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Prospective Analysis of Future Aquaculture Development

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1. Summary

The Committee on Fisheries Sub-Committee on Aquaculture, during its third session, held in Trondheim, Norway in 2003, requested that the Secretariat should provide a prospective analysis of future challenges in global aquaculture as a basis for a discussion of the longer term direction of the Sub-Committee's work[1]. Responding to this request, FAO embarked on a complex process that concluded in this **Prospective Analysis.** The process included national aquaculture sector overviews of all major aquaculture producing countries (over 100)[2], five regional workshops that discussed regional aquaculture development status and trends, seven regional aquaculture development status and trends reviews[3], a global expert survey on aquaculture development using the Delphi Technique, and a global review of the status and trends in aquaculture development based on the outcome of all these efforts[4] and other available documentation. An expert workshop was finally convened to build consensus on the draft global aquaculture review and to craft this Prospective Analysis.

Results of this lengthy and complex process, which included the valuation of demand for and supply of fish and fishery products are consistent in pointing to the gap between these two forces of fish and fish products market in the next two decades[5]. In addition, the scientific community and development agencies all concur that the production from capture fisheries is likely to remain more or less constant, making it doubtful for the sub-sector to be able to close this gap. The implication of these findings is that, to maintain the current level of consumption of fish and fish products, aquaculture production will have to cover the excess demand.

There exists a wide range of perceptions towards aquaculture, marked by negative and positive extremes. The most negative view presents aquaculture as having little or no value. The most positive regards aquaculture as the answer to many problems. The two extremes provide benchmarks for various grades of perceptions on the shortcomings and/or benefits of the sector.

A balanced view recognises a mix of advantages and disadvantages and offers a scenario where the use of resources for social and economic development will lead to some environmental impact that could and should be mitigated. Views on the sector in any event need to be based on solid evidence if they are to amount to anything more than mere opinion, however strongly or emotionally expressed. Responsible advocacy for particular directions in aquaculture development is one which is objectively guided by science.

While aquaculture production is projected to increase substantially, although at a slower rate than in the past, accounting for 39 percent of global fish production in 2015[6], questions remain as to whether the industry will be able to grow fast enough to compensate for the expected fish shortage. As mentioned earlier, there are indications that aquaculture could cover this gap, but, in addition to many unknowns, there are also many forces which could

[1] ***Committee on Fisheries. Report of the second session of the Sub-Committee on Aquaculture. Trondheim, Norway, 7-11 August 2003***. FAO Fisheries Report. No. 716. Rome, FAO. 2003. 91p.
[2] http://www.fao.org/figis/servlet/static?dom=root&xml=aquaculture/naso_search.xml
[3] See page 5 for the seven regional aquaculture development review references
[4] ***State of world aquaculture: 2006***. FAO Fisheries Technical Paper. No.500. Rome, FAO. 2006. 134p.
[5] ***State of the world fisheries and aquaculture: 2002***. FAO. 2002. 150p.
[6] ***State of the world fisheries and aquaculture: 2002***. FAO. 2002. 150p.

pull aquaculture production in the opposite direction, thereby making it difficult for the industry to grow substantially enough to meet the expected demand in the decades to come. Thus, the exact answer to the question of whether aquaculture will meet the expected shortage of fish and fish products remains anyone's guess.

A government's commitment to provide increased support to the aquaculture sector is a prerequisite for its sustainable development. The commitment generally takes the form of clear articulation of policies, plans and strategies and adequate funding support. The challenge, and a potentially constraining factor, is the level of commitment of governments, particularly those of developing countries. Will it falter as new global economic opportunities arise, or shift as the competition for scarce financial and natural resources increases? Such competition could come from emerging and promising sectors, such as ready made garments, information technology, poultry and pharmaceuticals. While the level of commitment will vary within and among regions, depending on the importance of aquaculture in national economies and wellbeing, it is nonetheless expected that in countries where aquaculture contributes substantially to growth, poverty alleviation and food security, the commitment will hold and the level of support increase.

2. Introduction

Global production from aquaculture has grown substantially, contributing in ever more significant quantities to the world's supply of fish for human consumption. This increasing trend is projected to continue in forthcoming decades. The sector's vision is to contribute more effectively to food security, poverty reduction and economic development by producing - with minimum impact on the environment and maximum benefit to society - 83 million tonnes of aquatic food by 2030, an increase of 37.5 million tonnes over the 2004 level. From an activity that was primarily Asian, aquaculture has now spread to all the continents. From an activity that was focused on freshwater fish, particularly the cyprinids, it now encompasses all the aquatic environments and many aquatic species. From an activity that was primarily small-scale or non-commercial and family based, it now also includes large scale commercial or industrial production of high value species that are traded at the national, regional and international levels. Its Asian dominance and its small-scale based aquaculture operations, however, are still evident in the present structure of the sector.

The increasing recognition by governments to implement aquaculture programs based on sound policies, the growth in population and increasing purchasing power of people, the opening of new markets facilitated by trade liberalization, and the technological advances bring greater opportunities for further development of the sector. On the other hand, the stagnating level of capture fisheries, the need to further strengthen capacities of institutions and other stakeholders, the increasing consumer demand for diversified, safe and quality products, the scarcity of land and water resources, and the need to support small-scale farmers pose as major challenges to the sector.

Aquaculture has an important role to play in global efforts to eliminate hunger and malnutrition through supplying fish and other aquatic products rich in protein, essential fatty acids, vitamins and minerals. Aquaculture can also make significant contributions to development by improving incomes, providing employment opportunities and increasing returns on resource use. With appropriate management, the sector appears ready to meet the demand gap for aquatic food (fish) for the coming decades, a consequence to the increasing global population and stagnant capture fishery production. The main challenge for policy makers and development agents is to create an "enabling environment" to support the expansion needed to meet this potential. This enabling environment is multi-faceted and requires significant political will, policy support and investment. The failure to provide this environment may result in the inability for the fisheries sector to provide the supply of aquatic food required to even maintain current levels of consumption.

3. The process of the prospective analysis

The process included national aquaculture sector overviews of all major aquaculture producing countries (over 100), five regional workshops that discussed regional aquaculture development status and trends, seven regional aquaculture development status and trends reviews, a global expert survey on aquaculture development using the Delphi Technique, and a global review of the status and trends in aquaculture development based on the outcome of all these efforts and other available documentation. An expert workshop was finally convened to build consensus on the draft global aquaculture review and to craft this **Prospective Analysis**.

In analysing the prospects of future aquaculture development, three key factors have been examined and evaluated. They are: the factors that contributed or contributing to the important growth; the factors that constrained or constraining development of the sector; and the opportunities and challenges for the future development of aquaculture.

To simplify this process, the global aquaculture sector is classified into **well established**, **emerging** and **infant** categories, with countries in each of the seven aquaculture regions[7] grouped into one of the three categories based on each region's relative position with respect to its contributions to global aquaculture production by weight and value in 2004. Each category is then analysed based on three related sets of contributing and constraining factors: (a) **policy, institutional, legal and management**; (b) **markets, trade and finance**; and (c) **research and development**. Due to the marked intra- and inter-regional and country variations in the history, practice and potential of aquaculture, it is not logical to consider the analyses and conclusions of the factors to apply equally to all regions and countries engaged in aquaculture activities. On the other hand, some of the factors that are external to the aquaculture sector, or factors over which the sector has little or no control, such as political instability, civil strife, war and natural disasters, could adversely impact countries and regions or three categories analysed.

It should also be noted that there are exceptions to this simplified classification. Some countries, such as the Islamic Republic of Iran and Egypt, which are relatively well established in terms of aquaculture development, are grouped in a lower category since they are located in a region whose contributions to total global aquaculture is low. The converse is also true, as in the case of countries such as Nepal and Pakistan in the Asia region which is placed in the well established category because its contribution to global aquaculture is the highest among regions. Another exception is North America, which, despite its low contributions, is placed in the well established category because of its relatively advanced state of development with respect to all the three sets of factors. However, in all such exceptional cases, appropriate qualifications and explanations are provided to clarify and strengthen the analyses.

[7] See page 5 for the seven regional aquaculture development review references

4. Scope of this document

The scope of this document includes an examination of the key factors that have contributed or are contributing to the growth of aquaculture globally during the past two decades, a discussion of the factors that constrained or are constraining its development, the identification of the challenges and opportunities for the future development of the sector, and the presentation of recommendations for moving forward. The analysis also provides some indications of the role of the COFI Sub-Committee on Aquaculture in shaping the future of aquaculture globally. Improvements to this document will be made on the basis of the comments and advice received by the members of the COFI Sub-Committee during its third session.

Since this document is a result of a long process as described earlier, it is recommended that those who are interested in details for further understanding the basis for some of the inferences and recommendations should refer to the following seven regional aquaculture development trends reviews and the global aquaculture development trends review, which are also outputs of this process. It is also recommended that the previous global aquaculture development trends review published in connection with the Conference on Aquaculture in the Third Millennium (see below) be also consulted.

FAO. ***State of world aquaculture:*** *2006*. FAO Fisheries Technical Paper. No.500. Rome, FAO. 2006. 134p.

FAO/Network of Aquaculture Centres in Central and Eastern Europe. 2006. *Regional review on aquaculture development trends. 5. Central and Eastern Europe – 2005*. FAO Fisheries Circular. No. 1017/5. Rome, FAO. xx pp. (in press)

Hecht, T. 2006. *Regional review on aquaculture development. 4. Sub-Saharan Africa – 2005*. FAO Fisheries Circular. No. 1017/4. Rome, FAO. 96 pp.

Morales, Q.V.V & Morales, R.R. 2006. *Síntesis regional del desarrollo de la acuicultura. 1.América Latina y el Caribe – 2005/Regional review on aquaculture development.1. Latin America and the Caribbean – 2005*. FAO Circular de Pesca/FAO Fisheries Circular. No. 1017/1. Roma/Rome, FAO. 177 pp.

NACA/FAO. 2001. *Aquaculture in the third millennium*. R.P. Subasinghe, P.B. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. *Technical proceedings of the conference on aquaculture in the third millennium*, Bangkok, Thailand. 20-25 February 2000. Bangkok, NACA and Rome, FAO. 471 pp.

Network of Aquaculture Centres in Asia-Pacific. 2006. *Regional review on aquaculture development. 3. Asia and the Pacific – 2005*. FAO Fisheries Circular. No. 1017/3. Rome, FAO. 97 pp.

Olin, P.G. 2006. *Regional review on aquaculture development. 7. North America – 2005*. FAO Fisheries Circular. No. 1017/7. Rome, FAO. xx pp. (in press)

Poynton, S.L. 2006. *Regional review on aquaculture development. 2. Near East and North Africa – 2005*. FAO Fisheries Circular. No. 1017/2. Rome, FAO. xx pp. (in press)

Rana, K.J. 2006. *Regional review on aquaculture development. 6. Western Europe – 2005*. FAO Fisheries Circular. No. 1017/6. Rome, FAO. xx pp. (in press)

5. Special note on sub-Saharan Africa

An instructive counterpoint to rapid aquaculture development elsewhere is its development in sub-Saharan Africa. It is the only region where per capita consumption of fish has dropped, a trend we can ill afford to see continue or worsen, especially when the decline in fish consumption has not been offset by the increase in consumption of other animal proteins. It is also the only region where the contribution to the world aquaculture output remains below one percent. This makes Africa a high priority region for aquaculture development. There is a need for development agents and institutions to join hands to ensure that aquaculture and fish production in sub-Saharan Africa becomes part of the overall development process for the continent. Most countries in sub-Saharan Africa have limited resources to deliver quality public goods and services without donor support and many have an under-developed private sector that could operate in its stead. There is thus a need for renewed and long-term assistance to Africa's aquaculture sector; it is also imperative that all learn from mistakes of the past.

The recent review by FAO[8] identified political stability and good governance as the two overarching conditions required for making aquaculture development in sub-Saharan Africa. It is also believed that there should be more emphasis put on private sector investment in aquaculture in sub-Saharan Africa. Private sector efficiency should be facilitated by the establishment of an enabling public sector environment combined with a strategy to undertake development within the limits of available resources. Positive impacts of growing aquaculture development should be further complemented by aggressive implementation of Poverty Reduction Strategy Papers (PRSPs), development of national aquaculture strategies and sound legislation. Providing incentives and risk reduction measures for Foreign Direct Investment is also necessary and can have trickle-down effects to boost development of small- and medium-scale scale aquaculture enterprises.

The availability of quality inputs such as seed and feed in sufficient quantities, good quality information and available capital as well as access to land and water resources will contribute to reducing risks and enhancing sustainability. During the process of increasing the benefits of aquaculture to Africa, including direct and indirect advantages to the most needy, it will be imperative that the good image of aquaculture be maintained. Adoption of appropriate environmental management practices for protection and sustainable use of aquatic resources will be vital in this regard. It is also imperative to maintain high standards for food safety. Finally, development of skills and effective communication and knowledge transfer through the efficient use of modern information technology will link Africa better to other regions.

[8] ***State of world aquaculture: 2006***. FAO Fisheries Technical Paper. No.500. Rome, FAO. 2006. 134p.

6. Policy, institutional, legal and management factors

One of the milestone developments in the recent history of aquaculture was the FAO-convened global conference in Kyoto[9], which raised the institutional profile of aquaculture by formally recognizing it as a separate socio-economic activity within the fisheries sector, with the potential to make substantial contributions to economic development. Thus, the Kyoto Declaration established the foundation for institutional bifurcation of fisheries into aquaculture and capture fisheries and highlighted the need for sustained commitment and support by policy makers. A positive outcome of the Kyoto Declaration is the establishment of United Nations Development Programme (UNDP) funded aquaculture development cooperation programme (ADCP)[10] which initiated regional networks of aquaculture centres in Asia, Africa and Latin America, of which the Asian network became an independent intergovernmental organization dedicated to aquaculture development (the Network of Aquaculture Centres in Asia-Pacific - NACA) in 1989.

The subsequent holding of the Conference on Aquaculture in the Third Millennium[11] and the crafting of and building consensus on the Bangkok Declaration and Strategy for Aquaculture Beyond 2000[12] are important international events that accelerated the sector development process by reiterating the need and the potential for aquaculture to contribute to the global food and societal development. Formation of the FAO Committee on Fisheries (COFI) Sub-Committee on Aquaculture[13], which is currently the only global inter-governmental forum for exclusively discussing aquaculture, is also recognised as recent institutional milestone development.

There are many other forums that have contributed to advocating for the importance of aquaculture worldwide. These have not only improved the much needed awareness, but also sparked activities which contributed to the sector's growth.

This section describes a number of policy, institutional, legal and management factors believed to have significantly contributed or contributing to the sector's growth. It also discusses those factors which has constrained or constraining the development of the sector.

6.1 Factors that contributed or contributing to the sector growth

Under this category, six main factors enhanced the growth of aquaculture globally. These include:

(a) formulation of fisheries and aquaculture policies, plans, regulations and strategies;
(b) national and international commitments to financially and technically support aquaculture development;

[9] ***Report of the FAO technical conference on aquaculture, Kyoto Japan, 26 May- 2 June 1976***. FI/R188. 1976. FAO, Rome.

[10] ***Aquaculture development and coordination programme interregional project findings and recommendations.*** Report prepared for the participating governments by FAO. Rome. UN/FAO. 1991.

[11] ***Aquaculture in the Third Millennium.*** NACA/FAO. 2001. Subasinghe, *et.al*. Proceedings of the Conference on Aquaculture in the 3d Millennium, Bangkok. 20-25 Feb. NACA Bangkok and FAO Rome. 471 pp.

[12] ***Aquaculture development beyond 2000: The Bangkok declaration and strategy.*** NACA/FAO. 2000. 23 pp.

[13] ***Report of the Expert Consultation on the Proposed Sub-Committee on Aquaculture of the Committee on Fisheries. Bangkok, Thailand, 28-29 February 2000.*** FAO Fisheries Report. No. 623. Rome, FAO. 2000. 36p.

(c) preparation of a strategy to improve collection of global information on aquaculture status and trends;
(d) aquaculture networks and alliances;
(e) producer associations, private sector and civil society; and
(f) application of co-management principles, particularly in culture-based fisheries.

National fisheries and aquaculture policies and plans on the rise - An encouraging trend noted and which has also contributed significantly to the sector growth is that, increasingly, more counties have formulated or are in the process of formulating fisheries policies, plans, regulations and strategies that facilitated and are expected to facilitate the growth and efficient management of the aquaculture sector. The engagement of all stakeholders in the process of developing these policies and strategies and their subsequent participation in implementation, including the promotion of codes of conduct and best management practices, are considered as significant achievements and have resulted in positive outcomes. For effective implementation of policies and plans many countries are providing capacity enhancement support not only to government ministries and public sector agencies dealing with administration, extension and research and development and legislation, but also to informal organizations and institutions representing the private sector, consumers and other stakeholders.

A recent study by FAO on integration of fisheries into key national policy documents relating to poverty reduction and rural development showed that the sector has been most effectively mainstreamed in Asia (in the case of poverty reduction strategy papers and national development plans), closely followed by Africa[14]. The study, however, suggested that further efforts be made by governments, in particular policy makers and direct practitioners, to ensure the effective integration of fisheries, including aquaculture, into national policy developments relating to poverty reduction and rural development, paying particular attention to gender issues and internationally recognized fishery development instruments such as the Code of Conduct for Responsible Fisheries[15].

National and international interests to aquaculture development in Africa are renewed – After sometime, Africa appears be receiving greater attention of national and international development agencies over the past five years[16]. As indicated earlier, in sub- Saharan Africa, aquaculture contributes less than 1 percent to total fish supply. However, the potential for growth is high and the task is enormous. There have improvements in national interests as well as international interest in harnessing this potential. FAO has been assisting, along with other international development players, in Africa to develop National Aquaculture Strategies in many countries, based on state requests[17]. These initiatives clearly demonstrate the desires by the governments to explore ways to unlock the potential for their national aquaculture development.

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[14] ***Mainstreaming fisheries into national development and poverty reduction strategies: current situation and opportunities***, by A. Thorpe. FAO, 2004. Fisheries Circular No.997, Rome.
[15] ***The State of World Fisheries and Aquaculture: 2004***. FAO, 2004. 168pp.
[16] Sorgeloos, P. 2001. Technologies for sustainable aquaculture development, Plenary Lecture II. *In* R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, & S.E. McGladdery (Eds.) *Aquaculture in the Third Millennium.* Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. pp. 23-28. NACA, Bangkok and FAO, Rome.
[17] ***Report of the FAO-Worldfish Center workshop on small-scale aquaculture in sub-Saharan Africa: revisiting the aquaculture target group paradigm. Limbé, Cameroon, 23-26 March 2004,*** John Moehl, Matthias Halwart and Randall Brummett (Eds.), CIFA Occasional Paper No. 25, FAO, Rome 2005, 54p.

Two significant recent developments demonstrate governments and international development partners' commitment to realizing the potential of fisheries and aquaculture to contribute to food security, poverty reduction and economic development in Africa. The first relates to the August 25, 2005 Abuja Declaration on sustainable fisheries and aquaculture in Africa, adopted by the Heads of State Meeting of the New Partnership for Africa's Development (NEPAD) Fish for All Summit in Nigeria[18], and the second is the launching of the Global Program on Fisheries (PROFISH), a new global partnership of developing countries, donors and technical agencies led by the World Bank[19]. The Summit also endorsed the NEPAD Action Plan for investment in support of fisheries and aquaculture development in Africa (Box 1). It was further agreed that the Plan be used as a guideline for formulating and implementing policies, programs, projects, and strategies at national, regional and continental levels[20]. The implementation of the Action Plan is expected to follow a "piloting" approach, with Fast-track Programs to be identified for immediate action.

Box 1. Summary of NEPAD Priority Investment Areas in Africa

NEPAD Objectives	***Aquaculture****
Improved productivity	• Developing sector-wide strategies at national level for expansion and intensification of aquaculture • Supporting priority aquaculture zones • Encouraging private-sector investment across the sector • Applying proven technologies to increase production
Environmental sustainability	• Maintaining the competitive advantage that Africa's environment provides for aquaculture production
Market development and trade	• Harnessing the opportunities for small and medium enterprise development provided by expanding domestic markets for fish, including growing urban demand • Supporting the emerging regional trade in aquaculture products • Harnessing the opportunity of expanding export markets for high-value aquaculture products to increase investment in African aquaculture production and processing
Food security and nutrition	• Expanding the adoption of integrated small-scale aquaculture as a means of increasing rural productivity and food security • Exploiting the potential of aquaculture production to contribute to food security programs

* Action Plan shown in the box covers Aquaculture part only

The PROFISH has a major focus on Africa, to improve sustainable livelihoods in the fisheries sector and to make concrete progress towards meeting the World Summit on Sustainable Development's (WSSD) goals in fisheries. Although not an investment programme,

[18] http://www.fishforall.org/ffa-summit/africasummit.asp

[19] http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTARD/0,,contentMDK:20663251~pagePK:210058~piPK:210062~theSitePK:336682,00.html

[20] ***NAGA, 2005.*** WorldFish Center Quarterly Vol.28 No. 3&4 Jul-Dec 2005, pages 19-22; and www.fishforall.org/ffa-summit/africasummit.asp)

PROFISH is expected to catalyze an increased investment in fisheries policy reform, good governance, pro-poor fisheries strategies, and other strategic national and regional investments. At a global level, PROFISH aims to help develop and promote solutions to core fisheries problems, including knowledge building and poverty issues in fisheries[21].

Need for reliable information is addressed **-** In recent years, with the rapid growth of the aquaculture sector, demand for reliable and timely information on the status and trends of aquaculture has greatly increased to: formulate and monitor sound policies and development plans; respond to reporting requirements of international agreements; and respond to public demand for transparency and accountability. There have been many attempts to improve the information base on aquaculture, globally. In the shrimp, salmon and marine cage fish sectors, there are significant developments in information gathering and dissemination by the producer associations, development agencies, private sector interests and even by the States[22].

On a global basis, the COFI Sub-Committee on Aquaculture, during its first session in April 2002 and the second session in August 2003, considered information needs for aquaculture as a priority area for attention at the global level and recommended that FAO develop a strategy for improving collection and processing of data and information on the status and trends of aquaculture. To address such needs, FAO convened an expert consultation in 2004 and prepared a draft strategy and outline a plan for improving information on status and trends of aquaculture. For effective implementation of the plan, the strategy calls for financial and technical assistance support from development partner agencies, including FAO, to enhance the capacity of states whose data collection systems are weak[23]. The draft Strategy will be presented to the COFI Sub-Committee on Aquaculture in September 2006 for approval and it is envisioned that a project for implementing the Strategy by 2007 will be initiated.

Networks and alliances are highly valued **-** As mentioned earlier, a positive outcome of the Kyoto Declaration is the establishment of a number of regional networks of aquaculture centers that are technically promoted by FAO. In the Asia region, the NACA was established in 1980 and became an independent inter-governmental organization in 1989. The lessons learned from the establishment and operations of NACA have shown that:

(a) technical cooperation among member governments works, as it facilitates the exchange of known technology, exchange of scientific findings, dissemination of new knowledge and information, and exchange of expertise,
(b) NACA programs promote ownership and continuity of initiatives as they address priority issues and needs expressed by governments,
(c) NACA programs produce early, visible and measurable results for increasing aquaculture production in the region, and
(d) NACA focuses on research that promote scientific understanding of vital interrelationships of salient dependent and independent variables for the improvement of production systems in the region[24].

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[21] ***NEPAD Fish for All Summit, Abuja, Nigeria, August 25, 2005.*** Address by Warren Evans, Director of Environment, The World Bank, page 3, and www.worldbank.org/

[22] http://www.aquatt.ie/, http://www.feap.info/feap/ http://www.shrimpnews.com/ http://fis.com/salmonchile/ http://www.enaca.org/modules/tinyd2/index.php?id=1

[23]***FAO Fisheries Department. 2005. Towards improving global information on aquaculture.*** FAO Fisheries Technical Paper. No. 480. Rome, FAO. 172p.

[24] http://www.enaca.org/

FAO has been active in exploring the potential to establish NACA-like networks in other regions of the world. This effort, as recommended by the COFI Sub-Committee on Aquaculture, sparked the establishment of the Network of Aquaculture Centers of Central and Eastern Europe (NACEE) in 2004. The Research Institute for Fisheries, Aquaculture and Irrigation (HAKI) in Hungary has become the coordinating institution of NACEE and the new network is in the process of, among others, collecting and synthesizing information on research and development activities of the NACEE member institutes, including activities on education, training, and capacity building, sharing proposals for joint R&D activities, and exploring possibilities of web-based networking as tools for improving information exchange. Although not a true-NACA-like network, NACEE has the potential to become a NACA-like independent inter-governmental organization in the future.

FAO is also engaged in other regions, especially in Latin America and sub-Saharan Africa, exploring regional networks, for the purpose of promoting sustainable development of aquaculture. In the Latin American region, two feasibility studies were recently carried out, one by FAO and the other by the Asia Pacific Economic Cooperation (APEC)[25]. In sub-Saharan Africa, a Sub-Committee on Aquaculture to the Commission on Inland Fisheries of Africa (CIFA) was established in 2005. In the Near East region, the Regional Commission for Fisheries (RECOFI) was established in 2004. The RECOFI's recent initiatives include the development of a regional aquaculture information system (RAIS), and finalization of a project to strengthen the policy, institutional and legal framework for aquaculture in the member countries[26].

The Southeast Asian Fisheries Development Center (SEAFDEC), another important intergovernmental body in Southeast Asia, has also been effectively promoting aquaculture development through training, research and information services. Several regional networks dedicated to fish trade have also been established and are contributing the global aquaculture development[27].

In the field of research, an important strategic alliance is The Consultative Group on International Agricultural Research (CGIAR), which includes 15 international research centres that work with national agricultural research systems and civil society organizations, including private sector. The centres are supported by governments, international and regional organizations, and private foundations. One of the Centers is WorldFish Center (WFC)[28], whose mission is to reduce poverty and hunger by improving fisheries and aquaculture. In addition to Asia, WorldFish Center is involved in research work in Africa (Malawi, Cameroon and Egypt), and will assist NEPAD in the implementation of the Action Plan for fisheries and aquaculture.

Many networks of producer associations and groups assisted by private sector as well as donor and development agencies do exist and have contributed significantly to the sector development.

[25] Source: Establishment of an Aquaculture Cooperation Network in Latin America and the Caribbean, Jose Aguilar-Manjarrez, pages 35-37, FAO Aquaculture Newsletter, July 2005, No.33

[26] The Third Session of the Regional Commission for Fisheries (RECOFI), Alessandro Lovatelli, pages 38-39, FAO Aquaculture Newsletter, December 2005-No.34.

[27] http://www.infofish.org/ http://www.infopesca.org/

[28] http://www.worldfishcenter.org/cms/default.aspx

Efficient producer associations formed **-** From the aquaculture self-help groups, including women's groups in one of the poorest villages of India, to the more formal regional and international producer co-operations (such as Federation of European Aquaculture Producers – www.feap.org, Salmonchile in Chile - www.salmonchile.cl - and the Brazilian Shrimp Farmer Association - www.abccam.com.br, Global Aquaculture Alliance – www.gaalliance.org with their headquarters in Europe and the United States of America, producer associations (PA) have been playing a major role in global aquaculture development. At a special session on PA at the Second Meeting of the Subcommittee on Aquaculture[29], the Sub- Committee acknowledged PA as an important player in the development of sustainable aquaculture and recommended that they should be provided with appropriate support to strengthen their capacity, particularly that of small farmers associations, and encouraged to establish regional-level PA.

While there are varying degrees of accomplishments among the PAs, some of the common ones are: shaping and influencing policy and regulations; providing technical services; facilitating access to markets; developing and promoting codes of conduct, best management practices and self-regulatory practices; and sharing of knowledge. In the case of countries with market distortions and weak governance, there is emphasis on "getting organized to resist exploitation by middlemen and local pressure groups" and on mobilizing credit[30]. On the other hand, in the more developed countries such as in Europe and North America, the PA tend to have more focus on scientific and human resources development to keep pace with cutting edge technology and stronger representation in government policy-making.

These regional and international PAs have also been active in the dissemination of knowledge and promotion of Codes of Practice, Good Aquaculture Practices, Better Management Practices, etc. As these PA have direct access to producers, their role has been important in translating government's decisions into practical actions at farm level. Thus, PA, as knowledge sharing networks, have been providing opportunities to stakeholders to improve the efficiency and value of technical cooperation and capacity development.

Contributions of private sector and civil society participation increased **-** As part of their overall privatization strategy, many countries engaged in the promotion of aquaculture development are expanding the scope of their privatization program to the aquaculture sector. In sub-Saharan Africa, for example, Kenya's approach is to play a supportive role by: fostering participative policy formulation, providing a conducive legal and investment framework, establishing public private partnerships, providing basic infrastructure support, promoting self regulation, providing a research platform, undertaking zoning for aquaculture and providing monitoring and evaluation support. Several other countries in the sub-Saharan Africa region (Uganda, Madagascar, Mozambique, Malawi, Cote d'Ivoire and Gambia) have adopted similar policy decisions expected to trigger the rapid evolution of commercial aquaculture in the next decade. In the case of Nigeria, this approach has been in existence for a while and has contributed to the development of the country's commercial aquaculture. There is also a trend in some countries in the sub-Saharan Africa region to privatize research facilities, with initial encouraging results in terms of production.

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[29] ***Committee on Fisheries. Report of the second session of the Sub-Committee on Aquaculture. Trondheim, Norway, 7-11 August 2003.*** FAO Fisheries Report. No. 716. Rome, FAO. 2003. 91p.

[30] ***Producer Associations and Farmer Societies: Support to Sustainable Development and Management of Aquaculture***, Courtney Hough and Pedro Bueno, page 79, 2003 FAO Fisheries Circular No. 886, Rev.2, Review of the State of World Aquaculture

In Asia and Latin America, private sector participation in aquaculture is not new. Although governments played a significant role in promoting aquaculture initially, many Asian and Latin American countries, while creating an enabling environment for private sector to engage more in aquaculture development, now rely fully on the private sector as a major service provider for aquaculture. Most state-owned seed production facilities have become private. Feed production is entirely a private sector activity. Many private laboratories are providing support and technical advice to aquaculture development including health management and developing vaccines and other bio-remediation protocols.

Civil society groups, including NGOs, are also making substantial contributions to policy formulation and implementation and support to poor aquaculture farmers. The groups were instrumental in influencing the sector to address the issues that arose from shrimp farming practices that were not conducted in a responsible manner and lead to social and environmental problems such as the destruction of mangroves in many countries in Asia and Latin America. The group's advocacy role also focuses on creating awareness among consumers on food safety issues. Further, NGOs have been providing financial, technical and capacity building support to poor aquaculture farmers, mainly in countries in sub-Saharan Africa and Asia regions.

Co-management principles applied **-** Co-management is an emerging trend and usually applied in the management of common property resources, such as floodplains and forests, at the community level. The World Bank has defined co-management as "the sharing of responsibilities, rights and duties between the primary stakeholders, in particular, local communities and the nation state"[31]. The same definition has been adopted by the World Conservation Congress: 'a partnership in which government agencies, local communities and resource users, nongovernmental organizations and other stakeholders negotiate, as appropriate to each context, the authority and responsibility for the management of a specific area or set of resources'. Co-management partnerships are evolving between producer organizations and governments, where government trusts the organizations to manage some aspects of the sector and in turn the producer organization advocates and represents its members in national decision making process.

Co-management is useful for, among others, exchange of resources (such as technology and technical expertise and other capacity enhancement support by public sector and information about harvesting volumes or indigenous knowledge provided by communities) and risk sharing and conflict resolutions. In the context of the aquaculture sector, the application of co-management has been effective in culture-based fisheries, a form of aquaculture practiced communally in small water bodies in rural areas. This form of culture has the potential to increase fish production with minimal input of resources (e.g. in Sri Lanka, Viet Nam, Bangladesh and Thailand). An evaluation of this type of program in three countries (Bangladesh, the Philippines and Thailand) by ADB (2004), found that it had contributed to the development of self-help initiatives, local ownership, and decision making in communities.

31 http://lnweb18.worldbank.org/EAP/eaprural.nsf/40ByDocName/StateBankofVietnamandTheWorldBankinVietnam

6.2. Factors that constrained or constraining the sector growth

Despite having made good progress in policy formulation, institutional development and formulation of strategies, there are still areas which need further strengthening, more so in the countries in the sub-Saharan Africa, Asia and the Pacific, Central and Eastern Europe and North Africa regions. In analysing such needs, it is useful to consider three factors. First, implementation of policies and strategies will be more effective if there is an overall enabling environment (good governance), which is lacking in varying degrees in many such countries. Second, the sector has seen remarkable growth in recent years, particularly with respect to culture of high value species, such as shrimps. These species are mainly for exports. Because most of the producing countries historically relied on traditional methods of fish farming and produce for home consumption and/or domestic markets, they were not exposed to the stringent export-related rules and regulations on food safety and other environmental and social concerns. Third, and this follows from the two factors above, capacity development is a long-term process and needs commitment and continued support by governments.

Clearing the web of laws - While the regulatory framework governing aquaculture exists in many countries, enforcement of regulations is complex and needs strengthening because of the numerous interests involved, the diversity of natural resources used, the cost, and the variety of institutions concerned[32].

Aquaculture interacts with the environment and is dependent on land, water and aquatic species. It also produces a product for human consumption that needs to comply with the safety and quality standards of both national and international markets. Furthermore, aquaculture producers also involve small and marginal farmers, whose interests need to be safeguarded. Thus, land laws, water laws, environmental laws, trade laws, social-related laws and others applying more generally (e.g. public health and sanitary laws and tax laws), which are under the jurisdiction of different agencies, have an effect on aquaculture development. In countries with weak institutional capacities (e.g., in the sub-Saharan Africa, Asia and the Pacific, Central and Eastern Europe and North Africa regions) diversity and complexity of the legal frameworks often result in unsatisfactory enforcement of laws applicable to aquaculture.

There is now growing understanding and recognition of the multiple interests involved in or affected by aquaculture development and management. Some developing countries have made progress in drafting specific set of rules for aquaculture (Aquaculture Act). Even among the countries with well developed national legal and regulatory frameworks, only few countries appear to have specific Aquaculture Acts and in most cases the national Fisheries Act/Environmental act provisions are invoked. This may still adequate in those countries however, they are faced with increasing difficulty with regulating aquaculture activity, importance given to adoption of better management practices, codes of conduct and codes of practice through self-regulation with the support of PA and other stakeholders. It is essential that governments take steps to strengthen the capacity of the institutions involved through, among others, clear formulation of responsibilities, promotion of decision making in a transparent manner, and provision of resources for training of staff.

[32] ***Van Houtte, A. 2001. Establishing legal, institutional and regulatory framework for aquaculture development and management.*** *In* R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, & S.E. McGladdery (Eds.). *Aquaculture in the Third Millennium.* Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. 103-120pp.

Strengthening human resources development **-** Greater efforts need to be made towards meeting human resources development (HRD) goals, mainly in countries in Asia and the Pacific and sub-Saharan Africa in which aquaculture plays a significant role in poverty alleviation and in countries in Central and Eastern Europe which are adapting to emerging opportunities in the aquaculture sector as a result of new market based economic policies. A NACA/FAO survey[33] in Asia revealed that 93 percent of the countries considered HRD as a major problem facing aquaculture, and 71 percent of the nations noted lack of skilled personnel as a major impediment to further development. Another survey on aquaculture development in Africa identified eight strategies as important to the development of the sector, of which five related to HRD, particularly in relation to small-farmers and extension workers[34]. HRD is pivotal to aquaculture development particularly in the context of the ever-increasing global call for promoting aquaculture development that is socially and environmentally acceptable. Given the challenges facing the sector, HRD in aquaculture needs to have a holistic approach and adapt its training and research programs accordingly.

Inadequate aquaculture extension services have been identified as a major constraint in most of the countries around the globe. This is clearly apparent in Africa, many countries in Latin America and Asia. The traditional Asian proverb "give someone a fish and he eats for a day; teach someone to fish and he can feed himself for a lifetime" still carries a powerful message. Extension training needs to be based on new models that will require greater interaction between extension trainees, farmers and other stakeholders such as NGOs and private sector suppliers. There is also a need to develop research capabilities to meet the increasing needs and challenges imposed on the sector, but inadequate research funding by governments is an issue. The private sector needs to be encouraged to invest in research and governments need to provide appropriate incentives. Capacity enhancement can also be enabled through increased networking among educational providers and researchers, including in other disciplines (e.g. health, nutrition, engineering fields). Capacity building support is further needed in the complex area of aquaculture legislation, particularly those relating to access to resources and user rights by small farmers and trade issues.

Further strengthening producer associations **–** Although PA have been strengthened over the past and has been a contributory factor for sector growth, the small-scale producer sector is yet to be formed into clusters and/or associations, globally.

Strengthening capacity of PA, mainly small PA in most countries in Asia and sub-Saharan Africa and emerging PA in Central and Eastern Europe has been a concern over the past decade. Lack of professionalism of PA is an issue as they are not fully recognized and appreciated as serious stakeholders in the development process by the public sector lead aquaculture agencies. PA capacity needs to be strengthened so that they could be considered as professional bodies and would have the means to operate as authoritative, credible, viable and independent organizations. While initial institutional and financial support by governments, larger PA, donors and NGOs is essential, the goal should be to develop small PA to a sustainable level as federations. In the case of PA in Central and Eastern Europe,

[33] ***FAO/NACA. 1996. Survey and Analysis of Aquaculture Development Research Priorities and Capacities in Asia***. FAO Rome, Nov 1997. 263 p.

[34] ***Machena, C. & Moehl, J. 2001. Sub-Saharan African aquaculture: regional summary.*** *In* R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, & S.E. McGladdery (Eds.) *Aquaculture in the Third Millennium*. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. 341-355pp.

special efforts should be given to build their capacity to deal with the principles of market economy.

Avoiding the pitfalls of privatization – There has been considerable problems in privatisation processors and efforts in aquaculture sector in many counties. The capacity of the lead government agencies in many countries responsible for effective privatization of fisheries facilities, such as hatcheries and nurseries, needs strengthening. There have been cases where many of the facilities could not be privatized as those were initially inappropriately located in terms of suitability of culture due to poor water quality and soil conditions and access to infrastructure and marketing facilities. In other instances, the potential benefits of privatization could not be achieved due to lack of expertise in proper valuation of sale or leases of facilities. It is essential that governments promote privatization of facilities that are considered as technically and financially feasible investments by private sector[35].

It is equally important that governments realise that state hatcheries and fish farms effectively undercut local private enterprises and can stifle aquaculture development in a locality. There is a fine divide between state promotion and support and competition in the market place. State hatcheries can act as training grounds, broodstock centres or hatchery facilities for species that cannot be bred by the private sector, the vision of government should be to see when the state venture can withdraw from production operations to enable the private sector to take over.

Limited access to good quality water and land - As factors of production, the basic issues on water and land are access and degradation. Water and land are essential for aquaculture, but, equitable and easy access to these resources that are environmentally safe is becoming increasingly complex. Access to these resources is rendered difficult by the increasing competition among users; it is also linked to property rights and distributional regimes and influenced by a country's policy and institutional and legal frameworks. The problem is particularly acute for small-scale farmers.

The issue of maximizing water use efficiency is being addressed by water re-use or recycling methods and adding value to water through integrated farming. In freshwater aquaculture, rainwater harvesting and using fishpond discharge for crops are ways of maximizing water use efficiency. In the context of brackish water or marine water aquaculture, release of discharge is not feasible as saline water is not suitable for agriculture. To reduce sediment and organic load from shrimp farms, a mitigation measure is the use of low water discharge or zero discharge systems. The risk of introducing disease organisms in such systems is also low due to recirculation of water instead of releasing and changing it with new water. Pollution or degradation of water resources in the aquaculture context is being mainly addressed through emphasis on better management practices. Other specific measure that are being used include low-cost treatment systems of discharges, zoning, regulations on location and densities of aquaculture facilities, standards and regulations on water and effluent discharges and codes of practices on water and effluent management.

The problem of competing or conflicting resource use is more acute for land. Globally, with increased population, urbanization and conversion of land for residential and industrial use are on the rise. However, land resource is finite and land borders immutable. Traditionally, some countries in Asia have discouraged the conversion of agricultural land to aquaculture

[35] ***State of world aquaculture: 2006***. FAO Fisheries Technical Paper. No.500. Rome, FAO. 2006. 134p.

due to concerns on rice self sufficiency. In such countries, a shift in policy to allow conversion of agricultural land to aquaculture is allowing diversification. An example is Viet Nam. In other countries, conversion is strictly regulated under law or is currently an issue of concern and increasingly subject to regulation/zoning and considered in the context of an integrated coastal zone management plan. In the Philippines, conversion of agricultural land to fishpond needs prior clearance from the Department of Agrarian Reform. Furthermore, due to environmental and social concerns, aquaculture is no longer allowed in the remaining mangrove forests in all such countries.

As land becomes more scarce, open waters (both nearshore and offshore) of the sea is increasingly being considered for aquaculture using cage culture techniques. The Philippines is promoting the development of mariculture parks where an area is identified and supported with infrastructure in the form of moorings. A large offshore aquaculture project is being launched for the Gulf of Mexico as a solution for aquaculture development[36]. However due to increasing environmental pressure and greater restrictions for the use of coastal zones this situation has changed offering more limited availability of coastal land for aquaculture.

Over the years, the concerns on land and water use in aquaculture have been addressed carefully by many producing countries. Land use planning, aquaculture zoning, and efficient use of water resources based on multiple or integrated use of water have been practiced in many countries at different scales. Nonetheless, there are cases where use of water for human consumption has been given priority over fish farming.

[36] ***Bridger, C. 2004. Efforts to develop a responsible off shore aquaculture industry in the Gulf of Mexico***: A compendium of Offshore Aquaculture Consortium Research. Mississippi-Alabama Sea Grant Consortium, Ocean Springs, MS pp 200.

7. Economic, market, trade and financial factors

With global landings from capture fisheries remaining relatively stable and the demand for fish and fishery products increasing growing, economic and market forces are exerting a strong influence on development of aquaculture. Although aquaculture products are primarily consumed domestically, there has been an impressive development of regional and international trade for a number of aquaculture products, mainly of high value species. Markets are responding to discerning consumers demand for quality and safe products. Issues such as socially and environmentally responsible aquaculture practices, food safety, traceability, certification and eco-labelling are thus becoming increasingly important. This section discusses the factors which contributed or contributing to the sector growth and those which constrained or constraining the growth of the aquaculture sector.

7.1 Factors that contributed or contributing to the sector growth

The factors that have contributed to the sector's growth are mainly trade liberalization, which have had a positive effect on food security, heightened the need for compliance with food safety and quality and animal health requirements, and facilitated investment and technology transfer in developing countries. Further, increased global market competition for fishery products has prompted the sector to improve capacity to diversify products to cater to a wide range of consumer demand, and search for new markets or diversify markets. While offering many benefits and opportunities, fish markets, trade and finance need attention in a number of areas that have constrained aquaculture development: strengthening countries' capacity to comply with stringent international stringent consumer requirements, safeguarding interests of small and poor farmers who are most vulnerable to the impact of compliance with such measures, addressing disease-related issues arising from unregulated trans-boundary or movement of live aquatic animals; addressing feed quality and shortage issues; addressing inadequate infrastructure development issues; and addressing access to finance, water and land issues. The ever increasing trade barriers, negative image of aquaculture, and change in feeding habits of people from meat consumption to vegetarian are major factors that could constrain future development of the sector.

Trade liberalization **-** The value of international fish trade over the past two decades has increased significantly from US $ 15.5 billion in 1980 to US $ 63.3 billion in 2003. Trade has particularly benefited developing countries and Low-Income Food Deficit Countries – LIFDCs. Trade has had a positive effect on food security, heightened the need for compliance with international food safety and quality regulations and animal health requirements, and facilitated investment and technology transfer in developing countries. A recent study of China's development policy adjustments, after it acceded to the World Trade Organization (WTO), provides a broad perspective of the positive effects of compliance with WTO regulations on a developing nation's aquaculture sector[37].

The growth in trade has particularly benefited developing countries as their net earnings (export minus import) from fishery products increased from US $ 3.4 billion to US $ 18.3 billion over the same period. Developing countries net earnings from fishery products exceeds the foreign exchange revenues earned from any other traded food commodity. The LIFDCs

[37] L***uping, L. & Huang, J. 2005. "China's Accession to WTO and Implications for the Fishery and Aquaculture."*** Aquaculture Economics and Management. 9:195-215.

also play an active role in trade of fish and fishery products, accounting for more than 20 percent of the total value of fishery exports in 2003, with net export revenues estimated at US $ 8.6 billion[38]. The extent of global trade in aquaculture products is difficult to analyze because producing countries generally do not have well documented information on trade of aquaculture products, but based on the species traded, mainly shrimp, salmon, tilapia, basa (in Vietnamese to *Pangasious* sp.) and catfish, it is implied that much of the traded fish and fish products are from aquaculture practiced in developing countries.

With the entry of China into the WTO in 2001, all major fishing or fish farming countries, other than the Russian Federation and Viet Nam, both of which are at advanced stages of negotiations to join the WTO, are now members of the organization. Along with the growing membership in the WTO, both bilateral and multilateral trade agreements have played an increasingly important role in international trade in aquaculture products. There has also been a steady reduction in customs tariffs on both fish and aquaculture products in recent years and negotiations for further reductions continue, as part of the ongoing efforts to remove barriers to trade. Average tariffs on imports from developing countries are now estimated at 4.8 percent, a cut of 27 percent from previous levels[39].

A recent study of China's development policy adjustments, after it acceded to the WTO, provides a broad perspective of the positive effects of compliance with WTO regulations on a developing nation's aquaculture sector[40]. In general, the study found the adjustments stimulating favourable impacts on the aquaculture sector. Domestic fish markets are gradually integrating, indicating that, in the case of increased exports of aquatic products, fish prices in border areas are likely to increase and transmitted to other markets, benefiting fishers in the process. Domestic prices of aquatic products are well below world market prices, suggesting expansion of exports. China is also adopting measures to control and prevent fish disease to meet stricter WTO requirements. More fundamentally, there has been an overall policy shift from directly intervening in the economy to playing an indirect, regulatory and fostering role in commerce and trade.

Although a general conclusion about trade is that income from exports is good for the economy, a different perspective however is raised by the World Fish Centre for Africa[41]. The situation is that, sub-Saharan Africa has a trade deficit that is expected to worsen and exporting fish, primarily from capture fisheries, to other continents could undermine regional food security. In this context, two issues were raised. First, while the fish removed from African markets can in principle be replaced by imports and the foreign exchange earnings from exports can stimulate national economies, the benefits of international trade versus the stimulus to local economies through increased processing, and national and regional trades have not been fully analysed or demonstrated. Second, too strong a focus on international export can be detrimental to Africa's food security because it diverts policy makers' attention,

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[38] ***Fish Trade and Food Security, page 1. Paper prepared for Tenth Meeting of the FAO sub-Committee on Fish Trade,*** Santiago de Compostela, Spain, 30 May-2 June 2006)

[39] ***Josupeit, H., Lem, A. & Lupin, H. 2001. Aquaculture products: quality, safety, marketing and trade.*** *In* R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, & S.E. McGladdery (Eds.) *Aquaculture in the Third Millennium.* Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. 249-257pp.

[40] ***Luping, L. & Huang, J. 2005. "China's Accession to WTO and Implications for the Fishery and Aquaculture."*** Aquaculture Economics and Management. 9:195-215.

[41] ***Kurien, J. 2003. "The Impact of International Trade on Food Security."*** Report of the Expert Consultation on International Fish Trade and Food Security, Casablanca, Morocco, 27-30 January 2003. FAO Fisheries Department Report No. 708.

research and management efforts, and donor support away from the small scale fisheries which supply local, provincial or national markets, and focuses these limited resources on the export-oriented industrial or semi-industrial fisheries.

A point that could be made in regards to such a perspective on international trade is that the growth of both small-scale and industrial or commercial aquaculture is needed for the well being of the sector as a whole, and they should not by any means be considered as mutually exclusive[42]. As indicated earlier, governments need to promote policies and programs that will facilitate graduation of small scale farmers to the commercial level. Further, if trade liberalization results in negative impacts on small-scale or resource poor farmers or other vulnerable members of the society, governments need to develop and implement sound "safety net" programs.

The following section highlights the benefits of trade liberalization in regards to three areas: food security, compliance with food safety and quality and animal health requirements, and investments and technology transfers.

Contribution to food security - A recent FAO study that examined the impact of international trade in fishery products on food security concluded that at the global level trade has had a positive effect on food security. The study mentions that trade generates employment, higher incomes and foreign exchange. Higher employment rates and incomes have enabled countries to raise their standard of living and to alleviate food security concerns. Many developing countries and Low Income Food-deficit Countries are reported to have become net foreign exchange earners from trade in fishery products and such earnings can contribute to the nation's debt repayment and import of essential food stuffs, including fish. The study points out that country case studies, however, show that the relationship between such as access to different markets, different fisheries management regimes and different governance structures. In eight of the eleven countries, international trade has had a positive impact on food security. The study recommends conducting additional case studies to broaden the understanding of the causes for positive and negative impacts of fish trade on food security[43].

Compliance with food safety and quality - Governments, particularly those that are promoting export of aquaculture products, along with private sector, are giving increased attention to address consumers and other stakeholders growing concerns about fish food safety and quality. In Asia, in 2003, Thailand launched a comprehensive food safety and quality ("Farm to Plate") program to maintain its competitiveness in the export market and to promote domestic consumption. The country also declared 2004 as "Food Safety Year" to increase awareness and improve systems for safe aquaculture production[44]. In 2004, Viet Nam also intensified its efforts at improving food safety and quality of its seafood products, particularly those for exports, through a wide-ranging program a suite of product safety and quality protocols and farmers' education. Similar initiatives and activities have taken place in other regions. Overall, compliance to food safety standards have improved tremendously over the

[42] ***De Silva, S.S. 2001. A global perspective of aquaculture in the new millennium.*** *In* R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, & S.E. McGladdery (Eds.) *Aquaculture in the Third Millennium.* Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. 431-459pp.

[43] ***Fish Trade and Food Security, pages 2 and 3, Paper prepared for Tenth Meeting of the FAO Sub-Committee on Fish Trade***, Santiago de Compostela, Spain, 30 May-2 June 2006).

[44] ***International Trade and Aquaculture in Asia: Pedro B. Bueno*** Emerging Trends and Experiences in Asia-Pacific Aquaculture: 2003, NACA and FAO 2004).

past decade and compliance to international food safety standards is no longer considered a special requirement, globally.

Most Latin American and Caribbean countries have facility certification programs run by their health authorities, two of which stand out- the Standard Sanitary Operation Process (SSOP) and the Hazard Analysis and Critical Control points (HACCP) - and are applied for exports, including to US and EU markets. Institutions in some countries also have the capacity to carry out Residue Control Programmes in aquaculture operations and in facilities and their certification guarantees the quality of aquaculture products, through traceability. In Eastern Europe, in almost all the countries, major international standards (i.e. ISO 9001, HACCP) have been established and are applied by the sector. For some commodities such as salmon the certification programs are similar with equivalent standards practically worldwide.

Recently there has also been an increased focus on food safety issues related to the production level of aquaculture products. As traceability becomes more and more important for consumers and importing governments and at the same time methods to trace inappropriate use of chemicals or even use of banned chemicals becomes better there is a need to address food safety not only at the processing level but also at pre-harvest levels.

Meeting animal health requirements - In response to the recent serious disease outbreaks due to trans-boundary movement of live aquatic animals, a number of international and regional workshops, including expert consultations, to address the issue have been conducted in Asia. An important output of one of the workshops is the framing of the Asia Regional Technical Guidelines on Health Management and the Responsible Movement of Live Aquatic Animals that was adopted as a regional strategy by 21 governments in 2000. The Guidelines, along with a Manual of Procedures and an Asia Diagnostic Guide, take into full consideration the provisions of the WTO's Agreement on the Application of Sanitary and Phytosanitary (SPS) Measures, the OIE Aquatic Animal Health Standards, and the FAO-sponsored Code of Conduct for Responsible Fisheries. Other workshop outputs are: manuals on import risk analysis and disease surveillance and zonation, guidelines for harmonization of quarantine procedures for live fish and emergency preparedness and response to aquatic animal diseases, and establishment of regional aquatic animal health resource base[45].

Overall, general aquatic animal health management and compliance to international treaties and agreements have been improved worldwide. The use of antibacterials, veterinary drugs and other chemicals has declined and compliance to food safety trading standards is being improved. The work of the Codex Alimentarious Commission (CAC) towards setting safety standards on aquaculture products is continuing. Both the public and private sectors have contributed to this achievement. The move has helped aquaculture push forward.

Facilitated investment and technology transfer - Globalisation has facilitated investment in aquaculture development in many countries in Africa, Asia and Latin America. There are examples of inter continental investment as well as foreign direct investment (FDI) in the aquaculture sector, particularly for high value products, in LAC and Asia. Investments are in the form of independent operations, joint ventures or acquisitions. Continuation of such initiatives will support the growth of the sector, particularly for internationally traded commodities. Technology transfer on the other hand had been rapid through the expansion of multinational companies worldwide, particularly in commodities such as salmon.

[45] ***Emerging Aquatic Animal Health Issues in Asian Aquaculture: The Regional Response, C.V. Mohan and R. Subasinghe***. In. Emerging Trends and Experiences in Asia-Pacific Aquaculture: FAO, 2003

Marketing efforts - There has been an increase in scale and effectiveness of marketing efforts by the public and private sector to capture and retain a greater share of the market and proactively respond to consumers' diverse preferences and concerns by adding value through quality and safety. In general, increased competition has prompted the sector to focus on two areas: improve capacity to diversify products to cater to a wide range of consumer demand, and search for new markets or diversify markets.

Satisfying specific demands of consumers - With an increase in global population, the rise in purchasing power of many developing countries, and a growing awareness of health benefits from fish consumption (particularly the recent focus on the benefits of Omega3 polyunsaturated fatty acids) fish trade has been promoting a wide range of species and product forms to accommodate diversified tastes and presentations desired by both domestic and international consumers, making fish one of the most versatile food commodities. Modern fish distribution channels have developed buying criteria with precise requirements for quality, portions and sizes, price and delivery times. Processed fish for human consumption can be frozen (whole, fillet and portion), cured (dried and smoked) and canned, all of which add value to the product. It is also worth mentioning that alongside quality issues, supermarkets and rage retailers around the world are demanding, on behalf of their customers, increasingly detailed requirements on environmental and ethical criteria, unrelated to food safety.

International trade in live fish has also increased due to technological developments and improved logistics. Live fish is particularly preferred in China and Southeast Asia. There are niche or ethnic markets for aquatic products in all regions and many countries. Where there is demand for live fish, they are displayed in aquariums and tanks in seafood restaurants, supermarkets, and retail outlets[46].

All roads leading to new markets - The search for new markets or diversification of markets continues and calls for increased application of competitive marketing strategies that would yield high financial returns. In the Asian context, a good case is the export market for tilapia. Dubbed as the "aquatic chicken" of the 1980s and the "poor man's fish", tilapia has established a position within the supermarkets in developed countries and its success is largely attributed to the provision of fillets at an affordable price. Taiwan Province of China exports tilapia mostly to the United States, Saudi Arabia and Korea Republic, but Viet Nam is fast establishing itself with cheaper prices, while the People's Republic of China is now the biggest producer and also exporting to some of the same markets. China's strategy to boost tilapia's competitiveness includes upgrading its productivity, quality control and management systems, distribution, and government incentives.

Another example of expanding markets is the massive growth of farmed channel catfish in the United States that was spurred by an industry-initiated and industry-led marketing strategy. Farming of catfish, which was initially largely confined to the southern United States, rapidly spread to other parts of the country, mainly due to the development of large feed mills and processing plants and an effective national advertising campaign that was financed from a levy of a few cents for every pound of feed purchased by growers. Consequently, production increased from 35,000 tonnes in 1980 to 80,000 tonnes by 2000[47].

[46] ***FAO: 2004: The State of World Fisheries and Aquaculture***. 168pp.
[47] ***Tucker, C.2003.Channel Catfish.*** In: J.S. Lucas and P.C. Southgate (Eds), 2003.Aquaculture Farming Aquatic Animals and Plants. Fishing News International pp 346-363

The Latin America and the Caribbean presents a case of the need to have a strategic marketing approach to regain market share in an existing market and expand to new markets. This is the case where the shrimp market has been negatively impacted due to the US anti dumping measure and, as a consequence, now faces stiff potential competition from Asian shrimp suppliers. A study of the market suggests adoption of a broad strategy that would include reduction of costs, reinforcement of internal markets, and gaining of worldwide market acceptance as providers of safe products.

7.2 Factors that constrained or constraining the sector growth

While offering many benefits and opportunities, economics, fish markets, trade and finance need attention in a number of areas that have constrained aquaculture development: strengthening countries' capacity to comply with stringent international non tariff trade barriers, safeguarding interests of small and poor farmers who are most vulnerable to the impact of compliance with such measures, addressing disease-related issues arising from unregulated trans-boundary or movement of live aquatic animals; addressing feed quality and shortage issues; addressing inadequate infrastructure development issues; and addressing access to finance, water and land issues.

Increasing non-tariff barriers to trade **-** Notwithstanding WTO rules and regulations that are meant to level the international trading field, importing countries have been increasingly imposing stringent export market requirements and import standards on developing country producers and exporters. Compliance to some of these food safety and quality and animal health, environmental and social, and animal welfare, requirements are seen as non-tariff trade barriers to trade by exporting countries (Box 2).

There are three interrelated issues that warrant attention of governments in Asia, but the measures suggested could be applied to other regions except Western Europe and North America. These are: strengthening countries' capacity to comply with international non tariff trade barriers, safeguarding interests of small and poor farmers who are most vulnerable to impact of compliance with such measures, and addressing issues on trans-boundary or movement of live aquatic animals.

Weak compliance capacity **-** In general, while countries have initiated measures to address the challenges of non-tariff trade barriers, governments need to make greater efforts to stay competitive and gain from aquatic trade. The countries capacity to comply with various non tariff trade barriers needs to be further strengthened to allow them to engage more actively and effectively in the standard setting process of international bodies such as Codex Alimentarious and OIE. AquaMarkets 2003[48] also emphasized the importance of developing "common positions" through cooperation and advised the countries to put forward their position more effectively to international setting bodies. Backed by robust technical, social and economic analyses, countries need to emphasize the philosophy of the WTO's sanitary and phytosanirary agreement (SPS) "special considerations of the requirements of developing countries".

[48] ***Regional Seminar and Consultation on Accessing Markets and Fulfilling Market requirement,*** organized by NACA in Manila, 2-6 June 2003. It was hosted by the Agriculture and Trade and Industry ministries of the Philippines and assisted by FAO and WTO

Box 2. Trade conflicts in fish products: the example of farmed catfish from Viet Nam

As aquaculture production continues to increase, trade conflicts in farmed fish products are rising as well. One of the most notable conflicts occurred in the recent case of catfish farmed in Viet Nam and exported to the United States market. In 2002, the independent processors and Catfish Farmers of America, a trade association of U.S. catfish farmers and processors, brought a petition to the United States International Trade Commission regarding dumping of frozen catfish fillets into the U.S. market by Viet Nam. Catfish farming is the largest aquaculture industry in the United States, and in 1999 Viet Nam exported less than 1,000 tons of what was labelled "catfish" into the U.S. market. By 2001 that number was over seven times larger.

The Vietnamese product was marketed in the U.S. under the name "catfish", and included the species *Pangasius bocurti*, *Pangasius pangasius*, and *Pangasius micronemus*, or the common names of "basa" and "tra". The species farmed in the U.S. are from the Ictaluridae family. The domestic industry in the U.S. campaigned for labelling laws to prevent the naming of basa and tra as catfish, and at the same time to protect their own industry, resulting in a provision in the Farm Security and Rural Investment Act of 2002 stating that for the purposes of the Federal Food, drug or Cosmetic Act, the term "catfish" may only be considered to be a common or usual name for fish classifies within the family Ictaluridae. subsequent to this decision however, Vietnamese basa and tra were still accepted by consumers as a similar product to U.S. catfish, and maintained their market share. Consequent action by the US was to declare that Viet Nam was dumping product on the U.S. market, and processors were levied antidumping duties of 36 to 64 percent.

Source: Roheim (2004; draft). Taken from Saving Fish and Fishers, Towards Sustainable and Equitable Governance of the Global Fishing Sector, page 72, The World Bank, May 2004

With most countries in Asia giving increased attention to food safety, there is a growing proliferation of product certification systems, making it necessary to harmonize standards for food safety to avoid potential confusion among consumers and exporters and additional cost burdens. According to an IFPRI study, "food safety certification will become important to the survival of all fishers in the next two decades, and eco-labelling will become important to most"[49]. To promote harmonization of standards, with technical support from FAO, NACA and other relevant agencies, countries could establish a set of technical guidelines on food safety in aquaculture production modelled on the Asia regional health management and trans-boundary movement technical guidelines[50].

Further, as part of the capacity enhancement program, AquaMarkets 2003 emphasized transparency and cooperation in information sharing and the need to strengthen information and intelligence capacities with information technology. It also raised the prospects of developing countries establishing mutual arrangements that facilitate and reduce cost on

[49] ***IFPRI, 2003, Outlook for Fish to 2020. Meeting Global Demand.*** A 2020 Vision for Food, Agriculture, and the Environment Institute

[50] ***Food Safety and Quality in Aquaculture*** by Michael Phillips, Rohana Subasinghe, Lahsen Ababouch, Emerging Trends and Experiences in Asia-Pacific Aquaculture: 2003

information flow, including the possibility of moving into e-commerce, speed up the processing of "documents", and improve the efficiency of handling and moving products. According to UNESCAP, establishing common customs and procedures and operations would reduce very high compliance costs, which had been estimated to be 7-10 percent of the value of global trade[51]. When applied to global trade in aquatic products, the common approach could potentially result in a cost savings of US $ 3.9 to 5.6 billion.

Fears of small farmers - The impact of compliance with the increasing number and stringency of export market requirements on developing country producers and exporters is higher costs of production. There is a growing concern that the high cost of compliance could become a heavy financial burden on producers and other stakeholders producing products for export. This is particularly the case for non-organized small-scale producers and the associated network of support services and associated small-scale industries. The concern is that this inability to meet stringent export quality and safety requirements would lead to their marginalization or exclusion from markets. Studies have highlighted that difficult access to capital and high capital requirements for certain farming systems technologies can either discourage small farmers from taking up aquaculture or eventually marginalize those who are already engaged in farming. When combined, the two factors - - high capital for adoption of technologies and high cost of compliance - - could have a more pronounced adverse impact on small farmers. According to an Asian Bank Development Study[52], organizing small farmers into associations or "self-help groups" is a way to collectively achieve a strong capacity to enter and stay in aquaculture, effectively demand and absorb institutional services and technical assistance, cope with natural hazards and economic risks, address barriers to property and financial access, and acquire and use capital and operating assets. This phenomenon has been proven by the work of NACA, MPEDA and FAO in small-scale shrimp farming sector in Andhra Pradesh, India, where farmers are being grouped into cluster of manageable size, the "AquaClubs".

In the context of non-tariff trade barriers, to allow small farmers to take advantage of the economies of scale and to enable them to comply with market requirements in a cost-effective and responsible manner, governments need to apply policies and strategies that would facilitate the continuation of the development of farmers into producers associations or "self-help groups" through capacity building and other technical assistance measures. Moreover, studies have shown strong relations between trade and growth. But, the point is stressed that "liberalization alone cannot be an answer, but needs accompanying policies, such as market reforms, macroeconomics stabilization, exchange rate adjustment and adequate safety nets". There is a need for the continuation of these policies.

Recent studies also show that trade liberalization can alleviate poverty, but the evidence is still not strong since findings vary among countries, perhaps is it a wealth distribution issue[53]. Further studies on this important issue continue and the findings would be useful to formulate improved policies on economic growth and poverty reduction. One such recent study in the fisheries sector is the ongoing NACA/STREAM initiative. Supported by the Department for International Development of the United Kingdom (DFID) "EC-Poverty Reduction

[51] ***UNESCAP, Training Manual on Increasing Capacities in Trade and Investment Promotion***, 2001

[52] *Asian Development Bank. 2004. "Farming Tilapia in Fishponds in Central Luzon, Philippines. Case Study 5."* Special Evaluation Study of Small Scale Freshwater Aquaculture Development Vol II, p 75-91. ADB, Manila, July 2004.

[53] ***UNESCAP. 2001. Training Manual on Increasing Capacities in Trade and Investment Promotion***, U.N. New York, 2001. 210 p.

Effectiveness Fund," the study seeks to identify options for improving the effectiveness of poverty reduction in Asian countries through international seafood trade. The emphasis of the study is on aquaculture production and the commodities covered are shrimp and marine fish, especially reef fishes, including ornamentals.

Risks of trans-boundary movement of aquatics - Unregulated trans-boundary movement of live aquatic animals is one of the major reasons for increased occurrence and spread of several serious diseases, impacting on aquaculture productivity, livelihoods, trade and national economies. Since 2003, the emerging diseases, arising from spread of aquatic animal pathogens, mainly include: epizootic ulcerative syndrome (EUS) in fresh and brackishwater fishes, white spot syndrome virus (WSSV) and Taura syndrome virus (TSV) in cultured shrimp and viral nervous necrosis (VNN) in grouper. Continued occurrence of koi mass mortality in Indonesia (estimated losses of US $ 15 Million) and the recent outbreak of koi herpes virus (KHV) in Japan (US $ 1.4 Million) reflect the potential magnitude of financial losses that could result from such trans-boundary diseases. KHV outbreaks in the Asian region in particular have significant trade implications for the high-value ornamental koi carp industry, and the important food fish common carp. For continued growth in aquaculture and trade in aquatic animals, governments need to give special attention to disease control and management and demonstrate compliance with international standards for animal health. Continued technical assistance to governments by international organizations such as FAO, NACA, the South East Asian Fisheries Development Centre (SEAFDEC) and World Organisation for Animal Health (OIE) is also essential, particularly in the areas of strengthening national capacity for implementation of the guidelines that have emerged from the recent regional and international workshops on animal health management.

Feeding fish the right feed - Although dependency on the direct use of feed input varies significantly between different aquatic species, farmed aquatic species require the right aquafeed to various degrees. Species that are primarily dependent on aquafeed include carnivorous finfish, omnivorous/herbivorous finfish and crustaceans, while the filter feeding finfish depends primarily on endogenous food present in the aquatic environment or on the food produced through external fertilization. It was estimated that about 24.4 million tonnes or 41.0 percent (76.6 percent of total finfish and crustaceans produced) of global aquaculture production in 2004 was dependent upon direct use of feed.

The trend in global production of fishmeal appears to be relatively stable and current indications are that there is little likelihood of increasing production. The demand for fishmeal by the growing aquaculture and livestock sectors, which will be competing for a stagnant supply of raw fish, may eventually drive the price upwards to a level where fish and shrimp farmers may not be able to afford to buy fish meals to effectively produce their animals. It was recently estimated that the global aquaculture sector uses about 35 percent of total fish meal supply, which is a significant increase when compared to the 10 percent estimated use in 1988. By 2010, aquaculture's share of fish meal usage is estimated to increase to 48 percent[54]. Globally, prices of fish meal and fish oil are expected to increase by about 18 percent by 2020, compared with an overall 15 percent fish price increase.

It is also expected that prices of aquaculture products will rise. This increase will enable the high value species farming industries, which are the most reliant on feeds containing fish

[54] Source: http://www.iffo.org.uk S.M. Barlow: "The World Market Overview of Fish Meal and Fish Oil" Paper presented to the 2nd Seafood By-Products Conference, Alaska, November 2002 and FAO 2006 Asia- Pacific Region Aquaculture Sector Reviews: A Regional Synthesis

meal and fish oil, to command a higher share of the fish meal market. There is a good likelihood of shifts in the degree of demand for fish meal even within the aquaculture sector, with the fresh water sector demanding relatively less as it has a greater opportunity of using non-marine sourced feed ingredients, particularly slaughterhouse and brewery wastes, and agricultural milling by-products. On the other hand, the purchasing power of maricultured fish and crustaceans farmers will enable the mariculture industry to afford higher fish meal prices as demand increases.

In general, with a stable production and a rise in fish meal prices, there is considerable pressure on the aquaculture sector to reduce its reliance on feeds containing fish meal and also increase the efficiency of its current usage of this resource. While the feed issue affects most parts of the global aquaculture sector, its impact on the Chinese aquaculture sector is likely to be relatively greatest as the sector is already quite dependent on imported fish meal.

The situation in sub-Saharan Africa is different. There are only few commercial aquaculture in operations, especially at the industrial scale. Thus, the availability of locally produced aquafeeds is limited. As commercial aquaculture is expanding, it is expected that the domestic aquafeed industry will grow with the expansion of commercial aquaculture enterprises/farms. Availability of farm-made aquafeeds produced by small-scale commercial feed producers is also likely to increase and play a pivotal role in the expansion of rural commercial aquaculture. However, because of the stiff competition between man and aquaculture as well as other sectors such as livestock, the cost of production vs. cost of import will be the governing factor for improvement in local commercial aquafeed production in the Region.

The use of trash/low value fish in aquaculture is also an important factor for future development. Approximately 5-6 million tonnes of trash/low value fish are used as direct feed in aquaculture. Trash fish are primarily used for marine cage farming in China and in some south-east Asian countries including Viet Nam, Indonesia, Thailand and Cambodia, and secondarily in tuna cage farming in the some of Mediterranean countries and in Mexico. Marine aquaculture sector in China consumed about 4 million tonnes of trash/low value fish in 2000[55] and the demand for trash/low value fish is likely to increase unless viable alternatives are available and used. The total use of trash/low value fish by the aquaculture industry in Viet Nam was estimated to be between 176 420 and 323 440 tonnes[56] and it is projected that by the year 2013, the requirement for Viet Nam would be about 1 million tonnes[57] (De Silva, 2006).

It seems the use of trash/low value fish in aquaculture feed is unlikely to be sustainable. There are also concerns that the continued use of trash/low value fish may result in adverse environmental effects and biosecurity risks. There are also mounting claims that the so-called trash fish could be used as human food. Not only environmental and biodiversity issues are emerging, the value of the catch is reducing and so economic factors are coming into play. Fishmeal supply from global fishmeal fisheries is stable and therefore there will be increasing competition for fish for feed – one that will challenge aquaculture sector to find alternative

[55] ***D'Abramo, L.R., Mai, K. & Deng, D.-F. 2002. Aquaculture feeds and production in the People's Republic of China*** – progress and concerns. *World Aquacult.*, 33(1): 25–27.

[56] ***Edwards P., Tuan, L.A. & Allan, G.L. 2004. A survey of marine trash fish and fish meal as aquaculture feed ingredients in Vietnam***. ACIAR Working Paper 57, 56 pp.

[57] ***De Silva, S.S., 2006. Feeds in Asian aquaculture: the key to its long term sustainability***. Paper presented in FAO Expert Workshop on "Use of Feed and Fertilizer for Sustainable Aquaculture Development", Wuxi, PR China, 18-21 March 2006.

sources of oil and protein if it is to sustain its current rates of expansion. APFIC Regional Workshop on low value and "trash fish" in the Asia-Pacific region developed an action plan based on the understanding of supply and demand cycle for low value/trash fish possible points for intervention[58]. The identified points for intervention included fishery interventions, improved utilization of trash fish and development of improved feeds for aquaculture dependent upon trash fish and recognition that there is a clear need for consistent policy between aquaculture development and fishery management, based on a common understanding and information base for decision making.

Continued supply of quality seed – The issue of seed supply and availability has been a constrain to aquaculture development in some regions, and will remain as a constrain, particularly in sub-Saharan Africa. Seed quality also is an essential attribute for optimizing the potential for aquaculture production (better yield and good returns) and is related to the quality of the broodstock used and the seed produced. Genetic quality and good hatchery/nursery management are the two main factors affecting seed quality. It is important to understand the factors that contribute to poor quality seed and develop interventions (e.g. better management practices) to address the problems since, in all aquaculture systems; stocking quality seed does not necessarily ensure a successful crop. Seed certification and accreditation of practices should be continuously explored.

Inadequate infrastructure development **-** In all regions except Western Europe and North America, the lack of adequate and quality infrastructure is a key constraint on development of both domestic and international markets for aquatic products. For domestic markets, a network of quality roads that connects rural producers to urban and peri-urban market centres is highly essential to increase profitability and competitiveness of businesses and to stimulate aquaculture growth. A study on the impact of market incentives on the scale and intensity of fish production in southern Cameroon indicated that, in the peri-urban domain, prices were 48 percent higher, the number of buyers was three times greater, and the average purchase per customer was nearly double than that of the rural area. Further, in many parts of Africa, due to weak market infrastructure facilities, post harvest losses exceed 30 percent of the catch[59]. Asia and the Pacific region also faces similar transportation challenges due to the long distances involved between producers and markets. To place the transportation issue in global perspective, an estimated 900 million rural dwellers in developing countries, most of them poor, are without reliable access to markets[60].

Because of the highly perishable nature of aquaculture products, governments also need to consider providing cold-chain infrastructure support, such as ice plants, cold storage and suitable transport facilities, by creating an enabling investment climate for private sector participation. Aquaculture products destined for export markets require a relatively higher level of infrastructure support. While good roads are important, access to well functioning seaports and airports, regular supply of energy and efficient information and communication technology services is also critical for development of the export sector. As providing exclusive infrastructure support to the aquaculture sector is neither practical nor financially viable, it is important that such support be considered within the overall institutional and legal

[58] ***FAO, 2005. Report of APFIC Regional workshop on low value and "trash fish" in the Asia-Pacific region,*** Hanoi, Viet Nam, 7-9 June 2005. FAO RAP Publication 2005/21, 32 pp, Bangkok

[59] ***Bene, C. & Heck, S. 2005. "Fish and Food Security in Africa."*** NAGA July-Dec 2005. WFC. Penang, Malaysia.

[60] ***2006 World Development Indicators***, The World Bank

framework of a government's various infrastructure development programs that also recognize the special needs of the rural development sector.

To jump start aquaculture development and to encourage new investors, many countries have designated zones, or enclaves in certain geographic locations, and provided various forms of infrastructure support facilities. Some examples of such facilities exist. In the Islamic Republic of Iran, a large area of coastal land was developed, including the construction of drainage and road networks and electrical grid. Malaysia has set up Aquaculture Investment Zones; the Philippines, has established mariculture parks with mooring facilities; and South Africa, proposes to set up a mariculture park (Namaqwaland) with, among others, marketing support facilities[61]. Depending on the level of development of their aquaculture sector, governments will need to consider encouraging the private sector to build and operate such infrastructure facilities, recovering costs through user charges, and respecting the rules of the environment and nature, as is now the case in other sectors. Appropriate land use planning and maximising/integrating resource use would be essential. With the increasing expansion of mariculture at offshore sites, which require expensive infrastructure support, Governments need to adopt policies that would also encourage foreign direct investment (FDI).

Limited access to financial services - Aquaculture enterprises of all scales require access to a number of services, such as financial, extension, technical and marketing. It is the responsibility of governments to ensure provision of quality services that are affordable and timely. An issue that continues to plague countries in the Asia and the Pacific, sub-Saharan Africa and the Latin America and the Caribbean regions is access to financial services by small farmers. While credit, savings, insurance and payments and money transfer facilities, all of which are part of financial services, are important, the focus of this section is on access to credit that would aid small and poor farmers to develop and sustain their aquaculture operations. The credit issue is generic and affects other rural development sectors as well, but the magnitude of the problem is more acute in the aquaculture sector. One of the reasons is the high risks associated with aquaculture operations and the inability of small and poor farmers to provide collateral required by formal or public sector financial institutions. Collateral is more of an issue as investment and operating capital requirements increase, as is the case with culture of high-value species.

There are a number of sources of credit, such as public sector financial institutions, specialized financial institutions, NGOs, and private sector, including producer associations. There are limited studies on the demand for aquaculture credit by small farmers. However, there is evidence that the level of funds channelled through the existing sources is highly inadequate. The demand for financial services in the aquaculture sector is diverse and requires differential financial products that could be offered by different sources, depending on their respective comparative advantage. Microfinance provides a broad range of financial services to poor fishing communities, including women, who lack access to traditional financial services. However, as microfinance, characterized by small loans, has inherent limitations in terms of financing capital investment needs, mainstream financial institutions are still required to supplement and fill in such investment gaps[62].

The challenge for the aquaculture sector is to scale up and adapt existing promising programs and continue the search for new and innovative means of effectively channelling funds.

[61] ***State of world aquaculture: 2006***. FAO Fisheries Technical Paper. No.500. Rome, FAO. 2006. 134p.
[62] ***FAO.2003. Microfinance in fisheries and aquaculture: guidelines and case studies,*** by U. Tietze and L.V. Villareal, FAO Fisheries Technical Paper, No 440

Despite the access-related shortcomings, there are some encouraging cases and models, such as India's national bank for agriculture and rural development's (NABARD) financial support to poor self-help aquaculture groups, Thailand's private sector's financial assistance to small and poor farmers, and Bangladesh's Palli Karma-Sahayak Foundation's (PKSF) channelling of microcredit funds, including for aquaculture activities, through its partner organizations, mainly NGOs. PKSF is the world's largest autonomous apex microcredit funding institution and its model has been replicated in Pakistan and Nepal. Other such autonomous institutions are: Argentina's Fonda de Capital Social (FONCAP), and Bosnia-Herzegovina's Local Initiatives Department (Creating Autonomous National and Sub-regional Microcredit Institutions, Dr. Salehuddin Ahmed, Paper presented at Asia Pacific Region Microcredit Summit Meeting of Councils, Dhaka, 2004, www.pksf-bd.org). With the United Nation's declaration of 2005 as the International Year of Microcredit, as part of its commitment to achieve the Millennium Development Goal of reducing the proportion of people living in poverty by half by 2015, it is expected that such renewed efforts by governments would also positively impact the small and poor farmers in the aquaculture sector.

8. Research and development factor

The rapid growth of the aquaculture sector is, to a large extent, stimulated by the application of R&D-led technological innovations, ranging from genetic improvement of farmed fish to sophisticated designs of cages for fish culture in offshore sites. Further, an encouraging development has been the recent expansion of the scope of R&D from technological to institutional, social-economic and environmental issues and incorporation of the findings in the formulation of various aquaculture policies, guidelines and best management practices. However, there have been R&D related factors that limited further development of the sector. This section discusses both categories of factors. This section attempts to discuss some important research and development related factors which have contributed or contributing to the sector growth and also have constrained or constraining the growth of the aquaculture sector.

8.1 Factors that contributed or contributing to the sector growth

The application of R&D-led technological innovations, ranging from genetic improvement of farmed fish to sophisticated designs of cages for fish culture in offshore sites, has spurred aquaculture growth. Further, with the recent holistic or systems approach to addressing R&D needs that encompass institutional, socio-economic and environmental areas, along with the traditional focus on technical factors, policy makers are provided with better information to formulate policies and guidelines for the sector.

Pushing the technical frontiers - The recent technological innovations in aquaculture could be grouped into five areas: aquatic animal reproduction and genetics, health management, environmental management, feed improvement and holding systems development[63].

Reproduction and genetics - Generally, the application of genetic principles to increase production from aquatic animals lags far behind that of the plant and livestock sectors. While only a small percentage of farmed aquatic species have been subject to formal genetic improvement, the potential to do so for other species in the future is immense and needs continued R&D. The culture of tilapia and carps, species that are widely cultured in most regions, notably in Asia by small farmers, is benefiting from genetics research. An example is the development of GIFT (Genetic Improvement of Farmed Tilapia – Box 3) fish. GIFT is not to take advantage of sex differences.

Although GIFT tilapia has been introduced widely into a number of Asian countries, there is currently no scientific information on the negative impact of its use on the environment. While recognizing that genetic intervention has strong potential to enhance aquaculture production, it is important that such intervention, as with agriculture, should be applied in a manner that takes into consideration social and environmental safety concerns. It is also crucial that research on such genetic intervention should be a continuous process.

Another significant achievement in the area of reproduction is the domestication of the *P. vannamei* shrimp species and the development of specific pathogen free (SPF) broodstock.

[63] ***Review of the State of World Aquaculture, FAO Fisheries Circular No 886, Rev 2, 2003***, Recent Technological Innovations in Aquaculture, by Rohana P. Subasinghe, David Curry, Sharon E. McGladdery and Devin Bartley.

Similar R&D work continues for domestication of giant tiger shrimp (*P. monodon*), the most widely used species in Asia before the outbreak of white spot disease that caused substantial economic losses to the sector. These developments will eventually significantly reduce dependence on wild-caught postlarvae which has a high risk of introducing pathogens into the culture environment and also result in substantial by-catch losses of other aquatic organisms.

Box 3 - Tilapia: Food of the Masses: Benefits of Genetics Research

The Consultative Group on International Agricultural Research (CGIAR) reports an approximate 70 percent gains in growth rate of genetically improved farmed tilapia as one of its recent outstanding achievements (www.cgiar.org). The GIFT (Genetic Improvement of Farmed Tilapia) strain of tilapia was developed through selective breeding under a program led by ICLARM in the Philippines (now ICLARM is named the WorldFish Centre in Malaysia), one of the 15 CGIAR- supported international centres that works with national research systems and civil society organizations, including the private sector.

To apply the GIFT findings among practitioners, a follow on regional project involving five Asian countries (Dissemination and Evaluation of Genetically Improved Species in Asia or DEGITA) was prepared and coordinated by the WorldFish Center. The project's main aim was to ascertain the genetic, socio-economic and environmental aspects of the production of the GIFT strain in different agro-ecological conditions and culture systems, The results of trails conducted in the five countries, comparing the performance of the GIFT strain with other commercially available strains, showed that the GIFT strain performed better in all countries. For example, on an average farm, the harvesting weight of the GIFT strain was 18 percent higher in the Peoples Republic of China and 58 percent higher in Bangladesh. The break-even price was also found to be 7-36 percent lower for the GIFT strain.

A recent ADB impact evaluation of the GIFT, involving four Asian countries, shows that tilapia farming now contributes very significantly to food security, incomes, and employment. The study adds as an example that, in the Philippines, farmed tilapia is now recognized as the most important food fish for poor consumers. In 2003, the President of the Philippines stated that the round scad (*Decapterus* spp.) would soon be replaced by tilapia as the food of the masses.

Source:
(a) Tilapias as alien aquatics in Asia and the Pacific: review by Sena S. De Silva, Rohana P. Subasinghe, Devin M. Bartley and Alan Lowther, FAO Fisheries Technical Paper 453, 2004, pages 42 -43 and
(b) An Impact Evaluation of the Development of Genetically Improved Farmed Tilapia, and their Dissemination in Selected Countries, Asian Development Bank, 2005, pages iv, 37, 41-42.

Health management - As a consequence of the recent fish disease outbreaks that have caused substantial economic losses to the sector across regions, governments and donors are now placing greater emphasis on the need for successful management of such outbreaks through contingency planning, early detection and a rapid response. Infectious disease is currently the single most devastating problem in shrimp culture and presents ongoing threats to other aquaculture sectors as well. The recent production of specific pathogen free (SPF) and specific pathogen resistant (SPR) shrimp broodstocks are considered as major breakthroughs in shrimp disease management intervention. To address the strict food safety and quality

requirements on the part of importing countries, there is an increasing use of microbial inoculants and probiotics instead of antibiotics and chemicals. The former are intended to improve the water and soil quality, minimize the risk of bacterial infection through exclusion, or improve feed utilization. There is also an increasing use of nutraceuticals, including herbal products, to replace chemical therapeutants. Another important development has been a decrease in the need for reactive treatments using traditional methodologies such as antibiotics, or culling and disinfection. The use of molecular techniques for pathogen screening and identification is providing significant insights into pathogenesis (disease development), showing strong potential for disease control and prevention programs, as well as for treatments of diseases (e.g. DNA vaccines).

As part of the continued efforts to improve aquaculture health management, progress has been made in the critical area of establishing standards for quantitative assessment of health status for certain finfish, while work is in progress with respect to shrimp and molluscan health. The health status techniques could be used to develop simple and rapid predictive health tests under field conditions by field technicians, veterinarians, and farmers themselves.

Environmental management - Great strides have been made in the last decade in mitigating nutrient and organic inputs from aquaculture. Similar efforts are being made to control and manage escaped fish from farming facilities. 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 fish farmers.

Intensification may sustain profitability of farming operations, but does so at a cost. At times, it brings management complications (water and health in particular). Also, there are often concerns about the environmental carrying capacity that is strained by increased numbers of farms and/or intensity of production systems. How the sector will perform in terms of production will depend on how well these issues will be dealt with.

As discussed earlier, in addition to management and carrying capacity concerns, aquaculture has often attracted largely unsubstantiated negative publicity as an environmental polluter (through excess organic matter outputs, escapes of farmed individuals, use of chemicals etc) This negative publicity, which occurs mostly in countries and regions producing high value commercial commodities, particularly shrimp, salmon and other exportable species, has often overshadowed the significant socio-economic benefits that responsible aquaculture can generate (contribution to poverty alleviation through employment creation, income generation, provision of protein-rich food and foreign exchange earnings). Recent studies[64] indicate that the output of nitrates and phosphates from aquaculture could be considered insignificant or of low relevance in terms of contributing to nutrient loading in some regions of the world although they may have local impacts on eutrophication and algal blooms.

Farmer and consumer associations, the civil society, as well as institutional buyers like the supermarket chains and other key stakeholder groups are actively promoting the development of standards and codes which aim at ensuring an environmentally and socially responsible

[64] ***Karakassis, I., Pitta, P. & Krom, M.D. 2005. Contribution of fish farming to the nutrient loading of the Mediterranean***. Scientia Marina 69:313–321.
Larraín, C., Leyton, P. & Almendras, F. 2005. Aquafeed country profile – Chile and salmon farming. International Aquafeed, 8(1):22-27.

aquaculture. Such improvements have been noticeable world-wide for some commodities, particularly salmon. They are likely to continue contributing to improving aquaculture public image, thereby giving the production an upward push.

Improved feed **-** An ongoing heated debate concerning aquaculture development is the use of fishmeal, or high protein intake, in aquafeeds. Many consumers have expressed reservations about its use because of a number of environmental and social issues: decline of wild catch, eutrophication, or pollution associated with excess nutrient waste, feeding fish to non-piscivorous fish, and using fish that could be used for human nutrition, especially in nutritionally deficient areas. Although the major user of fishmeal remains terrestrial livestock production, aquaculture is expected to increase its share of the global supply. The fish meal is produced from species which are not currently used for human foods due to a variety of factors such as: oiliness, size, boniness, damage or poor preservation. The expansion of carnivorous fish a shrimp production (e.g. salmon, bream, brass and shrimp farming) demands that the aquaculture sector responds to consumers concerns by looking into ways to replace fishmeal and fish oils with vegetable based equivalents produced from sustainable sources. Biotechnology appears to offer opportunities for such developments through production of specific proteins and lipids which could supplement plant-based feeds (or reduce inclusion of fish meal and fish oil).

Significant progress has been made on development of cost effective supplementary feeds for hatchery produced fish fry and shrimp larvae. Processing of plant ingredients (viz. fermentation, extrusion) and addition of amino acids (methionine, lysine), phytase, cholesterol, etc. have resulted in the production of easily digestible and cost-effective feed for aquaculture industry. Addition of protein hydrolysates, free amino acids (FAA) and lipid fractions in microdiets (MD) assist assimilation and absorption of microdiets in the larval digestive system. Predigetion of dietary protein may influence maturation of gastrointestinal tract and secretion of digestive enzymes; thereby larval performance.

Lipid fractions may be directly or indirectly involved as precursors or activators in the assimilation and absorption process. Use of prebiotics and probiotics in larval diets shows positive effects. In response to increasing consumer demands for quality and safe products, tools are already under development, or commercially available, that can detect and assay toxins, contaminants, and residues in aquatic products. Further, various bioremediation preparations, using biotechnological approach for degradation of hazardous waste to environmentally safe levels, have been developed. In closed recirculating system, use of biological filter reduces nitrogenous load (harmful ammonia and nitrite are converted to less toxic nitrate), whereas the hydroponic system is efficient in reducing both nitrogenous and phosphorous concentrations in the cultured systems. These are farmer-friendly as well as eco-friendly production systems.

Improved seed **–** Quality of seed, where genetically clean and strong or healthy will be a key factor which will govern the sustainability of the future aquaculture. The seed quality and the quantity will only come from a good seed network. The main actors in a seed networks are the breeders, hatchery and nursery operators, traders, growers and other input/service providers. Seed networking has become an important component of seed production which enabled accessibility and delivery of fish seed in areas distant from traditional sources thus stimulating aquaculture development in marginal and remote rural areas. Seed networking should be promoted and supported with enabling policies and required infrastructure.

Broodstock management will be a key issue in meeting the projected fingerling requirement to 2020. To meet this challenge, in the freshwater sector, the required increase in fingerling production from 2003 production will range, for example, from 8 percent to 1 300 percent for carp and 8 percent to 4000 percent for tilapia. There will therefore be a need for a technology shift in freshwater aquaculture technology from intensive-water use land-based systems to water-saving and water productivity-enhancing interventions. Integrate fish seed production with irrigation systems and irrigated agriculture and optimizing the use of irrigated agricultural land as seen in several countries can be further explored for their expansion/commercialization potential. The use of cages and hapas for fry to fingerling rearing is becoming increasingly popular in some countries, particularly those having large numbers of perennial water bodies. Such initiatives not only contribute to the enhancement of productivity of irrigation water bodies; they also enable landless households to generate income and animal protein from fish culture activities provided there is equal access to such resources.

Many rural farmers have adopted technology innovations and applied indigenous knowledge in order to meet their livelihood necessities. In the seed production sector, farmers have developed innovations, for example, on hatchery technology (i.e., bamboo/wood based circular technology), breeding techniques (i.e., Bundh breeding in India), nursing techniques (i.e., removal of egg stickiness by washing with milk prior to nursing in jars, application of fermented manure including oil cakes, stunting fish technology), local methods for fish collection and transportation, and others. Many such innovations and indigenous knowledge remain undocumented.

Improved holding systems **-** A notable technological advancement in salmon farming in countries such as Chile, Norway and Scotland has been observed. Improvements have been made in the design of sea cages. From wood/steel-framed rectangular support structures, with walkways around them, cages are now circular with plastic support structures and the use of boats for maintenance instead of walkways. The design changes have not only lowered operating costs and improved profitability, but have helped reducing environmental impacts significantly. A recent related development consists of specially designed cages for offshore marine finfish (Atlantic salmon, pompano, and other pelagic finfish) culture; they can be submerged 40 feet from the surface. At such offshore sites, removal and dilution of wastes is facilitated by greater water exchange; there is also greater salinity stability. Another recent development, which occurred in shrimp culture, has been in closed-recirculation systems, which have shown great potential for reducing fishmeal consumption compared with open-field farming.

Seeking solutions beyond the technical boundaries **-** In recent years, the scope of fisheries related R&D, including aquaculture, is gradually expanding to include social, economic and environmental issues, along with the traditional focus on technical factors. This shift in R&D approach was in large measure influenced by the concerns expressed in the Study of International Fisheries Research. The Study criticized fisheries research for being "disengaged from the needs of national development objectives and from policy needs in general" and for "failing to deliver information of practical value to management decisions"[65]. The SIFAR paper adds that, as an outcome of the Study criticism, there has been a gradual shift towards a more systems-based approach which sets fisheries and their management within a broader

[65] ***Research and policy outcomes in fisheries-changing the paradigm***? Support unit for International Fisheries and Aquatic Research, SIFAR, FAO, March 2004, www.onefish.org/id/202161)

context of social, environmental and economic factors – the "interdependent and mutually reinforcing pillars of sustainable development"[66].

The SIFAR paper also emphasizes the need to understand and address institutional weaknesses, in the absence of which knowledge from research, however apparently relevant, will remain disengaged from the needs of producers. There is now an emerging trend to address policy and institutional issues as well. For example, in India, multidisciplinary and multisectoral systems-based R&D programs supported by the STREAM Initiative are providing new insights into livelihoods strategies of members of poor self-help aquaculture groups and federations, giving people a voice in policy development, and encouraging the groups to shape policies that respond to their needs, such as easy access to credit and lease of waterbodies. There are other studies and examples available from initiatives such as those of the Mekong River Commission (MRC).

Another good case of systems-based R&D is the Consortium program on shrimp farming and the environment, whose key objectives were to: analyze and share experiences on the environmental and social impacts as well as better management practices (BMPs) of shrimp aquaculture (Box 4); and create a framework to review and evaluate successes and failures and conduct policy debate on management strategies (www.enaca.org/shrimp).

There are opportunities for research to address a number of key gaps in the Consortium program: the need to better understand impacts of the World Trade Organization and services agreement on shrimp aquaculture development and certification; the need for further research on coastal wetland restoration on abandoned shrimp farm land; the need to better understand social dimensions of BMPs, including poverty impacts, and the implications of engaging small-scale producers in shrimp certification; the need to better understand economics of BMP implementation; and the need to conduct studies on legislation, including minimal legal requirements to support implementation of core BMP principles. Environmental problems and social conflicts that aquaculture was seen to generate as well as the basic shift from aquaculture development to aquaculture for development with emphasis on the social objectives of the country deserve more attention[67].

[66] ***World Summit on Sustainable Development***, Johannesburg, 2003.

[67] ***Annon. 2001. Aquaculture development: financing and institutional support.*** *In* R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. *Aquaculture in the Third Millennium*. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. pp. 259-263. NACA, Bangkok and FAO, Rome.

Box 4 – Shrimp Farming and the Environment – a Consortium Programme

In August 1999, the Consortium, comprising the World Bank, NACA, the World Wildlife Fund (WWF) and FAO, initiated the program, which involved complementary country and global case studies on various aspects of shrimp culture and stakeholder consultations. The program was completed in 2002. www.enaca.org/shrimp). There are indications that the Consortium approach is having positive impacts in a number of areas: some elements of BMPs have been incorporated into several "codes of conduct" or "codes of practice" being developed around the Asia region; the findings and approach adopted have contributed to the development of a new government policy orientation towards poverty focused aquaculture in Viet Nam; the Bangladesh case studies and approach provided a basis for dialogue between NGOs and the government and led to wider appreciation of social issues in shrimp culture development, the Consortium's thematic review on mangroves provided a basis for development of a global Code of Conduct for the Management and Sustainable Use of Mangrove Ecosystems; and the FAO Sub-Committee on Aquaculture considered the BMP principles as an important basis for possible future international agreement on management principles for shrimp aquaculture

Source:
Regional efforts to improve management of shrimp farming: what more needs to be done? M.J. Phillips, Rohana P. Subasinghe, Jason Clay, Ronald Zweig, Jesper Clausen, Arun Padiyar and Katherine Bostik. Emerging trends and Experiences in Asia-Pacific Aquaculture: 2003, FAO 2004.

8.2 Factors that constrained or constraining the sector growth

Aquaculture development has been hampered by three factors relating to the essential requirements of R&D, namely insufficient funds, lack of core research staff and weak research infrastructure facilities. Despite their significant potential, small and poor farmers have not, until recently, received adequate attention and support from policy makers and planners. Consequently, their contributions are not quantified or fully appreciated and their issues and needs remain poorly understood.

Insufficient essential R&D capacity - Insufficient funds, lack of core research staff and weak research infrastructure facilities have constrained public sector aquaculture research in all the regions except Western Europe and North America, the two regions where most of the technological innovations continue to evolve and benefit the other regions[68]. All three issues are critical and need to be addressed at the same time. In Central and Eastern Europe for example, despite the positive political and economic changes, valuable human resources, knowledge and experience are still underutilised[69]. However, inadequate core funding and weakened infrastructure have been cited as significant restricting factors for development of aquaculture research[70].

[68] ***World Bank et al,*** 1992 and ***Policy and Research Series 19***. A study of International Fisheries Research .The World Bank, UNDP, Commission of the European Community and FAO of the UN, 1992).

[69] ***Varadi, L., Blokhin, S., Pekar, F., Szucs, I. & Csavas, I. 2001. Aquaculture development trends in the countries of the former USSR area.*** *In* R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. *Aquaculture in the Third Millennium*. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. pp. 397-416. NACA, Bangkok and FAO, Rome.

[70] ***FAO/Network of Aquaculture Centres in Central and Eastern Europe. 2006***. *Regional review on aquaculture development trends. 5. Central and Eastern Europe – 2005*. FAO Fisheries Circular. No. 1017/5. Rome, FAO. xx pp. (in press)

Insufficient funds - In some countries of the regions chronically plagued with shortage of funds, very little research work can be effectively conducted; most of the limited funds are used for meeting fixed expenses not directly associated with research, such as salaries of a large number of support staff. This is no different to any other production sector. Even the available budget is not directed to aquaculture, perhaps governments think aquaculture is too risky as we have seen and experienced in many places. However, it is important that more funds are allocated for research, which will be the only way to reduce risks. Research into broodstock development, hatchery production, breeding of species, feed research and management improvement are all critical for sector sustainability. We must learn from the significant improvements made through research in the livestock sector.

Some research institutes earn revenue through commercial production (for example, shrimp larvae and fish products), but the amount is insignificant and the arrangement is at best a temporary solution. An emerging trend has been the incorporation of private funding from aquaculture operators, including producers associations, for specific research and development projects. Indeed, this cooperation is increasingly imperative for the successful implementation of research programs. Governments need to create an enabling environment that would motivate the private sector to constructively engage in research priority settings and contribute to funding and monitoring and evaluating such programs. While few producers associations are able to afford and conduct major research programs on their own, they are often able to assist public sector research institutes with the organization of field trials and on-site training programs.

In Europe, the Federation of European Aquaculture Producers (FEAP) plays an active role as a partner in the implementation of a range of research, training and development projects grouped within the European Framework Programme for Research. One of such projects is "Aquaflow" (http://www.aquaflow.org/) initiated to provide a wide and rapid information flow on the progress of EC-sponsored aquaculture research[71]. There are similar initiatives in Latin America.

Lack of core research staff - The quality of research outcome is largely influenced by the quality of research personnel. However, the financial, professional and other incentives vital for recruiting and retaining high quality researchers are not satisfactory in many countries of the reported regions. Low salaries make researchers move to the private sector or other organizations, such as NGOs, private universities and international aid bodies. Further, absence of adequate financial incentives also drives many researchers, including those who receive fellowships for training abroad, to migrate to developed countries. The quality of research is also affected by inadequate procedures for evaluating programs and staff, which often lead to a lack of accountability and the likelihood that promotions will be based on considerations other than professional outcomes. Another related issue is professional development of staff based on a sound human resources development program. There is a lack of professional university level training in aquaculture globally. This needs to be rectified. Some of the issues are beyond the control of the aquaculture sector and can be effectively addressed in the context of public administration reforms that most countries have initiated.

[71] ***Producer Associations and Farmer Societies: Support to Sustainable Development and Management of aquaculture, by Courtney Hough and Pedro Bueno***, FAO Fisheries Circular No 886, page 84

Weak infrastructure **-** The quality of research also suffers due to weak research infrastructure facilities. Although many bilateral and multilateral-assisted projects contributed to the establishment of research stations equipped with specialized research laboratory and library facilities, and to the provision of research vessels, shortage of operations and maintenance funds after closure of projects greatly hampered the continuity and effectiveness of research programs. Continued funding for existing and new facilities will depend on the economic and social importance of the aquaculture sector and the priorities that government development policies give to the sector and to research. Ideally, research policies should be explicit and reflect the priorities of national development policies.

Responding to research needs of small and poor farmers **-** The great bulk of global aquaculture, especially in the Asia and the Pacific, sub-Saharan Africa, most parts of Near East and North Africa and Latin America and the Caribbean regions, is practiced by small and poor farmers located in rural areas, where the activity makes important contributions to nutrition, household food security and poverty alleviation. Despite their significant potential, small and poor farmers have not, until recently, received adequate attention and support from policy makers and planners. Consequently, their contributions are not quantified or fully appreciated and their issues and needs remain poorly understood[72].

An important area that requires further research is the need to formulate low risk technical options for small farmers. Many of the introduced technologies are not demand driven and thus are inappropriate and unsuited to the needs of the intended beneficiaries. For the needs to be appreciated in community settings, R&D should be used to evaluate social aspects found in rural areas that negatively affect the adoption of technologies; indigenous knowledge; power relationships; intra-household allocation of resources; role of gender; labour supply and demand; and marketing prospects. It is also important to understand and appreciate the complexities of land tenure[73].

The principles of the multidisciplinary and multisectoral systems-based R&D approach apply equally to assessing the needs of small farmers. It is important that the R&D framework is based on the principles of "farmer participatory research" or "farmer-first-and- last-research" approach that ensures full participation of farmers in the research process, including participation in decisions regarding the research agenda and evaluation criteria. It is reported that participatory research "involves small, resource-poor farmers to generate or adapt appropriate technology on-farm"[74].

In recognition of the importance of small-scale fisheries, in late 2003, the Director-General of the FAO convened a Working Party on Small-scale Fisheries of FAO's Advisory Committee on Fisheries Research (ACFR) to undertake an evaluation of the sector, review strategies and mechanisms to bridge the gap between research and action and provide views on key elements that would be included in the draft guidelines on small-scale fisheries[75]. FAO

[72] ***A Global Perspective of Aquaculture in the New Millennium***, Sena S. De Silva, page 444, Aquaculture in the Third Millennium, FAO, 2001.
[73] ***African Aquaculture: A Regional Summary with Emphasis on sub-Saharan Africa***, Cecil Machena and John Moehl, page 350, Aquaculture in the Third Millennium, FAO, 2001.
[74] ***Typologies and Concepts 1-Definitions, Assumptions, Characteristics and Types of Farmer Participatory Research***, Daniel Selener, pages 1, 11 and12, in Participatory Research and Development For Sustainable Agriculture And Natural Resource Management : A Sourcebook , Edited by Julian Gonsalves, Thomas Becker, Ann Braun, Dindo Campilan , Hidelisa de Chavez, Elizabeth Fajber, Monica Kapiriri, Joy Rivaca-Caminade, and Ronnie Vernooy, IRDC 2005 , www.irdc.ca.
[75] ***A research agenda for small-scale fisheries***, D. Staples, B. Satia and P.R. Gardiner, FAO 2004, page 2

subsequently prepared a research agenda for small-scale fisheries that highlights the need to address a range of issues grouped under five major themes: policy, legislation, governance and institutional arrangements; contribution, role and importance of small-scale fisheries; management approaches to small-scale fisheries; post-harvest issues and trade; and information systems.

In bridging the gap between research and action, the research agenda places a much greater emphasis on policy formulation and socio-economic research to augment the more biotechnical approach adopted in the past. Since many national fisheries and research institutes are not currently well equipped to undertake such research, there is a need to establish linkages with other centres of expertise, such as universities, ministry of planning, international organizations experienced in community and co-management approaches. For the research agenda to have its full effects, important measures include: development of staff capacity; provision of adequate funding support; involvement of stakeholders in research, including policy makers, fishers, civil society organizations and other national and local planning sectors; development of effective communication techniques; undertaking of "just in time" research, for example the effects of globalization of trade on small-scale fisheries; and explicit recognition of small-scale fisheries in international and national instruments governing fisheries.

9. Unexplored opportunities and strategies

9.1 Introduction

Unexplored opportunities in the context of this global prospective analysis essentially require the aquaculture sector to have a vision for the future and accompanying strategies to achieve that vision in a manner that will be economically, socially and environmentally sustainable. The sector indeed has a vision: to contribute more effectively to food security, poverty reduction and economic development by producing 83 million tonnes of aquatic food by 2030, an increase of 37.5 million tonnes over the 2004 level. The production target, which is based on projected population growth over the next two decades, is expected to maintain the current per caput consumption level[76].

To facilitate the process of identifying unexplored opportunities, it is useful to first take stock of the past trends that brought aquaculture sector to the current status and then develop a strategic framework to pursue such opportunities. The global aquaculture review[77] reported six general development trends: (a) continuing intensification of aquaculture production; (b) continuing diversification of species use; (c) continuing diversification of production systems and practices; (d) increasing influence of markets, trade and consumers; (e) enhancing regulation and improving governance of the sector; and (f) increasing attention on better management of the aquaculture sector. The global review notes that the trends do not necessarily apply equally to all the regions due to intra and inter regional differences in the development stage of aquaculture. The trends mainly reflect the behaviour of the sector in the countries where aquaculture is well established, notably China and other Asian countries.

In support of the above trends, four areas of unexplored opportunities have been identified: (a) application of innovative capacity enhancement programs; (b) search for new technologies; (c) development of new aquatic products and markets and integration into eco-tourism sector; and (d) development of new financial products. Some of the areas are not strictly unexplored, but would require considerable support to realise their full potential. It is suggested that implementation of the unexplored opportunities and other existing aquaculture development programs be based on a strategic framework that would require the lead ministry or agency to integrate such opportunities and programs in its national development plans or poverty reduction strategy.

This chapter discusses the four areas of unexplored opportunities and suggests a strategic framework to implement the opportunities.

9.2 Unexplored opportunities

In support of the above global trends, four areas of unexplored opportunities have been identified: (a) application of innovative capacity enhancement programs; (b) search for new technologies; (c) development of new value added aquatic products and markets and integration into eco-tourism sector; and (d) development of new financial products.

[76] ***State of world fisheries and aquaculture. 2002***. FAO, Rome. 150pp.
[77] ***State of world aquaculture: 2006***. FAO Fisheries Technical Paper. No.500. Rome, FAO. 2006. 134p.

Application of innovative capacity enhancement programs - As the pivotal factor to sustainable aquaculture development, the need for capacity enhancement stands out in the search for unexplored opportunities. Two areas, using Information and Communications Technology (ICT) and scaling-up approach, are discussed.

Information and communications technology - Continuous dramatic developments in ICT are creating new opportunities to communicate, impart learning and share knowledge in a timely and cost effective manner. The challenge for governments and other stakeholders supporting aquaculture development is to seize and apply such opportunities to the benefit of the sector. One such ICT means of learning that the sector could explore is use of the services provided by Global Distance Learning (GDLN) Affiliates, a global partnership of learning centres (www.gdln.org). GDLN Affiliates offer the use of advanced information and communication technologies, including access to interactive global dialogue videoconferencing facilities, meeting rooms and high speed internet connection, to its various clients around the world for consultation, coordination and training events. GDLN Affiliates are located in more than 60 countries worldwide. GDLN Affiliates' services could possibly be used for, among others: (a) consultations by policy makers, (b) capacity enhancement training of policy makers and members of the Sub-Committee on Aquaculture, and (c) sharing of experiences and best practice cases among stakeholders. The benefits of GDLN are that it cuts time and space and could be suitable for policy makers who are pressed for time.

An ICT area that could be used more effectively is internet facilities. For example, the aquaculture sector could benefit immensely if Chinese research works and experiences are translated into other languages and posted on the web. Another ICT area that the aquaculture sector could benefit from is the application of satellite radio technology, which is being used in Africa and Asia and the Pacific regions[78]. The technology, using simple, inexpensive receivers, could reach remote populations for dissemination of extension messages.

Networks - The establishment of new networks of aquaculture centres along the patterns of NACA and NACEE, particularly in the sub-Saharan Africa region, could contribute to development of the sector at a faster pace. In line with the Kyoto Declaration, governments and international aid agencies need to consider supporting the establishment of such networks and centres.

Scaling up - Scaling up successful development efforts is a useful strategy to accelerate poverty reduction. To share and learn from real life experiences about how countries and institutions have scaled up poverty reduction efforts, the World Bank sponsored a successful Conference on Scaling up Poverty Reduction and Global Learning Process (Shanghai, May 2004). The conference was preceded by a year-long learning process during which experts and policy makers exchanged their views on more than one hundred case studies on poverty reduction (www.worldbank.org). Following the pattern of the Shanghai conference, a similar conference on successful efforts, or best practices, in the aquaculture sector could be considered at a regional or global level. The theme (s) could be issues of immediate concerns, such as application of codes of conduct, self-regulation and best management practices, empowerment of small farmers association, and ecosystem approach to aquaculture.

Legislation - Given the aquaculture sector's struggle with the current web of laws, the challenge is whether the sector would be able to craft a "State of Art" aquaculture act that

[78] ***ACDI/VOCA World Report***, Fall 2004, page 4

could be tailored or customized to meet the needs of countries with varying levels of aquaculture development There is no definite answer as to whether or when this could happen, but the challenge could be considered as an opportunity and translated into action by allocating resources to examine its feasibility, possibly with technical assistance provided by FAO and guided by the Sub Committee on Aquaculture.

Search for new technologies - The aquaculture sector will continue to be challenged to make further innovations to broodstock improvements and domestication, effectively combat emerging diseases, develop safe and quality feeds, and develop holding systems. The aquaculture sector also requires new technologies, including for small and poor farmers, to make more efficient use of natural resources (i.e. water, land, energy) and contribute to the economic efficiency of farming systems. The diversity of species cultured and production systems used present a unique set of challenges to technology development and application. Technology transfer should be done in a responsible manner and duly consider protection of aquatic biodiversity and impacts on the livelihoods of the poor.

In the case of reproduction, ongoing research on chemical treatment of shrimp gonad inhibiting neurohormone (GIH) isolation shows initial promise for countering the reproductive inhibitory effects of GIH; its further development is expected to continue. In the case of disease management, further research work is being carried out in the areas of domestication of *P. monodon*; development of commercial molecular probes for viral pathogens such as white spot, SEMBV, MBV, TSV, HPV, and YHV; development of standards for aquaculture health standard management, and development of economically viable probiotics. Vaccination is an alternative prophylactic method to control disease impacts. Vaccines have become an established, proven and cost-effective method of controlling certain infectious diseases in cultured animals. They also reduce the need for antibiotics, leave no residues in the product or environment and do not induce pathogen resistance[79].

While some commercial vaccines have proven effective in providing protection against certain diseases (mainly finfish), it is still not possible to vaccinate against shrimp and molluscan pathogens. Their development requires considerable research, including planning field trials and cost-benefit evaluation. Research in feed management is expected to continue to further develop appropriate feed substitutes/supplements for fishmeal and live feed for hatchery produced fry/post larvae. In the case of holding systems, research is expected to focus on open ocean aquaculture, including in high energy zone, and recirculation technologies for inland facilities.

Development of new aquatic products and markets and integration into eco-tourism sector - Given the expectations of the sector to contribute more substantially to food security and income generation, it needs to more actively look for opportunities beyond the food fish sector, such as seaweeds and ornamental fish that have great potential. Another new area worth exploring is integration of fisheries into the eco-tourism sector.

<u>*Seaweeds*</u> **-** The farming of seaweed has expanded rapidly and offers new investment opportunities as demand has outstripped the supply from natural resources. The seaweed

[79] ***Subasinghe, R.P., Bondad-Reantaso, M.G. and McGladdery, S.E. 2001. Aquaculture development, health and wealth.*** *In* R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. Aquaculture in the Third Millennium. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. pp. 167-191. NACA, Bangkok and FAO, Rome.

industry provides a range of products generating an annual production value of US $ 5.5-6 billion, of which food products for human consumption contribute about US $ 5 billion, and substances that are extracted from seaweeds (carrageenan, agar and alginate) account for a large part of the remaining billion dollars, while smaller, miscellaneous uses, such as organic fertilizers and animal feed additives, make up the rest. Seaweed extracts are used for cosmetic products, such as creams and lotions[80]. There are two distinct groups of seaweeds. The first group includes seaweeds of temperate waters solely and traditionally used for food purposes. The second group comprises seaweeds of tropical species mainly processed as a source of biopolymers (carrageenan, agar) that are used for various food and non-food purposes. The production of seaweeds for food purposes is mainly confined to East Asian countries and has a relatively stable production. In the case of seaweeds for biopolymers, the global demand for carrageenan is expected to continue to rise and new areas are being investigated for expansion[81]. There are opportunities for the expanded use of seaweeds for the extraction of micro-nutrients and production of other compounds besides their phyco-colloids.

Ornamental fish culture- Ornamental fish is a major aquatic product in the culture and trade of non-food species. Governments are increasingly promoting the culture and trade of ornamental fish due to its growing potential for increasing rural employment and income and generating foreign exchange earnings. By 2000, the global wholesale value of live freshwater and marine ornamental fish (live animals for aquarium) was estimated at US $ 900 million, with an estimated retail value of US$ 3 billion.

Southeast Asia is the hub of ornamental fish trade, supplying about 85 percent of the aquarium trade[82]. In sub-Saharan Africa, South Africa is the major producer of ornamental fish. Ornamental fish offers enormous potential in west and east Africa, particularly cichlids, cyprinids and catfish. In Central and Eastern Europe, some countries produce ornamental fish in food fish farm as secondary species. The Czech Republic is an exception where ornamental fish is produced as an integral part of aquaculture production. In 2003, the total value of export was estimated at US$ 120 million. In Latin America and the Caribbean, almost half of the countries produce ornamental fish for domestic and export markets.

A major threat to the development of the ornamental fish industry is the outbreak of disease. A single strain of koi herpes virus (KHV) has reportedly spread globally due to unregulated trade in ornamental fish and could become a considerable problem to ornamental koi carp as well as common carp, both cultured and wild. The effective implementation of the measures adopted by countries to arrest the spread of fish diseases will hopefully prevent the occurrence of such a disaster. Singapore, as the world's top exporter of live aquatic animals (ornamental fish) administers an Accredited Ornamental Fish Exporters Scheme where members are required to observe and comply with the terms and conditions of the program, as well as a Code of Practice for Accredited Ornamental Fish Exporters. The scheme emphasizes good management, hygiene practices and general layout of the premise, especially with reference to quarantine facilities.

Non-food use - There is a need to further exploit the potential of adding value to aquaculture products through development of non food uses, particularly in the context of increasing

[80] ***The State of World Fisheries and Aquaculture 2004***, FAO. 150pp.
[81] ***Asian Regional Trends in Aquaculture and Related Fishery Activities***, Shunji Sugiyama and Simon Funge-Smith, Emerging Trends and Experiences in Asia-Pacific Aquaculture: 2003.
[82] Useful references to marine aquarium trade can be found at: Global Marine Aquarium Database: www.unep-wcmc.org/marine/GMAD/ and www.marine.wri.org.

production costs. The use of waste by-products of processing such as oils and viscera (salmon), skins (tilapia), chitins (shrimp) and anti-arthritic compounds (green mussels), needs to be further researched.

There are also initiatives on using low value cultured fish in the pet food industry. Use of cultured fish provides the control over ingredients used for producing fish; i.e., organically farmed fish used in pet food. Although ethics of this is yet to be debated, it appears that the process is economically viable.

The ecotourism trigger **-** To appreciate the concept and potential of aquaculture-related ecotourism, it is useful to first recognize the importance of tourism, including ecotourism, to promote economic growth and reduce poverty. Tourism is one of the biggest industries in the world, having generated 692.7 million international arrivals and US $ 462.2 billion worth of international receipts in 2001 (www.uneptic.org). It also represents a growing 70 percent of the service exports of least developed countries. According to the United Nations World Tourism Organization (UNWTO), the tourism sector has immense potential to help the global anti-poverty fight. UNWTO, together with UNCTAD, recently launched a new initiative ST-EP (Sustainable Tourism –Eliminating Poverty) to encourage sustainable tourism - social, economic and ecological - which especially alleviates poverty in the world's poorest countries. At WTO's 2003 Assembly in Beijing, a resolution was passed mandating the Secretary General to aggressively pursue the implementation of ST-EP (www.world-tourism.org).

Ecotourism, defined by The International Ecotourism Society (TIES) as "responsible travel to natural areas that conserves the environment for the well-being of local people", is based on a number of principles, including building environmental and cultural awareness and respect, and providing financial benefits and empowerment for local people (www.ecotourism.org). According to UNEP, as a development tool, ecotourism can advance the three basic goals of the Convention on Biological Diversity (CBD): conserve biological (and cultural) diversity, promote sustainable use of biodiversity and share benefits equitably. Aquaculture, based on the culture of a wide variety of aquatic species under different environmental systems by a large number of small and poor farmers, mostly located in rural areas, can also promote the CBD goals and offers a great potential to integrate its activities into a country's overall ecotourism development program. Integration has the benefits of economy of scale and synergy, for instance inclusion of aquaculture operations as part of a wild life tour.

A number of countries are engaged in promoting aquaculture-related ecotourism. Recreational fisheries in lakes and reservoirs play a significant role in Central Eastern Europe, notably in the Russian Federation, Ukraine, Belarus, Moldova and the Baltic States[83]. In Malaysia, there is a growing interest to integrate aquaculture operations with tourism, such as marine cage culture and put and take fishing ponds[84]. A potential area where aquaculture-related ecotourism could be further developed is offshore sites. Visits to cage culture sites could be promoted as part of marine expeditions.

[83] ***Aquaculture Development Trends in the Countries of the Former USSR*** Area, Laszio Varadi, Sergey Blokhin, Ferenc Peckar, Istvan Szucs and Imre Csavas, page 423, Aquaculture in the Third Millennium, FAO, 2001.

[84] ***Current Status and Development Trends of Aquaculture in the Asia Region, by Hassanai Kongkeo***, page 287, Aquaculture in the Third Millennium, FAO, 2001

A more concerted effort by the sector to develop a well-planned and managed program, by integrating aquaculture operations into a country's ecotourism program, is likely to produce enormous benefits. As a relatively new venture, Governments will need to create awareness, support capacity building and ensure closer coordination between the fisheries ministry and other related ministries, such as forests and environment and tourism, and the private sector ecotourism operators. Further, Government's may wish to approach UNWTO for policy advice, funding and technical support to promote ecotourism.

Development of new financial products - With progressive intensification and diversification of aquaculture, there is likely to be demand for more financial products, namely venture capital and aquaculture insurance, globally. The Asia region's capability to develop and bring to the market new technologies, without recourse to foreign investment, is severely limited. The reason is the lack of a well developed venture capital market that is willing to invest in new projects of potentially high financial risk. An exception to this gap is Thailand which has a consortium of several private sector companies for the development of a shrimp-breeding program. However, the program involves a government agency that is a major share holder. There are very few examples available on this aspect, however many countries and companies are seriously considering the importance of venture capital. In the future, with further developments in the sector, governments will need to consider creating a framework that would motivate potential venture capitalists to invest in high risk and high return projects.

In the case of aquaculture insurance, Europe, North America and Oceania (mainly New Zealand) are generally better off in terms of coverage compared with the other regions. In Asia, due to difficulties involved in aquaculture insurance management and the limited profitability of pilot schemes, the market has yet to develop and is mainly supported by state-owned insurance companies. In the USA, a limited number of aquaculture establishments have insurance coverage. South America is also not well served, with only Chile having coverage facilities for about a decade. In sub-Saharan Africa, only South Africa is served by aquaculture insurance services.

In terms of insurance of growing systems, a recent survey indicated that not many insurance companies are eager to support shrimp hatchery production. However, there is interest in covering offshore submersible and semi-submersible cages in the near future. The challenge for the insurance market is to provide affordable and easily accessible insurance products including a large majority of small and poor farmers in Asia, sub-Saharan Africa and Latin America and the Caribbean regions (Do small-scale farmers really need insurance? Is it worth to have one?); they are engaged in low-risk, low-investment, low-input, low-output aquaculture. In general, governments will need to put in place appropriate policies and, along with the private sector, generate awareness and support capacity building. To reach out to the small and poor farmers, the private sector will need to establish linkages with micro-credit and finance institutions[85]. Possibilities of group insurance schemes could be explored.

9.3 Strategic Framework

The realisation of the unexplored opportunities and the implementation other existing aquaculture development programs will require an integrated approach to development. This implies that they will need to be based on a strategic framework that would require the lead

[85] ***Review of the Current Status of World Aquaculture Insurance*** by Raymon van Anroy, Paddy Seeretan, Yong Lou, Richard Robert and Maroti Upare, Forthcoming FAO Fisheries Technical Paper, 2006

ministry or agency to integrate such opportunities and programs in their national development plans or the poverty reduction strategy papers. Since the fisheries and aquaculture sector will be one of a competing number of intra-ministerial voices when it comes to mainstreaming natural resources strategies into national development plans or poverty reduction strategy papers, the challenge is to highlight the manner in which fisheries and aquaculture sector can contribute to poverty reduction, food security and foreign exchange earnings. A formal endorsement of the opportunities and programs in the national strategy documents would improve the chance of achieving the aquaculture sector's objective of increased production.

10. Challenges and opportunities

Generally, a government's commitment to provide increased support to the aquaculture sector is a prerequisite for its sustainable development. The commitment is projected in the form of clear articulation of policies, plans and strategies and availability of adequate funding support for implementation. The challenge, and a potential future constraining factor, is whether the level of commitment of governments, particularly those of developing countries, will falter and development priorities will shift, possibly due to new global economic opportunities or competition for scarce financial and natural resources from other emerging and promising sectors, such as ready-made garments, IT, poultry and pharmaceuticals. `

While the level of commitment will vary within and among regions, depending on the degree of development, it is nonetheless expected that countries where aquaculture contributes substantially to growth, poverty alleviation and food security will increase the level of national commitment, as is being manifested in the commitment of the sub-Committee on Aquaculture to look for ways and means to further develop the sector.

While a government's commitment is indeed necessary for aquaculture development, it is not sufficient to ensure sustainability. The aquaculture sector needs to operate under a sound overall macro-economic and institutional framework. Political instability, a factor external to the sector, can also be a major constraining factor and adversely impact institutional development of the sector, which needs long-term continued support. As an example, the poor performance of the aquaculture sector (as well as many other economic sectors) in sub-Saharan Africa is largely due to civil unrest, strife and war, some lasting as long as twenty-seven years[86]. Recalculating the period of intervention reveals that the sector has only been supported for an average of twenty-one years. The average period of support could in fact be even much shorter if post-conflict reconstruction and government start up support period are considered. Such shorter periods of support hampers institutional development of the sector.

Some specific issues that warrant attention to reinforce the level of commitment and support are noted below.

New areas of human resources development - HRD is pivotal to aquaculture development, but its success depends on whether capacity development of public and private sector personnel would be able to keep pace with new developments in technology, international trade and legislations. Related issues that are beyond the control of the aquaculture sector are: "brain drain" or migration of trained personnel to developed countries, and "human capital' and "social capital" losses due to the devastating effects of HIV/AIDS in many parts of the world, particularly in Africa.

Long-term small farmers capacity enhancement program - Enhancing the capacity of small farmers, including motivating them to form local-level producer associations, is a major priority action and can be accomplished over time. Both government and private sector, including national producer associations and NGOs, will need to make special efforts to further promote this type of arrangement. It seems that governments will also have to strike a

[86] **Hecht, T.** 2006. *Regional review on aquaculture development. 4. Sub-Saharan Africa – 2005*. FAO Fisheries Circular. No. 1017/4. Rome, FAO. 96 pp

balance between promotion of large farmers engaged in export of high valued aquatic products and development of small farmer operations.

Ever increasing trade barriers **-** Markets and trade strongly influence the growth of any sector such aquaculture, especially when the sector's product is internationally traded. International trade of farmed fish has been progressively increasing over the last decades. This growth in trade has induced some countries to use high import tariffs on fish and fishery products as a way of protecting domestic aquaculture industries against foreign competition.

The future of fish exports from the developing countries could be seriously threatened by stringent regulations that are being progressively imposed by the major fish importing countries. Its impact will be more on small-scale producers as they may not be able to bear the high costs of compliance and eventually may be pushed out of business. It is important that trading standards and quality/safety criteria are set on the basis of proper risk analyses, and are achievable, and that small producers are provided adequate assistance to improve the quality of their operations or organization in order to be able to access markets and improve compliance.

An issue that warrants serious attention is the potential impact of increasingly stringent export requirements and standards (food safety and quality) on small PA members. This by any means does not suggest that the quality and safety standards should be lowered; nevertheless, the issue is the ability and the cost of compliance to those by the small producers. In addition to providing technical support to small PA to adopt codes of practices and/or better management practices, governments should encourage small PA to organize themselves into clusters and/or manageable production units to share and reduce costs[87].

Negative image of aquaculture - While some cases of unplanned management and improper practices of aquaculture in some parts of the world have triggered environmental, health and social-related concerns, the significant benefits of adoption of responsible and sustainable aquaculture practices, particularly aquaculture's contributions to poverty alleviation through employment creation, income generation, food security and protein supplementation, and foreign exchange earnings, have often been overshadowed. The negative image issue mostly concerns all countries and regions engaged in production of certain high value commercial aquatic commodities.

To safeguard the aquaculture sector's growth potential, it is essential to continuously project the correct image through, among others, engaging civil society, media and other concerned stakeholders in constructive dialogues and sharing with them information and data, including best practices, in a transparent manner. The sector could also exploit the emerging opportunity of increasing demand by consumers for "greener" production technologies by encouraging producers, mostly those involved in high value commercial commodities, to adopt cost effective culture practices backed by credible certification programs.

Another approach could be establishment of museum-aquarium-ecoparks similar to FishWorld in Philippines by SEAFDEC. FishWorld was opened in response to the need for informal public education so necessary for responsible aquaculture and fisheries, and for environment protection and sustainable development in general. SEAFDEC considers Fish World as an important step in "greening" the minds, hearts and spirits of people

[87] ***Improving the sustainability of small-scale shrimp aquaculture: experiences in cluster management in India***. FAO Fisheries Technical Paper (in press).

(www.seafdec.org). At the producer level, two recent steps taken to improve negative image could be replicated by other producers in the future. Firstly, the Thai National Shrimp Association succeeded in planting mangroves or rehabilitating them. Secondly, the Sri Lankan ornamental fish farmers association's initiated the promotion of the breeding of endangered species.

Rising energy costs - Even before the current worldwide energy crisis, energy cost represented an important share of the production costs in many commercial aquaculture operations. With further intensification and the use of more sophisticated technologies, it is likely that more energy will be needed, thereby exacerbating the energy cost problem. As for land and water, aquaculture must compete with other activities for energy. To alleviate the problem, researchers around the world are finding low-cost energy sources. More efficient pumps have been suggested as one of the options. Another is the use of re-circulating systems. While recirculation requires energy, it does not need water pumped from lower levels and so is energy efficient.

Wind powered pumps are being used on a limited scale in freshwater aquaculture in many countries, but their capital cost is high. The inability to design a low cost high volume pump for saltwater shrimp farming has also restricted its use. Solar-powered pumps suffer from the same problems. In addition, farmers are also developing strategies and practices to reduce energy requirements. 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 technique. However, more research is required on these production techniques.

Land availability - With the possible few exceptions, there is little new land available for fish farming in most countries around the world, especially in Asia, the leading aquaculture producer. Land shortage is and is likely to remain one of the major constraints to aquaculture expansion globally.

Offshore culture - In spite of the limited land and water resources, attracted by high prices which are triggered by high demand, entrepreneurs are likely to find new ways (in addition to intensification) of producing enough fish to meet the demand. One of the plausible ways is offshore cage culture and enclosure systems, probably with big corporations taking the lead as the economies of scale will require the production of enormous quantities of fish for farms to be profitable.

Aqua feeds - The use of aqua feeds plays and will continue to play an important role in aquaculture development and production. The availability and cost of feed can be a critical to aquaculture. Irregularity of feed supplies, or shortages, adds to risks and may jeopardize operations; this has been a problem in many countries, especially in Africa and some parts of Asia.

Insurance - With progressive intensification and diversification of aquaculture to systems and species requiring sophisticated technologies, access to capital will be a key factor to development. Not only will the need for capital be for investment and operating costs, but also for protecting aquaculture from natural disasters and calamities such as recent Tsunami and disease outbreaks, through insurance. Insurance is not well established in aquaculture in the developing word, owing to various factors; mainly due to high risks involved and small-scale nature of operations. It will be a challenge for the future to protect these high tech

investments which will probably attract more risks than generally experienced in conventional aquaculture through organised insurance.

Carrying capacity - Intensification may sustain profitability of farming operations, but does so at a cost. At times, it brings management complications (water and health in particular). Also, there are often concerns about the environmental carrying capacity that is strained by increased numbers of farms and/or intensity of production systems. How the sector will perform in terms of production will depend on how well these issues will be dealt with.

Information technology - Continuous dramatic developments in Information and Communications Technologies **(**ICT) are creating new opportunities to communicate, impart learning and share knowledge in a timely and cost effective manner. The challenge for governments and other stakeholders in aquaculture development is to seize and apply these opportunities to the benefit of the sector.

More research and development - As pressure for aquaculture expansion continues to rise, R&D faces the challenge of staying ahead and providing policy makers, researchers and practitioners with cutting edge knowledge and ideas that could be translated into action for sustainable development of the sector. Because most of the technological innovations originate in developed countries, their transfer to and application in developing countries is necessary. As discussed earlier, this transfer could be hampered by the lack of qualified personnel and by funding constraints. It is thus important that governments provide necessary support to develop the technical capacity of public and private sector research and extension personnel to a level that would allow them to effectively disseminate application of such knowledge to farmers and potential entrants.

Adequate focus on research into the needs of the small-scale production sector is essential to keep small producers in business. Globalization and industrial and cooperate farming undoubtedly will have an effect on competitiveness of the small-scale farming sector, thus requiring special R&D assistance.

Political stability and governance - Good governance, including political stability, has a major influence on aquaculture development at all scales, the costs of doing business, attracts investment in the sector and enhances the industry's competitiveness both at home and globally. Macro-economic policies, such as fiscal policies, access to manpower and skills, and technology play an equally important and similar role. Increased participation of stakeholders in the governance of the sector will be increasingly more important than before. There will be greater emphasis on strengthening farmers association and self-regulation by the industry which will ensure greater sustainability.

11. Role of the COFI Sub-Committee on Aquaculture

The efforts made to understand and project the role of COFI Sub-Committee on Aquaculture in global aquaculture development brought a broad consensus that the future of global aquaculture largely lies in the hands of the private sector in partnership with the national governments. The role of the government in creating an enabling environment for the sustainable development of the sector remains undisputed.

The COFI Sub-Committee, as the only global inter-governmental body specifically responsible for dialogue and decision making on aquaculture, should seek to:

- serve as a forum for exchange of experiences and monitoring progress within the sector;
- review, discuss and agree on standards and guidelines;
- deliberate on emerging issues, and function as a forum for stakeholders to debate and agree on key issues and actions;
- develop priority programmes and actions for FAO and stakeholders to follow up (e.g., through regional/inter-regional projects), and identify avenues for raising funds for their implementation; and
- provide advice and guidance on the FAO work programme and budget.

In order for the Sub-Committee to be effective in accomplishing these tasks, it needs to ensure:

- an effective collaboration and contribution of all concerned of aquaculture;
- a good representation of all stakeholders (FAO Members, NGOs, IGOs, UN Agencies, etc.);
- good links with relevant ongoing regional programs and organizations;
- an effective communication system for projecting issues onto the agenda; and
- intersessional work addressing urgent matters, which can be conducted by or coordinated by the Secretariat.

The third session of the Sub-Committee will discuss their role in shaping the future of aquaculture development and advise FAO and the Secretariat accordingly.