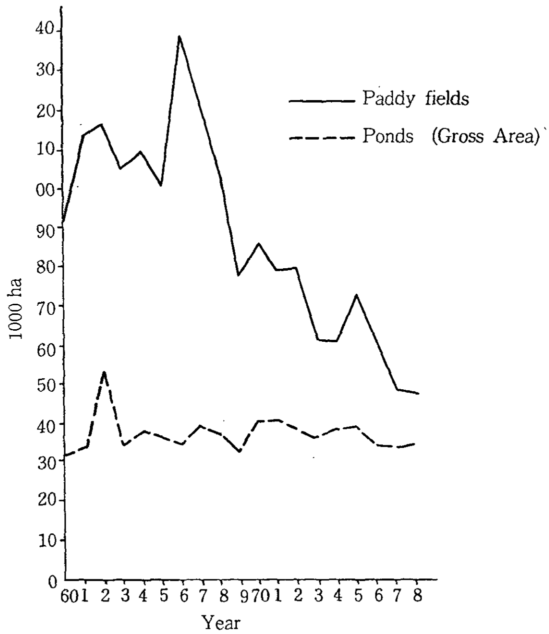

Figure 4. Area in Fish Culture, Indonesia, 1960–1978 (1,000 hectares)
SOURCE: *Fisheries Statistics of Indonesia, 1977,* Table 3.1

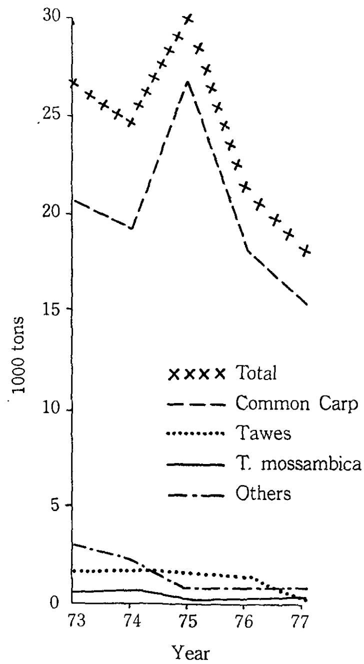

Figure 5. Paddy Fish Production by Main Species, Indonesia, 1973–1977 (1,000 tons)
SOURCE: *Fisheries Statistics of Indonesia, 1977,* Table 3.5.

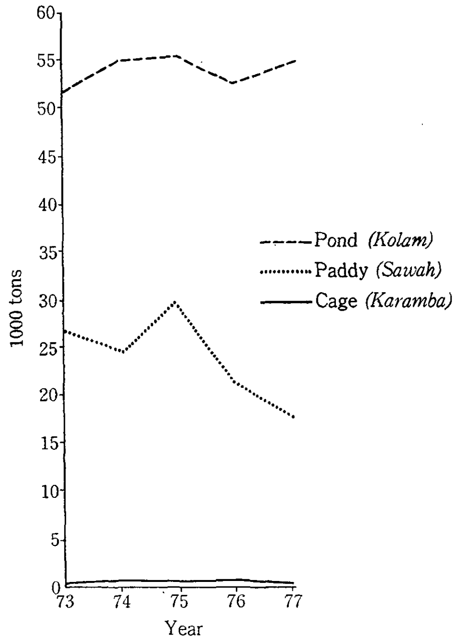

Figure 6. Pond, Paddy and Cage Fish Production, Indonesia, 1973–1977 (1,000 tons)
SOURCE: *Fisheries Statistics of Indonesia, 1977,* Table 3.3.1, 3.4.1, 3.5.1.

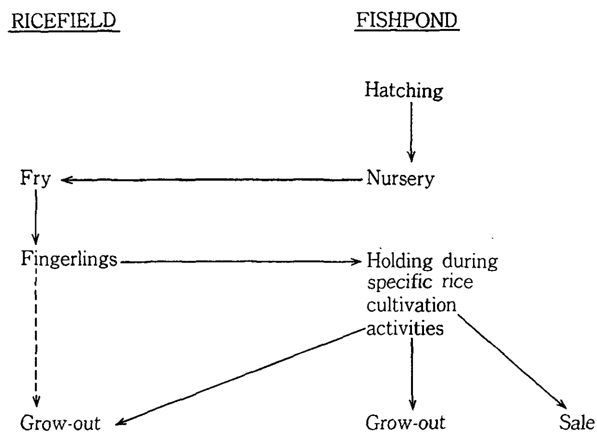

Figure 7. Relationships between Ricefield and Fishpond

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