

Prospective analysis of aquaculture development

The Delphi method



Cover photographs:

Clockwise from top left:

Tilapia are transferred to a floating cage once they reach the juvenile stage. Credit: courtesy of Lake Harvest Aquaculture (Pvt) Ltd; An example of tropical cage culture technology using modern material. Credit: courtesy of Lake Harvest Aquaculture (Pvt) Ltd; Quality assurance means consistently checking products, ensuring cleanliness and hygiene at every juncture of the production process. Credit: courtesy of Lake Harvest Aquaculture (Pvt) Ltd; high-quality farmed tilapia requires excellent feed, such as this sampling manufactured to a specific formula from the finest cereal crops. Credit: courtesy of Lake Harvest Aquaculture (Pvt) Ltd

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The Delphi method

by

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Preparation of this document

This study was undertaken as part of a larger project to evaluate the prospective future of aquaculture in different regions of the world. It complements national and regional studies of aquaculture that were part of the process but uses a different methodology: the Delphi method. Because aquaculture in much of the world is relatively new, and quantitative forecasts have underestimated the actual expansion of aquaculture, the Delphi method was seen as a means of identifying constraints to further expansion and also possible opportunities without quantification. It also offered a way to assess different policy options for implementing change.

Abstract

In order to evaluate the major impediments to aquaculture development in different regions of the world and to indicate opportunities for expansion, a Delphi analysis was undertaken. The Delphi method is particularly useful for sectors such as aquaculture where discontinuities exist and where historic trends cannot be easily extrapolated into the future. The recent global expansion of aquaculture is unlikely to continue at the same pace; however, certain regions have underexploited resources and offer considerable potential. The Delphi method allowed experts in different regions to indicate where the potential and constraints are; they were also encouraged to offer their policy solutions.

Experts from Latin America and the Caribbean were particularly optimistic about opportunities for future aquaculture expansion in their region. With a plentiful natural resource base and sufficient demand for fish products, their principal concern was lack of financing and of human capacity. Other regions such as Eastern Europe were less sanguine partly because of problems with species or with external factors such as negative public perceptions towards aquaculture. However, there was a consensus in all regions that aquaculture should be encouraged. Reasons given ranged from the contribution of aquaculture to food security and poverty alleviation to the role of aquaculture in reducing pressure on wild fisheries.

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Foreword

As an additional means of collecting expert advice, the Delphi method complements national and regional overviews of aquaculture development. Rather than focusing on historic trends or even the present situation, the Delphi approach encourages a more forward perspective into the future. Six regions of the world were covered accounting for more than 90 percent of present aquaculture output; only one region was excluded because of lack of participation. The conclusions of this study are specific to each region but they have relevance elsewhere.

I would like to particularly recognize the efforts of Mr Nathanael Hishamunda of the FAO Fisheries and Aquaculture Economics and Policy Division who led this important study and prepared its report. The invaluable contribution of Ms Florence Poulain, a consultant, and Mr Neil Ridler of the University of New Brunswick, who assisted with collating and analysing the information, is also recognized. Appreciation is also extended to those who willingly participated in the exercise and provided their insights. Mr Diego Valderrama and Ms Olivia Liberatori's editorial work in the manuscript is greatly acknowledged.

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1. Background and summary

1.1 INTRODUCTION

The purpose of this study was to assess the constraints and opportunities facing aquaculture in different regions of the world. Aquaculture output was worth US\$86 billion in 2006 compared to US\$27 billion in 1990, with almost half of the current global consumption of foodfish coming from aquaculture. Recognizing the increasing contribution of aquaculture to people's livelihoods and countries' economies worldwide, as well as the potential challenges to further development of the sector, the Committee on Fisheries Sub-Committee on Aquaculture of the Food and Agriculture Organization of the United Nations identified the need for a "Prospective analysis of aquaculture development" in its second session held in Trondheim, Norway, from 7 to 11 August 2003. The Prospective analysis seeks to supplement the National Aquaculture Sector Overviews (NASOs). In particular, the objectives of the analysis are to:

- (1) qualitatively forecast the future of regional and global aquaculture development;
- (2) determine and analyse important future events and policies which could affect aquaculture development regionally and globally; and
- (3) determine priority areas for action in aquaculture (regionally and globally).

The results of the analysis will serve as a basis for the discussion of the longer-term direction of the work of the Sub-Committee on Aquaculture.

There are marked regional differences; some regions such as Asia and Latin America, have enjoyed impressive growth while others, such as Africa and Eastern Europe, have experienced erratic expansion. For a sector that is relatively new outside Asia and whose growth has been consistently underestimated, reliance on historical trends to forecast future growth has its limitations. Given such discontinuities, an alternative approach to obtain forecasts is to survey experts for their opinions. The end result may not be quantitative in nature but it does give indications on what the constraints and opportunities for further development are. This was the approach adopted in this study. It is expected that the conclusions reached by the experts, particularly on issues where there was consensus, will be useful to policy-makers.

The first section of the report summarizes the methodology selected for the study – the Delphi method – as well as the overarching results of the analysis, at a global level. Subsequent sections concentrate on specific regions, with their constraints to development, opportunities and suggested policy initiatives.

2. Method

2.1 THE DELPHI METHOD

In order to encourage a true debate about the opportunities, constraints and issues facing aquaculture in different regions of the world, it was decided to adopt the “Delphi method”. The Delphi method was developed in the late 1960s as a forecasting methodology and works formally or informally, in large or small contexts. The results provided by Delphi represent the synthesis of the opinion of a particular group of experts and is not intended to produce statistically significant results. The value of the Delphi method rests with the idea it generates.

The word Delphi refers to the hallowed site of the most revered oracle in ancient Greece where advice and predictions were sought from the gods through intermediaries. Centuries later, the term was applied to a technique developed after World War II, much to the dismay of its founders. A set of procedures developed at the RAND (an acronym for Research and Development) Corporation designed to improve methods of forecasting came to be known as “Delphi” (IIT, 2006). The founders thought the term implied something “smacking a little of the occult” whereas, as a matter of fact, precisely the opposite is involved: the technique encourages feedback and transparency. It is a very useful means of obtaining forecasts when there is less than perfect information.

The Delphi technique was developed as a method for obtaining qualitative, rather than quantitative, forecasts. When change is non-linear and discontinuous, traditional forecasting methods based on time-series regressions are inappropriate and could produce misleading projections. The Delphi method recognizes human judgement as legitimate and assumes that the testimony of experts can provide useful inputs in generating forecasts. The technique therefore expects to have unanticipated results and is organized in such a way that innovative thinking is encouraged. There is no peer-pressure nor are there inhibitions due to hierarchical positions of experts; the process is anonymous, and spatially separate. Every opinion is given the same weight whatever the position or discipline of the expert. It appears therefore to be ideal for anticipating challenges and policies for a sector such as aquaculture that is new in much of the world, and whose development by 2020 will be influenced by many uncertainties and unknowns.

The Delphi technique is an adaptive iterative survey method. It offers a number of advantages; firstly, during later rounds of the process, questions can be formulated based on replies given earlier; this enables all experts to explore issues they may have never considered before. Secondly, it is anonymous, which avoids the limitations of group decision making such as deference to seniors or a dominating “expert”. Thirdly, it may be relatively cheap and efficient, saving expense and time on face-to-face meetings, although there has been no cost-effectiveness comparison – in terms of budgets and time – of different participatory methods.

As mentioned above, the method presents several advantages, some of which are:

- anonymity – thus avoiding the limitations of group decision-making, e.g. over-dominant group members, deference to seniors;
- input of experts; and
- iteration with controlled feedback.

The Delphi technique has been applied to aquaculture in different contexts. It was used in the southeastern United States to develop criteria for aquaculture sustainability (Caffey, 1998). Out of three criteria (economic, environmental and social), the experts judged the first to be the most critical for sustainability.

In Chile, the Delphi method was used in 2003 as a means of evaluating the full potential of the aquaculture industry (Ministerio de Economía, 2003). The aim was similar to this study: to conduct a prospective analysis of aquaculture by examining the entire range of constraints and opportunities. A total of 167 experts participated in the survey, with the level of expertise ranked for each one. Stakeholder experts included not only producers from the aquaculture sector but also those involved in other sectors. Academics and government personnel were also invited to participate. The study was designed to explore prospects not only for existing but also potential aquaculture species and to provide guidance to Chilean policy-makers during 2003–2010.

Another Delphi study of aquaculture widened the stakeholder concept still further by including non-experts as well as experts. This stakeholder Delphi study was applied to the use or non-use of horizontally integrated aquaculture (Bunting, 2008). Such aquaculture offers the potential for mitigating some harmful environmental effects of cage culture, as well as being more socially acceptable, so the aim of the study was to determine the factors which prevented the adoption of this technology (Ridler *et al.*, 2007). Respondents ($n=24$) arrived at a general consensus on most constraints (primarily economic), but as the study mentions certain stakeholders were omitted, which may have biased results. A scoping exercise to identify stakeholders would be a valuable refinement for a similar expanded Delphi approach.

2.2 APPLICATION OF THE DELPHI METHOD IN THIS STUDY

Rather than a combined expert-stakeholder approach, the method used in this study relied only on experts from different regions. Delphi techniques often involve 15 to 60 participants but for this study 305 experts were initially surveyed. The experts were identified by FAO staff in seven regions of the world. The experts, who were either personal acquaintances or professionals selected after a scan of relevant publications on the Internet, were asked to share their views on issues and problems relating to aquaculture development in their region of expertise. Experts were not informed by FAO who else was participating.

Unfortunately, out of 17 experts initially identified for the Near East, only one responded to the first questionnaire; therefore the region had to be omitted from further rounds. As a result this report was based on six regions: Africa, Asia and the Pacific, Latin America, North America, Eastern Europe and Western Europe.

For questions where an impact/role of suggested factors was requested, participants were asked to rank each of their suggestions using a numerical scale from 1 to 5 in a column next to their suggestions. The resulting opinions were summarized (under category headings) and collated in an Excel format. The arithmetic median¹ and standard deviation (STDEV)² were calculated for the major category headings. These were then ranked from lowest to highest median value. If all participants agreed, the standard deviation would be zero. A STDEV close to 0 indicates a high degree of consensus. Whenever consensus was low (STDEV above 1), experts were asked to re-rate and/or justify their responses. All the results and semi-anonymous discussions were recorded and are available upon request.

2.3 RESPONSE RATE

In the first round, 305 questionnaires were sent out via mail; 54 responses were received. Respondents were assigned to different groups depending on their region of expertise: Africa, Asia and the Pacific, Latin America, North America, Eastern Europe and Western Europe (as explained previously, the Near East was excluded). The

¹ In a set of numbers, the median is the number separating the higher half from the lower half. It is found by arranging all the observations from the lowest to the highest value and picking the middle one.

² The standard deviation is a measure of how widely values are dispersed from the average value (the mean) of the sample.

TABLE 1
Breakdown of responses by round for the Delphi Prospective analysis of aquaculture development

Regions	Number of experts in region	Responses – first round	Responses – second round	Responses – third round
Africa	56	17	10	9
Asia and the Pacific	65	13	9	5
Eastern Europe	41	3	2	2
Latin America	36	4	5	4
Near East	17	1	NA	NA
North America	50	6	5	2
Western Europe	40	10	8	NA
Total responses	305	54	39	22

second-round questionnaire was mailed to the participants who responded in the first round. Thirty-nine responses were obtained in the second round. For the third round, a total of 22 responses were obtained (no third-round questionnaires were mailed to experts from Western Europe as all questions/issues were fully explored in the initial two rounds). The breakdown of responses by round is presented in Table 1.

2.4 QUESTIONS

The first round of the Delphi prospective analysis on aquaculture development asked experts:

- i) to suggest factors which in their mind have contributed to today's aquaculture development; to rate the impact of these factors on the growth of aquaculture per region; to rate their expected impact/role on the growth of aquaculture per region over the next 15 years;
- ii) to indicate other factors which might contribute to reduce aquaculture growth over the next 15 years; to rate the likelihood of occurrence of these factors; to rate their expected impact on aquaculture growth over the next 15 years if they were to occur;
- iii) to indicate whether aquaculture should be encouraged per region; what the objectives of developing aquaculture should be; to rate the importance of each of the objectives listed;
- iv) to list the major unexplored opportunities for aquaculture in the region; and
- v) to suggest effective and practical means of developing aquaculture.

Responses in the first round helped define questions for the second and third rounds. In particular, the second round asked experts to suggest practical means to lessen/contain the impacts of those factors identified as having negatively affected aquaculture growth and expected to continue to affect aquaculture growth negatively in the next 15 years, or to suggest actions to implement those factors identified as positive for aquaculture development but unlikely to happen.

The text of the first-round questionnaire was slightly modified for Africa. Experts were asked what the main contributing factors for the slow growth of aquaculture had been in the region and to suggest additional factors that might contribute to reverse aquaculture development in Africa over the next 15 years. The reason for these modifications is that Africa has not enjoyed the same expansion of aquaculture as other regions, and so the Delphi questionnaire for that region focused on constraints and strategies for mitigating those constraints. These strategies were ranked for their potential impact and their likelihood of being implemented. Because of food insecurity and poverty issues in Africa and the potential contribution of aquaculture, a complete list of mitigating strategies for each constraint is attached even when there was not consensus. This lengthened the Africa Appendix (Appendix 1), but it is hoped that the ranking and the extensive list of suggestions will guide policy-makers devise appropriate strategies and policy instruments.

3. Overall results

3.1 SHOULD AQUACULTURE BE ENCOURAGED AND WHY?

Experts in all six regions surveyed (Africa, Asia and the Pacific, Latin America, North America, Eastern Europe and Western Europe) agreed that aquaculture should be encouraged. However, their reasons differed. No check list of possible reasons was given; instead, experts were asked to suggest their own. These suggestions were ranked in later rounds. In three regions (Africa, Asia and North America), aquaculture's role as a source of food was ranked as "very important" whereas in Eastern Europe and Latin America its contribution to economic development was considered paramount. In Western Europe the principal role of aquaculture was to improve sustainability of fisheries (Table 2).

This latter rationale – the contribution of aquaculture to sustainability of fisheries – was unexpected. Aquaculture and fisheries are often perceived as competitors for markets or for coastal resources, yet the experts evidently thought that aquaculture would have a beneficial impact on fisheries. The positive contribution of aquaculture to fisheries was emphasized not only by experts from Western Europe, for whom it was the primary rationale for aquaculture development. North American experts ranked aquaculture's contribution to sustainability as "very important". Explicitly they stated that aquaculture production would halt depletion of wild fish stocks and contribute to rebuild the living aquatic resource base. Experts in Asia also thought that aquaculture should be developed because of its "important" contribution to sustaining aquatic resources and fisheries.

3.2 WHAT FACTORS HAVE CONTRIBUTED TO THE POSITIVE DEVELOPMENT OF AQUACULTURE IN THE PAST?

Surveys in the initial round were similar for all regions, with the exception of Africa. Experts were first asked what factors had contributed to the past positive development of aquaculture. Demand factors were considered to have a "very large impact" in all regions, whether because of a growing preference for fish, the lower price of farmed fish, the profitability of farming certain species, or the declining output of substitutes to farmed fish. Supply factors such as the availability of suitable sites, and of financing (in Western Europe) also had a "very large impact".

When asked what factors would contribute to aquaculture development in the future and would be "very likely to happen", market demand was paramount (Table 3). This was expected because of higher expected incomes (in Eastern Europe), increasing consumer demand for fish (Western Europe), and less competition from agriculture and fisheries (Latin America). In Asia, explicit policies to support aquaculture are expected to drive demand.

TABLE 2

Summary of major reasons for supporting aquaculture (according to regional experts), where 1 = very important and 2 = important

Challenges	Africa	Asia and the Pacific	Latin America	North America	Eastern Europe	Western Europe
Economic development	1	2	1	1	1	
Improve sustainability of fisheries/resources	2	2		2		1
Source of food	1	1		2		

TABLE 3

Summary of major factors that have positively affected and will impact aquaculture development (according to regional experts), where 1 = most important reason; 2 = factor that will become increasingly important

Challenges	Africa	Asia and the Pacific	Latin America	North America	Eastern Europe	Western Europe
Demand factors		1+2	2	2	2	2
Financing and sites				1		1
Supporting policies		2				
Economic contribution		1+2	1			
General environment		1	1			

3.3 WHAT FACTORS AFFECTED AQUACULTURE DEVELOPMENT NEGATIVELY IN THE PAST – WILL THEY BECOME MORE DETERMINANT OVERTIME?

Experts were asked about constraints to aquaculture development in their regions: what factors had slowed down development and were expected to become more influential over the next 15 years (until 2020). In the second round, experts were asked to suggest mitigating policies.

Because of the slow and erratic development of aquaculture in Africa, experts were initially asked what factors had negatively affected aquaculture in the continent, and whether those factors would become more acute over time. This question was posed to recognize challenges in the region that should be addressed by policy-makers as a priority. Several factors were cited including lack of capital for investment, constraints on feed and seed availability, poor capacity, and lack of research. *However the principal factor cited was the “absence of suitable policies”* subsumed into: a) wrongly focused national policies, with an overemphasis on small-scale subsistence aquaculture (driven in particular by the international donor community) and aquaculture as a means of rural livelihood; b) the oversight of profit when promoting aquaculture; c) lack of clear property rights; d) neglect of private-sector investments; and e) lack of business-friendly legislation. Second and third rounds then explored mitigating policies that might counter these constraints.

In the first round, Latin American experts cited technology transfer and markets as limiting constraints but these were expected to improve (technology transfer), or simply disappeared from the discussion by the third round (market access). In contrast, lack of technical support (particularly for farming endemic species) and lack of financing were cited among the major concerns.

In North America, lack of financing is a constraint expected to become more acute overtime. Opposition from the public and the media and spatial limitations are also expected to have very large negative effects on aquaculture development.

In Asia, constraints that are expected to become more restrictive include stringent trade barriers, environmental issues, lack of domestic feed industries, poor government policies, and the media’s sensationalist coverage of aquaculture. Experts in Eastern Europe are concerned about the region’s competitiveness due to rising energy and feed costs or non-optimal growout conditions for salmonids. In Western Europe, market access is a constraint expected to become “much more important than before”; similarly, competition over coastal resources, breeding programmes for major species and public opposition are constraints that will become increasingly important.

Tables 4 and 5 summarize the major challenges by region, including those constraints that are expected to become increasingly important in the future.

3.4 WHAT ARE THE “UNEXPLORED OPPORTUNITIES” THAT WOULD HAVE A VERY LARGE POSITIVE IMPACT IN REGIONS?

In addition to private profit-driven aquaculture development, which experts consider has been ignored in the region, unexplored opportunities in Africa include trade (both

TABLE 4
Summary of major challenges by regions (according to regional experts), where 1 = "very important"

Challenges	Africa	Asia and the Pacific	Latin America	North America	Eastern Europe	Western Europe
Supporting policies	1	1	1	1	1	1
Capital	1	1	1	1		1
Capacity	1	1			1	
Seed	1				1	
Extension services & research	1		1			
Feed	1	1	1		1	1
Technology	1	1	1	1		1
Infrastructures	1					
Market	1	1			1	1
Governance	1					
Access to/use of water and sites	1	1		1	1	1
Negative publicity and opposition	1	1	1	1		1
Environmental management		1	1	1	1	1
Trade barriers/international competition		1		1		1
Disease outbreaks		1	1		1	1
Environment issues (incl. climate change)	1	1			1	
Cost and price fluctuation		1		1	1	1
HIV/AIDS	1					
Macro environment	1		1			
Natural disasters		1				
Migration of trained staff	1					

TABLE 5
Most important challenges to aquaculture development (according to regional experts), where 1 = currently "very important" and 2 = challenges that will become increasingly important

Challenges	Africa	Asia and the Pacific	Latin America	North America	Eastern Europe	Western Europe
Supporting policies	1	1	2			
Capital	2		2	2		
Competitiveness	1				2	
Feed	1	2				
Access to/use of water and sites		2		1		2
Negative publicity and opposition		2		1		2
Trade barriers/International competition		2			2	2
Environment issues (incl. climate change)		2				
Human capacity	2					
Technical support			2			

intraregional and international), the cultivation of aquatic plants, the concept of nucleus farms with small-scale satellite farms, networking national institutions, and national broodstock management programmes.

Unexplored opportunities with potentially very large impacts in Asia are: genetically improved species, appropriate environmental management, cooperative fish farming and improvement of product quality in order to meet international standards. This latter focus on product quality coincides with the two policies that experts think are most practical and would have a "very large positive impact" if implemented: improving market access and ensuring that food safety standards are met.

Latin American experts considered that the region has adequate spatial, geographical and water resources available. Regional integration remains an unexplored opportunity.

TABLE 6
Major opportunities for aquacultural development (according to regional experts), where 1= “very important”

OPPORTUNITIES	Africa	Asia and the Pacific	Latin America	North America	Eastern Europe	Western Europe
Improved/new species		1	1	1	1	
Technological innovations			1	1		1
Profit-driven aquaculture	1					
Promoting quality products		1				
Environmental management		1				
Capacity building			1			
Legislative framework			1			
Incentives for fish feed					1	

Policies that would make “a very large” contribution emphasize capacity building and education, as well as providing a suitable legislative framework. Recommended policies include training of government and private personnel and education of the general public about the potential of aquaculture.

Unexplored opportunities that would have a “very large positive” impact on aquaculture development in North America are expanded land-based aquaculture, diversification into new species, and value-added processing. This coincides with factors that experts think will have a predominant role in the next fifteen years: technology and markets. Experts ranked multitrophic aquaculture, offshore aquaculture, and diversification into new species as projects that would have a very large positive impact. Other factors included improving access to financing, simplification of regulations, and giving aquaculture a more prominent role within government bureaucracies.

In Eastern Europe, unexplored opportunities include introduction of new species and incentives to produce fish feed. Practical means that would have a very large positive impact include extensive and semi-intensive freshwater aquaculture in reservoirs and pond fish breeding using specialized technologies. In Western Europe, new technologies aimed at diminishing impacts on the environment and increasing efficiency are considered to be an unexplored means of influencing aquaculture development. Two strategies that would have a very large positive impact are identification and allocation of marine sites and generous economic incentives.

Table 6 summarizes the major opportunities for aquacultural development by region.

4. Common constraints and strategies

4.1 LACK OF (GOOD) POLICIES

In some regions experts thought that policies had been appropriate. Government policies in Asia and the Pacific were credited for the past development of aquaculture. Policies were thought to have had a “large positive” impact. A clear commitment to aquaculture by policy-makers, in addition to inconsistent environmental regulations, fueled growth of the industry. This support is poised to become “much more important than before”. Loose environmental controls were no longer considered an asset. Environmental management of aquaculture will have a “very large positive” impact in the future.

In Latin America, past successes were due in part to contributions from the public sector, which had had a “large positive impact”. The public sector contribution is expected to become even more important in the future. This is also connected with concerns in the region over the absence of legislative frameworks and of environmentally-friendly aquaculture practices.

Unsuitable policies were considered to be one of the most important explanations for the slow development of aquaculture in the past, particularly in Africa. If no changes are made, the impact of these policies will likely be “even more negative” in the future. Experts thought the problem was a complete absence of policies, or wrongly focused policies. The major concern was the past disregard for commercial, business-oriented aquaculture. Legislation was unfriendly to business investment, property rights were unclear and donors were too focused on small-scale subsistence aquaculture. Mitigating strategies were aimed at re-orienting aquaculture towards the private sector and its profit orientation. This would require good governance and education of public sector officials and Non-governmental organizations (NGOs). Nucleus farms, foreign investment, fiscal incentives, pilot commercial farms to act as demonstration farms, were among the suggestions.

While Latin American experts considered that the public sector had historically played a valuable role in the region’s aquaculture development, they were concerned that the lack of institutional support would jeopardize aquaculture expansion in the future. Environmental pressures would also negatively hurt aquaculture. For this reason the experts considered that one factor that would make a “very large” positive contribution in the future would be for policy makers to adopt a pro-active commitment to aquaculture with concomitant procedures. This would include laws, regulations and codes of conduct.

Experts in North America and Western Europe had somewhat similar views about the role of the public sector. In general they considered that the public sector had played a valuable role in the past. In both regions this beneficial impact was illustrated by government support for research, particularly private/public research partnerships. Experts also expected this role to become “more important” in the future as a determinant in the success of aquaculture. In both regions experts expressed concerns that future development could be jeopardized by overadministration. In North America, overregulation threatened new technologies such as offshore cage culture or multitrophic aquaculture. Politicians and policy-makers might tighten regulations in response to vocal critics of aquaculture. In Western Europe there were more concerns

on bureaucratic impediments to aquaculture. Thus “large positive effects” would result from simplification of bureaucratic procedures in obtaining licenses, improving administrative structures and making aquaculture administration more flexible.

Experts in Eastern Europe expressed no opinion about past policies, but there were concerns about future pollution problems (as in Latin America) and the lack of environmental controls. Integrated coastal management was suggested for both Asia and Eastern Europe as a solution to conflicts over coastal resources.

4.2 FINANCING

With the exception of Europe, access to financing for aquaculture investment was considered a constraint in all regions. In Africa, Asia and Latin America, unavailability and difficult access to capital was expected to deter investment in the sector even more negatively in the future. Difficulty accessing capital in North America was identified as a very negative constraint in the past, being likely to continue for the next fifteen years.

Experts in Western Europe reported relatively few problems with financing. In fact, financing (both private and public) was ranked as one of only two factors that had had a very large positive impact in the past. However, experts were less optimistic about the future. Lack of capital was identified as one of several factors that might have a negative impact on aquaculture development over the next fifteen years.

Suggested mitigating strategies in the regions can be classified into a few categories: means of increasing capital directly, means of increasing access to bank credit, and means of reducing risk. To increase availability of capital, suggestions ranged from microcredit schemes, nucleus farming, attracting foreign investment and large scale farms (which would have their own sources of capital) and direct funding by public agencies. Experts in Asia and Latin America suggested that international agencies could assist with financing. They also thought that national development banks could provide soft loans to rural farmers who often have no collateral. This suggestion of regional and national government financial support for farmers without collateral was shared by experts in North America. Aquaculture associations were also viewed as a possible source of financing, particularly for rural farmers.

To increase access to bank credits, the most common suggestions were to improve financial capacity of farmers and to educate bankers about aquaculture. Assistance with business plans was suggested by experts in Africa and Asia. The development of sound business planning could be done in conjunction with bankers. Providing information about aquaculture to banks was seen as a means of educating bankers about different risks associated with the sector. Tours of successful ventures could be organized, and information disseminated about aquaculture expansion elsewhere.

Linked to the need to access bank credit was the need to minimize risks. Farmers need to be informed about risks that might fuel the skepticism of bankers towards aquaculture. Similarly, providing easier access to insurance should also encourage bankers to lend. Another suggestion was to increase the length of aquaculture leases as a means of reassuring bankers about the secure nature of the enterprise.

4.3 FEED CONSTRAINTS AND POLICIES

In three regions, experts stated that feed had been a constraint in the past or would be in the future. In Africa, limited availability and access to good quality and relatively cheap feed had negatively affected aquaculture development in the region. This constraint was expected to have an even more negative impact in the future, unless there were mitigating strategies. In Asia, the lack of domestic feed industries was considered to have handicapped aquaculture in the past, but the major concerns were focused on future supplies. The unavailability of high quality formulated feed and the failure to

protect trash fish would have a “very negative impact” on the industry over the next fifteen years. However, experts thought that protection of trash fish was very unlikely in the future. In Eastern Europe, the principal concern was the high cost of feed rather than its availability. The rising price of feed ingredients had had a “very large negative” impact in the past; encouraging a domestic feed industry would make a “very positive” contribution to future growth in the region.

Suggestions on how to promote a feed industry were similar in all three regions. The overall goal was to create a more supportive environment for a feed industry, which might require incentives (although there was no consensus on this in Asia), joint ventures, and diversification into fish feed by animal feed enterprises. Using local ingredients where cost effective and importing fish meal (if necessary) were policies suggested. To obtain economies of scale, village-scale feed-mill factories – encouraging large-scale farmers to produce fish feed – and cooperatives might be practical. A proactive public policy initiative would be for authorities to investigate the reasons for the lack of feed mills, conduct feasibility studies and then call for external assistance with an appropriate package aid.

4.4 SEED CONSTRAINTS AND POLICIES

The availability and quality of seed has also been a constraint in Africa but not so much in other regions, according to the experts. In Asia, however, future access to seed is expected to become more important. As in Europe and North America, this is partly linked to the need for breeding programmes of new commercial species.

Mitigating strategies for seed production include promoting private hatcheries through incentives, facilitating research in fish breeding and better training. Economic models of successful hatcheries could also be developed as a way of encouraging investment. To inform growers about seed availability, dissemination of information (perhaps by Internet) was also proposed.

4.5 PERCEPTIONS OF AND OPPOSITION TO AQUACULTURE

In all regions, except Africa and Eastern Europe, opposition to aquaculture was considered to be a threat to future development. In some regions, opposition was thought to be caused by misinformation; in other regions, opposition has been triggered by certain attributes of aquaculture. Mitigating strategies were recommended according to the perceived cause.

In Asia, public mistrust promoted by sensationalist media was seen as having a very likely, large negative effect over the next fifteen years. A similar perception, promoted by certain NGOs, was reported by experts in the Americas and Western Europe.

To counter these negative perceptions, mitigating strategies would include: improving communication with the public through proactive media campaigns, ensuring that sound information is available and publicizing the positive aspects of aquaculture on employment and economic development. Aquaculture’s role in reducing pressure on overfished capture fisheries should also be publicized. On the other hand, the industry needs to become open and transparent, and governments must address issues such as fish health and pollution.

To counter opposition produced by conflicts over limited coastal resources (a major concern in Asia, North America and Western Europe), the experts suggested the establishment of mariculture parks, zoning, and integrated coastal management. The public should be informed of the advantages of aquaculture by way of credible cost-benefit studies. In this respect, planners should weigh negative externalities incurred by coastal residents against positive externalities provided by aquaculture. Siting decisions should not be determined on the grounds of historical precedence or be unduly influenced by lobbyist activity.

4.6 TECHNOLOGY

Technological advances were considered a key to overcome constraints in most regions. Experts thought that there had been too much emphasis on tilapia aquaculture and on cage culture in Africa; more focus should be placed on the marine environment in the future. In Asia and the Pacific, North America and Western Europe, technological advances (from engineering to breeding to processing) had played a large role in the past and would become even more important in the future. Two constraints that might be overcome by technology were the scarcity of commercial species and shortages of coastal space. Improved breeding and the development of indigenous species were advocated in Asia and Latin America to counter the first problem. Offshore aquaculture was seen in all regions as a potential solution to coastal space constraints, although no consensus on its true potential was achieved in North America. Experts in Mexico expressed concerns on its feasibility whereas other experts in the region considered that offshore culture provided a response to spatial constraints and to the aesthetic concerns from coastal residents.

4.7 SUMMARY

Corrective measures and strategies suggested by experts to reverse the impact of the most important constraints facing aquaculture development across regions are summarized in Table 7.

TABLE 7

Summary of corrective measures suggested by the experts, where 1= "very important"

Corrective measures		Africa	Asia and the Pacific	Latin America	North America	Eastern Europe	Western Europe
Legislation	Aquaculture to be given higher profile		1	1			
	Ensure strong advocacy alliances amongst stakeholders/aquaculture lobby	1	1				
	Prepare (proactive) aquaculture legislations			1		1	
	Improve institutional frameworks/adequate administrative procedures			1		1	
Capital	International agencies to provide support/loans		1	1			
	Convince governments/financial institutions on the profitability of aquaculture projects	1	1				
	Educate bank loan officers on aquaculture potential and risks	1	1				
	Assist producers to elaborate good business plans	1	1		1		
	If business plans are solid, provide government loan guarantees	1	1				
	Promote producers cooperative	1	1		1		
	Mobilize funds locally	1	1	1			
	Develop microfinance institutions and/or schemes specific for aquaculture	1		1			
	Improve public image for lenders	1			1		
Capacity	Provide thematic training for existing personnel	1				1	
	Workshops/annual training seminars for extension workers	1				1	
	Provide information (user friendly form/magazines in native languages)	1				1	
Seed	Broodstock improvement	1				1	
Extension services	Improved training for extension workers	1		1			
Feed	Provide more support to R&D activities for aquaculture feed development	1	1	1			1

	Corrective measures	Africa	Asia and the Pacific	Latin America	North America	Eastern Europe	Western Europe
Market	Promote herbivorous species		1	1			
	Explore/expand markets	1	1				
	Promote quality of aquaculture products	1	1				
	Promotion of aquaculture products (media, fairs, etc.)	1	1				
	Advertisements and public campaigns in favour of aquaculture products	1	1			1	
Access to and use of water and sites	Establish and prioritize zoning		1		1		
	Atlas/updates on availability of fish farming sites				1	1	
	Clear land law and policy (with access rights defined)	1	1			1	
	Establish more cooperation amongst stakeholders (especially concerned authorities)	1	1				
Negative publicity and opposition	Positive media campaigns/make sure dialogue occurs		1		1		1
	Farmers and industry associations to improve image and credibility of the industry by promoting science-based debates, reports for media on benefits of aquaculture, etc.		1		1		
	Better communication with media (positive aspects/scientific results)		1		1		
	Strengthen aquaculture sector advocacy (including talks at universities, chambers of commerce, nutrition forums, etc.)						
Environmental policies and management	Develop proper regulations to support sustainable aquaculture/keep sites viable			1	1		
	Coastal zone management and consultation to alleviate competition over the use of coastal resources				1		1
	Regulations and sanctions on farms to reduce environmental impact			1			1
	Clear environmental protection policies					1	1
	Develop/improve management tools		1				1
	Effective monitoring		1		1		1
Disease outbreaks	Effective and safe disease prevention, diagnosis, control and treatment measures		1	1			
	Adopt codes of conducts and best management practices		1	1			
	Regulations on imports into and transfers within country		1	1			1
	Quarantine systems (for import)	1		1			
	Provide training in disease management		1	1			
Environmental issues (including climate change)	Develop management tools/best practices		1				1
	Raise awareness (amongst technicians, for instance)		1				1
	Build capacity/have officers specialized in environmental control		1			1	
Cost and price fluctuation	Genetic improvement		1			1	

5. Results by regions

5.1 AFRICA

5.1.1 Development objectives

All experts believed that aquaculture should be encouraged in Africa in order to improve livelihoods through increased incomes, employment and well being (or reduced poverty) and also to improve nutrition and food security. These two objectives were given a “very important” rating. Two other objectives were ranked as “important”: aquaculture’s ability to generate foreign exchange and growth, and its potential to improve sustainability of resources. Finally, the goal of developing rural areas was given “moderate” importance.

5.1.2 Challenges

In order to identify challenges, experts were asked to indicate which constraints had handicapped the development of aquaculture in the region. After these were collated, a second round of the Delphi survey asked the experts to rate the constraints according to whether they were likely to worsen. The aim of this exercise was to assess the perceived severity of constraints, and therefore their priority. If any given constraint is likely to worsen, then that would make it a higher priority for action compared to constraints that are expected to ease in the years ahead.

Constraints were classified in three distinct categories: 1) constraints which had negatively affected aquaculture development and were expected to worsen if no corrective action were taken; 2) constraints which had negatively affected aquaculture but were not expected to worsen; and 3) factors that have not affected the sector thus far, but could slow development in the future. Later rounds of the survey asked the experts for their strategies to contain and lessen these constraints.

5.1.3 Challenges expected to further slow down development of aquaculture

The single most important factor which had negatively affected aquaculture development and was expected to impede further progress was an absence of *appropriate policies for aquaculture development*. This was sometimes viewed as a complete lack of policies or the existence of wrongly focused national policies. Experts mentioned specifically the lack of clear property rights (including land rights for women) in some countries. However, a more general concern was the absence of policies promoting commercial (business-oriented) aquaculture. This was expressed as:

- legislation that is unfriendly to the private sector, overlooking profit in promoting aquaculture;
- predominance of government- or donor-driven investments as opposed to private, commercially-oriented ventures;
- overemphasis (driven in particular by the international community) on small-scale subsistence aquaculture;
- neglect of larger, private sector investments; and
- overemphasis on aquaculture as a means of rural livelihood when first introduced in the region. According to the experts, these wrongly-focused policies had negatively affected aquaculture development in Africa and are likely to become more acute unless appropriate action is taken to reverse them.

TABLE 8
Absence of appropriate policies in Africa and suggested mitigating strategies

Constraint	Possible mitigating strategy	Contribution	Likelihood
Overlooking profit (or lack of policies) for aquaculture development	Focus on policies favouring commercial aquaculture	Very strong	Almost certain
	Free up the private sector to spur aquaculture development	Very strong	Almost certain
	Profitability is needed if farmers are to remain in aquaculture. Donors, NGOs and governments to promote aquaculture as a business rather than as a social activity; teaching farmers to be rational weighing returns against risks before making the decision to venture into aquaculture.	Very strong	Almost certain
	Recognize that aquaculture is risky and provide good governance	Strong	Almost certain
	Involve all key stakeholders in the elaboration of aquaculture policy and strategic frameworks		
	Train and expose policymakers, technocrats and farmers in aquaculture policy advocacy and making		
	Identify/formalize national aquaculture policy frameworks		
	Governments and donors (including NGOs) to develop economic models for standard aquaculture projects, focus on risks or obstacles to business		
Overfocus on small-scale subsistence aquaculture	Package and disseminate information on realistic investments in profitable aquaculture		
	Encourage aquaculture as a business including small-scale operations. It should be noted that small-scale aquaculture can only work if there are seed, feed, processing, and extension service facilities in a country. This role can also be assumed by an industrial farm that integrate small-scale producers as satellite farms	Very strong	Almost certain
	Donors (including NGOs) and governments to understand that aquaculture as a social activity seldom works, encourage them to think of long-term sustainability, which would include profitability, and encourage them to promote aquaculture as a business	Very strong	Almost certain
	Governments to insist that donors (including NGOs) prepare and present to farmers business/market plans with realistic assumptions of the aquaculture systems they promote before encouraging them into the activity		
	Pilot commercial farms through projects could be encouraged		
	Public sector should elaborate policies and a strategies aimed at profitable and commercial aquaculture		
	Sensitize potential investors on the profitability of commercial aquaculture and provide credit schemes so small-scale farmers can intensify production		
	Encourage NGOs to have a business/pragmatic approach to aquaculture		
	Explain the advantages and disadvantages of entrepreneurial investment in particular externalities (demonstration effects)		
	Illustrate how some countries have developed aquaculture from <i>non-subsistence</i> aquaculture (examples coming from South Africa or Madagascar or other continents).		
	Encourage governments and donors (including NGOs) to prepare business/market plans for hypothetical farms, and compare risks and returns from other crops		
	Disseminate information on the potential of aquaculture in the region with clear guidance on the most appropriate areas and aquaculture practices		
	In promoting aquaculture, concentrate on farmers with education and ambition		
	Provide tax relief for commercial operations		

Constraint	Possible mitigating strategy	Contribution	Likelihood
Neglect of larger private sector investments	Encourage mother-infant operations as with some agricultural products in Zambia Provide incentives to private investors Raise policy-makers and donors' awareness of the benefits of size in farming (large-scale farms) in absorbing risks and providing technological expertise and markets to small-scale farmers, as well as stimulating the fish feed industry Have a strong, commercial aquaculture group that can lobby effectively in favour of large investments For aquaculture sustainability, access to natural resources should be open to a large spectrum of the society. It is also important to maximize the social benefits from the use of these resources rather than economic profits for the few (larger private investments). Thus, larger private investments should be considered as a means of empowering semi industrial/medium-scale and small-scale farmers.	Very strong	
Slow recognition of inputs required as stand-alone industries	Organize study tours in the region where there are seed and feed enterprises Encourage experimentation in feed by larger companies Encourage broiler feed firms to enter aquaculture feed industry (diversify)		

Table 8 summarizes this “lack of suitable policies” and mitigating strategies suggested by the experts. The group of experts was asked whether mitigating strategies would make a “very strong”, “strong”, or “possible” contribution. They were also asked their opinion on the likelihood of these changes occurring over the next fifteen years: whether changes were “almost certain to happen”, “likely to happen”, had “a 50 percent probability of happening”, or had a “very low probability of happening”. Responses are shown on the two right columns in Table 8. Many mitigating strategies were not ranked by the experts (corresponding cells in Table 8 have been left blank).

Challenges related to factor inputs and expected to further slow down aquaculture development

Other factors that have negatively affected aquaculture development and are expected to continue affecting the sector *more negatively* than in the past are constraints that are specific to factors of production. Experts were asked again for practical suggestions on how to ease these constraints. Responses are listed in Appendix 1.

One identified constraint is the unavailability of, and difficult access to, *capital*. Financial resources for investment in aquaculture have been very limited in most sub-Saharan Africa, including interested commercial-level aquaculture producers. The situation has been exacerbated by the deficiency of adequate credit facilities and the reluctance of financial institutions to support aquaculture as a commercial enterprise (difficult access to loans). The lack of credibility of the industry – perceived as bearing a high risk of failure due to earlier failures of aquaculture projects – remains a major constraint in convincing farmers and investors of the economic viability of aquaculture, deters bankers from lending and limits access to credit. Mitigating strategies are suggested in Appendix 1.1.

A second factor likely to constraint development even further was the *poor technical capacity* in both government and private institutions. According to the experts, aquaculture development has been hampered and is likely to continue being hampered by the shortage of human capacity and poor technical expertise at both the administration and farm levels. Poor understanding (technical expertise) of aquaculture by key technical staff in governmental fisheries departments is especially apparent in their lack of capacity to establish visionary policies and the deficiency of entrepreneurial skills which are much needed in aquaculture development. In this regard, experts especially underlined the chronic shortage of expertise in developing aquaculture business plans and the insufficient technical and intellectual support which affects extension advice. Mitigating strategies are suggested in Appendix 1.2.

Feed and seed were also identified as existing constraints. The limited availability and access to reliable good quality and cost-effective fish feed and the virtual absence of a supporting industry have affected and will continue to affect regional aquaculture growth. Aquaculture development in Africa has also been slowed down by limited access to reliable, good quality and cost-effective fish seed. These constraints are likely to continue affecting the sector in the future. Mitigating strategies are suggested in Appendices 1.3 and 1.4.

Technological limitations also constrain aquaculture development. For example, limiting farming to pond culture of a few fish species, primarily tilapia, has contributed to the slow development of the sector in the region. Mitigating strategies are suggested in Appendix 1.5.

Poor extension services and inadequate research are additional constraints. Issues include weak government-supported extension services, inadequate extension systems, poor research-farmer linkages, and limited research information from which investors and other interested parties can learn. Mitigating strategies are suggested in Appendix 1.6.

Other identified constraints were poor basic infrastructure such as roads and electricity, and poor aquaculture-specific infrastructure such as water distribution systems. Some additional factors included limited physical resources (water and land) in some countries, poor and deteriorating national economies in most countries in general and the agriculture sector in particular, HIV/AIDS and climate change. All these factors have negatively affected aquaculture development and are expected to continue affecting the sector even more negatively than they did in the past. Mitigating strategies are suggested in Appendix 1.7.

Challenges that are expected to persist

Experts considered two factors which have negatively affected aquaculture development and would continue to do so. The first constraint was related to the *market* and included the absence of a reliable market for aquaculture products, deficient infrastructures limiting access to markets (roads), the cost and difficulty in meeting quality standards (e.g. Hazard Analysis and Critical Control Points [HACCP]), the low purchasing power of the local population, competition from capture fisheries, and consumer preferences for marine wild-caught fish or for meat. These factors have adversely affected aquaculture development in Africa. However, low prices of locally-captured fish from natural freshwaters and the large supplies of cheap marine wild-caught fish that once hindered aquaculture development are not seen as a problem in the upcoming 15 years.

With respect to marketing, and particularly international marketing, the following strategies were suggested by experts: governmental support for producer-led fish marketing; support for the establishment of strong and legally recognized national fish farmers organizations which can be internationally linked to others; promotion of intra-regional trade to obviate HACCP standards and transport costs; increased access to price information; and providing assistance to farmers to synchronize fish production in order to guarantee regular supply (see Appendix 1.8).

The second factor was *poor governance*. Weak governments, weak local farmers' and development institutions, the lack of interagency coordination, the existence of civil conflicts in many countries, corruption and ideological aversion to free markets by some government officials were included in this category. Mitigating strategies are suggested in Appendix 1.9.

Challenges that have not yet materialized but could occur in the future

The factors discussed in this section were identified by experts as not yet having affected aquaculture development in their region, but as being likely to do so in the

future unless appropriate preventive steps are taken. Some of these factors will have more negative impact than others on the sector.

The migration of trained staff (i.e. aquaculture-trained staff leaving the sector for opportunities in other areas of the economy), funding of government hatcheries (this issue generated substantial disagreement amongst experts) and inappropriate technical information packages would have a very large negative impact on aquaculture development in the future if they were to occur. The lack of political will and the lack of awareness on the economic importance of aquaculture at the decision-maker levels would have a moderate negative effect on the development of the sector (Appendix 1.10).

However, experts believe that these two last factors (lack of political will and continued funding of government hatcheries) have low chances of occurring. Policy makers are increasingly supportive of aquaculture development in many countries and financial austerity forces most decision makers to define priorities when allocating resources, which limits government spending on publicly owned hatcheries. In contrast, migration of trained staff from aquaculture was identified as having a high probability of occurrence in the future. Inappropriate technical information packages and the lack of awareness on the economic importance of aquaculture were estimated to have a 50 percent probability of occurrence.

5.1.3 Opportunities

In addition to strategies aimed at mitigating the effects of negative factors, experts were asked to suggest policies which would have a “very high” positive impact on aquaculture development in Africa over the next 15 years (if they were implemented). For brevity purposes, the list below excludes mitigation policies that were previously suggested when discussing constraining factors.

Suggestions included:

- establish a single lead agency for the sector;
- encourage formation of national, subregional, regional and international networks for information exchange and training;
- strengthen technical and organizational (fish farmers associations, groups, cooperatives) capacity of fish farmers;
- strengthen producers’ understanding of aquaculture socio-economic aspects (business plan, record keeping, etc.) and assist them with business plans for aquaculture;
- shift technical education away from the training of government extension agents to the training of fish farm managers;
- provide public sector support to private entrepreneurs in setting up the technological infrastructure required for aquaculture (hatcheries, feed mills, cold chains, etc.);
- sell or lease public infrastructure used for seeds and feed production to private producers; and
- provide high-quality technical expertise (from aquaculture managers, not researchers or development experts), probably from outside the region initially, to work with medium-scale investors (US\$20 000–30 000 start-up costs) to overcome basic marketing and technical problems. Trainees could be employed as farm managers.

Other suggested opportunities were:

- to develop a “one-stop-shop” for assistance to interested investors;
- to support the development of a fish marketing infrastructure, especially intraregional markets;
- to assist feed formulation based on locally available ingredients if fishmeal is too expensive or unavailable; and

- to facilitate the installation of private hatchery operators and support their activities.

5.1.4 Unexplored opportunities

Experts found that, if explored in detail, the following opportunities could have a “very large positive” impact on the development of aquaculture:

- the expansion of cage culture on a commercial basis;
- the establishment of complexes of nucleus and small-scale farms;
- the development of coastal aquaculture (including aquatic plants);
- the creation of national broodstock management programmes;
- the formation of links and synergies amongst national institutions to focus aquaculture growth; and
- the inspection of more suitable aquaculture lands and waters such as wetlands and rivers.

5.2 ASIA AND THE PACIFIC

5.2.1 Development objectives

Experts of the Asia-Pacific region were initially asked for the factors which had contributed to the success of aquaculture in the region and whether these factors would become more important or less important in the future. They were also asked for factors which had negatively affected aquaculture in the region and, in later rounds, for mitigating strategies.

To assist policy-makers in Asia and the Pacific, experts were asked for their ideas on unexplored opportunities, and also effective and practical means that would help develop aquaculture over the next fifteen years. Later, these were ranked by all experts according to whether they would have a “very large positive” effect or a “large positive” effect. This ranking could help policy-makers prioritize their strategies.

As in other regions, all experts believed that aquaculture should be encouraged in Asia and the Pacific. The most important reason for developing aquaculture was its role as a source of food. Reasons that were “important” rather than “very important” were aquaculture’s role as a source of income, employment and foreign exchange, and its ability to enhance the sustainability of fisheries.

5.2.2 Factors generating positive impacts and related challenges

When asked which factors had contributed to the past success of aquaculture in Asia and the Pacific, the “very large positive factors” were of economic and environmental nature. The economic explanation for past successes was mostly related to the increased market demand for fish, whether domestic or international. Over the next fifteen years, market demand is expected to be even “more important than before”. Experts anticipate that accessibility to international markets and aquaculture’s ability to produce fish that cannot be provided by capture fisheries will be particularly important. The emphasis on substituting aquaculture for capture fisheries is linked with concerns over possibly stagnating, even declining, catches from fisheries. Also “more important than before” were the economic benefits of aquaculture and its employment potential.

In addition to economic factors, environmental conditions such as the suitability of culture environments, the availability of species and the stagnating supply of fish from the wild fisheries sector had had a “very large positive impact” on aquaculture growth in the region. There was some divergence among experts about the adequacy and suitability of natural resources in the region. Weak environmental controls were considered to have had a large positive effect during the initial development of aquaculture, but experts rated these as no longer relevant in the future.

Factors which had a “large” rather than a “very large” past impact were technology and its dissemination, financial and technical support from international agencies and governments, and adequate infrastructure. Of particular importance was also the priority given by governments, as demonstrated by plans and policies, to aquaculture. According to the experts, one of the obstacles to aquaculture development in the past was the subordination of aquaculture to agriculture and capture fisheries, indicating a low profile for the activity. A clear commitment towards aquaculture is the only factor cited that is expected to become “much more important than before” over the next fifteen years. Experts therefore consider that the priority governments place on aquaculture will be critical in determining its future development in the region.

5.2.3 Factors generating negative impacts and related challenges

Experts were asked to cite factors which they think had slowed development of aquaculture in Asia and the Pacific and whose negative impacts are expected to become *more important* in the future. Such factors are of large concern to policy-makers. In the second round, experts were asked to identify practical means to lessen or contain the negative impact of these factors. Factors and mitigation strategies are summarized in Appendix 2.

Negative factors include trade barriers, environmental destruction, difficult access to land and water resources combined with overexploitation of coastal resources, poor farmer training, genetic degradation, sensationalist media, bio-security risks, poorly planned aquaculture enterprises, lack of financial resources, and lack of domestic feed industries. Specific suggestions on how to mitigate these problems are given in Appendix 2.1. Experts highlighted two factors as potentially having a “very large negative impact” on aquaculture development in Asia and the Pacific: lack of feed (whether formulated or trash fish) and conflicts over resource use. The latter was estimated to be “very likely to happen” over the next fifteen years.

5.2.4 Opportunities

Experts were asked for their ideas on opportunities for aquaculture development in Asia and the Pacific. Some of these strategies were already being implemented whereas others were unexplored. Experts were asked to rank opportunities according to whether they would have a “very large” or “large” positive impact. The goal was to advise policy-makers in the region on which strategies experts consider should be regarded as priorities.

Four opportunities (whether already being implemented or unexplored) that would have a “very large positive impact” are: raising quality standards, appropriate environmental management, genetic improvement of fish and promoting cooperative fish farming. The latter was intended to improve the livelihoods of small-scale local farmers. Raising quality standards was linked to concerns over continued access to markets. Experts considered that market demand had contributed to past success in the region, and would become “more important” over the next fifteen years.

In addition to the opportunities likely to generate a very large positive impact, a long list of opportunities could potentially yield a “large positive impact”. These can be subsumed into a few categories. For improved environmental management, experts suggested that there should be clear planning guidelines for new sites, more use of portable recirculating systems and the introduction of incentives as an alternative to regulatory instruments. Economic-oriented policies that would have a strong positive impact include exploring the potential for exports of freshwater species, increasing value added, and developing intraregional trade. Other important opportunities involve providing additional incentives to investors, including exemption from income and other taxes for ten years, and providing more information to the public about aquaculture.

Technical opportunities that would have a strong impact are: near-shore and offshore aquaculture, marine culture, including molluscs and seaweed, introducing pen/cage culture in a profit-sharing agreement with local communities, coral reefs, development of new species, integrated aquaculture, raceway aquaculture using irrigated water, and improving technical extension services.

Cooperation was seen as another venue for opportunities. In general, experts emphasized that cooperation would generate a “very large positive impact”. This includes partnerships between government agencies, local governments and industries, and a collaborative rather than competitive approach between regions. This was reinforced by another suggestion that there should be pilot projects and networks to encourage regional collaboration.

A final general category of opportunities is subsumed under “improving policies”. These include: developing integrated aquaculture development plans, improving the efficient allocation of budgets, ensuring that local communities benefit from aquaculture, and supporting land-lease programmes involving technical assistance, pond design, training and feed and seed supply.

5.3 LATIN AMERICA

5.3.1 Development objectives

Experts in Latin America were also asked initially for the factors that had contributed to the success of aquaculture in the region and whether these factors would become more or less important in the future. They were also asked for factors that negatively affected aquaculture in the region; in later rounds, they were also asked for mitigating strategies.

To assist policy-makers in Latin America, experts were asked for their ideas on unexplored opportunities in addition to effective and practical means that would help develop aquaculture over the next fifteen years. Suggestions were then ranked by all experts according to whether they would have a “very large positive” effect or a “large positive” effect. This ranking could assist policy-makers in defining priorities for strategy implementation.

All experts believed that aquaculture should be encouraged in Latin America. The most important reason cited was aquaculture’s contribution to economic development. Reasons that were “important” rather than “very important” were aquaculture’s contribution to employment generation and to diversification of economic activities. Its role as a source of protein was judged as only “moderately” important.

5.3.2 Factors generating positive impacts and related challenges

When asked which factors had contributed to the past success of aquaculture in the region, the “very large positive factors” were of economic and technological nature. As in Asia, the increased market demand for fish, whether domestic or international, had a very large economic impact on past successes. Demand provided immediate market opportunities. The private sector capacity (also ranked “very important”) ensured that entrepreneurs availed themselves of these opportunities. It is interesting to note that the private sector capacity is expected to become less important over the next fifteen years; experts considered that the private sector is now well established and ahead of governments and regulations. Combined with the increased price of fish was a decline in the price of agricultural alternatives for farmers (rice and sugar), which induced a movement into fish farming. The decline of agricultural prices is expected to become even more important in the future.

Declining production from the marine capture fisheries is also expected to be “much more important” than before, which will reinforce the relative attractiveness of aquaculture. Thus, experts consider that the historic success of aquaculture in Latin America has been due to both “pull” and “push” forces. High fish prices

have increased the profitability of aquaculture while low agricultural prices have discouraged investment in agriculture. Experts also anticipate that these same forces will become even more important over the next fifteen years, further inducing aquaculture expansion in Latin America. Fish prices, and therefore the incentive to farm fish, are expected to increase while at the same time price declines of traditional crops are expected to accelerate. Market conditions are likely to be even more important than in the past.

As a technological factor, new farming techniques had *a very large* positive impact in the past. Somewhat less important were low production costs, production efficiency and better management of diseases, nutrition, genetics, biotechnology and environmental issues, which were thought to have had *a large* impact (although not a very large impact). Experts thought these technological factors would become more important over the next fifteen years.

Notably, the contribution of the public sector was expected to become increasingly important. Experts in both Africa and Asia did not mention this factor. Hence a second round of questions asked the experts to clarify and suggest policies for the public sector.

Suggestions on improving capacity of the public sector and enhancing public policy were ranked by the experts in order of importance. The most important strategy was to establish and enforce adequate administrative procedures to facilitate orderly expansion. The second most important policy cited was the need to increase training for public sector employees. Other public sector improvements would involve ensuring that it is proactive and adaptable, encouraging public-private partnerships (implicating municipal and local governments), and increasing awareness of the public sector's capabilities and limitations (Appendix 3.1). When asked which public policies could affect aquaculture negatively, lack of legislation and codes of practice were ranked as major impediments. Lack of technical support was also ranked as having a "very large" negative contribution to aquaculture development.

5.3.3 Factors generating negative impacts and related challenges

Experts were asked to cite and rank factors that might slow development of aquaculture in Latin America over the next fifteen years. Factors that would have a very large negative impact are:

- lack of technical support;
- lack of financing for aquaculture;
- lack of technologies to farm endogenous species; and
- occurrence of natural disasters such as hurricanes. Lack of technical support and lack of financing for aquaculture were judged "likely to happen", which should seriously concern policy-makers.

Factors with a detrimental effect on aquaculture development but not as severe as the ones mentioned above are:

- lack of administrative procedures and legislation;
- environmental concerns;
- macroeconomic problems;
- lobbying by NGOs;
- spread of diseases;
- civil unrest; and
- decreased availability of fish feed.

The first three factors were judged "almost certain to happen". Lobbying by NGOs and decreased availability of fish feed were considered "likely to happen", while spread of diseases and developing technology to farm endogenous species had "a 50 percent probability of happening". Again these are potential priorities for aquaculture policy-makers, particularly the first two (administrative procedures and environmental

measures). As mentioned above, establishing procedures for the orderly (sustainable) expansion of aquaculture was considered the top priority for public policy.

In the second round, experts were asked to identify practical means to lessen or contain the negative impact of these factors. These are summarized in Appendix 3.2.

5.3.4 Opportunities

Experts were asked for their ideas on explored and unexplored opportunities for aquaculture development in Latin America. Experts were very optimistic in general. Comments were made on the excellent locations and available water resources, on the good climatic conditions, on the existence of surplus labour, and on regional integration. They also saw “very large positive” impacts from the culture of tilapia. Government policies focused on providing proactive procedural and legislative frameworks and on education would make a very large contribution to development. The emphasis on administrative and procedural arrangements is consistent with their top policy priority, which was to implement appropriate legislation and regulations. Education was defined in the broadest terms: from training in the private and public sectors to educating the general public on the potential of aquaculture.

Opportunities that would have “large” (as opposed to “very large”) positive impacts include:

- farming native species (particularly marine and new species) and ornamental fish;
- improved investment incentives such as preferential interest rates, making farming technology more accessible;
- diminishing the level of uncertainty for new entrepreneurs through demonstration projects and technical assistance; and
- community aquaculture.

5.4 NORTH AMERICA

5.4.1 Development objectives

As done previously with Asia and Latin America, experts in North America were initially asked for the factors that had contributed to the success of aquaculture in the region and whether these factors would become more or less important in the future. They were also asked for factors that had affected aquaculture negatively in the region and, in later rounds, for mitigating strategies.

To assist policy-makers in North America, experts were asked for their ideas on unexplored opportunities and effective and practical means that would help develop aquaculture over the next fifteen years. Subsequently, opportunities were ranked according to whether they would have a “very large positive” effect or a “large positive” effect. This ranking could help policy-makers prioritize their strategies.

All experts believed that aquaculture should be encouraged in North America. There were two reasons considered “very important”: increasing food supply and improved sustainability. Aquaculture’s potential contributions to sustainability were of varied nature: re-establishing Canada as a world leader in sustainable aquaculture, reducing the depletion of wild stocks, making productive use of arid land or abandoned quarries, and employing native species. Reasons that were “important” as opposed to “very important” were aquaculture’s contribution to employment generation and to economic development. Its contribution to maintaining traditional ways of life (e.g. preservation of a maritime culture and economic support to isolated rural communities) was judged as only “moderately” important.

5.4.2 Factors generating positive impacts and related challenges

When asked which factors had contributed to the past success of aquaculture in the region, the “very large positive impacts” were generated by economic factors and by partnerships. As noted for Asia, the increased market demand for fish (whether

domestic or international) had a very large economic impact on past successes. This demand was reflected in consumer preferences for fish, and the availability and competitive prices of inputs for aquaculture ventures. Linked to market demand was the emphasis on quality to satisfy food safety concerns. The availability of suitable sites and good environmental conditions were also contributing factors. Partnerships were ranked as “very large positive factors” because scientists and producers were organized. There have been a number of productive research partnerships between universities, governments and aquaculture businesses.

Some factors had a “large” rather than a “very large” impact. These factors were:

- high profitability;
- research, technical, capital and government support; and
- rural development programmes and policies.

High profitability was linked to the willingness of entrepreneurs to take risks and recognition of the economic potential and technical feasibility of aquaculture at the national level. Research and technological development was linked to academic-public partnerships as mentioned above. Capital and government support was particularly useful in the early years when the farming of particular species was unknown. Policies for creating employment and social benefits and for reducing trade deficits were already in place; aquaculture was perceived as a useful activity within these general goals.

In the future the importance of these factors is expected to change. Market positioning and technological development are expected to become “much more important than before”. Market positioning was linked to advantageous geographical locations. The focus of technological development was on the development of environmentally sustainable practices. Two illustrations were made: integrated multitrophic aquaculture and offshore aquaculture.

Employment policies, research partnerships, availability of local inputs and an emphasis on quality to meet food safety concerns were considered to become “more important” than before.

5.4.3 Factors generating negative impacts and related challenges

Experts were asked to identify factors that had been a constraint to aquaculture development in North America in the past. These constraints appear to be country-specific, at least in part. Experts were asked to suggest mitigating policies (see Appendix 4.1). They were then asked to cite factors that might slow development of aquaculture over the next fifteen years, and to rank them according to the severity of their impacts.

The most important constraint to aquaculture development has been difficult access to financing; this was ranked as a “very large negative” factor. Constraints which had “large negative” impacts include:

- full utilization of available sites;
- problems accessing land sites in Mexico;
- emphasis on profits at the expense of the environment (Mexico);
- aboriginal land and water claims;
- preferences of coastal residents for water front properties; and
- lack of, or poor, policies to protect the environment.

The suggested mitigating policies are ranked in Appendix 4.1 according to the degree of impact they would have.

Over the next fifteen years, two recent factors are expected to have a “very detrimental” impact on aquaculture development. The first is public opposition to aquaculture. This opposition manifests itself as negative media reports and/or a general negative perception by the public. This opposition is in some cases led by particular interest groups (e.g. the fishing industry) or residential cottagers who do not want their ocean view marred by cages. Linked to this is the second expected

major impediment: an increasing residential population near aquaculture sites. The experts considered that increasing spatial constraints are “almost certain to happen”.

Constraints that would have a “large” impact are:

- negative externalities such as disease and environmental problems;
- political and regulatory impediments such as a failure to establish regulations for offshore aquaculture;
- politicians reacting to vocal opposition to aquaculture;
- lack of capital;
- international competition;
- exports hurt by foreign exchange appreciation;
- economic constraints such as rising prices of fish feed and lack of economies of scale; and
- the failure of producers to organize into coherent marketing and lobby groups.

Growing international competition is “almost certain to happen” while opposition to aquaculture, lack of capital, negative externalities and legal impediments to aquaculture are “likely to happen”. Specific suggestions to mitigate these constraints are given in Appendix 4.2.

5.4.4 Opportunities

Experts were asked for their ideas on opportunities for aquaculture development in North America. Some of the identified opportunities were unexplored.

The experts saw “very large positive” impacts from more land based aquaculture, diversification into new species, value-added processing and multitrophic aquaculture. From the policy perspective, very large benefits would flow from simplifying regulations, giving aquaculture a higher priority in government bureaucracies, better access to financing, and investing in innovations.

There was no consensus on the impact of offshore aquaculture. For some experts in Mexico it was not technically feasible whereas for others there were concerns over its environmental and social implications. Some experts, however, viewed offshore aquaculture as a means of solving aesthetic concerns (because cages would be submerged) and of providing more space for aquaculture.

Opportunities that would have a “large”, rather than “very large”, positive impact include the use of abandoned gravel quarries, which are abundant in Mexico and are used for trash (with perhaps fiscal incentives to quarry owners), and the development of alternative species. From the legislative and regulatory perspectives, there should be high-level aquaculture development programmes with support from federal and provincial/state governments, and even regional aquaculture plans with full participation of all stakeholders. Extension of leases was also thought to have a “large” positive impact. To increase markets, generic seafood advertising should be encouraged to augment per capita consumption of fish; a comprehensive nutritional programme in rural areas would also be beneficial.

5.5 EASTERN EUROPE

5.5.1 Development objectives

Experts in Eastern Europe were initially asked for the factors that had contributed to the success of aquaculture in the region and whether these factors would become more or less important in the future. They were also asked for factors that had negatively affected aquaculture in the region and, in later rounds, for mitigating strategies.

To assist policy-makers in Eastern Europe, experts were asked for their ideas on unexplored opportunities and on effective and practical means that would help develop aquaculture over the next fifteen years. Subsequently, opportunities were ranked according to whether they would have a “very large positive” effect or a “large positive” effect. This ranking could help policy-makers prioritize their strategies.

All experts believed that aquaculture should be encouraged in Eastern Europe, primarily because of economic reasons. Employment through economic growth and rural development were the two reasons cited as “very important”.

5.5.2 Factors generating positive impacts and related challenges

When asked what factors had contributed to the past success of aquaculture in the region, abundance of water and availability of cage sites were cited as having generated “very large positive impacts”. Equally important was the profitability of salmonid culture. Of these three factors, only the profitability of salmonid culture was expected to become *much more important* than before. Abundance of water and availability of cage sites were expected to be *more important*.

Factors considered to have had a large positive impact in Eastern Europe were economic and political transformations, market demand, environmental quality and experience in freshwater aquaculture. Market demand and environmental quality are expected to become *much more important* than before, whereas the other factors will be as important as in the past.

5.5.3 Factors generating negative impacts and related challenges

Experts were asked to identify factors that constrained past aquaculture development in Eastern Europe. They were also asked to suggest mitigating policies (see Appendix 5). Subsequently, they were asked to cite factors that might slow development of aquaculture over the next fifteen years, and to rank them by the severity of their impacts.

The most important constraint to past aquaculture development was the rise in price of feed ingredients and of electricity. Somewhat less important were the limited number of commercial species, a lack of legislative and regulatory frameworks, the financial debt of farms, a drop in demand for aquaculture products, and the tax policy. Additional factors were the lack of skilled personnel, the lack of competitiveness in aquaculture and the unavailability of high-quality, reasonably priced feed. In the future, factors that will become *much more important* are: the lack of skilled personnel, the lack of competitiveness and the unavailability of quality feed.

Factors that are expected to be *as important as before* are the financial debt of farms, a drop in demand for aquaculture products, and the high price of feed and seed. Lack of commercial species, poor legislative frameworks, energy prices and tax policies will be *less important*.

For policy-makers intending to mitigate constraints, the two that appear most susceptible to policy action are the lack of skilled personnel and the unavailability of quality feed. Both factors have had a large negative impact in the past and are expected to become much more important over the next fifteen years. The lack of competitiveness reflected in non-optimal conditions for aquaculture is less susceptible to policy.

Other factors that might contribute to reduce aquaculture development in Eastern Europe are the lack of integrated coastal management, diseases, environmental pollution and the lack of environmental regulations. These areas also could be the focus of policy-makers.

5.5.4 Opportunities

Experts were asked for their ideas on opportunities for aquaculture development in Eastern Europe. Some of the identified opportunities had been previously unexplored.

Experts saw “very large positive” impacts from the introduction of new species, incentives to farmers, and fish breeding. In general, experts considered that markets would grow with rising per capita incomes, but marketing would be useful and have a large positive impact. Integrated coastal management and the development of sound,

widely accepted codes of conduct were policies that would also have a large positive effect.

5.6 WESTERN EUROPE

5.6.1 Development objectives

Experts in Western Europe were initially asked for the factors that had contributed to the success of aquaculture in the region and whether these factors would become more or less important in the future. They were also asked for factors that had negatively affected aquaculture in the region and, in later rounds, for mitigating strategies.

To assist policy-makers in Western Europe, experts were asked for their ideas on unexplored opportunities and on effective and practical means that would help develop aquaculture over the next fifteen years. Subsequently, opportunities were ranked according to whether they would have a “very large positive” effect or a “large positive” effect. This ranking could help policy-makers prioritize their strategies.

All experts believed that aquaculture should be encouraged in Western Europe, primarily in order to improve the sustainability of fisheries resources. Generating job opportunities, aquaculture’s impact on growth, and promoting coastal and rural communities were considered somewhat less important. Maintaining traditional ways of life was considered of only moderate importance.

5.6.2 Factors generating positive impacts and related challenges

When asked what factors had contributed to the past success of aquaculture in the region, financing and the dedication and professionalism of farmers were factors considered to have generated “very large positive impacts”. Farmers’ dedication was expected to play *a more important* role over the next fifteen years. Financing was expected to be *as important* as it was in the past.

Factors that had generated a large positive impact in Western Europe were research and technological development (e.g. scientific progress in farm management and techniques). General market opportunities (including transport and consumer demand for fish) and institutional policy support for the sector were also considered important. In the future, consumer demand and institutional support, together with farmer dedication, are expected to be even more important. Experts therefore considered that the development of aquaculture in Western Europe in the past was “largely” due to government support and they expect that this support will become even more important in the future. This should be of interest to policy-makers.

5.6.3 Factors generating negative impacts and related challenges

Experts were asked to identify factors that constrained past aquaculture development in Western Europe. Experts were then asked to suggest mitigating policies (see Appendix 6). They were then asked to cite factors that might slow development of aquaculture over the next fifteen years, and to rank them based on the severity of their impacts.

The identified most important constraints to past aquaculture development were competition over coastal resources, bureaucracy and public administration, environmental protection policies and media exposure by NGOs. These constraints, in addition to the increasing importance of nature conservation, high interest rates, competition from developing countries, market access, poor breeding programmes for important species and public concerns over the negative impact of aquaculture, were ranked as “very largely negative”. Concerns over administration appear to be linked to lengthy procedures and lack of public personnel, with little expectation of change in the future: the lengthy procedures are judged to be “very likely to happen”.

Some of these constraints are expected to worsen over the next fifteen years. One constraint that is expected to become “even more important” in the future is market access. Public concern over the negative impacts of aquaculture, competition over coastal use, competition from developing countries, breeding programmes and the stress on nature conservation are expected to become “more important than before”. The others constraints will remain as important.

Other factors might contribute to reduce aquaculture development in Western Europe. Economic instability in places such as Turkey might have a very large negative impact. Other constraints include environmental issues, access to water, market failure, health concerns, and high input costs. These are factors thought to be “highly likely to happen”.

5.6.4 Opportunities

Experts were asked for their ideas on opportunities for aquaculture development in Western Europe. As found with other regions, some ideas represented unexplored opportunities.

The experts saw “very large positive” impacts from new technology, which could increase (marine) yields, and enhance the environment. Two other policies that would have a very large positive impact are identification of marine sites suitable for mariculture and the use of economic incentives.

Other opportunities exist with a “large” rather than “very large” positive impact. They include innovative technology such as offshore and multitrophic aquaculture, water-recirculation techniques, and alternative sources of fish feed.

With regard to public policy, opportunities are focused on a few general areas. One is improved public administration. As mentioned above, experts thought that bureaucracy and environmental policies had had a very large negative impact in past aquaculture development in Western Europe. Suggestions for improvement included simplification of bureaucratic procedures in obtaining licences, a more flexible administration of the sector by officials, industry-friendly legislation, development of national aquaculture strategies and incentives for the promotion of rural aquaculture. Increased public awareness of the sector could generate a “large positive” impact. Better public information, image development and continuing education for farmers were also proposed. Finally, policies to promote and enhance the image of aquaculture among the public would also have a strong impact. Market strategies oriented towards standards and labels and ensuring quality products were also suggested.

6. Conclusions

During 2005, experts in six different regions were surveyed using the Delphi methodology. Questions in the initial round were different across regions because of different aquaculture experiences; second and third-round questions were adapted from answers given in the first round.

Not surprisingly, all experts advocated the development of aquaculture in their regions, although different rationales were given. While aquaculture's contribution to employment and growth was to be expected, the potential role of aquaculture in improving sustainability of capture fisheries was unexpected. In three regions, this positive contribution was ranked as either "very important" or "important".

In all regions but Africa, market demand was considered critical and also propitious to aquaculture development. The main concern in Africa was the lack of suitable macro policies. However, experts thought that there would be improvements in the future if more emphasis were placed on private-sector investment in aquaculture. Also, intra regional and international trade offer important market opportunities for Africa.

In Asia, ensuring quality control to gain access to markets was seen as critical. Technology is seen as a key factor in the Americas and Europe, whether to offset public opposition to aquaculture, develop offshore aquaculture technology, or to increase productivity and therefore competitiveness.

As expected, the Delphi method promoted innovative thinking and some consensus on major issues at the end. Deficiencies of policy in Africa were considered a major cause of aquaculture's slow development in that continent. Too much emphasis on small-scale aquaculture and not enough attention to commercial aquaculture were seen as a primary cause; the current situation is likely to deteriorate unless changes are implemented.

In all regions except Africa, the business-orientation of farmers was acknowledged as a primary factor in aquaculture's success. In Asia and the Pacific, the Americas and Europe, this business approach was seen as a motor of development. Consumer preferences for fish provided an incentive for entrepreneurs by raising fish prices; in some regions this price rise was reinforced by declining output from capture fisheries. In Eastern Europe, for example, profitability of salmonid culture played a very large role in developing aquaculture and was expected to become even more important in the future. In all regions except Africa, maintaining access to markets was ranked as a major challenge for the future. This will require policy intervention on fish standards, and compliance with importers' regulations.

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Appendix 1

Africa

APPENDIX 1.1**Unavailability of, and difficult access to, capital**

Constraint	Possible mitigating strategy
Shortage of financial resources for investment in aquaculture	<p>Governments to set up special development funds for private and public investment in aquaculture</p> <p>Assess the potential importance of aquaculture in national economies and advise governments to contact financial institutions on this basis</p> <p>Improve investment climate through political stability, stabilization of macro economic structural policies, and better and realistic incentives to attract foreign capital/ investment for aquaculture</p> <p>Assist producers to elaborate good business plans to convince lenders</p> <p>Encourage “mother-infant” operations for small-scale farmers so they can access technology, marketing, etc., from the larger farms (large farms generally have easier access to loans)</p> <p>If business plans are solid, provide government loan guarantees. Get pre-financing from donors</p> <p>Encourage large-scale (corporations) type of investments/ enterprises to facilitate access to loans</p> <p>Promote producer cooperatives to facilitate access to loans</p> <p>Establish an incentive scheme to attract foreign investments. To prevent sector domination, a minimum national participation could be required</p> <p>Introduce contract farming through fish processors and exporters (fish marketers)</p> <p>Let the private sector handle large investment projects; successful demonstrations will not only convince lenders, but also attract capital</p> <p>Create trust funds or credit lines</p> <p>Governments to develop microfinance institutions</p>

Constraint	Possible mitigating strategy
High risk of failure	<p>Reduce aquaculture business risks by improving seed, feed and by providing reliable technical information</p> <p>Train/help potential farmers to conduct good feasibility studies</p> <p>Excepting for the largest farms, ensure that there is a reliable domestic urban market, and that any produce will be competitively priced</p> <p>Diversify activities to minimize risks</p>
Reluctance of financial institutions to support aquaculture as a commercial enterprise	<p>Create awareness among managers through training and visit tours; select demonstration farms</p> <p>Sensitize and convince financial institutions through documented success stories on aquaculture as a business (opportunities, potential, economic evaluation)</p> <p>Train reliable fish farmers to establish business plans</p> <p>Have the public sector (governments) and financial institutions/bankers conduct joint studies on the commercial viability of the various aquaculture enterprises to convince lenders</p> <p>Work with medium-scale producers</p> <p>Governments could borrow from international funding agencies to provide capital to private entrepreneurs</p> <p>Adopt a manpower-based development approach, thereby reducing dependency on lending institutions</p> <p>Mobilize funds locally</p> <p>Educate credit institutions (bankers) on aquaculture potential and risks</p> <p>Assist producers to elaborate good business plans to convince lenders</p>
Lack of credibility of the industry	<p>Disseminate information concerning some good examples of successful aquaculture industries (e.g. Nigeria, Madagascar, Zambia, Mozambique, etc.)</p> <p>Organize visits of successful ventures for lenders</p> <p>Conduct studies on previous experiences and find out reasons for failure</p> <p>Sensitize financial institutions on the profitability of aquaculture industries (select certain operations as demonstration farms)</p>

Appendix 1.2

POOR CAPACITY

Constraint	Possible mitigating strategy
Shortage of human capacity and poor technical expertise at both the administration and farm levels	<p>Short and long-term on-the-job training (apprenticeships) of all stakeholders (farmers, farm managers, extension workers, researchers and technical staff at the department level) on existing privately managed commercial or demonstration farms would seem the most cost-effective</p> <p>Organize field visits for farmers, farm managers and local technical staff in countries with similar history and good progress in aquaculture development</p> <p>Introduce vocational training for fish farming at secondary and high school level</p> <p>WorldFish Centre and FAO to disseminate the best techniques for different species and size of farms</p> <p>Encourage and support use of foreign workers qualified in aquaculture production (including volunteers)</p>
Poor capacity of key staff	<p>Inform civil servants in short bulletins on the potential of aquaculture and possible policies in each country, i.e. what has worked elsewhere</p> <p>Strengthen the government's capacity in aquaculture research and policy management</p> <p>Provide, in user-friendly form, information on the importance of aquaculture, how to approach aquaculture and any significant research findings</p>
Entrepreneurial skills: limited expertise of technical staff in developing business plans	<p>Through formal and informal training, strengthen entrepreneurial capacity of farmers and farm managers</p> <p>Government and donors should invest in high-quality training for farm managers, not extension agents or researchers.</p> <p>Government and donors to organize workshops for extension workers</p> <p>Government and donors to organize workshops in appropriate areas to train all stakeholders (farmers, farm managers, extension workers, researchers and technical staff at the department level) in basic business skills</p> <p>Import professional expertise and establish more linkages</p>
Poor capacity affects extension advice	<p>There is a need for assessment and reform of the agricultural/aquaculture/fisheries advisory services at the national, provincial and local level</p> <p>Government to form linkages and ensure that there is technology transfer and support to develop aquaculture</p>

Appendix 1.3

FEED RELATED CONSTRAINTS

Constraint	Corrective measures
Lack of a feed industry	<p>Governments to encourage other feed production sectors to provide aquaculture feeds</p> <p>Development of small-scale techniques for on-farm production of feeds (or coops)</p> <p>Government could provide tax or other incentives for the development of these secondary industries</p> <p>Create conditions to establish fish feed industries</p> <p>Encourage animal producers to diversify</p>
Lack of access to reliable good quality and cost-effective fish feed	<p>Support and attract private sector investment in fish feed production as a business</p> <p>Encourage feed producers for poultry and other animals to diversify</p> <p>Public/private sector investment in research to identify appropriate, high-quality and readily available feed</p> <p>Encourage conversion of pond extensive to semi-intensive systems</p> <p>Consider possibilities and opportunities for regional and/or subregional subsidiaries of multinational fish feeds companies</p> <p>Support and facilitate research in production of fish feeds from locally available materials/ingredients</p> <p>Support business development in aquaculture feeds</p> <p>Encourage large-scale farmers to produce feed</p> <p>Producers could form coops to produce feed or animal feed producers could be encouraged to diversify</p> <p>Incentives for feed industry</p> <p>Establish pilot project of fish feed production with local ingredients</p>

Appendix 1.4

SEED CONSTRAINTS

Constraint	Corrective measures
Limited access to reliable good quality and cost-effective fish seed	<p>Develop and train hatchery operators in broodstock management and improvement</p> <p>Initiate pilot profitable private fish seed production units and duplicate them in other areas of the country/region</p> <p>Encourage and support private hatchery operators through incentives and technical assistance</p> <p>Boost public and private sector investments in seed production research</p> <p>Put in place fish seed quality assurance systems monitored by producer organizations and enforced by public agencies</p> <p>Support and facilitate research in fish breeding</p> <p>Privatize public hatchery facilities where it has not been done yet</p> <p>Develop and disseminate economic models for commercially viable hatcheries to help seed production flourish as a business</p> <p>Encourage specialization in private seed production</p> <p>Disseminate information on seed availability (through internet for example)</p>

Appendix 1.5

LIMITED AND INAPPROPRIATE TECHNOLOGIES

Constraint	Corrective measures
Aquaculture limited to few fish species (i.e. tilapia)	Adaptive research to bring in new (indigenous) species Promote aquaculture of other fish species Use of introduced, better performing and commercial high value species
Poor water distribution plus unreliable weather	Survey, identify, map and zone areas that are appropriate for aquaculture Adopt culture systems that fit the historical weather patterns Develop water-efficient culture systems

When asked about mitigating strategies that might reverse the effects of poor management practices in aquaculture, experts suggested the following ways to improve technological performance in the region.

Factor	Practical means
Develop codes for small fish hatchery management	Learn from other parts of Africa and elsewhere where such guidelines already exist Support from FAO and other international development and research institutions Regional collaboration Consultative processes led by the lead public agencies
Focus on improving performance of farmed fish	Have producer organizations demonstrate “best practices” and learn from them Train selected farmers in efficient seed production and hatchery management and monitor the performance of their farms Government to undertake or support applied breeding research programmes
Establish management programme of threats to production	Not a problem yet. But in the future conduct farmers on-site training programmes First, undertake investigation on how the programme can be established (feasibility study, define criteria for selection of the site/country, set pilot project)

Appendix 1.6

POOR EXTENSION SERVICES AND INADEQUATE RESEARCH

Constraint	Corrective measures
Inadequate government-supported extension services	<p>Build capacity</p> <p>Open extension to private sector</p> <p>Decentralize extension services to local levels and operate through NGOs, farmers and private sector</p> <p>Improve interagency coordination including NGOs</p> <p>Train and expose more graduates in practical business-oriented aquaculture</p> <p>Include aquaculture extension courses in university curricula</p> <p>Have technical information disseminated by feed suppliers or universities</p> <p>Organize farmers in viable producer groups/associations to allow for joint procurement of technical and extension services</p> <p>Improve budgets for extension services</p>
Inadequate research-farmer linkages	<p>Change mandate of research to be more impact oriented</p> <p>Encourage on-farm research</p> <p>Support and facilitate participatory research (farmer-researcher partnership approach) and on-farm trials of research findings</p> <p>Establish demonstration centres as close to the farmers as possible</p>
Limited research information from which new investors/interested parties could learn	<p>Produce and facilitate acquisition of commercial aquaculture documentation</p> <p>Create subregional and regional networks for scientific and technical research exchange</p> <p>Support and facilitate south-south information exchanges, study tours and research collaborations</p> <p>Support and encourage publication of research and technical findings</p> <p>Create and operate producers' database</p> <p>Have responsible government agencies prepare short bulletins summarizing major research findings which could be distributed through producer organizations</p>

Constraint	Corrective measures
Inadequate aquaculture extension systems	<p data-bbox="601 213 948 244">Train more extension workers</p> <p data-bbox="601 265 1039 296">Improve salaries of extension workers</p> <p data-bbox="601 317 1033 348">Provide adequate working equipment</p> <p data-bbox="601 368 1053 399">Improve inter-institutions coordination</p> <p data-bbox="601 420 993 451">Use NGOs to deliver information</p> <p data-bbox="601 472 1262 607">Identify best examples of extension services in the region, adapt them to a particular country and include resulting extension programme in the National Aquaculture Development Strategy</p> <p data-bbox="601 627 1272 721">Decentralize extension systems while ensuring the participation of all stakeholders in the process so that they can suggest best ways to do it (the extension)</p>

Appendix 1.7

OTHER FACTOR-INPUT RELATED CHALLENGES

Constraint	Corrective measures
Limited physical resources (water, land)	<p>Adopt integrated planning and coastal management</p> <p>Adopt intensive production system</p> <p>Adopt low technology, high volume production systems</p>
Deterioration of national economies in general and agriculture sectors in particular	<p>Undertake business-friendly economic reforms</p> <p>Create tax incentives in agriculture</p> <p>Undertake macroeconomic structural adjustments and stabilization reforms</p> <p>Discourage embezzlements of public funds from poor to rich countries</p> <p>Increase budgetary allocations for agriculture sector</p>
Poor macroeconomic situations	<p>Loans and grants to be mobilized within and from outside</p> <p>Promote efficient use of available resources and set up a realistic aquaculture development plan</p>
HIV/AIDS	<p>Encourage ongoing projects addressing HIV/AIDS to direct interventions to aquaculture potential areas</p> <p>Obtain correct information on the impact of HIV/AIDS on aquaculture workforce</p> <p>Sensitize communities; integrate HIV/AIDS awareness aspect in aquaculture extension.</p>
Climate change	<p>Mitigation measures should accompany aquaculture development efforts in an area, e.g. alternative sources of water by pumping should be at reach in an area where commercial aquaculture depends on natural water supply</p> <p>Higher taxes on fuel that have to be invested in alternative energy production and energy savings</p> <p>Provide information on good management of water resources and land use</p>

Appendix 1.8

MARKET ISSUES

Constraint	Corrective measures
Lack of reliable markets for aquaculture products	<p>First explore markets before investing in aquaculture</p> <p>Governments to develop marketing physical infrastructures such as roads, rural electrification</p> <p>Open and streamline subregional and intra regional market opportunities</p> <p>Minimize initial investments to avoid oversupply (produce what you can sell)</p> <p>Develop capacity of producers to process, store and market jointly through producer organizations</p> <p>Develop an effective market intelligence and information system</p> <p>Focus on domestic urban markets and/or markets in adjacent countries</p> <p>Encourage big investors</p>
Poor roads limit access to markets	<p>Identify and zone appropriate areas with good infrastructure for aquaculture development (make a good site selection)</p> <p>Locate farms near markets and procurement centres (good site selection)</p>
Cost and difficulty in meeting HACCP	<p>Educate and train producers, extension officers and fish handlers</p> <p>Avail HACCP information to producers, extension officers and fish handlers</p> <p>Encourage major investors. They will establish standards that others can benefit from</p> <p>Temporarily avail public funding to support HACCP and other quality assurances measures beyond the farm gates</p>
Competition from capture fisheries	<p>Explore and disseminate information on potential markets for aquaculture products outside the production point</p> <p>Avoid harvest at peak of fisheries landings</p> <p>Improve the quality of aquaculture products (size of fish, taste, etc.) by application of required techniques</p>
Consumer preference for marine capture fish	<p>New markets and develop value addition</p> <p>Improve quality of farm products/delivery of fresh products to the market (marketing strategy)</p> <p>Organize aqua products fairs</p>

Constraint	Corrective measures
Low incomes	Find new market options Identify production systems which fit within socio-economic environment
Consumer preference for meat	Advertisements and explore markets with different consumers Explain the nutritional importance of fish (not really a problem in Africa region)
Lack of markets for commercial farmers	Market surveys and advertisements, cooperatives and linkages with other farmers with established markets Organize national, subregional and regional markets as well as international

When asked about mitigating strategies that might reverse the effects of poor management practices in aquaculture, the experts suggested the following ways with respect to the marketing of aquatic products in the region.

Help farmers develop international markets for tilapia and catfish	Support organized and producer-led fish marketing Facilitate the establishment of strong and legally recognized national fish farmers organizations which can be internationally linked to others Promote intraregional trade first to obviate HACCP standards and transport costs, and to increase access to information such as prices Support farmers to synchronize fish production to guarantee regular supply
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Appendix 1.9

GOVERNANCE ISSUES

Constraint	Corrective measures
Weak governments, weak local farmers' and development institutions.	<p>Reform public institutions to steer towards support and promotion, rather than engaging in production directly</p> <p>Shift government support of aquaculture institutions from subsistence aquaculture systems to business-oriented private sector aquaculture enterprises</p> <p>Support emergence of viable producer organizations</p> <p>Establish and support inter-agency committee for aquaculture management and promotion</p> <p>Training in the public sector, development institutions and farmer organizations</p> <p>Encourage community development with cooperatives and producer organizations for mutual support.</p>
Lack of interagency coordination	<p>Establish and support inter-agency committee for aquaculture management and promotion</p> <p>Have one lead agency with a mandate to promote and coordinate the sector</p>
Corruption	<p>Clear policies and transparency in contracts/transactions, etc.</p> <p>Less bureaucracy and one central point for applying licences</p> <p>Suppliers and project developers should be made accountable for money obtained from donors</p> <p>A strong, commercial aquaculture group that can lobby effectively</p> <p>The real impact of corruption needs to be assessed at all levels. It can occur even at international institutions, which nevertheless benefit from accurate anti-corruption services (e.g. reforming UN agencies and organization) due to their democratic nature. Measures recommended are: implementation of an international anti-corruption system for multilateral and bilateral funding; development of national anticorruption systems; support to national institutional reforms (decentralization) in order to strengthen the role of a healthy public sector. Fighting corruption at every level and defending an efficient public sector by all means is a guarantee of sustainable development</p>

Constraint	Corrective measures
Corruption (cont.)	1. Reduce regulations where possible, and make regulatory processes transparent; 2. Empower economic police (as in Botswana); 3. Designate an independent Auditor-General; 4. If an environmental impact statement (EIA) is required for a minimum-size farm, there should not be a perception that it will be needed even for smaller farms (i.e. Zambia); 5. Develop a register of those competent to undertake an EIA. This register should not include government officials because then there is an incentive to insist on an EIA to generate income (Zambia); 6. Property rights/leases should be transparent and free from political influence
Ideological aversion to free markets by some government officials	Create more awareness of the benefits of free markets for aquaculture Provide workshops on basic economics aimed at the youngest policy-makers
Existence of civil conflicts in many countries	Government policies to guarantee security of aquaculture properties

Appendix 1.10

POOR INFORMATION AND COMMUNICATION

Aggravating factors	Mitigation strategy
Lack of political commitment to aquaculture development in most African countries	<p>Provide documentation on the importance of aquaculture for income generation and food security</p> <p>Organize exchange visits for policy-makers in countries where aquaculture is well developed</p> <p>Regularly document (through policy and legislation updates) policy makers' commitment to aquaculture development and request action from them</p> <p>Major development agencies to tone down environmental concerns, tone down grassroots approach and get governments to promote their countries for major aquaculture investments</p> <p>Support local experts to undertake in-country time-bound aquaculture assignments with additional or better remuneration</p> <p>Encourage trained staff to become farmers themselves</p> <p>Undertake civil service reforms to ensure better working conditions for well trained staff</p>
Lack of awareness of the importance of aquaculture at decision-making level	<p>Generate and disseminate more success stories in the sector</p> <p>Assess the contribution of aquaculture to national and regional economies and disseminate information at the decision-making level</p> <p>Conduct workshops on technical and economic viability of aquaculture investments</p> <p>FAO to play a major role in raising awareness of aquaculture benefits, instruct major donor governments</p>
Lack of information on aquaculture strategies in other countries in Africa	<p>Establish one lead agency for the sector</p> <p>Establish policy, regulatory and strategy frameworks for sustainable aquaculture development</p> <p>Establish incentives to attract investments to commercial aquaculture</p> <p>Initiate pilots – demonstration farms for commercial aquaculture</p> <p>Take advantage of the political will demonstrated through a reduction of government's role in production, inputs dealing and supply, and through the public funding of private aquaculture businesses and enterprises to attract international support to the sector</p>

Aggravating factors	Mitigation strategy
Lack of information on aquaculture strategies in other countries in Africa (cont.)	<p>Undertake regional reviews and advocacy through intra regional bodies</p> <p>Promote legislation which actualizes ‘political will’ by ratifying international, regional and subregional conventions, protocols and other undertakings relating to aquaculture</p> <p>Recognize that foreign investors can contribute to develop aquaculture</p> <p>Improve regulatory procedures so that investors face fewer hurdles and less permit time (e.g. one-stop shops, one lead institution)</p> <p>Use FAO to collect and disseminate ‘Best Practices of Political Will’</p>
Increased focus on high quality information delivery between research, extension and farmers	<p>Focus on high-potential areas</p> <p>FAO and WorldFish Center could summarize major research findings and disseminate them on the Web. Where the internet is unavailable, short summaries could be made available.</p> <p>Increase the private sector’s role and introduce competition in service delivery, research and extension</p> <p>When possible, have researchers and extension workers jointly deliver information to farmers</p> <p>Develop systems (database) for information requests and delivery</p> <p>Develop aquaculture extension manuals which can be readily understood by farmers</p>
Inform women about aquaculture activities and facilitate their access to land	<p>Specific programmes aimed at women and land policies</p> <p>Use various channels to inform women about aquaculture activities and land use legislation</p>
Inappropriate technical information packages	<p>Instruct researchers to work with the private sector to capture best practices</p> <p>Establish regional centres to include demonstrations of viable aquaculture production systems and to serve as outlets for technical information</p>

Experts thought that an unexplored opportunity related to the dissemination of technical and marketing information was using local farmers as information agents. Farmers have common backgrounds and interests; policy-makers could take advantage of this to improve communication channels. Suggestions are presented below.

Encourage cooperation among farmers

Unexplored opportunity	Action
Use common background of farmers	<p data-bbox="601 296 1272 362">Encourage/promote producers' organizations as a tool for availing information on seed, feed and markets</p> <p data-bbox="601 383 1272 449">Document good examples (success stories) and share them with other farmers</p> <p data-bbox="601 470 1272 536">Use the experiences of outstanding farmers for technical assistance in other countries</p> <p data-bbox="601 557 1272 590">Exchange visits among farmers in the region (network)</p> <p data-bbox="601 611 1272 706">Organize farmers into producer groups and coordinate and synchronize production to meet demands of specific markets</p> <p data-bbox="601 727 965 760">Production for specific markets</p> <p data-bbox="601 781 1272 876">First conduct work with one species until its farming becomes commercially viable, and then avail funds to producers/universities to experiment with other species</p> <p data-bbox="601 897 1272 957">Facilitate exchange journeys among farmers, aimed primarily at promising producers</p>

Appendix 2

Asia and the Pacific

Appendix 2.1

Practical means to lessen/contain the impact of factors identified as negative for past and future aquaculture development

	Practical means
Stringent trade barriers, rules and regulations	<p>Ensure fairness in trade between North and South through third parties (WTO)</p> <p>Improve quality of products</p> <p>Develop domestic and intraregional markets</p> <p>Adopt unified common standards and legislation</p> <p>Organize farmers to comply better with technical barriers to trade</p> <p>Bilateral Free Trade Agreements (FTAs) (between producing and consuming countries)</p>
Concerns with environmental destruction	<p>Develop proper regulations to protect environment</p> <p>Build capacity in environmental control</p> <p>Develop and promote best management practices and codes of responsible practices through marketing-based incentives</p> <p>Improve technology in aquaculture</p> <p>Have an effective environmental management regime which covers all activities potentially damaging to the environment</p> <p>Rehabilitate mangrove forests, natural water bodies and aquatic resources</p> <p>Conduct EIA before developing aquaculture activities</p> <p>Raise awareness of environmental impacts</p>
Difficult access to land and water resources	<p>Establish mariculture parks</p> <p>Recognize customary tenure rights</p> <p>Improve access to land and water resources, through adequate irrigation infrastructure</p> <p>Proper planning of access to land and water resources so that acceptable areas (both for farmers and those with other interests/uses for the resource) are identified</p> <p>Ensure strict enforcement of laws and regulations governing property use and access</p>

	Practical means
Difficult access to land and water resources (cont.)	<p>Establish access rights systems while defining land and water laws</p> <p>Establish water legislations</p> <p>Ensure better coordination between aquaculture and other sectors dependent on land and water resources</p> <p>Ensure more cooperation amongst stakeholders</p> <p>Establish and prioritize zoning for development</p> <p>Identify availability and constraints</p>
Poor farmer training	<p>Extension services to improve farmers' training in collaboration with local communities</p> <p>Conduct demonstrations at successful farms for extension field staff, and prospective investors, as well as coastal fishermen</p> <p>Industries and science institutions to address training and extension, including basic literacy and sciences</p> <p>International organizations in collaboration with in-country major/influential stakeholders and educational institutions to define training packages and strategies</p> <p>Increase farmers' scientific consciousness</p> <p>Make creative use of information technology in complement with other media</p> <p>Governments to support knowledge and new technologies in aquaculture</p> <p>Public sector to increase funding for farmers' training activities</p> <p>Develop commercial incentives for better advisory services to farmers</p> <p>Strengthen training capability of aquaculture extension organizations at grass-root level</p> <p>Strengthen farmers' associations (no consensus was reached here)</p>

	Practical means
Genetic degradation/ unfavourable alterations to genetic diversity	<p>Strengthen breeding programmes in aquaculture seed production</p> <p>Carefully plan enhancement and restocking programmes</p> <p>Establish gene banks</p> <p>Increase research efforts geared towards genetic improvement of cultured species and knowledge of aquaculture genetics</p> <p>Conduct Research and Development (R&D) on genetic improvement and biodiversity</p> <p>Accredit system in aquaculture seed production and distribution</p> <p>Put proper regulations in place to preserve genetic diversity</p> <p>Institutions to share information towards improving genetics in breeding (ensure close cooperation between those who have the information and those who need the information)</p>
Overexploitation of coastal resources	<p>Raise public awareness</p> <p>Provide education, incentives and other packages that would maintain continuity of educational and compliance programmes</p> <p>Establish fishing seasons to protect the propagation and development of juveniles</p> <p>Establish property rights for aquaculture</p> <p>Zone and assess the carrying capacity of each zone</p> <p>Effective coastal zone management plans</p> <p>Mangrove reforestation and conservation</p> <p>Land reforms in coastal areas (no consensus reached)</p>

	Practical means
Poor government policies	<p>Clarify government short and long-term objectives and strike a balance between short and long-term interests</p> <p>Credible institutions like the UN to assist or intervene in order to improve policies</p> <p>Ensure advocacy alliances among stakeholders other than government, e.g. farmers' associations</p> <p>Ensure stronger stakeholders' participation in planning and policy development including government agencies (local as well as central), private sector, local communities and fish farmers</p> <p>Use proven past events/experiences of other countries</p> <p>Decentralize policy making processes</p> <p>Aquaculture to be given higher profile (i.e. not to be subsidiary to fisheries or agriculture policies as is often the case)</p>
Lack of domestic feed industries	<p>Utilize local ingredients where cost effective</p> <p>Import feed on the basis of comparative advantage</p> <p>Create more supportive environment for domestic feed industry development</p> <p>Provide more support to R&D activities for aquaculture feed development</p> <p>Switch to or develop and promote herbivorous species</p> <p>Concerned authority or organization to do some of the followings: (1) investigate the causes for the lack of domestic feed industries, (2) conduct feasibility studies on developing domestic feed mills and (3) call for external assistance and investment with appropriate packages</p> <p>Develop local domestic feed industry through joint ventures with more developed countries</p> <p>Establish small scale (village size) feed-mill factories</p> <p>Create financing mechanisms for the domestic feed industry (no consensus)</p> <p>Encourage the growth of commercial fish and shrimp farming (no consensus)</p>

	Practical means
Sensationalist media	<p>Ensure that dialogue occurs</p> <p>More scientific outreach activities</p> <p>Incorporate social responsibility (i.e. avoid social conflicts by distributing benefits of development equitably) in industry strategies</p> <p>Improve science and communicate scientific results</p> <p>Have sound information available</p> <p>Improve communication with public media</p> <p>Farmers and industry associations to improve image and credibility of the industry (e.g. by promoting science-based debates on issues and creating alliances with scientific community)</p> <p>Develop farmer's news and demonstrations on television, farmers' networks and farmer websites</p> <p>Governments and the industry to organize proactive media campaign</p> <p>Strengthen the advocacy of aquaculture sector</p> <p>Communicate concerns to media on sensationalist news coverage and their negative impacts on the industry</p> <p>Sanction irresponsible lobby groups propagating incorrect information</p> <p>Ensure that governance processes are open and informed (this helps maintain an informed public or section of the public)</p>
Biosecurity risks	<p>Stakeholders to comply with biosecurity measures through relevant and appropriate incentive trade packages</p> <p>Train technical staff in risk assessment</p> <p>Raise public awareness (improve education)</p> <p>Provide more training and adopt proper regulations</p> <p>Provide (more) training in disease management</p> <p>Develop more practical precautionary regulations/codes of conduct for good aquaculture practices</p> <p>Fisheries (aquaculture) agencies to be staffed with agriculture officers (for quarantine) and veterinarians (for fish disease)</p>

	Practical means
Biosecurity risks (cont.)	<p>Apply import risk analysis models (quarantine protocols)</p> <p>Promote organic farming</p> <p>R&D</p> <p>Better enforcement/implementation of precautionary regulations/codes of conduct in aquaculture practices</p> <p>Universities, IUCN (International Union for the Conservation of Nature and Natural Resources), relevant government departments, etc., to suggest remedial measures</p> <p>Bring to an end the use of harmful chemicals/drugs in aquaculture</p> <p>Stakeholders to improve availability of information on biosecurity</p>
Poorly planned aquaculture enterprises	<p>Include subjects related to aquaculture and fisheries in education curricula</p> <p>Public sector to provide better information services and technical support to private sector in establishing aquaculture businesses</p> <p>Lending/funding institutions should require fund recipients to do proper planning and to comply with sustainable practices as part of loan conditions</p> <p>Access to better information and advice in developing business plans</p> <p>Establish aquaculture development committees</p> <p>Train farmers and entrepreneurs in developing business plans</p> <p>Fisheries departments to hold seminars/workshops to train large, medium, and especially small farmers in aquaculture farm planning</p> <p>Improve planning tools, especially financial and economic packages</p>

Lack of financial resources	Practical means
	<p>Convince governments and investors on the profitability of aquaculture projects</p> <p>Public sector (government) to play a leading role in improving access of aquaculture businesses to investment at the early development stage of the industry</p> <p>Aquaculture associations to provide funds to rural farmers (start up grants, revolving funds)</p> <p>Financial institutions and farmers to cooperate more</p> <p>Government to provide support and show commitment</p> <p>Involve financial institutions in training of farmers and entrepreneurs</p> <p>Educate financial (bank) loan officers</p> <p>International agencies such as FAO, ADB, UNDP to provide support</p> <p>National development banks to provide soft loans to rural farmers who live far way from lending institutions and have no collateral</p> <p>Governments/consultants to help farmers/investors prepare bankable projects (good business plans)</p> <p>Concerned authorities to assist in outsourcing financial loans. For instance, after screening appropriate recipient farmers or developers, governments or related institutions may serve as guarantors for loan repayment based on the project development scheme, financial profile and assessment done by a credible independent body</p> <p>Lending institutions such as SMEDA (Small and Medium Enterprise Development Authority), industrial and agricultural banks to introduce small-farmer investor-friendly policies, with loan facilities available at the village level</p> <p>Local community groups to pool funds and provide cheap loan schemes to rural farmers (no consensus)</p>

Appendix 2.2

OTHER FACTORS WHICH MIGHT CONTRIBUTE TO REDUCE AQUACULTURE DEVELOPMENT IN THE REGION AND PRACTICAL MEANS TO LESSEN/CONTAIN THE LIKELIHOOD OF OCCURRENCE OF THESE FACTORS

Other factors	Practical means
<p>Limited water, i.e. frequent draughts</p>	<p>Develop mariculture, where applicable</p> <p>Develop integrated farming systems</p> <p>Adopt mixed farming practices such as silvo fisheries to reduce evaporation from pond water (co-culture with some aquatic plants that have minimum impact on pond dynamics)</p> <p>Better manage water – irrigation and delivery systems</p> <p>Introduce appropriate culture practices such as waste (including or especially wastewater) reclamation and reuse (W2R2) system, zero discharge system to minimize use of water</p> <p>Adopt lower cost recirculation technologies</p> <p>Exert controls of excessive use by other sectors – agriculture, tourism</p> <p>Carefully plan and prioritize water availability</p> <p>Develop well management for water use</p> <p>Set up user-pay policy</p>
<p>Diseases</p>	<p>Assurance of health of broodstock or seed</p> <p>More responsible introductions of species</p> <p>Establish effective and safe disease prevention, diagnosis, control and treatment measures</p> <p>Establish good biosecurity systems at the border and in farms within a country. Some planning and sharing of management practices are important</p> <p>Prompt information dissemination on outbreak of diseases</p> <p>Farmers’ adoption of best management practices (BMPs) on health management</p> <p>Employ services from livestock veterinary officers</p> <p>Educate farmers on diseases</p> <p>Widespread application of the concept that prevention is better than cure in aquaculture</p> <p>Promote ecosystem-friendly culture practices</p> <p>Improve disease resistance of cultured species through genetic improvement</p> <p>Introduce disease resistance species</p> <p>Put robust biosecurity programmes in place</p>

Other factors	Practical means
Industrial – Toxic metal pollution	<p>Carefully select aquaculture sites</p> <p>Aquaculture stakeholders to actively promote the environment/voluntary monitoring and surveillance of illegal waste discharged from the industry</p> <p>Raise public awareness</p> <p>Introduce early warning systems</p> <p>Better control water exchanges with outside</p> <p>Set up zoning systems</p> <p>Set up monitoring and response systems</p> <p>Promote organic farming</p> <p>Governments to regulate, control or prohibit the use of heavy metals</p>
Increasing energy costs (high oil prices)	<p>Use market incentives for development and adoption of alternative energy sources such as biodiesel/biofuels (gasohol), solar energy, fuel cells, wind mills and wave energy</p> <p>R&D on energy saving culture systems</p> <p>Higher technical efficiency in the use of energy (modify existing aquaculture systems/models with less power input)</p> <p>Governments to assist farmers in utilizing renewable energy</p> <p>Switch to less energy-intensive farming systems and species (no consensus)</p>
Poor economic efficiency of traditionally cultured species	<p>Improve cultured species</p> <p>Develop/research new cultured species with larger economic potential</p> <p>Introduce improved culture technologies</p> <p>Switch to other species</p> <p>Promote value addition of aquaculture products</p> <p>Develop new techniques which can improve efficiency and bring down costs</p> <p>Give priority to genetic improvement programmes such as breeding</p> <p>Place emphasis on improvement of species with high market potential (no consensus)</p>

Other factors	Practical means
Poor economic efficiency of aquaculture practices	<p>Provide technical and management training</p> <p>Introduce new technologies</p> <p>Improve culture efficiency through better management and production techniques</p> <p>Provide adequate extension services to producers</p> <p>FAO/NACA/STREAM, etc. to advise</p> <p>Develop high efficiency aquaculture systems</p> <p>Develop new technologies</p> <p>Promote value addition of aquaculture products</p>
Resource use conflicts (e.g. land and water) coupled with bad planning	<p>Place aquaculture in the context of multiple users/ integrated management</p> <p>Adopt land and water use zoning</p> <p>Develop sound planning processes and ensure the creation of incentives which discourage excessive (poor) resource use</p> <p>Involve stakeholders' in conflict resolution</p> <p>Adopt and enforce appropriate legislations</p> <p>Adopt planning tools, e.g. GIS, zoning schemes</p> <p>Increase consultation with the public through public forums to allow inputs of stakeholders in land use planning</p> <p>Design local government committees and collaborate with them in developing regulations</p> <p>Concerned stakeholders to conduct proper feasibility studies to reduce resource users conflict</p> <p>Improve coordination with other sectors relying on the same resources</p>
Public opposition to occupation of space in coastal areas by aquaculture	<p>Effectively promote sustainable resource sharing in media and public forum</p> <p>Place aquaculture in the context of coastal multiple use (integrate aquaculture into other coastal developments)</p> <p>Improve public awareness on the advantage and importance of coastal/marine aquaculture (through pilot demonstrations for example)</p> <p>Improve coastal/marine aquaculture and reduce its impacts on the environment</p> <p>Use of integrated coastal area management in concerned development agencies</p>

Other factors	Practical means
Public opposition to occupation of space in coastal areas by aquaculture (cont.)	<p>Conduct credible studies to demonstrate cost-benefits to community of aquaculture projects in the area</p> <p>Design local government committees to plan for and determine the use of space including coastal stakeholders (district local councils)</p> <p>Set up public relations campaigns</p>
Weak or lack of environmental controls and enforcement	<p>Institutional capacity building, support of regulations and development of guidelines</p> <p>Aquaculture stakeholders to actively participate in monitoring, control and surveillance of pollution (through local government committees for example)</p> <p>Legalize environmental regulations</p> <p>Federal and provincial environment protection agencies to enforce measures to control/reduce industrial pollution such as sugar mills, tanneries, textile, auto batteries, pulp-paper, refinery, seaport and city sewage</p> <p>Voluntary adoption of BMPs and Codes of Conduct</p> <p>Stronger farmers' associations for self-policing</p> <p>Educate decision-makers or concerned authorities</p> <p>Use international trade incentives as persuasive schemes to effectively control and enforce regulations</p> <p>Governments to improve enforcement</p> <p>Close cooperation with environmental advocates/NGOs to highlight wrong doers</p>
Poor planning and lack of management skills	<p>Develop long-term management strategies</p> <p>Strengthen the training and education of farmers (for example through in-country or across-borders farmers exchanges and visits) and of relevant personnel</p> <p>Governments to provide support for knowledge and new technologies</p> <p>Improve extension services</p> <p>Promote sustainable commercial aquaculture development</p> <p>Fisheries departments to be reorganized, restructured, adequately staffed with sufficient financial budgeting for planning</p>

Other factors	Practical means
Lack of international codes on movements of live fish and introductions of exotic species	<p>Better regional coordination in common issues of interest</p> <p>Set up and enhance quarantine systems</p> <p>Develop a national strategy on movements and introductions of species (such as codes, fish health certificates)</p> <p>Fisheries departments to study, submit draft for legislation by government</p> <p>Put in place a comprehensive extension system</p> <p>Raise farmers' awareness and disseminate information on the consequences (pros and contras in monetary and environmental terms) of such movements without careful management</p>
Lack of clear legal frameworks regulating site use	<p>Develop model legislation</p> <p>Governments to set up legal frameworks in consultation with province and district councils</p> <p>Learn from other countries' laws and regulations</p> <p>Offer training on legal issues</p> <p>Allow flexibility and modification of codex that are not workable</p>
Compliance with International Code of Conduct and Code of Practices	<p>Utilize intergovernmental fora to increase pressure for compliance</p> <p>Elaborate technical guidelines for governments and farmers</p> <p>Provide market incentives for products produced in compliance with international codes</p> <p>FAO to increase vigilance and take corrective actions</p> <p>Create incentives for voluntary adoption of BMPs</p> <p>Government to create awareness on International Code of Conduct and Code of Practices in workshops with stakeholders</p> <p>Strengthen farmer associations</p> <p>Fairness in trade issues</p> <p>Provide training on International Code of Conduct</p> <p>Modify international codes for better adaptation to local conditions</p>

Other factors	Practical means
Excessive enforcement of aquaculture-related regulations by concerned authorities	<p>Raise awareness on the long-term benefits of such regulations</p> <p>Balance regulations with market incentives and codes of practice</p> <p>Provide adequate staffing, transport facilities and financial means to fisheries departments</p> <p>Provide education and incentives to regulation enforcement officers</p> <p>Actors (e.g. farmers, suppliers, buyers) to better cooperate in the market chain (self regulation)</p> <p>Strong enforcement through high penalties and charges</p>
Non-integrated planning	<p>Provide appropriate training to concerned parties</p> <p>Adopt better planning processes including participation of all stakeholders and integration of aquaculture in rural development schemes</p> <p>Enhance cooperation between different organizations</p> <p>Use of planning tools such as GIS, zoning schemes</p> <p>Provide integrated plans to prospective investors on sustainable aquaculture projects including information on feasibility, land leases, microfinancing, farm design, training, etc.</p> <p>Promote integrated large-scale aquaculture</p> <p>Develop a nationwide integrated plan</p>
Change in peoples' eating habits (food preferences)	<p>Allow flexibility in the industry so as to quickly adjust to consumer preferences</p> <p>Promote food safety scheme from farm to table</p> <p>Improve the post-harvesting and processing of aquaculture products</p> <p>Provide public education and scientific extension</p> <p>Conduct advertising campaigns highlighting the nutritional benefits, wholesomeness and good taste of aquaculture products</p> <p>Promotion of aquaculture products using effective mass media</p>

Other factors	Practical means
Low prices caused by oversupply	<p data-bbox="601 213 1058 244">Farmer associations to moderate supply</p> <p data-bbox="601 265 1148 360">Effective production planning through farmers' association, organizations in collaboration with stakeholders</p> <p data-bbox="601 381 1139 412">Work on developing new or expanded markets</p> <p data-bbox="601 433 1179 501">Advertise and improve distribution and marketing channels of aquaculture products</p> <p data-bbox="601 522 898 553">Diversify cultured species</p> <p data-bbox="601 573 1233 671">Maintain good balance in supply and demand of aquaculture products through good market studies and better functioning of farmers' associations</p>
Public concerns on the sanitary conditions of aquaculture products	<p data-bbox="601 692 1243 789">Educate producers towards improving the quality of aquaculture products through the adoption of drug-free production systems, Code of Conduct and BMPs</p> <p data-bbox="601 810 1282 878">Educate consumers through public campaigns and effective media</p> <p data-bbox="601 899 1243 996">Promote quality products by encouraging production methods in compliance with international standards and requirements</p> <p data-bbox="601 1017 951 1048">Promote aquaculture products</p>

Appendix 3

Latin America

Appendix 3.1

ACTIONS TO IMPLEMENT THE CAPACITY AND CONTRIBUTION OF THE PUBLIC SECTOR

Capacity and contribution of the public sector

Put in place and enforce adequate administrative procedures to facilitate orderly expansion

Implementation of proactive and adaptive public sector that facilitates technology transfer and technical assistance, encourages R&D and education, facilitates access to financial support, etc.

Involve municipal and local governments in aquaculture

Increased training for public sector employees to support aquaculture

Foster increased private-public sector partnerships

Increased awareness of public sector capabilities and limitations

Increase connection links with industry

Appendix 3.2

OTHER FACTORS WHICH MIGHT CONTRIBUTE TO REDUCE AQUACULTURE DEVELOPMENT IN THE REGION AND PRACTICAL MEANS TO LESSEN/CONTAIN THE LIKELIHOOD OF OCCURRENCE OF THESE FACTORS

Negative factors	Containment means
Lack of institutional support (legislation, codes of practice, etc.)	<p>Governments to recognize and prioritize aquaculture as an important economic activity</p> <p>Create or adapt Technology Transfer Institutions</p> <p>Prepare, pass and ratify proactive legislations including codes of practices and sanitary measures (e.g. HACCP) and put in place adequate administrative procedures</p> <p>Make educational plans, facilities and related material available to policy makers and users</p> <p>Training and capacity building for public sector</p>
Environmental concerns	<p>Governments to recognize that problems exist and find ways to tackle them rather than hiding them</p> <p>Develop practical and realistic environmental standards for aquaculture</p> <p>Get the industry well organized (producers' associations, good and permanent contacts with local governments and fellow associations, good public relations) and apply adequate codes of practice</p> <p>Instruct the industry on the potential for environmental damages</p> <p>Improve public awareness (for example, through existing media) of aquaculture benefits</p> <p>Encourage semi-intensive aquaculture activities</p> <p>Conduct EIAs before approving new farms/projects</p> <p>Develop practical and operational environmental regulation systems (including EIAs) with proper sanctions for their violation</p>
Economic policy issues of a general nature	<p>Prepare national and/or regional aquaculture development plans to orient both private and public activities in this field</p> <p>Publicize the potential of aquaculture to create jobs, supply protein, and to foster economic development in general</p> <p>Provide proper advice on international/global markets</p> <p>Provide incentives to the private sector to conduct R&D at the early stages of development</p> <p>Design adequate strategies to promote exports and/or local consumption as appropriate</p> <p>Implement economic policies which promote/encourage private sector investment</p>

Negative factors	Containment means
Economic policy issues of a general nature (cont.)	Develop and implement data collection models which are conducive to reliable statistics Set up computerized national statistics programmes Governments to systematically control private sector activities and its development
Lack of technical support	Create adequate institutional facilities, train monitors and help small-scale producers directly Public investments in extension services/programmes Increase financial support to training activities to improve training institutions, promote research and improve education of technical public sector staff Prepare and distribute adequate documentation Provide farmer-friendly manuals such as fliers and curricula to disseminate new technologies
Lack of financing for aquaculture	Design appropriate financial schemes such as creating microcredit with specific lines for the aquaculture sector Give proper licensing to aquaculture and enhance or backup aquaculture trust for banking/credit issues Call for investment proposals through open contests and finance the best alternatives available Source external funding Adopt self-financing farming technologies and informal lending mechanisms Integrate aquaculture in locally funded activities Develop revolving funds with low interest rates International financing agencies to provide loans via government. Governments to provide these funds to farmers at concessionary rates and long term payback periods Categorize aquaculture as a type of agriculture, requiring the same government financial support and incentives (there were divergences here in experts' rating)

Negative factors	Containment means
Lobbying by NGOs	<p data-bbox="601 213 1283 281">Publicize the potential of aquaculture to create jobs, supply protein, and to foster economic development in general</p> <p data-bbox="601 302 1283 399">Publicize aquaculture as having the potential to reduce dependence on capture fisheries, thereby preserving natural ecosystems</p> <p data-bbox="601 420 1283 488">Prepare adequate information, dissemination materials and training to staff</p> <p data-bbox="601 509 1283 540">Address the issues of concern. Don't conceal them</p> <p data-bbox="601 561 1283 629">Get the industry organized to respond responsibly and consistently</p> <p data-bbox="601 650 1283 718">Promote semi-intensive aquaculture (divergences in expert's rating)</p> <p data-bbox="601 739 1283 808">Develop proper environmental and social regulations to support sustainable aquaculture</p>
Decreased availability of feeds	<p data-bbox="601 818 1248 849">Look for alternative locally-produced feed and compost</p> <p data-bbox="601 870 1248 901">Increase use of plant protein</p> <p data-bbox="601 922 1248 990">Conduct more R&D for alternative raw materials and synthetic components</p> <p data-bbox="601 1011 1248 1042">Promote integrated aquaculture</p> <p data-bbox="601 1062 1248 1094">Adopt closed systems using natural feed (plankton)</p> <p data-bbox="601 1114 1248 1145">Use of herbivorous and omnivorous species</p> <p data-bbox="601 1166 1248 1234">Develop good connections with feed industry and new technologies in feed products</p> <p data-bbox="601 1255 1248 1324">Support technologies for development of new and less expensive protein sources</p> <p data-bbox="601 1344 1248 1413">Improve culture practices to diminish feed conversion factors</p>
Lack of technologies to farm endemic species	<p data-bbox="601 1413 1276 1531">Coordinate and give critical mass to R&D activities and make sure financing is made available for extended periods of time</p> <p data-bbox="601 1551 1276 1583">Support local research through better regional cooperation</p> <p data-bbox="601 1603 1276 1634">Training to personnel</p> <p data-bbox="601 1655 1276 1723">Select and focus on a small number of species with greatest potential and develop their farming technologies</p> <p data-bbox="601 1744 1276 1813">Foster greater linkages with countries possessing same or similar species and look for possibilities of transferring their technologies into the country</p>

Negative factors	Containment means
Spread of diseases	<p>Design and implement adequate administrative controls</p> <p>Organize the industry around farmers associations and clusters</p> <p>Have adequate laboratory facilities and trained staff</p> <p>Prioritize sanitary programmes and strengthen regional cooperation</p> <p>Establish government managed quarantine systems</p> <p>Adhere to established codes of conduct and practices</p> <p>Set up regulations on imports into and transfers within countries</p> <p>Develop and enforce proper health management practices and strong regulation with relevant private and public sector involvement</p>
Hurricanes or other catastrophic events	<p>Arrange for disaster prevention and recovery systems</p> <p>Develop efficient warning systems and emergency preparedness to farmers communities and local regional governments</p> <p>Timely disseminate relevant information</p> <p>Establish public rehabilitation banks in different areas of the country</p>
Civil unrest	<p>Generate employment</p> <p>Increase wealth distribution</p> <p>Develop proper communications with all stakeholders and support strong and realistic social/economic regulations for aquaculture considering proper share of incomes</p>

Appendix 4

North America

Appendix 4.1

PRACTICAL MEANS TO LESSEN/CONTAIN THE LIKELIHOOD OF OCCURRENCE OF NEGATIVE FACTORS FOR PAST AND FUTURE AQUACULTURE DEVELOPMENT, WITH RANKING (IN THE "IMPACT" COLUMN, 1 REFERS TO A VERY LARGE POSITIVE IMPACT AND 2 TO A LARGE POSITIVE IMPACT)

Negative factors	Containment means	Impact
Difficult access to financing	Improve the public image of aquaculture through the media; organize informative workshops for lenders	1
	Ensure aquaculture producers have access to the same insurance policies available to agriculture producers	1
	Increase financing available through lenders such as the Nova Scotia (NS) Fisheries and Aquaculture Loan Board in the case of Canada	2
	Improve business risk management through federal programmes	2
	Improve bankers understanding of risks associated with different kinds of aquaculture operations	2
	Extend lease periods and reduce the regulatory burden	2
	Make loan guarantees available for farmers willing to diversify into other species	2
	National and regional governments to create specific aquaculture development funds. Decisions to grant funds should be based on technical and economic feasibility of projects, rather than on collateral	2
	Promote fiscal incentives to companies that link small producers to large-scale commercial chains	2
Help organize producers so that they take advantage of economies of scale in buying inputs and selling products	2	
Lack of/poor policies for protecting the environment	Funding and buy-in (support) from the highest levels of government	1
	Have a credible agency collate the information/misinformation and indicate its conclusions (as there is a lack of transparency about site selection criteria and conflicting scientific evidence about sea lice/causes of declining catches of Pacific salmon)	1
	Continue with environmental monitoring programmes to ensure sustainability and communicate results	2

Negative factors	Containment means	Impact
Lack of/poor policies for protecting the environment (cont.)	Set up informed environmental standards that are monitored routinely by independent authorities	2
	Prepare codes of conduct for producer associations and make sure they are adhered to	2
	Provide a rewards/incentives scheme or impose fines for performance outcomes	2
	Generate ecological baselines of regional ecosystems to identify critical areas and determine their carrying capacities	2
	Create regional technical consulting experts committees that help regional authorities in decision-making, regarding sanitary and environmental regulations	2
	Promote responsible aquaculture practices among producers, linked to fiscal and administrative incentives (i.e. reduction in the number of technical auditing visits depending on compliance)	2
Existing land sites almost fully utilized	Develop more integrated systems and use recirculation systems	2
	Encourage investors to fully utilize land-based sites and create more	2
	Territorial and coastal zoning should be mandatory and should be the basis for planning aquaculture and other natural-resource demanding activities	2
	An atlas of suitable areas for aquaculture development should be made available to the public	2
Problematic access to land sites (in Mexico)	National Aquaculture Planning should include the creation of “aquaculture parks” which can be areas suitable for aquaculture where basic infrastructure, including year round site access, is ensured. This can stimulate investment	2
	Aquaculture should be included in regional development plans, so that the specific needs (i.e. roads) are met	2
	Regional aquaculture development plans should include cost-benefit analysis of opening access to potential aquaculture sites	2

Negative factors	Containment means	Impact
Maximization of economic profits at the expense of the environment (in Mexico)	Economic valuation of natural resources in areas suitable for aquaculture should be carried out, and, where appropriate, special “ecological service taxes” should be legally implemented	2
	Technical (environmental) auditing visits to farms should be mandatory; depending on the tangible efforts to reduce environmental impacts by the farmers, frequency of visits could be reduced	2
	Identify economic/ecological indicators upon which to base cost/benefit ratios	2
	Determine the “opportunity costs” of resources (i.e. groundwater, swamps) in relation to alternative direct human uses, as well as the ecological services these resources provide	2
Insufficient policies for increasing seafood supply	Continue to develop new products and markets	1
	With a seafood deficit in the United States of America and a declining surplus in Canada, increased seafood supplies will either come from domestic aquaculture or from imports. Given the economic benefits from aquaculture, the former would seem preferable if environmental concerns and societal perceptions can be satisfied. The key is to increase transparency by governments and business	1
	Structured training and professional extension services that include nutritional education, management and technical training to small-scale farmers	2
	Set up demonstration centres where aquaculture technologies can be transferred to local farmers. Centres to be linked to universities and/or research centres	2
	Foster production/market chains both at regional and national level	2
	Stimulate seafood demand through culturally-oriented culinary/nutritional campaigns	1
Policy for managing resources	Improve long-term planning at provincial and federal level	2
	Create regional intersectoral committees where representatives of farmers, government and the academic sector can discuss and recommend, based on scientific evidences, policies and management strategies for the sustainable use of resources.	2
	Continuous monitoring of ecosystems health and assessment of environmental impact, as tools for sustainability assurance	2
	Economic valuation of natural resources used by aquaculture	2
	Creation of an atlas of critical ecosystems and species	2

Negative factors	Containment means	Impact
Desire to have residential waterfront property	Improve communication/promotion of aquaculture as a legitimate user of the water	1
	Coastal planners to weigh negative externalities experienced by property owners against positive externalities from aquaculture	1
	Coastal zoning taking into account traditional land use as well as suitability for harmonious coexistence of human activities	2
	Revise legal tenure of waterfront properties	2
	Atlas of vulnerability of coastal sites suitable for aquaculture	2
Aboriginal land/water claims	Encourage aquaculture operations to be community-minded and improve public image	1
	Use participatory approach when assessing resources and planning aquaculture development	1
	Determine fair price for lease and fair negotiation	2
	Respect legal and/or traditional (aboriginal) tenure of land and water and give priority to human settlements and direct consumption of water	2

Appendix 4.2

FACTORS THAT MIGHT CONTRIBUTE TO REDUCE AQUACULTURE DEVELOPMENT IN THE FUTURE AND PRACTICAL MEANS TO LESSEN/CONTAIN THE LIKELIHOOD OF OCCURRENCE OF THESE FACTORS, WITH RANKING (IN THE "IMPACT" COLUMN, 1 REFERS TO A VERY LARGE POSITIVE IMPACT AND 2 TO A LARGE POSITIVE IMPACT)

Negative factors	Containment means	Impact
Negative media reports about environmental and health risks of aquaculture	Better communication about the positive aspects of aquaculture as well as direct and credible responses to false or misleading claims	1
	Positive media campaign	1
	Have the industry produce media reports on several aspects of aquaculture including social and economic benefits of aquaculture within a context of responsible practices and quality assurance in aquaculture farms	1
	Deliver seminars and talks in universities, chambers and associations on the importance of aquaculture and the measures adopted to mitigate social and environmental impacts	1
	A continuous united effort must be made to get the right message across to the medical profession, nutritionists, and food service specialists. The seafood sector must present a united front for this strategy to be effective – sometimes shellfish farmers want to avoid finfish farmers because of the latter's more publicized issues	2
	A credible agency should be responsible for mediating between opponents and proponents with their often conflicting evidence. A disinterested university would appear most credible	2
Opposition by coastal residents	Improve public consultation and educate public on all aspects of aquaculture (including the positive ones)	1
	Improve public awareness of aquaculture practices	2
	Coastal zoning should define exclusive areas for aquaculture and others exclusive to residences, avoiding resource use conflicts	2
	Participatory approach in planning regional development	2

Negative factors	Containment means	Impact
Increasing residential population near aquaculture sites	Coastal zone management and consultation can alleviate the issue	1
	Properly treat wastewater and sewage properly to keep sites viable	1
	Waterfront property has many uses and if aquaculture on the whole detracts, then local authorities and affluent waterfront owners will be reluctant to allow aquaculture facilities: adopt environmentally-friendly aquaculture	2
	Support traditional activities of resource use in balance with new stakeholder needs	2
	Territorial zoning should include buffer areas and well defined boundaries	2
	Urban planning should be long-term. Likewise, even though areas suitable for aquaculture are usually not suitable for urban development, this sector should plan ahead taking into consideration potential urban growth.	2
Failure to encourage offshore aquaculture and to implement acceptable regulations	Do not allow offshore aquaculture unless government (through taxation of offshore farmers) has a plan to regulate, monitor and enforce standards.	1
	Participatory design of implementation strategies. Presentation of pros and cons based on scientific evidences. These should include all sectors that have a stake	1
	Discourage offshore aquaculture if it is difficult to manage, monitoring is expensive and entrepreneurs have too much at stake (high divergences in experts' rating)	1
	Carry out thorough studies with a holistic approach that produce sound baselines, as well as predictive models on which to base regulations. Permanent contact with sectors should be maintained during the process	2
	Improve regulations and adequately demarcate offshore sites (high divergences due to one expert who believes offshore aquaculture should be encouraged)	2
	Officials and politicians reacting to vocal opposition to aquaculture	In describing the economic benefits of aquaculture and lobbying policy-makers, the industry needs to be more proactive
Call for support of politicians (at all levels) by engaging early, providing balanced information, and focusing on successes		1
Positive media campaigns are needed		1
Create intersectoral and regional experts committees to play a mediating role between the industry, the opposition and the government		2

Negative factors	Containment means	Impact
Growing competition from low cost foreign producers	Offer fresh product/better market access/branded products/safe foods	1
	Create more value added	1
	Diversify into other species and integrate culture of different species	1
	Increase productivity and efficiency as much as economically, socially and environmentally possible	1
	Consolidate production and marketing to gain economies of scale	2
	Encourage international pressure to eradicate dishonest competition	2
	Provide tax incentives to export-oriented companies and differential energy costs to small-scale farmers, while dishonest external competition can be minimized	2
Continuing negative public perception	Better communication about the positive aspects of aquaculture as well as direct and credible responses to false or misleading claims	1
	Positive media campaigns are needed	1
	Introduce intelligent media campaign on the national and local benefits of aquaculture	1
	Publish easy-reading reports of aquaculture news	1
	Create social benefit funds from contributions made by aquaculture companies (high divergences – one expert thinks this is a very bad idea)	1
	The industry should invite journalists to see sites and talk to communities so more balanced information could be disseminated	2
	Conduct more social science research particularly on public perceptions towards aquaculture and how to influence those perceptions	2

Negative factors	Containment means	Impact
Continuing opposition by the fishing industry	Participatory approach in planning aquaculture development that include fishermen's associations	1
	Stimulate diversification and investment on aquaculture by fishing companies	1
	Positive media campaign is needed but with a different spin as aquaculture is seen as straightforward competition	2
	Encourage those in the fishing industry to become farmers (as Norway did)	2
	Governments must explain that in many communities fishing is a sunset industry and must accept the rise of new sectors	2
	Improve public consultation regarding co-existence of the two industries	2
Lack of investors	Positive media campaign is needed	1
	Improved catastrophic insurance, partly subsidized as in agriculture, would reduce financial risk	1
	Make sure investment costs are not being wasted by, for example, protracted and expensive permitting, or copious and unnecessary environmental monitoring	2
	Require long-term planning (strategy) to mitigate barriers to new investments (i.e. federal/provincial regulations)	2
	Make new sites available and get existing sites in the right hands	2
	Improve business risk management through federal programmes	2
	Public-private sector funded demonstration aquaculture centres to provide certainty to potential investors	2
	Co-investment of government/private capital for aquaculture ventures	2

Negative factors	Containment means	Impact
Opportunity cost of capital in relation to alternatives (i.e. less risk or higher returns to capital)	Co-investment of government/private risk capital to stimulate certainty	1
	Make sure investment costs are not being wasted by, for example, protracted and expensive permitting, or copious and unnecessary environmental monitoring	2
	Support growing operations that meet modern challenges	2
	Improve business risk management through federal programmes	2
	Lower interest rates to match those in the agriculture sector	2
	Promote the integration of aquaculture projects taking advantage of already established operations (i.e. breweries, agriculture, feeds, etc.) whose by-products are potential inputs for aquaculture production	2
Resource use conflicts, especially regarding land and water	Involve extensive consultation with the public, federal/provincial agencies and special interest groups, etc., in aquaculture lease/licence review processes	1
	Provide more cost-benefit analysis and not just give priority to the primordial user	1
	Expand integrated management planning and improve regulatory cooperation	2
	Positive media campaign is needed	2
	Territorial zoning according to traditional and potential land use	2
	Establish inter-sectorial regional development plans	2
	This is a natural problem for every industry, and the only solution is to make sure the industry has a good image of efficiency and thrift	2
Environmental externalities	Set up environmental monitoring programs and communicate results to the public	1
	Have a credible agency analyse all environmental and health information/misinformation and disseminate results to the media	1
	Insist on a refundable bond for clean-up	2

Appendix 5

Eastern Europe

Appendix 5.1

PRACTICAL MEANS TO LESSEN/CONTAIN THE IMPACT OF NEGATIVE FACTORS FOR PAST AND FUTURE AQUACULTURE DEVELOPMENT

Negative factor	Practical means
Lack of skilled labour and management	<p>Provide thematic training to existing personnel (in agriculture schools, for example) and organize annual training seminars for management</p> <p>Facilitate access to new technology and information</p> <p>Organize practical training courses</p> <p>Publish information in specialized magazines in mother tongues</p>
Non-optimal conditions for coldwater aquaculture and mariculture	<p>Develop suitable farming technologies for coldwater species</p> <p>Knowledge and application of new technology and information</p> <p>Development of local feed industry</p> <p>Produce fish feed on own farms by partially replacing fish meal with agricultural by-products</p>
Unavailability of quality feed	<p>Accredit foreign feed companies in the country</p>
Drop in consumer demand for aquaculture products	<p>Advertise aquaculture products to increase consumption</p> <p>Increase the average weight of market fish</p> <p>Increase the share of high value species (such as sturgeon, trout) in supply of farmed fish</p> <p>Create value addition through fish processing (such as filleting, smoking)</p>
High price of fish feed and seed	<p>Genetic improvement</p> <p>Modernization of hatcheries</p> <p>Modernization of local feed industry</p>
Limited introduction of commercial species	<p>Allow for more introductions of new high value species (African catfish, paddlefish, marine species)</p> <p>Develop genetically improved broodstock and reproduction and farming technologies of new species</p>

Negative factor	Practical means
Lack of/poor legislative regulatory frameworks	Prepare and implement aquaculture and fisheries law
	Improve and implement institutional frameworks
	Establish new aquaculture and management “rules” and regulations
Tax policy	Have a stable and clear tax policy
Rise in prices of energy and feed ingredients	Implementation of resource efficient (saving) technologies
	Application of polyculture concepts to traditional pond aquaculture
	Comprehensive mechanization of industrial processes

Appendix 5.2

FACTORS THAT MIGHT CONTRIBUTE TO REDUCE AQUACULTURE DEVELOPMENT AND PRACTICAL MEANS TO LESSEN/CONTAIN THE LIKELIHOOD OF OCCURRENCE OF THESE FACTORS

Negative factor	Practical means
New threats, associated with climate change or natural resources	<p>Improvement of prophylactic work against fish diseases</p> <p>Employ non-lethal mechanical devices to scare away predator birds</p> <p>Conduct more studies on the biology of predator birds</p> <p>Make an extensive use of preventive and curative measures against carp herpes virus (RHV)</p>
Lack of integrated coastal management	<p>Development of integrated aquaculture</p> <p>Improvement of rural infrastructure</p> <p>Improve the aquaculture sector management (administration) by concentrating most related services in one ministry</p>
Inappropriate use of water resources	<p>Rational use of water resources</p> <p>Application of recycling systems</p> <p>Legislation on water use and discharge</p>
Development and production economics	<p>Stabilization of tax policy</p>
Technical problems associated with larval/ juvenile production	<p>Application of new water-quality control technologies</p> <p>Application of new artificial starting feeds</p> <p>Build modern hatcheries or renovate existing ones and equip them with modern technologies in the next five years. (The core of the problem is that existing equipment is deficient)</p>
Diseases	<p>Improvement of prophylactic work</p> <p>Application of new medicines and ways of treatment</p> <p>Adopt new ecological methods and drugs to fight infectious and invasive fish diseases</p>
Environmental pollution	<p>Toughen penalties for polluting natural waters</p> <p>Establish and implement environmental law dealing with discharges of untreated sewage waters and cattle-breeding material, <i>inter alia</i></p> <p>Have some aquaculture officers specialize in environmental protection</p>
Site availability	<p>Have clear land laws and policies</p> <p>Ensure annual update of availability of fish farming sites (information supplied by the ministry in charge of aquaculture)</p>

Negative factor	Practical means
Feed availability	Develop local feed industry Improve the position of aquaculture in national economies (this will encourage domestic feed industries)
Lack of environmental regulations	Set up clear policies on environmental protection

Appendix 6

Western Europe

Appendix 6.1

PRACTICAL MEANS TO LESSEN/CONTAIN THE IMPACT OF NEGATIVE FACTORS FOR PAST AND FUTURE AQUACULTURE DEVELOPMENT, WITH RANKING (IN THE "IMPACT" COLUMN, 1 REFERS TO A VERY LARGE POSITIVE IMPACT AND 2 TO A LARGE POSITIVE IMPACT)

Negative factor	Containment means	Impact
Public concerns on the negative impact of aquaculture	Ensure openness and transparency of industry	1
	Improve communication with the public using media more effectively, including preparing scientific-based information for media (articles, TV spots, films)	1
	Provide better information and education to consumers via mass media	1
	Governments, industry and conservation groups to collaborate	2
	Elaborate and implement aquaculture legislations which address issues of public interest such as fish health, environment, etc.	2
Competition over use of coastal resources	Support (through research, incentives) offshore fish farming	2
	Improve water planning and management	2
	Use of improved and resource efficient technologies	2
	Allocate sites among competing activities through the implementation of coastal zone management plans	2
	Extend the leasing period of sites approved and allocated to aquaculture	2
	Promote/adapt integrated aquaculture	2
	Develop closed systems using recirculated water	2
High interest rates for borrowers	Make aquaculture more competitive	2
	Introduce aquaculture-specific loan programmes (e.g. bank loans)	2
	Cooperation with banks (no consensus)	2
Competition from developing countries	Work on quality, and on public perception of quality in aquaculture	2
	Promote research on new species and strains of highly valuable species	2
	Develop market niches	2

Negative factor	Containment means	Impact
Bureaucracy and public administration	Single administrative body in charge of aquaculture to prevent authority overlapping and lengthy procedures (no consensus reached amongst experts)	2
	Have thorough aquaculture legislation, streamlined regulations and an informed administration	2
	Reduce regulatory bottlenecks, included simplified bureaucratic procedures for licensing	2
	Experienced personnel and administrators in charge of aquaculture	2
Environmental protection policies (EPP)	Ensure compliance with appropriate requirements such as those of the WFD (Water Framework Directive)	2
	Impose strict regulations and heavy penalties on farms to reduce environmental impact (prevent escapees, control of sea lice)	2
	More effective monitoring of farms	2
	Develop management tools to assess potential areas for aquaculture development and impose limits on maximum production level in a single site for cage farms	2
	EPP should be clear; the exaggerated power exerted by non competent “free ecologists organizations” should be strongly reduced. Such organizations should be listened to but their “politic power” should be either diminished or made accountable	2
Market access	Further development of farmer partnerships to ensure safe and continuous deliveries	2
	Promote action to open new markets	2
	Joint action of producer organizations	2
	Removal of trade barriers	2
Deficient breeding programmes for important species	Provide support (including grants for basic and applied research on strategic species such as tuna) to breeding programmes	2
	Support for research on domestication of endemic species	2
	Collaborative research across the European Union	2
Increasing importance of nature conservation	Aquaculture must be approached also as an important tool to conserve coastal resources (see valliculture for example)	1
	Increasing importance of economics	2
	Adopt different uses of waterbodies according to ecological status	2
	Development of technologies that protect biodiversity (i.e. waste reduction, minimization of farm escapes, minimal release of disease agents)	2
	Improve water planning and develop water management plans and strategies	2

Negative factor	Containment means	Impact
Increasing public awareness on fish welfare matters	Increase use of quality labels (ecolabelling)	2
	Establish and develop consistent legislation concerning fish health and welfare	2
	Develop regulations on animal treatment	2
	Public education through media: the public must be aware that aquaculture, when well conducted, does not stress fish; it respects welfare conditions	2
	A scientific approach to evaluate the cost of welfare and assess welfare conditions are needed	2
	Define and conduct research on fish welfare	2
	Develop, publish and implement codes of best practices for animal welfare, backed up by force of law	2

Appendix 6.2

FACTORS THAT MIGHT CONTRIBUTE TO REDUCE AQUACULTURE DEVELOPMENT AND PRACTICAL MEANS TO LESSEN/CONTAIN THE LIKELIHOOD OF OCCURRENCE OF THESE FACTORS, WITH RANKING (IN THE "IMPACT" COLUMN, 1 REFERS TO A VERY LARGE POSITIVE IMPACT AND 2 TO A LARGE POSITIVE IMPACT)

Negative factors	Containment means	Impact
Dumping from other countries	Lower costs of production	2
	Bring antidumping cases to the WTO when there is concrete evidence	2
	Strong national, EU control and monitoring of key aquaculture industries and products coming from other EU regions as well extra-EU countries	2
	Dumping cases within the aquaculture industry have chiefly been initiated to protect less efficient producers. Thus, antidumping measures do not represent solutions for structural business problems, which should be solved by policy means other than trade remedies. The only effect of protectionist trade measures is to artificially breed unsustainable industries	2
	EU actions to prevent dumping (no consensus)	2
Falling prices of aquaculture products	Develop strategies that expand niche markets, such as organic products	2
	Focused marketing	2
	Focus on value-added features of products. Both cost leadership and differentiation should be pursued in order to keep product prices at viable levels	2
	Produce more efficiently	2
	Development of highly valuable products	2
Large amounts of red tape needed to obtain licenses	Lobby politicians and policy-makers on the importance of streamlining bureaucracies in order to develop a viable, economically sustainable industry	2
	Have strong, integrated producer organizations that can argue at national and international levels	2
	Small enterprises could undergo simplified procedures	2
	Extend lease period of production sites	2
	Focus on coordinating the different authorities by creating a single administrative body in charge of aquaculture	2
Difficulties to find adequate personnel	Develop better training courses	2
	More attention given to schooling at different levels (vocational and university). Specific MSc's on Aquaculture and Fisheries, not as part of other university curricula	2
	Promote aquaculture education at intermediate and higher levels	2

Negative factors	Containment means	Impact
Cost of feed, labour, energy	Improve feeding systems and feed	2
	Studies should continue to look for alternative sources of feed; promote associations of farmers that produce energy at cheaper costs; seek alternatives to reliance on fishmeal-based diets	2
	Pursue automation and mechanization as a means to reduce staffing	2
Increasing production costs	Explore means of reducing production costs such as greater horizontal and vertical integration of production	2
	The authorities' chief task in this respect is to create a business environment that reduces the regulatory burdens on businesses. An entrepreneurial and business-friendly regulatory regime in tandem with contemporary and future environmental concerns could stall and reverse a trend of increasing production costs	2
	Better farm management	2
	Seek to add value to products, such as development of niche market products, to compensate for increased production costs	2
	Cost of feed and cost of labour should be controlled, together with cost of energy (no consensus)	2
Sanitary risks	Strong control on the quality of the production chain	2
	Regular fish health control	2
	Strict controls of fish movements	2
	Better farm management	2
	Integrated biosecurity strategy on farms	2
	Apply EU regulation of approved/non-approved zones when importing live fish	2
Food safety	Applying provisions for dioxin, antibiotic and metal residues	2
	Adoption of independently audited HACCP, ISO 9000 and other procedures to ensure food safety	2
	Introduction of HACCP procedures, including feed, water, etc.	2
	Control on the quality of the feed components	2

Negative factors	Containment means	Impact
Increased pressure to reduce nutrient loads (especially at sea)	Development of low pollution diets	2
	Research into totally enclosed systems	2
	Improved breeding systems	2
	Development of management tools for assessing potential localities	2
	Improved water planning	2
	Studies on compensative (mitigation approaches) should be carried on (e.g. biotech to increase digestion rate for released organic matters)	2
Environmental sensibility	Increased use of integrated systems – aquaculture/plant production, farmed fish – molluscs and crustaceans, farmed fish – wild fish	2
	To improve good technologies and management, technicians to become aware of environmental limitations	2
	Look for alternative locations	2
Pressure on water resources	Invest in recycling technologies	2
	Diversify products from fish farms through polyculture and integrated systems	2
	Set up well-thought programmes for water utilization, at regional levels. For example, encourage water recirculation technologies and closed systems	2
	Better culture techniques	2
Lack of convenience products	Discussions between producer organizations and buyer groups	2
	Refine existing products	2
	Improve variety of farmed products	2
Failures in marketing	Better use of existing funds by matching public-supported research and the needs of the industry	2
	Direct marketing or contract others to do a professional job	2
	Fund research to identify why marketing has failed and implement actions resulting from research	2
Lack of research funds	Lobby for increased public funding of an industry that is a key employer in parts of the European Union, or contact local political representatives	2
	Increase support rates from the European structural funds	2
	Increase the contribution of private sector for funding aquaculture-related research	2
Population structure	Implement integrated management targeted at minimization of escapes	2
	Funding by government to cover the costs associated with compliance to European norms and standards	2

Negative factors	Containment means	Impact
National and EU legislation	Main focus should be on improving the domestic and Community regulatory regime, and to a lesser degree on protectionism	2
	Negotiate on specific requirements of aquaculture	2
	Close cooperation with the stakeholders in preparation of legislation	2
	Seek harmonization across European countries	2
	Planning on coastal resource utilization, at regional level	2
	Ensure that legislation is fit for purpose	2
Lack of sheltered sites for cage farms; need for offshore cages	Cannot create more sheltered sites, so must develop alternative technologies, such as onshore or offshore culture	2
	Research on offshore cages	2

Knowledge of the technological and socio-economical factors that have contributed to the past development of aquaculture in diverse regions of the world is essential to understand the current challenges facing the sector and to formulate appropriate policies to spur growth in those regions where aquaculture has failed to develop adequately. Because forecasts for aquaculture development cannot be easily extrapolated from historical trends, the Delphi method was used to establish an interactive dialogue on factors and challenges to aquaculture development with experts from all around the globe. Results of this analysis should provide policy-makers with valuable information to assist them in their efforts to promote regional aquaculture development.

