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THE BANGKOK DECLARATION AND THE STRATEGY FOR AQUACULTURE DEVELOPMENT BEYOND 2000: THE AFTERMATH

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PREFACE

Since the FAO Technical Conference on Aquaculture held in Kyoto in 1976, aquaculture has gone through major changes, ranging from small-scale household activities to large-scale commercial farming. Over the past three decades, the sector has expanded, diversified, intensified and advanced technologically. As a result, its contribution to food production has increased significantly. A large proportion of global aquaculture production comes from small-scale producers in developing countries, especially in Asia. It significantly contributes to food security, poverty alleviation and social well-being in many countries. The contributions of aquaculture to trade, both local and international, have also increased over recent decades and its share in the generation of income and employment for national economic development has increased – globally.

Recognizing the growing importance of aquaculture as the contribution of capture fisheries would be stabilized or even decreased in the near future, FAO has collaborated with NACA (Network of Aquaculture Centres in Asia and the Pacific) in organizing the Conference on Aquaculture in the Third Millennium in Bangkok in February 2000. The Conference which was hosted by the Government of Thailand reviewed the progress made since the Kyoto Conference, present status of aquaculture and discussed future opportunities and role that aquaculture could play within the context of future development, from the local to the global level. The Conference adopted the Bangkok Declaration and Strategy on Aquaculture Development Beyond 2000 which undoubtedly became major guidelines for policy-makers and aquaculture operators worldwide, especially those in the developing countries.

The Declaration addresses the role of aquaculture in alleviating rural poverty and improving livelihoods and food security while maintaining the integrity of biological resources and the sustainability of the environment. The Strategy comprises 17 elements that focus on measures that governments, the private sector and other concerned organizations can incorporate into their development programmes for the aquaculture sector. It also highlights the need for regional and inter-regional cooperation and coordination to assist in its implementation.

In order to assist Member States of FAO in implementing these Declaration and Strategy, the FAO Regional Office for Asia and the Pacific has assigned Mr. Damrong Silpachai, a well recognized Thai expert on aquaculture, to look into various issues as given in the Declaration and Strategy and recommend action required to support its implementation by the Member States. Specific case studies are also conducted in Bangladesh and the Philippines which will be published in due course. It is our sincere hope that this document would elaborate further the importance and future role of aquaculture in the region and in particular the need to strengthen cooperation and coordination among concerned agencies/organizations for sustainable aquaculture development.

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EXECUTIVE SUMMARY

1) This paper reviews the recommendations of the Bangkok Declaration, which evolved from the Conference on Aquaculture in the Third Millennium held in February 2000 in Bangkok. It has been more than a year since the conference, and the prospects of implementation of the recommendations by the member states are the concern of FAO: hence this assignment.

2) In a brief review of global aquaculture, emphasis is given to its impressive growth since the early 1980s. By 1998, China accounted for 68.7 percent of aquaculture production worldwide, dwarfing that of all other countries. The ever-rising production in China is supported by the culture of aquatic organisms at the low end of the trophic level. While low prices may seem to deprive the economy of China's aquaculture of fair earnings, local consumption has remained robust, although more food fish is required to match the needs of a growing population.

3) The sectoral review reveals the rapid rise of commercial aquaculture production, although the fast increase in the value of fish was attributed to a growing propensity towards high-valued commodities. Aquaculture exports have earned handsome amounts of foreign exchange for the producing countries, often at the expense of environmental degradation and loss of lives and property due to subsequent natural disasters and to resource-use conflicts. Aquaculture has been at the forefront in terms of natural resource-use conflicts, open access and weak political system, poor legislation and law enforcement. The sustainability of commercial aquaculture continues to remain in doubt as long as water pollution, environmental degradation and excessive use of finite natural resources are to be blamed on aquaculture.

4) As an optional food production activity, aquaculture involves various users, systems, practices and species. National planners assign a high priority in nation building to aquaculture, particularly when capture fishery is approaching its upper productive limit. Among all food production sectors, aquaculture has raised the hopes of national planners as a means to address the serious problems of hunger, poverty and unemployment.

5) Commercial aquaculture has little to do with food security, since it supplies food to the affluent sectors of society. Small-scale aquaculture practiced in harmony with the existing farming system makes quality daily meals more affordable for rural folk deprived by scanty infrastructure and by poverty. The synergy with other farming practices which small-scale aquaculture brings to deprived farming families translates into not only greater volumes of production but also a more balanced composition of the diet. It should become an important means to increase awareness of the value of land and water resources, for which heavy competition is in the offing.

6) Policy and regulatory instruments are necessary to set the tone for development activities. The pragmatism of public policy and of regulatory instruments attributed to the political system, prevailing structure of society and its social values is recognized. The technical guidelines based on the knowledge and experience of industrialized countries may prove to be too sophisticated, too costly and somewhat ineffective in the context of developing countries, where different social structures and values prevail. The FAO Code of Conduct for Responsible Fishery and measures prescribed under the UNCED Agenda 21 provide excellent checklists of what

development agencies can readily apply; however, serious planning at the national and sub-national levels must be adjusted to the dominant economic and social values.

7) Heavy dependence on land and water resources for the prosperity of aquaculture makes it inappropriate to plan it in isolation. At the national level, however, land and water management is vested in many state authorities, whose infrequent coordination often makes holistic planning extremely difficult, not to say impossible. The national fishery authorities with whom FAO has been working are largely technical agencies with little interest in or responsibility over economic and social issues. The application of technical aquaculture solutions to the serious socio-economic problems of land and water management does not appear to have been effective.

8) At the regional level, trans-boundary aquaculture requires cooperation among countries to prevent potential damage from spilling over borders that may or may not conform to the natural demarcations. The FAO code of conduct already provides a comprehensive set of guidelines on these matters and the regional and inter-regional agencies are already addressing the issue.

9) The FAO fishery statistics division has made commendable efforts to cope with unreported data due to weak statistical systems in most developing countries. From what has been reported and credited, China has demonstrated an admirable tendency to produce a high volume of aquaculture products at relatively low prices. Lower commodity prices should make aquaculture products accessible to low-income groups and thus enhance food security.

10) The development of commercial aquaculture brings with it a totally different scenario and a different set of technical and socio-economic problems. The competition over common finite natural resources which commercial aquaculture will have to encounter in the future makes its development policy different from that of small-scale aquaculture. Technology will be required to maximize profits and sustainability: production of high-value commodities, measures to enhance food safety as required by international standards, efficient use of farm inputs, biotechnology, etc. Commercial aquaculture must fend off the broadsides of environmental and consumer activists over production and trade issues.

11) The measures suggested by the Bangkok Declaration are applicable to a variety of situations, and users are at liberty to adapt them. Development planners are no doubt aware that the diversity of the types of aquaculture requires diverse sets of development strategy. Successful aquaculture development does not confine itself to technical aspects; factors influencing the economic aspects and the social milieu must also be dealt with adequately. This implies that a multi-disciplinary policy could be more effective than the sectoral development approach. Unfortunately, the lack of integrated decision-making mechanisms in most developing countries could make it difficult to adopt this suggestion.

12) Aquaculture extension deserves serious review. The fast-evolving political and administrative structures in many countries have raised the questions of its function, changing role and benefit, and who should pay for the services. Developing countries could try a participatory research approach bringing researchers and farmers together to create a new

paradigm of learning. The success of the Land Grant programmes, which began in the United States in 1862, could be emulated.

13) As a global agency, FAO has been promoting aquaculture as a sector and as a component of rural development. The following areas should be considered:

a) FAO could provide expertise and guidance on global legal instruments and commitments agreed to by the member states at the various global forums.

b) Given the demand-led development of commercial aquaculture, its future growth is likely to be determined by the private sector and its enterprises. In facilitating the sustainability of commercial aquaculture, FAO could contribute more to aquaculture research through cost-sharing partnerships between universities and the private sector.

c) FAO could also assist member states in advocating the Code of Conduct for Responsible Fishery as a means for guiding the national technical agencies towards holistic planning, which involves socio-economic factors, and as a means for international cooperation, particularly where a set of natural resources is shared in the development of aquaculture.

d) Aquaculture should be promoted by assisting member states as an integral part of the existing farming patterns in order to establish local hatcheries in which farmers could procure fish seed for periodic stocking at an affordable price. Fish seeds and other inputs could be made available through barter for research information. Such an arrangement could help generate pertinent information about this type of aquaculture for all stakeholders to share and appreciate one another's values.

e) The efforts made by the various regional organizations dedicated to fishery and aquaculture development, such as the International Council for Aquatic Resources Management, the Network of Aquaculture Centres in Asia-Pacific, the South East Asia Fishery Development Centre and the Mekong River Commission, are highly complementary. More efforts, such as through the coordination rendered by the Asia-Pacific Fishery Commission, could help harmonize holistic planning, as already guided by the FAO code of conduct and supported by the Bangkok declaration. With their wealth of technical capabilities, these regional organizations can combine their expertise with the national authorities responsible for policies and for the implementation of socio-economic programmes. In the absence of integrated decision-making mechanisms at the national level, the usual national counterparts of FAO could serve as coordinators to harmonize the available aquaculture technology with their contemporary political, economic and social realities, by having the people at the centre.

f) As aquaculture continues to domesticate new aquatic organisms, the role of national research institutes must be promoted. The research areas in brood stock management, seed propagation, feed and feeding, diseases, farm management, etc, offer wide opportunities for almost any institution to participate. The promotion of aquaculture of indigenous species, such as that now attempted by the Mekong River Commission, should be supported. Cooperation between the aquaculture industry and national research institutes needs to be strengthened, not only for the effectiveness of their endeavours but also for the safety of the consumers and the harmony of all socio-economic activities dependent on the common natural resource base.

g) Multi-disciplinary research team, such as the one assembled in Vietnam with the help of IDRC, could be organized at national and sub-national levels to facilitate the learning of both academics and rural folk. The development of human resources is essential to sustainability, and participatory research should be a way to address it.

1. Aquaculture development trends in Asia

Asia is the home of aquaculture, a practice which dates back to thousands of years. In the course of its development, the nature of aquaculture has become more intricate, intertwining with other food production sectors under the influence of political, social, economic, technological and cultural factors. With advancement of technology, the involvement of more aquatic species and farming practices has become possible, and more choices can be offered to the consumers. Population growth, economic growth and the development of disposable income and higher purchasing power, and social factors such as traditional fish consumption patterns, will shape future demand for fish and fishery products (Westlund, 1995). Issues of sustainability can also change our perception of desirable forms of aquaculture development and management (Roberts and Muir 1995). Under the evolving global trade negotiations and agreements, new ways of aquaculture may have to be adopted, so that the environmental and resource costs of production, as factors of sustainability, are kept within agreed limits. It could become increasingly difficult to pursue the traditional methods of aquaculture where a particular species is produced for a market, based exclusively on prices. Under the World Trade Organization, suppliers would have to satisfy a set of requirements to ensure sustainable development of aquaculture.

In the past decades, aquaculture around the world was pursued with nutritional and economic objectives without really taking into account the environmental and social costs. The perceived negative impact of aquaculture has already constrained the pace of its development, mainly in the coastal zones (Shahadeh and Pedini, 1995). The downstream development of aquaculture, e.g. in processing, packaging, distribution and marketing, can influence the demand for food fish. Social lifestyles, such as adoption of fish as healthy food in developed countries, and changing family structures may also alter consumption patterns.

This review of global or regional aquaculture development relies heavily on FAO fishery statistics, which supply quantitative and analytical information portraying the time-series production and value of aquaculture annual outputs. FAO has endeavoured to assist national fishery statistical agencies to improve data collection and analysis in order to serve the formulation of national fishery policies. Statistics in general and fishery statistics in particular have somehow remained a weak area, owing to lack of support and poor staffing. The great variety of physical, socio-economic and cultural situations under which aquaculture is practised makes it difficult even for a well-trained statistician to discern them. Over the years, FAO has had to make serious efforts categorizing and setting standards for the collection and interpretation of the field data in order to make the statistical presentation comprehensible at the levels where it is meant to be used.

At the global level, time series fishery statistics give at least an idea of the development. In terms of weight and value, one can estimate the relative importance of the fishery resources. As a function of the economic demand, the price of a fish would reflect how much the competitive markets want it. Certain species of fish or shellfish which are relatively unknown to the consumers in developed countries are likely to be sold only at a low price, despite the comparable quality of their flesh from a culinary and nutritional point of view. This makes comparing the prices of a fish to its usefulness to man in terms of nutrition a little unfair.

The global aquaculture production shows a highly skewed picture. Based on FAO aquaculture statistics, Asia in 1995 produced 87 percent (18.27 million tonnes) of the total; Europe 1.41 percent (6.20 million tonnes); North America 2.86 percent (0.60 million tonnes); South America 1.56 percent (0.329 million tonnes); Oceania 0.45 percent (0.0947 million tonnes); and Africa 0.39 percent (0.082 million tonnes). The world's top ten countries accounted for 85.84 percent of aquaculture production by volume. They came in the following order: China (60.90 percent), India (7.67 percent), Japan (3.90 percent), Indonesia (2.91 percent), Thailand (2.22 percent), United States (1.97 percent), Republic of Korea (1.75 percent), the Philippines (1.65 percent), Bangladesh (1.53 percent) and Norway (1.34 percent).

The expansion of aquaculture by broadening the meaning of the term has brought some changes to aquaculture statistics and the scope of future development. When culture-based fishery is considered as a form of aquaculture, the statistics account for the harvest from a larger body of water into which some stocking was made. Stocking of inner seas in Japan and large-scale stocking of reservoirs in China have long been practiced, and this can make a difference to aquaculture in terms of production. Fishery management has become an important tool in aquaculture. The rapid increase in the annual production of Bangladesh comes from floodplain fishery. This could make floodplain fishery in a country such as Cambodia, a case for aquaculture statisticians to take up for further statistical refinement. They probably would end up with a higher tonnage due to aquaculture development without technological or managerial improvement.

Among the cultured species, carp and other cyprinids accounted for 10.34 million tonnes of the 1995 production, and tilapia and other cichlids for 659 000 tonnes. Shrimp production was reported at 931 800 tonnes. Aquaculture development has been market-driven. Marine shrimp production increased 5.25 percent over the previous year despite heavy crop losses in Taiwan due to shrimp disease. The other main factors contributing to high production in aquaculture are the availability of water resources and long experience in aquaculture.

The significance of Chinese aquaculture only became evident in the 1950s despite its having been practiced for thousands of years. Before then, the Yangtze and Pearl River deltas were the principal areas for fish culture, producing some 15 000 tonnes annually in the 1940s. Since the 1950s, and particularly since the 1980s, the culture of fish in fresh, brackish and marine waters has expanded rapidly in all but two provinces, Qingha and Xizang (Tibet), where the harsh climate and topography of the Tibet-Qingha plateau limit production (Qian, 1994). By 1995, annual production reached 17.6 million tonnes of finfish, shellfish and aquatic plants, valued at US$16 300 million (16.3 billion), from a total of around 6.4 million ha in inland and marine areas.

Forced by the decreasing per-capita share of land resources in China, the government has focused its fishery development policies on expanding inland, brackish-water and marine aquaculture (Qian, 1994). According to Wu (1996), per-capita agricultural land decreased from 0.19 ha in 1949 to 0.09 ha in 1995.

As resolved and declared by the Conference, it is clear that aquaculture has yet to reach its potential, and this is the reason why the member states should be interested in developing it. According to FAO statistics, the sharp increase, particularly in the last five years, signifies a great potential for aquaculture. The popular notions which link aquaculture to food security, poverty alleviation, employment opportunity, and earning of foreign exchange are, to say the least, not automatic. Closer examination reveals that aquaculture, when practised alone, rarely lends itself to those developmental objectives. However, aquaculture can – and often does – complement other food-production activities to make the recycling of farm materials more effective.

Industrial or commercial aquaculture is a popular food-production activity primarily supplying international markets. Despite its claim to high profits, industrial aquaculture has been associated with pollution and environmental degradation. When fuller cost accounting is performed, the costs to the public sector to make up for the damage or to restore the environment are often much greater. The sufferings experienced by local communities because of environmental degradation are more immediate and severe. For the rural poor, the loss in opportunities due to environmental damage makes a bad situation worse.

Raising carnivore species such as bass, salmon or black tiger shrimp leads to more consumption than production of proteins. The present level of aquaculture technology is too low to make efficient use of high-protein pellet feed. The feed of these carnivorous fish and shrimp contains a high proportion of fishmeal and soya meal. Fishing for small pelagics that are processed into fishmeal has been criticised for depriving natural stocks of valuable fish, such as salmon and tuna, of their essential food.

All foregoing weaknesses of aquaculture are not good enough reasons for abandoning it. Aquaculture holds a good promise, particularly in decades to come. Increased food demand due to population growth, lower per-capita availability of arable land and water, pollution, toxicity and environmental degradation as well as competition from other sectors for developmental funding, will make it imperative for aquaculture and other food-production activities to make effective use of the available land and water.

In terms of production, world aquaculture grew 2.4-fold from 1989 to 1998, approaching 30.9 million tonnes, an annual percentage rate of 11.0 from 16.5 million tonnes in 1989. It is clear from FAO aquaculture statistics that Asia is by far the lead producer, accounting as it does for more than 90 percent of the production volume.

Table 1. World aquaculture production (in thousand tonnes) from 1989 to 1998

	1989	1990	1991	1992	1993	1994	1995	1996	19971	1998
Africa	96	82	93	101	92	96	105	120	118	189
America, North	450	411	470	525	541	532	560	563	644	656
America, South	153	186	257	295	287	342	409	556	660	670
Asia	**14 269**	**14 498**	**15 955**	**18 881**	**22 173**	**25 206**	**28 563**	**30 955**	**32 732**	**35 815**
Europe	1 479	1 611	1 445	1 379	1 379	1 505	1 608	1 690	1 766	1 960
Oceania	44	46	68	71	74	73	95	107	110	141
World	**16 490**	**16 835**	**18 287**	**21 253**	**24 547**	**27 754**	**31 346**	**33 992**	**36 031**	**39 431**

In terms of production volume, aquaculture is highly concentrated in 12 leading countries, whose 1998 aquaculture production, excluding aquatic plants, accounted for 90 percent of the total volume produced during that year and 78.9 percent of total value. In the 1998 ranking, seven countries of Asia came first, followed by the United States and two countries of Europe.

As the top aquaculture producer, China has maintained an impressive lead over the second highest producer, India: China's production is more than ten times greater than India's. Aquaculture production in China has gone beyond capture fishery production. With 6 045 million tonnes of fish, crustaceans and molluscs produced in 1989, China took a six-fold lead over the second place, a margin which had increased to 10.2-fold by 1998. Closer examination should reveal how China and India have been quite successful in aquaculture.

Figure 1. World Aquaculture Production

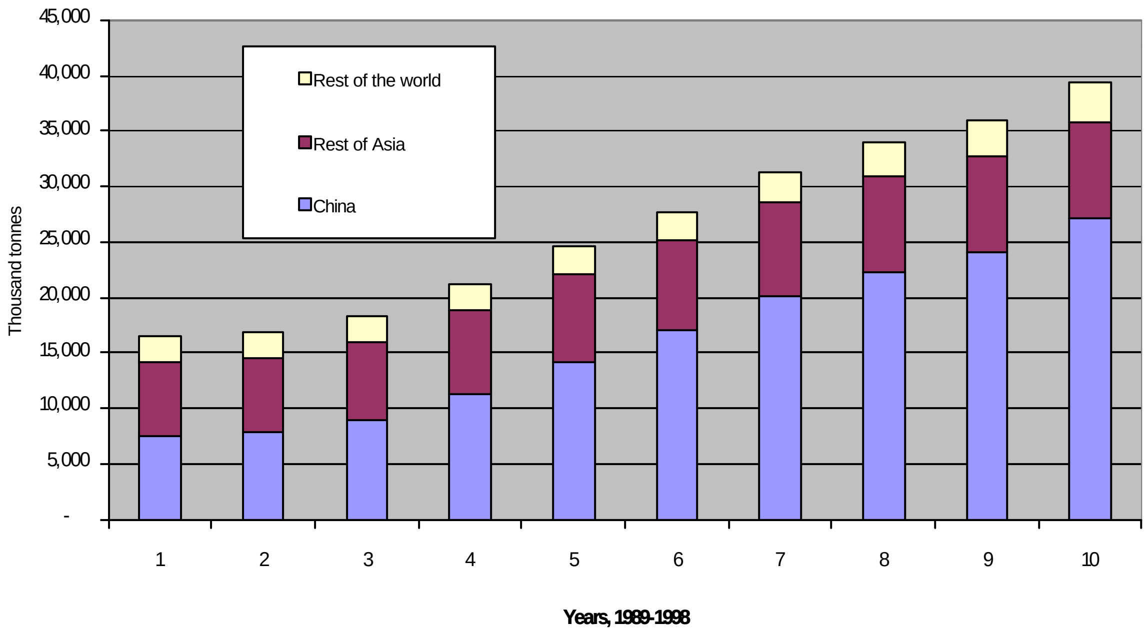


Table 2. Annual production of aquaculture fish, crustaceans and mollusc (in thousand tonnes) of the 12 top producers, from 1989 to 1998

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
China	6 045	6 182	6 881	8 256	10 357	12 967	15 856	17 715	19 316	20 795
India	1 005	1 012	1 221	1 389	1 427	1 528	1 686	1 783	1 862	2 030
Japan	781	804	803	814	833	781	820	829	807	767
Indonesia	448	500	518	550	600	598	625	733	663	697
Bangladesh	187	194	203	257	282	320	280	450	513	584
Thailand	260	292	353	371	457	510	560	557	552	570
Viet Nam	163	260	165	168	183	207	452	433	494	522
United States	369	315	364	414	417	391	413	393	438	445
Norway	114	150	161	138	173	218	278	322	367	409
Korea Rep	404	377	342	376	392	343	368	358	392	327
Spain	223	203	225	169	126	178	224	232	239	314
Philippines	361	380	109	387	392	388	362	349	330	312
World	**16 490**	**16 835**	**18 287**	**21 253**	**24 547**	**27 754**	**31 346**	**33 992**	**36031**	**39 431**

With the production of 14.3 million tonnes of all types of aquaculture in 1989, Asia contributed 86.5 percent to the world's aquaculture in weight, and 79.7 percent in value. Initial annual growth during the period was small: 1.6 percent in 1990. However, the subsequent annual rate peaked at 18.3 percent in 1992. With slower growth in the subsequent years, the rate for the period 1989-1998 was reduced to an annual percentage of 10.8, yet enabling Asia to capture a 90.8 percent share of the world production in weight, and 82.9 percent in value.

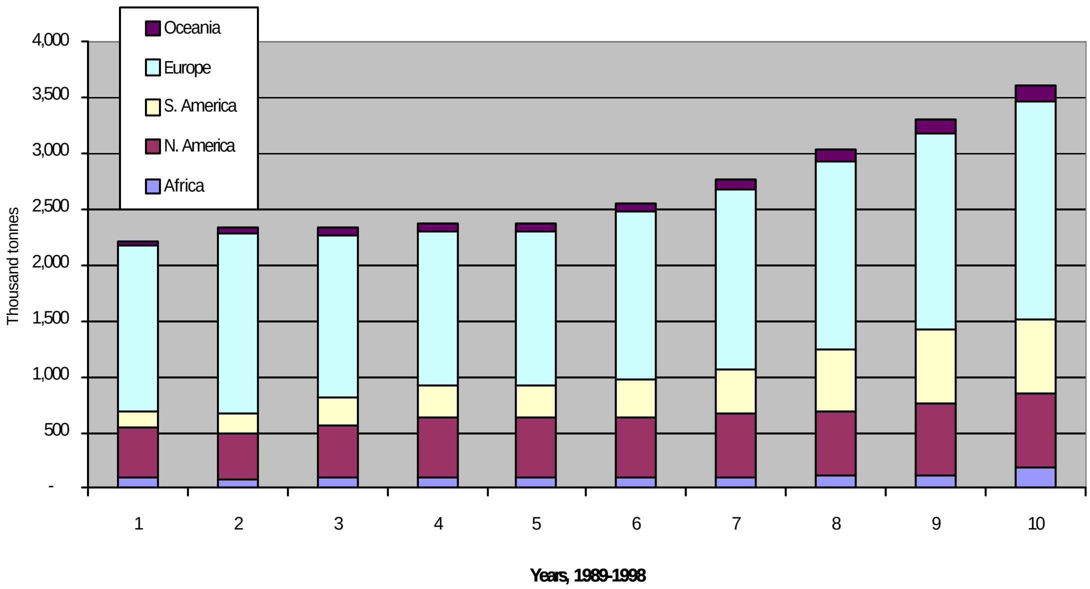
The influence exerted by China in world aquaculture was highly apparent. In 1989, China took a 46.2 percent share of world aquaculture in weight – a share which grew to 68.7 percent in 1998. Similarly, China took a 53.4 percent share in Asian aquaculture, which rose to 75.6 percent over the same period. A clear picture can be observed in the average percentage rates during the period: China's average percentage rate was 15.1, Asia excluding China 3.5, and other continents 5.6. During 1989-1998, the overall aquaculture production in China was as much as 57.3 percent of the world's production, leaving 28.2 percent to the rest of Asia and 14.5 percent to other continents. This shows that without considering China's aquaculture, the growth rate of the rest of Asia was slower than that of other continents. Given the overwhelming contribution of China, production trends in either Asia or the world only reflect the trends of Chinese aquaculture, i.e. very rapid growth during this period.

By treating aquaculture in China separately, it becomes clear that the growth rates of aquaculture in Asia and in the world kept barely above population growth. The various forms of aquaculture should be treated separately since each cultured organism has specific requirements for survival and growth.

Aquaculture continued to grow from the previous decade. In the period from 1989 to 1998, world aquaculture (including China) grew from 16.5 million tonnes to 39.4 million tonnes, an annual percentage rate of 10.5. Asia is home to aquaculture, with 86.3 percent of fish, shellfish and other aquatic organisms produced in 1989. This share kept on increasing until it reached 91.1 percent in 1994, then levelled off slightly to 90.8 percent by 1998. China is by far the most important producer, taking a 53.6-percent share of the world production in weight in 1989 and, with an average increase of 2.5 percent a year, reaching 75.6 percent in 1998. Given such a handsome lead, any changes in the world aquaculture production must have China as the major influencing factor.

For the rest of the world outside Asia, aquaculture grew from 2.6 million tonnes in 1989 to 4.1 million tonnes ten years later. Unlike in Asia, seaweed aquaculture had an overall share of only 2.4 percent in the average annual aquaculture. The share of Europe, which accounted for 10.6 percent of aquaculture production during 1989-1998, grew relatively slowly, at annual percentage rates of 3.2 during the period. North America had an overall share of 1.9 percent during the period, growing from 450 000 tonnes in 1989 to 656 300 tonnes in 1998, an annual rate of 4.3. Although sharing only 1.4 percent of the overall aquaculture production in this decade, South America was one of the fast-growing regions in aquaculture. Annual production was of 153 100 tonnes in 1989. Growth at an impressive 17.8-percent annual rate pushed production in 1998 to 669 700 tonnes. Despite the 0.3 percent share of Oceania during the period, the reports from the 27 countries of Oceania to FAO showed a rise of aquaculture production from 43 500 tonnes in 1989 to 140 900 tonnes in 1998, an average percentage rate of 13.9. Africa, which is represented by 58 countries in FAO fishery statistics, had a share of 0.4 percent of the average annual aquaculture production during the 1989-1998 period. Despite water shortages in most parts of Africa, the increase has been impressive, at 7.8 percent per year throughout the period.

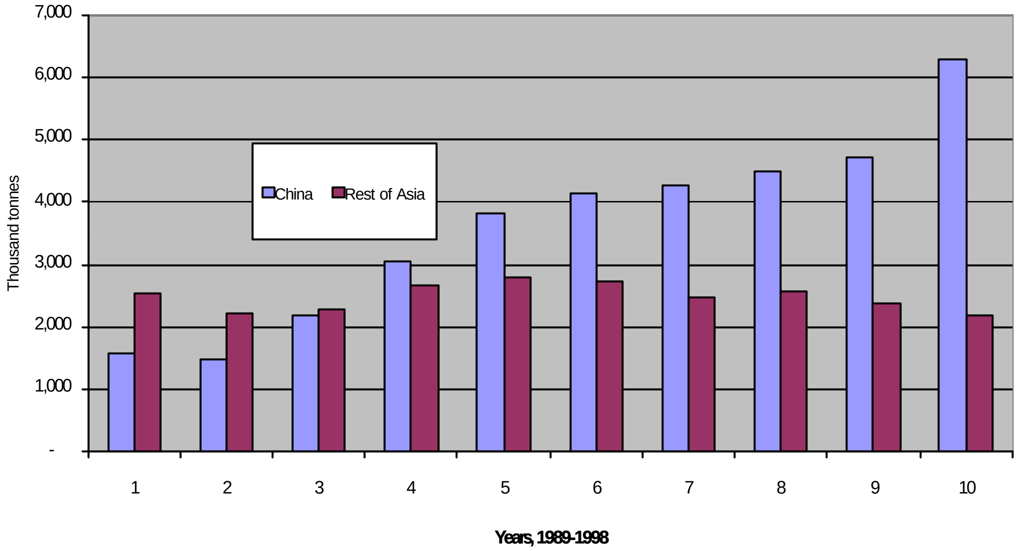
Figure 2. Aquaculture outside Asia, 1989-1998



By its sheer annual production volume, China has charted the development of world aquaculture. What has happened to Chinese aquaculture, in terms of volume and value, has had a strong bearing on the development of aquaculture in the rest of Asia and of the world. It is important, therefore, to analyse carefully the changes in volume or values that China's aquaculture has brought in the past and what they are likely to be in the future.

Over the 1989-1998 period, China's production of aquatic plants accounted for 57.7 percent of world production; that of the rest of Asia was of 41.0 percent. Leaving only 1.2 percent to countries in other continents in the share in aquaculture production by seaweeds, any comparison in aquaculture production would not be justified unless seaweed aquaculture, which existed in 23 of the 177 reporting countries, is taken into account. Moreover, seaweed aquaculture in China expanded at a faster rate, of 16.6 percent per year over the period, compared with 0.1 for the rest of Asia.

Figure 3. Aquatic plant culture in Asia



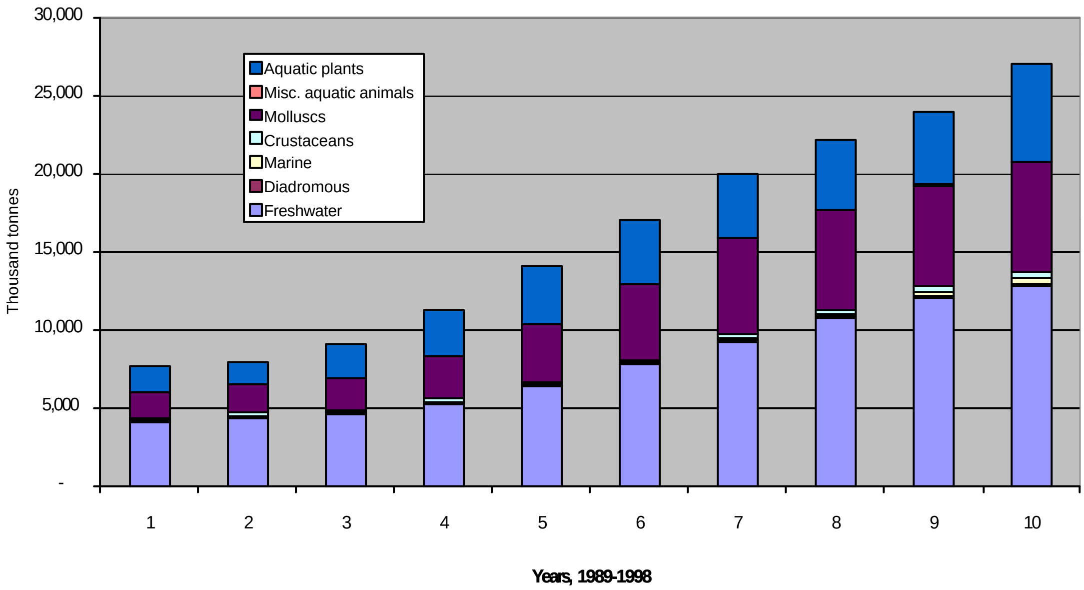
During the period, China produced 67.2 percent of aggregated aquaculture commodities in Asia, while other countries in East Asia produced 14.4 percent, Southeast Asia 10.2 percent, East Asia 7.8 percent and West Asia 0.3 percent. Including China, the composition of Asian aquaculture commodities was 43.7 percent freshwater fish, 25.4 percent aquatic plants, 22.4 percent molluscs, 3.8 percent high-value crustaceans, 2.7 percent high-value diadromous fishes, 1.7 percent of marine fishes and 0.2 percent other aquatic animals.

China's aquaculture was strongly dominated by the production of freshwater fishes, which accounted for 48.0 percent of the average annual production during 1989 and 1998. Molluscs made up 26.6 percent, aquatic plants 22.3 percent, while crustaceans, marine fishes, diadromous fishes and other aquatic animals contributed 1.4, 0.8, 0.7 and 0.1 percent respectively to the average annual production of the country.

China's freshwater aquaculture maintained a consistent growth, and at an average yearly rate of 13.5 grew from 4.1 million tonnes in 1989 to 12.8 million tonnes in 1998, a threefold increase in a decade. The Chinese carps, the principal cultivating species, led by silver carp (*Hypophthalmichthys* *molitrix*), grass carp (*Ctenopharyngodon idellus*), common carp (*Cyprinus carpio*) and bighead carp (*Hypophthalmichthys nobilis*), in that order, were cultivated. The production of Nile tilapia (*Oreochromis niloticus*) accounted for 2.1 percent of the average annual production during this period, ranking eighth among the most important freshwater fish species cultivated in China. The annual production of freshwater fishes grew by an average percentage rate of 13.5 during this period and was topped by Nile tilapia (21.8 percent per year), crucian carp (*Carassius carassius*) (19.7) and common carp (17.2). The silver carp, the top producer among freshwater fishes, grew at an annual rate of 9.9 percent. It should be noted that FAO fishery statistics list among freshwater fishes *Osteichthyes*, which accounted for 4.1 percent of the average annual aquaculture production, with an annual percentage rate of 19.8. This could be due to the large-scale stocking of lakes and reservoirs in China, which resulted in a large harvest. Although insignificant in terms of volume during this time, the production of Mandarin fish (*Siniperca chuatsi*) was first reported in 1995 at 35 400 tonnes. This high value (US$10 000 per tonne, about ten times the average value) apparently became popular and the reported annual production rose at the rate of 30.4 percent per year to 83 100 tonnes in 1998, a twofold increase in four years.

The production of molluscs in China grew at the rate of 17.4 percent per year, from 1.6 million tonnes in 1989 to 7.0 million tonnes in 1998, a little more than a fourfold increase. The Pacific cupped oyster and the Japanese carpet shell were the leading molluscs in China's aquaculture, with shares of 12.0 and 6.6 percent respectively of the average annual production in weight. With a production volume of 447 500 tonnes in 1989 and a 31.2 percent annual growth rate, the Pacific cupped oyster (*Crassostrea gigas*) produced 2 279 800 tonnes in 1995, after which the annual production levelled off for two years before it rose again by 21.7 percent over 1997 to attain the production level of 2 833 200 tonnes in 1998. In a similar growth pattern, the annual production of Japanese carpet shell (*Ruditapes philipinarum*), of 185 500 tonnes in 1989, rose by 49.0 percent a year on average to 913 300 tonnes in 1993, before levelling off in the following three years. The average annual growth resumed in 1997 and 1998 (annual percentage rate of 13.3) to attain the production level of 1 404 400 tonnes in 1998, a 7.5-fold increase over that of 1989. A more dramatic fluctuation in annual production was shown by the high-valued Yesso scallop (*Pecten yessoensis*). Although a steep growth rate was observed in 1993 when production rose from 338 000 tonnes in 1992 to 728 400 tonnes (a 115.5 percent increase), the period 1989-1997 witnessed a continuous increase in annual production, though it fell to a mere 0.2 percent increase in 1997. The crop failure in 1998 had annual production taking a nosedive by 37.2 percent from 1 001 500 tonnes to 629 400 tonnes.

Figure 4. China's aquaculture



Growing at the annual rate of 16.6 percent, the production of aquatic plants rose from 1.5 million tonnes to 6.3 million tonnes in the same period. The majority (77.7 percent) of aquatic plants grown in China belonged to a brown seaweed, the Japanese kelp (*Laminaria japonica*), while the red seaweed, Laver or Nori (*Porphyra tenera*), accounted for 6.1 percent of the average annual production during 1989 to 1998. Other aquatic plants, not identified as species, were also grown and their average annual production had a 16.2 percent share during the same period. From a harvest of 1 364 600 tonnes in 1989, the annual production a year later dropped by 10.5 percent to 1 221 500 tonnes. The period from 1990 to 1993 witnessed a rapid annual growth (35.1 percent per year) from 1 221 500 tonnes in 1990 to 3 009 100 tonnes in 1993, but slowed down (3.5 percent) between 1993 and 1995 to resume fast growth (10.5 percent) between 1995 and 1997. The growth in production in the final year (1998) went down to a mere 0.8 percent, reaching 3 965 100 tonnes. The Laver (Nori) had a similar growth pattern in the annual production, and with an annual rate of 16.5 percent, production of 92 600 tonnes in 1989 quadrupled to 364 400 tonnes in 1998. Other types of molluscs, which contributed to 16.2 percent of mollusc production, grew by 18.9 each year on average, from 115 100 tonnes in 1989 to 461 700 tonnes in 1997. In 1998, the production of miscellaneous molluscs registered a tremendous increase of 321.7 percent from the 1997 level, to 1 947 000 tonnes in 1998.

Despite their smaller share in the annual production (1.4 percent), crustaceans were important in China's aquaculture because of their higher value and different culture environment. Three species of crustaceans made up the reported production: fleshy prawn (*Penaeus chinensis*), Chinese river crab (*Eriocheir sinensis*) and giant river prawn (*Macrobrachium rosenbergii*), which shared 64.9, 19.2 and 7.6 percent of China's average annual crustacean production during 1989-1998 respectively. The remaining 8.3 percent went to miscellaneous crustaceans. The annual production of the fleshy prawn during this period was negative: its annual percentage rate stood at –2.9. The reported production fluctuated considerably from year to year, revealing difficulties in stabilizing production. The 1990 production dropped slightly to 184 800 tonnes from 185 900 tonnes in 1989 before it rose by 18.8 percent to the peak of 219 600 tonnes in 1991. Production dropped over the next four years (–33.8 percent a year) to the lowest level of 63 900 tonnes in 1994. A surge in growth was reported for 1995, and with an annual percentage rate of 22.3 for the remaining four years, 1998 production stood at 143 100 tonnes, 23.0 percent less than a decade ago. The annual production of the Chinese river crab during the decade was different altogether from that of the fleshy prawn: it grew at a rate of 49.5 percent per year, from 3 300 tonnes in 1989 to 123 200 tonnes, without a single year of negative growth. The giant river prawn had a short history, since its production has only been reported since 1996. In the first reporting year, production stood at 37 400 tonnes, and with a yearly rate of 28.7 percent, production for 1998 was reported at 61 900 tonnes. Apart from the known species of crustaceans, China cultivated miscellaneous species, which accounted for 8.4 percent of the production of this subgroup. Although the overall annual percentage rate during 1989-1998 was as high as 32.0, the initial phase of growth from 1989 to 1992 was somewhat slower (17.5 percent) before climbing sharply (80.5) to the 1994 first peak of 28 100 tonnes. The following three years did not fare as well: the 1997 production of miscellaneous marine crustaceans was of 21 500 tonnes, 23.6 percent less than the 1994 first peak. The sharp rise of 145.2 percent achieved in 1998, to 52 700 tonnes, created a new hope for this type of aquaculture, however.

The cultivation of marine fishes in China contributed only 0.8 percent to the average annual production during 1989-1998. Although the annual growth in volume, from 33 000 tonnes in 1989 to 306 700 tonnes in 1998 (28.1 percent a year on average) was significant, the aquaculture of marine fishes was not reported by species.

Among some 30 species of diadromous fish known to aquaculture, the Japanese eel (*Anguilla japonica*) is the only one that China cultivated. Smooth growth at 13.7 percent a year was reported for the 1989-1997 period; however, 1998 production fell 2.5 percent from the previous year.

1.1 Aquaculture in East Asia (excluding China)

The average annual aquaculture production in East Asia minus China was small, only about one fifth of the volume produced by China. Aquatic plants cultivated in the two Koreas, Japan and Taiwan accounted for 56.2 percent of their average annual production during 1989-1998. Molluscs, the second-largest subgroup of organisms produced by these East Asian countries, were grown largely in Japan and the Republic of Korea. The Pacific cupped oyster was popular in the Republic of Korea, Japan and Taiwan, where its annual production made up 22.6, 17.2 and 9.2 percent of the overall annual production of the respective countries. The oyster is the only mollusc reported to be cultivated in Hong Kong, although the volume was relatively small. The Yesso scallop was cultivated in Japan, yielding 16.2 percent of the annual production for the country; however, the Republic of Korea is the only country outside Japan to have reported production of this mollusc, since 1993. While the Republic of Korea cultivated as many as 13 species or groups of molluscs, Taiwan reported 8 and Japan 2.

High-value marine fishes had an 18.1 percent share of Japan's annual aquaculture production in weight. Japan reported the production of eleven species or groups; among them, the Japanese amberjack (*Seriola quinqueradiata*) and the silver bream (*Pagrus auratus*) shared 11.2 and 5.1 percent of the annual production during 1989-1998 respectively. The Republic of Korea reported the cultivation of eleven species or groups of marine fishes; however, their annual production was only 1.3 percent of the overall aquaculture production in the country. In Taiwan, where the annual production of marine fishes accounted for 3.9 percent of total production, some twelve species or groups were reported as cultivated, and the growth of this type of aquaculture accelerated after 1993 (26.8 percent per year for the period 1993-1998).

Diadromous fishes had only 4.8 percent share in the annual aquaculture production in these economies for the period 1989-1998, and Taiwan, Japan and the Republic of Korea had a 2.9, 1.8 and 0.1 percent share in the sub-regional average annual production during 1989-1998, respectively. Taiwan cultivated five species of anadromous fishes; and the once highly popular Japanese eel (*Anguilla japonica*) appeared to be outpaced by milkfish (*Chanos chanos*). After 1990, the eel production continued to experience negative growth, of –13.7 percent per year by 1998. Although displaying an increasing trend, milkfish production still fluctuated highly, meaning that there were difficulties. In Japan, where five species of diadromous fishes were cultivated, the Japanese eel and the rainbow trout (*Oncorhynchus mykiss*) were the most popular. The Japanese eel, which accounted for 2.4 percent of the total annual production in weight, experienced persistent negative growth, with a yearly rate of –6.4 percent for the period 1989-1998. The annual production of coho salmon (*Oncorhynchus kisutch*) and rainbow trout during the period displayed a similar negative trend (–8.7 and –2.4 respectively). In the Republic of Korea the cultivation of diadromous fishes was limited to three species: Japanese eel, rainbow trout and ayu sweetfish (*Plecoglossus altivelis*); however, the production trend was in contrast to that of Japan. Overall, the increase during 1989-1998 was moderate, with an annual percentage rate of 12.5.

China excluded, Taiwan led all other East Asia countries in freshwater aquaculture production during 1989-1998. Of 23 species or groups of aquatic organisms cultivated in the sub-region, as many as 12 were reared in Taiwan and tilapias took the lead by far among freshwater fishes. With the exception of 1993, annual production of freshwater fishes showed negative growth throughout the period. Freshwater fishes accounted for 1.4 percent of aquaculture production in Japan, where two species (common carp and gold fish) and two groups (tilapias and miscellaneous freshwater fishes) were reported. Japan, too, registered negative growth in freshwater aquaculture, with annual percentage rates of 5.9 during the period.

As one of the pioneers in marine shrimp aquaculture, Taiwan continued to cultivate as many as nine species or groups of crustaceans of the total of 13 that East Asian countries have been producing. Crustaceans made up 8.6 percent of the average annual production in Taiwan during 1989-1998; and the giant river prawn (*Macrobrachium rosenbergii*) and giant tiger prawn (*Penaeus monodon*) dominated other crustaceans in terms of weight. Overall, the annual production was cut by slightly more than half (53.6 percent) from 31 500 tonnes in 1989 to 14 600 tonnes in 1998. The fluctuations followed no specific patterns: this indicates the uncertainties of this type of aquaculture, and outbreaks of disease were a major problem in the past.

The cultivation of miscellaneous aquatic animals was reported in three East Asian economies outside China. As leader in this category, the Republic of Korea was active in the cultivation of sea squirts and aquatic invertebrates, and some production of softshell turtle was reported from 1995 onwards. Production of these aquatic animals fluctuated widely from year to year and no particular pattern could be found. The situation was similar for Japan, where river and lake turtles were cultivated along with the two groups of invertebrates, though there was no report on the cultivation of softshell turtles. Taiwan reported the cultivation of frogs and softshells, with the latter making good progress. After negative growth in the first two years of the 1989-1998 period, Taiwan reported rapid growth from 1992 onward, with an annual percentage rate of 108.5, so that softshell turtle production grew from a mere 22 tonnes in that year to 3 782 tonnes in 1998. The annual production of frogs also exhibited a positive trend, although the wide fluctuation in production could be attributed to persistent difficulties in ensuring good harvests.

Table 3. Composition (in percentage) of aquaculture organisms cultivated by countries in East Asia, 1989-1998

	China	**Hong Kong**	**Taiwan**	**Japan**	**DPR Korea**	**Korea Rep**	**E Asia less China**
Freshwater fish	48.1	49.3	26.5	1.4	0.6	1.5	3.4
Diadromous fish	0.7	1.9	34.9	4.6	–	0.5	5.3
Marine fish	0.8	43.1	3.9	18.1	–	1.3	7.9
Crustacean	1.4	–	8.6	0.2	–	0.1	0.8
Mollusc	26.6	5.7	21.8	33.5	7.0	33.3	25.7
Misc. aquatic animals	0.1	–	0.7	0.7	–	2.9	1.1
Aquatic plants	22.3	–	3.6	41.5	92.4	60.4	55.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

A striking difference in the cultivation of miscellaneous aquatic animals was noted: China had only the cultivation of softshell turtle (*Trionyx sinensis*), while Taiwan, Japan and the Republic of Korea cultivated frogs (*Rana* spp.), river and lake turtles (*Testudinata*), sea squirts (*Ascidiacea*) and aquatic invertebrates (*Invertebrata*). Although the volume of China's aquaculture was less than half that of the three East Asian countries, the rate by which the softshell turtle culture grew was very impressive: its annual percentage rate over 1994-1998 was 93.6.

1.2 Aquaculture in Southeast Asia

The Southeast Asian sub-region consists of Brunei Darussalam, Cambodia, Indonesia, the Lao PDR, the Philippines, Singapore, Thailand and Viet Nam. With the exception of the land-locked Lao PDR, all countries in the sub-region have access to the sea and their coastlines can be exploited for coastal aquaculture. Four out of ten countries produced as much as 92.9 percent of the aquaculture production volume of the sub-region during the decade under study, namely the

Philippines (33.6 percent), Indonesia (28.6 percent), Thailand (18.3 percent) and Viet Nam (12.4 percent). The increase in annual production of the sub-region was of 9.9 percent per year for the period 1989-1995, and began to level off (2.2 percent yearly growth rate) subsequently when it approached 3.0 million tonnes in 1998. The growth rates for the Philippines and Indonesia, 4.7 percent and 4.9 percent respectively, remained lower than the sub-regional rate. Although the faster growth rates came from Viet Nam (14.0 percent) and Thailand (9.1 percent), the smaller producing countries such as Myanmar and Brunei Darussalam showed impressive increases, of 32.1 percent and 29.3 percent respectively.

The lead country in the sub-region was the Philippines, which accounted for 33.6 percent of the average annual production volume for the sub-region in the decade 1989-1998. Aquaculture in the Philippines was highly diversified. There were 26 major species groups: 7 species of freshwater fishes, 2 of diadromous fishes, 5 species groups of marine fishes, 4 species of crustaceans, 2 of molluscs and 6 of aquatic plants. Of the three Southeast Asian countries that produced seaweeds, the Philippines accounted for four fifths of the production. The Philippine production was composed mainly of red and green seaweeds (55.2 percent by volume), species which are not cultivated in Indonesia or Viet Nam, the other two seaweeds countries. The 1989-1998 decade saw rapid production growth (10.7 percent per year), despite a 22.8 percent drop in 1997 amounting to 182 000 tonnes less than the 801 000 tonnes produced the year before.

Disregarding the seaweeds, the annual production of fish and shellfish showed a positive trend (6.4 percent increased) from 1989 to 1991 then turned negative at an annual percentage rate of –3.8. In further detail, the leading aquaculture production in the Philippines was diadromous fishes. The production of the national fish, milkfish (*Chanos chanos*), accounted for 47.7 percent of all aquaculture production (excluding seaweeds). Another diadromous species, Baramundi (*Lates calcarifer*), displayed somewhat spotty production records and accounted for only 0.3 percent of the diadromous fish production. Freshwater fishes accounted for 24.7 percent of the overall aquaculture production by volume, which largely comprised tilapias. Generally, production was somewhat stagnant despite fluctuations. Nile tilapia (*Oreochromis niloticus*) dominated the production in this subgroup, taking a four-fifths share of the average annual production during the decade. Cyprinids, snakeheads, torpedo-headed catfish and giant gourami were cultivated in the Philippines, albeit on a much smaller scale. The smaller share of miscellaneous freshwater fishes in FAO fishery statistics signified a well-developed aquaculture system in the Philippines, where most of the cultured species have been clearly identified and reported. The production of crustaceans accounted for 18.9 percent of the average annual production, which comprised six species. The period 1989-1991 did not see much growth in this sub-sector: its increase was only of 3.0 percent a year. The sudden rise in giant tiger prawn production in 1992-1993 slightly dropped in the next three years before plunging by –43.7 percent from 80 500 tonnes in 1996 to 45 300 tonnes in 1997, and by a further –7.7 percent to 41 800 tonnes in 1998. By volume, the giant tiger prawn took 90.8 percent, with the Indo-Pacific swamp crab, endeavour shrimp and banana shrimp taking 4.0, 3.9 percent and 1.4 percent respectively. For mollusc production, the green mussel and the slipper-cupped oyster, which accounted for 56.0 percent and 44.0 percent of the subgroup respectively, made up 8.3 percent of the Philippines' annual aquaculture production. The production of marine fishes was the smallest, accounting for only 0.4 percent by volume. Nonetheless, the highly uneven production figures of these high-value species appeared to indicate some serious production problems facing the fish farmers.

As the second-best country in the sub-region in terms of average annual production volume over 1989-1998, Indonesia took a 28.9 percent share in the aquaculture production of the Southeast Asian sub-region. Indonesian aquaculture capitalized on 21 major species groups: 10 of freshwater fishes, 3 of diadromous fishes, various species of mullets in mariculture, 6 of crustaceans and 1 of red seaweed. By aggregate production volume, freshwater fishes accounted for 41.7 percent, followed by diadromous fishes (21.6 percent), crustaceans (20.2 percent) and aquatic plants (15.1 percent). Aquaculture production grew at an annual percentage rate of 4.9 from 1989 to 1998.

Of the ten freshwater fish species Indonesia reported to FAO as aquaculture statistics, the common carp was predominant, representing 18.3 percent of the average annual aquaculture production for the country. Despite a precipitous drop in 1997, common carp aquaculture in Indonesia has enjoyed moderate growth, of 8.5 percent per year throughout the decade. The Mozambique tilapia (*Oreochromis mossambicus*) and Nile tilapia (*Oreochromis niloticus*) had a 6.2 and 2.7 percent share in the average annual aquaculture production respectively. The Mozambique tilapia grew at a sustained rate (11.8 percent per year), from 27 000 tonnes in 1989 to 52 800 tonnes in 1995. In the three following years, annual production fell –7.5 per cent per year to 41 800 tonnes in 1998. The Nile tilapia exhibited a different pattern of growth: it grew slowly (7.2 percent per year) from 12 300 tonnes in 1989 to 18 600 tonnes in 1995; and more vigorously in the remaining three years, to 29 000 tonnes in 1998 – an annual percentage rate of 15.9. Three species of diadromous fishes were included in aquaculture statistics by Indonesia: milkfish (*Chanos chanos*), river eel (*Anguilla anguilla*) and Baramundi (*Lates calcarifer*); the first species was by far predominant. Production increased gradually from 1989 to 1993, then dropped for two years. It rose again (20.7 percent) in 1996 then decreased to 156 900 tonnes in 1998. The cultivation of crustaceans in Indonesia involved four species of Penaeid and Metapenaeid shrimp and two species of crab. The giant tiger prawn dominated this subgroup, having a 12.6 percent share in the average annual aquaculture production during 1989-1998.

1.3 Aquaculture in South Asia

The South Asian sub-region comprises Bangladesh, India, the Maldives, Nepal, Pakistan and Sri Lanka. The Maldives has no reported aquaculture production and is therefore excluded from this paper. All countries, except land-locked Nepal and Bhutan, have access to the sea and their coastlines can be exploited for coastal aquaculture. Sri Lanka has a relatively limited scope for freshwater aquaculture; coastal aquaculture has been developing rapidly, although resource-use conflicts allegedly slow it down.

Overall, the aquaculture of South Asia contributed in volume 7.9 percent to Asian and 7.1 percent to world productions. Among freshwater fishes, the Indian major carps (*Roho labeo*, Catla and Mrigal), Chinese carpss (common carp, grass carp, silver carp and bighead carp) and some unidentified cyprinids represented nine species or groups of carp. The cultivation of certain tilapias was reported from Sri Lanka, the only country in South Asia with statistics on tilapia cultivation. The rainbow trout, the only diadromous fish reported for the sub-region, was cultivated in India and Pakistan. All maritime countries in the sub-region cultivated some species of crustaceans, notably the giant tiger prawn.

India was the leader in the sub-region by far, grabbing an 80.2 percent share of the average annual aquaculture production by volume during 1989-1998. The cultivation of rainbow trout and marine fishes was still negligible, statistically speaking. Freshwater aquaculture, which contributed 95.7 percent in weight, was represented by a 71.9 percent share of the three species of the Indian major carps, 15.1 percent of miscellaneous freshwater fishes, 7.3 percent of climbing perch (*Anabas testudineus*) and torpedo-shaped catfish (*Clarias* spp.). The production of all Chinese carps, except the bighead carp, was reported from 1993 onwards, and had a 1.4 percent share in the overall aquaculture production during the period.

Among crustaceans, aquaculture production was reported for the giant river prawn (*Macrobrachium rosenbergii*), the giant tiger prawn (*Penaeus monodon*) and from 1995 the Indian white prawn (*Penaeus indicus*). Statistics did not speak well for the giant river prawn since the 1995 production was missing and the average annual production of 393 tonnes (4.3 percent of all aquaculture production) was too negligible for the statistics of a large country such as India. The rapid rise in annual production by 323 percent, from 178 tonnes in 1996 to 753 tonnes in 1997, and by 100 percent to 1507 tonnes in 1998, was impressive. However, the key player in crustacean aquaculture in India was the giant tiger prawn, which seized a more than 99-percent share in the crustacean annual production of the country during the decade. The sharp rise in 1993-1994 clearly indicated the boom of marine shrimp culture, which soon levelled off. The drop in production in 1997 and resumption in 1998 were due to the usual problems in disease outbreak and resource-use conflicts one often hears about in this industry.

The next aquaculture leader in the sub-region was Bangladesh, which produced 337 100 tonnes a year of fish and crustaceans during 1989-1998. Bangladesh produced only freshwater fishes and crustaceans in aquaculture, and the average annual production accounted for 1.4 percent of Asian and 1.3 percent of world aquaculture in weight. Although reports were only available from 1997 onwards, the estimated annual production of silver carp and *Roho labeo* was in the lead, followed by Catla. Common carp, mrigal and grass carp did equally well, each contributing some 2.1 percent to the annual production. The majority (55.9 percent) of aquaculture production came from miscellaneous freshwater fishes cultivated in low-lying ponds in the vast floodplains of the country. Although Bangladesh has an extensive coastline with a high potential for marine shrimp aquaculture, and some development in this direction has taken place, the available report on crustacean aquaculture was limited to the production of miscellaneous freshwater crustaceans and various penaeid shrimp, each of which contributed 10.1 percent in weight to the annual aquaculture production of the country.

1.4 Aquaculture in West Asia

The West Asian sub-region comprises Afghanistan, Bahrain, Cyprus, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey and the United Arab Emirates. Iran, Turkey and Israel are major countries of this sub-region that are engaged in aquaculture: their shares are 35.8 percent, 28.7 percent and 21.0 percent of the sub-region respectively. The sub-region grew at an annual percentage rate of 6.5 during 1989-1998, although the initial three years registered slow growth.

The leading country in the sub-region, Iran, suffered negative growth until 1993, before its 4.8 percent annual growth between 1993 and 1998 was attained. The great majority (93.2 percent) of aquaculture in Iran was in freshwater where silver carp, common carp, grass carp and bighead carp, in that order, made up the statistics. From 579 tonnes in 1991, production of the rainbow trout increased to 4 994 tonnes in 1998, a 762.5 percent increase in the course of seven years. Iran has also engaged in marine shrimp aquaculture, and the reported production, 31 tonnes in 1992, showed a rapid increase, to 869 tonnes in 1998.

Turkey, the second-largest producer of the sub-region, continued to cultivate the common carp and certain cyprinids, though not very successfully. Sea bass culture began to show promise as of 1992, although with a temporary drop in 1995, and production rose from 1 800 tonnes in 1992 to 18 800 tonnes in 1998 – an annual increase of 47.2 percent. Turkey also concentrated on salmon aquaculture, particularly the Atlantic salmon (*Salmo salar*), which began to show impressive results by 1995. Fast growth (24.6 percent per year) in the culture of anadromous fishes was recorded during 1989-1994; even faster growth, of 36.2 percent a year, was achieved during 1994 to 1998. Turkey began in 1995 to produce Natantia decapod, and the trend looked promising. In the meantime, the culture of the Mediterranean mussel had reached 2 000 tonnes a year.

Although Israel scored an overall rate of 2.7 percent per year during 1989-1998, production stagnated for three years before dropping sharply in 1992 to 12 200 tonnes. The average increase during 1992 and 1998 was of 4.8 percent a year. The mainstay of Israel's aquaculture continued to be composed of common carp and tilapias, although the rainbow trout has emerged as a popular fish since 1996. Among the diadromous, the gilthead seabream (*Sparus aurata*) and flathead grey mullet (*Mugil cephalus*) appeared to give new promise to local aquaculture. The giant river prawn cultured in Israel did not amount to much in terms of annual production.

Saudi Arabia, which had a 3.9 percent share in the sub-regional production and produced only 1 230 tonnes of tilapias and 10 tonnes of giant tiger prawn in 1989, managed to increase production by 17.0 percent a year, and in 1998 produced 3 300 tonnes of freshwater fishes, mainly tilapias, and 1 700 tonnes of giant tiger prawn. Saudi Arabia began to produce African catfish in 1996, and Baramundi and grouper in 1998. The aquaculture production in the sub-region increased slowly, at the rate 4.6 percent a year during 1989-1993, then began to accelerate to 15.7 percent a year during 1993-1998. Israel, one of the most experienced countries in aquaculture, is the third in the sub-region in terms of aquaculture production in the decade under study.

1.5 China's aquaculture

Freshwater aquaculture dominates China's fish farming business, and the Chinese carps is the principal species reared in most inland water bodies. Not only is multi-culture practiced in farm ponds to take maximum advantage of the natural ecological inter-relationship of the Chinese carps, but also some 65 percent of the 2 million hectares of water storage reservoirs has been exploited as culture-based aquaculture. With more than one billion mouths to feed, the Chinese government should consider aquaculture an obvious option for its food policy. As aquaculture is reaching out far and wide, risks should be minimized, for example by using hardy, prolific and fast-growing species.

Since 1984, China has expanded aquaculture in both inland and marine waters. Expansion in area and intensity of production has been the key. The use of open waters such as lakes, reservoirs, rivers and paddy fields for freshwater aquaculture has steadily increased, from 2.8 percent a year in 1984 to 6.9 percent a year between 1991 and 1995. The national average yield from ponds increased from 1 390 kg/ha in 1985 to about 4 000 kg/ha in 1995. In Guangdong, where aquaculture is highly concentrated, yields of more than 6 600 kg/ha have been reported since 1995.

Seaweeds lead China's aquaculture in terms of production. As the number-one crop, as much as 90.3 percent of the brown seaweed Japanese kelp (*Laminaria japonica*) was produced in the country, compared with 8.4 percent in DPR Korea and 1.1 percent in Japan. China also produced in 1998 some 38.0 percent of the red seaweed Laver or Nori (*Porphyra tenera*), after Japan (41.3 percent) and ahead of the Republic of Korea (19.9 percent).

Eight species of carp and cyprinids have been farmed in China on a commercial scale and some of these species are produced commercially nowhere else. The Chinese carps (silver, grass, bighead, and common carp) have been pond-reared in an efficient poly-culture system for centuries, and their annual production has been at the top. The crucian carp, white amur bream, mud carp and black carp are also widely farmed commercially. Cultivation of the white amur bream was reported from nowhere but China, which registered the production of 449 000 tonnes in 1998.

Emphasis has been given in recent years to diversifying into luxury freshwater species such as the mandarin fish (*Siniperca chuatsi*), freshwater crab and prawn, softshell turtle, and eel. In 1995, carp accounted for 99.7 percent of freshwater fish production and represented 52 percent and 45 percent of national aquaculture production by tonnage and value respectively. Production of silver, grass, common and bighead carp totalled 2.47, 2.07, 1.40 and 1.24 million tonnes, respectively.

The most popular mollusc species in China's aquaculture are the Pacific cupped oyster (*Crassostrea gigas*) and the Japanese carpet shell (*Ruditapes philippinarum*), which in the decade ending 1998 grew at the average annual rate of 53.3 and 65.7 percent respectively. In 1989, China produced 448 000 tonnes of Pacific cupped oyster; however, the harvest ten years later rose more than six-fold to 2.833 million tonnes. With a slightly lower annual production, the Japanese carpet shell registered a slightly faster annual growth rate: its yield of 186 000 tonnes in 1989 increased 7.5-fold to 1.404 million tonnes a decade later.

China also aimed for high-value aquaculture products. At least 10 percent of inter-tidal mudflats, shallow sea-beds and bays have been added to coastal aquaculture every year since 1985; the rate increased to 13.4 percent between 1992 and 1995. By 1995, the figure stood at 715 000 ha. Aquaculture in shallow seas and inter-tidal mudflats has become a national emphasis. China's marine crustacean production began to rise rapidly in 1991, reached 92.8 percent per year growth in 1993 then decreased sharply over the next three years. The rate of decrease in 1996 was as much as 70.3 percent. The situation improved with a 196.0 percent increase in 1997, which brought production almost back to the 1995 level. The increase continued in 1998, but at a slightly lower rate, 145.2 percent. Fleshy prawn production, which stood at 185 900 tonnes in 1989, has been highly inconsistent from year to year. An increase of 18.8 percent in 1991 was followed by three straight bad years, which lowered production to 63 900 tonnes. Although recovery has been on the way since 1995, the 1998 production of fleshy prawn remained just below what China produced a decade ago.

Another high-value product, the Yesso scallop (*Pecten yesoensis*), of which only China and Japan are major producers, was attempted. Japan produced slightly more scallop before 1991 when Chinese production was of 188 700 tonnes. Reaching a 115.5 percent rate of increase in 1993 with 728 400 tonnes, production began to level off. The sharp decrease of 37.2 percent in 1998 put the production of scallop just under the 1993 level.

One most dramatic development in China's aquaculture is the culture of the Chinese river crab (*Eriocheir sinensis*). China is the only country producing this expensive crab, although the Republic of Korea has begun to show some production since 1994. In 1989, crab production was of 3 300 tonnes; it had risen to 123 200 tonnes a decade later – an average annual increase of 51.4 percent.

The softshell turtle (*Trionyx sinensis*) is known to aquaculture in China, in the Republic of Korea, in Taiwan and in Thailand. Taiwan had been consistent in improving turtle production throughout the years and China began to report production in 1994, with 4 400 tonnes. With an almost fourfold increase the following year, China has made impressive progress in the production of this delicacy. In 1998, China had a 93.8 percent share in softshell production, leaving Taiwan, Thailand and the Republic of Korea far behind.

The progress of Chinese aquaculture over the past decade has come about among a host of problems. In the past few years, the government has taken many legislative initiatives to facilitate land and water development, particularly to bring together the control of these finite natural assets under fewer ministries. With a reported shortage of freshwater and land in a country where populations are growing fast, the problems that China faces are in the area of natural resource management.

Expansion of aquaculture in China relates strongly to the quality of the aquatic environment. The deterioration of water quality in several lakes and reservoirs, rivers and some coastal areas continues to deprive aquaculture. Industrial and domestic effluents, particularly around populous cities, could easily add to the rapid hyper-nutrification and eutrophication if subjected to inadequate treatment. The increasing occurrence of red tides would make it extremely difficult to ensure safe timing for aquaculture crops.

Table 4. Main aquaculture species produced by China, 1989-1998 (in thousand tonnes)

	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Pacific cupped oyster	448	503	534	752	1 029	1 915	2 280	2 285	2 329	2 833
Japanese carpet shell	186	234	328	576	913	1 107	1 069	1 094	1 257	1 404
Marine mollusc	208	224	212	185	230	264	1 051	1 188	1 042	1 022
Yesso scallop	129	147	189	338	728	826	916	1 000	1 001	629
Sea mussel	491	496	498	539	510	415	415	366	398	541
Razor clam	138	140	165	199	223	253	307	343	354	415
Blood cockle	52	56	57	56	75	97	125	132	130	158
Silver carp	1 336	1 399	1 361	1 541	1 807	2 139	2 473	2 800	3 070	3 133
Grass carp	935	1 023	1 046	1 232	1 465	1 790	2 071	2 408	2 632	2 808
Common carp	461	522	594	706	892	1 128	1 399	1 592	1 761	1 928
Bighead carp	629	658	680	770	902	1 054	1 237	1 400	1 535	1 567
Crucian carp	205	212	219	254	292	385	534	690	858	1 032
Freshwater fish	192	187	247	262	433	535	614	740	878	971
Nile tilapia	89	106	120	157	191	236	315	394	485	526
White amur bream	144	162	153	182	219	282	336	379	435	449
Japanese eel	60	68	81	92	100	110	120	147	167	163
Mud carp	78	80	80	81	90	100	110	130	150	160
Black carp	39	37	36	52	66	103	103	119	138	153
Chinese river crab	3	5	8	10	18	31	42	63	101	123
China	**6 045**	**6 482**	**6 881**	**8 256**	**10 357**	**12 967**	**15 856**	**17 715**	**19 316**	**20 794**

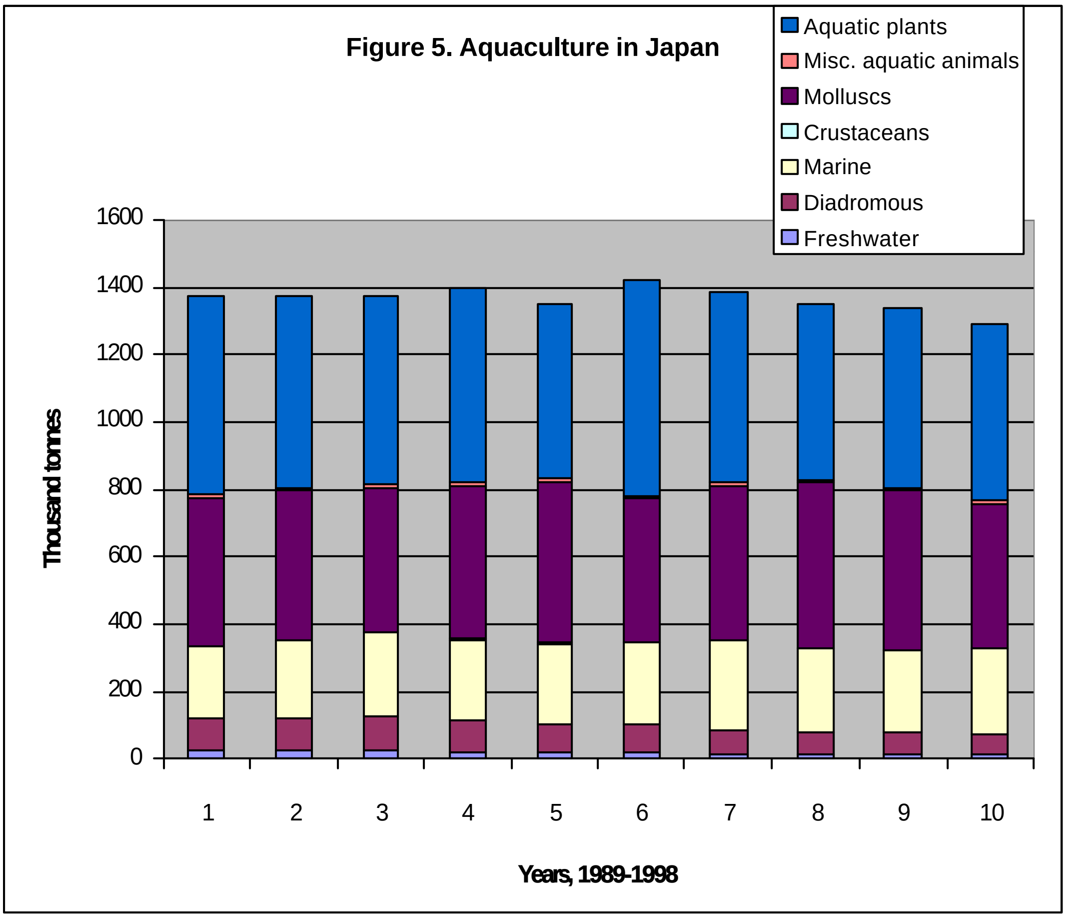
The prospect of growth in aquaculture is good despite the problems alluded to above. Aquaculture has been made part of farming and increasing demand from local markets would put fish production high on any government's economic priority list. With a higher cost for aquaculture products, high-end technology in water treatment, fish feed and therapeutic agents would be more affordable.

1.6 India's aquaculture

Although India has taken up marine shrimp farming for many years, freshwater aquaculture has continued to be dominant. In terms of annual production, India has for many years ranked as a top aquaculture producer, next only to China. With a steady increase in the volume of annual harvest to 2.03 million tonnes, India was able to double aquaculture production in the decade ending in 1998. The Indian major carps (*Labeo rohita, Catla catla,* and *Cirrhinus mrigala*) continued to be popular and their annual yields continued to rise at a fast pace. As shortage of land and water has become much more severe in India, the harvest of miscellaneous fishes (grouped into the so-called *Osteichthys* or bony fish) has declined precipitously. The Chinese carps (grass carp or *Ctenopharyngodon idellus,* common carp and silver carp, *Hypophthalm-ichthys molitrix*) have recently become more popular: their production a little more than doubled in the last six years of the decade.

In seizing the opportunity that coldwater aquaculture and coastal aquaculture have offered to produce high-value species such as the rainbow trout (*Onchorhychus mykiss*), the giant tiger prawn (*Penaeus monodon*) and the giant freshwater prawn (*Machrobrachium rosenbergii*), India has done quite well. The annual harvest of the black tiger shrimp almost tripled over the decade under survey and some production of the giant freshwater prawn was noticeable.

1.7 Japan's aquaculture



Ranking third in the world in terms of annual production in weight, aquaculture in Japan is highly diversified; the ten aquatic organisms farmed belong to nine FAO-listed species groups. Among cultivated fin fish, the common carp, Japanese eel, Japanese amberjack (*Seriola quinqueradiata*), rainbow trout and silver seabream (*Pagrus auratus*) are listed. The Yesso scallop and Pacific cupped oyster are two species of mollusc that Japan has produced in bulk. The Laver, Wakame (*Undaria pinnatifida*) and Japanese kelp, the essential ingredients of traditional Japanese dishes, have also been grown in large quantities. In terms of the overall production, Japan's aquaculture has been somewhat stagnant during the past decade; in fact, it has begun to show clear signs of decline since 1997. 1998 production was just below that of 1989, a decrease of 2.3 percent in a decade.

Most important in terms of production volume are the group of aquatic plants that comprise Laver, Wakame and Japanese kelp. The Laver (*Porphyra tenera*), also known as Algue nori and Lechuga nori, is a red seaweed grown in East Asia by Japan, China and the Republic of Korea. Smaller quantities have been produced by DPR Korea and by Taiwan. Like other species, the annual Laver production has been rather constant, with a slight decrease in the last few years. With an almost fourfold increase in annual production in China, Japan's demand on Laver could be satisfied without growing it at home. Meanwhile, the production in the Republic of Korea is also increasing albeit slightly. The situation for the Wakame is more stressful since the production in all three countries, Japan and the two Koreas, has gone down in the last decade.

The Yesso scallop (*Pecten yessoensis*) provides a similar picture. The average growth of 2.5 percent per year would be too little to supply the local market. Over the same period, China has quintupled scallop production and could make up for what is still lacking.

Table 5. Japan's aquaculture production (in thousand tonnes) of the main species, 1989-1998

	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Japanese amberjack	153	161	161	149	142	148	170	146	138	147
Silver sea bream	46	52	60	66	73	77	72	77	81	83
Japanese eel	40	39	39	36	34	29	29	29	24	22
Rainbow trout	16	15	15	14	14	13	13	14	13	14
Common carp	17	16	16	15	13	13	13	12	12	12
Yesso scallop	180	192	189	208	241	199	228	266	254	226
Pacific cupped oyster	256	249	239	245	236	223	227	223	218	199
Japan	**785**	**804**	**803**	**818**	**833**	**781**	**820**	**829**	**807**	**767**

1.8 Indonesia's aquaculture

Indonesia has practiced aquaculture for a long time and in a great variety of forms. As FAO aquaculture statistics show, Indonesians have cultivated a great many species for domestic consumption and export. Of this long list of species, nine species of carp, tilapia, milkfish and seaweed are the most important. The common carp (*Cyprinus carpio*) has been popular, and the world came to know its pen culture in the sewage flowing from Java. Production of the common carp overtook that of milkfish by 1995, with 152 700 tonnes as compared with 151 200 tonnes for the diadromous fish. Its production has continued to rise ever since.

As fingerlings must be obtained from the wild and are in limited supply, the cultivation of milkfish in the Pacific countries has progressed slowly. Although artificial breeding has succeeded to some extent in recent years, the average growth was pegged at 2.7 percent a year for the past decade. Since the advent of marine shrimp culture, milkfish production has fluctuated considerably.

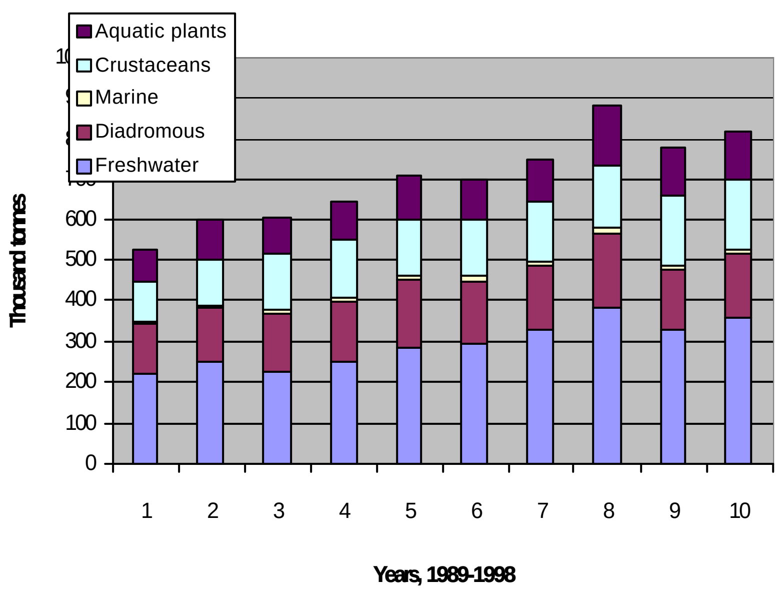
The cultivation of the red seaweed (*Rhodophyceae*) has been confined to Indonesia. This cheap aquatic plant was grown extensively around the archipelago, though its statistics were only compiled recently. Seaweed cultivation has been inconsistent and the influence of marine shrimp culture could be a factor affecting its growth. On the other hand, the annual production of the giant tiger prawn (*Penaeus monodon*) and banana prawn (*Penaeus merguiensis*) has grown considerably. In the decade ending 1998, the average annual growth rates were recorded at 6.9 percent for the giant tiger prawn and 8.0 percent for the banana prawn.

The Mozambique tilapia (*Oreochromis mossambicus*), introduced into Indonesia in the 1950s, has continued to be cultivated in large parts of the archipelago. The subsequent introduction of Nile tilapia (*Oreochromis niloticus*) has added richness to pond culture of these two chiclids, whose annual yields have remained high. According to FAO fishery statistics, the annual production of Mozambique tilapia has remained greater than that of Nile tilapia, with a much slower rate of increase in annual production, however. In the decade ending in 1998, the annual production of Mozambique tilapia rose one and a half times, from 27 000 tonnes in 1989 to 41 830 tonnes in 1998. Faster by comparison, the annual production of Nile tilapia increased 2.3-fold, from 12 309 tonnes in 1989 to 29 000 tonnes a decade later.

Table 6. Indonesia's aquaculture production (in thousand tonnes) of the main species, 1989-1998

	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Common carp	88	89	84	94	131	135	153	178	147	148
Milkfish	119	132	141	147	164	153	151	162	143	148
Mozambique tilapia	27	42	41	45	43	47	53	60	45	42
Nile tilapia	12	12	13	15	18	18	19	26	28	29
Java barb	21	28	20	21	22	23	38	33	24	29
Nilem	21	14	10	10	11	12	12	19	11	12
Giant tiger prawn	64	67	97	98	87	83	89	96	96	103
Banana prawn	19	18	19	22	29	24	32	29	31	32
Indonesia	**448**	**500**	**518**	**550**	**600**	**598**	**645**	**733**	**663**	**697**

Figure 6. Aquaculture in Indonesia



Indigenous to Java, the silver barb (*Puntius javanicus*) and Nilem carp (*Osteochilus hasselti*) have remained popular, although their annual production was lower than that of the chiclids. Similar observations go for the freshwater catfish (*Clarias* spp.), giant gourami (*Osphronemus goramy*), snake-skinned gourami (*Trichogaster pectoralis*) and kissing gourami (*Helostoma temminckii*), which have been long cultivated in the archipelago. The highly fluctuating production statistics of these species could be attributed to a number of factors, including haphazard data collection, since a considerable quantity of those native fish are apparently unreported.

The coastal aquaculture in Indonesia featured the milkfish, mullet and sea bass. As in the Philippines, the Mozambique tilapia is often cultivated in brackish-water ponds owing to its euryhaline nature. The sudden burst in production of the river eel (*Anguilla* spp.) to 18 900 tonnes in 1996 and its subsequent precipitated decline was noted.

Marine shrimp culture has been going strong in Indonesia with the clear objective of export. The annual production rate for both black tiger and banana shrimp showed a steady increase. The absence of production fluctuation has become a strength for this export commodity in the world market. The production of *Metapenaeus* shrimp was less steady; however, the volume in some years was impressive.

The culture of mud crab and swimming crab in Indonesia was noted. Although their annual production has remained low, the practice could one day break new grounds as the market for crabs has been expanding.

1.9 Bangladesh's aquaculture

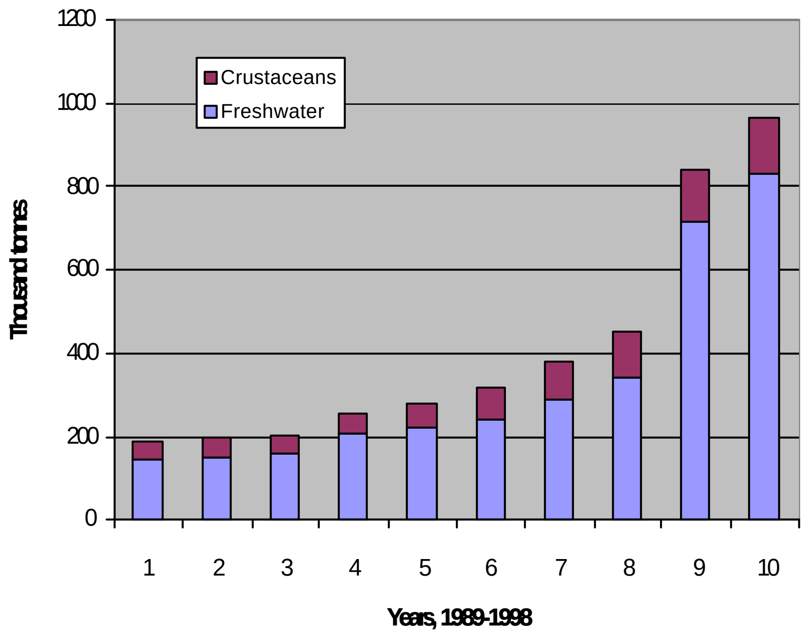
Situated on a rich delta, Bangladesh has one of the most extensive river systems, covering one of the world's richest inland fishery resources. In 1998, Bangladesh's capture fishery landed 839 141 tonnes of quality fish, including the anadromous *Hilsa*. The high population density has deprived Bangladesh of the water and land needed for producing enough food. Aquaculture has begun to be developed in Bangladesh, though wealthy landlords, who normally maintain large dugout ponds on their premises, have long been known to cultivate the Indian major carps.

Table 7. Bangladesh's aquaculture production (in thousand tonnes) of principal species, 1989-1998

	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Roho labeo	–	–	–	–	–	–	–	–	82	95
Silver carp	–	–	–	–	–	–	–	–	82	95
Catla	–	–	–	–	–	–	–	–	66	77
Common carp	–	–	–	–	–	–	–	–	33	39
Mrigal	–	–	–	–	–	–	–	–	33	38
Grass carp	–	–	–	–	–	–	–	–	33	
Bangladesh	**187**	**194**	**203**	**257**	**282**	**320**	**380**	**450**	**513**	**584**

Aquaculture, as normally practiced in Bangladesh, is strictly stocking, often with fish seed collected from the wild. Most ponds are flooded during the yearly monsoon and some wild fish are trapped once water has receded. Rich natural food in the ponds makes feeding the fish a luxury; a large crop is produced anyway when the ponds are harvested just before the advent of the monsoon. Given the richness of the natural fish fauna in the Ganges-Yamuna-Brahmaputra river basin, varieties of fish are kept in ponds for harvest afterwards. Higher aquaculture production rates could be attained technically through proper stocking and feeding; however, so long as capture fishery continues to satisfy the demand of the local landlords, investment in aquaculture may not start in earnest.

Figure 7. Aquaculture in Bangladesh



Bangladesh fishery statistics have improved in recent years, and one could do with more reports on aquaculture production. The main aquaculture species are confined to the Indian major carps (Roho labeo, Catla and Mrigal). Bangladesh has also cultivated Chinese carps, and substantial production of silver carp and common carp has been reported. As statistics attest, progress in inland aquaculture has been somewhat slow.

The same scenario does not hold, though, when it comes to coastal aquaculture in Bangladesh. Investment to convert the rich coastline and its mangrove was brought with the required aquaculture technology into Bangladesh and India. Annual production of marine shrimp rose threefold from 18 235 tonnes in 1989 to 66 080 tonnes a decade later.

1.10 Thailand’s aquaculture

Aquaculture in Thailand has been facing waves of development almost every decade. There was a miracle-fish fever in the 1950s when FAO sent its fishery missions around the Third World carrying the promise to eradicate hunger with the prolific and fast-growing tilapia. The country was blessed in 1964 when Nile tilapia (*Oreochromis niloticus*), a fish presented to HM King Bhumibhol by Emperor Akihito of Japan, began to breed prolifically in a palace pond. The Department of

Fisheries built a breeding pond in every fishery station around the country for the fish, which soon was firmly established in Thailand. In the meantime, a pioneering work in the cultivation of snake-skinned gourami (*Trichogaster pectoralis*) in paddy fields was highly successful; the salt-dried fish has remained popular until today. The artificial breeding brought the cage culture of the Pangas catfish (*Pangasius sutchi*) to the limelight; much effort was also devoted to the breeding of the giant Mekong catfish (*Pangasianodon gigas*), with considerable success. Training in artificial spawning of fish went from national to village level, and fishery officers with needles and syringes were a common sight. The culture of catfish (*Clarias batrachus*) stole the scene in the early 1970s, with widespread environmental repercussions on other farming activities for the first time. The fish-poultry, and fish-duck combination were widely practiced. Frequent outbreaks of fish disease dampened the hopes of fish farmers; some fish diseases made the catfish ugly in the eyes of the public. A serious fish epidemic that swept Southeast Asia in the late 1970s was blamed on the catfish. A catfish replacement was found: the striped snakehead (*Channa striata*), a hardy fish that can be kept alive for a long time.

Figure 8. Aquaculture in Thailand

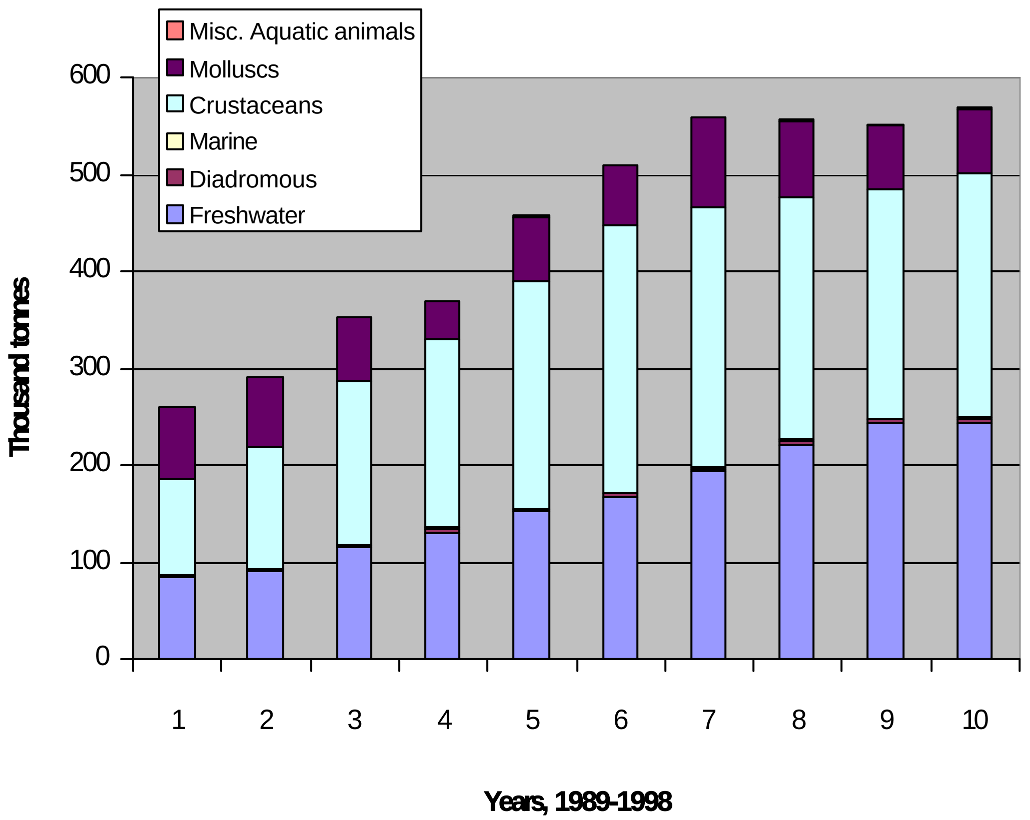


Table 8. Thailand's aquaculture production (in thousand tonnes) of the main species, 1989-1998

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Nile tilapia	21	23	28	43	54	59	76	90	102	102
Catfish hybrid	12	18	29	24	31	34	44	48	53	53
Thai silver bard	13	15	16	24	22	24	27	38	42	42
Snake-skinned gourami	13	12	13	13	15	17	17	14	14	14
Pangas catfish	14	13	15	14	12	13	12	10	10	10
Giant river prawn	8	7	8	10	9	10	8	8	8	8
Giant tiger prawn	81	108	155	179	220	260	257	236	224	240
Blood cockle	13	12	26	19	21	11	14	16	8	8
Blue mussel	59	58	36	14	24	26	51	35	43	43
Thailand	**260**	**292**	**353**	**371**	**458**	**510**	**560**	**557**	**552**	**649**

In 1980s, cage culture was busy with the goby. The marble goby (*Oxyeleotris marmorata*) was a fish of export quality, and the fish market in Hong Kong always had large orders for it. The introduction of the African catfish (*C. gariepinus*) brought Thailand a new hope, given its fast growth rate. The crossing between the tasty *Clarias macrocephalus* and *C. gariepinus* created a popular hybrid that retained the quality of high growth with high quality flesh. In the past decade, Thailand's aquaculture grew 8.7 percent a year. Of the main species, it is clear that Thailand's aquaculture caters to domestic consumption, with the exception of the giant tiger prawn, for which the country has captured a 40-percent share of the world's production. As in many countries, production of the Nile tilapia has continued to increase: almost fivefold in the past decade for Thailand, much greater than the world's average. Pond cultivation of the catfish hybrid and Thai silver barb (*Puntius gonionotus*) has increased the fish supply considerably. On the other hand, the swamp rearing of the snakeskin gourami (*Trichogaster pectoralis*) and pen culture of the Pangas catfish (*Pangasius pangasius*), which face growing problems of pollution and environmental changes, have seen production remain more or less static.

Where aquaculture has to depend on public property, production is harder to secure. Mussel, oyster and blood cockle cultivation are carried out on public property. The fluctuation of the production of these molluscs demonstrates the case.

1.11 Viet Nam's aquaculture

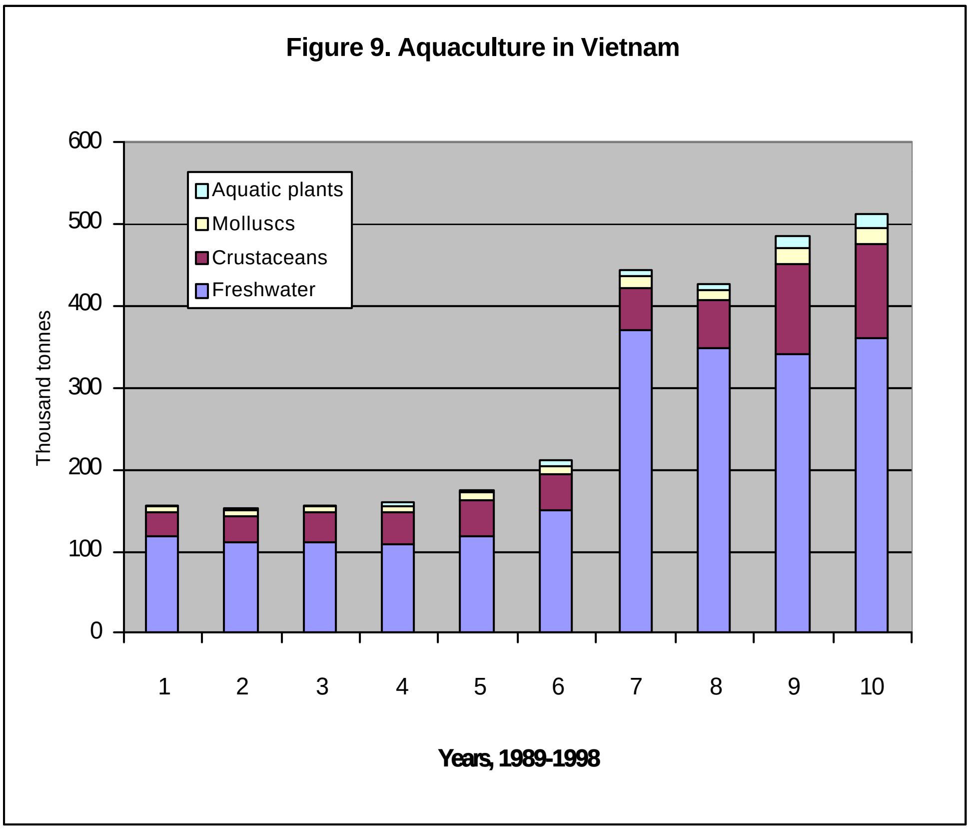
Ranking seventh in the world in terms of aquaculture production in 1998, Viet Nam has brought forward shrimp aquaculture aiming at export markets. As one of five main giant tiger prawn exporters, Viet Nam's production followed all others in 1989. Increasing by an average annual rate of 11.5 percent up to 1996, Viet Nam's giant tiger prawn production rose by 80 percent to 81 000 tonnes in 1997, overtaking the Philippines and India, and became the third in the group. Although the rate of increase in 1998 was a mere 7.4 percent, Viet Nam was able to maintain its third place behind Thailand and Indonesia.

Banana prawn (*Penaeus merguiensis*) has been cultivated in fewer countries than the giant tiger prawn owing to the availability of seeds. All five giant tiger prawn countries, including Singapore and Guam, have been involved in banana prawn cultivation, though the last two only on a moderate scale. Viet Nam's production is second only to Indonesia's; its annual rate of increase was of 17.1 percent during the past decade. Viet Nam's 1998 production of banana prawn was estimated at 23 200 tonnes.

Viet Nam cultivates other crustaceans to feed the export markets, while integrating aquaculture into rural development as a means of achieving food security and poverty alleviation.

Table 9. Viet Nam's aquaculture production (in thousand tonnes) of the main species, 1989-1998

	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Giant tiger prawn	21	23	27	28	32	34	39	45	81	87
Banana prawn	6	6	7	8	8	9	10	12	22	23
Viet Nam	**163**	**160**	**165**	**168**	**183**	**217**	**452**	**433**	**494**	**522**



1.12 The Republic of Korea's aquaculture

The Republic of Korea ranked tenth in 1998 in terms of aquaculture production after the United States and Norway. Even though the annual production was a mere 1.1 percent of the world's aquaculture production, the Republic of Korea's aquaculture is unique in many ways. The main production comes from three species of seaweed, four species of mollusc and one species of halibut.

Of the three countries in the world that have been producing the brown seaweed Wakame (*Undaria pinnatifida*), the Republic of Korea is the leader. The other two countries are Japan and DPR Korea. In a highly variable annual production, the Republic of Korea shared between 60 and 80 percent of Wakame production worldwide during the past decade. On average, total Wakame annual production dropped 3.85 percent per year, leaving the 1998 production at 343 400 tonnes. Although the fluctuation in annual production is least in the Republic of Korea, the 1998 production dropped by 44.5 percent to 239 700 tonnes – some 15 percent less than a decade ago.

Annual fluctuations have also been great on the production of a higher-value seaweed, the Laver, of whose world output the Republic of Korea has about 20 percent share. The Republic of Korea was second to China in terms of growth rate and came third after China and Japan in terms of production. The years 1990 and 1995 were particularly disastrous for Laver cultivation, and 1996 was more disastrous still. The direct environmental influence has been the main factor of unreliability.

On mollusc aquaculture, the Republic of Korea has made key investments in four species: the Pacific cupped oyster (*Crassostrea gigas*), the inflated ark (*Scapharca broughtonii*), the Korean mussel (*Mytilus coruscus*) and the Japanese carpet shell (*Ruditapes philippinarum*). Blood cockle has also been cultivated, on a smaller scale.

Table 10. Republic of Korea's aquaculture production (in thousand tonnes) of the main species, 1989-1998

	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Bastard halibut	0	1	2	3	4	5	7	9	26	22
Pacific cupped oyster	243	219	215	235	258	172	191	185	201	176
Inflated ark	17	18	17	21	12	14	9	20	13	23
Korean mussel	8	10	9	10	55	40	75	70	64	18
Japanese carpet shell	65	62	46	54	10	19	15	18	14	17
Republic of Korea	**404**	**377**	**342**	**375**	**392**	**343**	**368**	**358**	**392**	**327**

Although oyster has been cultivated throughout the world, the Republic of Korea has been next only to China and Japan in oyster production. The Pacific cupped oyster has been popularly cultivated in France, New Zealand and the United States, where annual production exceeds 10 000 tonnes. The cultivation of inflated ark (*Scapharca broughtonii*), a relatively expensive commodity, is confined only to the Republic. Its annual production has varied widely. Nineteen ninety-eight was a particularly good year for inflated ark production since the harvest reached 23 000 tonnes, up 75.0 percent from the previous year. The Korean mussel (*Mytilus coruscus*) is also exclusive to the Republic, and aquaculture there has been relatively successful in the past five years or so. Mussel aquaculture was highly unstable as its production and prices varied widely. The harvest in 1993 was as high as 55 200 tonnes, up 469.5 percent over the previous year. What was rather unusual was that with the sudden surge in supply, the value of the mussel also rose 8.1 percent to US$623 per tonne. The precipitous 72 percent drop in volume in 1998 to a mere 17 800 tonnes also caused the value to drop 58.1 percent to US$231 per tonne.

The Republic has also produced Japanese carpet shells, which are also cultivated in France, Spain, the United Kingdom and the United States. Korea is second to China in terms of volume of annual production, which is highly inconsistent. In fact, this type of aquaculture has been on the decline: a drop of 73.6 percent over the past decade. The production volume for 1998 was 17 200 tonnes.

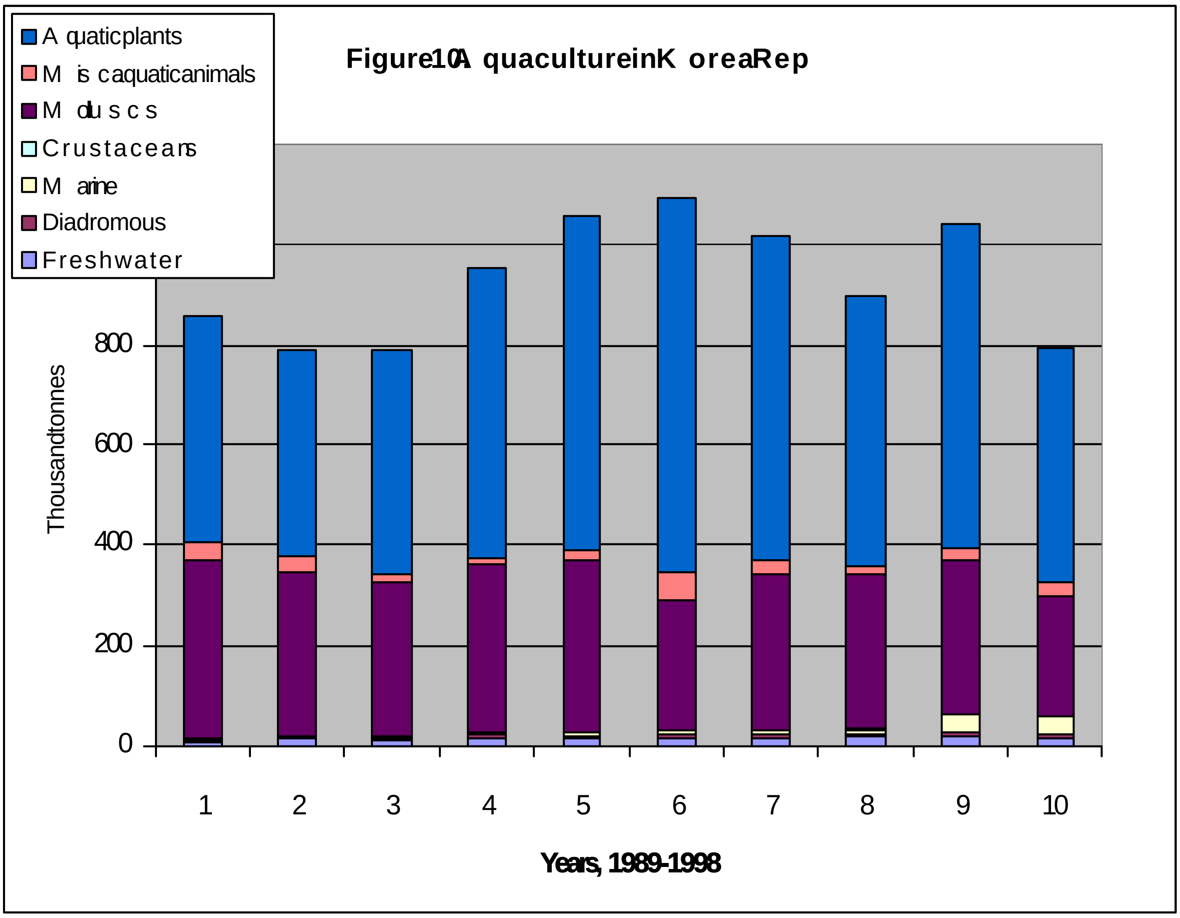
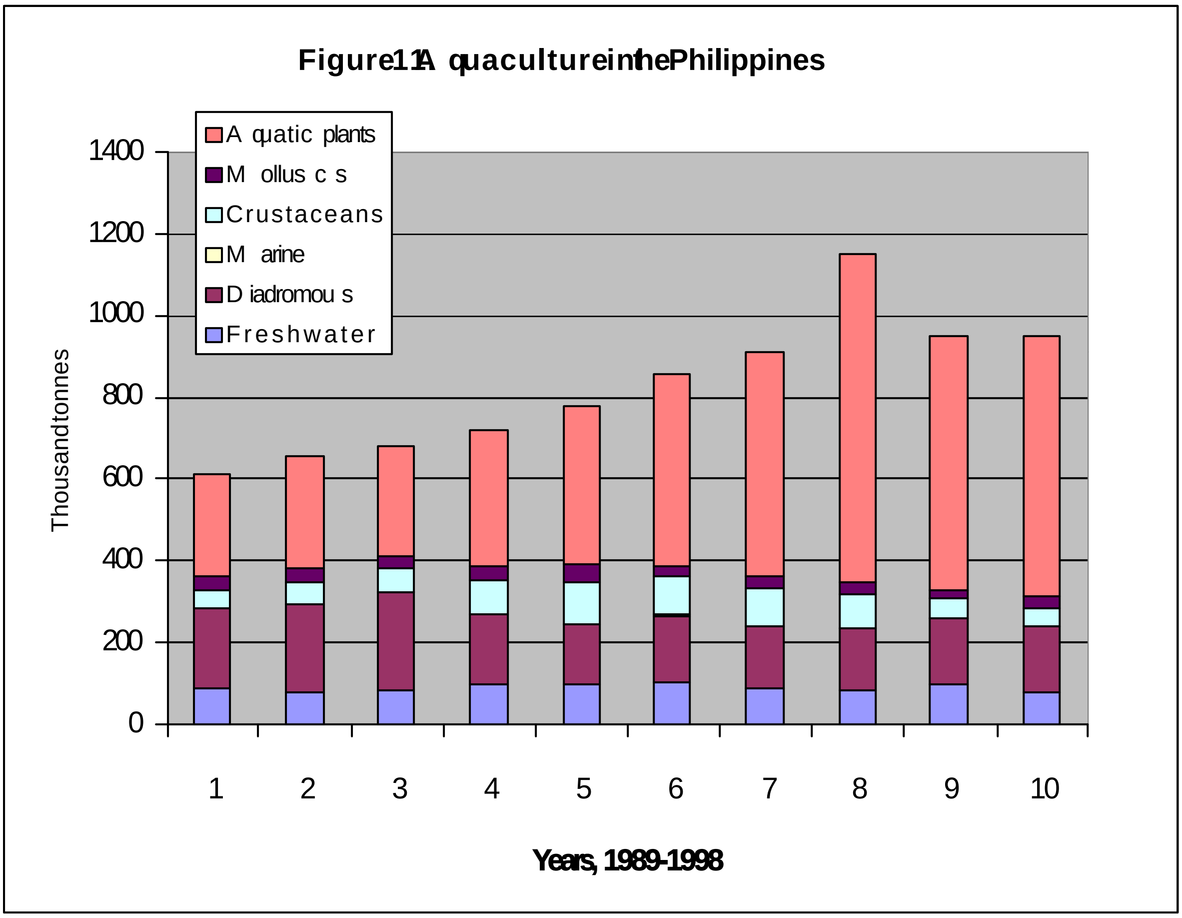


Figure 10 Aquaculture in Korea Rep

The Republic of Korea has been doing well with bastard halibut cultivation, which is also grown in Japan and nowhere else. The production of this high-value fish was only of 249 tonnes in 1989, about one seventeenth of the Japanese production that year. With the average rate of annual increase at 67.8 percent, production peaked in 1997 at 26 300 tonnes. The 1998 production level of 22 300 tonnes showed a 15.2 percent decrease over the previous year. What was remarkable about bastard halibut aquaculture was that the Republic had only a 5.5-percent share, the rest going to Japan. That share rose to 75.4 percent in 1997 then dropped to 74.6 percent in the following year.

1.13 The Philippines' aquaculture

Ranking fourth in the world in 1998 after China, India and Japan in terms of annual aquaculture production in weight, aquaculture in the Philippines was preponderant, with 55.3 percent of aquatic plants during 1989-1998 on average. The share of aquatic plants in the annual aquaculture production was only 42.7 percent in 1989; it continued to grow at a relatively faster rate over other types of aquaculture, and finally captured a 67.3 percent share of the national production in 1998. Excluding seaweed aquaculture, the Philippines ranked ninth in the world in 1998, since Indonesia, Bangladesh, Thailand, Viet Nam and the Republic of Korea had a higher fish and shellfish production. Over 1989-1998, the growth of aquaculture in the Philippines was at the annual percentage rate of 4.7. The overall growth was greatly influenced by the rapid growth of seaweed production, from 268 700 tonnes in 1989 to 642 600 tonnes in 1998, a rate of 10.2 percent per year. The culture of diadromous fish – particularly milkfish (*Chanos chanos*), the national fish of the Philippines – continued to experience negative growth, at the rate of –1.9 percent per year over the ten-year period. The production of freshwater fish also had a negative annual percentage rate, of –1.4; however, the production of Nile tilapia (*Oreochromis niloticus*) grew overall despite annual fluctuations. Commercial marine shrimp farming in the Philippines came to the fore in 1994 when production soared to 90 400 tonnes before declining to 36 800 tonnes in 1998, in line with other shrimp-producing countries. Mollusc production, which was dominated by the green mussel (*Perna viridis*) and the slipper cupped oyster (*Crassostrea iredalei*), experienced less annual fluctuations and remained somewhat stable during the period.



In seaweed aquaculture, the Philippines ranked second in the world, after China. There are four main kinds of seaweed cultivated here, three of which account together for less than 5.0 percent, the lion's share going to the fourth species, the eucheuma seaweed (*Eucheuma cottonii*). The annual production of the green seaweed Caulerpa (*Caulerpa* spp.) was 16 100 tonnes in 1989 and 19 800 tonnes in 1996, but it dropped to 3 700 tonnes in 1997 and in 1998.

Table 11. Philippines' aquaculture production (in thousand tonnes) of the main species, 1989-1998

	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Milkfish	193	211	234	171	149	161	151	150	161	162
Nile tilapia	43	55	59	77	81	74	70	68	78	61
Giant tiger prawn	44	48	46	76	86	90	89	76	40	37
Green mussel	16	18	17	20	25	11	15	21	12	16
Slipper cupped oyster	13	13	12	15	18	12	12	12	14	13
Philippines	**361**	**380**	**409**	**387**	**392**	**390**	**362**	**349**	**330**	**312**

2. Aquaculture issues in the Bangkok Declaration

2.1 THE DECLARATION'S OBJECTIVES

It has been more than a year since the Bangkok Declaration evolved from the Conference on Aquaculture in the Third Millennium held in February 2000 in Bangkok. As a part of the commitments made by FAO, this report is prepared to present the multifarious aspects of aquaculture in the light of the recommendations embodied in the Bangkok Declaration with the hope that they will be implemented. The programme areas identified in this report are for the consideration of FAO in its continued effort to promote aquaculture at global and regional levels.

The importance given to aquaculture as the fastest-growing food-producing sector is justified in terms of its overall production and annual rate of increase. Closer examination of aquaculture activities reveals a high concentration of production in Asia, and in China in particular. Available statistics show that although China has low per-capita arable land and water, aquaculture production in this populous country has continued to rise at almost miraculous annual rates. A number of factors supporting the thriving aquaculture in certain parts of the world among particular cultural, social and political settings clearly lie beyond the purview of biological science and fishery statistics. Multi-disciplinary research may be resorted to shed light on "*China's aquaculture miracle*".

The growing competition for access to basic natural resources such as land and water is a direct consequence of rapid population growth. The per capita availability of these finite natural resources in many parts of the world has shrunk to the dire minimum. Overexploitation of the natural resource bases by man has an impact on climatic changes and on their amplitude. Given the way that the sectoral developmental approach turns planning into "business as usual", the holistic view of the impact on land and water would be too blurred to continue to compete for the use of finite natural resources.

Simple projection of demographic trends in relation to arable land has evolved some worrisome scenarios. Table 1 shows countries such as Bangladesh, Bhutan and Viet Nam as countries where the number of projected population to finite arable land is highest; to their agrarian economies, the shrinking share of arable land is indeed a serious threat to survival.

Availability of freshwater is an inevitable concern of aquaculture promoters throughout the world. Irrigation draws as much as 70 percent of global freshwater for agriculture, and to double its produce to meet global food requirement by 2025, the annual water use by agriculture would have to increase by about 30 percent. The industry sector, which draws 22 percent of freshwater at present, is expected to increase its demand in the future. The growing population would raise the essential human demand on freshwater, which comes before any other use. Several areas of Asia, e.g. in South Asia and China where population densities are high, survive with a very low 2 000 m^3 of freshwater per capita. By 2025, China, with a projected population of 1.5 billion, will have only

1 500 m^3 of freshwater available per capita, while India's 1.4 billion people will have to make do with a mere 1 800 m^3 of freshwater per person.

Table 12. Projected availability of arable land with population growth in selected countries

Country	2000 Population (million)	2025 Projected population (million)	% increase per year	Population/ha arable land (2025)
Bhutan	2.1	3.9	2.61	11.4
Bangladesh	129.2	178.8	1.36	8.7
Viet Nam	79.8	108.0	1.27	7.3
Singapore	3.6	4.2	0.64	7.0
Nepal	23.9	38.0	1.95	7.0
China	1 277.6	1 480.4	0.62	6.3
Sri Lanka	18.8	23.5	0.94	4.6
Lao PDR	5.4	9.7	2.47	4.5
DPR Korea	24.0	29.4	0.85	3.7
Pakistan	156.5	263.0	2.19	3.5
India	1 013.7	1 330.4	1.14	3.2
Myanmar	45.6	58.1	1.02	3.1
Philippines	76.0	108.3	1.49	3.1
Indonesia	212.1	273.4	1.07	3.0
Korea Rep	46.8	52.5	0.48	2.5
Cambodia	11.2	16.5	1.63	2.0
Thailand	61.4	72.7	0.71	1.5
Japan	126.7	121.2	-0.19	1.4
Iran	67.7	94.5	1.4	1.0
Malaysia	22.2	31.0	1.4	0.5
World total	**6 055.00**	**7 823.70**	**1.08**	
Africa	784.4	198.3	2.12	
Asia	3 682.60	4 723.10	1.04	
Southeast Asia	518.5	683.5	1.16	
South Central Asia	1 490.80	2 049.90	1.34	

As a measure to implement Agenda 21, FAO in cooperation with other international organizations has initiated an International Action Programme on Water and Sustainable Agricultural Development to assist developing countries in planning, developing and managing water resources on an integrated basis. To conserve water-quality and water-quantity requirements for optimum agricultural production, and to prevent water pollution, the programme promotes the sustainable management of capture fishery and the development of an environmentally sound approach to intensive aquaculture.

Pollution presents a major threat to the use of the finite water resources. Untreated sewage, chemical discharges, spillage of toxic materials, leaching of harmful products, agriculture chemicals and atmospheric pollutants that come in rainwater all make the use of freshwater unsafe. The groundwater resource has also been extensively exploited by most Asian nations: Bangladesh 35 percent, India 32 percent, Pakistan 30 percent, and China 11 percent. The long-term consumption of water containing arsenic salts has become a serious public health problem in Bangladesh. Excessive groundwater withdrawal has contributed to land subsidence in Bangkok, Jakarta and Manila, and saltwater intrusion has rendered much of the groundwater unusable.

International water sharing has produced frequent conflicts as competition for available freshwater resources increases. Many countries share their freshwater use along international rivers and in groundwater basins and aquifers. The Ganges-Brahmaputra system is shared by Bangladesh and India under a treaty signed in 1997. More than 70 locations, mainly in Africa, the Middle East and Latin America, continue to make the news because of conflicts over access to freshwater. Even within a nation, the nature of open access to public water bodies, on which most aquaculture operations depend, makes them highly vulnerable to resource-use conflicts. Where regulatory and social orders are somewhat inadequate to cope with the conflicts, overexploitation and degradation of the environment are likely to result. Various approaches have been devised to deal with the situation; however, experience shows that this task is too large and complicated for a sectoral effort.

Aquaculture is a term with a broad meaning, which has been revised from time to time to accommodate an evolving situation. It covers a wide range of users, systems, practices and species, from the backyard household pond for traditional livelihood to large-scale aquaculture systems that go on round the clock. The impressive increase in the world's aquaculture output, particularly during the past three decades, has given new hopes to fishery planners in the light of the dwindling production of capture fishery to meet the need for food of the rapidly increasing world population. Aquaculture, particularly of the high-value species, represents a new prospect for many developing countries in Asia and South America to bring forth the foreign currency needed to shore up their economies from the recent economic crises.

The Bangkok Declaration did not fail to address the poverty issue. Poverty reduction has re-emerged recently as a sensational theme that has continued to dominate the debates at various global forums. The popular UNCED Agenda 21 elaborately addressed the issue of poverty, and a comprehensive set of guidelines has been prescribed under it. The year 1995 saw the World Summit in Copenhagen where heads of state committed themselves to poverty eradication. The year 1996 was proclaimed by the UN General Assembly the International Year for the Eradication of Poverty and subsequently the 1997-2006 decade the International Decade for the Eradication of Poverty. Given that aquaculture can be practised in a wide variety of situations, it must have a role to play in the global efforts to eradicate poverty.

From the seventeen different points listed in the declaration, it is clear that the participants in the conference, though largely concerned with fishery and aquaculture development, did not press for an exclusive view on aquaculture, owing to the fact that aquaculture is one of many means to use finite natural resources for the purpose of producing food. In the first three topics, the declaration made it clear that human resources are most important and new knowledge must be acquired so that man can wisely manage natural resources for his purpose. The sharing of information was meant for all stakeholders, who should benefit from new knowledge and technology in food production. The next three items of the declaration address the deprived sector of human society, by aiming at using aquaculture as a means to ensure food security and alleviate poverty.

The declaration noted that some poorly planned and poorly managed aquaculture operations have had a negative impact on the environment. Conversely, aquaculture has also been negatively affected by other, unplanned activities. The note stressed that no activity should jeopardize the others and that the use of technology and observation of the FAO Code of Conduct for Responsible Fishery were meant for the harmonious coexistence that underlies the principles of sustainable development. The objectives of aquaculture development, as stated in the declaration, are:

a) To continue to evolve to its full potential as a food-producing activity that makes a net contribution to global food availability, household food security, economic growth, trade and improved standards of living until it reaches its full potential;
b) As an integral component of the development, to contribute towards the sustainable livelihood of the poorer sectors of community, the promotion of human development and the enhancement of social wellbeing;
c) To promote practical and economically viable farming and management practices which are environmentally responsible and socially acceptable through sound aquaculture policies and regulations;
d) To assent to and apply the framework of relevant national policies, regional and international arrangements, treaties and conventions to further the national aquaculture development processes in a transparent manner;
e) To promote – in cooperation with state, private sector and other legitimate shareholders – responsible growth in aquaculture;
f) To increase the efficiency and effectiveness of aquaculture development efforts by strengthening regional and inter-regional cooperation; and
g) To advocate, wherever appropriate, the use of the FAO Code of Conduct for Responsible Fishery by all parties that undertake to formulate improved policies and implement procedures for aquaculture development.

2.2 THE DECLARATION'S ISSUES

The seventeen aspects of aquaculture listed by the declaration to member states, the private sector and other concerned stakeholders are given as strategic guidelines for carrying out the above objectives.

2.2.1 Invest in people through education and training

The declaration recognizes the most important aspect of development – the human resource. As a practical branch of science, aquaculture provides much opportunity for learning, in terms of variety of species and the various aspects of farming operations. Knowledge of the physical, chemical and biological properties of the soil and water and of the species of aquatic organisms is fundamental. A wide array of scientific observations can be made from ponds where aquaculture is practised. A body of water is a comprehensive ecosystem from which anyone with proper guidance can learn. A pond is indeed a marvellous classroom and a laboratory in itself. The life of fish and other aquatic organisms brings learning of an ecological realm distinctively different from that of terrestrial ones. Viewing aquaculture in this way, the cultivation of fish and other aquatic organisms does not only take knowledge and skills to generate essential food for human: aquaculture can also lend itself to learning and to science.

Fish farmers themselves have learnt a great deal from aquaculture through observation and practice. At the dialogue on “Knowledge for a sustainable food system” held at the UN Headquarters in April 2000, the Commission on Sustainable Development was informed of the central role of farmers in research and development that could be recognized by supporting training programmes of farmer organizations and by increasing research programmes collaborating with farmers from beginning to end. Although the products of the farmers’ learning may not be stored or expressed in scientific language, they can always be disseminated by simple or practical interchange. Traditional knowledge, as it is sometimes called, has gained greater recognition as to its value and usefulness, and increasing efforts in scientific research have begun to explore it in earnest. Fish farmers are practical and useful depositories of knowledge and their abilities could be used in the development of basic science curriculum for rural schools.

Educational systems have continued to evolve and so as schooling in manner and form. Classroom study used to set a classic paradigm which is now about to change in many countries. National educators now accept the fact that not all children can afford formal higher education, and the conventional primary and secondary schooling that prepares children exclusively for higher education should be changed. Shortage of modern educational equipment, particularly in teaching science, was thought of as a deprivation, and most rural schools are simply unable to teach children scientific lessons properly. Parents, who are depositories of knowledge relevant to agriculture and rural lifestyle in their own right, now take part in educating their children under an innovative educational model. It is within the purview of the declaration that such learning and teaching can and should take place.

With aquaculture at the core, its upstream and downstream industries link a vast number of institutions to the chain of food production activities. Using their relationship to chart their cooperation and networking, one can easily see the emerging mutual benefits. Information technology has made networking an easy tool for communication. Aquaculture and its related industries have plenty of materials to keep the network going to everyone’s benefit. Modern training, education and communication tools, e.g. the Internet and distance-learning, could be used to promote regional and inter-regional cooperation and networking in the development of curricula. Scientists may use their skills in exchanging abstract ideas with other scientists in different parts of the world, and subsequently convert them into practical learning material which they can share with fish farmers.

In the scientific spirit, one would not be wholly satisfied with current achievements: scientists always strive to improve situations or things. Current achievements need not be a problem on which scientists normally set to solve, they may one day become less useful, allowing superior replacements to be evolved through science. The multi-disciplinary nature of aquaculture makes it another branch of applied science that offers a greater opportunity of continuous learning.

The suggestions given by the declaration to maintain a balance between practical and theoretical approaches when training farmers and industrial staff are highly relevant. Theory and practice are like the two sides of the same coin. A theoretical approach needs not be impractical; it simply is an effective means for conveying a useful and practical idea. A practical approach needs not be so difficult that it is impossible to conceive theoretically. Once a scientific principle is understood, a theoretical explanation can always be given. All this should make investment in people highly productive. It is in fact the only means to elevate mankind to the next level. The declaration suggests that there must be human resource development for the promotion of aquaculture. In turn, aquaculture may facilitate the development of the human resource.

2.2.2 Invest in research and development

A young branch of science, aquaculture has much to do in terms of research to acquire the knowledge necessary to enable it to move forward. Increasing competition for the common natural resources, mainly land and water, makes it imperative for aquaculture research and technology to be developed rapidly if this food-producing activity is to be kept. Aquaculture is like the youngest child born to a family at a time when hardship is about to strike. It has to learn at a very young age the numerous aspects of life from a great many people.

As aquaculture continues to add new aquatic organisms to the already huge list of fish, shellfish, molluscs, crustaceans, invertebrates and aquatic plants already cultivated throughout the world, there are myriad technical and management aspects that need be learnt to master these organisms. As discussed at the APEC/BOBP/NACA Regional Workshop on sustainable sea-farming and grouper aquaculture held in Medan, Indonesia, in April 2000, bringing grouper under cultivation still requires learning about many aspects, which require to be researched and developed:

a) Domestication: genetics, meat quality, growth performance, feed conversion;
b) Full control over seed production: obtaining and handling brood stock from the wild, spawning, diseases, dealing with capture fishery, rearing brood stock in captivity, sexual reversion, induced spawning, larval rearing, feed, etc.
c) Feed: reliable supply and quality of trash fish, question of net protein supply, pellet feed development, food conversion, cost, ingredients, etc.
d) Cage development: location, materials for net, anchoring, safety, etc.
e) Diseases: types of diseases, prevention and cure;
f) Marketing: credibility, reliability, price, quality of product.

With such a huge task, there is always room to eliminate duplication and waste of efforts. More investment, in terms of funds, manpower, quality of research, application of research results, etc, would be required; however, careful planning to satisfy both short-term and long-term demand must be carried out. The private sector has an important role to play to evolve new technology that is readily applicable for profitable business. The stock of basic research already invested in by various public research institutions is essential for the private sector to move forward. Therefore, the longer-term contribution to public research must be made by the private sector, either in the form of direct contributions or through tax incentive arrangements. While research is being pursued, researchers from the private and public sectors could draw mutual benefit, in terms of additional knowledge and experience, through their constant association. The fragmentation of research and development institutions has notoriously contributed to the duplication of efforts.

The human pillars of agriculture development (researchers, extension workers, and farmers) have worked successfully in the West where the social milieu is favourable. Highly educated people, e.g. scientists and researchers in many countries, often distance themselves from farmers and workers. Such a social predisposition may not be conducive to work in the field among farmers. The social distance between researchers and extension workers can be observed in many societies. Wherever professional and personal attributes are held to tenaciously, the work among the three pillars of agriculture development tends to suffer.

Agricultural services have recently undergone critical scrutiny in many European countries, where government extension services are viewed as inefficient and out of touch with the needs of the clients and of society in general. The trend is to reduce the role of the state and to promote private enterprise. A number of useful principles have been brought into play, such as the notion of public-private goods. Farmers nowadays are forced to compete on the world markets, and they must have high-quality extension services, not only to assist them in handling the constant flow of new and complicated trade regulations but also to sell their products at the maximum profit. Extension services provided by the public sector (from tax money) have been viewed as inefficient, either because employers are not demanding enough or because customers have no power to order service. If farmers' organizations can control the extension personnel, either through direct contract with a private firm or through direct hiring, the services should meet the needs of customers and employers. "Nothing is given at no cost" appears to be the principle. However, extension reform can hardly be applicable across the board, as specific situations differ from one country to the next (Hoffman *et al*, 2000).

The declaration suggested regional and inter-regional cooperation in research and development. This should be viewed with prudence. As with extension services, the social and economic context differs from one country to another, making regional and inter-regional cooperation in research somewhat difficult. There are a number of areas, however, where less location-specific technical applications may suitably support such cooperation.

2.2.3 Improving information flows and communication

The declaration viewed the improvement of the information flow and of communication as a way to manage the sector efficiently, largely by avoiding the duplication of efforts and thus saving on cost. Sharing information is particularly useful in those cases where international boundaries fall within a larger natural ecosystem. The Great Mekong River basin, for example, covers the territories of several countries (China, Lao PDR, Thailand, Cambodia and Viet Nam). Any action taken by any of the riparian countries in, for example, stocking a body of water within the basin with a particular species of fish would eventually affect others. Article 9.2 of the FAO code of conduct clearly prescribes the measures required for the responsible development of aquaculture, including the protection of trans-boundary aquatic ecosystems, support collaboration on sustainable aquaculture, choice of species, surveying distribution of introduced species, and site management.

Article 9.2.4 of the code specifies: "*States should establish appropriate mechanisms, such as databases and information networks, to collect, share and disseminate data related to their aquaculture activities to facilitate cooperation on planning for aquaculture development at the national, sub-regional and global levels*." In collaboration with interested partners, states may develop appropriate means to monitor aquaculture activities and to facilitate policy formulation and development planning. Information and data relating to aquaculture practices and production, economic performance and their impact are indispensable tools for effective planning. In order to save cost, regional collaboration could facilitate the planning of the data collection system to ensure quality output without duplication of efforts.

Information sharing could also help maintain genetic diversity by avoiding inbreeding; maintaining stock integrity by avoiding the hybridization of different stocks, strains or species; minimizing the transfer of genetically different stocks; and assessing periodically their genetic diversity. In cases of disease outbreak, information can help tighten the inspection of trans-border shipments of live aquatic organisms to prevent the pathogen from spreading. Information is particularly useful for marketing purposes; market information services, such as the one INFOFISH provides, can help both aquaculture practitioners and fish consumers.

2.2.4 Improving food security and alleviating poverty

Viewing aquaculture as an underdeveloped sector despite its great potential, the declaration has placed it under the global theme of poverty alleviation, now actively advocated under the banner of the First United Nations Decade for the Eradication of Poverty (1997-2006). To attack the scourge of poverty, the declaration rightly aims at resolving the problems of basic human needs, which have nutritious food at the core.

Inaccessibility to food, the direct cause of hunger, is the combined result of poverty and poor food distribution, not food availability. Food is traded and consumed where there is money and wealth. Of the total food export value of US$436.5 billion worldwide in 1999, Western Europe accounted for US$202.5 billion (46.4 percent), 75.7 percent of which was consumed within the trade region. Asia was the second-largest food exporter, accounting for 17.6 percent of the trade value and using as much as 59.2 percent for intra-regional consumption. North America and Latin America ranked third and fourth right after Asia in terms of value of their food exports. The smaller proportion of their intra-regional food trade was probably due to the smaller population in the two trade regions (Table 13).

Table 13. Global food trade by region

Trade region	Export value (US$ billion)	% in value of global food export	% in value of intra-regional
Western Europe	202.5	46.4	75.7
Asia	76.9	17.6	59.2
North America	69.0	15.8	26.7
Latin America	53.1	12.2	16.6

Source: WTO 1999 Annual Report

The declaration suggested attacking food security and poverty problems at the core by making aquaculture policy focus on the poor. This should mean that the states must understand better the life of the poor, their ability to help themselves, and the assistance that they may need. Unfortunately, such understanding is outside the realm of fishery biologists; therefore, cooperation with a social institution would be necessary to provide information on this aspect of life, which must be well understood before the policy is implemented.

The first half of the first UN decade for the eradication of poverty was spent straining to gain a deeper understanding of poverty. At the top, a large team assembled by the Governance Department of the UK Department for International Development met in August 1999 to put together a synthesis for the *World Development Report 2000/1* on the political responsiveness to poverty reduction. The team, led by Moore and Putzel, produced five strategic guidelines for donors:

a) Democracy has differential outcomes for the poor.
b) States create and shape the political opportunities for the poor.
c) There is no reason to expect that decentralisation will work in favour of the poor.
d) There is a wide range of possibilities for political alliances benefiting the poor.
e) Many of the policies needed to improve governance will benefit the poor.

In a larger context, 117 heads of state and government had met at the World Summit for Social Development (Copenhagen, 6-12 March 1995) on the basis of their common pursuit of social development in the form of social justice, solidarity and harmony, and of equality with and among countries to launch a global drive for social progress and development as embodied in the ten commitments of the Copenhagen Declaration on Social Development. Commitment 2 was dedicated to the goal of eradicating poverty in the world through decisive national and international cooperation, as an ethical, social, political and economic imperative of humankind. In partnership with all actors of civil society, the heads of state and government agreed to:

a) Formulate or strengthen, as a matter of urgency and preferably by 1996, national policies and strategies for substantially reducing overall poverty in the shortest possible time, reducing inequalities and eradicating absolute poverty by a target date to be specified by each country.
b) Focus efforts and policies to address the root causes of poverty and provide for the basic needs of all. Such efforts should include the elimination of hunger and malnutrition; the provision of food security, education, employment and livelihood, primary health-care services, including reproductive health care, safe drinking water and sanitation, and

adequate shelter; and participation in social and cultural life. Special attention would be given to the needs and rights of women and children, who often bear the greatest burden of poverty, as well as to the needs of vulnerable and disadvantaged groups and persons.

c) Ensure that people living in poverty have access to productive resources, including credit, land, education and training, technology, knowledge and information, and to public services, and that they participate in decision-making that would enable them to benefit from expanding employment and economic opportunities.
d) Develop and implement policies to ensure that all people have adequate economic and social protection during unemployment, ill health, maternity, child-rearing, widowhood, disability and old age.
e) Ensure that national budgets and policies are oriented, as necessary, towards meeting basic needs, reducing inequalities and targeting poverty as a strategic objective.

Within aquaculture, many things could be addressed to help the poor out of their social and economic plight. At the national level, the aquaculture policy needs to have clear objectives. Like other types of animal husbandry, fish cultivation is a means to convert low-cost amino acids into some form of animal flesh of the highest possible economic value. Thus, if tilapia and shrimp can both readily take a certain type of feed, the aquatic animal of choice for breeding is clearly shrimp rather than tilapia. However, the profit margin is not the only factor to consider. Given the capital and operating investment, the kind of technology involved and the risk of crop failure are much higher for shrimp. The high costs and risk may lead one to rethink his investment. In China, aquaculture production strives to produce the cheaper freshwater species, mainly common and other Chinese carps. This should not be taken to mean that China prefers cheaper fish to high-valued species. Experience and familiarity for thousands of year with carp have a great influence on Chinese fish farmers when they choose farm animals. Naturally, the lower risk is another factor. The popular cultivation of molluscs and aquatic plants proceeds from the same kind of reasoning. Because of the higher capital investment, operation cost, expensive technology, and risk, the cultivation of high-valued species (diadromous, marine fishes and crustaceans) has been confined to certain geographical areas where cost and risk could be minimized.

Promotion of low-value fish farming affordable by the poor may not sound like an effective development plan that can be taken readily out to the public. It does not make much sense – whether for the rich or for the poor – to do something so cheap and lowly. It is the investment, running cost and the risk that one may talk about: the promotion should focus on the proven technology that helps fish farmers to produce a sure crop of fish at a profit. A highly perishable commodity, fish is often farmed in remote areas where transportation and storage facilities are difficult to find. Harvesting a huge crop can turn into a big problem unless some efficient transportation or post-harvest technology can help prevent it. Another way to deal with the problem is to harvest continually – taking a smaller haul of the fish at a time, but doing so frequently. Researchers may devise efficient gear to crop the cultivated fish in such a way that non-targeted fish remain undisturbed, in order to ensure their uninterrupted growth. Good records could help fish farmers maintain their fish stocks and learn how to maximize the daily weight gain of their fish. This concept has long been learnt in the animal population dynamics, and it should work well for rural aquaculture.

It was with a noble intention that the Bangkok Declaration suggested that information on the nutritional advantages of fish be disseminated widely, so that pregnant and lactating women, their infants and pre-school children may benefit from eating fish – the high-quality protein food. This also applies to Section 2.2.3 above. Consumers have the right to know about the products on offer in the market. Improving the dissemination of seafood market information was one of three issues identified as important by former US State Secretary James Baker when he negotiated on global fish trade with China in April 1996. Creating a market locally is also a florid idea, given that fish is difficult and costly to keep fresh after the harvest. Not only do the local people have access to superior-quality food at relatively low cost, better-quality fish can also be supplied. After all, the poor need not be given only things one considers inferior when rural aquaculture can give them superior food at an affordable price!

The declaration under this subheading sounds very optimistic about the promotion of small-scale aquaculture. It suggests initial public sector support: technical advice, a subsidy or a low-interest loan. It all sounds like a philanthropic project. One may implement development projects with a kind heart, but handing out things without something in return should be taken out of the agenda.

Despite their economic status, small fish farmers or the poor are our equals as human: they must not be treated as if they were begging. In the course of their hard life, they have amassed a wealth of information on how life can be led under adverse conditions. Such information could help development workers to understand their job better, and development agencies would be better off paying for the information than spending their money on free handouts. Participatory research is one of the many ways possible to facilitate the exchange of farmers' information for access to cheap credit.

A note of caution was made on the promotion of Viet Namese small farmers' experience on community-based natural resources management. As long as small-farm activities fit well into the community's plans that draw on basic natural resources (e.g. land and water), they may not deprive the community. Each small farm should be part of the larger community plan in terms of resource use and marketing of output. Freshwater drawn by aquaculture should not deprive other farms and irrigation. Similarly, wastewater from a fish farm must not be a threat to other crops or activities.

2.2.5 Improving environmental sustainability

Where sustainability is the key, any activity such as aquaculture should blend with other activities without causing disruption or incongruence. The first measure is to use basic natural resources efficiently. Efficient use often translates into synergy brought about by a combination of complementary activities, such as aquaculture, horticulture and livestock. Good practice is the second measure that anyone aiming at sustainability must apply. Given that aquaculture is still in its infancy, much more research and development is yet to be evolved. In the field of marine shrimp culture, the role played by the Global Aquaculture Alliance, conceived by 56 people in 12 countries in 1997, in promoting the good shrimp farming practices is appreciated. The third measure is to protect the environment from any negative impact that aquaculture may generate; as a precautionary measure, a multi-disciplinary assessment should be attempted.

In making efficient use of inputs, as suggested by the declaration, one should derive from it the economic meaning of "maximizing profit". All too often, that efficiency translates into maximum yield, which naturally falls under the law of diminishing return when the inputs are increased. This means that only production at a level below maximum yield can contribute to the highest profit. This law is applicable to any input – water, land, seed, labour or feed. Unfortunately, this is not in the interest of the feed or therapeutic dealers, who seek increased volumes of trade. Poultry farms have become the victims of competition among themselves, and the risk in intensive farming is much greater. Here comes another opportunity for poultry drug suppliers: where the crops are on the brink of failure because of the greater likelihood of diseases, the volume of drug sale should soar. The heavy application of chemicals and therapeutic agents in shrimp farms appears to imitate the poultry business.

Polyculture of fish (stocking a pond with complementary species, e.g. the major Chinese or Indian carps) is known to have the fish make the best use of natural, live feed, since each species of fish consumes different kinds of organic materials available in the pond. Stocking with fish of different sizes is also known to have similar results. The success of China and India with these practices needs not be reiterated here. The steady increase of the annual production of the Chinese carps and Indian major carps attests to low risk and to rare loss of crops. With naturally available fish feed and small amounts of fertilizers, polyculture has demonstrated its capacity to produce large crops with hardly any negative impact on the environment.

Integrating aquaculture into overall farming is a smart idea since all farm activities can be linked to water use and nutrient recycling. In semi-arid locations, fish ponds help hold water as reservoirs while the fish are produced. Where the quality of the water must be kept, feeding the fish must be done with care to avoid polluting the culture medium. A farm pond, when dug in proper proportions to its watershed, can retain the water from intermittent rainfalls for subsequent use by livestock and for hand irrigation. It sometimes attracts small game that makes petty hunting a spare-time hobby on the farm. The practice of recycling water, however, may not work in some localities. A large group of rice farmers in Kanchanaburi, Thailand, protested vehemently to the irrigation authority in May 2001 over the deliberate heavy withdrawal of water from irrigation canals, which had left them with insufficient water for their paddy. This is a clear case of resource-use conflict, which can easily escalate into social hostility.

Contrary to popular belief, installing aquaculture facilities on a coastal estate should be avoided. Coastal land almost anywhere attracts all sorts of activities and people and has become too costly for farming of any kind. Most countries in Europe and North America can hardly site land-based aquaculture farms on a coastal landscape. Developing countries may still do so for a few years but the option is fast disappearing. For this reason, development of technology for water-based aquaculture should be given a higher priority.

2.2.6 Integrating aquaculture into rural development

Under this subheading, the Bangkok Declaration handles the same themes in a different way: aquaculture should be viewed within the larger context of rural development. The following five principles are again hammered home:

a) multi-sectoral approach;
b) incorporation of aquaculture into rural development as a means to improve resource utilization;
c) use of aquaculture as an option for improving people's livelihood;
d) involvement of all stakeholders in planning rural development activities, including aquaculture; and
e) wide dissemination of development information.

The first two suggestions recognize the inadequacy of a mere promotion of aquaculture technology. In his attempt to promote integrated farming systems, Altiery (1995) described the original Green Revolution concept as neither helping to improve the livelihood of small farmers nor reducing the vicious circle of rural poverty and environmental degradation. Underdevelopment cannot be addressed solely by improved production and technology. Altiery believes that the social, cultural and economic issues play the larger part in it. In agriculture, high-input technology and practices lead to soil erosion, salinization, pesticide pollution, desertification and loss of biodiversity. In aquaculture, similar practices have caused widespread environmental degradation, water pollution, salinization, and violent conflicts over the use of water.

The next two suggestions put the life of the people at the centre and aquaculture is one of many means that stakeholders could employ to suit their socio-economic settings. This approach is clearly not technology-driven, and fishery specialists may be less eager to provide such a service. Without mentioning the involvement of other sectors in rural development, the last suggestion of providing aquaculture technology should be through the dissemination of information to the widest possible audience.

2.2.7 Investing in aquaculture development

The suggestions made by the declaration deal with both public and private sector development of aquaculture. They recognize the role played by the public sector in infrastructure building, fundamental research and extension services. The public sector contribution is essential to long-term development, as it provides a convenient springboard for the private sector to make profitable interventions. However, public investment largely, if not solely, comes from tax money, which should benefit the public rather than a specific group of people. More direct contributions could come from farm-gate levies for the development of the sector. Here again a strong farm cooperative, or the like, must take the responsibility to manage the collection and spending of funds.

The factors that will bring aquaculture into the limelight are indeed multi-faceted. More financial input should be forthcoming as aquaculture can demonstrate its ability to give a comparatively higher return on investment. Not everyone can speak of success for every site, since aquaculture is strictly geo-climatically specific. Within the natural capabilities to produce, all cultured aquatic organisms can give aquaculture their best performance under ideal natural conditions. Not all locations can meet the requirements of the cultured organisms, and the limitations make site selection a necessity. As different sites come under review, one often finds the ideal ones to be most expensive, the less ideal ones to require extra investment, and there are still those not at all suitable for the organisms that one plans to cultivate.

It is often hard to carry on planning for a specific activity, be it aquaculture or anything else. It is important to make this observation now, since aquaculture development is not always meant to be the prime mover of all compatible farming activities. In most cases, aquaculture is not promoted in isolation; multi-disciplinary development is more likely to be chosen as the central theme.

One obvious concern of those who prepared the Bangkok Declaration is to be found in their suggestion of continued public investment in rural aquaculture and in applied research to help fish farmers in the long run. Those who view development as a dynamic process have no need for such a piece of advice: they already concur. In general, investment can be made in:

a) human resource development, ideally through participatory research;
b) compensatory payment for information that villagers could give to enrich researchers or academics with their traditional knowledge; and
c) some form of rural credit facility to allow villagers to try out their new knowledge about aquaculture or other farming activities.

In order to ensure the sustainability and profitability of an investment, a variety of mechanisms would be necessary to screen them. Once selected, an investment must be subjected to periodic performance assessment. In commercial aquaculture, investors would be required to adopt a code of practice to safeguard the environment and other investors, should the unexpected happen to unleash harm.

2.2.8 Strengthening institutional support

This section of the declaration on strengthening institutional support consists of pragmatic regulatory frameworks that should be evolved through a participatory approach. Such frameworks are seen as tools of certain institutions, which also cater services in education and training, research and extension, to support legislation, policy and regulatory frameworks. As a spin-off, the institutions are supposed to address the needs of government ministries and all public sector agencies in dealing with administration, education, research and development. They would also address the needs of organizations and institutions representing the private sector, NGOs, consumers and other stakeholders. The agencies of all types that help other agencies to function the way they should eventually boil down to one – the government.

There are indeed several forms of government doing regulatory work and they depend on the prevailing political regime. Generally, there are central and local governments (although they may be known by other names) with some other forms of administration. The process of evolving a regulatory framework (legal and judiciary institutionalization) generally rests with a legislative body which prescribes the framework known as the Constitution. Such a supreme body of laws may be called by any other name at the whim of the prevailing political regime. A wide array of other laws would be enacted under the Constitution to address particular concerns. In some instances, there are "soft laws" as well – laws which have not been formally enacted but which are effectively enforced by society: cultural values and power relations. They have become the forms of social structure that we human beings use as social animals to coexist with one another.

The dynamism of a society is such that no law can remain effective and valid to the end of time. At a certain point in time, revisions become necessary to incorporate a new element or to abolish the old and outdated. It is the duty of the state to disseminate knowledge of the amended rule to all those it affects – the law enforcement authorities and the common citizen. This process is held valid not only for the law or other forms of regulations concerning civil or military orders; those pertaining to development would also follow. Aquaculture, a small but vital discipline of food production, is of course no exception.

2.2.9 Applying innovation in aquaculture

Still in its infancy, aquaculture should have plenty of room for innovation. The huge variety of aquatic organisms that can be brought under some form of aquaculture can add up to millions of possibilities. Considering the various forms of technology applicable to aquaculture, the probability of innovation could approach infinity. Within aquaculture itself, new methods for seed propagation, formulation of feed for larval rearing and grow-out operation, for water treatment and water-saving devices, and so on, can be initiated.

Innovation often occurs in the area of advanced technology, frequently from space programmes. New kinds of metal alloys can be used in certain structures that require extraordinary support, such as mooring fish pens at sea. Physical, chemical and biological methods of water treatment have been researched. Water-saving devices in the home and in agriculture can have a direct impact on aquaculture, largely in terms of water availability. Ways to make use of fish and shellfish waste, such as the production of chitosan, not only help solve pollution and waste problems but also increase the value of aquaculture commodities.

The suggestion of the Bangkok Declaration to assemble the known forms of aquaculture technology into an adaptable "toolbox" is an idea that could be implemented immediately by most governments. However, the toolbox should target aquaculture extension personnel, to help them select the appropriate technology for a specific group of farmers. Where the technology is most appropriate, an unplanned extension, although successful in terms of recruiting a large number of farmers to aquaculture practice, all too often suffers from glutting the market, which deprives fish farmers of their anticipated profit. The boom-and-bust pattern of aquaculture and other cash-crop production is well known.

Aquaculture is making critical inroads into many areas. Stock enhancement and ranching programmes are getting into coastal fisheries and ocean fisheries, where common property issues nurture frequent conflicts. The creation of artificial reefs at strategic locations as a means to enhance stock has so far been carried out by public agencies, due to the high cost involved. Although additional substrates where growing biota can sustain more fish stocks around artificial reefs, it remains to be studied, particularly in tropical waters, how multifarious fish species would interact with one another for the eventual benefit of man. Habitat alteration is in fact a form of manipulation that favours some aquatic species and discourages others.

Sea ranching takes aquaculture to much wider spatial limits to allow a known aquatic organism to graze and grow in the open seas before returning home at the time of harvest. Salmon fisheries have set an ideal example for others to emulate. Yet, sea ranching is not a problem-free undertaking: disputes see litigants trade accusations in court over the plundering of grazing fish at sea. As the enforced economic zone has been extended as far as 200 nautical miles when the Law of the Sea came into force, a majority of the grazing grounds along the continental shelves have been taken away from the traditional common-property areas. This legal tussle is expected to continue; in the meantime, aquaculture scientists are free to learn how to create and control fish that will graze the faraway seas.

Eutrophication and nitrification that occur in several tropical seas and freshwater lakes have caused undesirable algal blooms and lowered water quality, sometimes with dire consequences. One way of coping with eutrophication is by limiting land-based enrichment of the bodies of water; however, the cooperation of many types of industry and numerous coastal communities would have to be sought and heavy investment on a complicated and costly water treatment system would be required. Turning to the water itself, biotechnology could be devised to remove the nutrients inadvertently added by some species of aquatic plants and animals. Many kinds of mollusc are capable of filtering microscopic algae that bloom thanks to water enrichment. Many known species of edible seaweeds draw on the available nutrients while they are still in soluble form. Such operation, known as "nutrient stripping", clearly saves the huge cost of preventing eutrophication on the one hand, and produces additional tonnage of nutritious seafood and raw materials for the food and cosmetic industries on the other hand.

Despite the extensive damage to coastal environment that marine shrimp farming has inflicted in many countries, the attractive return on investment has continued to motivate scientists to evolve new forms of technology to make such farming environmental friendly. The ability of marine shrimp to thrive in low salinity provides one option to take marine shrimp farming further inland, where it confronts other major land crops, including rice – a non-saline resistant. Although land-based shrimp farms along the coasts of many developing countries will still be able to compete with other types of land use for some years to come, prospects in most developed countries have dwindled to almost nothing. Eventually, aquaculture scientists will be forced to evolve a "closed system" that shields marine shrimp farming operations from other incongruent activities.

Offshore cage culture has been developed in many countries where the technology for high-value fish crops such as tuna is available. Artificial upwelling is created by huge air bubbles that bring with them to the surface the nutrient-rich water mass of the ocean floor, adding the needed nutrient for occasional algal blooms that attract large shoals of plankton eaters. Whatever aquaculture scientists will devise as their tools in the future will have social and economic implications that they will have to deal with as well.

2.2.10 Improving culture-based fishery and enhancement

Unlike traditional aquaculture, culture-based fishery increases production in natural environments by controlling a part of the life history of certain aquatic species by transplanting their seed or fry into the open waters. The hatchery-produced juvenile fish are allowed to grow on natural foods and propagate until they are ready for harvest. By the very nature of this practice, reliance on the natural environment does not make the rate of return predictable. Estimates vary from 1 to 15 percent of the number released, depending on species and locality. Notwithstanding the low and uncertain return of the released fish, culture-based fishery is practiced in many parts of the world. Its main types include:

a) sea or ocean ranching as practised in Japan with various marine finfish and the Kuruma prawn, and in the Pacific Ocean and Baltic Sea with salmon;
b) coastal lagoon farming, as in the Mediterranean;
c) stocking and restocking in freshwater lakes and reservoirs, such as in China; and
c) floodplain fishery management, such as in Cambodia.

Sea ranching, the release of juvenile fish that are allowed to graze a large aquatic pasture and subsequently return for harvest, has been practiced in the United States (mainly Alaska, Washington and Oregon), Canada, Japan, the former Soviet Union, New Zealand, Iceland and the Baltic countries. The homing behaviour and responsiveness to induced spawning make the Pacific salmon (*Onchrhynchus* spp.) an ideal species for sea ranching. In fact, the Nordic countries began to sea ranch more than a hundred years ago by releasing salmon smolts into the Baltic Sea. Hatchery production of salmon dates back to 1872 in the United States, when the US Fish Commission established its first hatchery on the McCloud River in California.

Despite its hatchery production of salmon fry since 1877, Japan has considered its sea ranching successful only since 1961, when a new method of intermediate feeding and timely release of chum salmon fry was introduced. Among the salmon species raised in different countries, pink and chum salmon are found in countries of the former Soviet Union, chinook and coho are predominant in the Pacific Northwest. Canada has made rapid progress in salmon farming industry in the past two decades. Numerous other aquatic species have been used in sea ranching. Almost half a century ago, Japan initiated a national culture-based fishery project to release the hatchery-produced commercially valuable fish and shellfish juveniles into the Seto Inland Sea. These aquatic organisms included the Kuruma prawn, red sea bream, blue crab, sole, flounder and yellowtail. The success of the project has now convinced the fishermen to carry out the release of fry and manage the propagation work on a national scale to cover all of Japan.

Coastal lagoon farming is a traditional practice in many European and Mediterranean countries. Among the Mediterranean countries, Italy has the largest area of brackish water (called "valli") for the purpose. "Valli culture" stocks commercially valuable species like *Anguilla anguilla, Mugil cephalus, Liza aurata, L. saliens, L. ramada, Chelon labrosus, Dicentrarchus labrax* and *Sparus aurata*. Restocking of the valli is carried out by means of anadromous, natural and annual migration of these species. Artificial restocking is also employed. "Brush-park fishery" is another form of aquatic habitat manipulation that man has used to produce food fish. This low-technology aquaculture has been practiced widely in coastal lagoons and brackish water in many parts of the world. A brush park comes in a variety of forms and sizes and basically consists of an inner core of densely packed tree branches surrounded by a more substantial wooden framework, which is fished periodically, usually by encirclement. Brush-park fisheries under various names are found in Benin, Nigeria, Côte d'Ivoire, Ghana, Togo and Madagascar. In Sri Lanka, brush-park fishery is practised in the Negombo lagoon, from where the practice was exported to Mexico. On a similar idea, artificial reefs have been installed in a number of countries, notably Japan, for the purpose of stock enhancement, coastal protection and demarcation of specific fishing grounds.

Stocking of inland waters has been the most widely advocated practice for the management of freshwater fisheries. Various species of fish (herbivorous, carnivorous, or omnivorous) have been used. While a similar practice is for game or recreational fishery (commercial rod-and-line sport fishing) in countries like the United States, most developing countries practice it to produce food fish from the high yielding herbivores and plankton feeders. More than half of the approximately 2 000 000 hectares of reservoirs in China is stocked with common carp, and other Chinese carps in varying densities, through regular release of large quantities of fingerlings. In many instances, fish harvests from these reservoirs are composed of 90 percent or more of the fish that was stocked. Israel also stocks many reservoirs, built for the purpose of irrigation, with tilapia, mullet and carp. A similar practice is known in Sri Lanka, the Philippines and Thailand.

Several major river systems in the world feature extensive network of swamps, lagoons, lakes and ponds that remain underwater for some months in a year. These seasonal aquatic habitats offer an opportunity for food fish production in many tropical countries. Management of the floodplains for aquaculture takes proper timing to coincide with the seasonality of the fishery and the water level in the floodplain. The majority of tropical fish time their breeding to the annual flood, and their young are raised successfully in the floodplains before returning to the main river systems. Where the inundation lasts longer, the young fish have more time to feed on natural foods and they grow to a larger size. Depending on the topography of a floodplain, physical barriers may be created to direct water through certain channels at the end of the season where fish can be conveniently harvested. Floodplain fishery is widely practised in Africa where large river systems and their associated floodplains exist. Floodplain fishery dates back to the 1940s in Sudan, and some structures were built on the Ubangi River in Zaire as evidence of the practice. Floodplain fishery as practised in Cambodia is well known to most countries in Asia.

Although the economic value of floodplain fishery is not widely recognized, it is believed that substantial quantities of fish from these traditional grounds are underreported. FAO fishery statistics report annual production of 65 to 85 000 tonnes from 1987 to 1997, but the estimates given by a number of observers during an e-mail forum operated by the Network of Aquaculture Centres in Asia-Pacific were in the range of 280 to 445 000 tonnes, four to five times more. This could reflect negligence from many quarters. The improvement of culture-based fishery as a form of aquaculture would involve area planning, which would bring many other non-aquaculture sectors into play. Stocking juvenile fish in a body of water could be taken as a means to shape and strengthen social togetherness. Holding the event regularly should nurture a sense of involvement, ownership or even control. As already pointed out, it took Japan almost a hundred years of continuous stocking of fish into natural bodies of waters until the wide acceptance spread out the practice to the whole country as of 1961.

2.2.11 Managing aquatic animal health

Diseases of fish and shellfish deter aquaculture growth, affect socio-economic development and deprive rural livelihoods. The absence of disease outbreaks in the past cannot be a reason for complacency. The natural process in a pristine environment, which is just the opposite of intensive fish farming conditions, constantly performs self-purification.

An open aquatic environment offers a greater chance for fish diseases to spread far and wide. Recently, Dr Sergio Paone of Clayoquot Sound, Canada, expressed his concern against open net-cage salmon farming. In his view, salmon farms act as disease amplifiers causing pathogens to reach high population levels, something rarely found in the wild. From such concentrated pools of pathogens, the disease can spread by contact between the cultured and wild fish, or by the transfer of effluent or salmon farm sewage. Importation of live fish or eggs for hatchery and farming purposes can cause fish diseases to transfer. According to Dr Paone, such disease transfers have brought wild salmon runs in many rivers in Norway to the point of extinction.

Pond sanitation is the key to fish health. Wherever good sanitation practices cannot be ensured, serious diseases may break out causing partial or total loss of the fish stocks, and with them go the investment, efforts and anticipated profit. Overcrowding of fish due to intensive fish-rearing practices, malnutrition and inferior water quality are known to favour occurrence of diseases among cultivated fish and shellfish. Fish kills can sometimes occur due to toxic algae (blue-green algae and dinoflagellates).

Diseases can be classified according to groups or species of cultivated fish and shellfish affected, organs affected, age of fish, seasons, causative agents and extent of incidence (isolated or epizootic). Parasites come in various forms: bacteria, viruses, fungi, protozoans, worms, crustaceans and mussel larvae. Diseases can occur from unfavourable conditions created by environmental, nutritional and constitutional make-ups.

Coordination and arrangements for fish disease prevention exist with the International Office of Epizootics, EIFAC, FAO and other international and national organizations. The significance of preventive, regulatory and control measures of communicable diseases and the importance of health inspection and certifications should be borne in mind. Diagnosis of common diseases of selected fish and shellfish, including isolation, culture and identification of the more common bacterial and fungal pathogens, and treatment procedures for common diseases, should be put into practice.

In marine shrimp culture, disease is the most notorious hurdle. Once manifest, the disease leads to economic loss, although other indirect damages, such as reputation, trade, employment, transportation, chemical and drug use, and environmental costs cannot be easily enumerated. Subasinghe of FAO (2000) estimates the economic losses to shrimp diseases suffered by developing countries in Asia at no less than US$1 400 million in 1990 alone. The losses were larger subsequently. In coping with fish and shellfish diseases, aquaculture scientists must gain a true understanding of the relationship between host, pathogen and the environment that may trigger a pathogenic incidence. Given the limited success in the prevention or cure of aquatic diseases, Subasinghe described a new and broader approach for preventing farm-level environmental deterioration and a "systems management approach" to aquatic animal health. The approach involves both on-farm management and the management of the environment where farms are located. Broader area planning to ensure safe use of natural resources, particularly land and water, would be necessary to optimize the use of the resources and to minimize resource-use conflicts. Effective regulatory measures keep the environment cleaner than applying chemicals or therapeutic agents, and should be far safer in the long run.

Further research is necessary to address the problem at the core. Subasinghe suggests the following areas for further research:

a) quality control and more efficient and cost-effective use of inputs such as water, seed and feed;
b) the role of good nutrition in improving aquatic animal health;
c) harnessing the host's specific and non-specific defence mechanisms in controlling aquatic animal diseases;
d) development of affordable yet efficient vaccines for economically important tropical fish;
e) use of immunostimulants and non-specific immunity enhancers to reduce susceptibility to disease; and
f) use of probiotics and bioaugmentation for the improvement of aquatic environmental quality.

The application of genetic technology in aquaculture is a recent practice for all but a few aquatic species. This technology can be applied as part of SMA to fish health, to increase disease resistance, and to act as a diagnostic tool to confirm the presence or absence of specific pathogens.

2.2.12 Improving nutrition in aquaculture

Nutrition and feeding strategies play a central role in the sustainable development of aquaculture. Fish will not grow unless their energy intake is in surplus of what they need as daily energy requirements to facilitate movement, feeding and other activities. What is given to the fish in a pond may not be taken readily if their sensory organs are not functioning properly. Biologists too often assume the perfect functioning of the fish's sensory organs despite the varying situations in the environment. Water turbidity often deters feeding of fish that gather food by sight. Floating pellets can hardly be taken by bottom feeders, which sense the presence of food by means of barbels or lateral lines, their tactile organs. Their food gathering faculties often limit the ability of fish to capture food, despite their desire to eat it. Most plankton feeders, such as the silver carp, will find it difficult to chew a hard lump of pellet.

Provided ingestion by fish is ensured, the feed must be nutritious to the extent that its properly formulated ingredients provide all essential amino acids, fats, carbohydrates, vitamins and minerals to the fish at different stages of life. High quality feed should be highly digestible, however, not easily disintegrated while in water before ingestion. Good feed should have a longer shelf life and higher conversion ratios.

High-input aquaculture has been blamed for not contributing to food production since it can be a net user of protein in the form of feed. To many experts, fishmeal is the only ingredient providing the essential amino acids needed by fish to grow. These experts argue for the retention of fishmeal as an essential ingredient of fish feed, while other ingredients that contain other amino acids could be used, as fishmeal substitutes, in feed for livestock.

There is a growing trend to avoid overuse of fishmeal due to increasing demand and dwindling supply. Better use of fishmeal is being sought, for many believe that fast-improving post-harvest technology should make use of the limited supplies of fishmeal at greater benefit to man. The widely publicized issue of genetically modified organisms that are used as ingredients of fish feed has been taken in many different and incongruent directions, due mainly to the lack of a deep understanding of the issue. In any event, genetically modified organisms will continue to be an issue that affects fish nutrition, since several feed ingredients, such as soybean meal, cottonseed meal and certain vegetable oils, will not find easy replacement in the near future.

2.2.13 Applying genetics to aquaculture

Genetically improved fish have been cultivated throughout the world for the past decade. A variety of genetic techniques are employed in commercial aquaculture. These include domestication, selection, intra-specific crossbreeding, inter-specific hybridization, sex reversal, and breeding and polyploidy. Genetically improved fish and shellfish from different phylogenetic families are used. Thanks to these genetic techniques, many traits of cultured fish are improved, e.g. growth rate, feed conversion efficiency, disease resistance, tolerance of low water quality, cold tolerance, body shape, dress-out percentage, carcass quality, fish quality, fertility and reproduction, and harvestability (Dunham, 1995).

Despite a late start, divergent strains of cultured species of fish and shellfish have been developed. The process of domestication helps produce strains of fish that grow faster and whose taste is more palatable than the wild strains after only a few generations. Genetic research and breeding of cultured fish have occurred mostly during the last two decades. Within a species, the availability of strains from different geographical locations and different breeding histories and characteristics makes it interesting to perform an evaluation. Domestication has helped the selection of desirable characteristics, e.g. body weight and texture, coloration or resistance to disease. Sex reversal and breeding and polypoidy have benefited aquaculture production since the late 1980s.

Genetic improvement for better growth and palatability may unintentionally deprive the fish of the immunity needed to defend themselves against infection and natural enemies. Small hatcheries may make negative selective breeding by using smaller brood stocks that are easier to breed. Unsystematic brood-stock management can also result in inbreeding that leads to an accumulation of undesirable genes.

Genetic applications are often understood as a transgenic process which involves insertion of foreign DNA material into that of other species. Genetic improvement has been known to increase productivity and sustainability through higher survival, increased turnover rate, better use of feed and other resources, reduced production cost, and environmental protection. Genetic improvement has been known since the domestication of animals, although advancement has made it possible to deal today with molecular genetics.

2.2.14 Applying biotechnology

Biotechnology, according to the definition given by the Convention on Biological Diversity, is "*any technical application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for a specific use*". The key components of modern biotechnology are:

a) Genomics, the molecular characterization of all species;
b) Bioinformatics, the assembly of data from genomic analysis into accessible forms;
c) Transformation, the introduction of single genes conferring potentially useful traits into plant, livestock, fish and tree species;
d) Molecular breeding, the identification and evaluation of desirable traits in breeding programmes with the use of marker-assisted selection;
e) Diagnostics, the use of molecular characterization to provide a more accurate and quicker identification of pathogens; and
f) Vaccine technology, the use of modern immunology to develop recombinant DNA vaccines in order to improve the control of lethal diseases.

Interpreted in this broad sense, the definition of biotechnology covers many of the tools and techniques that are commonplace in agriculture and food production. Interpreted in a narrow sense, which considers only the new DNA techniques, molecular biology and reproductive technological applications, the definition covers a range of different techniques such as gene manipulation and gene transfer, DNA typing and cloning of plants and animals. Biotechnology provides powerful tools for the sustainable development of agriculture, fishery and forestry as well as of the food industry. When appropriately integrated with other technological methods for the production of food, agricultural products and services, biotechnology can be of significant assistance in meeting the needs of an expanding and increasingly urbanized population in the next millennium.

In its official statement, FAO gives its recognition of the potential that genetic engineering can help increase production and productivity in agriculture, forestry and fishery. Through genetic engineering, higher yields on marginal lands that cannot grow enough food to feed people in some countries would be made possible. This technology has already demonstrated several benefits to man, e.g. reduction of the transmission of human and animal diseases through new vaccines, or enhancement of pro-vitamin A and iron in rice that helps improve the health of the poor. Other biotechnological methods make organisms improve food quality and consistency; they also help clean up oil spills and heavy metals in fragile ecosystems. Tissue culture gives farmer healthier planting materials and higher yields. Faster and much more targeted development of improved genotypes for all living species can be made possible by marker-assisted selection and DNA fingerprinting. These techniques also provide new research methods which can assist in the conservation and characterization of biodiversity. The new techniques will enable scientists to recognize and target quantitative trait loci and thus increase the efficiency of breeding for some traditionally intractable agronomic problems such as drought resistance or improved root systems.

Notwithstanding the vast benefits, concern over the potential risks posed by certain aspects of biotechnology was also expressed by FAO. The risks in using genetic engineering fall into two basic categories: the effects on human and animal health and the environmental consequences. Scientists engaging in these advanced methods have been asked to exercise due caution in order to reduce the risks of transferring toxins from one life form to another, of creating new toxins or of transferring allergenic compounds from one species to another. The possibility of outcrossing could lead, for example, to the development of weeds or undesirable organisms that could upset the ecosystem balance. Biodiversity may also be lost, due to the massive displacement of traditional cultivars by a small number of genetically modified cultivars, for example.

There are numerous areas in aquaculture where biotechnology can be deployed: fish nutrition, genetics, health and environmental management. Certain aquaculture practices, e.g. in breeding, confinement and feeding, can influence the genetic traits of cultivated organisms. The convenient use by many breeders of slow-growing brood stocks or of inbreeding has already had a negative impact in aquaculture: slower growth and sometimes inferior quality of the cultivated organisms which were subjected to the maltreatment over a period of many years. Certain organisms have developed tolerance to low water quality, e.g. the giant freshwater prawn (*Macrobrachium rosenbergii*), which withstands the cultivating condition of low and fluctuating levels of dissolved oxygen. Accustomed to the feeding time, certain cultivated organisms have refused the natural feeds that are plentiful in the pond.

As for the culture medium in mariculture, due care should be exercised not to allow any potential contamination since its spreading may be much harder and costlier to contain. Conflicts over the GMO issue often surfaces in the media around the world, sometimes with emotionally charged accusations. This is partly due to the complexity of the issue, which even scientists of different disciplines cannot come to grips with.

2.2.15 Improving food quality and safety

The overriding objective of aquaculture is to increase the supply of food, particularly fish, shellfish and other aquatic organisms that possess high-quality protein and certain essential minerals. It is not expected that the food would come with something detrimental to health, as this would completely ruin the original intent. It is important that food be safe. Food safety should be more a human right than an economic consideration. To produce high-quality aquaculture products, improvement in diets, feeding regimes and harvesting strategy is what one must consider. The fish trade must follow the tradition of trade of all other foods; and promotion, application and adoption of international food safety standards, protocols and quality systems in line with international requirements, such as the Codex Alimentarius, should be made. There are, in fact, international protocols for monitoring residues of aquaculture and fishery products for traders to follow strictly. Although remaining a voluntary option in many countries, appropriate and informative labelling of aquaculture products should be initiated. National authorities may initiate and maintain collection, analysis and dissemination of relevant and scientifically sound information to producers and industry in order to allow them to make informed decisions in the safety of aquaculture products. As long as consumers have confidence in the aquaculture products developed by the industry, the development of this food-producing sector should be sustainable.

2.2.16 Promoting market development and trade

The measures used by some countries banning seafood exports from certain countries, based on the latter’s failure to observe certain conservative measures, or for other reasons, have made the WTO Dispute Panel and Dispute Settlement Body very busy. As aquaculture products are part of international trade, WTO regulations must be strictly observed and complied with. Given the trade regulations currently in force, producers, processors and manufacturers should be assisted to comply with them. Since access to pertinent information would help both producers and processors to deal appropriately with the market situation, assistance in providing information, or creating a market information system would be helpful. The market information provided by INFOFISH should be taken into consideration.

Information on changing consumption patterns has been maintained by the United Nations, which continue to monitor the progress of UNCED Agenda 21. Voluntary labelling of aquaculture products and providing consumers with pertinent information, such as nutritional values, and environmental friendly characteristics, may be initiated.

2.2.17 Supporting strong regional and inter-regional co-operation

At the regional level, many multi-lateral organizations are active in fishery and aquaculture development. These organizations have a wealth of expertise and information on which national institutions and member states may draw. Organizations like ICLARM, NACA, SEAFDEC and MRC have been promoting fishery and aquaculture in Southeast Asia for many years. The Asian Institute of Technology, located just north of Bangkok, has also been active in rural aquaculture development, and especially its outreach services for North-eastern Thailand, the Lao PDR, Cambodia and Viet Nam. The fish trade information services of INFOFISH have been highly valuable. The FAO Regional Office for Asia and the Pacific, located in Bangkok, is playing a pivotal role coordinating national and regional efforts geared to the promotion of sustainable fishery and aquaculture. The FAO Code of Conduct for Responsible Fishery has been advocated not only by FAO RAP but also by SEAFDEC.

In a give-and-take tradition, assistance to these regional organizations can be in the form of providing relevant and correct information in order to enhance regional information in various aspects. Such contribution made professionally by all participating states should be reflected in the high quality of information upon which all member states depend. Through such information, international collaboration in terms of technical cooperation among developing countries and of information interchange could help promote and strengthen economic and social relationships.

Aquaculture, like many other development sectors, is evolving continuously, and regular monitoring of its progress would be necessary for all concerned. The policy and operational priorities of regional organizations must be adjusted to the changing situation, and the cooperation of member states is necessary.

3. Aquaculture concepts as addressed in the Bangkok Declaration

3.1 THE MAIN TYPES OF AQUACULTURE

The rapid progress of aquaculture during the past decades was measured in terms of the fast increase in volume and value of its production. Commercial aquaculture, particularly shrimp and salmon, made headlines. Small-scale aquaculture in China continued to add production to fishery statistics at an impressive annual rate. All these have formed the general impression about the trend and potential of aquaculture.

The term "aquaculture" embraces a broad meaning in terms of practices, locations, constraints, potentials and even objectives. According to FAO, aquaculture is the "farming of aquatic organisms, including fish, molluscs and crustaceans and aquatic plants". With such a broad definition, both large- and small-scale and high- and low-input would be inclusive. It is noted that while the principal motivations of commercial aquaculture relate to productivity and profit, those of small-scale aquaculture could be anything from food security to income generation, farming diversification, even risk reduction. There are, of course, types of aquaculture between these two extremes; given their broad meaning, it would be meaningless and unnecessary to assign a name to every one of them.

3.1.1 Rural aquaculture

The backyard ponds which some farming families in a rain-fed area maintain to store water frequently hold some fish, either from stocking or naturally. This is aquaculture of a kind, by definition. It is not a tradition of these pond owners to make any serious efforts to manage the pond solely for the production of fish. The ponds, as water storage devices, serve integrated farming as an assurance that all on-farm activities will do well. The fact that "water is life" cannot be ignored, not only in food production, but also in the way we lead our life in general. However, this fact is often overlooked.

Most small farmers anywhere in the world are likely to welcome an offer to have a pond dug somewhere on their farms, not necessarily to keep fish. Aquaculture extension workers often made this welcoming offer when they came with a scheme to promote aquaculture within a specified region and the support of earth-moving equipment, bags of fish seed and fertilizer, and the provision of a short training to familiarize farmers with the way to take care of fish. For most farmers in Asia, keeping fish for food is not something that needs to be taught since fish, by long tradition, is a staple. The use of fish in farmers' daily meal may need some encouragement and demonstration only in places where people are traditional meat eaters.

The reason for having a pond dug on a farm should be clear, particularly where rain is either rare or unpredictable. In a region where rain-fed agriculture is practised, water is a critical factor which determines how much of a crop can be reaped. Having water storage is indeed a form of insurance against shortage. Rain-fed farmers diligently draw water from the pond to give to plants or animals in times of need. Wherever electricity is available or pumping is possible, smart farmers arrange some sort of irrigation to modernize their farming practice and thus save labour. The advantages a small pond provides are obvious. However, while enjoying the benefit of on-farm water storage, some farmers sometimes forget that their small volume of water may not last the entire dry season.

Dried-up farm ponds are a frequent sight in semi-arid farming areas, not simply because the farmers overestimated the amount of water in their ponds but also because evaporation and seepage conspired to dry them. Farmers know that evaporation is a function of the sun: the more sunshine, the faster the evaporation. So, to many of them, water plants such as water hyacinth or water crest come in handy to reduce evaporation by providing the ponds with some shade. So convinced are they of this that most fail to notice the ponds actually dry up faster. The fact is that water plants have a much larger leaf area than the pond surface they colonize; they draw pond water through their root systems and let it evaporate through the leaves to keep cool. Coupled with the low relative humidity and high wind, it takes only a few months for a pond to dry.

The loss of pond water through seepage is largely inconceivable to farmers in developing countries. It should be clear to them that porous soil does not keep water well. Where a good layer of clay or compact silt exists, farmers expect their ponds to be watertight. In some areas of countries such as Bangladesh, the majority of farms are located on vast tracks of the river delta. Clay or compact silt often overlays the porous layers of sand and gravel that once upon a time were carried from the watershed by big floods in some years. The plight of small farmers in those areas is a function of the volume of the pond and of the quantity of water which they wish to store: wherever horizontal expansion was difficult, they had the pond dug deeper into the earth, and sometimes hit the porous layers of sand below. Soil auguring to map the underlying soil layers was rarely performed before a pond was dug. This technique and its usefulness are still unknown in many parts of Asia. When soil auguring is not performed, digging runs the risk of rendering the pond useless for water storage.

The fish released earlier grows while there is still some water in the pond. The last fish is caught and cooked on the day the pond is about to dry up. Before then, fish has been hooked or trapped almost daily, and the farm family has enjoyed the additional provision of nutritious food. Of course, no record is kept of how much fish is taken and eaten. When aquaculture extension workers return to inquire about the performance of the pond in relation to its fish production, the farmers are embarrassed over the current state of the dried-up pond. The Asian Institute of Technology, in its Outreach programme, took such an aquaculture service to the field with a team of graduate students practicing participatory research. In an assessment of the aquaculture performance, they found most of the ponds that they had helped dig had dried up and there was no trace of any fish either. The group of overseas students could not comprehend the situation, given the problems in communication and differences in culture and tradition, and concluded that their outreach programme in North-eastern Thailand had failed to produce the anticipated results.

Given the skills of the AIT graduate students and the conclusions they drew, it should not come as a surprise that millions of these small farm ponds leave little trace in aquaculture statistics. According to an estimate made by FAO, the volume of fish produced by small farm ponds such as these may be as much as six times that officially reported. This gives us some idea of how much fishery statistics may have missed, but not of the total volume of aquaculture production since the base figures are not available.

The foregoing shows that commercial aquaculture does not necessarily represent the whole development sector by the sheer volume of its fish production. Much of the fish production from small farm ponds goes unreported, yet contributes directly and truly to food security. Commercial aquaculture produces a large volume of high-valued products destined for the well to do. It helps to generate more food supply for the world, but, by the nature of its consumers, its contribution to food security could be misconstrued.

3.1.2 Commercial aquaculture

Commercial aquaculture has formally represented aquaculture in terms of statistics, export and national policy support. It has also raised concern over its future potential, as by becoming one of the major natural-resource users, it would become unsustainable. Commercial aquaculture has already opened a new chapter by using biotechnology, particularly transgenic techniques to produce new fish strains that grow considerably faster than the natural stocks. A sudden change in lifestyle in certain rural areas was observed with due social concern, and conflicts between investors who are largely non-residents have flared up in many places. In various parts of the world, the dwindling areas under mangrove have claimed shrimp aquaculture as one of the culprits. In all, commercial aquaculture has brought to many rural communities around the world an upheaval, in terms of its ability to change a large number of inland and coastal landscapes, national fishery policies, export composition, rural lifestyles, and the use of modern technology such as biotechnology. Commercial aquaculture has also brought about many conflicts: incompatibility between marine shrimp and rice farming, pollution from marine shrimp aquaculture that affects other types of culture, pollution from other careless activities that affects shrimp farming, and so forth.

Commercial aquaculture does provide an additional supply of food fish in the world market; however, its contribution to food security may not be realized in the strict sense of the word. Similarly, its contribution by increasing employment and income is evident at the national level; poor and unskilled labour may only take a small share of the cake. Where the local well-off shrimp farmers dispose of their farm products in big lots, rural life may get busy and become disorderly thereafter. Like money, shrimp aquaculture can break many more happy families than poverty does.

As commercial aquaculture benefits directly from research, the private sector has begun to invest in it. For the funding and use of research by the public sector to become more effective and transparent, a careful assessment is required. Although the private sector could have contributed a relatively greater share than the public sector through income tax to fund aquaculture, a more direct tax deduction could provide it with stronger support.

Zoning serves as the means to alleviate problems faced by commercial aquaculture. It can also contribute to reduce the negative impact of shrimp aquaculture on the environment. Like aquaculture development in many Asian and South American countries, shrimp farming in Sri

Lanka is only practiced on a commercial scale in its coastal zone. Much of the shrimp farming occurs in a regulatory vacuum and without concern for the local communities. The situation of shrimp farming in 1998 as reported by Charles Angell was uninviting: most farms were short of capital, poorly sited and managed by incompetent staff. There was a widespread clearance of mangrove in the North Western province, outbreaks of shrimp diseases, crop failures and poor production.

The geographic information system can be used to provide relevant information on physical, chemical, biological and sociological factors affecting coastal aquaculture. Detailed parameters, such as elevation, soil pH and soil texture, vegetation and land use, user conflicts, access to infrastructure, salinity and water quality, can be stored and displayed. This technical information is essential for policy decision, and can help identify the most suitable locations for aquaculture or other activities.

3.2 STRATEGIES FOR AQUACULTURE DEVELOPMENT BEYOND 2000

If aquaculture is to contribute to the enhancement of the world's food security, it should be apparent that the focus must be on small-scale and rural aquaculture. China has been very successful in integrating small-scale aquaculture into the Chinese farming systems and has had an impressive aquaculture output. Within the limitations of arable land and water, the future increase of aquaculture production in China could come from two main sources: a) by making fuller use of on-farm resources; and b) by practising continual thinning to keep the biomass of cultured stock at its highest rate of increase.

Two main scenarios should feature future commercial aquaculture operations in view of their high demand on basic natural resources. First, the development of new technology to make their use of natural resources highly efficient; second, the ability to demonstrate to the world market that the operations are "green" and "safe".

3.2.1 Acquiring new knowledge for those in need

Like its terrestrial counterpart, livestock, aquaculture was practised long before the present name was given to it. The Bangkok conference recognized aquaculture as "diverse" since it consists of a broad spectrum of users, systems, practices and species. The different forms of aquaculture would need a wide range of knowledge to satisfy one and all. Given current knowledge of aquaculture, the institutions of higher learning everywhere would find it a burden to satisfy everyone. Even if they were willing to render such a service, the application of knowledge would not occur easily.

Innovative methods of learning have been evolved in various corners of the world. Some – like the ones this consultant was taught – may not be employed and many could disappear. Learning is a complex process which cannot be reduced to taking pupils to class and expecting them to learn what they are taught.

3.2.2 Participatory research

Participatory research is a simple concept which can facilitate effective learning. The method is designed to select the right persons to work together, and while they share their experience, to have them learn something of common interest. When a researcher makes a scientific investigation in a rural area, his interest may fall on a topic of interest to villagers. If, for some reason, the researcher and the villagers were put to work together, they would perhaps find that they call an object or an idea by different names. If the object under investigation were of common interest, they would learn from one another the different names of something they know. Naming things is the simplest form of learning, which is known as “descriptive”. The participation of two or more individuals of different background in something of common interest could result in sharing useful experience. The learning process they could employ is in the form of experimentation or collection of empirical information to prove their hypothesis.

Due to a serious shortage of trained manpower, many developing countries cannot afford to send their researchers out in the field to do the “dirty work”. After the completion of their high education, they are sent to a lofty office for technical and subsequently administrative jobs. Such a loss of researchers to non-technical assignments was common in most developing countries in the early days when university graduates were few. Even when more scientists have become available, field research may not be viewed as a desirable assignment. These scientists end up doing all sorts of research, mainly in the laboratory or in other pleasant surroundings. Such a mentality can be taken as common.

To attract (or force) scientists to field investigation, for the kind of research likely to address actual rural problems, some mechanisms must be devised. The Land Grant and Sea Grant programmes evolved on this ground, and they are still implemented.

Participatory research in aquaculture can be deployed to address a huge number of research possibilities. A great number of aquatic organisms are awaiting aquaculture scientists’ explorations. Feeding needs not stop at dumping formulated feed into ponds: the methods by which different species of fish gather food are largely researchable.

The association of scientists and rural dwellers could bring benefits to both. The scientists are likely to gain in-depth knowledge of the background of the subject under investigation. The difficulties in explaining the scientific project in simple and non-technical terms could help them before they have to brief the policymakers in easily comprehensible terms. On the other hand, the rural dwellers would acquire a non-formal opportunity to learn something from the researchers about things of high relevance to them or to their community. In the learning process, they may master a few analytical techniques that they may employ later as a tool for lifelong learning.

3.2.2.1 Pragmatism of the multi-disciplinary approach

A multi-disciplinary approach can enhance at different stages the effectiveness of research and the dissemination of its results. At the planning stage, each member of the multi-disciplinary research team can contribute his background, expertise and database to the planning, making it complete and comprehensive. Often, certain research objectives can be satisfied with the results of a discussion or multi-facetted analysis of the data provided by the members of the multi-disciplinary research team. This results not only in pooling existing knowledge at the planning stage, but also in a comprehensive research plan which saves time and the effort of gathering evidence in the field.

Each member of a multi-disciplinary research team can also contribute to the design of field data-gathering methodology. The survey form designed by such a research team is more likely to be comprehensive and better formulated. Social scientists on the team often help improve a questionnaire, making it more effective to solicit factual answers from respondents of different social backgrounds. A good question is more likely to obtain a good answer.

The gathering of field data is indeed costly, as it involves the physical preparation and logistics to facilitate the work of research personnel in the field. Seasonal factors have to be observed for both safety and research considerations. Well-designed research can often minimize fieldwork, resulting in less drudgery for the research personnel.

Multi-disciplinary analysis of field data often yields deeper knowledge of the object under study. No single-discipline scientist can derive the full meaning of a set of field data extracted from real life in a natural setting. Aquaculture, for example, does not concern exclusively the live of aquatic organisms under cultivation; it also concerns the life of the man who operates the farm. The fishery biologist is adept at interpreting fishery biology data and the physical benefits derived from such biology, whereas the social scientist can help interpret the motivations and concerned attributes to actions of the fish farm operator. A synthesis of these multi-disciplinary views would make a comprehensive analysis of the same set of field data, resulting in research of a better quality for a relatively low investment.

The results of multi-disciplinary research often aim at benefiting certain groups of beneficiaries, and the dissemination can very well be carried out in an effective manner. One important but often-neglected aspect of sharing research information is sharing among scientists who are members of a multi-disciplinary team. The exposure to research methodology, analysis, attributes, and interpretation of data by other scientific disciplines can contribute to better cross-sector communication among subject matter specialists. The assembly of a multi-disciplinary research team can therefore benefit in several ways: a) by formulating a broader-based research plan which addresses priority development issues better; b) by better sharing information already researched by different scientific disciplines, which the team members contribute at the planning stage; c) by minimizing time, efforts and cost in gathering new data; d) by a more complete interpretation of new data, leading to a better assessment of the development issues; e) by exposing each member of the research team to other scientific disciplines and gaining wider association with specialists, who by profession think differently, thus contributing to stronger professionalism; and f) at the national or international levels, by increasing the ability of team members to work together, and thus achieving the desirable intellectual strength necessary for effective development endeavours.

3.2.2.2 Making a net out of a pipe

The traditional methods of dissemination of technical information to users chart three players in the game. Like most other technical disciplines, aquaculture has been supported by a) researchers who evolve technical know-how, b) extension workers who digest the technical information into a simpler and comprehensible form, and convey it to fish farmers or producers, and c) fish farmers, who acquire the technical information from extension workers and apply it to their farms. Researchers are expected to evolve a technology which can be translated by extension workers into useful and comprehensible information disseminated to fish farmers. In many developing countries where strong disparities remain in the social hierarchy, most researchers would have little interest in the lowly status of farmers and their welfare. Socially induced ignorance contributes to the irrelevance of their research work in relation to the prevailing problems faced by farmers, and consequently renders it useless even if the extension services continue to disseminate them. In such a social system, it is taken for granted that whatever is given from the top should be taken with gratitude. The information only flows from top to bottom, and since the farmers find no mechanism to voice their grievances to the researcher, nothing will flow back from bottom to top.

In countries where the social hierarchy has more or less dissolved, a farmer can walk into a public office to demand technical information relevant to his needs. Since employment in such a country can only be guaranteed by a high level of performance, it is the interest of the researcher or public office bearer to produce the kind of service that meet the user’s need. Attention must be paid to the welfare of farmers and fieldwork is viewed as an essential part of the job. The long tradition of a number of land-grant colleges and universities in the United States that have participated in offering programmes in agriculture, engineering and home economics to the public arose from the 1862 Morrill Act, which was expanded with funds for research under the Hatch Act in 1887. The close collaboration between researchers and farmers transforms the “pipe” into a network in which the extension can still serve as go-between playing both sides of the field.

3.3 INFORMATION FOR DEVELOPMENT

Information is an asset. This is largely true in highly competitive societies where people are equipped to deal with logic or abstract ideas. Information is also an asset in commercial circles where the first person to acquire certain information can have a competitive edge. Information is highly valuable when it is a trade or military secret, since it can be used to harm or threaten others to advantage. Information on health is an asset since we can use it to stay in shape and avoid ailments. Information is valuable where an intellectual recipient can apply it to a good, gainful or intended purpose. Years of formal education expose students to the ways of logic, the ability to relate and digest certain informational attributes and to put it to work.

For those with less schooling, logic is something highly abstract and incomprehensible. Information often comes as signs, either statements on paper or sounds on the radio or pictures on television; it is also expressed by verbal or body language. Unless recipients can decipher the signs or signals efficiently, the information does not get through to the intended target. Nonetheless, information continues to be the only input that will generate analysis and resultant knowledge, and it must continue to be supplied. The point is whether supplying information to farmers and the poor is helpful; my view is that it is most unlikely that it would. Too much effort would be needed to give them back the schooling opportunities that they have missed. Too much effort would go into mere dissemination of information. The aim of supplying information should not be a technological transfer or the short-term increase of a farm produce: it is human resource development. The aim is to make people continue to learn from information they later seek. Learning is a lifelong endeavour.

4. RECOMMENDATIONS ON IMPLEMENTATION OF THE DECLARATION

4.1 THE CHARACTERISTICS OF THE BANGKOK DECLARATION

Judging from the issues embedded in the Bangkok Declaration, the first two directly concern human resource development and the third the means to achieve it. The fourth is the social and economic goals; while the fifth, sixth and tenth suggest a multi-disciplinary approach. The three in between are more on aquaculture development, over generation, formalization and utilization of technology. The eleventh through fourteenth deal with high technology, probably outside the realm of poverty if the failure of the Green Revolution is accepted. The penultimate two concern food distribution and trade, which can be regarded as downstream aquaculture activities. The last one is of course the interest of most participants to and sponsors of the conference, and it is indeed an important issue to strike home.

To implement the declaration is obviously not exclusive to fishery authorities, whether at the regional, national or sub-national level. Management of common resources appears to be buried in rural development. Studying the declaration, one may get a feeling that the situation we will face in the future will be more or less what it is today. Naturally, such feeling does not conform with the projections of many world organizations over population, land and water management, pollution, environment or even climatic change.

As one of the regional instruments, the Bangkok declaration provides a useful set of guidelines for future development –in aquaculture as in other food-producing activities. The declaration can serve as a useful reference for regional organizations, national authorities and technical groups in their exchanges of information and knowledge. Finally, it should be viewed as something useful for joint undertakings, and as a new and broader perception about aquaculture.

4.2 REGIONAL ORGANIZATIONS FOR AQUACULTURE DEVELOPMENT

The existing organizations, particularly those active in aquaculture development, such as ICLARM, NACA, SEAFDEC and MRC have been making efforts in line with the objectives of the Bangkok declaration. Although their mandates have been conceived at different times and in different places, these organizations can complement each other in the implementation of the declaration.

In the past decade, ICLARM placed its focus on research into the integration of aquaculture and agriculture (IAA) systems in Asia and Africa. The main purpose was to benefit small farmers the way they manage their meagre resources through the involvement of farmer-researcher teams and to underscore the importance of water as the life-essential commodity. ICLARM spent nine years developing the RESTORE software, which has now been released, to help determine IAA sustainability indicators. Since the year 2000, ICLARM has undertaken a review of inland aquatic resource systems to define research agendas for aquaculture and fishery development in inland aquatic resource systems, e.g. reservoirs, small lakes, floodplains and wastewaters. Earlier, ICLARM invested in integrated resource management to improve land and water resource management through IAA. ICLARM has developed participatory research procedures for farmers to use the IAA approach. Under IAA, farmers will develop skills to manage the finite natural resources. RESTORE has been distributed to other agencies for testing, and ICLARM has been employing the software in its projects.

ICLARM has also focused on sustainability. Over many years, ICLARM has developed and tested a set of sustainability indicators for evaluating IAA performance on small farms. ICLARM has formulated a range of simulation models of IAA systems at different levels of integration; and these models have been disseminated through various means, including training.

Aiming to reach the poor, ICLARM also concentrates its efforts on low-external input technology. A project in Bangladesh, which ended in the year 2000 after eight years of implementation, reviewed its experience of IAA in collaboration with national aquatic research agencies to test several low-input models. ICLARM has had experiences in working with NGOs testing IAA and monitoring the results. In a variety of socio-cultural contexts, such as in Bangladesh, in the Lao PDR and in Africa, ICLARM worked to measure the adoption and dissemination of technology and its impact on small land-holders. Its aim was to advise policymakers on how to maximize the impact of development efforts.

ICLARM has ventured into locations on earth where water was precious and has taught people through aquaculture and by learning-from-doing, how to make the best use of scarce resources for sustainable livelihood. ICLARM sought to work outside the fishery sector, inter alia, with forestry and agriculture, and local administration. ICLARM has much experience in fish-rice systems, having studied alternative resource management strategies in flood-prone ecosystems to develop, through a participatory approach, options for viable income generation which have been found to work well. Overall, ICLARM has been working in the field, under a wide range of socio-economic, geo-climatic and physical conditions, collaborating with other concerned sectors such as forestry, agriculture and rural development, using aquaculture as an option to work hand-in-hand with the poor in order to improve their livelihood by optimizing scarce natural resources.

The Network of Aquaculture Centres in Asia-Pacific (NACA) has been serving Asia and the Pacific with its effective chain of aquaculture centres for research and exchange of information, which make it possible for its member countries to share common benefits. NACA deals with all the technical aspects of aquaculture. The organization has devoted much effort to shrimp and grouper aquaculture, resulting in its fast development from a haphazard venture to a sustainable and profitable primary business. NACA has worked with various agencies, national universities, donors and development banks. Particularly, it has developed close working relations with most national fishery authorities in the region.

Another area NACA has taken a keen interest in is the Regional Technical Cooperation Programme in Assistance for the Safe Trans-boundary Movement of Live Aquatic Animals in Asia. This programme involves 21 governments and multi-agency collaboration implementing measures guided by the FAO Code of Conduct for Responsible Fishery. The project offers to provide a unified platform on the development of technical guidelines for quarantine, certification and reporting for all concerned agencies.

NACA has been involved in the collection, analysis, organization, processing and rapid delivery of farm-level data and information from 16 countries to guide actions at different operational levels. Quick access to a huge volume of aquaculture data would support any review and analysis of various types of aquaculture ventures to provide solid background information when planning a development or commercial undertaking. As an agency collaborating with FAO in setting up the conference leading to the Bangkok declaration, NACA has been active in assisting governments in formulating policy, legislation and management plans for sustainable aquaculture development. Through a strong information programme, NACA has been offering different forums in which interested individuals or agencies can participate and draw benefit from.

The Mekong River Commission (MRC) agreed formally in 1995 to cooperate in all fields of sustainable development, use, management and conservation of the water and related resources of the Mekong River basin. Its core programmes are in navigation, flood control, fishery, agriculture, hydropower and environmental protection. Its national Mekong committees act as focal points for cooperation and for liaison with the secretariat.

From May 2000, MRC signed an agreement with the Danish international aid agency DANIDA that made financial support available to a five-year programme of management and preservation of fishery resources in the Mekong River Basin. As one of seven components funded by DANIDA, MRC is supporting a project on aquaculture of indigenous fishes for a period of five years from July 2000. MRC also supports the strengthening of fishery information systems under a 36-month project as of July 2001, aiming to train fishery statisticians in standard methodology and classification, including setting up a system for dissemination of the information to different clients. From January 2002, MRC aims to promote, over the next four years, aquaculture in mountainous areas through a watershed-based approach and to conserve local capture fisheries in remote locations. Under the Water Utilization Programme, MRC will also assist member countries to promote and improve joint water management of the Mekong River basin.

Signed on 6 March 2000 was a partnership cooperation between the Asian Development Bank and MRC which involves, *inter alia*, water resources planning and management, environment, navigation and river works, energy, human resources development, agriculture, fishery, forestry and watershed management, poverty reduction and tourism. MRC will give ADB access to data and other information relevant to the bank's development activities. In return, ADB will provide MRC with information and documents in the fields related to the activities in the Greater Mekong River basin and studies in the MRC member countries.

A US$4.5 million programme of Management of the Reservoir Fisheries in the Mekong Basin, Phase II, which began in March 2000, aims at sustaining per capita fish consumption and to increase fish production by about 20 000 tonnes a year. The programme will develop, test and introduce models for reservoir fishery co-management, and develop co-management strategic guidelines to be applied in the four member countries. The co-management will build the capacity of the various stakeholders in the management of reservoirs at national, provincial and local levels. The three-year Phase I, also financed by Denmark, includes activities in the Lao PDR (Nam Ngum Reservoir), Thailand (Sirindhorn Reservoir) and Vietnam (Central Highlands).

The Aquaculture Department of SEAFDEC has been active since 1973 in the promotion of aquaculture, particularly among its member countries. The department specializes in training that imparts different aspects of aquaculture technology. It has emphasized research which delves into those technical aspects of aquaculture that will also support its training on innovation in aquaculture. During the past decade, the department has been active in a resource co-management programme in a number of locations in the Philippines, and during the past few years has expanded to other SEAFDEC member countries.

In summary, it can be stated that the existing regional organizations involved in fishery development in Southeast Asia (ICLARM, NACA, MRC and SEAFDEC) have a productive blend in their programmes of action, which not only support the efforts of their member countries but also complement each other.

As stated by the Bangkok Declaration, states, the private sector and other concerned organizations are encouraged to implement the Strategy for Development of Aquaculture Beyond 2000. In the short span of time since the Kyoto Conference, aquaculture has become considerably more diverse and a wider range of stakeholders are involved in it. The declaration views greater diversity in aquaculture as a greater opportunity for productive co-operation.

The great diversity and complexity of aquaculture offers plenty of opportunities for international cooperation. Cooperating countries may derive mutual benefit from joint research programmes, e.g. in field-testing scientific findings in widely different environments. Given the large number of subjects to be researched, allocation of research responsibilities at the planning stage should enable developing countries to avoid duplicating efforts and make effective use of limited resources. The sharing of technical experience, of educational material and of information is another area of mutual benefit for cooperating countries. In the area of fish health, international cooperation would generate mutual benefit when virulent fish diseases could be contained.

The existing regional and international organizations have been active in the promotion of aquaculture. As specialized agencies, they have plenty to offer in terms of technical assistance. Their frequent and familiar contacts with their counterparts at national and sub-national levels have fostered a rich exchange of technical expertise, and a good number of technical innovations have transpired. The role that these regional and international organizations play has indeed helped shorten development processes in aquaculture, and the emergence of aquaculture as the fastest food-production sector should be credited to their efforts.

As aquaculture is leaping forward into unfamiliar ventures, cooperation among the expanding groups of stakeholders would be necessary. Aquaculture should not be viewed strictly from its technical perspective, since its future prosperity and sustainability depend on many other aspects, such as political or socio-economic influences. Within the technical realm, aquaculture must be broadened to embrace biological science as well as other natural sciences, engineering, computer science and physics.

4.3 GLOBAL AND REGIONAL INSTRUMENTS

While technical inputs are essential to all socio-economic development efforts, political commitments are also indispensable. Few countries in the world, particularly developing countries, have been able to maintain their national policies over a long period even after the end of a leader's tenure of office. Of the five types of political systems usually acknowledged (collapsed states, personal rule, minimal institutionalized states, institutionalized non-competitive states, and institutionalized competitive states), the last type has had the greatest benefit for the poor. National leadership in most of the developing world is taken under either long-lasting dictatorial rule or short-lived leadership which two or more rival groups whose national policies are usually very different take turns to hold. Politics and development, particularly the efforts to narrow the income or social gap in favour of the poor, has been the subject of great interest in this United Nations Decade of Poverty Eradication. In a study on politics and poverty, Moore and Putzel (1999) provided from their analysis five strategic guidelines for development:

a) Democracy has differential outcomes for the poor.
b) States create and shape the political opportunities of the poor.
c) There is no reason to expect that decentralization will be favourable to the poor.
d) There is a wide range of opportunities for political alliances in favour of the poor.
e) Many of the policies needed to improve governance will benefit the poor.

The main concerns have been expressed in countless public gatherings. The statement given by the chairman of Transparency International, Peter Eigen, in a conference on Integrity Improvement Initiatives in Developing Countries which was held in April 1998 in Berlin, sums up the situation:

“Corruption is present in almost every country, but has most devastating effects in developing economies because it hinders any advance in economic growth and in democracy.”

The global instruments evolved over time have brought nations together, notably under the United Nations umbrella, to assist one another for the ultimate benefit of mankind. Eminent experts who contributed to these global instruments partook of their experience, on which they seriously debated to distil the best and justifiably fairest quality rules. The United Nations Conference on Environment and Development and its Agenda 21, the Cancun Declaration, and the FAO Code of Conduct for Responsible Fishery are just a few pertinent instruments for fishery and aquaculture development.

Efforts have been made to promote the adoption of these global instruments by national authorities, which are expected to translate them, within the local context and situation, into action. Agencies such as SEAFDEC have made efforts to regionalize the FAO code of conduct through seminars and workshops. National administrative fragmentation has made it difficult, in most cases, to realize the result in a relatively short time. After a long while, efforts become dull and people often face them with indifference.

Sectoral development through technical assistance has been pursued in developing countries, largely as short-term interventions. Upon the transition to a new technological level, the communities tend to abandon the old to accept the new. The capability of people in such communities is, in fact, the instrument of change, not technology per se. For this reason, lasting developmental impact rests upon the human resource, which can be developed through life-long education. Unfortunately, this area within the FAO mandate is one which has no active programme, according to Seilert (2001).

Poverty is a debilitating experience unnecessary to humankind. It is fostered by social distortion and inequity. It results from a lack of opportunities due to an unkind social environment and the inability of individuals to imbibe information and knowledge. To address this problem, many development themes have promoted a “pro-poor” concept, which “puts the people at the centre”.

The cerebral cortex, the outer layer of the brain, is identified as the seat of learning. The child begins to learn the moment it perceives the world. Learning is the acquisition and storage of information in a way that allows its use to modify future behaviour. Although the Swiss psychologist Jean Piaget believed that intellectual development moves through set stages at each of which the child is capable to learn different things, his views have been challenged by British psychologists Barbara Tizard and Martin Hughes, who believe that children may use more complex ideas in conversation with their mothers than they reveal to teachers or researchers (Richmond, 1989). Mothers are teachers by nature, merely in the way they nurture their children, and they are directly involved in the process of learning. For this reason, involving women in development is thought to be a better way of getting more individuals through the learning process, and most pedagogic circles are fully convinced that “teaching a man, an individual learns; teaching a woman, learning is for the entire family”.

The involvement of foreign experts, no matter how experienced they are in their fields of expertise, is costly due to high remuneration and the disbursements involved in their relocation. Since learning takes place from early childhood, parents and the communities are in fact the most suitable persons to teach. Laboratories or well-equipped classrooms should facilitate faster and better learning, provided different scenarios can be manipulated to reveal clearly the essence of the lessons the teacher intends to impart. Most poor communities, particularly in developing countries, cannot afford to have such an arrangement, not only due to the cost involved but also because of the lack of ideas. A number of rural children have grown up with nature, advanced through the formal education system and finally become learned persons. Nature and the environment are, in fact, the most convincing laboratories or classrooms for continuous learning, should every opportunity that arises be captured for a lesson. Many development agencies, such as ICLARM, have begun to exploit the learning opportunities that always exist in the lives of rural people; and through “participatory learning”, outsiders and villagers can together learn the flow of lessons that are useful and pertinent to living.

4.4 FOCUS ON LIFE-LONG LEARNING

Schools, colleges and universities in many developing countries produce and serve elites that have the means to send their children to expensive courses where they receive the best tuition. Most farmers, villagers and the poor have no such means. Society thus drifts towards more intellectual inequity, and consequently wider social and economic gaps. The nation gradually falls apart; and if an unbecoming political situation develops, social and economic chaos is almost at the door. No one in such countries is happy, for the closest environment (neighbours, friends, fellow human beings) is already polluted. Universities and institutions of higher learning are generally well equipped to teach and train for development. The International Development and Research Centre-assisted programme of the Vietnam Farming System Network, should be observed closely. Most countries in Southeast Asia should be more or less ready to mount such a programme. Democratization has helped streamline the administration and educational systems, making them more conducive to mutual learning.

Higher education and research are an inseparable pair, particularly in the field, where innovativeness makes a great economic difference. Involving university postgraduate students in research as a degree requirement has been attempted before. Most agricultural universities have elaborate networks of experimental stations where the students can work on the farm or nearby. FAO was involved in such a programme in Egypt, Jordan, Morocco, Sudan and Tunisia. However, the objectives of the programme were limited to higher learning, leaving the farmers out of the learning process. The Land Grant programme continues in the United States but it is not limited to agriculture. As much benefit could be gained by the parties involved, FAO should, were we to decide to help along, make sure that the primary objective was to involve the farmers and the poor in life-long learning. The activity is a human resource development, and it is humans who can ensure the sustainability of technology already transferred or yet to be evolved.

5. THE ROLE OF FAO IN PROMOTING SUSTAINABLE AQUACULTURE

The role of FAO is governed by its mandate as specified in its constitution. Briefly, it falls within the areas summarized by Seilert (2001) as follows:

a) to collect, analyse, interpret and disseminate information;
b) to promote research and education;
c) to promote conservation of natural resources;
d) to promote improved methods of production, processing, marketing and distribution;
e) to promote the adoption of policy, national and international frameworks; and
f) to furnish technical assistance including support for the implementation of the purposes of the organization.

Among the programmes already identified in the FAO Strategic Framework 2000-2015 and FAO Medium Term Plan for 2002-2007, none supports the role of promoting research and education. This area is specified in the first two items of the Bangkok declaration and should be proposed for inclusion in the Medium Term Plan for the subsequent years.

In the area of improving information and the flow of communication as stated in Item 3 of the declaration, FAO has had many programmes, e.g. development of the Fishery Global Information System, Provision of Fishery Information and Statistics, Marine Fishery Resources Identification and Biodata, Global Monitoring and Strategic Analysis of Inland Fishery and Aquaculture, Resources Assessment and Management of Fishery Resources, and Global Analysis of Economic and Social Trends in Fishery and Aquaculture (Seilert, 2001).

Improvement of food security and alleviation of poverty, improvement of environmental sustainability and integration of aquaculture into rural development (Items 4-6 of the declaration) have been the main thrusts of FAO, although in departments outside Fishery. As a development organization of the United Nations, FAO has been advocating the multi-disciplinary approach to development. This is an area where the Department of Fishery could draw on the expertise from other FAO departments as may be required to implement the programmes suggested by the declaration.

Items 7-13 of the declaration are strictly about aquaculture and fishery, already addressed by the FAO Department of Fishery. The department has also been active in the improvement of food security and safety (Item 14), and the market development and trade in connection with the World Trade Organization. Under the Medium Term Plan, FAO has programmes that provide technical support to fishing technology, fish use and trade.

Through its regional office in Bangkok, FAO could support programmes that bring together the strengths of all regional organizations to support aquaculture as a key option in the use of limited natural resources for food production. Considering the commitments of all states to the Rio Declaration of the United Nations Conference on Environment and Development in June 1992, particularly its Agenda 21, and to the FAO Code of Conduct for Responsible Fishery, which emerged from the May 1992 Declaration of Cancun, the Bangkok Declaration should offer them a useful tool to implement their formal commitments. In this light, the regional office could be assisted by FAO headquarters in following up the commitments as addressed at the various high-level assemblies and in coordinating with the regional office to obtain feedback on such matters from the relevant national agencies.

These international instruments (Agenda 21, FAO code of conduct and Bangkok declaration) should provide all states with a formal reference to the political commitments in order that policies and programmes could be evolved in time to fulfil the promise. As these instruments cut across various specialized sectors, fishery or aquaculture alone would not be in a position to act in isolation. The promotion of unified decision-making by Agenda 21 could guide the effective coordination at national level so that the planning and implementation of programmes addressed by these instruments could be carried out.

Fishery as a subsector of agriculture in most countries depends on water and other finite natural resources for its advancement. The sharing of natural resources makes it improper to plan fishery or aquaculture in isolation. However, the history and specific mandate of national fishery agencies should not be conducive to inter-sectoral intervention. This should be taken as a challenge for FAO.

In the promotion of commercial aquaculture, the following measures to safeguard the industry from the onslaught of other sectors in increasing competition for the common resources should be put in place.

a) The continued promotion of the FAO Code of Conduct for Responsible Fishery through NACA and the aquaculture department of SEAFDEC should result in appropriate national policies that guide commercial aquaculture to a sustainable development path.
b) Research in the area of cutting-edge technology should be brought under greater collaboration between the public research agencies and the private sector. This is for the reasons of cost-sharing and effective use of the new technology. Many aspects of research in commercial aquaculture are of interest to research institutions in developed countries; hence the possible collaboration. FAO could contribute to the exchange of research needs that may result in collaboration among these research institutions, perhaps through NACA.
c) The vast experience FAO has acquired through its various programmes in different parts of the world should be put to use wherever possible. The application of participatory research, community-based natural resource management and people participatory programmes requires appropriate politico-social milieus. The IDRC-assisted programme in Vietnam could be carefully studied, and its lessons drawn for replication somewhere else, in China or in Thailand for instance.

To promote systematic human resource development, particularly to support low-input aquaculture, national public universities in member states should be encouraged to concentrate their graduate or postgraduate research on-farm. The Asian Institute of Technology in Thailand has implemented an outreach programme in Thailand, and subsequently in Cambodia and Vietnam. The programme has been successful in establishing contact between researchers and farmers in view of their mutual learning experience. In carrying out a similar programme, national public universities should use their leading edge, in terms of familiarity with the local situation of their students (some of AIT students come from overseas). This type of programme can help strengthen the extension services by creating a farmers' network. To implement such a network, NACA could be supported by FAO. As a global agency, FAO is promoting aquaculture as a sector and as a component of rural development.

FAO should continue to play its important role in aquaculture development at the global and regional levels; however, its aquaculture development policies should be bifurcated. Commercial aquaculture is best supported by the FAO sectoral approach through its Department of Fisheries, whereas the FAO Rural Development arm would be more appropriate for the promotion of low-input aquaculture as a means of poverty alleviation.

6. COLLABORATION WITH OTHER AGENCIES

6.1 THE HARMONY OF THE EXISTING REGIONAL AGENCIES IN AQUACULTURE DEVELOPMENT

The existing regional organizations, ICLARM, MRC, NACA and SEAFDEC, are very familiar with the situation in Asia. This familiarity must have given them certain knowledge of the socio-economic aspects of the communities, but this cannot be taken for granted. Additional expertise would still be required when a multi-sectoral programme is launched.

6.2 COLLABORATION WITH ICLARM

The programme focus to which ICLARM has devoted its effort particularly during the last decades conforms to the global development necessities. The pursuit of maximum commodity yields has not made farming sustainable, and the need to explore sustainable natural resource management practices has taken precedence.

Resource-poor farmers rarely practice aquaculture, because it is capital-intensive. The approaches advocated by ICLARM, like those advocated by FAO, are not solely to produce more fish: aquaculture makes farmers aware of the importance of water as a vital commodity – not just a natural resource – whose conservation would help promote farming efficiency and make it environmentally sustainable. The integrated-farming approach has been widely accepted as a development strategy that addresses effectively the problems of rural poverty and food security.

A farmer participatory research protocol that brings farmers and scientists together to transform existing farming systems of resource-poor farmers into integrated aquaculture-agriculture (IAA) farming systems is the aim of the ICLARM approach. This transformation process is guided by a set of sustainability indicators to ensure that the farming systems are ecologically and economically sustainable and that many resource-poor farmers can adopt them.

For years, mainly in Africa, ICLARM has evolved various research and development mechanisms to work with the rural community, mainly to empower them to combat poverty.

6.2.1 Development of integrated aquaculture-agriculture farming system indicators

From 1994 under the six-year project on "Development of sustainability indicators for integrated aquaculture-agriculture farming systems", funded by the German BMZ/GTZ with the collaboration of the University of Kassel (GHK) and national institutions in the Philippines, ICLARM developed and tested IAA sustainability indicators on small farms which led to the development of the RESTORE software.

IAA principles for integration are based on the nutrient inputs or ecological services that an activity can provide to others. The purpose of such integration is to improve income and nutrition in small farms for the more efficient use of the otherwise unused or underused farm materials. The integration also has the potential to counteract the effects of environmental degradation.

To use IAA effectively, more data on the economic, ecological and nutritional benefits will need to be gathered. Moreover, clear definitions, criteria and quantitative indicators will need to be evolved. IAA indicators also require tools to measure their ability to control the development process. The inputs from the worksite in the Philippines have been analysed by GHK personnel, and their refinements were to be available by the time the project closed down in June 1999.

In line with the main thrusts of the UN system, ACIAR[*] programmes through ICLARM have explored countries both in Asia and Africa to learn the people's ways of life and the factors influencing their decisions. To help improve their income and livelihood, low-input IAA technology has been developed with the participation of farmers. ICLARM also spent nine years, from 1991, implementing the project "Integrated resource management group and development of the RESTORE software" to improve the way farmers manage their land and water resources through IAA.

The ICLARM strategy is to bring together farmers and scientists to transform existing farming systems into IAA farming systems. A set of indicators is used to ensure that the transformation process is making progress towards farming systems that are economically and ecologically sustainable. The indicators are also used to measure whether resource-poor farmers can afford to adopt the technology developed.

Last year, ICLARM released the software RESTORE version 1.0 with a revised *User Manual and Field Guide*. Attempts were made to evaluate the RESTORE process and software with farmers' groups under current projects. ICLARM also conducted RESTORE training courses upon request.

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[*] The Australian Centre for International Agricultural Research.

6.2.2 Project in Bangladesh on the integration of aquaculture into farming systems

Under the “Research for the development of sustainable aquaculture practices” project, ICLARM tested out the philosophy in Bangladesh. From June 1993, the seven-year project, funded by USAID in collaboration with Bangladesh fishery research institutes and nine local NGOs, developed low-external input IAA practices that fit into farming systems in Bangladesh. A flat country with a large population spread over the flat delta of three world-class river systems, Bangladesh has a number of small ponds which were dug in the process of earth removal, primarily for elevating the homestead. The year-round supplies of fish from the vast natural habitats, the lack of aquaculture technology and input, the intensive capital input of aquaculture, and the volatile market situation could be the reasons for an estimated 59 000 ponds to lie derelict or underused since they were created. The project’s investigations include feeding grass carp with grasses and duckweed (*Azolla* spp.) and exploratory cage culture of grass carp in the Hail Hoar, a large floodplain in North-eastern Bangladesh.

6.2.3 Possible programme areas for FAO-ICLARM collaboration

The contribution of aquaculture to economic development in terms of massive production of fish and shellfish that add to the world’s food supplies is well supported both by its rationale and by vested interest in many sectors. Its contributions to food security, rural livelihood, and poverty reduction are widely recognized.

For aquaculture to contribute to poverty reduction is not easy. ICLARM, after more than a decade, is compiling field data to evolve workable technical models which it aims to replicate in other parts of the world. Not overly optimistic, it is well aware that the wide diversity in cultures and traditions as well as in stages of development would make outright replication difficult, technically speaking. With the strong funding support and the reputation of the organization, ICLARM should be able to do a good job in evolving workable development models that small farmers in different parts of the world will accept. The diverse and versatile nature of aquaculture renders it a flexible development component of farming systems almost anywhere. It also has the vocation to be used for water conservation.

The fact is that sound technical inputs would not be easily adopted unless a supportive political, sociological and economic atmosphere prevailed. A sectoral approach like aquaculture development may be too narrow to influence easily prevailing socio-economic and political conditions. Wherever the situation is not ripe, the technical approach would go to waste.

The programme situations in some Asian countries have become suitable for trying out the IAA and integrated resource management (IRM) development models of ICLARM. China has a long tradition of aquaculture and small farmers have long practised the integrated farming approach. In the Ninth Five Year Plan and the Long-Term Objectives for the Year 2010 on Land and Water Conservation, China attaches great importance to the land and water conservation projects of the seven largest river valleys. In 1998, China revised the Land Administration Law to give the power to the Ministry of Land and Resources to administer land use. The decentralized administrative system in China should also make it conducive to the ICLARM approach.

Vietnam's experiment on the farming systems network brings the multi-disciplinary approach to different farming situations in rural areas. This experiment should complement the ICLARM experience in Bangladesh and Malawi.

Vietnam has a wealth of experience in on-farm participatory research programmes, particularly under IDRC assistance, which can be used in planning a new programme. Since 1990, the Vietnam Farming Systems Network (VNFSN), a consortium of nine agricultural universities and research institutes, has received assistance from IDRC to carry out a nationwide on-farm participatory research programme. According to Vo-Tong Xuan (1998), VNFSN involves 111 scientists in its work. At each institution a multi-disciplinary research group was formed. Members of the group consisted of scientists, faculty members, researchers, research assistants, extension workers, and others, who came from various institutions and backgrounds. The group promoted approaches and methods in farming system research and extension methods. This approach was instrumental in setting research priorities and in the development of appropriate agricultural systems that are economically and environmentally sustainable. There were 28 research sites over six different agro-ecological zones.

The new Constitution of Thailand has created sub-district councils, which are legally empowered to exercise control over the natural resources within their jurisdiction. Although the decentralization has been a result of a long political struggle, the sub-districts may not be quite ready to shoulder this new and complex responsibility. The ICLARM IAA and IRM would be the kind of natural resource management that meet their needs.

What can FAO do to facilitate the fielding of the ICLARM IAA and IRM activities to compile the various experiences that different cultures and geographical locations can generate? FAO may give technical and financial support to a consultation involving a team of experts in various disciplines, including aquaculture, and target these countries for the advocacy. The consultation has added to the FAO experience, such as in the Aquatic Resource Management for Local Communities programme and in the outcome from the discussion held in Chiang Rai, Thailand, in 1999.

6.3 COLLABORATION WITH NACA

NACA started as an FAO/UNDP regional project in 1980 and was transformed into an autonomous regional organization in 1990. At present, NACA is supported by 14 members and 6 participating governments. Its mandate is to promote the expansion of regional aquaculture to increase food production, improve rural income and employment, diversify farm production and increase foreign exchange earnings and savings.

The NACA study on fish health management enumerating the loss of fish farming through disease provides the first evidence of a strong link between disease and environmental factors; thereby fish health management capability in the region was strengthened. NACA also played a pivotal role in the impact assessment of aquaculture on the environment, and the formulation of policy and development of management systems to promote sustainable aquaculture.

In contrast to shrimp aquaculture, NACA promotes resource-efficient aquaculture through its regional centres in China and India, which aim to benefit resource-poor rural communities. Its strategy to promote aquaculture for rural development can contribute to food security and rural poverty alleviation.

Through technical cooperation among developing countries and collaboration with other international and regional organizations, NACA is capable of mobilizing national expertise and institutional support to implement regional projects that complement or strengthen the national capabilities in a particular field. To facilitate on-farm research and technology transfer, NACA has a plan to establish a regional aqua-farmers' network in order to field its activities.

FAO can cooperate with NACA in a number of ways as it has been doing in the past. The regional networks that NACA is operating can serve as efficient channels in mobilizing expertise and disseminating information.

6.4 COLLABORATION WITH SEAFDEC

The Aquaculture Department of SEAFDEC has been implementing its programme of regionalization of the FAO Code of Conduct for Responsible Fishery to encourage SEAFDEC and ASEAN member countries to adopt, with some regional adjustments, the code under its Article 9 on aquaculture development. FAO is obliged to assist in this area, since the promotion of the code of conduct is a core FAO mandate.

The SEAFDEC department of aquaculture is implementing a coastal aquaculture project aiming to advocate new, environment-friendly methods of shrimp aquaculture. The department has established pilot projects at a site in Haiphong, Vietnam, and one in Thailand in collaboration with the Department of Fisheries. FAO could continue to provide it with the relevant expertise, particularly on environmental matters.

The Aquaculture Department has cooperated with the SEAFDEC Secretariat during the past several months in the organization of a "Regional conference on fishery in the new millennium – Fish for the people", to be held tentatively in October 2001 in Bangkok. According to the decision given at the last programme committee meeting in November 2000, SEAFDEC will continue to implement the 2001 programme at its current level. The millennium conference is expected to evolve a declaration and a strong programme for SEAFDEC to implement over five years, starting 2002. The involvement of FAO in the SEAFDEC new programmes would only be possible after they have been unveiled. However, there should be programme opportunities in the new five-year plan of SEAFDEC for FAO to work with the Aquaculture Department in aquaculture.

6.5 COLLABORATION WITH MRC

Collaboration with the Mekong River Commission should benefit development agencies in their human resource development and programme contribution, given the fact that the Mekong River basin has assembled the multi-disciplinary challenges that have been brought under the administrative and development umbrella of the commission. All core programmes of MRC relate to the use and sharing of water. MRC has also provided a stage for international cooperation: since 1995 external donors have been active, and the contributions by the riparian countries in financial or technical aspects would be established for the equitable and sustained benefit of all.

7. CONCLUSIONS

Aquaculture issues addressed by the Conference on Aquaculture in the Third Millennium and embodied in the Bangkok Declaration constitute a comprehensive set of guiding principles for NACA member countries. The declaration made no clear distinction between commercial aquaculture and small-scale aquaculture, which is generally practiced as an on-farm food production activity. Aquaculture was seen as a promising activity leading to economic prosperity, greater employment opportunity, food security, and poverty eradication. The member countries, development agencies and private sector concerns were requested to implement the measures embodied in the declaration as a means of aquaculture development into the next millennium.

Adopting aquaculture or any other agricultural activity as a means of food or commodity production naturally depends on a great many factors. Food-producing countries, particularly those in the developing world, face numerous and complex international issues arising out of globalization. Apart from the commitments which they have made to the various international trade instruments and which they must strive to honour, the heavy burdens of debt may force these governments to adopt production policies meant to provide them with certain benefits. Most of these policy alterations, such as withdrawal or increase of certain subsidies on farm inputs, tax incentives, provision or withdrawal of price insurance, change in charges for irrigation, or even currency devaluation under the pretext of promoting export, can have a devastating impact over the technical promotion of aquaculture. The impact of shrimp aquaculture is recognized largely as a trade opportunity, and claims of success have received a mixed response in view of the resultant environmental and social chaos it creates. The promotion of aquaculture technology is unlikely to succeed where socio-economic conditions are not ripe, making an exclusively technical intervention an unpromising strategy.

The success of aquaculture promotion has been left undefined, although economic and social improvements have been implied as important indicators of progress. All economic activities, including aquaculture, impinge on the environment to a certain degree, and certainly all economies rely to a certain extent on the use of natural resources. The third Christian millennium will certainly see more fervent claims made by a variety of economic activities on finite natural resources, particularly land and water; aquaculture will be further squeezed between these increasingly pressing economic needs.

Intensive capital investment is a major factor preventing small farmers from adopting aquaculture as an exclusive food-production activity. Fish is normally kept where water is stored, with or without care and feeding. This informal aquaculture is largely practised and its production goes largely unreported. Promotion of informal aquaculture could lead to a more efficient use of water and other on-farm resources for food production. It is a venue for participatory research to make a network out of the traditional extension systems. The experience accumulated by FAO through numerous projects in Africa and Asia could be used to promote informal aquaculture as a means of food security and poverty alleviation. Options for collaboration with ICLARM and NACA are given.

The high value and export potential of its products make aquaculture a priority area for development in many countries. In massive investment using modern technology that keeps operations going round the clock, commercial aquaculture needs to keep its good image as an environment-friendly food-producing sector offering safe products to consumers. Targeting high-income consumers, commercial aquaculture contributes little to food security, general employment, or poverty alleviation. In future, it will have to compete with other food and development sectors for finite natural resources, and more regulatory measures will be introduced. During the coming decades, the FAO Code of Conduct for Responsible Fishery and the guidelines under the UNCED Agenda 21 would make it convenient for member states to evolve national policies that work under their particular socio-economic and political environments. FAO could cooperate with SEAFDEC in the promotion of the code of conduct in the region.

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