

Review on recent policy and strategy documents prioritizing the needs for supporting sustainable growth of aquaculture in Asia-Pacific

By Patrick White

Background

Aquaculture already makes a significant contribution to food security. At the global level it helps fill the gap between the rising global demands for fishery products and the limited increases in capture fisheries production.

Various studies (FAO 2012, WRI 2010) have recently predicted that the seafood supply from aquaculture and Fisheries will reach around 220 million tonnes by 2050 with aquaculture production achieving a doubling of production over the next 40 years. This can only be achieved by intensification of aquaculture and expansion into new areas.

Fish is highly nutritious, tasty and easily digested. It is much sought after by a broad cross-section of the world's population, particularly in developing countries. It is estimated that around 60 percent of people in many developing countries depend on fish for over 30 percent of their animal protein supplies, while almost 80 percent in most developed countries obtain less than 20 percent of their animal protein from fish. However, with the increased awareness of the health benefits of eating fish and the ensuing rise in fish prices, these figures are rapidly changing.

Aquaculture development in the Asia Pacific region has been driven by the private sector. Originally this was primarily the small scale farmers but more recently larger companies, multinational companies, and investment banks (World Bank, RaboBank etc.) are now starting to invest in aquaculture.

The goal of sustainable intensification is to increase food production from existing aquaculture areas whilst minimising pressure on the environment. Intensification of aquaculture is achieved by increasing inputs and/or improving management (efficiency) of the production system to boost productivity per unit area or per unit volume. This typically means the increased production of aquaculture from a farming unit, through a more "intensive production method. These inputs include increased stocking density, use of improved breeds, artificial feed or fertilisation to increase natural food supplies, health management and increased and improved management or manipulation of the culture environment (e.g. management of water exchange, aeration, wastes, water temperature, nutrients and feeding practices and ecological composition).

Increase in production is also achieved by increasing efficiencies in the production system and value chain. (e.g. improved animal health; feed conversion efficiency, reduction of post-harvest losses).

In some countries, intensifying production from existing land area is not possible (due to environmental carrying capacity limits or other associated constraints) or not necessary (in those countries with very limited aquaculture development, with scope for expanding production area). In these circumstances, intensified production may be achieved by expansion of production area and increased use of inputs to achieved this (e.g. intensified production of seed for stocking, production of more efficient feeds; use of new production technology; improved production methods that reduce mortalities or improve growth).

Increasing the resilience of aquaculture operations also sustains production, or enables production increase, by avoiding the “dropping out” of farmers due to impacts (e.g. flooding, drought, pollution, price crashes etc.) on the viability or economics of their farming activity. It can also be achieved by enabling farmers to invest more effort or resources to increase production, by reducing risks of losses through a more reliable production system.

However, intensifying aquaculture production in a *sustainable* manner is a massive challenge. Intensification of aquaculture has been an ongoing process in the region which aims to increase the productivity and economic efficiency of aquaculture through more efficient use of inputs (materials, energy and investment) and resources (water, land, feed ingredients), application of new technologies and changed production management practices.

The intensification and expansion of aquaculture without proper planning and management has raised increasing concern over the sustainability of the industry due to its impacts on the environment and natural resources and associated socioeconomic issues. There is increasing scarcity of water and land resulting from the population growth in the region as well as more frequent impacts of climate variability and extreme weather conditions. There is competition for other essential resources such as energy, fishmeal, fish oil and other feed ingredients that could also constrain the growth of the industry. Sustainable intensification of aquaculture means *doing more with less*. Aquaculture must become a more efficient user of natural resources, both in terms of farm productivity and efficiency.

Maintaining environmental integrity while increasing productivity will require a reduction in their unit production environmental footprint. Many farming practices that are regarded as sustainable today will simply not be sustainable when conducted on a larger scale.

Sustainable intensification will be the key to maintain the required growth of aquaculture for meeting increasing demand for fish in the region and as well as in the world. It is seen as a key feature of achieving blue growth in the aquaculture sector. Blue growth is defined as:

*Sustainable growth and development emanating from economic activities in the oceans, **freshwaters**, wetlands and coastal zones that minimize environmental degradation, biodiversity loss and unsustainable use of aquatic resources, and maximize economic and social benefits”.*

To understand the way forward in Asian aquaculture intensification, an FAO Regional Consultation on Sustainable Intensification of Aquaculture in Asia and the Pacific was held in Bangkok Thailand from 9-11 October 2012. The consultation was with 47 participants from 17 country governments, 5 international and regional organizations, 6 universities and national think-tanks and private sector.

This review is based on four main initiatives

1. **FAO Regional Consultation on Sustainable Intensification of Aquaculture in Asia and the Pacific** which was held in Bangkok Thailand from 9-11 October 2012. The regional consultation was jointly organized by Asia and Pacific Fishery Commission and Network of Aquaculture centres in Asia-Pacific. This regional initiative was supported by FAO to support sustainable intensification of aquaculture for sustainable growth of the sector in the region to meeting the future increasing demand for fish in the world and contribute to poverty alleviation. At the regional consultation, there were 47 participants from 17 country governments from Asia and the Pacific, 5 international and regional organizations, 6 universities and national think-tanks and private sector. The consultation included 12 thematic presentations from renowned scientists and practitioners covering wide range of subjects related to sustainable aquaculture

intensification, 17 country presentations and extensive discussion on key issues and needs for research and technology dissemination in promoting sustainable intensification of aquaculture. The consultation greatly promoted the sharing of up to date scientific knowledge related to sustainable intensification and relevant experiences and lessons the countries gained in the process of aquaculture development. The key issues related to aquaculture intensification and the priority needs for research and development that were identified by the consultation participants provide an important entry point for country governments, regional and international organizations, academia and other stakeholders in their effort to support the sustainable intensification of aquaculture in the region.

2. **5th APFIC Regional Consultative Forum Meeting** to "Promote sustainable intensification of aquaculture for food and nutritional security in Asia-Pacific" which was held from 19-21 June 2014 in Hyderabad, India. An aquaculture session was held that shared the information on progress made through ongoing initiatives supporting sustainable intensification of aquaculture and highlighted the remaining issues/gaps in sustainable intensification of aquaculture.
3. **SEAFDEC/AQD Regional technical consultation on sustainable aquaculture development** in Southeast Asia towards 2020 (RTC on Aquaculture) held on March 17-19, 2010 in Bangkok, Thailand. This consultation was a preparatory activity for the ASEAN/SEAFDEC Fish for the people 2020 conference. The RTC was held to follow-up the developments on aquaculture after the 2001 Millennium conference on fisheries and to define the strategies for sustainable aquaculture development in the next decade. The "ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security Towards 2020" or "Fish for the People 2020: Adaptation to a Changing Environment" that was held from 13 to 17 June 2011 in Bangkok, Thailand. The Conference identified the priority issues that are envisaged to impede the sustainable contribution of fisheries to food security in the region.

Four other related reports were also included in the overall review, these were;

- **SEAFDEC work programme 2012- 2016** 'Meeting social and economic challenges in aquaculture' (MSECAP) was developed to address the four categories of problems discussed and adopted for development of action plans during the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security Towards 2020, held in June 2011. These issues define the scope and coverage of the MSECAP as follows: (i) enhancing the role of aquaculture in addressing food, income and livelihood security through improved governance, multi-agency collaboration, and comprehensive and inter-disciplinary approaches; (ii) promoting sustainable aquaculture through enabling policies that support the management of natural and environmental resources; (iii) enabling mechanisms, institutions and infrastructure to encourage adoption of better aquaculture practices; (iv) understanding and improving linkages from production to marketing and trade of fishery products to support small and medium enterprise (SME) development; and (v) strengthening the capacity of aquaculture stakeholders by mainstreaming specific rural and peri-urban aquaculture programs and policies in local, national and international development programs.
- **NACA work plan 2014+**. The research and development mandate of NACA is addressed through five interlinked thematic work programmes that support sustainable aquaculture and aquatic resource management, policy development and inter-governmental cooperation in the region. These are 1) Sustainable Farming Systems, 2) Aquatic Animal Health, 3) Genetics and Biodiversity, 4) Food Safety and Certification, 5) Emerging Global Issues. Three additional cross-cutting work programmes facilitate and support implementation of the thematic work programmes: 1) Education and Training, 2) Gender and 3) Information and Communications.
- **WorldFish Research Focal areas**. WorldFish has two strategic objectives: To reduce poverty and vulnerability through fisheries and aquaculture and sustainably increase food and nutrition security through fisheries and aquaculture. To achieve this, the 6 main focal areas

for Research include: 1) Build adaptive capacity to Climate Change impact on fisheries and aquaculture in developing countries. 2) Improve value chain inputs and outputs to increase the value of aquaculture and fisheries. 3) Address gender and equity by strengthening the rights of marginalized fish dependent people reduce inequality and poverty. 4) Improve human nutrition and health. 5) Develop sustainable aquaculture technologies to increase productivity, resilience and development impact from small and medium scale aquaculture. 6) Develop policies and practice for the resilience of small-scale fisheries and aquaculture and increase their contribution to reducing poverty and hunger.

- **Phuket Consensus** (2010) which was a re-affirmation of commitment to the Bangkok Declaration and Strategy adopted in 2000 articulated 17 strategic elements for aquaculture development. The Global Conference on Aquaculture 2010 re-affirmed through the Phuket consensus commitment to the Bangkok Declaration and Strategy for Aquaculture Development and recommended these actions: 1) Increase the effectiveness of governance of the aquaculture sector, 2) Encourage and facilitate greater investments in scientific, technical and social innovations, 3) Conduct accurate assessments of the progress and contributions of aquaculture, including aquatic plants, to national, regional and global economies, poverty alleviation and food security, 4) Intensify assistance to the small farmers, 5) Support gender sensitive policies and implement programmes, 6) Increase and strengthen collaboration and partnerships, 7) Give special emphasis on the least aquaculturally developed countries and areas.

At the 32nd session of the Asia-Pacific Fishery Commission, Member Countries endorsed the following priority areas to enable aquaculture to effectively contribute to regional and global food and nutritional security in the coming decades.

Capacity development

- Strengthen regional capacity in aquaculture planning and management through the development and use of relevant tools.
- Develop a training course to address a regional ecosystem approach to aquaculture.
- Strengthen national and regional capacity in transboundary disease control.
- Enhance the capacity of farmers in effective prevention and control of aquaculture diseases.
- Build capacity for fish genetic improvement in the region.

Regional advice and best practices

- Develop a regional strategy and related guidelines or standards for sustainable use of aquaculture feeds, ingredients and feeding practices.
- Strengthen regulations on good hatchery/nursery operation practices.
- Establish a regional mechanism for effective sharing of aquatic genetic resources.
- Develop appropriate policy and strategies for protecting the interests of small-scale farmers through more equitable benefit-sharing mechanisms along the aquaculture value chain.
- Promote a farmer group approach in implementation of Best Management Practices/Good

Aquaculture Practices and certification.

- Improve the access of small aquaculture producers to mainstream markets.
- Establish appropriate aquaculture insurance schemes and other social safety-nets to reduce the vulnerability of aquaculture farmers to natural and other hazards.
- Improve aquaculture preparedness and integration into broad climate change adaptation planning.

Priority Needs Framework

The synthesized Priority Needs Framework is based on the reviewed documents. It has a two layer structure describing the priority area and priority needs. This is consistent with the outcomes as priority areas and outputs as priority needs.

6.1 Priority area 1. Governance

The FAO definition of Governance covers both: (i) the activity or process of governing; (ii) those people charged with the duty of governing; and (iii) the manner, method and system by which a particular society is governed. In fisheries it is usually understood as the sum of the legal, social, economic and political arrangements used to manage aquaculture. It has international, national and local dimensions. It includes legally binding rules, such as national legislation or international treaties as well as customary social arrangements.

The term governance is widely used nowadays to cover institutions, instruments and processes ranging from short term operational management to long term policy development and planning and from conventional forms of administration to modern forms of participative decision-making processes. Although these activities represent a continuum from the higher to the lower scales of the fishery sector, they tend to be divided in policy (high level governance) and management (medium to low level governance).

Almost every country has a policy on aquaculture, a national strategy and plan and the administrative machinery for regulation, management and development. Even in some countries where aquaculture is still governed, managed & control under the Fisheries Acts such as in Thailand, specific policy and programmes are drawn for aquaculture. However lack of capacity and cost of monitoring, limit the effectiveness of regulations.

For sustainable and responsible aquaculture development there should be facilitating but also controlling legislation and regulations. With most issues dealing with aquaculture inputs, resource use and outputs, there are key common governance root-problems/governance issues. The most common issues include the existence of non-related policies for fisheries and aquaculture, lack of integrated planning, of communication, of understanding of the interactions, of adequate research, of training and insufficient consideration of the different ecological and management scales. In addition implementation is poor or lacking, or the policies, legislation and regulations are not understood by farmers. Responsible government units should translate relevant policies into understandable statements. In general, there is a lack of use of the ecosystem approach to fish production in general.

Priority needs include:

- Promote aquaculture planning tools
- Promote aquaculture management tools
- Training and capacity building program
- R&D for planning and funding
- Aquaculture Zoning
- Area and cluster-based management
- Co-management by public and private sector
- EAA adoption and implementation
- Better management practices, as a supplementary self-regulatory mechanism

6.2 Priority area 2. Regional collaboration and cooperation

The common regional problems present an excellent scope for regional cooperation and the collaborative approach to make efficient use of resources governments and donors and overcome

constraints. Cooperation in areas of mutual interests can effectively muster resources, expertise and institutional support to implement regional projects, promoting synergy, avoiding duplication of activities and expanding the range of beneficiaries.

NACA already provides a mechanism for multilateral cooperation on issues of common interest in the region, and sharing of information on regional developments and concerns in aquaculture.

Priority needs include:

- Regional and international cooperation on aquatic animal health
- Regional and international cooperation on aquatic genetic resources management
- Collaboration on food security, improving socio-economic welfare and improving human nutrition

6.3 Priority area 3. Genetics, Breeding and Seed production

Most Asian countries have a developed seed production facilities for major commercially important aquaculture species. Genetic quality and hatchery production management are equally important in ensuring a sufficient good quality seeds.

Quality seeds can be produced through the use of good hatchery production techniques and methodologies including the use of quality breeding stock, suitable broodstock maturation diets, improved hatchery protocol using enriched live feeds, good quality fry diets, grading and sorting and improved health and nursery rearing protocols.

Quality seeds can also be produced by using appropriate broodstock management methods that can minimize inbreeding which results in performance loss and improved performance of the cultured species using conventional selection methods such as hybridization, mass selection, within family and family selection, or combined selection. However the deteriorating genetic quality of broodstock has been problematic for many years. The difficulty is that many private hatchery operators have the capacity for appropriate/correct broodstock management. There is a need to bring the knowledge of genetic and broodstock management and implement the broodstock management programs.

There are considerable performance gains possible with selective breeding that remain to be captured. The purpose of the genetic selection is to enhance traits such as growth rate, survival, disease/stress tolerance that ultimately lead to the production of good quality seedstock. However only an estimated 10% of the seedstocks used in aquaculture technically come from known genetically enhanced stocks and the remainder of the stocks remain essentially wild type.

For species with no established breeding technologies, and possibly low seed production capabilities, the source of seedstock will be a limiting factor as commercial production would depend entirely on wild seeds.

Priority needs include:

- Genetic improvement through selective breeding
- Broodstock management programs
- Application of molecular tools in broodstock management
- Effective sharing and distribution
- Fish movement regulations
- Responsible live fish movements
- Improve seed production and hatcheries
- Domestication and hatcheries for new species
- National breeding programs

- Good hatchery practice guidelines
- Hatchery training
- Genetic characterisation of genetic resources
- Management guidelines for important genetic resources
- Awareness of genetic and biodiversity issues

6.4 Priority area 4. Biosecurity and disease management

Aquaculture in Asia and the Pacific has grown very rapidly especially during the last two decades, but with intensification a large number of infectious diseases have emerged threatening the sustainability of aquaculture in the region. The occurrence of aquatic diseases has not only severely impacted production and livelihoods, but has also threatened food security.

Like any land-based form of raising livestock where large numbers of animals are placed in a very limited space, aquaculture can provide pathogens with conducive conditions for transmission. In addition with transport of live aquatic animals (such as broodstock, fry, fingerlings) between areas or countries there is a real and substantial risk of introducing new diseases to the receiving area, an event that is routinely observed to occur in the aquaculture industry, often causing massive economic damage. It is likely that intensive aquaculture conditions increase their prevalence within the farm and an increasing risk of transmission of pathogens and parasites between farms.

Biosecurity systems can comprise of measures such as the installation of disinfection baths, dedicated husbandry equipment for each pond, tank or cage, screening of broodstock and seed for diseases, presence of reservoir ponds, water filtration and treatment for incoming and outgoing water and proactive monitoring of the animals and rearing water during the culture. However, even if these measures are already being practiced there is the risk of disease outbreak such as in shrimp farms in Thailand that get affected by EMS.

Effective disease control is a challenge that must be met through the participation of technology providers, technology practitioners, industry associations, regional and national governments, and advisory organizations.

Priority needs include:

- Improving region cooperation in aquatic animal health surveillance, reporting, management and emergency response.
- Developing national aquatic animal health management plans including surveillance, management, emergency response and zonation mechanisms.
- Development of SPF lines of seed for important production species.
- SPF hatchery certification and the agencies accredited to issue the certification
- Capacity building in pathology and molecular diagnostic tools diseases of production significance
- Molecular diagnostic methods for the detection of fish and shrimp viral diseases
- Disease monitoring and reporting
- Regional harmonisation of diagnostic procedures
- Regional harmonisation of the registration of veterinary and nutritional substances used in aquaculture
- Development of vaccines against key production diseases as a safe alternative to the use of veterinary drugs
- Better animal health management practices at farm level
- Contingency planning and disease emergency response mechanisms
- Capacity building (on-farm, watershed, national, regional, international)
- Development of alternative safe drugs

- Genetic selection for disease resistance

6.5 Priority area 5. Nutrition, feeds and feeding

Aquaculture production in the Asia and the Pacific has been increasingly dependent on feeds and this trend will continue as long as resources for the feed production are available. However, there continues to be other culture systems which use either farm made feeds or agro-industrial by-products such as semi-intensive freshwater pond culture. These systems can be intensified using increased or intensified using the same inputs and not resorting to industrial pelleted feeds for example there is a recent trend in shrimp farms in Thailand that are continuing to rely on natural food and reduced inputs.

Fish meal and fish oil are significant components of feeds but they are finite resources, and as such feed producers and feed formulators are optimizing the use of these feedstuffs in feeds and trying to find alternative plant ingredients. There is a lower limit to the inclusion of these feedstuffs in compounded feeds for specific species for culture without loss of efficiency. These alternative resources should come in adequate supply, cheap, effective, and with acceptable quality to consumers. There are also challenges and criticisms to the calculations of fish-in/fish-out ratios and recommendations to consider efficiency of the reduction in terms of protein, nutrients and energy.

The subsector is heavily dependent on “trash fish” or “low-value fish” almost always as the only food source of the cultured stocks. It has been estimated that the marine aquaculture sector in China in 2000 consumed about 4 million tonnes of low-value fish. Demand for trash fish or low-value fish is likely to increase unless viable alternatives are made available and used, and unless the efficacy of use of these feed sources is improved. This is a contentious issue from a resource use view point, reflected in the very high fish to fish conversion rates.

Priority needs include:

- Feed formulation for commercial and farm made feeds.
- Cheap and local ingredients
- Feed quality standards
- Use of fertilisers to boost natural productivity of extensive or semi-intensive systems
- Alternative plant based proteins
- Improved access to feed
- Environmentally sound fertiliser supplies
- More efficient feeding practices and improved FCR
- Conversion from trash fish to compound feed
- Alternatives to fish meal and oil

6.6 Priority area 6. Sustainable production technology and methodology

Sustainable aquaculture technologies focus on increasing aquaculture production and productivity to maximize impacts on food security and livelihoods without compromising the environment or significant social conflict.

There should be focus on determining how to help farmers secure the assets needed to develop productive and profitable businesses. This means working with a range of partners to develop appropriate technologies or implement existing ones, improve management, secure access to essential inputs (quality seed, fertilizers and feed and affordable credit) and improve connections to markets.

Better management practices (BMPs) are defined as the management of activities to increase resource utilisation efficiency, thereby increasing farm productivity and reducing unit production cost. Many BMPs also reduce the environmental impact of aquaculture by reducing resource

consumption and wastage. BMPs are measures that can be implemented by farmers directly to improve their economic returns, without need for third party market or certification systems but follow the standards or guidelines to improve their farm management practices.

By their nature, BMPs refer to a wide range of interventions that can be made to improve or optimise performance in financial, social, animal health, environmental and other areas or sub-categories.

Priority needs include:

- Better management practices for key aquaculture production systems such as intensive pond culture of shrimp, tilapia, carp and tra catfish by on gathering information and documenting good practices and translating them into appropriate forms that could be adapted by the farms
- Improved aquaculture technology particularly for pond and cage culture
- Transfer more efficient technologies
- Target less aquaculture developed countries and countries with the greatest potential for aquaculture
- Transfer of successful technologies

6.7 Priority area 7. Environmental management

The recent growth of aquaculture has had impacts on the environment. Impacts to the environment and ecosystem include habitat destruction and modification, unregulated collection of wild broodstock and seeds, introduction of alien species, including pest species, introduction of exotic pathogens, loss of biodiversity, discharge of nutrient rich aquaculture wastewater, salinization of soil and water. Although efforts have been made by some the countries in the region to increase production and at the same time minimize impacts of aquaculture on the environment, there is still a strong requirement for better environmental management, use of innovative technologies, organic aquaculture and closed systems where possible, etc.

Particulate organic waste from faecal materials and uneaten food in intensive aquaculture production, particularly fish cage culture, has the greatest potential to generate waste. These wastes can enrich aquatic ecosystems and may bring about physical and chemical changes in the water and sediment which may result to anoxic condition in extreme cases. Pond, pen and cage culture systems of both finfish and crustaceans can generate huge amount of organic waste that may cause drastic change to the natural ecosystems adjacent to them.

Whether a nutrient becomes a pollutant in an aquatic system is a function of whether it is a limiting nutrient in a given environment, its concentration, and the carrying capacity of that ecosystem. In fresh waters, phosphorus is typically the limiting nutrient, so its addition will dictate the amount of primary production (algal growth). In marine environments, nitrogen is typically the limiting nutrient, so its addition will do likewise.

Priority needs include:

- More efficient feeds and feeding practices
- Effluent discharge regulations (eg. existing rules under UNEP/GPA on pollution from land-based activities)
- Managing the impact of domesticated stocks on the genetic diversity of wild relatives.
- Environmental impact regulations
- Assess impacts of aquaculture
- Environmentally friendly culture systems
- Better practices for environmental management

- Develop conservation plans for threatened species
- Encouraging the use of Certification schemes (i.e. GAA/BAP, GlobalGAP, ASC-shrimp) which have detailed checklists

6.8 Priority area 8. Stock enhancement and Culture Based Fisheries

Stock enhancement using individuals reared in aquaculture facilities can be a way of supplementing depleted stocks, particularly in inland waters. Stock enhancement is very successful in inland waters, particularly in China. An example of enhancement of marine waters is the scallop fishery in Hokkaido, Japan which has resulted in a four-fold increase in annual harvests. The success in stock enhancement depends on setting the management goals and identifying the right species for release.

However some stock enhancement activities in the marine environment have failed because of lack of proper habitat for released juveniles. Repairs or improvements to water bodies are often conducted to improve production / productivity. There may be some management (e.g. nursing seed to larger size in hapas before release, stocking or harvesting according to expected water draw down schedule etc., controlling access to the water body etc.).

Culture-based fisheries is frequently conducted as a secondary use of an existing water body, for example an irrigation reservoir, and most often is based on the natural productivity of the system (ie. unfed).

Nonetheless, culture-based fisheries have increasingly proved to be an effective means of enhancing fishery resources, income and nutrition of communities or simply improving the productivity of water bodies. Their adoption or application on an expanded scale has in fact been identified as a high-priority item in the agenda for development.

The major types of culture-based fisheries include:

- stocking and restocking in freshwater lakes and reservoirs
- floodplain fisheries management.
- sea/ocean ranching
- coastal lagoon farming
- Crab fattening

Priorities include;

- R&D for CBF
- Develop CBF
- Management strategies to resolve culture capture conflicts
- Stock enhancement for threatened or over exploited species

6.9 Priority area 9. Efficient resource use and avoiding conflicts

Fish in aquaculture systems are very efficient converters of feed into protein – more efficient than most terrestrial livestock systems. For instance, poultry converts about 18 percent of the food consumed and pigs about 13 percent as compared with 30 percent in the case of fish. Most of this difference comes from the fact that fish are poikilotherms (their body temperatures vary along with that of the water in which they live) and therefore do not expend energy maintaining a constant body temperature.

The physical resources available for aquaculture are slowly but steadily declining from numerous pressures (i.e. conversion to other uses, domestic, agricultural and industrial demand on freshwater supply, degradation of the water and soils).

There can be spatial interactions between aquaculture and other users of the aquatic resource. Conflicts are particularly common when aquaculture is introduced into a region where other use of the space is already established. For example, new cage-culture farms can be placed in areas that were formerly used by fishermen directly for fishing or as passage to fishing areas. In many instances, fishermen and fish farmers may gain access to the aquatic system under different sets of rules and legal rights. Where such disparate property systems are not fully integrated and uses are partially or fully exclusive, conflicts are bound to arise. If property rights are ill-defined or if they are spread across a large number of users, then solutions may be difficult to realize.

Priorities include;

- Expansion in new areas (agriculture, irrigated, unused areas and water bodies)
- Access to water
- Improve energy efficiency
- Improve feed and feed use efficiency
- Responsible use of aquatic resources
- Encourage production of low trophic level species
- Develop IMTA systems and find ways to develop a commercial business model.

6.10 Priority area 10. Aquaculture business, livelihoods and farmer resilience

Aquaculture presents considerable opportunities to diversify rural livelihoods – especially in staple, crop-based farming systems that are becoming economically uncompetitive due to their small-scale and relatively low value of staple crops however there are constraints which include good business and financial management, lack of saving habits.

Priorities include;

- Development and extension of better management practices for major aquaculture production systems
- Livelihood development
- Lower production costs
- Stock insurance
- Access to credit
- Risk mapping
- Business training

6.11 Priority area 11. Climate change and natural disasters

Climate Change can affect the ability to achieve good productivity and aquaculture development. For example, increased temperatures can affect productivity both positively (higher winter temperatures) and negatively (extreme pond water temperatures). Also, climate change can affect fishmeal fisheries and reduce availability of related ingredients for aquaculture feeds, although a positive downside to this is that aquaculture can be forced to reduce its dependency on these fisheries.

Climate changes are already being recorded such as more frequent and stronger typhoons, long dry spells resulting to droughts, frequent heavy rains resulting to severe flooding are some of the phenomena that are linked to climate change. These changes are projected to impact broadly across ecosystems and economies, increasing pressures on all livelihoods and food supply chains, including those in the fisheries and aquaculture sector.

Climate change is a compounding threat to the sustainability of aquaculture development. Impacts occur as a result of gradual warming, the increasing acidity of the oceans and associated physical and chemical changes as well as from frequency, intensity and location of extreme climatic events. How

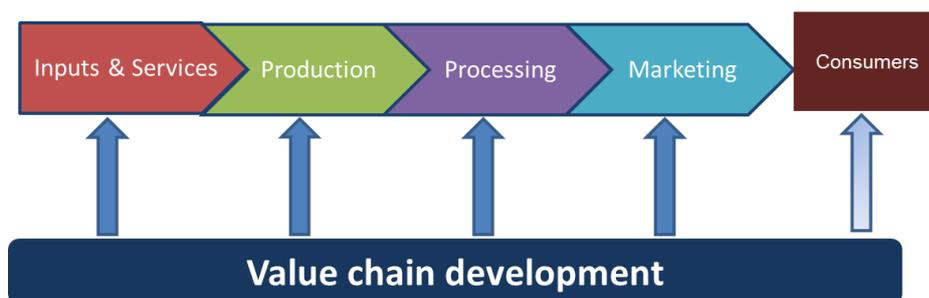
these changes affect the aquaculture organisms in general, the different aquaculture systems and structures, the various support systems to aquaculture operations, and to the fish farmers, are largely unknown.

Priorities include;

- GHG emission reduction and mitigation
- Regional policy for specific risks
- Regional strategy for risks and vulnerability
- Evaluating vulnerabilities of culture systems and productivity
- Evaluating vulnerability of species
- Gather baseline information on impact to ecosystems
- Identify weakness and gaps in National capacity
- Increase information and communication between Government Departments
- Understanding coping mechanisms
- Reduce farmer vulnerability
- Build capacity to respond and adapt
- Strengthening adaptive capacities
- Alternative green energy
- Biofuel production
- Identify CC opportunities
- Genetic tools for climate change adaptation
- Promote awareness to farmers
- Climate smart aquaculture systems

6.12 Priority area 12. Value chain management

Aquaculture producers have discovered that adopting new technologies is often not enough to increase their productivity unless the 'value chain' for their products is enhanced at the same time. The 'value chain' involves the full range of activities required to bring a product to market and includes all the different phases of production, processing, packaging, marketing and delivery to the consumer.



Value chain development may involve one or more of the following:

- Improving efficiency in any of the processes involved in producing, processing and trading a product. For example, by increasing output from the same level of input (efficiency), improving access to or quality of inputs used, or streamlining logistics. This could also include improvement of the business environment.
- Producing or marketing more sophisticated products with increased value per unit;
- Reducing negative impacts of the value chain, such as waste, pressure on natural resources or exploitation of people
- Changing or adding functions, upstream or downstream, in the chain. This often leads to vertical integration in the chain

- Improving coordination between actors in the chain, either horizontally (at the same node in the chain, e.g. fishers associations), or vertically (with actors in other nodes of the chain).

Priorities include;

- Improving efficiency
- Value added products
- Reducing negative impacts (wastes, resources)
- Vertical integration
- Improving coordination

6.13 Priority area 13. Trade and market development

The volume of world aquaculture production is currently becoming closer to the volume of world fisheries production for human consumption. Aquaculture production will continue to expand and have dramatic impacts on markets for wild fisheries. Growth in catfish and tilapia aquaculture has satisfied market demand in the whitefish markets, as harvests of the wild product have decreased considerably. Falling supplies of wild ground fish have also stimulated commercial production of farm-raised cod in Norway. In each of these cases, the aquaculture sector has emerged to increase fish supplies and try to meet the market demand.

The transformation of the supply chain causes greater challenges for both farmers and small- to medium-sized suppliers, while urban consumers tend to benefit from the supermarket revolution in terms of improved economic and physical access to food.

The intra-regional market is becoming important for the trade of seed, feed and fish. Inter-regional markets are important for a limited number of commodities (principally shrimp, tilapia, striped catfish). Since the majority of production is still utilized domestically, there is strong potential for intensified production to creating surplus, leading to gluts and subsequent dumping. The role of the Government be more on properly implementing the present regulations related to trade and negotiation with governments in case of existing trade barriers.

Priorities include;

- Reduce post-harvest loss
- Market research and development
- Consumer advocacy
- Market development for low cost aquaculture commodities

6.14 Priority area 14. Certification and standards

Certification plays an increasing role in driving demands for sustainability. This is exerted through a range of mechanisms such as public certification, third party certification as well as the responsible sourcing arrangements of buyers. The latter is probably the principal driver.

Despite existing standards, not all farms can and do comply and so there is the need to build their capacity to comply.

Priorities include;

- National certification schemes
- Good aquaculture certification and standards
- Consumer awareness
- Build farmer capacity to comply.

6.15 Priority area 15. Food safety

The expansion of aquaculture farming activities over the years has made the health of the culture animals under constant threat from pathogens. In an effort to control the occurrence of such diseases, many farmers use antibiotics and other chemicals without knowing that some could be toxic to humans and pose danger to the environment. Improper use could also induce the development of resistant pathogens in the cultured aquatic species and human consumers and the environment.

The responsible use of veterinary medicines and other chemicals in aquaculture must be included as relevant measures.

Priorities include;

- Implement Food safety regulations for domestic as well as export market
- Strengthen National residue testing and monitoring
- Address human health issues
- Address nutritional needs
- Determine presence and level of chemicals in fish and shrimps
- Status of antibiotics and chemical
- Guidelines on the responsible use of antibiotics and chemicals
- Regional harmonisation of the registration of veterinary and nutritional substances used in aquaculture
- Development of vaccines as alternatives to use of veterinary chemicals

6.16 Priority area 16. Social responsibility, Gender and equity

Some aquaculture farms and their support facilities may have been sited in water bodies or on land to which are shared with other users of the aquatic resource. These areas may be used by coastal communities for fishing, recreation, tourism and other uses. There may be competition between aquaculture and other users of the resources.

Farm work is potentially dangerous because of the types of equipment employed and the nature of the work in and on water. Workers may not fully understand the risks at farms and safety instructions related to them. There is an obligation for employers to provide a safe working environment for employees which are stipulated in the certification guidelines such as ThaiGAP.

A very high number of female workers engaged in fish processing (including in processing factories) and in (informal) small-scale fish trading operations. Gender, along with intersectional factors (such as economic class, ethnic group, age or religion), is a key determinant of the many different ways by which aquaculture affect food security and nutrition outcomes, availability, access, stability and diet adequacy, for the population groups directly involved in fish production and supply chains, but also beyond. Men are dominant in direct production work in fisheries and aquaculture. Much of women's work, such as post-harvest processing and vending, is not recognized or not well recorded, despite its economic and other contributions.

Priorities include;

- A gender analysis of the industry and different culture systems
- Access and use of resources
- Assessing power and decision making
- Pro female development alternatives
- Increase corporate social responsibility initiatives especially of larger farms

6.17 Priority area 17. Small scale producers

Small-scale aquaculture farmers dominate aquaculture production in Asia Pacific nations, contributing around of 80% of total production by volume. While they are innovative and productive, they tend to be poorly organised and suffer many disadvantages in the marketplace due to lack of economies of scale.

Globalisation is both an opportunity and a threat to small-scale farmers. New market opportunities are emerging but international competition is intensifying and market access requirements are becoming more stringent. There is a danger that these pressures, particularly the costs of complying with food safety and environmental requirements, may exclude small-scale producers from the marketplace. There is a need to assist small holders to adapt to these changes and to increase their competitive position and the sustainability of both their production base and thereby their livelihoods. Through a collaborative approach, groups of small-scale producers can cooperate to achieve the economies of scale, improved market leverage and resource use efficiencies required to remain competitive, and to facilitate more effective servicing of the sector.

Priorities include;

- Development of Farmer organisations or groups
- Improving distribution of profits along value chain, particularly to farmers
- Business training
- Capacity building for access to markets
- Improving access to markets
- Cluster based certification
- R&D for climate change impacts
- R&D for markets
- Transfer technologies

6.18 Priority area 18. Emerging issues

The challenge for the rapidly growing aquaculture industry is to develop and apply technologies that ensure sustainable production methods that will reduce environmental damage, increase productivity across the sector, and respect the diverse social and cultural dimensions of fish farming that are observed globally. The aquaculture industry currently faces a number of technology trajectories, which include the option to commercially produce genetically modified (GM) fish. The use of genetic modification in aquaculture has the potential to contribute to increased food security. Other issues include emerging aquatic animal disease problems causing high mortalities and economic losses.

Priorities include;

- Policy guidance on emerging issues
- Regional strategies on emerging issues
- R&D resources for emerging issues

6.19 Priority area 19. Training and capacity building

For a rapidly developing aquaculture industry there has to be a supply of people who have an understanding of how to operate and manage. There is a need also for a supply of trained technicians and graduates to support the farmer in fields such as disease identification and treatment, feed technology, seed production. Many fields of aquaculture use systems and technologies that have been recently developed and are still fast evolving. Typically the necessary techniques are tested in universities or government research centres, sometimes with input from international specialists, and then the methods have to be transferred to outside producers.

Education and Training assists capacity building at all levels is an essential requirement for sustainable development. Activities may take the form of training courses, study visits and personnel exchange.

Priorities include;

- Identifications on training needs and levels of training programmes
- Training manuals and extension materials
- Routine education and training
- Organising exchange programs
- Organise expertise and capacities
- Target key stakeholders
- Develop participatory and transformational learning methods and styles

6.20 Priority area 20. Information and communication

Information Technology and Communications Strategy (ICTS) is now used to bringing into the regional programmes more intellectual inputs and resources without spending a lot more money.

A large factor in the success so far achieved in regional aquaculture development is the cooperation among governments and the coordinated participation of national institutions in regional activities. Coordination has facilitated numerous and diverse activities enabled the pooling of scarce national resources and a wide and equitable sharing of results.

The resources existing in the region that can be brought to bear on aquaculture development are enormous. Getting this vast reservoir of human and physical resources applied and focused on regional priorities would greatly accelerate the expanded development of aquaculture regionally and within states.

Information and Communication Technology would facilitate an effective and economic regional coordination of efforts. NACA has been investing in resources and efforts to enhance the regional information system-which now includes databases that support specific projects as well as special and general information packages.

Priorities include;

- Website information
- Information for farmers that do not have access to electronic communication such as via TVs/DVDs, radio and mobile phones.
- Serial publications with key ones translated into local languages.
- Building capacity in website management and online publication
- Target key stakeholders

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Annex 1. Major policy and strategy documents

The main policy and strategy documents for sustainable intensification of aquaculture are as follows;

The FAO-APFIC-NACA FAO Regional Consultation on Sustainable Intensification of Aquaculture in Asia and the Pacific

The main objective of the regional consultation was to develop a regional strategic policy framework to guide national governments and regional organizations in promoting sustainable intensification of aquaculture in the Asia-Pacific region. The consultation also sought to identify priority actions for the region and, where possible, practical measures for their implementation. The consultation specifically focused on intensifying aquaculture through more efficient use of resources and environmentally sound practices. Farm productivity and environmental performance must be improved through a combination of forward-looking policies, better management practices and technological improvements, rather than by increasing inputs to the system.

The consultation sought to consider the above issues within the prevailing socio-economic context of aquaculture in the Asia-Pacific region – a sector characterized by large numbers of small-scale, family-operated farms that require special attention if aquaculture is to continue to contribute significantly towards their welfare. The consultation sought to identify practical interventions that accounted for this context in order to drive real change. This would provide an important entry point for country governments, regional and international organizations, academia and other stakeholders in their effort to support the sustainable intensification of aquaculture in the region.

The FAO Regional Consultation on Sustainable Intensification of Aquaculture in Asia and the Pacific was held in Bangkok Thailand from 9-11 October 2012. The regional consultation was attended by 47 participants from 17 country governments from Asia and the Pacific, 5 international and regional organizations, 6 universities and national think-tanks and private

sector. The consultation included 12 thematic presentations from renowned scientists and practitioners covering a wide range of subjects related to sustainable aquaculture intensification, 17 country presentations and extensive discussion on key issues and needs for research and technology dissemination in promoting sustainable intensification of aquaculture.

At the consultation presentations were made on knowledge, technologies, management practices and situation analysis across all thematic areas related to sustainable intensification of aquaculture.

Thematic presentations. Resource persons provided their insight on key issues related to sustainable intensification of aquaculture, such as aquaculture inputs, aquaculture health management, trade in aquaculture products, interaction between aquaculture and the environment and the related social and economic issues.

- Aquaculture sustainability towards 2030
- Feeds and Feeding: Problems and plausible approaches in intensification and attaining sustainability
- Marine capture fisheries as a source of food for aquaculture in the Asian Region
- Sustainable intensification in aquaculture production: Role of domestication and selective breeding
- Carbon footprint to move towards sustainability
- Intensification of Aquaculture in Asia-Pacific: The China case
- Role of trade, markets and value chain management in the substantive intensification of aquaculture: The case of Bangladesh
- Planning and management tools for sustainable intensification of aquaculture
- Small farmers: Better practices & challenges in moving towards sustainability
- Promising aquaculture practices for sustainable intensification
- Sustainable intensification of aquaculture value chains: Perspectives from an EU FP7 research project
- The role of the private sector in sustainable aquaculture

Country presentations. Government representatives from 17 countries in the region shared their successful experiences in how to promote the sustainable development of aquaculture through improved planning, management, enabling policy measures and public services.

Working group sessions. The consultation conducted three dynamic working group sessions for developing the regional strategy promoting sustainable intensification in Asia and the Pacific. The working group sessions and their outputs were summarized as follows:

- Working Group Session I: Priority issues and options for sustainable intensification of aquaculture. Participants identified key issues, constraints and opportunities in the sustainable intensification of aquaculture, focusing on key Asian aquaculture commodities and systems in detail.
- Working Group Session II: Development of a regional strategy and action framework to support sustainable intensification of aquaculture. Participants discussed and drafted a regional strategy and action framework for promoting sustainable intensification of aquaculture in Asia and the Pacific with the inputs from the thematic presentations and outputs of previous working group session.
- Working Group Session III: Development of strategy and action framework for promoting the sustainable intensification of aquaculture at the national level. Participants discussed strategies and plans to facilitate sustainable intensification of aquaculture at the national level, drawing on the experience papers and case studies presented by national representatives and outputs of the Working Group Session II.

The 5th APFIC Regional Consultative Forum Meeting

The purpose of the meeting was to share the experiences and progress in different areas related to sustainable aquaculture intensification, to identify the gaps and recommended policy strategies to promote the intensification of aquaculture (SIA) in the region. The specific advantage of the regional approach is that it goes beyond the global coordination activities, which typically involve only project managers and this will also involve a selection of national project coordinators and country representatives.

The Regional Consultative Forum Meeting (RCFM) of Asia and Pacific Fisheries Commission (APFIC) entitled “Responsible management of fisheries and aquaculture in the Asia-Pacific” was held in Hyderabad, India on 19-21 June 2014. The RCFM is an important platform for the government of APFIC members, international and regional fisheries/aquaculture organizations and economic bodies and private sector to discuss hotspot and emerging issues related to the development and management of fisheries and aquaculture in Asia and Pacific region. Based on this consultation, the RCFM draws policy recommendations and relevant strategies for tackling important regional issues pertaining to sustainable fisheries and aquaculture in the region.

The aquaculture session focussed on promoting sustainable intensification of aquaculture (SIA) in the region. Recommendations from the meeting were presented to the APFIC 33rd Session and the Commission recommended further regional consultation to prioritize necessary actions at regional and national levels and to develop strategic action plan for supporting sustainable intensification of aquaculture in the region.

The RCFM identified a number of measures that would promote the sustainable intensification of aquaculture including;

- **Improve the supply of quality seed** of genetically improved strains and diversified species. There are considerable performance gains possible with selective breeding that remain to be captured, since most aquaculture stocks are not highly domesticated or remain essentially wild type. Poor broodstock and genetic management also result in performance loss and these trends will contribute greatly to the improvement of less intensive farming systems.
- **Strengthen aquaculture biosecurity and health management.** Intensified aquaculture requires more efficient feeds and feed utilization. This also links to the impacts of effluents. Feed costs are the major cost of production and therefore sustainable intensification will be highly dependent upon how the feed component of the system can be addressed.
- **Improve the availability of high quality and cost-effective aquaculture feed** and the utilization of the feeds and feed ingredients. Efficient and more digestible feeds can reduce adverse environmental impacts leading to higher yield, cleaner/lower water use systems and thereby contributing to moving towards sustainability. Lowering protein level diets would allow more efficient use of feed resources without necessarily compromising performance.
- **Promote efficient use of land, water and energy.** Aquaculture will increasingly be challenged for space and water in the region and thus innovations will include utilization of new areas for aquaculture and increased water utilization efficiency. At the same time, consolidation of aquaculture production units is occurring with changing labor and ownership patterns.
- **Reduction of environmental impacts of intensified aquaculture.** Intensified aquaculture typically requires increased levels of feeding. This raises the challenge of

management of effluents and impacts on receiving waters. Reduction, recycling or treatment of wastes and effluents from aquaculture facilities becomes an increasing priority. This also links to both farm bio-security and feed use efficiency.

- **Promote Culture-based fisheries** as an option to intensify production of open waters. The open waters of Asia offer considerable potential to increase production of fish from food through responsible enhancement. The promotion of culture-based fisheries (CBF) is likely to deliver more immediate yield increases than the investment in technology of intensive approaches such as feed and breed improvement. This is a complex issue since it relates to access to water bodies, social equity arrangements, and competition of water use as well as biodiversity dimensions.
- **Promote aquaculture as an attractive livelihood.** Aquaculture presents considerable opportunities to diversify rural livelihoods. Aquaculture intensification can offer a more competitive farming strategy that could maximize the productivity of small land units. However, there are risks and constraints associated with the intensification or diversification of small farm systems and these requires specific targeted policy, financial and technical assistance.
- **Increase the resilience of farmers in coping with climate change impacts and natural disasters.** Climate change and climate variability are affecting aquaculture in the Asia-Pacific region. This is seen as increased vulnerability to storm damage, flooding, and unseasonal water shortage. As aquaculture intensifies, so does investment and concentration of assets, increasing the risk of catastrophic loss and consequent adverse impact on livelihoods. Aquaculture also has an obligation to reduce its contribution to greenhouse gas emission and improve its energy use efficiency. Aquaculture also has the potential to contribute to the generation of renewable energy.
- **Facilitate trade and marketing of aquaculture products.** The intra-regional market is becoming important for the trade of seed, feed and fish. Inter-regional markets are important for a limited number of commodities (principally shrimp, tilapia, striped catfish). Since the majority of production is still utilized domestically, there is strong potential for intensified production to creating surplus, leading to gluts and subsequent dumping. There is a market linkage between white fish from aquaculture (e.g. tilapia, striped catfish) that compete in the global market with wild marine capture fishery products (cod, Pollack etc.). In countries with significant inland fisheries (e.g. Cambodia), seasonal or periodic abundance can also result in depressed prices, and this market instability undermines sustainable intensification. Cross border trade between large producing countries can undermine local aquaculture seed and grow-out operations. Markets and prices therefore impact and constrain the economic potential for intensification.
- **Promote aquaculture certification as a driver for sustainability of aquaculture industry.** Certification plays an increasing role in driving demands for sustainability. This is exerted through a range of mechanisms such as public certification, third party certification as well as the responsible sourcing arrangements of buyers. The latter is probably the principal driver.

SEAFDEC/AQD Regional technical consultation on sustainable aquaculture development

The Regional technical consultation (RTC) was held with the following objectives:

- (i) review the progress and development of aquaculture in the region since the 2001 Millennium conference;
- (ii) assess and identify the issues (including climate change) that need to be addressed in the next 10 years to sustain fisheries development; and to

- (iii) define the strategies needed to address gaps and in the context of emerging opportunities and emerging challenges faced by the region.

SEAFDEC/AQD, in collaboration with the SEAFDEC Secretariat, convened the Regional technical consultation on sustainable aquaculture development in Southeast Asia towards 2020 (RTC on Aquaculture) on March 17-19, 2010 in Bangkok, Thailand, as preparatory activity for the ASEAN/SEAFDEC Fish for the people 2020 conference. The RTC was held to follow-up the developments on aquaculture after the 2001 Millennium conference on fisheries and to define the strategies for sustainable aquaculture development in the next decade.

The proceedings contain the papers presented at the meeting and a synopsis of plenary discussions on various themes that are relevant to aquaculture research and development in the region. The outputs of this meeting are expected to help guide SEAFDEC and its partners in coming up with the region's resolution and plan of action for sustainable aquaculture development in the next decade.

Meeting social and economic challenges on aquaculture in Southeast Asia. Faced with rapidly declining production from capture fisheries, aquaculture has significantly contributed in increasing production of fish from Southeast Asia and enabled developing countries to benefit from trade within and outside of the region.

- Enhancing the role of aquaculture in addressing national and regional issues on food security, nutrition, poverty, supplemental and alternative livelihoods, employment and income generation
- Promoting sustainable aquaculture through enabling policies that support the maintenance of natural and environmental resources while taking into account its externalities, costs, resource use conflicts, and environmental impact management measures
- Enabling mechanisms, institutions and infrastructure that encourage the adoption of better aquaculture practices that ensure meeting requirements of various aquaculture certification schemes that will benefit producers at all scales of operations and consumers in local and international markets
- Understanding and improving linkages across various stages (production, marketing and trade of fishery products) by creating an enabling environment with policies and institutions supportive of small, medium enterprises (SME) development
- Strengthening the capacity of small-scale fish farmers, farmers organizations, LGUs and other stakeholders through specific rural and peri-urban development programs

Supply of good quality seed for sustainable aquaculture. Success in sustainable production in aquaculture is largely dependent on the availability of good quality seedstock and optimal husbandry techniques. Quality of seeds is influenced by the broodstock, particularly its source, genetic quality and nutrition; methods used in maintenance of broodstock, hatchery and nursery culture; and modes of harvesting, marketing and distribution.

- Stock availability. Inadequate seed supply and poor quality of broodstock and hatchery-bred seeds in the region
- Domestication and genetic improvement of stocks which include genetic characterization of cultured species
- Marker-assisted selection. Possible negative impacts on biodiversity and retrogression
- or reduction of genetic quality in improved stocks, method for transfer of technologies on strain improvement, and distribution of improved stocks
- Broodstock and hatchery management. Lack of proper husbandry techniques at the larval and broodstock phases to produce good quality seeds; maintenance of genetically improved

stocks; need for fine tuning of nutritional requirements to improve existing formulations and feeding management, including feed quality assessment

- Socio-economic issues associated with genetic improvement. Lack of policy on hybridization, guidelines on genetic and management schemes for production and stock enhancement, issuance of certification for hatcheries which follow Good management practices, contingency plans on what should be done to correct possible mistakes in stocking genetically improved stocks
- Disease management. There are risks associated with translocation of stocks; hence, a clear need for continued improvements in management strategies and their implementation to prevent entry of serious aquatic pathogens
- Effects of climate change. The changes that take place in the aquatic environment due to climate change will have effects on the farming systems and operations; hence, will necessitate the need to develop stocks/ strains that will better adapt to climate change

Healthy and wholesome aquaculture. The frequent occurrences of infectious diseases in aquatic animals and irresponsible culture practices have threatened the sustainability of aquaculture.

- **Nutrition to promote healthy farmed aquatic animals**
 - Effective feed management lacking.
 - Fish meal substitutes not adequately studied.
- **Disease diagnosis, control, monitoring and surveillance of aquatic animals**
 - Diagnostic procedures favouring intensive & large-scale operators.
 - Investigations lacking to prove efficacy of probiotics.
 - Promotion and wider application of biosecurity needed.
 - Transboundary diseases.
- **Environmental integrity, certification and food safety**
 - Over-development of aquaculture that exceeds the carrying capacity of the environment leads to water pollution, fish kills and other environmental problems
 - Contamination of fish meat with industrial, agricultural & domestic wastes causes off-flavours and consequently product rejection and other marketing problems
 - Emergence of zoonotic disease agents; spread of disease to wild fish populations
- **Protecting the environment and adapting to climate change.** Much of the current controversy is centered on the continued destruction of the aquatic environment and resources due to irresponsible aquaculture practices.
 - **Protecting the environment.** Increasing pressures on natural resources, such as water and habitats, and awareness of the importance of improving environmental management in ASEAN, will continue to drive the aquaculture sectors towards reduction of the impacts of aquaculture on the environment, and making more efficient use of natural resources for aquaculture.
 - **Adapting to climate change.** Although aquaculture contributes less to climate change, ways on mitigating greenhouse gas emissions from aquaculture are needed. There are adverse changes in the physico- chemical parameters in fresh- and sea water due to climate change, particularly on those that might affect the growth and survival of aquaculture species. Aquaculture can also be an adaptation solution, for example as a livelihood option for agriculture farmers in coastal areas affected by saline intrusion due to sea-level rise, for water storage in drought affected regions