



## Promoting Sustainable Aquaculture Development to Increase Fish Supply and Improve Livelihoods of Rural People in Southeast Asia

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The most crucial challenges for the countries of Southeast Asia today are combating poverty and improving food security in the rural sector. The World Bank reported that the problem is most acute and widespread in Southeast Asia where over three quarters live in rural areas (Shah, 2011). To address this challenge, the governments in many countries in the region have identified aquaculture as one of the sectors that could help support their drive towards addressing food security agenda and combating poverty. Edwards (2000) outlined the potential contributions of aquaculture to the livelihoods of the rural poor (**Box 1**). In terms of human nutrition, the contribution of aquaculture is significant, with fish being one of the main sources of animal protein, vitamins, minerals and fatty acids. Southeast Asia relies heavily on fish for food and for protein (Hishamunda *et al.*, 2009). Fish and other aquatic products are seen as good sources of animal protein and other nutrients for vulnerable groups, particularly those in the coastal areas. Apart from the importance of aquaculture in nutrition, it is also seen as a major agent for economic growth, especially in generating employment, trade and export earnings.

Aquaculture, especially commercial aquaculture, can provide employment not only through fish farming activities

*per se*, but also through the employment opportunities generated in the aquaculture support industries or those induced by aquaculture (FAO, 2008). For instance in Vietnam, more than a half million people are employed in aquaculture. For the country's policy makers, aquaculture is a tool for rural diversification – providing jobs and alternative to urban migration (Hishamunda *et al.*, 2009).

### Promotion of Sustainable Aquaculture in the ASEAN Region

Recognizing the immense benefits that could be obtained from aquaculture in terms of addressing food security and in meeting the country's developmental goals, the Southeast Asian Fisheries Development Center (SEAFDEC) and the Association of Southeast Asian Nations (ASEAN) have joined hands to address in a concerted manner the important issues that would affect the sustainable development of aquaculture for food security, especially in the rural communities. During the ASEAN-SEAFDEC Millennium Conference in 2001, the concerned Ministers from the ASEAN and SEAFDEC countries adopted the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region (SEAFDEC, 2001). This Resolution and Plan of Action which included a component

### Box 1. Potential contribution of aquaculture to the livelihoods of the poor

#### Direct benefits

- Food of high nutritional value, especially for vulnerable groups such as pregnant and lactating women, infants and pre-school children
- Own enterprise' employment, including those for women and children
- Income through sale of relatively high value fish products

#### Indirect benefits

- Increased availability of fish in local rural and urban markets, which could bring prices down
- Employment on larger farms, in seed supply networks, market chains and manufacture/repair functions
- Benefit from common pool resources, particularly the landless, through cage culture, culture of mollusks and seaweeds, and enhanced fisheries in communal water bodies
- Increased farm sustainability through: (i) construction of ponds which also serve as small-scale, on-farm reservoirs; and (ii) rice/fish culture as a component of integrated pest management

Source: Edwards, 2000

on aquaculture served as policy framework that steer the ASEAN countries towards sustainable development and enhanced the contribution of fisheries to food security in the region (Pongsri, 2009).

The 2001 Resolution on aquaculture (SEAFDEC, 2001; Ekmaharaj, 2008) stipulated the need to: "Increase aquaculture production in a sustainable and environment-friendly manner by ensuring a stable supply of quality seeds and feeds, effectively controlling disease, promoting good farm management and transferring appropriate technology"; and "Promote aquaculture for rural development, which is compatible with the rational use of land and water resources, to increase fish supplies and improve the livelihoods of rural people". On the other hand, the provisions in the 2001 Plan of Action in relation to aquaculture are shown in (Box 2).

## Implementation of the 2001 Plan of Action by Member Countries: Aquaculture

To assess the implementation of the progress of the Resolution and Plan of Action adopted in 2001 in various aspects (themes) of aquaculture and consequently to assist the Member Countries in defining the next decade's strategies for sustainable aquaculture, SEAFDEC/AQD convened the three-day Regional Technical Consultation (RTC) for Sustainable Aquaculture Development of Southeast Asia Towards 2020 in March 2010 in Bangkok, Thailand (Acosta *et al.*, in press). During the RTC, the representatives from the SEAFDEC-ASEAN Member Countries reported on the status of implementation of the 2001 Plan of Action on the various aspects of aquaculture in their respective countries, which is summarized below.

**Supply of good quality seeds.** Most countries still have problems in supply of good quality seeds as seeds for stocking are either gathered from the wild or imported from neighboring countries (for example, in the case of Brunei Darussalam and Cambodia). In Malaysia, while mass production of fishes and shrimps is being done, the country is still very much dependent on the wild for the supply of seeds especially for mollusks and mud crab.

For freshwater species, genetic improvement programs have progressed in some of the countries particularly on tilapias (Indonesia, Malaysia, Philippines, Thailand, and Vietnam) and carps (Indonesia, Malaysia, Thailand and Vietnam). Depending on the status of their breeding programs, improved strains of these commodities are already available and are being disseminated to the farmers through their respective government and private sector hatcheries. Reports also indicated that while some of these countries have established their own breeding programs, majority of the countries especially at the farmers' level, lack the capacity to maintain the good quality broodstock and seeds. There are also issues which need to be addressed in terms of dissemination of good quality seeds (especially the improved strains) and in making these accessible to a wide range of farmers.

**Environment-friendly aquaculture.** There is now an increased awareness and realization among the ASEAN countries on the importance of implementing environment-friendly aquaculture practices. Majority of the countries have initiated actions that will minimize the negative impacts of aquaculture activities on the environment. Policy guidelines (*i.e.* through responsible aquaculture) and various laws are being formulated and enacted to protect the fisheries habitats/aquatic environment and avoid degradation. However, weak enforcement of regulations and other constraints (for instance, lack of funding, institutional capacities and public awareness) are very much evident in most of the countries in the region and these restrict the successful implementation of the guidelines and regulations.

**Getting out of the fish meal trap.** Almost all of the country representatives reported that fish meal and fish oils are widely used as dietary component in feed formulations particularly for intensive fish and shrimp farming. The country reports also indicated that most of the countries are still dependent on imported ingredients for the manufacture of commercial feeds for farming of aquatic species.

There is also an increasing recognition of the need to reduce dependence on fish meal and other fish-based products; hence, efforts in majority of the countries are underway in terms searching for alternative protein source



**Box 2. 2001 Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region - Aquaculture**

- Ensure that national policies and regulatory frameworks on aquaculture development are directed towards sustainability and avoidance of conflicts
- Ensure production of high quality seeds on a consistent and sustainable basis
- Promote good management practices that reduce effluent pollution load and comply with relevant effluent standards
- Reduce the risks of negative environmental impacts, loss of biodiversity and disease transfer
- Improve the efficient use of aquatic feeds by regulating the quality of manufactured and feed ingredients
- Improved capabilities in the diagnosis and control of fish diseases
- Formulate guidelines on the use of chemicals in aquaculture, establish quality standards, and take measures to reduce or eliminate the use of harmful chemicals
- Build human resource capabilities for environment-friendly, healthy, wholesome and sustainable aquaculture
- Promote aquaculture as an integrated rural development activity

Source: SEAFDEC, 2001

biotechnological innovations include development of genetically superior strains of fishes, development of feed that provide balanced and nutritious diets, vaccines and immune-stimulants to improve diseases resistance, and molecular tools for fast and accurate disease diagnosis. Efforts are also being made on genetic marker development and research on probiotics for diseases prevention and control in aquaculture. Among the Member Countries, Thailand has achieved much progress in biotechnology research. The gap however, lies in enhancing education to develop new and more advanced biotechnology techniques to improve production, reduce costs and bring product quality to international standards. Moreover, further efforts should be made to bring the benefits of biotechnology research to aquaculturists and to a wide range of farmers.

**Aquaculture for rural development.** Promotion of aquaculture activities for rural development is an important priority of the Member Countries. In majority of the countries, cultivation of freshwater fish is mostly done, which includes small-scale backyard farming especially in rural communities. In some of these countries (for instance in Cambodia), local and international NGOs have been collaborating closely with the governments to develop rural aquaculture, especially in poor communities.

In rural communities where culture-based fisheries are being practiced (for instance, in Thailand), strong coordination/cooperation arrangements are still needed to effectively address the concerns of many farmers, particularly the marginalized groups. Moreover, the Government's strong support to rural aquaculture through development projects and extension programs is strongly needed to ensure that the rural people will also benefit from the technologies developed through aquaculture R&D.

**Summary.** Country reports indicated that while progress has been made in the ASEAN countries in terms of implementing the 2001 Resolution and Plan of Action on Aquaculture, there were constraints and issues which still need to be addressed (**Box 3**).

as feed ingredient. Most of the countries have also begun implementing policies that will regulate the quality and use of manufactured feeds and feed ingredients.

**Healthy and wholesome aquaculture.** Efforts are being made by most of the countries to promote healthy and wholesome aquaculture. In Cambodia, although disease outbreak in aquaculture has never occurred and is not yet a problem of fish farmers, the Government has begun preparing guidelines and creating standards to promote environment-friendly aquaculture. In most of the countries, the strategies that are being implemented include: building the capacity of national staff on fish health and management; intensive information and communication campaign for good aquaculture practices (GAqP) for different species and aquaculture systems; implementation of HACCP at the farm level and other food safety programs; full traceability system for aquaculture production; registration and accreditation of hatcheries and farms; and establishment of early warning systems for diseases.

**Biotechnology for aquaculture.** Except in a few countries with more developed aquaculture, limited biotechnology R&D is being undertaken in most of the Member Countries due to lack of capacity (human and infrastructure). In Cambodia, Myanmar and Lao PDR, biotechnology application is mainly on the use of hormones in fish breeding. In Brunei, apart from hormone treatment of tilapia, the aquaculture industry undertakes research on propagation of Specific Pathogen-free (SPF) shrimp and later, on fish.

In countries with more developed aquaculture (*i.e.* Indonesia, Malaysia, Philippines, Thailand, and Vietnam),



Fisherfolks learning to prepare marinated deboned fish (Guimaras, Philippines)

### Box 3. Issues and constraints in the sustainable development of aquaculture in the region

<p><b>Supply of good quality seeds</b></p> <ul style="list-style-type: none"> <li>• Inadequate and unreliable supply of good quality seeds for stocking</li> <li>• Seasonality and inconsistency of seed production</li> <li>• Reliance on the wild and neighboring countries for source of seedstock; imported stocks are sometimes found weak and of poor quality</li> <li>• Inconsistent supply of disease-free fingerlings; quality and health of fish seed need to be addressed</li> <li>• Government fishery stations are bound to meeting seed production quotas; prioritization of quantity could compromise quality of seed</li> <li>• Limited capacity and knowledge of farmers on broodstock management</li> <li>• Breeding programs in some Member Countries are progressing; however, there is lack of mechanism and funding support for long-term maintenance of genetically improved strains</li> </ul>
<p><b>Environment-friendly aquaculture</b></p> <ul style="list-style-type: none"> <li>• Increasing incidence of water pollution due to improper use of artificial feed</li> <li>• Negative environmental impacts associated with intensification of aquaculture</li> <li>• Poor implementation of policies, regulations (e.g. zoning, limits in number and size of farms) that will promote environment-friendly aquaculture at the local/community level</li> </ul>
<p><b>Getting out of fish meal trap</b></p> <ul style="list-style-type: none"> <li>• Aquaculture sector relies heavily on imported commercial feed ingredients (fish oil, fish meal)</li> <li>• By-catch from fishing vessels are continuously utilized for local consumption and fish meal; the practice contributes to stock depletion of fishery resources</li> <li>• Mud crab and marine fish farming are heavily dependent on trash fish</li> <li>• Lack of knowledge on effective feeding management (including feed formulations)</li> </ul>
<p><b>Biotechnology for aquaculture</b></p> <ul style="list-style-type: none"> <li>• Lack of knowledge and capacity on biotechnology techniques</li> <li>• Lack of funding support</li> <li>• There is a need to enhance education and capacity building programs on advanced biotechnology techniques</li> </ul>
<p><b>Healthy and wholesome aquaculture</b></p> <ul style="list-style-type: none"> <li>• Several farmers still import fingerlings for stocking; hence, increasing the chance of transfer of pathogens</li> <li>• Reliance on prophylactic drugs; residues of chemicals in aquatic products pose food safety and health risks</li> <li>• There is a need to establish and strictly implement standards, and guidelines to control the use of chemicals in aquaculture</li> <li>• Incidence of diseases was reported in some countries due to intensification of farming and improper use of feeds (e.g. WSSV disease outbreaks reported in commercial shrimp farms)</li> <li>• Lack of staff with expertise on aquatic animal health</li> </ul>
<p><b>Aquaculture for rural development</b></p> <ul style="list-style-type: none"> <li>• Aquaculture development in rural areas remain at very low level</li> <li>• Development programs on aquaculture in poor communities are affected by social problems (e.g. poaching)</li> </ul>
<p><b>Socio-economics</b></p> <ul style="list-style-type: none"> <li>• Cost of production increasing due to widespread use of commercial feeds</li> <li>• Investments in mariculture high and not affordable to several farmers</li> <li>• Lack of training and extension programs for mariculture; lack of extension workers</li> <li>• Difficulty of most farmers to meet the stringent requirements and standards for export of aquaculture products</li> <li>• Weak institutional partnerships and linkages among government agencies, civil society and the private sector</li> <li>• Poor link of small-holder farmers (small-scale producers) to the market chain</li> </ul>

## Initiatives of AQD

SEAFDEC/AQD has been at the forefront of promoting and harnessing the potential of aquaculture in the region to help address the looming scarcity in fish supply and alleviate poverty. AQD supports the member countries through its primary role in development of aquaculture technologies that are environment-friendly and are suitable to the needs of the region. To ensure that AQD addresses the areas of concern of responsible aquaculture development (i.e. technology feasibility, food safety, socio-economic viability, and environmental integrity), the Department has used the Resolution and Plan of Action on aquaculture as the overall framework for implementation of its programs (SEAFDEC/AQD, 2009). As such, AQD's R&D activities in the region have always been guided by the priorities, which focus on the: (1) Development of responsible

aquaculture technologies and practices; (2) Responsible use of aquatic genetic resources for the purpose of aquaculture; (3) Adoption of measures to avoid environmental degradation; and (4) Promotion of environmentally sound culture methods and commodities.

AQD supports the implementation of the Resolution and Plan of Action through research and development in the priority areas of broodstock development and seed production, farming systems and ecology, nutrition and feed development, fish health management, and socio-economics. Through these efforts, AQD has generated and transferred a number of aquaculture technologies as shown in **Box 4**.

To disseminate the above-mentioned aquaculture technologies developed by AQD, 391 international and

#### Box 4. Aquaculture technologies generated and transferred to the region

- Multi-species marine fish hatchery (to raise milkfish, sea bass, grouper, snapper and rabbitfish)
- Milkfish grow-out culture in modular ponds, pens, and cages
- Grow-out farming of marine fish
- Mud crab hatchery, nursery and grow-out in brackishwater ponds and mangrove pens
- Abalone hatchery, nursery, and grow-out in cages
- Environment-friendly shrimp farming in brackishwater ponds
- Tilapia and bighead carp hatchery and grow-out in ponds and/or cages
- Seaweed farming
- Feed formulations for several farmed aquatic species

local training courses had been conducted and 12,500 participants from various stakeholder groups from 50 countries had been trained. In terms of publications, from 2005 to 2010, AQD already published 161 scientific papers, 99 of which are in internationally peer reviewed scientific journals (ISI-CC covered journals). Through such research publications and achievements in developing a critical mass of experts, AQD has been widely recognized for its important contributions in the sustainable development of aquaculture in the Southeast Asian region.

### Strategies for Sustainable Aquaculture Development in the Next Decade

Aquaculture has shown rapid growth and has continued contributing to national economic development. In Southeast Asia, Hishamunda *et al.* (2009) reported that from 2000 to 2006, the annual average growth rates in total aquaculture output (including aquatic plants) more than doubled those from 1990 to 2000. However, despite its good prospects, the aquaculture sector in the ASEAN countries is still facing new challenges as it moves towards the goal of sustainability.

During the March 2010 RTC on Aquaculture, the participants discussed the key issues on aquaculture in the next decade and formulated strategies on how to address such issues. The list of issues and recommendations focused on: (i) Meeting Social and Economic Challenges of Southeast Asian Aquaculture (**Box 5**); (ii) Quality Seed Production for Sustainable Aquaculture (**Box 6**); (iii) Healthy and Wholesome Aquaculture (**Box 7**); and (iv) Protecting the Environment and Adapting to Climate Change (Acosta *et al.*, 2010).

Success in sustainable production in aquaculture is largely dependent on the availability of good quality seed stock 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, and hatchery and nursery culture; and modes of harvesting, marketing and distribution.

Moreover, significant progress has been achieved in improving the quality of seed stocks, particularly on the tropical finfish, through breeding and genetics. However, issues related to sustaining the genetic gains from breeding research, maintenance and availability of and accessibility to quality seed still constrain the growth of the aquaculture industry.

The frequent occurrences of infectious diseases in aquatic animals and irresponsible culture practices have threatened the sustainability of aquaculture. There is certainty that in

#### Box 5. Meeting social and economic challenges of aquaculture in Southeast Asia

##### ISSUES

- Commercial aquaculture has grown fast leaving behind many small-scale/small-holder aquaculture operations in Southeast Asia
- Inequitable distribution of opportunities and benefits especially for aquaculture farmers in rural areas
- Misuse of aquatic resources for aquaculture purposes
- Mechanisms and infrastructures that will encourage adoption of better aquaculture practices by farmers at all levels are still lacking

##### RECOMMENDATIONS

- Enhance the role of aquaculture (contributions and impacts) in addressing national/regional development issues
- Promote sustainable aquaculture through enabling policies, mechanisms, institutions and infrastructure that encourage the adoption of better aquaculture practices
- Address emerging issues on the impacts of climate change and global trade on aquaculture with emphasis on small-holder fish farmers
- Enhance multi-agency collaboration between and among stakeholder groups
  - Improve linkages and strengthen the capacity of various stakeholder groups

#### Box 6. Supply of good quality seed for sustainable aquaculture

##### ISSUES

- Inadequate seed supply and poor quality of broodstock and hatchery bred seeds
- Possible negative impacts on biodiversity and reduction of genetic quality in improved stocks
- Lack of proper husbandry techniques at larval and broodstock phases to produce good quality seeds
- Lack of policy, guidelines on genetic management schemes
- Risks associated with translocation of stocks
- Climate change effects on farming systems and operations

##### RECOMMENDATIONS

- Build and/or further strengthen public-private sector partnerships
- Governments need to establish, strengthen and maintain links with major players in seed production and distribution chains
- Small-scale farmers to seek assistance from the Government to (i) build capacity in adopting new simple technologies and innovations, (ii) gain access to quality broodstocks and seeds, (iii) establish effective marketing channels
- Scientists to continue doing research on existing genetic resources and improvement
- Key players must establish links to collectively address genetic issues, support sound policies and promote implementation of better farm management practices



## Box 7. Healthy and Wholesome Aquaculture

### ISSUES

#### Nutrition to promote healthy farmed aquatic animals

- Need for more effective feeding management
- Fish meal substitutes not adequately studied

#### Disease diagnosis, control, monitoring and surveillance for aquatic animals

- Diagnostic procedures favouring the intensive and large-scale operators
- Investigations lacking to prove efficacy of probiotics
- Promotion and wider application of biosecurity needed
- Transboundary diseases

#### Environmental integrity and food safety

- Over-development of aquaculture that exceeds the carrying capacity of the environment
- Contamination of fish meat with domestic wastes
- Emergence of zoonotic disease agents and spread of disease to wild populations

### RECOMMENDATIONS

#### Nutrition to promote healthy farmed aquatic animals

- Fast-track the search for suitable alternative fish feed ingredients
- Good and thorough evaluation of fish meal substitutes in artificial feed
- Assess viability of alternative protein sources
- Social and cultural acceptance of consumers to be considered in search of alternative feeds
- Promote the culture of species that require no or low fish meal diet
- Develop and apply good feeding practices

#### Disease diagnosis, control, monitoring and surveillance of aquatic animals

- Widespread use of standardized diagnostic tests
- Heighten the understanding of diseases in rural communities through training and provision of simple manuals
- Encourage the use of levels 1 and 2 diagnostic techniques in small-holder and rural communities
- Governments to provide support to facilitate the use of affordable, field friendly method of detection and screening of diseases
- Continue support for training of fish health specialists to develop capability for fish disease diagnostic techniques
- Conduct large-scale field trials or evaluation surveys to scientifically assess the efficacy of probiotics and immunostimulants
- Apply widely the concept of biosecurity (through Good Aquaculture Practices; compliance to Code of Conduct)
- Develop domesticated and genetically improved SPF stocks for all cultivated species
- Government to engage in high health broodstock development to facilitate access to small-scale hatchery operators
- Enhance collaboration among agencies to control serious disease outbreaks
- Member Countries to support coordinated regional initiatives to handle new and emerging diseases
- Extend surveillance of diseases to wild population of aquatic animals

#### Environmental integrity, certification and food safety

- Create and enforce regulations to avoid conflict in use of common resources
- Member Countries to support and participate in initiatives to set up coordinated Asian regional standards, certification
- Develop and promote environment-friendly aquaculture systems
- Meet food safety requirements and ensure that aquaculture products do not contain biological/chemical hazards

the next decade, practices that threaten food safety and create negative impacts on the ecosystem (for instance, the indiscriminate use of antibiotics, chemicals, and abuse in the use of fish meal and fish oil in commercially available artificial feeds) will continue. To assist the Member Countries in addressing the problem, SEAFDEC has been promoting the concept of a 'healthy and wholesome aquaculture'. The concept, which was adopted as part of the 2001 Resolution, is a holistic approach to fish disease management for food safety and security (Lavilla-Pitogo *et al.*, in press). It also promotes the use of efficient feeds (cost effective and low polluting) to optimize production of robust and healthy farmed aquatic animals with the least negative impact on the environment.

## Box 8. Adapting to Climate Change

### ISSUES

- Aquaculture contributes less to climate change; finding ways to mitigate greenhouse gas emissions from aquaculture still needed
- Adverse changes in physico-chemical parameters in fresh and seawater due to climate change (water acidification, warming of water temperature, rise in seawater levels and drought)
- Research needs/strategies that will help aquaculture sector adapt better to climate change is another big challenge in the region

### RECOMMENDATIONS

#### Mitigating emissions of greenhouse gases from aquaculture

- Review energy consumption in aquaculture and greenhouse gas emissions associated with direct energy inputs
- Define strategies for mitigating gas emissions from aquaculture

#### Adaptation techniques

- Conduct mapping of aquaculture sites that are vulnerable to climate change
- Identify aquaculture species, strains, farming systems, techniques that will adapt better to climate change
- Assess and improve infrastructures/habitat to ensure safety of coastal farming/fishing communities
- Enhance awareness on the importance of aquaculture/fisheries in climate change initiatives
- Increase resilience and overall capacity of various stakeholder groups on aquaculture to enable them to adapt to climate change. Capacity building and knowledge transfer are strategies that could strengthen the stakeholders
- Improve cooperation within the aquaculture sector and with other sectors

## Box 9. Protecting the environment

### ISSUES

- Excessive use of antibiotics and chemicals
- Abuse in feeds and fertilizers

### RECOMMENDATIONS

- Implement stricter monitoring and control to avoid excessive use of antibiotics and other chemicals in aquaculture
- Improve feeding and fertilization management and efficiency and develop effective substitutes for fish derived feed ingredients
- Improve the management of aquaculture sector and strictly enforce regulations to ensure activities are carried out in an environment-friendly manner

## 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. SEAFDEC and its Member Countries are strong supporters of the FAO Code of Conduct of Responsible Fisheries (CCRF) and have committed to responsible aquaculture. However, despite the progress on SEAFDEC initiatives that promote the CCRF, and as pressures increase on the natural resources of the region, the ASEAN aquaculture sector is still confronted with issues related to environmental protection and wise and efficient use of resources. Increasing the efficiency in aquatic resource use and minimizing adverse environmental interactions and impacts due also to climate change (**Box 8** and **Box 9**) will continue to be the priorities for the next decade.

## Conclusion

The issues and recommendations of the 2010 RTC on Aquaculture shall be presented at the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security in June 2011 to refine and finalize the resolution and plans of action on aquaculture towards 2020. These strategies are expected to make aquaculture in the region sustainable for future generations, improve the economies of the ASEAN countries, and uplift the lives of rural folk in the region.

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