DEVELOPMENT OF AQUACULTURE INDUSTRY IN SOUTHEAST ASIA: AN OVERVIEW

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ABSTRACT

Southeast Asia, a Subregion of the Asia-Pacific Region, is composed of countries of diverse socio-economic circumstances. Fisheries production, particularly that of the aquaculture sector, is relatively developed and is important to the economy of this area. Some 80 economic aquatic species are the subject of culture. Many of these species, which include fin fish, crustaceans, molluscs, and seaweeds, are produced in consequential quantities.

Total production from the Subregion in 1983 amounted to about 880 000 mt which represented nine percent of total world aquaculture production in said year, and a 100% increase in the area within the decade (1975-1983). Unit production is comparatively low as it is usually done with the use of the extensive level of management developed after long years of experience by fish farmers. Higher rate of production in recent years is a trend especially for high value and exportable species like the penaeid shrimps. Aquaculture production tends to have accelerated growth while capture fisheries production tends to increase very gradually or levels off.

Technical and non-technical constraints occur which hinder rapid progress of aquaculture in Southeast Asia. This will require the attention of research institutions and governments. However, bright prospects for future increase in production in this industry are developing in the area. Specific instances to support this forecast are discussed.

INTRODUCTION

Available statistics show that fisheries production is important to the economy and food supply of most countries of the world. Aquaculture production is an important aspect of this production sector.

The Asia-Pacific Region is the center of development of world aquaculture and its Southeast Asian Subregion can be considered the gem for this type of production development (Fig. 1).

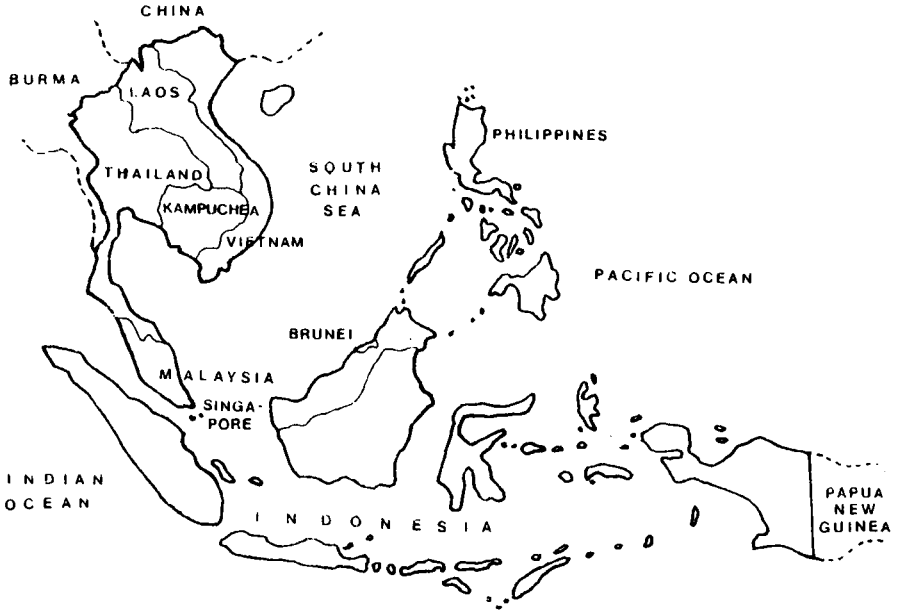

Fig. 1. Definition of the Southeast Asian Subregion as employed in this paper

The nine countries included in the Southeast Asian Subregion vary greatly in their socio-economic conditions (Table 1). These circumstances have an impact on the general economic and fisheries/aquaculture development of the countries. In area, the countries vary from as small as 618 km^2 (Singapore) to 1.9 million km^2 (Indonesia). The total land area of the countries in the region is 3.8 million km^2 or close to 2% of total world land area. However, the population of 360.9 million is equivalent to about 7% of total world population. In population density, the countries vary from as sparse as 19 persons/km^2 (Laos) to as dense as 4 000/km^2 (Singapore). The population growth rate also varies considerably with Singapore registering the lowest at 1.5% and Brunei the highest with 3.3%. The economic condition of the countries as indicated by per capita GNP also varies considerably. Based on equivalent US dollars, this ranges from US$85.00 (Laos) to US$22 150.00

Table 1. Vital socio-economic statistics of Southeast Asian countries

Country	Area (km^2)	Population (1000)	Population density (No./km^2)	Population growth rate (%)	Per capita GNP (US$)	Fisheries production[3] 1983 (mt)	Per capita fish consumption[4] (kg/year)	No. of fishermen[4]	No. of fish-farmers[5]
Brunei	5 765[1]	221[1]	38	3.3[1]	22 150[1]	2 949	40	2 069	
Indonesia	1 919 443[2]	165 150[2]	86	2.3[2]	540[2]	1 672 355	11.8	1 713 425	834 655
Kampuchea	181 035[2]	7 420[2]	41	*	100[1]	63 750	24.4	*	*
Laos	236 800[2]	4 440[2]	19	*	85[1]	20 000	3	*	*
Malaysia	329 749[2]	15 680[2]	48	2.8[2]	1 990[2]	725 898	40-43	107 273	16 967
Philippines	300 000[2]	54 670[2]	182	2.8[2]	660[2]	1 319 674	41	817 660	210 039
Singapore	618[2]	2 560[2]	4 142	1.5[2]	7 260[2]	19 099	43	1 321	*
Thailand	542 373[2]	51 300[2]	95	2.5[2]	850[2]	2 104 577	23.1	82 597	*
Viet Nam	329 556[2]	59 460[2]	180	*	189[1]	505 000	10-12	*	*
Total for SEA countries	3 845 339	360 901				6 433 302		2 724 345	1 061 661
World total	207 495 243	5000 000				77 256 500			
Percent, SEA on world	1.85	7.20				8.33			

[1]World Almanac, 1987 (The per capita income, not GNP, is given)
[2]Asian Development Bank, Key Indicators of Developing Member Countries of ADB, Vol. 17, 1986
[3]FAO 1985 Yearbook of Fishery Statistics, Vol. 60, 1987 (Figures for 1983 were taken for comparative purposes)
[4]Mainly from FAO Data Base taken from national statistics
[5]Southeast Asian Fisheries Development Center (SEAFDEC), 1983 Fishery Statistical Bulletin for South China Sea Area (1985)

*Data not available

(Brunei) with the others registering very wide-ranging intermediate values. Fisheries is important in the region varying from 2 949 mt (Brunei) to 2 104 577 mt (Thailand) in 1983. This situation also has some bearing on the per capita consumption of fish in each country which varies from 3 kg/yr (Laos) to 43 kg/yr (Malaysia and Singapore). Indonesia has the largest number of fishermen (1.7 million) and fish farmers (800 000) followed by the Philippines with 800 000 fishermen and 210 000 fish farmers.

World fisheries production from 1938 to the present has gradually increased from 21 million mt (1938) to 84.9 million mt in 1985 or an increase of over 300% in 46 years equivalent to about 7% increase per year. Of this, 6 to 10 million mt or about 10% come from aquaculture. The world aquaculture production by kind of resource in 1983 consists of the following:

Kind of resource	*Production (mt)*
Finfish	4 447 946
Crustaceans	123 445
Molluscs	3 245 530
Seaweeds, etc.	2 393 782
Total	10 210 703

The distribution of world aquaculture production by region in 1983 is as follows:

Region	*Production (mt)*	*Percent of total*
Asia-Pacific (A-P)	8 412 131	82.4
Europe and Near East (E-NE)	1 221 511	12.0
North America (NA)	312 691	3.0
Latin America and the Caribbean (LA-C)	220 505	2.2
Africa (AF)	43 865	0.4
Total	10 210 703	100.0

Of the Asia-Pacific aquaculture production, the Southeast Asian Subregion produces over 800 000 mt or 10% of the production from this region.

In the Southeast Asian countries, the total fisheries production has been growing gradually. From 1981 to 1985, this increased from 7.1 million mt in 1981 to 7.9 million mt in 1983 but declined slightly to 7.6 million mt in 1985 (Table 2). This subregional production composes 9-10% of the total world production. In aquaculture, the countries produced from 150 mt (Brunei) to 440 000 mt (Philippines) in 1983, with the Southeast Asian countries producing a total of about 885 000 mt or equivalent to about 9% of the total world aquaculture production (Table 3).

PROFILE OF SPECIES BEING CULTURED IN SOUTHEAST ASIA

It is extremely difficult to prepare a comprehensive checklist of species that are the subject of aquaculture in Southeast Asia. There are species that are mainly used for human food (finfish, molluscs, and crustaceans), species that are used mainly in industry (industrial seaweed, pearl, and window pane oyster), species that are used as food organisms for the culture of other species (phytoplankton, zooplankton, brine shrimp, etc.), and species used as cash crop for export (ornamental fish). For purposes of this paper, species used for human food and for industry, either consumed locally or exported are discussed. These consist of finfishes, crustaceans, molluscs, seaweeds, and others. In the region, it is estimated that over 80 species are cultivated consisting of 48 species of finfish, 13 species of crustaceans, 13 species of molluscs, 5 species of seaweeds, and 5 species of other vertebrates (Tables 4, 5).

Finfishes

It is estimated that there are close to 50 species of finfish cultivated in Southeast Asia. This includes freshwater, brackish and marine species. The major marine and brackishwater species include milkfish, sea bass, grouper, snapper, sea bream, rabbitfish, mullet, jack, eel, and gobies. The freshwater species include carps and related cyprinids, tilapias, clarias catfishes, gouramies, snakehead, certain eels, and certain gobies. In 1983 about 595 000 mt of finfish were produced through aquaculture in the region. Highest production by species include milkfish, with over 300 000 mt; carps and related cyprinids with over

Table 2. Fisheries production of Southeast Asian countries, 1981-1985 (in mt)

Country	1981	1982	1983	1984	1985
Brunei	2 367	2 357	3 055	2 226	2 986
Indonesia	1 918 758	1 982 159	2 204 816	1 992 535	2 067 090
Kampuchea	68 700	58 650	63 750	65 000	68 000
Laos	20 000	20 000	20 000	20 000	20 000
Malaysia	804 094	682 569	741 089	664 967	632 185
Philippines	1 686 636	1 787 744	1 977 580	1 935 399	1 867 701
Singapore	16 112	19 346	19 549	25 468	23 032
Thailand	1 989 025	2 120 133	2 260 024	2 134 846	2 123 600
Viet Nam	622 000	640 00	710 000	765 000	800 000
SEA production	7 127 692	7 312 958	7 999 863	7 605 441	7 604 594
World production	74 840 400	76 762 900	77 256 500	83 096 000	84 945 300
Percent SEA production to world production	9.52	9.53	10.35	9.15	8.95

Source: FAO Yearbook of fishery statistics, 1985, Vol. 60 (1987)

Table 3. Fisheries and aquaculture production in Southeast Asian countries, 1983

Country	Total fisheries production[1/] (mt)	*Capture fisheries* Production[1/] (mt)	% of total	*Aquaculture* Production (mt)	% of total
Brunei	3 055	2 905	95	150[3/]	05
Indonesia	2 204 816	1 937 917	88	266 899[2/]	12
Kampuchea	63 750	62 850	99	900[3/]	01
Laos	20 000	19 640	98	360[3/]	02
Malaysia	741 089	687 749	93	53 340[2/]	07
Philippines	1 977 580	1 532 507	77	445 073[2/]	23
Singapore	19 549	17 510	90	2 039[2/]	10
Thailand	2 260 024	2 168 299	96	91 725[2/]	04
Viet Nam	710 000	685 000	96	25 000[3/]	04
Total for Southeast Asian (SEA) countries	7 999 863	7 114 377		885 486	
World totals for same period	77 256 500	67 045 797		10 210 703	
Percent SEA production on world production	10.4	10.6		8.7	

[1/]FAO 1983 Yearbook of Fisheries Statistics, Vol. 56 (1985)
This includes both capture and culture fisheries

[2/]Source: SEAFDEC, 1983 Fishery Statistical Bulletin for South China Sea Area (1985)

[3/]From recent publications and previous estimates from a survey by the author

100 000 mt; the tilapias with 51 000 mt; gouramies with 18 000 mt and catfishes with over 10 000 mt (Table 5).

Crustaceans

World fisheries production of crustaceans is relatively low in tonnage but very high in value. The total crustacean production through aquaculture in Southeast Asia in 1983 is about 60 000 mt. This is equivalent to almost 50% of total world crustacean production through culture. Most of these species are high value species that are exported to major importing developed countries. There is a continuing demand and persistent relatively high price for this commodity. It is estimated that there are about 13 crustacean species cultured in Southeast Asia. The major species belong to the penaeid shrimp which include the *Penaeus* and *Metapenaeus* shrimps followed by the non-penaeid shrimps. The giant freshwater prawn has also been cultured and is produced commercially in the Subregion. There is one species of crab, the *Scylla serrata* being cultivated with small amount of production from the Subregion (Table 5).

Molluscs

Most of the molluscs being cultured are for human food but the pearl oysters are cultured to produce precious pearls and shells. Some 98 000 mt of molluscs were produced through culture in Southeast Asia in 1983. There are about 13 species cultured of which the major ones are: the blood cockle *(Anadara granosa)* followed by the green mussel *(Perna viridis)* and the food oysters *(Crassostrea* spp. and *Ostrea* spp.) (Table 5).

Seaweeds and Others

Of the seaweeds, the brown, green, and red seaweeds or macro algae are cultured in certain countries of the Subregion. Red algae belonging to the genus *Eucheuma* is a major source of an industrial product, the carrageenan. Crop of this algae which is cultured is exported from the region. This species can also be used secondarily for human food but the main food species which have been cultured belong to the green seaweed *Caulerpa.* Five species are cultured in the region and the production in 1983 mainly from the Philippines is about 130 000 mt (Tables 4, 5). Other species which are cultured both for food and industry and for the export trade include frogs and other amphibians,

Table 4. Aquaculture production in Southeast Asian countries by resources, 1983

Country	Finfish (mt)	Crustacean (mt)	Molluscs (mt)	Seaweed, others (mt)	Total, by country (mt)
Brunei	*	-	150[1/]	-	150
Indonesia[2/]	238 895	28 004	*	*	266 899
Kampuchea[3/]	900	*	*	-	900
Laos[3/]	360	-	-	-	360
Malaysia[2/]	14 592	218	38 530	*	53 340
Philippines[2/]	270 068	12 985	29 816	132 204	445 073
Singapore[2/]	2 000	39	*	-	2 039
Thailand[2/]	49 139	12 739	29 841	6	91 725
Viet Nam[3/]	19 000	6 000	*	*	25 000
Total for SEA countries	594 954	59 985	98 337	132 210	885 486
World total	4 447 946	123 445	3 245 530	2 393 782	10 210 703
Percent SEA on world production	13.4	48.6	3.0	5.5	8.7

[1/] Author's estimate based on 1985 survey

[2/] SEAFDEC 1983 Data Base (1985)

[3/] From recent publications and previous estimates from survey by the author

* Practiced but data not available

– Practice is not applicable or amount produced is negligible

Table 5. Production profile for species produced through aquaculture in Southeast Asia (1983)
(Based on SEAFDEC 1983 Fishery Statistical Bulletin for South China Sea Area, Bangkok, Thailand, 1985)

SPECIES/SPECIES GROUP	Brunei (mt)	Indonesia (mt)	Kampuchea (mt)	Laos (mt)	Malaysia (mt)	Philippines (mt)	Singapore (mt)	Thailand (mt)	Vietnam (mt)	Total by species (mt)
I. FINFISH										
1. Milkfish (*Chanos chanos*)	-	81 506	-	-	*	240 610	-	*	*	322 116
2. Seabass *dates calcarifer)*	*	1 105	-		227	*	*	1 084	-	2 416
3. Grouper *(Epinephelus* spp)	*	*	-	-		*	*	*	-	*
4. Snapper *(Lutjanus* spp)	-	-	-	-		*	*	*	-	*
5. Sea bream (Sparidae)	-	-	-	-		-	*	*	-	*
6. Rabbitfish *(Siganus* spp)	-	*	-	-		*	-	*	-	*
7. Mullet *(Mugil* spp)	-	4 129	-	-		*	-	223	-	4 352
8. Jacks (*Caranx* spp)	-	*	-	-		*	*	*	-	*
9. Carps and related cyprinids[1/]	*	81 438	-	*	12 387	590	*	7 823	*	102 238
10. Tilapia (*Oreochromis mossambicus and* O. niloticus)	*	23 812	*	-	1 373	13 928	*	12 125	*	51 238
11. Catfish (*Clarias batrachus* and *C. macrocephalus*)	-	592	*	*	3	*		9 924	*	10 519
12. Eels (*Pluta* sp and *Anguilla* spp)	-	3	-	-	*	*	-	70	*	73
13. Gouramies (*Osphronemus gouramy, Trichogaster* spp and *Helestoma temmineki)*		7 394	*	*	*	147		10 260	*	17 801
14. Snakehead *(Ophiocephalus* spp)	-	*	*	*	*	*	-	4 787	*	4 787
15. Marble goby (*Oxyeleotris marmoratus*)	-	*	*		*		*	*	*	*
16. Other brackishwater finfish[2/]	-	19 328	-	-	516	14793	-	2 027	-	36 664
17. Other freshwater finfish[3/]	-	19 588	-	-	86	-	-	816	-	20 490

II.	CRUSTACEANS										
	18. Penaeid shrimps (*Penaeus* spp and *Metapenaeus* spp)	*	15 866	-	-	166	12 060	39	10 399	*	38 530
	19. Non-penaeid shrimps (*Parapenaeopsis* spp, etc)	-	11 729	-	-	*	*	-	1 151	*	12 880
	20. Freshwater crustaceans (*Macrobrachium rosenbergii*, etc.)	-	*	-	-	1	-	*	1 153	*	1 154
	21. Mud crab (*Scylla serrata*)	-	*	-	-	*	*	*	*	-	*
	22. Other crustaceans (brackishwater)[4/]	-	409	-	-	51	925	-	36	-	1 421
III.	MOLLUSCS										
	23. Flat oyster (*Ostrea* spp)	-	-	-	-	-	-	-	3 461	-	3 461
	24. Cupped oyster (*Crassostrea* spp)	-	*	-	-	-	11 310	-	*	-	11 310
	25. Sea mussel (*Perna viridis*)	150[5/]	*	-	-	-	18 506	-	19 285	-	37 941
	26. Blood cockle (*Anadara granosa*)	-	*	-	-	38 530	-	*	7 095	*	45 625
	27. Pearl oysters (*Pinctada* spp)	-	*	-	-	*	*	-	*	-	*
	28. Other molluscs	-	*	-	-	*	*	*	*	*	*
IV.	SEAWEEDS										
	29. Brown, red and green seaweeds/ algae (Phaeophyceae, Rhodophyceae and Chlorophyceae)*	-	*	-	-	*	132 204	-	*	*	132 204
v.	OTHERS										
	30. Frogs and other amphibians (*Rana spp*)	-	*	-	-	*	*	*	1	*	1
	31. Turtles and other reptiles (*Tiionyx sp. Crocodilus* sp, etc.)	-	-	-	-	*	-	*	5	*	5

[1/]Include common carp; Chinese silver, grass, bighead and mud carp; *Puntius, Leptobarbus* and *Osteochilus* species; and goldfish

[2/]Include tilapia species, *Scatophagus* species, etc.

[3/]Include anabantids, gobies, *Notopterus* spp, etc.

[4/]Include mysids, other incidental entrants in impoundments

[5/]Based on 1985 survey by the author

[6/]These include mainly *Eucheuma spp, Gracilaria sp* of Rhodophyceae and *Caulerpa* spp of the Chlorophyceae

– Magnitude zero or not applicable

* Data not available

Rana spp.; and turtles and other reptiles *(Trionyx* sp. and *Crocodilus* sp., etc.) About five species of this economic aquatic vertebrates are cultured in the region but the production is still negligible amounting only to about 6 mt in 1983.

PRODUCTION TRENDS IN THE LAST DECADE

Generally for the Subregion, aquaculture productivity has gradually increased with time. This is true with the production for the different systems as well as the different species within the finfish, molluscan, crustacean, and seaweed groups. Of course, there are certain systems and areas, and/or species where setbacks have occurred due to specific reasons or causes.

The interesting thing about aquaculture production is its relation with capture fisheries. While capture fisheries tended to fluctuate or level off in most countries of the region, aquaculture production gradually increased to attain a relatively higher percentage contribution to the total fisheries production in the different countries as well as the region in general (Table 9).

National Production by Species

The total aquaculture production from all countries of the Southeast Asian Subregion is over 880 000 mt in 1983 which is equivalent to 9% of the total world aquaculture production and about 1% of the total world fisheries production. The leading aquaculture producers in the Subregion are the Philippines with over 440 000 mt, Indonesia with 267 000 mt, Thailand with 92 000 mt, Malaysia with 53 000 mt, Vietnam with about 25 000 mt, Singapore with 2 000 mt and small amounts produced by Kampuchea, Laos and Brunei (Table 3).

By resources or species, the major groups produced in Southeast Asia as of 1983 are: milkfish (36%), seaweeds (15%), carps and other cyprinids (12%), penaeid shrimps (6%), tilapia and other cichlids (6%), blood cockle (5%), sea mussel (4%), gouramies (2%), food oysters (2%), catfishes (1%), snakehead (0.5%), mullet (0.5%), and freshwater prawn (0.1%). There are other species belonging to the finfishes, crustacean, molluscan and seaweed groups which are produced to complete the large array of culture species in the Subregion (Table 5), however, the magnitude of production from these minor species is still negligible.

By species, for finfishes, the Philippines produced the most with about 270 000 mt/yr. mainly from milkfish; Indonesia follows with about 239 000 mt/yr. mainly from milkfish and carps and related cyprinids. This is followed by Thailand with about 49 000 mt distributed in a number of species but mainly the tilapias, gouramies, carps and related cyprinids, snakehead, and others (Tables 4, 5). The total production of finfish through culture in the Subregion amounted to about 595 000 mt or 67% of the production in the area and 13% of world production of this crop.

In the production of crustaceans, mainly the penaeid shrimps in brackishwater, Indonesia leads with about 28 000 mt, followed by the Philippines and Thailand with about 13 000 mt each in 1983. There is small production from Malaysia and Singapore. Only Thailand has a consequential amount of production of over 1 000 mt for the giant freshwater prawn. The total production of crustaceans from Southeast Asian countries in 1983 is about 60 000 mt which is 7% of the total aquaculture production but 49% of total world production for this crop (Tables 4, 5).

In the production of molluscs, Malaysia leads solely from the production of blood cockle with over 38 000 mt/yr in 1983 while both the Philippines and Thailand have a production of 30 000 mt in the same period. The production of the Philippines consists of oysters and mussels while that of Thailand consists of mussels, oysters, and blood cockles. Almost 100 000 mt of molluscs are produced from the Subregion in 1983 (Tables 4, 5). This is 11% of the total aquaculture production from this area and 3% of world production of this crop (Table

The culture of seaweeds is still not widespread in the Subregion as natural stocks are still available and are being gathered (e.g., Indonesia, Malaysia, Philippines, Thailand). However, consequential production through culture especially of the *Eucheuma* spp. is produced in the Philippines. The production of *Eucheuma* seaweed in the Philippines in 1983 was about 130 000 mt (Table 4). Frogs and other amphibians, turtles and other reptiles are produced in some countries of the region through culture such as in Thailand but these are still of very small quantities (Table 5).

Production per Unit Area

Data on the average production by species of cultured organisms in Southeast Asia are not readily available. If available, they may be

incomplete or if obtained by different agencies or institutions, variations in methodology can be a cause of varying interpretations. However, out of the scanty data in hand, the aquaculture production averages for different culture systems and for some species in the Subregion may be assessed (Table 6). In the Table, Southeast Asian aquaculture may be divided into three major systems, namely: mariculture, brackishwater culture, and freshwater culture. For the countries practicing mariculture for the year 1983, some idea of the average unit production (kg/ha/yr.) can be gleaned for blood cockle in Malaysia and sea mussels/blood cockle/oysters in Thailand. The average production kg/

Table 6. Aquaculture production averages for different systems and species in Southeast Asia (1983)

System/Country	Species	Total area used (ha)	Total production (mt)	Unit production (kg/ha/yr)
I. MARICULTURE				
Malaysia	Blood cockle	4 699	38 530	8 200
Thailand	Sea mussels, blood cockles and oysters	3 033	29 841	9 800
II. BRACKISHWATER CULTURE				
Indonesia	Milkfish, penaeids, mullet, seabass, etc.	193 724	134 073	690
Philippines	Milkfish, penaeids, etc.	1 96 269	183 770	940
Thailand	Penaeids, seabass, mullets, etc.	5 235	14 920	2 850
III. FRESHWATER CULTURE				
Indonesia	Carps, gouramies, tilapias, catfishes, etc.	165 003	132 828	800
Malaysia	Carps, tilapias, catfishes, etc.	5 810	13 850	2 380
Philippines	Milkfish (fishpens), Tilapia (cages/ponds), carps, gouramies, etc. (ponds)	13 770	99 280	7 200
Singapore	Freshwater species	309	541	1 750
Thailand	Tilapias, gouramies, catfishes, carps, snakehead, giant prawn, etc.	41 082	46 966	1 100

Source: Fisheries Statistical Bulletin for South China Sea Area, 1983 Southeast Asian Fisheries Development Center (SEAFDEC), Bangkok, Thailand, (1985)

Note: There are no available data in hand for other systems and species

ha/yr for blood cockle in Malaysia is about 8 mt/ha/yr while that for various cultured molluscs in Thailand is about 10 mt/ha/yr (Table 6). There are no complete records to assess the productivity of cage culture of marine finfish and of seaweeds in the Subregion nor of molluscs in the other countries in the area.

In the brackishwater culture, extensive culture system for milkfish cultured with penaeid shrimp and other finfishes and shrimps is extensively practiced in Indonesia and the Philippines. Here the average annual production per hectare in 1984 for Indonesia is about 700 kg/ha/yr , in 1985 for the Philippines, 950 kg/ha/yr (Table 6). The brackishwater pond production in Indonesia which was about 300 kg/ha/yr in 1960 gradually increased to attain a production of over 600 kg/ha/yr in 1984 while in the Philippines, from about 350 kg/ha/yr in 1940, this increased to almost 1 mt/ha/yr in 1985 (Table 7). In Thailand where semi-intensive culture in brackishwater ponds is practiced mainly for penaeid shrimp and sometimes for sea bass, mullets and other finfishes, and shrimps, the average production is between 2 to 3 mt/ha/yr (Table 6). The slow and gradual increase of production for this industry in Indonesia and the Philippines is an indication that they are the results of experience especially by small-scale fish farmers. In the Philippines, for instance, while the national average is about 970 kg/ha/yr in 1985, it is not uncommon that progressive, large-holding farms harvest from 1 to 3 mt/ha/yr. It is well known that the national average in Taiwan is 2 mt/ha/yr.

In freshwater pond culture as exemplified by Indonesia where this system is of long existence, the area used and production showed fluctuations. Within a 25-year period (1960-1984, Table 8) the area used was in the 30 000-ha level during the 60's and 70's but attained 40 000-ha level in the 80's (Table 8). The total annual production fluctuated from about 40 000 mt in 1960 to about 80 000 mt in 1983. Unit annual production varied from about 1 300 kg/ha (1960, 1970) to 1 900 kg/ha (1983). The average unit annual production for a 25-year period (1960-1984) was about 1 500 kg/ha. Gradual increase in total production and unit production with time during the period is indicated although not conclusive (Table 8).

Relationship of Capture Fisheries and Aquaculture Production

World aquaculture production was assessed by FAO in three different years (1975, 1980, 1983). In the area during these three assess-

Table 7. Increase in area and total and unit production of Philippines and Indonesian brackishwater ponds (1940-1985)

Year	Indonesia			Philippines		
	Area used (ha)	Total production (mt)	Unit production (kg/ha/yr)	Area used (ha)	Total production (mt)	Unit production (kg/ha/yr)
1940	*	*	*	60 998	21 349	350
1950	*	*	*	72 753	25 464	350
1960	145 144	43 078	297	123 252	60 120	488
1970	179 911	55 908	311	168 118	96 461	574
1980	188 601	97 898	519	176 231	135 951	771
1981	198 210	112 916	570	195 832	170 431	870
1982	208 695	129 279	619	195 832	180 484	922
1983	220 365	134 072	608	196 269	183 773	936
1984	225 197	142 404	632	206 525	198 729	962
1985	*	*	*	205 000	198 546	969

Source: National fisheries statistics for Indonesia and the Philippines. These ponds are mainly used for raising milkfish

* Data not available

Table 8. Data on freshwater fishponds in Indonesia (1960-1984)

Year	Area (ha)	Total production (mt)	Unit production (kg/ha/yr)
1960	30 179	39 801	1 319
1965	36 102	63 302	1 753
1970	40 023	51 345	1 283
1975	38 914	55 403	1 424
1976	34 235	52 631	1 537
1977	34 033	56 000	1 645
1978	35 555	57 680	1 622
1979	39 785	59 359	1 492
1980	38 501	66 379	1 724
1981	47 085	78 224	1 661
1982	38 909	69 245	1 780
1983	41 783	79 681	1 907
1984	40 942	76 528	1 869

Source: National fisheries statistics by the Directorate General of Fisheries, Indonesia (various years)

ment periods, total fisheries production increased from 6.7 million mt in 1975 to 7.9 million mt in 1983 or a 19% increase in an 8-year period. During the same period, the aquaculture production from the Southeast Asian Subregion increased from 440 000 mt to 885 000 mt or a 100% increase during the same period (Table 9).

In 1975, the aquaculture production from the different countries in the Subregion had from 3 to 9% of their total fish production or an average of 7% while that of capture fisheries constituted 91 to 97% or an average of 93%. The countries that lead in high aquaculture production compared to capture production in 1975 were the Philippines with a ratio of 9:91; Malaysia and Thailand, 7:93; and Indonesia, 6:94. In 1980, the aquaculture production in the Southeast Asian countries ranged from 3 to 18% of the total fish production in the different countries while capture fisheries composed from 82 to 97%. The relative proportion of aquaculture and capture fisheries production was 18:82 in the Philippines, 11:89 in Indonesia, 9:91 in Thailand, and 3:93 in

Table 9. Aquaculture production and capture fisheries production in Southeast Asia (1975/1980/1983)

	1975[1/]				1980[2/]				1983			
	Total fisheries production (mt)	Total aquaculture production (mt)	Aquaculture production on total (%)	Capture production on total (%)	Total fisheries production (mt)	Aquaculture production (mt)	Aquaculture: total (%)	Capture: total (%)	Total fisheries production (mt)[3/]	Aquaculture production (mt)[4/]	Aquaculture: total (%)	Capture: total (%)
Brunei	1 570	_	_	-	2 225	-	-		3 055	150[5/]	4.9	95.1
Indonesia	2 265 875	143 840	6.3	93.7	1 841 814	199 297	10.8	89.2	2 204 816	266 899	12.1	87.9
Kampuchea	84 700	*			51 600	*			63 750	900[5/]	1.4	98.6
Lacs	20 000	*			20 000	*			20 000	360[5/]	1.8	98.2
Malaysia	473 782	34 559	7.3	92.7	736 486	73 741	10.0	90.0	741 089	53 340	7.2	92.8
Philippines	1 442 981	125 008	8.7	91.3	1 556 602	285 502	18.3	81.7	1 977 580	445 073	22.5	77.5
Singapore	17 560	785	4.5	95.5	16 044	536	3.3	96.7	19 549	2 039	10.4	89.6
Thailand	1 552 836	106 300	6.8	93.2	1 797 960	160 962	9.0	91.0	2 260 024	91 725	4.1	95.9
Viet Nam	872 000	30 000	3.4	96.6	613 000	*			710 000	25 000[5/]	3.5	96.5
TOTAL FOR SEA	6 731 304	440 492	6.5	93.5	6 695 731	720 038	10.9	89.1	7 999 863	885 486	11.1	88.9
WORLD TOTAL	66 000 100	6 102 289	9.2	90.8	72 089 600	8 707 363	12.1	87.9	77 256 500	10 210 703	13.2	86.8
% SEA ON TOTAL	10.2	7.2			9.2	8.3			10.4	8.7		

[1/] After Pillay (1976) and FAO Data Base

[2/] After Pillay (1981) ami FAO Data Base

[3/] FAO Data Base

[4/] SEAFDEC (1985)

Estimates based on available references and previous estimates from survey by the author

— Magnitude zero or not applicable

* Data not available

Singapore. The average proportion of culture to capture fisheries production for the Subregion is 11:89.

In 1983, the aquaculture production in the different countries in the Subregion ranged from 1 to 23%, while that of capture fisheries from 77 to 99%. The leading aquaculture producers have the ratio of aquaculture to capture fisheries production as follows: Philippines, 23:77; Indonesia, 12:88; Singapore, 10:90; Malaysia, 7:93; and the rest with 5% or less in their aquaculture production. The average ratio of aquaculture to capture fisheries production during this period is 11:89. Aquaculture production from the Subregion constituted about 9% of the total world aquaculture production in that year increasing by 2% from that of 1975 which was 7% (Table 9).

Contribution of Different Species to Total Production

The milkfish is the single most important species produced through aquaculture in Southeast Asia with over 300 000 mt in 1983. Of course, it is realized that this species is produced mainly in Indonesia and the Philippines where it is an important food fish. The total production of milkfish constituted 36% of the total aquaculture production in the Subregion (Table 10).

Following milkfish but quite far behind is the cultured industrial seaweed, the *Eucheuma* species which contributed over 130 000 mt (15%) in 1983 exclusively from the Philippines (Tables 5, 6). Third in magnitude are the cultured carps and other cyprinids with over 100 000 mt or about 12% of the total aquaculture production from the Subregion (Table 10). This group of species also constitutes the highest among the freshwater forms cultured in this area. Saltwater shrimp and tilapia follow next with over 51 000 mt each (6%). The saltwater shrimps are valued export crops and their culture is rapidly growing and spreading in this area while the tilapias are important local food fish in most countries of the region (Table 10).

Of the molluscs, the blood cockle, almost exclusively produced in Malaysia with a little amount in Thailand and perhaps Indonesia, registered the highest tonnage in this group with over 45 000 mt or 5% of the total subregional production. This is followed by sea mussel with about 38 000 mt (4%); gouramies, 18 000 mt (2%); oysters, 15 000 mt (2%); catfishes, 11 000 mt (1%); snakehead, 5 000 mt (0.5%); mullet, 4 000 mt (0.5%); and freshwater prawn, 1 000 mt (0.1%) (Table 10).

Table 10. Production of different species through aquaculture in Southeast Asia, arranged by production size, 1983

Species/species group	Production (mt)	Percent of total
Milkfish	322 116	36
Seaweed	132 204	15
Carps and other cyprinids	102 238	12
Penaeid shrimps	51 387	6
Tilapias	51 238	6
Blood cockle	45 625	5
Sea mussel	37 941	4
Gouramies	17 801	2
Oysters	14 771	2
Catfishes	10 519	1
Snakehead	4 787	0.5
Mullet	4 352	0.5
Freshwater prawn	1 154	0.1

Source: Southeast Asian Fisheries Development Center (SEAFDEC), Fishery Statistical Bulletin for South China Sea Area, 1983. SEAFDEC, Bangkok, Thailand (1985)

It is anticipated that these major species being cultured will continue to increase in production in the coming years but more particularly those that have high market demand and especially those for export. The saltwater shrimps and some marine finfish as well as the freshwater prawn belong to this category. Local food fish species like milkfish, the tilapias, carp, and other cyprinids will increase only slightly or level off. The cultivated molluscs like the sea mussel, blood cockle, and oysters will rise depending on market demand and maintenance of good consumption qualities. Likewise, miscellaneous freshwater and marine finfishes will undergo increased use for culture in specific areas. The culture of novelty items like crabs, frogs and other amphibians, and turtles and other reptiles will tend to increase because of their market demand.

CULTURE SYSTEMS AND LEVEL OF INTENSITY FOR MAJOR SPECIES

The level of production in the aquaculture industry depends on the species and their cultural characteristics, the system used for the culture, and the intensity applied in the culture system. Different spe-

cies are adapted to specific types of culture system (e.g., blood cockle in open sea water, penaeid shrimp in ponds, etc.). Sometimes certain species can adapt to more than one type of culture system (e.g., finfish in ponds, pens, or cages).

Culture Systems

There are different types of culture systems that have developed in Southeast Asia and in many other areas of the world. This can be enumerated as follows:

1. Culture in ponds or impoundments
2. Culture in pens or enclosures
3. Culture in cages
4. Culture in open water, and
5. Ranching

Culture in ponds or impoundments is widely practised and can be applied to most aquaculture species. Two types of culture are used under this system, namely: 1) the stagnant or semi-stagnant pond or impoundment and 2) running water system. Stagnant and semi-stagnant ponds are used for freshwater finfishes as well as for the giant freshwater prawns, brackishwater and marine finfish, and penaeid shrimps. Running water pond culture has been developed mainly for the common carp especially in Indonesia.

Fishpens or enclosures were initially tried in the early 70's in a shallow eutrophic freshwater lake in the Philippines using milkfish for stock. This has proven to be very successful and the practice rapidly attained commercial scale and consequential production in a period of five years. Similar attempts to introduce the system in other bodies of water in the region have not been very successful but tests in more water bodies continue to be conducted.

The use of cages consisting of nets or bamboo and wood is practised in certain areas in the region. These are mainly for finfish such as tilapia and carp in freshwater; and seabass, grouper, bream, snapper and crabs, and shrimps in sea water.

Open water culture system is practised for certain species especially those that require wide areas for culture. These include sea mussels, oysters, blood cockles, and various species of seaweeds. The species used in this culture require constant change of the water medium from

which they derive their main source of nutrition.

Ranching is a recent development in aquaculture where the established reproductive habits of the cultured species is taken advantage of. Typically, species used in this system are those that reproduce in specific sites that are known but the juveniles migrate and return to the same site to repeat their life cycle. By augmenting through human management the reproduction of such species the amount of the returning marketable-sized forms can be increased to commercial levels. In other words, the species put under culture are harvested only during the stage when they return to the sites which can be managed by aquaculturists. Actual active stocking of such sites by suitable species may also serve this purpose. Although this system is not yet practiced in Southeast Asia, it is mentioned here because of its potential.

Intensity of Culture

The level of intensity of culture under the different culture systems in the Southeast Asian region may be classified under the following, categories:

1. Traditional management
2. Extensive management
3. Semi-intensive management
4. Intensive management

To describe the characteristics of these levels of culture intensities, the following criteria are considered:

1. Species used and stocking rates
2. Engineering design and layout
3. Use of fertilizers
4. Use of pesticides and elimination of metabolites
5. Food and feeding regime
6. Rearing duration and cropping frequency
7. Quantity and quality of production
8. Post harvest technology and marketing.

Traditional management. The traditional management is the lowest level of intensity of culture. It is the simplest to undertake and the one with no inputs or the least inputs during operations; also, the one with the lowest production. With this management, the stock is very variable with many extraneous species and no specific stocking

rate is observed. If the operation uses ponds, usually very big ponds, which may be uncleared and with makeshift dikes, are used. The depth of the pond water can be variable with some portions sometimes unwatered. Equipment such as pumps and aerators are not used and there is no feeding nor use of pesticides with the crop depending mainly on the natural fertility of the area. The production is usually of good quality but is generally variable and there is no special requirement for post-harvest technology and marketing. Traditional brackishwater fish farms in the Philippines which existed but are fast disappearing may produce from 100 to 400 kg/ha/yr.

Extensive management. The extensive management may originate from traditional operations that are improved in their engineering design and management practices. Instead of multi-species culture, monoculture stocking of a definite species or polyculture with planned combination is usually adopted. These ponds are fully cleared and levelled and properly laid out to provide means for water entrance, circulation, and drainage for water management. Pumps or aerators can be useful but are not usually necessary as the level of stocking is usually moderate. Fertilizers are used to enhance farm fertility but feeds are only used as needed to supplement natural food production or whenever required by the cultured stock. The level of harvest is higher than the traditional system with the stocked species dominant while some of the extraneous species may still be found in the harvest. For instance, in extensive brackishwater ponds where milkfish and tiger shrimp are reared in polyculture, the milkfish and the tiger shrimp predominate in the harvest, but other species like tilapia, other species of shrimps, finfishes, and crabs may also exist. The production is usually of good quality and is usually more uniform so that post-harvest technology and harvesting can be planned and implemented. Typical production from extensively managed brackishwater ponds in Indonesia and the Philippines may have a production of 500 to 2 000 kg/ha/yr.

Semi-intensive management. As the areas for expansion for the practice of aquaculture become more limited, increase in production can only be attained through intensification. In Southeast Asia where sites are abundantly available, this increase in production during the initial period of the industry was achieved through area expansion. Within recent years, however, especially during the last decade, sites started to be limited so that production increase can be better achieved through intensification. The semi-intensive level of management can utilize areas formerly used for the extensive system or entirely new areas can be developed. In either case, the appropriate engineering design which

consists of reducing large-sized culture units to smaller manageable sizes, providing facilities for effective water control and circulation, and perhaps excavation and levelling of the ponds to attain appropriate depths required in the culture are implemented. The stocking rate is relatively higher compared to that of the extensive management. Application of fertilizers, lime, and pesticides are regularly practised under this system. Feeding using good quality formulated feed to supplement natural food is a regular feature of this management. Pumps and aerators should be available for use when necessary. The harvest is of good quality usually confined to the species under culture which are produced in uniform sizes. Very little or no extraneous species should occur and a pre-planned post-harvest procedure and marketing are generally arranged. An example of semi-intensive brackishwater pond system such as that devoted for the raising of tiger shrimp in the region would require from 50 000 to 100 000 shrimp post-larvae (PL) per hectare per crop. For a culture period of 100 to 150 days, a harvest ranging from 1 to 2.5 mt/ha/crop may be derived. Of course, feeding in this case, as mentioned, is a must in the operation where 2 to 3 t of feed is generally used to produce 1 mt of the crop. The annual crop can be 2.5 to 6 mt/yr.

Intensive management. The intensive management is the result of further intensification in the level of management from the semi-intensive operation. This management requires size units which can provide complete control of water management in terms of quantity and essential qualities. The maximum stocking rates are utilized for the species under culture, aeration using artificial aerators, pumping and strict filtration of the water supply are practised especially if open water sources are used. High-quality feeds appropriate for the species under culture and applied in adequate quantities are used to maintain growth and produce quality crop. Provision for water replenishment whenever needed and facility for the elimination of metabolites are necessary. Facility for easy harvesting and pre-planned post-harvest technology and marketing should be provided. In between harvests, prophylactic treatment of the aquaculture system using lime and organic pesticides as well as bottom cultivation or tilling are practised. As practised in tiger shrimp intensive brackishwater ponds, stocking rates consisting of 100 000 to 300 000 PL/ha/crop for 100 - 150-day culture period is practised. Yields of 3 to 9 mt/ha/crop and with the possible 2.5 crops per year or an annual yield of 7 to 20 mt/ha/yr may be achieved (Table 11).

Table 11. Elements of different intensity levels of management of penaeid shrimp culture in Southeast Asia (Based on Philippine experience, 1985-1986)

Type	Development/ equipment cost (P/ha)	Annual operating cost (P/ha/crop)	Stocking rate (PL/ha/crop) (No. of crops/year)	Production (Kg/ha/year)
Traditional	20 000-50 000	5 000-10 000	Variable, mixed species (variable)	100-400
Extensive	50 000-100 000	10 000-75 000	10 000-50 000 (2)	500-2 000
Semi-intensive	200 000-500 000	75 000-250 000	50 000-100 000 (2.5)	2 500-6 000
Intensive	500 000-1 000 000	250 000-500 000	100 000-300 000 or over (2-5)	7 000-20 000

P or Philippine pesos 20 = US $1

Source: National survey made with a consultancy group by the author (1985-1986). The figures are estimates and varies from place to place and can easily change with time. Above designations as proposed are arbitrary and can have overlaps.

Comparative Costs

Something must be mentioned about the relative costs for development and operations under the different intensity levels of management. It is well agreed that development costs including essential equipment and annual operational cost in the traditional management would be minimal and can be estimated at P20 000 to P50 000/ha and about P5 000 to P10 000/ha, respectively. (Current exchange rate is about US$1=P20, Philippine pesos). The cost for extensive system for development/equipment and for annual operation will be higher though not too much higher. These can be as much as P50 000 to P100 000/ha and P10 000 to P75 000/ha, respectively. As the management level shifts to the semi-intensive and the intensive levels, considerable increase in cost will be required. For semi-intensive the development/equipment cost can be as much as P200 000 to P500 000/ha and for annual operations about P75 000 to P250 000/ha. In the intensive system these values can be P500 000 to P1 000 000/ha and P250 000 to P500 000/ha, respectively (Table 11). Estimates are based on current costs during 1985-1986 under Philippine conditions.

The above figures are estimates based mainly on the different intensity levels for penaeid shrimp culture as practiced in the Philippines. Based on the above, the cost of production for a kg of the crop under the semi-intensive and intensive management levels is estimated to be about P70 to P90/kg which are in turn being sold at P120 to P200/kg.

CURRENT PRODUCTION CONSTRAINTS AND THE ROLE OF RESEARCH INSTITUTIONS AND GOVERNMENTS

The production constraints for the accelerated development of aquaculture in Southeast Asia may be classified into two types:

1. Technical constraints
2. Non-technical constraints

Technical Constraints

A number of technical constraints have slowed down the development of the industry in the Southeast Asian Subregion. These are the following:

1. Inadequate knowledge of the biology of the cultivated species

2. Inadequacy or lack of seeds
3. Lack or poor understanding of the technology of suitable culture system to be used
4. Inadequacy or lack of the required inputs for management operations
5. Inadequacy or lack of properly trained managers, technicians, and skilled labor
6. Diseases and other causes of mortality.

Lack of knowledge of biology of cultivated species. Most aquaculture practices in Southeast Asia have developed through the experience of the fish farmer. Very little, if any, specific culture has evolved through research by concerned development or research institutions. Under these circumstances, technical knowledge on the biology of the cultured species is very inadequate with the result that the improvement in the culture of said species has become very slow as this is only gained through long and painful experiences. For instance, it was only after the reproductive cycle of the jumbo tiger shrimp *(Penaeus monodon)* was studied that hatcheries to produce post-larvae for culture were implemented. Many other species now used for culture still depend on wild fry (e.g., milkfish). Also, very little if any is presently being done on genetic studies and breeding for improvement of cultured species.

Inadequacy of seeds. The critical lack of seeds for stocking purposes in aquaculture is a very serious constraint to most of the species utilized in this production sector. Until this is adequately solved through the production of seeds under controlled conditions, this problem will continue to limit production through aquaculture. Reducing mortalities of available fry and mass production of fry from hatcheries will be needed.

Technology of appropriate culture system. The technology of the efficient culture system that should be used for a particular cultured species is still inadequate and, in fact, is lacking for some species. Also, unless more efficient culture system is adopted, especially for export species, the quantity produced and the cost of production cannot be competitive in the international market. The use of less efficient culture system would naturally increase the cost of production resulting in less competitiveness of the crop.

Inadequacy of manpower. Aquaculture manpower from the managerial or supervisory, the technician as well as the skilled labor levels are generally inadequate in the region and, in most cases, entirely

lacking. This is true even where there are suitable resources and sites for the practice of aquaculture and there is need for production from this sector. Support for regional and international training will be required while local national training especially of applied or practical nature will be necessary.

Lack of operational inputs. Application of essential inputs and facilities required for the proper management of aquaculture projects especially those used to enhance production is being practised. Fertilizers, both organic and inorganic, are not only lacking but are being utilized preferably for other uses (e.g., agriculture). Feeds to support aquaculture intensification may be inadequate, and if available, may not be of the proper quality. Pesticides and other chemical products to control pests, predators, and diseases are generally produced outside the region and therefore have to be imported using valuable foreign exchange. Essential facilities such as water pumps, blowers, and aerators are still not locally fabricated in the aquaculture-practicing countries thus providing a constraint in this aspect. Also, as aquaculture intensification progresses the need for environmental monitoring devices increases. Again, as these are fabricated outside the region, they have to be imported at relatively high cost.

Diseases and other causes of mortality. The aquaculture environment should be kept in good quality as environmental deterioration can be a cause for the appearance of diseases. Reduction in the habitat characteristics to levels below the tolerance limits of the cultured organisms can result in mass mortalities. Likewise, with intensification there is more likelihood that parasite and disease-causing micro-organisms will occur. The harmful effects of these unwanted organisms can further be aggravated by crowding of the stock which can result in stress or weakening of the cultured species. Wholesale mortalities can occur due to bacterial or viral infection in crowded aquaculture environment. If not properly remedied, critical oxygen deficiency, extremely low pH, or excessive turbidity can also be causes of mass mortalities. In the cases of the occurrence of parasites in the culture habitats, mass mortalities may not occur but depredation by parasites can result in inferior quality crop. All the above causes can result in a continuing constraint in the attainment of maximum productivity in the aquaculture industry.

Non-technical Constraints

The non-technical constraints include the following:

1. Lack of demand or market for the cultured product
2. Lack or inadequate source of financing for development and operation
3. Limitation of space in terms of water and land for the establishment or expansion of aquaculture
4. Conflict in the utility of land and water or other natural resources needed in aquaculture
5. Legal and institutional constraints
6. Socio-economic and political constraints

Demand and market constraint. A serious constraint in some developed cultures of specific species is the lack of demand or market for the crop with the result that their culture would be uneconomic. Sometimes, this can be remedied through proper processing and utilization but in case of over-production, the culture of species with poor market demand will be a losing proposition.

Competition in land and water use. The use of land and water for aquaculture production competes with other land and water uses. In the case of land, it was generally conceived that poor and waste lands may be appropriated for aquaculture. However, this is a mistaken notion as aquaculture land should be fertile, clayish, and with good source of water. These are the same characteristics needed for good agricultural land resulting in conflict of interest. Likewise, inferior water areas with rocky, sandy, and boggy soils are readily released for aquaculture. These areas, however, are least suitable for this purpose. There is also a conflict of interest in the use of coastal as well as inland waters for wild cropping or fishing with that for aquaculture.

Financing constraints. The establishment of aquaculture projects requires high overhead expenses. Prospective fish farmers with low or moderate income cannot afford to venture into this industry unless financial assistance through easy-term, low-interest credit is provided. It is generally agreed, however, that aquaculture ventures once established are quite stable and sometimes can be very profitable. In many cases, these are not clearly understood by financing institutions and even by the fish farmers resulting in the slow pace of development in this sector.

Limitation in area available. Land and water areas in most countries of the Subregion are generally still available for use in aquaculture. However, there are a number of places where land and coastal water areas are almost fully utilized (e.g., Singapore) or used for a priority in-

dustry like oil extraction (e.g., Brunei) so that aquaculture sites can also be limited.

Legal and institutional constraint. There are certain legal and institutional aspects that have also hampered aquaculture development. For instance, since aquaculture is a relatively young industry, there are no statutes nor laws nor are there specifically designated government agencies that will cater to the needs of aquaculture. In many instances, the sites being used for aquaculture cannot be delimited, titled, leased or awarded to practitioners for lack of the statutes and agency for this purpose. Institutionally also, the specific agency that would have the manpower to extend extension services or to issue licenses and permits may be inadequate if not lacking.

Socio-economic and political constraint. On the socio-economic and political aspects, aquaculture has been hamstrung because of many factors. For example, areas which are prospective sites for aquaculture are generally very depressed communities. As aquaculture is a capital-intensive venture especially initially, the population in these areas may not be suitable for undertaking the desired aquaculture development. Another serious socio-economic and political problem in existing as well as prospective aquaculture areas is peace and order condition or security problems in such areas (e.g., Philippines). Although this condition may be temporary, its deterioration or prolonged existence can greatly hamper development or completely erase some projects.

Technical institutions involved in aquaculture research and training are usually available which may be functioning as regional or national projects. In order to maximize the utility of these institutions their short as well as long-range programs should be frequently reviewed and modified so that they can cater to the most relevant problems of the industry. If the resources of these institutions are limited, priorities in their work should be properly set and cooperative work with related institutions should be sought. Frequent dialogues with the industry that these institutions serve should be conducted to update the most pressing needs that require solution. Research personnel need to be properly compensated and rewarded for good achievements and the institutions should be afforded wide level of autonomy and assisted to free them from strife.

Governments need to support the industry by avoiding bureaucratic obstacles in their administrative requirements. Additional support can be rendered by concerned government agencies in looking for

sources of financing, locating markets and facilitating the marketing of aquaculture crops and in removing other institutional and legal constraints that may beset the industry. Law and order and security for the industry at the aquaculture sites is another major responsibility of government which should be looked into with dispatch.

PROSPECTS FOR GROWTH AND EXPANSION OF THE AQUACULTURE INDUSTRY IN SOUTHEAST ASIA

The potentials for further growth and expansion of the aquaculture industry in this Subregion can be predicated on the following conditions existing in the area:

1. There are still available areas for the expansion of the industry.
2. Recently developed systems can be applied in existing as well as new areas.
3. More utilization of the potential increase of production through intensification.
4. Concentration of development for the most economic or profitable species.
5. Promotion of the growth of mariculture where expansion is almost unlimited.
6. Presence of dynamic private sector producers.
7. Closing the gap between capture and culture fisheries such as through ranching.

Expansion in Area

Aquaculture development in different areas in the region varies considerably. There are countries where aquaculture is fairly developed and areas for certain production systems have become crowded (e.g., brackishwater ponds in Philippine mangrove swamps, brackishwater areas for shrimp farms in Thailand). On the other hand, there are certain areas for possible development (e.g., Laos, Brunei, Kampuchea). Still large areas can be developed for various culture systems in Indonesia, Malaysia, Vietnam, and Kampuchea.

Application of New Culture Systems

Patterns of recently developed culture systems exist in some countries in the Subregion. These can serve as models for development in

other countries where such systems are not yet used. Examples of this system include such methods like the running water culture system for common carp in Indonesia; the culture of finfish in freshwater lake fishpens as practised in the Philippines; the integrated aquaculture, plant crop and animal husbandry as practised in Thailand; cage culture of marine finfish in Singapore; and blood cockle culture in open tidal flats in Malaysia. All the above systems besides others are especially developed in the mentioned countries which could be exchanged with the other countries of the region.

Production intensification

Even, without expanding in area, production from existing aquaculture projects can be increased through intensification. A good example of this system is the development of semi-intensive and intensive culture management for brackishwater shrimp farms. These types of management have now been developed and can be disseminated in different areas of the region.

Special development for the most economic and profitable species

Rapid growth of penaeid shrimp culture in the region as well as other areas in the world is dictated by the availability of export market and the high price paid for this product. This is a definite trend and will continue as long as the profitability of the product and availability of market continue. Other crops that have shown good profitability include high-priced marine species raised in cages such as the sea bass, grouper, snapper, and bream. Market potentials for mangrove crabs fattened in cages or ponds and the raising of novelty crops like the soft-shelled turtle, frog, and crocodile also show good promise.

Mariculture

Mariculture or sea farming is a relatively more recent initiative in aquaculture. However, its prospects is particularly bright in Southeast Asia where extensive available and suitable sites for the culture of several cultivable resources exist. The system that can be adapted to carry out the practices of mariculture can range all the way from the use of ponds or impoundments, pens or enclosures, net cages, and open water system. The resources that can be used vary greatly including various species of finfish, molluscs, crustaceans, and seaweeds.

Dynamic Private Sector Producers

A major factor in the accelerated expansion of aquaculture production in most of the countries in Southeast Asia is the presence of a very dynamic group of private sector producers. Aquaculture people in the private sector in this Subregion have been great initiators. Instead, of depending on government technical and financial assistance, they have ventured to make full use of their past experiences to expand or intensify their own projects. They often get together and organize among themselves in order to gain knowledge from each other. If new technologies are noted outside, the country, they have been ready to make study tour to these centers of development. It is not uncommon to see people in the industry from Indonesia, Philippines, and Thailand attending international or regional aquaculture meetings, seminars, or symposia or they themselves organizing specific local workshops. If the new technology is not readily available, some of the local private aquaculture concerns have gone into joint ventures or actually imported technology and technicians in order to pursue the desired development. Problems of adaptations and modifications to local conditions have occurred, but the transplantation of such technology has generally, so far, yielded positive results.

Ranching

Although this system is not yet used in this Subregion, it has all the potentials for utilization especially for the various diadromous species like milkfish and mullets. In Japan, where penaeid shrimp PL's are now produced in quantities beyond the needs of the controlled culture farms, the excess shrimp seeds are stocked in natural waters and later harvested through capture fisheries. In this sense, the stocking of hatchery produced stock in natural waters practically becomes a means of closing the gap between culture and capture fisheries. Ranching can be the means to achieve this aim and enhance overall fisheries production.

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