8. Trends and issues

INTRODUCTION

From the studies and the reviews presented in this document, it is clear that aquaculture is developing, expanding and intensifying in almost all regions of the world, except in sub-Saharan Africa. As the global population expands, demand for aquatic food products is expected to increase. Globally, production from capture fisheries has levelled off and most of the main fishing areas have reached their maximum potential. Sustaining fish supplies from capture fisheries will, therefore, not be able to meet the growing global demand for aquatic food.

The current contribution of aquaculture to the world aquatic production in 2004 is about 45.5 million tonnes (excluding aquatic plants). According to FAO projections (FAO, 2002), it is estimated that in order to maintain the current level of per capita consumption, global aquaculture production will need to reach 80 million tonnes by 2050. Aquaculture has the potential to make a significant contribution to this increasing demand for aquatic food in most regions of the world; in order to achieve this, however, the sector (and aqua-farmers) will face significant challenges.

The reviews of regional aquaculture development status and trends confirm that aquaculture is making a significant contribution to global production and that a number of key development trends are taking place. It is apparent that the aquaculture sector continues to intensify and diversify, is continuing to use new species and is modifying its systems and practices. This is being achieved with the growing awareness that the resources upon which it and society in general depend must be used responsibly.

Markets, trade and consumption preferences, strongly influence the growth of the sector, with clear demands for the production of safe and quality products. As a consequence, increasing emphasis is placed on enhanced enforcement of regulations and better governance of the sector. It is increasingly realized that this cannot be achieved without the participation of the producers in the decision-making and regulation process, which has led to efforts to empower farmers and their associations and move towards increasing self-regulation. These factors are all contributing towards improving management of the sector, typically through promoting "better management" practices of producers.

This chapter describes current general global trends in the aquaculture sector, with additional specific focus on trends applicable to individual regions. These trends, both global and regional, have emerged during the regional review process. This chapter also looks at the past trends that have led the aquaculture sector to its current status.

One clear distinction that has emerged during the review process is the disparity between the sub-Saharan Africa region and almost the rest of the world. It is clear that in sub-Saharan Africa aquaculture development has stalled, despite numerous interventions and support programmes by regional and international development agencies and lending institutions. This can be attributed to a number of causes relating to fish consumption preferences, general level of economic development in rural areas, the policy and governance environment and limiting social factors.

In 2003, the second session of the Committee on Fisheries Sub-Committee on Aquaculture convened in Trondheim, Norway, requested FAO to provide a prospective analysis of future challenges in global aquaculture as the basis for deciding the longer term direction of the Sub-Committee's work (FAO, 2003). In response to the Sub-Committee's request, FAO conducted an Expert Workshop in Guangzhou, China, in

March 2006, among other objectives, to bring expert opinion on the future prospects of aquaculture. One of the outputs of this expert workshop is an information document prepared for the third session of the COFI Sub-Committee on Aquaculture, to be held in September 2006 in India[1], entitled: *Prospective analysis of the future aquaculture development: the role of COFI Sub-Committee on Aquaculture* (FAO, 2006a). This document, which will be published later in the year, further extends the scope of the present chapter on status and trends in aquaculture development and provides a vision of how the aquaculture sector will develop and be managed as a responsible global producer of aquatic food in the coming two decades.

GENERAL TRENDS IN GLOBAL AQUACULTURE

This section outlines and combines the general aquaculture development trends documented in the regional reviews with those discussed and verified at the Global Aquaculture Trends Review Expert Workshop held in Guangzhou, China, in March 2006. It must be stated clearly that these trends are particularly relevant and reflect the behaviour of the sector in countries where aquaculture is well established. As Asia contributes to over 90 percent of global production, it is difficult to discuss global aquaculture without having a bias towards Asia; these general trends may not necessarily reflect the overall scenario in some other regions, e.g. sub-Saharan Africa.

Continuing intensification of aquaculture production

Various factors are driving the aquaculture sector to intensify. The main driving force appears to be the unavailability of sites. As the availability of sites for aquaculture is becoming increasingly limited and the ability to exploit non-agricultural land is restricted, along with economic drivers, the aquaculture production systems are being increasingly intensified.

Intensification may sustain profitability of farming operations, but this comes at a cost. There are management issues (water and health in particular) associated with intensification and the environmental carrying capacity and regulatory concerns that relate to increased numbers or intensity of farms.

Not all farmers are able to intensify and, as production costs rise, part of the sector may reduce intensity to lower costs or reduce vulnerability to health or environmental problems.

Under appropriate circumstances, there are opportunities for organic aquaculture to play a role and this may become an economically viable form of management.

The sector continuously looks for novel ways to use land and water environments for production. The exploration of new systems not only requires identification of suitable areas, but also needs to use tools such as surveys, studies of carrying capacity; water quality monitoring and Geographical Information Systems (GIS), remote sensing and mapping.

As intensification proceeds, the need for institutional support, services and skilled persons are also in the increase; the need for more knowledge-based aquaculture is clearly increasing and education and training in aquaculture has regained or is regaining its importance worldwide.

Continuing diversification of species use

Aquaculture continues to explore new species options, particularly high-value species, in regions and countries where aquaculture is well established. While facilities for mariculture of high-value species have increased, reduction in facilities for the production of low-value high-volume species such as cyprinids is evident in

[1] http://www.fao.org/fi/NEMS/events/detail_event.asp?event_id=32029

those countries (particularly China). In the future, however, reduction in freshwater aquaculture areas may be offset partly by expansion in marine areas particularly for the culture of relatively higher-value species.

Regions and countries where aquaculture is still in its early stages; particularly Africa and some South Asian countries, freshwater species production is still continuing. In some South Asian countries better opportunities for giant freshwater prawn, *Macrobrachium rosenbergii,* are visible.

The development of indigenous species production for enhancement or restocking is continuing and might be promoted in the future as a means for improving livelihoods for people that rely on fisheries. It is also evident that the use of indigenous species has reduced the disease risks involved in, and has provided more stability to, aquaculture production. Seed production of indigenous species are continuing in support of stock enhancement programmes of inland waters, which are increasingly looking towards the use of indigenous species as concern and awareness over biodiversity issues increase.

Countries are continuing to introduce species or strains for aquaculture, while efforts are made to develop specific strains for aquaculture, particularly the high-value species. Although countries are endeavouring to comply with international norms and standards for the movement and introduction of live aquatic organisms, commercially driven movements and introductions that are not responsible are also evident in many regions of the world.

In the shrimp farming sector, effort has redoubled to attain the capability to locally commercialize the production of specific pathogen free (SPF) and specific pathogen resistant (SPR) broodstocks of a number of species (*Penaeus vannamei, P. chinensis* and *P. monodon).*

Import risk analysis is increasingly becoming a standard tool for ensuring responsible movement and introduction of species and strains for aquaculture. There is a need for significant capacity building and training to mainstream its use and ensure its application. However, as a consequence to increasing concerns over impacts of introductions, there will be stricter regulations on the import of new species.

Continuing diversification of production systems and practices

As some traditional agricultural systems become increasingly uneconomic there has been a trend to promote or enable diversification. This may take the form of conversion from agriculture to aquaculture (e.g. rice land for aquaculture) or the integration of aquaculture into existing farming systems. People enter into such diversification to increase their earning capacity, without giving up their primary occupation as farmers. Further, secondary use of waterbodies for aquaculture is also increasing in Asia and Latin America, as a diversification in the use of waterbodies. This is becoming more viable in many countries as fish seed is now more widely available at affordable prices.

A critical feature of ensuring longer-term investment in sustainable aquaculture practices and avoidance of short-term environmentally damaging practices is the existence of farmer-friendly tenure systems. Increased terms of lease are often required and specific zoning of areas (e.g. mariculture parks) can provide an enabling environment for investment in aquaculture. Subsequent spin-off effects of employment and service sector opportunities may also accompany this. There is some evidence of such trends in some countries (China and countries of Southeast Asia); however, this trend will continue to expand into more countries and regions in years to come.

New systems require the development and dissemination of seed production technology (particularly the development of marine hatchery systems) and broodstock management for key species.

Appropriate infrastructure and services such as land-based handling and processing facilities (landing and holding facilities, transport and cold chains) and efficient

connections to markets are essential for success and countries are making improvements on these facilities and services.

Polyculture or integrated culture (particularly in marine systems) offers a means for diversifying products from a system, improving efficiency of resource use and reducing the negative environmental impacts. Although this has been a traditional practice in Asian freshwaters, as well as in coastal waters, particularly in China, there is need for more research and technology transfer on marine mixed plant/animal systems where such systems are less well developed.

Increasing influence of markets, trade and consumers

There is a trend of increasing fish consumption in many countries (although apparent consumption data [FAO, 2006b] shows a decrease in per capita consumption in many countries in sub-Saharan Africa) and this domestic and regional demand competes with export markets, particularly in Asia. Producers and processors are slowly moving towards greater value adding and development of processed products for export markets as an avenue for increasing foreign exchange earnings and improving profitability. In such circumstances, the choice of species for farmers is becoming geared to the demand for products in the international markets. Moreover, there is a trend towards targeting urban markets with standardized, value-added "easy-to-cook" or "supermarket-type" products.

New markets are continuing to develop and domestic demands are increasing in many countries, especially in Asia (e.g. China).

With more stringent demands of export markets, small-scale operators are facing increasing difficulties producing products for export. There is evidence that some small operators are leaving the sector as they become uncompetitive and unprofitable. A strategy to offset this is the formation of producer associations, which has demonstrated positive results in countries such an India as Viet Nam.

For some export commodities, exporting countries are looking at quota systems or mutual agreements on limiting production volumes in order to avoid destabilizing market prices.

There is a need to build capacity within the regions to enable countries and farmer groups to become capable of initiating or accessing market information and research, in particular, for the species targeting non-domestic markets. Processing and product diversification are developing in response to better market information.

There is a greater concern on the wholesomeness of aquaculture products and on making aquaculture operations environmentally benign.

The international and national demand for safe and higher quality aquatic products is increasing and there is a clear need to improve product quality and safety. There are improvements in cold chains and control systems for ensuring product quality and safety and more emphasis will undoubtedly be put in place for these aspects in coming years.

There is a clear trend towards development and implementation of safety and quality standards. In the last decade, greater emphasis was placed on better aquatic animal health management and food safety following public concerns and reports of contaminants in fish products in all regions of the world. Initiatives have been taken by the European Union to ensure that the benefits are translated in a harmonized manner across the Western European region and beyond. The use of antibiotics has declined significantly in the last decade in Europe and Latin America following the widespread use of vaccines in the salmon and bass and bream industries. Similarly, the stringent export regulations such as minimal residue levels for banned antibiotics and veterinary drugs have reduced the reliance on antibiotics in shrimp aquaculture in Asia and Latin America.

There is a growing trend towards the ecolabelling of aquatic products. FAO's guidelines for ecolabelling of capture fishery products are now in place, although

the same for aquaculture products are yet to be developed. Ecolabelling is often considered as no more than a marketing tool. However, with the increasing concern on environmental issues among the consumers worldwide, products that are grown in a responsible manner without harm to the environment are gaining a competitive edge particularly in the developed countries.

Enhancing regulation and improving governance of the sector

Aquaculture is maturing as a responsible sector and emphasis on better enforcement of existing legislation is becoming apparent. As enforcement of law is a continuing constraint in many countries, strong emphasis is being placed on increasing self-regulation by farmer associations and the sector in general. There is a general trend towards improving governance in aquaculture development and management.

As aquaculture often co-exists with agriculture in inland areas and with coastal and wetland natural resources elsewhere, there is a trend towards more integrated land use planning and registration of farms for aquaculture. This requires the establishment of farmer friendly tenure systems and appropriate environmental planning (e.g. land-use surveys and development of specific zoning, e.g. aquaculture zones), which is slowly gaining recognition.

It is clear that in some countries there is need to develop specific aquaculture legislation to better regulate the sector. The increasing requirement for traceability and certification is now leading towards adoption of mandatory registration of aquaculture facilities as part of national legislation.

Many countries are developing and implementing regulations on the use of antimicrobials, veterinary drugs and chemicals in aquaculture. Monitoring and surveillance programmes are also being established in some countries as a measure to reduce production losses from emerging diseases.

As an essential part of self-regulation of the sector, there will be further development of codes of practice and better management practices (BMPs) in collaboration with farmers. This also requires appropriate mechanisms for dissemination and communication of codes of practice through farmer organizations.

Aquaculture does not exist in isolation and increased regulation of the sector also requires that its external effects to be moderated. Against a trend of increasing intensification and increasing numbers of farms in some areas, there is a requirement for environmental impact assessment and routine environmental monitoring. Increasingly, there will be requirements for aquaculture to "pay the real cost"; for the environmental services that it utilizes. Mechanisms such as "polluter pays" and "resource rents" (user pays) will be put in place. This requires improved capacity for monitoring and concurrent development of laboratory infrastructure and capacity building within the competent agency or organization.

Effective regulation is only possible with an effective information system. This requires improved quality of aquaculture information and statistics. The types of information collected should be targeted at specific needs for management of the sector and there will be a concurrent need for information management systems that enable use of the information for local management and not be over centralized.

Drive towards better management of the aquaculture sector

In many countries, instead of high yield per unit area, aquaculture is now aiming more on economic sustainability and overall competitiveness. One of the key areas considered is the improved management of health. As pathogens and diseases are causing significant losses in global aquaculture, the sector is now giving strong emphasis to reducing the mortalities and losses due to diseases. This trend does not only focus on production and practice, but also the issue of acquiring quality inputs such as clean seed and quality feed, and sound advice to reduce risks of production failures.

The combined effect of all these trends is to drive the sector towards improved or better management. This is seen at the individual farm level as well as specific subsectoral levels. It has not occurred simultaneously throughout the aquaculture sector worldwide although, in the future, it will materialize as different pressures are applied (regulatory, market, environmental or social etc.).

SPECIFIC TRENDS IN GLOBAL AQUACULTURE

Besides the six general trends mentioned above, global aquaculture has shown some specific trends in addressing environmental and resource-use issues, responding to markets and trade, resolving social problems, improving economic performance, supporting poverty alleviation and food security, and strengthening national institutional, legal and policy frameworks.

Environment and resource use

Competition for land and water. Competition for land and water is leading to a higher degree of integration of agriculture and aquaculture, at least in Asia and Latin America. In Central and Eastern Europe, historically fish ponds were built on areas with poor soil conditions therefore competition with agriculture is not a major issue, especially not in the former Soviet Union countries, where land areas are being withdrawn from cultivation. There are opportunities for the integration of aquaculture with other human activities, which are based on adding value to utilization of water resources used for irrigation and recreation.

High energy costs. Similarly, increasing energy costs are leading not only, as expected, to finding low-cost energy sources but also to developing strategies and practices to reduce energy requirements (e.g. reduction in stocking density, aerator placements and changes in water exchange practices). In certain culture practices, energy cost for pumping could be minimized with the combined use of bio-remediation and low discharge or even zero discharge techniques, however, more research is required. The technology to use farm wastes from integrated farming to generate bio-energy is receiving renewed attention.

Continued reliance on fishmeal. Will the search for alternatives eventually result in greatly minimized requirement? Although the use of fish protein has been reduced through the use of proteins from terrestrial animals or vegetables there are limits to the level that non-fish proteins can be used. On the other hand, reduction of fish oil in aquatic animal diets is much more of a challenge. Even with reduced per unit usage, total requirement of fishmeal and fish oil is still growing with increased production levels and its availability and price will probably be one of the major constrains to the growth of the aquaculture sector.

Biosecurity. Countries continue to introduce species or strains for aquaculture. This will also be accompanied by the development of specific strains. Commercially driven, private-sector initiatives of unregulated introductions and transfers are evident in many parts of the world. However, at least in some countries, the mechanisms for introduction are becoming more stringent and Import risk assessment (IRA) is becoming increasingly a standard tool for ensuring responsible movement and introduction of species and strains for aquaculture. Significant capacity building and training is required to mainstream the use of IRA and ensure its effective application.

Genetic improvement and domestication. Improving aquaculture production demands genetic resource management of farmed aquatic species, including indigenous species and new species for development. Considerable improvements have been made to domesticate and improve key species through a variety of genetic improvement strategies including selective breeding, hybridization, chromosome-set manipulation and advanced genetic engineering technologies. Major species-groups that have been genetically improved include, *inter alia*, tilapia, carps, salmon, trout, oysters and catfish.

Important traits for genetic improvement include growth rate, conversion efficiency, environmental tolerances, disease resistance and body shape. Recent progress has been made in the domestication and genetic improvement of marine fishes and crustaceans.

Environmental management. Aquaculture has continued to attract largely unsubstantiated negative publicity as an environmental polluter. The output of nitrates and phosphates from aquaculture is considered insignificant in terms of contributing to nutrient loading in most regions of the world but may have local impacts on eutrophication and algal blooms. Great strides have been made in the last decade in mitigating nutrient and organic inputs from aquaculture. Notable advances and innovation in automated feeding technology has significantly reduced feed input whilst maintaining productivity and improving economic efficiency. These developments were strengthened by the increased use of fallowing by farmers. Such improvements have been particularly noticeable for some commodities such as salmon.

Most Latin American and Caribbean countries do not seem to have adequate national aquaculture plans and policies to guide the overall development and management of the sector; thus development has been mainly determined by the private sector and the requirements of international markets. Equally, there are numerous shortcomings in the control and surveillance to enforce environmental regulations, a case in point being the initial destruction of mangroves caused by the shrimp farming industry in several countries in Asia and Latin America that fortunately now has been largely rectified by improved awareness and better aquaculture siting and planning practices.

Markets and trade

With the emergence of application of stringent product export standards, particularly aiming at improving food safety, it is evident that the capability of the different countries to analyse for "contaminants" or "residues" at the level of precision required by the importing countries is lacking. These include antibiotics, pesticides and heavy metals. Further, the capability of each country to apply HACCP concepts in the production systems, as a precursor for addressing much needed traceability, is also questionable. While not having adequate capacity to address the issue, the countries are still facing difficulty in adopting harmonized standard for aquaculture products, whether for export or for domestic consumption. Although there are attempts to harmonize standards, at least by regional or economic/political grouping basis, it is difficult to predict how long it will take to develop globally harmonized standards, if at all possible.

The trade in aquaculture products and species for non-food uses is also increasing. This includes aquatic species of significant economic importance, particularly the ornamental species, now being cultured in many countries in the world, and being considered by many new entrants to the aquaculture industry.

Social impacts, employment and poverty reduction

From the socio-economic point of view, aquaculture has had an important impact on the economy of rural and less-privileged communities throughout the different regions, having created opportunities for employment and contributed to the available food. However, quantification of this impact is extremely difficult due to lack of adequate reliable data.

Institutions to support responsible development of aquaculture

It is increasingly clear that effective institutions are an essential requirement for the responsible development of aquaculture. Public and private-sector institutions at local, national, regional and international levels continue to develop.

Most governments are promoting responsible aquaculture using different approaches and strategies. The development and promotion of codes of practice, better management

practices, certification systems and standards are taking place, although at a slower pace, and are strengthening and empowering farmers.

Effective policies, legal frameworks and institutions are being created as they are necessary prerequisites for the development of aquaculture; however, in some countries, the enabling policies are still absent, obscure or complicated, thus hindering aquaculture. Some key challenges the aquaculture sector in any one country may have to confront are a lack of coordination between the multiple agencies that share regulatory responsibility, legislation that may not be in harmony with present and future status of the industry and with other related legislation, and unclear or conflicting priorities within the policy-making and regulatory spheres.

Farmers' organizations, civil society, and consumers' associations as well as institutional buyers such as the supermarket chains and other key stakeholder groups are beginning to exert stronger influence on policies and regulations, but are also actively promoting the development of standards and codes that aim at ensuring an environmentally and socially responsible aquaculture sector.

MAJOR REGIONAL AQUACULTURE DEVELOPMENT TRENDS

This section describes some major regional aquaculture development trends besides the general trends outlined earlier in this chapter. These specific regional trends have been derived from the regional aquaculture development status and trends analyses conducted by FAO during 2005 (See Chapter 1, Introduction).

Asia and the Pacific

Most countries in the region have policies strongly supportive of aquaculture development. In Australia, for example, the industry set itself a vision at a National Aquaculture Workshop held in Canberra in August 1999, which stated that by 2010 a vibrant and rapidly growing Australian aquaculture industry will achieve US$2.5 billion in annual sales by being the world's most efficient aquaculture producer.

There is a general trend in East Asia including China to expand to new species for culture particularly for premium species. The phenomenal growth of the river crab, mandarin fish, cobia and turbot in China are indications of such a trend. In the Republic of Korea, there has been a great increase in production of high-value fish species, such as olive flounder and black rockfish during the last few years and a new interest in culturing penaeid shrimps. The vision of the Republic of Korea is a restructured aquaculture industry with an optimal production system and enhanced competitiveness.

Reduction in its facilities for producing high-volume species such as cyprinids can be expected in China, perhaps not deliberately as in the Republic of Korea. However, reduction in freshwater aquaculture areas may partly be offset by expansion in marine areas particularly for the culture of relatively higher-value species.

There is a greater concern on the wholesomeness of aquaculture products and on making aquaculture operations environmentally benign. Furthermore, instead of high yield per unit area aquaculture in the East Asian subregion is now aiming more at efficiency, cost efficiency and competitiveness.

In shrimp farming there will be redoubled effort to have the capability to locally commercialize the production of SPF and SPR broodstock of *Penaeus vannamei, P. chinensis,* and *P. monodon*.

Of the countries making up South Asia, Nepal and Bhutan are completely landlocked and have the least developed aquaculture. The subregional trend therefore does not apply to Nepal and Bhutan where the main concern is to increase aquaculture activities and intensify existing operation. Elsewhere, freshwater aquaculture is likely to continue, grow and diversify. The culture of the giant freshwater prawn may increase as interest picks up.

In brackishwater aquaculture, the ambivalence towards shrimp farming continues in the sense that its contribution to the economy is recognized even as its negative effects on the environment, actual or perceived, are decried. Such situations will continue to lead to the adoption of environmentally friendly technologies such as zero discharge or low water exchange systems. Thus the use of bio-remediation in shrimp culture may increase and become a standard practice.

The infatuation with shrimps in South and Southeast Asia is likely to continue. This time the object is wholesomeness (safety and quality) and efficiency rather than just high-volume production. The region will have to come to terms with *P. vannamei* as at the moment only India and the Philippines have held out against its legalization although the Philippines is initiating steps to lift the ban on its culture. With the continued inability of the United States of America-based suppliers of broodstock to supply the massive number of SPF brood animals required, many of the hatcheries in the region are forced to use locally grown second or third generation stock. This will persist until a local capability to commercially produce SPF stock is established. Meanwhile, SPF broodstock producers, particularly from the United States, are now beginning to set up operations in a number of countries in the region.

The current focus of interest in Asia is the domestication of native penaeid shrimp species particularly *P. monodon*. Work is ongoing in many countries in Asia. Simultaneously, the major *P. vannamei* producing countries such as China, Thailand and Indonesia are developing local capability to produce their own SPF breeding stock. On a smaller scale there is also ongoing work on genetic improvement of the giant freshwater prawn, *Macrobrachium rosenbergii,* through collaborative work between Indonesia, Philippines and Thailand.

The growing scarcity of high health *P. monodon* broodstock that was one of the precursors for embracing *P. vannamei* has driven the various countries in the subregion finally to follow the lead of Thailand in giving high priority to broodstock development of the native species. Developing a captive breeding stock of *P. monodon* had not been a high priority in Indonesia, Malaysia and Philippines since wild-caught broodstock that are healthy enough had been readily available. Once high-health captive *P. monodon* breeding stock becomes commercialized and consistent in quality, many farms in Southeast Asia will likely revert to the native species. But the species is not likely to become the predominant species of choice again. Instead, the species mix will likely be shaped by the market and relative competitiveness.

There is a trend towards expansion into open marine waters using sea cages as is in the Philippines, but the growth of such development is unlikely to be high. In the Philippines, marine cages are attractive because of the high local demand for milkfish. Elsewhere interest for sea cages is more for the higher-value species such as grouper. This is especially so in China, Viet Nam, Malaysia, Thailand and Indonesia.

The rapid growth of the carageenan refining industry in China with its high demand for *Eucheuma* will fuel further expansion in seaweed farming in Southeast Asia. Chinese processors are driving farmgate prices for dried *Eucheuma* to record levels in the Philippines.

Expansion into marine waters for the production of food fish is taking place as competition for land and water becomes more acute. Aquaculture as a source of food rather than income is more related to freshwater aquaculture with the exception of the Philippines where the most important food fish species, i.e. milkfish is produced primarily in brackishwater and efforts are underway to produce a fast-growing saltwater-tolerant strain of tilapia. While the red strain of tilapia is known to be salt tolerant, this is not well accepted in the local Philippine market.

Aquaculture in the Pacific is undergoing a state of rejuvenation with the emergence of significant commercial activity and commodities suitable for rural development. Many governments lack the strategic framework required for aquaculture development.

Policies, legislation and strategic planning have not been properly addressed. Many failures in the past of government or private sector ventures have been attributed to poor economic and financial planning, leading to non-profitable scales of investment or unrealistic market expectations.

The Pacific label as a pristine and clean green image could be a marketing drawcard. There are successful examples. The marine ornamental trade also has the potential to increase its benefits from proper use of labelling and certification, and with operators employing ecologically sustainable techniques. Examples of sustainable practices being pilot-tested include pre-settlement larval capture systems and tending of coral gardens. Cultured black pearl requires a significant investment in marketing. There is a trend in some countries towards integrating this effort with their national tourism marketing campaign.

There is an increasing realization of the role aquaculture can play to supply fish protein, particularly for inland rural villages where access to fresh fish is limited and lack of electricity does not allow the long-term storage of food. Some parts of the Pacific, particularly the large Melanesian countries are facing a food crisis situation from increasing population pressure, which is leading to poor nutrition and health. Generating another primary food source would help alleviate the reliance on imported processed, i.e. tinned foods. Aquaculture is increasingly seen as a viable alternative source of essential cash needs (for school fees, social obligations and other expenditure items) and as a back-stop to declining fisheries revenues.

Drawing on indigenous farming practices and indigenous resources will be important to developing aquaculture appropriate to local needs and scales, in particular to addressing subsistence and semi-commercial needs, and extensive and small-scale farming. For example the region is trialing integrated freshwater shrimp with swamp "dalo" farming.

Biosecurity will become a key issue. Because the Pacific does not have a tradition of aquaculture there are few domesticated species that the region can draw on, and the introduction of new genetic material and translocation of species will be an integral aspect of the development efforts in aquaculture. Bearing in mind the high regard for biodiversity in the region there is a strong need for responsible practices. Addressing biosecurity will involve cross-sectional approaches, for example fisheries, quarantine, and veterinary and environment agencies.

Central and Eastern Europe

There is a long history of freshwater aquaculture, which is still based on the use of traditional methods and equipment with the dominant technology being extensive and semi-intensive polyculture carp-based production in ponds, although there are regions where other species play a dominant role (e.g. sturgeon, salmonids and whitefish).

There was a drop in aquaculture production in this region after the political and economical changes in the early nineties, which was followed by a slow increase after the stabilization of the sector. However, the production level in 2003 was still below that of 1993 and was only about 50 percent of the peak production level of 1990.

The low exploitation of marine resources is clearly indicated by the low marine aquaculture production per 1 km length of coastline in Eastern Europe, while the utilization of the Annual renewable water resources (ARWR) for freshwater aquaculture production is about the same in both subregions.

It appears that the development of marine aquaculture in the future has a better potential in Eastern Europe, even if the differences in geographic and climatic conditions between Eastern and Western Europe (where marine aquaculture is well established) are taken into account.

Market has been the driving force of aquaculture development in Eastern Europe since the early nineties, however, market orientation of some farms is slow and

aquaculture development is highly dependent on the overall economic situation and political decisions in a given country.

The post-harvest sector is relatively undeveloped, although there have been some positive changes recently. The sector continues to be dependent on supply of good quality seed and feed; economic efficiency in the use of these resources must be considered for all systems, including intensive and potential "organic" farming.

Marine and brackishwater production is very limited and about 70 percent of the production is from Croatia, where tuna production shows significant growth.

Aquaculture will remain an important supplier of healthful food for local populations; however, export production (especially niche market segments) will offer new opportunities. Local production is unlikely to satisfy the increasing demand for fish and seafood in the foreseeable future.

While aquaculture continues to be a significant contributor to rural development (especially through various forms of pond fish farming), it will play an important role in the recovery of species diversity in natural waterbodies.

There is some scope for marine aquaculture development in some countries where good conditions are available. Appropriate research, technology development and investment will become major requirements.

Human resources management (including language training) is a vital component of aquaculture development in the region, better collaboration among farmers, and between science and practice at national and international levels will become vital to regional aquaculture development.

Latin America and the Caribbean

With the development of new technologies and better management of the production systems, efficient production has been attained in spite of the disease problems that have affected shrimp aquaculture in several countries. Salmon aquaculture has strived to a high level of production.

As an activity truly led by the private sector and supported with technical and scientific support by the public sector, aquaculture has achieved a relatively important role in the economic development of most countries of the region, in particular Brazil, Chile, Ecuador and Mexico.

Rural aquaculture in Latin America is still largely dependent on state or international technical and financial support schemes. As this sector is very valuable in the overall improvement of rural life and alleviating poverty, alternative strategies must be sought to enhance rural aquaculture.

The aquaculture sector supports and employs a significant number of people: professionals, mid-level technicians, field operators, producers, fishermen and service providers. However, the actual impacts of employment are yet to be quantified.

Chile appears to be continuing to increase its salmon production to become the world leader while Brazil is likely to produce a lion's share of shrimp and freshwater aquaculture in the region in the foreseeable future. Other countries will also increase their production, diversify species and expand the sector in the years to come.

The species that are most widely cultured in the region are: salmonids, marine shrimp and tilapia. However, during the last 10 years, there have been important increments in the production of other groups of species such as seaweeds, molluscs, caracids and catfish.

Near East and North Africa

Across the region, aquaculture is expected to grow; in some countries this growth is expected to be significant. Beyond this, there are no universal trends in changes in aquaculture, since the individual combination of geophysical, economic and social factors in each country affects the farming systems that are practised at present, and can be developed in future.

When the region is considered as a whole, three trends in aquaculture are apparent, although it should be emphasized that each does not apply across the region. The three main trends in food fish production are; (a) increased culture of marine species, (b) intensification of aquaculture, and (c) more integrated agriculture-aquaculture. The main trend in non-food aquatic species is towards production of ornamentals.

Within marine species, both diversification and intensification are anticipated, driven by such forces as successful research by government laboratories providing technical knowledge and stock, availability of private investment and potential export markets. Intensification is mainly driven by such forces as limited availability of land and water.

Marine aquaculture of finfish and crustaceans has been increasing in the region, and the increase is expected to continue. Furthermore, several countries (Bahrain and Oman which are emerging regional producer countries and Saudi Arabia, a more established regional aquaculture producer) have identified increased mariculture as a specific goal. Bahrain will focus on production of juveniles of marine fish for sale, release and semi-commercial mariculture activities, and Oman and Saudi Arabia will concentrate on producing marine shrimp. Other mariculture trends of note are the development of marine cage culture in Iran (Islamic Republic of), production of fingerling gilthead seabream in Kuwait (for export within the region), and tuna fattening in Oman. In Tunisia, the trend towards increased diversification of marine species including bivalves, octopus, shrimp and tuna is, in part, influenced by European markets.

Within the last ten years, many countries in the Near East and North Africa region have imported new non-endemic aquatic species, particularly finfish, which are either already established as an integral part of aquaculture production, or are being studied as potential aquaculture species. Six of these newly introduced species are already contributing significantly to aquaculture production at the national level in some countries (e.g. gilthead seabream, tilapia, European seabass, meager, penaeid shrimp and European crayfish).

The common factor driving the growth of aquaculture across the region has been, and probably will continue to be, the need to increase the domestic food supply, partly because the wild catch may be unstable or falling. Other forces include the need to increase export revenues, and support of socio-economic programmes via provision of employment and affordable nutrition in poor regions. From within the sector, technical and organization progress and improvements in infrastructure, are also important driving forces.

Successful and sustainable development of aquaculture can be limited by a wide variety of factors in North Africa and the Near East. Some of these are beyond the control of the sector, such as civil war and drought which have directly affected Lebanon and Iraq in the last decade. Other factors can be influenced, in a limited way, such as land and water availability, or more extensively, such as technical challenges, underdeveloped markets, poor disease monitoring and control, complex administrative procedures and scarce funding (from bank credits, subsidies or investment) and inadequate training and research.

Successfully addressing four key priority issues is essential for the continued growth of aquaculture in North Africa and the Near East: i) farming systems, technologies and species; ii) marketing and processing; iii) health and diseases; and iv) policies, legal frameworks, institutions and investment. While there is a consensus among countries in the region about the importance of these issues, the relative importance of each of the four issues will vary from country to country, dependent largely on the state of development of the aquaculture sector in individual countries (developing or developed).

Limited availability of suitable sites for new aquaculture activities is a common problem in the region, and may be manifested as shortage of land, insufficient

freshwater, insufficient tidal fluctuation for land-based marine and brackishwater aquaculture, and few marine sites suitable for existing systems. Further challenges for some countries, particularly those with a developing aquaculture sector, is adequate supply of finfish fry/seeds and shellfish spat, and reliance on imported aquafeed. Research and technology transfer between countries in the Near East and North Africa are seen as key solutions to developing suitable new technologies that can be adopted for use in the remaining available sites, particularly those in the marine environment. Emphasis will need to be placed on finding systems that are suitable for the specific geographic locations and level of technology available.

In the Near East, interest in producing shrimps will continue to be high in the subregion. But the constant threat of diseases is also driving the leading producing countries such as Saudi Arabia, Oman and Iran (Islamic Republic of) to look into alternative species. In Iran some shrimp producers are looking into *P. vannamei* as an alternative to *P. indicus*. How this develops will depend both upon government policy and how well the species fares in the high salinity environment and harsh climate.

Already the subregion (Near East) is no longer totally dependent on wild-caught broodstock of *P. indicus* since breeding stock of the species can readily be grown in ponds. The practice now is to merely use unselected first generation breeders. There will be high interest in moving on towards a breeding programme similar to that now happening in Southeast Asia.

The subregion is also looking into the culture of various marine finfish species such as grouper, seabream and seabass as alternative species. Saudi Arabia, Iran (Islamic Republic of) and United Arab Emirates are already developing capability to propagate marine finfish and pursuing the recruitment of experienced people from Southeast Asia and training of their own nationals. European fish cage manufacturers and suppliers are making some inroads in the region.

North America

Aquaculture in North America over the past decade has grown at an average annual rate of 4.3 percent and in 2003 produced only 1.6 percent of global aquaculture output representing 2.7 percent of total value in 2003.

One noteworthy product of the North American aquaculture industry is the SPF and SPR broodstock of *P. vannamei* and to a much lesser extent *P. stylirostris.* Without the commercial availability of these selected strains the shrimp industry in China and Southeast Asia would have been hard put to recover from disease outbreaks and the lack of healthy natural broodstock with their consequent effects on the global supply and price of shrimps.

Aquaculture expansion is supported by the governments of both Canada and the United States but considerable public opposition has been generated over environmental concerns. These concerns centre on nutrient pollution, escapes, competition with wild fish, disease transmission and seafood safety. There is considerable misinformation being circulated regarding aquaculture, its environmental effects and the health risks of consuming cultured products.

Aquaculture production in North America contributes significantly to local economies in regions of the United States and Canada characterized by low levels of economic development and high rates of unemployment. Localized impacts can be highly significant. For example, catfish farming in Chicot County, Arkansas, generates a total economic impact of US$359 million, providing US$20 million in tax revenues and 2 534 jobs, accounting for 46 percent of total employment in the county (Kaliba and Engle, 2004).

One development in the United States that bears watching is the introduction of a bill in the United States Senate that would have created a law known as the "National Offshore Aquaculture Act of 2005". Although the bill as now proposed faces stiff

opposition due to environmental and other concerns, this is the first time an attempt has been made to provide a regulatory framework for the use of the EEZ waters in the United States for aquaculture. Its passage into law, if ever, may have significant effects on United States aquaculture production, import needs for seafood and global trade in aquaculture products. It should be noted that the United States national policy as stated in their National Aquaculture Act of 1980: is to "encourage the development of aquaculture" as a way of "reducing the United States trade deficit in fisheries products, for augmenting existing commercial and recreational fisheries, and for producing other renewable resources, thereby assisting the United States in meeting its future food needs".

Sub-Saharan Africa

Countries considered in the sub-Saharan Africa region (see Chapter 1) have considerable scope for aquaculture development but generally share similar key constraints hindering the unfolding of its potential. It should be noted, although a broad reference to sub-Saharan Africa is made in this chapter, countries such as South Africa, Nigeria, Kenya, Madagascar, and Ghana stand out in terms of progress made in national aquaculture development and the current overall status of aquaculture.

During the period 1998 to 2004 aquaculture production in sub-Saharan Africa increased from 46 882 tonnes to 80 434 tonnes.

Though non-commercial aquaculture (subsistence aquaculture produced mainly for household use) is still practised at low levels of intensity, the commercial sector appears to be at the threshold of a new dawn in the region.

Fish supply currently cannot meet regional demand. Throughout the region per capita consumption over the last two decades has decreased by an average of 2.1kg/person/year, and marine fish imports have increased by 177 percent during the same period. The supply deficit has clearly affected the price of fish, and it is clear that this has driven the development of commercial aquaculture.

The noticeable change to commercial farming and higher levels of intensification (such as greater use of farm-made feeds, inorganic fertilizers and better-managed and synchronized harvesting) are being observed. However, it is not fully understood whether the greater degree of commercial farming in comparison to 1999 is a consequence of non-commercial farmers switching to commercial farming or whether the "new wave" of commercial farmers are progressive new entrants into the sector, spurred on by the escalating fish price.

Except in South Africa, Madagascar, Mozambique and the United Republic of Tanzania, mariculture is underdeveloped and underexplored in the region as a whole. However, several countries have identified the potential for the farming of prawns, fish, seaweed or shellfish and some are on the threshold of initiating the development of mariculture sector.

Within the overall context of aquaculture in the region the commercial sector is making advances at all levels of scale and intensification. Apart from Nigeria and Madagascar, this sector now also appears to be making notable advances in Uganda, Ghana, Kenya, Côte d'Ivoire, Zambia and Malawi. It is predicted that the development and adoption of Strategic Aquaculture Development Plans in several countries will further trigger its development.

In most countries, non-commercial aquaculture is still considered to form part of a livelihoods diversification strategy to reduce risks and provide greater food security at the family level. The non-commercial sector, as in the past is constrained by various biotechnical, institutional, infrastructural and economic factors, the most important of which are the quality and type of extension provided and the lack of quality fish seed and feed. The level of management remains low and most farmers use the pond as a "bank" for food and cash as and when needed.

The cutback in donor support for aquaculture development, since the mid- to late 1990s, seems to have had notable effects on institutions. In particular, this is evident with respect to capacity (planning), management, research, training and the quality and intensity of extension. Several countries have reported that extension either has collapsed remained static or has seriously regressed. The most appropriate method for extension appears to be the participatory on-farm approach; however, this method is practised mainly by donor supported projects and its long-term sustainability has not been tested. Overall, it can be concluded that new and more effective means of extension are required.

It has been suggested that non-commercial aquaculture will not be likely to make significant contributions to national fish supply in any of the target countries. To increase national fish supply requires paradigm shifts in the support role of lead agencies and donors.

Western Europe

The continuing stagnation of capture fisheries and soaring demand for seafood products in Western Europe has spurred the expansion of the aquaculture sector in the Western European region since the 1970s. The rate of growth over the last decades, however, has not been consistent and shows characteristics of a new agro-food industry that is fast showing signs of slowing down in the last decade.

The major expansion in aquaculture between 1994 and 2003 was overwhelmingly dominated by marine finfish production particularly that of Atlantic salmon in northern Europe. Norway (71 percent), United Kingdom of Great Britain and Northern Ireland (19 percent) and Faeroe Islands (10 percent) were the major players driving the soaring increases in Atlantic salmon that accounted for almost all the increase in salmon production since 1994.

In southern regions of Western Europe seabass and seabream farming has similar significance for Greece, Turkey, Spain, Italy and France, which in 2003 accounted for 95 percent of production mainly from sea cages.

The increased production and supply of farmed species notably salmon, trout, bass and bream was accompanied by a steady fall in farmgate prices triggering restructuring of the industry farming the major species all over Western Europe.

These challenges have not negatively impacted on production. Falling prices were offset by substantial increases in volume of the key finfish species.

There has been a continued increase in interest for the farming of other species such as cod and halibut. The likely impact these new species may have, however, is difficult to ascertain at present and will probably be dictated by national regulatory authorities rather than technical constraints. The diversification initiatives are occurring against a backdrop of limited production sites and increasing environmental challenges.

Creative marketing is an emerging strategy for diversification. In the last decade quality labels have been promoted to attract sales. More recently organic labels have been created to command higher priced niche markets. Countries in the region have varying rules for organic production but as yet there are no European or internationally harmonized standards. While these strategies may raise prices on the margins of the industry its mass appeal is uncertain and its impact on increased production is unclear. There has been also interest in ecolabelling of aquaculture products in countries such as France and Italy but it is unclear if such labelled products progress from the current niche status to a more mainstream role in the retail sector.

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Annex

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