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OVERVIEW OF AQUACULTURE DEVELOPMENT IN SOUTHEAST ASIA

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ABSTRACT

The nine countries in Southeast Asia occupy a land area of 1.85% with a population of 7.4% in the world. In 1991, these countries had a total fisheries production of 10.2 million tons or 10.5% of the world total of 96.9 million tons. In aquaculture in 1990, world total production attained 15.3 million tons (15.7% of total world fisheries production) while the Southeast Asian countries produced 1.7 million tons (11 % of total world aquaculture production). The total fisheries production in Southeast Asia which is mainly capture fisheries has continued to increase gradually by about 3.3% from 1986 to 1990 while aquaculture production has been increasing at the rate of over 8.4% during this period.

The major areas for aquaculture in Southeast Asia include inland freshwaters, brackishwaters, and marine waters. Various systems exist in the region including ponds, pens and cages, delimited or fenced open water areas, and culture integrated with other production activities. Highest potential is in Seafarming while ranching is a recent innovation. The species being cultured in the region consist of about 50 fishes, 10 crustaceans, 10 molluscs, 5 seaweeds, and 5 miscellaneous aquatic vertebrates.

Aquaculture will increasingly supply food and industrial products considering the worldwide levelling off of capture fisheries production. Southeast Asia has the potential to contribute substantially to this need. Support for the industry inspite of this need is inadequate to meet its technical, economic, and management problems. A sound technological base through research and training and extension needs to be pursued vigorously.

INTRODUCTION

Southeast Asia consists of nine closely situated countries, namely: Brunei Darussalam, Indonesia, Kampuchea, Laos, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam. Collectively these countries occupy 1.85% of the world land area but they have 7.4% of the world population. These countries are very diverse in their physical, social, and economic conditions (ADB 1992, Table 1).

Fisheries in these countries is important. The total fisheries production in the region has grown slowly from 8.9 to 10.2 million tons or a growth of 3.87% annually (Table 2) in the recent five years (1985-1989). This regional production constitutes about 9.7% of world total production (FAO 1991). Aquaculture, however, is widespread and varied and has been growing more rapidly from 720,000 tons in 1980 to 1.2 million tons in 1986 and 1.7 million tons in 1990 or an annual growth of 8.4%. This regional aquaculture production represents 11.0% of the total world aquaculture production (FAO 1992, Table 3). Fish consumption is relatively high but varies lowest at 6 kilograms/person/year in Laos to 46 kilograms/person/year in Malaysia (Rabanal 1988). The long coastline of these countries and their extensive inland and marine shelf waters contribute in making fisheries and especially aquaculture a vital factor in their economies (Table 4).

SITES AND SPECIES USED FOR AQUACULTURE

Environments

The environments used for aquaculture in Southeast Asia are varied. These may be classified by: 1) salinity of water supply, 2) rate of water renewal, and 3) species used.

Salinity. According to salinity, sites used are either freshwater, brackishwater, or marine water. Inland freshwater aquaculture is probably the oldest site used and is very well distributed. Due to pressure of population and urbanization, however, this type of aquaculture has levelled off and is even declining is some areas.

Brackishwater aquaculture has a long history in the region. Estuarine tidal areas and swamps are usually developed for this purpose. Indigenous technology has been available, but its advance has been slow. Recently, with available international market for penaeid shrimps, brackishwater aquaculture technology has advanced.

Seafarming or mariculture has grown in the region but its full potential has not been attained (Rabanal, 1986).

Rate of Water Renewal. Aquaculture environments can vary from stagnant such as in freshwater ponds and semi-stagnant as in brackishwater ponds that are constantly refreshed with new water, or by active running water supply. The latter case is exemplified by the running water carp ponds used in Indonesia.

Table 1. Vital socio-economic statistics of Southeast Asian countries, 1991

Country	Area (km^2)	Population (million)	Population density per km^2	Population growth (%)	Per capita GNP 1990 (US$)
Brunei Darussalam	5,765	0.221**	38	3.3	22,150*
Indonesia	1,919,443	177.6*"	93	2.3	550
Kampuchea	181,035	8.2***	45	NA	NA
Laos	236,800	4.3	18	NA	170
Malaysia	329,749	18.2	55	2.8	2,320
Philippines	300,000	62.1	207	2.78	760
Singapore	618	2.8	4,531	1.5	12,310
Thailand	542,373	56.9	105	2.5	1,420
Viet Nam	329,556	67.7	205	2.1	189
Total for SEA	3,845,339	398.021			
World Total	207,495,423	5,385.3			
Percent SEA on world production	1.85	7.4			

*1988; **1989; ***1990; NA - Data not available

Note: Above data were taken mainly from Asian Development Bank (1992)

Table 2. Total fisheries production in Southeast Asia in recent years, 1987-1991

Country	1987 (tons)	1988 (tons)	1989 (tons)	1990 (tons)	1991 (tons)
Brunei Darussalam	3,915	2,041	2,318	3,350	1,652
Indonesia	2,583,874	2,789,100	2,948,406	3,043,183	3,186,000
Kampuchea	79,571	82,200	76,550	105,000	111,100
Laos	20,000	20,000	20,000	20,000	20,000
Malaysia	619,332	612,421	609,648	603,981	620,000
Philippines	1,988,718	2,010,363	2,098,787	2,208,823	2,311,797
Singapore	16,655	15,240	12,615	13,316	13,054
Thailand	2,799,091	2,642,059	2,699,835	2,786,383	3,065,170
Viet Nam	871,404	874,000	868,000	850,000	877,000
Total for SEA	8,962,560	9,047,424	9,336,159	9,633,036	10,205,763
World Total	94,378,600	99,016,100	100,208,300	97,433,500	96,925,900
Percent SEA production on world production	9.5	9.1	9.4	9.9	10.5

Source: FAO, 1991.

Table 3. Aquaculture production in Southeast Asia in recent years, 1986-1990

Country	1986 (tons)	1987 (tons)	1988 (tons)	1989 (tons)	1990 (tons)
Brunei Darussalam	0	2	2	2	2
Indonesia	410,554	456,727	490,091	501,458	558,855
Kampuchea	2,340	2,640	4,741	6,282	6,080
Laos	2,500	2,500	2,500	2,500	2,500
Malaysia	51,433	46,937	46,910	54,833	47,876
Philippines	470,923	560,970	599,564	629,325	672,316
Singapore	1,330	1,855	1,969	1,965	1,857
Thailand	128,417	174,492	219,101	260,181	253,326
Viet Nam	135,500	145,300	136,700	149,700	155,000
Total for SEA	1,202,997	1,391,433	1,511,478	1,606,246	1,697,812
World Total	12,206,738	13,179,669	14,556,515	14,419,829	15,331,822
Percent SEA production on world production	10.0	10.6	10.4	11.1	11.1

Source: FAO, 1992.

Table 4. Fisheries and related statistics of Southeast Asian countries, 1990

Country	Total fisheries production (tons)	Aquaculture production (tons)	Annual per capita fish consumption (kg)	Length of coastline (km)	Water area	
					Inland (km^2)	Marine (km^2)
Brunei Darussalam	2,350	2	40	161	803	NA
Indonesia	3,043,183	558,855	16	36,384	NA	775,000
Kampuchea	105,000	6,080	24	435	NA	40,000
Laos	20,000	2,500	6	-	NA	
Malaysia	603,981	47,876	46	4,405	15,797	418,000
Philippines	2,208,823	672,316	40	17,460	8,129	185,000
Singapore	13,318	1,857	41	138	NA	966
Thailand	2,786,383	253,326	22	2,614	45,450	305,000
Viet Nam	850,000	155,700	12	NA	NA	NA
Total for SEA	9,633,038	1,697,812				
Word Total	97,433,500	15,331,822				
Percent SEA on world total	10.0	11.1				
Percent SEA aquaculture production on SEA total fisheries production						17.6
Percent world aquaculture production on world total fisheries production						15.7

Source: FAO, 1991
FAO, 1992
Rabanal, 1988

Aquaculture in open waters (e.g. for mollusc and seaweed culture, and cage and pen culture) can be considered semi-stagnant as they are subjected to constant renewal through slow natural water movements.

Species Used. The major groups of farmed aquatic organisms are: 1) fish, 2) crustaceans, 3) molluscs, 4) seaweeds and other aquatic plants, and 5) miscellaneous aquatic vertebrates and invertebrates. About 250 species of aquatic organisms are farmed worldwide of which about 80 are cultured in the Southeast Asian region (Table 5).

Fishes compose the major taxonomic group of cultured aquatic organisms. Two major types are farmed, namely: freshwater and marine fishes. The saltwater forms are either cultured in brackish or in marine waters. In Southeast Asia, some of 50 species out of some 150 species cultured worldwide are probably farmed (Table 5). The region also produces 10.6% of the world production in this group (Table 6). The freshwater species farmed in SEA are about 35 while marine species number about 15. Of the freshwater species, the cyprinids or carps are dominant and widely distributed. Common carp and the Chinese and Indian major carps are more important as well as smaller cyprinids like the barbs. The tilapias, although introduced species, have become rapidly dominant in freshwater fish production in the region. Various catfishes and the gouramis are also important.

The marine species is dominated by milkfish while mullets and rabbitfish are of minor importance. The culture of carnivorous species of high market value such as sea bass, groupers, and to a lesser extent snappers, breams and jacks has recently grown in importance.

The cultured crustaceans in Southeast Asia are mainly marine forms. There is only one outstanding freshwater species cultured, the giant river prawn *(Macrobrachium rosenbergii).* Penaeid shrimps compose the major farmed crustaceans in the region resulting from the large international market that has developed in Japan, North America, and western Europe though the market is now dwindling. The farming of this group of species including seed production from hatcheries has now been well satisfied. Culture of other species which were previously just being gathered from the wild have been started. These are the mangrove crab *(Scylla serrata),* swimming crab *(Portunus* spp.), and the spiny lobster *(Panulirus).* Some 10 crustaceans are cultured in Southeast Asia while 35 species are cultured worldwide (Table 5). The region produces about 40% of world production in this group (Table 6). If the production of mainland China and Taiwan are included, the area produces over 70% of world production of farmed crustaceans.

Some 12 species of molluscs are cultured in Southeast Asia while there are 50 species farmed worldwide (Table 5). Although mollusc culture production is important to specific local economies, it has suffered setbacks in the international market and lately by environmental problem such as the red tide. Mussels and oysters suffer from contamination of *E. coli* and have been unacceptable for export and even in some local areas. Occurrence of red tide in specific sites in Sabah (Malaysia), the Philippines, and perhaps elsewhere in the region is another problem. Rapid pollution of many coastal waters also poses a problem

Table 5. Aquaculture production in Southeast Asia, by kind, 1990

Country	Finfish (tons)	Crustaceans (tons)	Molluscs (tons)	Miscellaneous invertebrates	Miscellaneous vertebrates	Seaweeds and other aquatic plants	Total (tons)
Brunei Darussalam	2	NA	NA	NA	NA	NA	2
Indonesia	381,485	97,370	NA	NA	NA	80,000	558,855
Kampuchea	6,080	NA	NA	NA	NA	NA	6,080
Laos	2,500	NA	NA	NA	NA		2,500
Malaysia	11,757	2,221	40,896	NA	NA	NA	54,874
Philippines	282,119	49,283	29,222	NA	NA	268,701	629,325
Singapore	433	303	1,229	NA	NA	NA	1,965
Thailand	93,060	72,803	51,399	NA	2	NA	217,264
Viet Nam	14,500	NA	NA	NA	NA	1,700	146,700
Total for SEA	882,245	221,980	122,746		2	350,401	1,617,565
World Total	7,322,699	613,338	3,120,401	32,695	1,227	2,988,242	14,078,602
Percent SEA production on world production	12.0	31.9	3.9	0.2	11.7	11.0	

NA, data not available. -, amount negligible or practice not applicable.

Table 6. Species cultured in Southeast Asia

	Scientific name	Common English name	Countries where cultured*
I.	Finfish		
1.	*Cyprinus carpio*	Common carp	B, I, K, L, M, P, T, V
2.	*Hypophthalmichthys nobilis*	Bighead carp	B, K, L, M, P, T
3.	*H. molitrix*	Silver carp	B, K, L, M, P, T
4.	*Ctenophatyngodon idella*	Grass carp	B, K, L, M, P, T
5.	*Cirrhinus molitorella*	Mud carp	P, S
6.	*Labeo rohita*	Rohu	K, P, T
7.	*Labeo* spp.	Rhinofishes	K
8.	*Carassius carassius*	Crucian carp	I, S
9.	C. *auratus*	Edible goldfish	I, S
10.	*Puntius gonionotus*	Thai silver barb	B, I, M, P, T
11.	*P. javanicus*	Java barb	I, K
12.	*Puntius* spp.	Asian barbs	I, K
13.	*Leptobarbus hoeveni*	Hoven's carp	B, K, M, T
14.	*Probarbus jullieni*	Jullieni carp	T
15.	*Helostoma temmincki*	Kissing gourami	I
16.	*OsteocMlus hasselti*	Nilem carp	I
17.	*Notopterus* spp.	Knife fishes	I, T
18.	*Oreochromis mossambicus*	Mozambic tilapia	B, I, K, L, M, P, T
19.	*O. niloticus*	Nile tilapia	I, L, M, P, T
20.	*Oreochromis* spp.	Tilapias	M, P
21.	*Clarias batrachus*	Walking catfish	I, L, P, T
22.	*C. macrocephalus*	Walking catfish	I, L, P, T
23.	*Pangasius pangasius*	Pangas catfish	M, T
24.	*P. sutchi*	Pangasius catfish	K, T
25.	*Channa striatus*	Striped snakehead	L, P, T
26.	C. *micropeltes*	Indonesian snakehead	L, K, T
27.	*Osphronemus goramy*	Giant gourami	I, P, T
28.	*Trichogaster pectoralis*	Snakeskin gourami	I, K, L, M, P, T
29.	*Trichogaster* spp.	Snakeskin gouramis	I, T
30.	*Anguilla* spp.	River eels	I

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Scientific name	Common English name	Countries where cultured*
31. *Oxyeleotris marmoratus*	Marble goby	M, T
32. *Anabas testudineus*	Climbing perch	T
33. *Fluta alba*	Freshwater eel	T
34. *Misgusnus anguillicaudatus*	Loach	P
35. *Chanos chanos*	Milkfish	I, P, T
36. *Lates calcarifer*	Giant sea perch or sea bass	B, I, M, S, T
37. *Epinephelus tauvina*	Greasy grouper	M, S, T
38. *Epinephelus* spp.	Groupers	M, S, T
39. *Mugil cephalus*	Gray mullet	I, T
40. *Mugil* spp.	Mullets	I, T
41. *Siganus guttatus*	Rabbitfish	P, S
42. *S. canaliculatus*	Rabbitfish	P, S
43. *Siganus* spp.	Rabbitfishes	P, S
44. *Lutjanus argentimaculatus*	Mangrove red snapper	M, S
45. *Lutjanus* spp.	Snappers	M, S
46. *Chrysophrys* major	Porgy or seabream	M, S
47. *Sparidae*	Porgy or seabream	M, S
48. *Caranx* spp.	Jacks	I, S
II. Crustaceans		
1. *Macrobrachium rosenbergii*	Giant freshwater prawn	B, I, M, T
2. *Penaeus monodon*	Jumbo tiger shrimp	I, M, P, T, V
3. *P. indicus*	Indian white shrimp	P
4. *P. merguiensis*	Banana shrimp	I, M, P, S, T, V
5. *P. japonicus*	Kuruma shrimp	S
6. *Penaeus* spp.	Marine shrimps	S, T
7. *Metapenaeus* spp.	*Metapenaeus* shrimps	I, P, T, V
8. *Scylla serrata*	Mangrove crab or mud crab	I, M, P, S, T
9. *Portunus* spp.	Swimming crabs	I
10. *Panulirus* spp.	Spiny lobster	S.
III. Molluscs		
1. *Mytilus smaragdinus*	Green mussel	M, P, S, T
2. *Perna viridis*	Green mussel	S, G
3. *Crassostrea iredalei*	Slipper oyster	P

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	Scientific name	Common English name	Countries where cultured*
4.	*Crassostrea* spp.	Cupped oysters	T
5.	*Anadara granosa*	Blood cockle	M,T
6.	*Modiolus* spp.	Horse mussels	T
7.	*Paphia* spp.	Short neck clams	T
8.	*Meretrix* lusoria	Japanese head clam	T
9.	*Tridacnidae*	Giant clams	I,P,T
10.	*Placuna placenta*	Window pane oyster	P
11.	*Pinctada* spp.	Pearl oysters	I,P,T
12.	*Pteria penguin*	Wing shell	P
IV.	Seaweeds and other aquatic plants		
1.	*Kappaphycus alvarezii*	*Kappa carragenous* seaweed	I,M,P
2.	*Eucheuma striatum*	Iota/beta carrageenous seaweed	I,M,P
3.	*E. denticulatum*	*Euchema* carrageenous seaweed	I,M,P
4.	*Caulerpa lentillifera*	Edible green seaweed	P
5.	*Caulerpa* spp.	Edible green seaweeds	P
6.	*Gracilaria verrucosa*	*Gracilaria* agar seaweed	V
7.	*Gracilaria* spp.	*Gracilaria* agar seaweeds	M,P,T,V
8.	Algae	Algae	I, M, P
V.	Miscellaneous aquatic invertebrates and vertebrates		
1.	*Rana* spp.	Frogs	I, T
2.	*Tryonix* spp.	Freshwater turtles	T
3.	*Testudinata*	Turtles	T
4.	*Crocodilus porosus*	Crocodiles	P,T
5.	*Crocodylus siamensis*	Thai crocodile	T

Source: Rabanal, 1988 (updated). Above list is what is known at present, it may be incomplete and may change in the future.

* B - Brunei Darussalam, I - Indonesia, K - Kampuchea, L - Laos, M • Malaysia, P - Philippines, S - Singapore, T - Thailand, V - Viet Nam

for mollusc culture. Industrial crop species such as pearl oyster, window pane oyster, and angel wing clam which used to be gathered from the wild are now depleted while the culture technology is not yet fully established.

Due to the above circumstances the Southeast Asian contribution to world farmed mollusc production is very meager or only about 0.5% of world production inspite of the large potential sites for culture and the presence of cultivable species (Table 6).

Seaweeds and other aquatic plants. Seaweeds used for food and industry have been gathered from natural waters in Southeast Asian countries for a long time. Recently, due to growing scarcity of natural stocks, seaweed culture was initiated in some Southeast Asian countries. The Philippines, Indonesia, and Viet Nam have reported commercial production of this group. About eight species may be in cultivation although perhaps only five belonging to two groups, the industrial crop and the food crop may be of commercial importance. About 10 species are farmed commercially worldwide (Table 6).

Southeast Asia produced about 11% of world farmed seaweeds in 1990, but the potential for much higher production exists in the region. Rapid and big fluctuation in price of the commodity has not contributed to a well planned production program in the region. The region continues to be one of the major producers of raw material while the main bulk of processing is done in developed countries outside the region.

Miscellaneous Aquatic Invertebrates and Vertebrates. Some five species of miscellaneous aquatic vertebrates are farmed in the region. There are no miscellaneous invertebrates of consequential amount cultured (Table 5). In other areas of the world sea squirts or tunicates, sea urchin, sea cucumbers, and sponges have started to be farmed. Even the vertebrates under cultivation in Southeast Asia are treated as novelties and perhaps not fully commercialized as economic venture. These include frogs, turtles, and crocodiles. There are, however, some potential and opportunities for the culture of this group of species in the region.

AQUAFARMING SYSTEMS AND PRODUCTION

Various aquaculture systems are now in existence in the region. These are 1) ponds or impoundments, 2) cages and pens, 3) open waters (marked or fenced), 4) aquafarming integrated with other production systems, and 5) ranching. These systems may be differently managed resulting in different levels of productivity.

Ponds or Impoundments

Ponds or impoundments compose the most common system prevailing in Southeast Asia. This system can be situated inland or along the coast so that these are usually land-based. It is used to culture mainly fish and crustaceans

and can be susceptible to management intensification. Ponds are used for the culture of most fishes including carps, tilapias, catfishes, and gouramis as well as milkfish, mullets, and sea bass. It is also the major system in the culture of shrimps and prawns.

Cages and Pens

Cages and pens came after the ponds. Their easy management and the relative low cost and economy in the use of available space, have made them more popular. They are used in a wide range of environments from reservoirs, lakes, rivers, and coastal coves or bays where suitable. Fishes in either fresh or saltwater are usually farmed but lately penaeid shrimps and the mangrove crab have been used.

Marked or Fenced Open Waters

To culture molluscs and seaweeds, marked or fenced open waters are usually used. Various materials are usually used to provide anchorage for the cultured organisms (e.g. wood or bamboo poles, fiber ropes or twines, metal wire, and nets and nettings, with or without floats and weights).

Integrated Aquafarming

Integrated fish farming has a long tradition in the region but its use has been fluctuating. Examples of these practices are rice-fish farming, fish farming integrated with animal husbandry, and culture of certain shellfish with seaweed. There seems to be lack of standardized technology for these practices so that there is need for training and extension to disseminate their usage.

Ranching

Ranching is a recent innovation. It is a system where substantial stocks of farmable aquatic organisms are released in their natural habitat where they can feed or graze and grow so that these can subsequently be harvested by the normal capture methods (Baluyot 1989). In many regions of the world this practice has become successful (e.g. salmon, kuruma shrimp, and abalone), but its practice is still very limited in Southeast Asia. Identification of suitable species and the appropriate sites will be required.

Intensity of Culture and Productivity

Culture systems are extensive, semi-intensive, or intensive. At the lower and upper extremes, the traditional system (lowest level) and the hyper intensive system (highest level).

Various criteria for intensification are based on: 1) stocking rate of culture organism, 2) amount of operational inputs (fertilizers, feeds), 3) amount and rate of water conditioning or renewal, 4) degree of sophistication of physical

infrastructures (engineering), and 5) availability of technology of culture including trained managers, technicians, and skilled labor. In all these levels of management, there is an upper limit beyond which further intensification can be harmful. For instance if the stocking rate is increased and the feeding rate and the aeration rate of a pond system are also raised, the production will continue to increase until it levels off. However, even before the highest point is reached the pond environment should be constantly monitored for any adverse environmental effects that may have been building up. Intensification can then be stopped at a suitable level. The hyper intensive level of management is designed to overcome the possible adverse environmental effects of further intensification such as the production of structures to eliminate metabolites-. However, the effects to neighboring areas of such action should likewise be considered and the economics of unlimited intensification should always be taken into account.

CONSTRAINTS AND RECOMMENDATIONS

Constraints

There are three types of constraints: technical, socio-economic, and administrative. The technical constraints include:

a. Lack of knowledge of the biology of cultured species
b. Inadequate supply of seedstocks for culture
c. Undeveloped technology of culture
d. Post harvest problems including processing, refrigeration, and handling
e. Deterioration of environmental quality of aquaculture sites
f. Lack of trained managers, technicians, and skilled laborers
g. Increasing losses due to advent of diseases and other causes of mortality

The socio-economic constraints are:

a. High cost of capital investment required to establish and operate projects
b. Lack or poor market demand for product
c. High cost of production due to expensive inputs
d. Lack of preferential credit to support industry
e. Unforseen losses brought about by the occurrence of natural calamities like typhoons, earthquakes, volcanic eruptions, etc.

The administrative or management constraints are:

a. Lack of needed infrastructures in aquaculture areas
b. Weak support to curb deleterious effects of environmental deterioration
c. Inadequate government support in terms of policy legal and institutional aspects, and credit

Recommendations

1. Promote cooperative programs, among institutions involved in aquaculture either interregional, regional, or national.

2. As the industry problems are extensive, priorities have to be set so that the most pressing problems could be tackled first.

3. More funding support will be required for research development, extension, and training in aquaculture, in particular with recent urgency on Seafarming and ranching.

4. Genetic studies and breeding should be pursued more aggressively to maintain and/or improve quality of cultured stocks.

5. Basic studies of immediate urgency on the technology of culture and on the biology of cultured species should be identified and pursued vigorously.

6. Market demand and margin of profit usually dictate the pace of development of any specific type of aquafarming, hence concerted studies should be made on the economics of production and product development of aquaculture commodities.

7. As the need for formulated feeds in aquaculture has increased considerably, adequate research will be required on the biology and nutrition of the different farmed species and the formulation of feeds from indigenous sources.

8. Many areas in the region are prone to natural disasters, therefore, the engineering design and structures of aquaculture industries should be geared to reduce to the minimum the dangers from these calamities.

9. Developed countries which are beneficiaries for a good number of aquatic species cultured in developing countries should contribute greater support for research in aquaculture in the region.

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