Capacities for Managing the Development of ASEAN Aquaculture

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Two core capacities are necessary to manage the development of any economic sector, *e.g.* fisheries. These are **governance**, in order that development is geared to the goals of society, directed towards those goals, and growth is orderly; and **innovativeness**, so that the resources are utilized with utmost effectiveness and efficiency, and producers have the ability to supply products in the quantity, reliability and form that meet market requirements, anticipate demand, and better yet, create demand. These two are linked: **good governance** provides a favorable environment as well as encouragement for science and technology -- and the brains that produce them -- to flourish; while **innovations** not only enhance the progress and welfare with new products, systems and processes but also support and facilitate better governance. In December 2015, full economic integration came into reality in the ASEAN with the establishment of the ASEAN Economic Community (AEC) which aspires to be a single market and production base, a highly competitive economic region, a region of equitable economic development, and a region fully integrated into the global economy (ASEAN, 2015). The aquaculture development strategies of the ASEAN Member States (AMSs) are aligned with such regional aspirations, but the question is whether the sector has the capacity to address the concerns over, meet the challenges of, and realize the aspirations for aquaculture development. Based on a review made by the author for an ASEAN-EU Project, this article provides positive indications of the region's capabilities in sector management, and science and technology.

In 2014, the AMSs produced more than 25 million metric tons of aquaculture products including plants, accounting for about 21 % of the total global output, and 53 % of the total fishery production of the ASEAN region, up from 21 % in 2000. The average yearly growth of ASEAN aquaculture production over the 15-year period from 2000 to 2014 was 14 %. This reflects an increase on average of 1,326 thousand metric tons a year (SEASOFIA, 2017).

Development of the sector in general has become orderly, with fewer conflicts and a greater ability to comply with legally prescribed and voluntary standards. The ASEAN-EU Project - Sustainable Ethical Aquaculture Trade (SEAT), for instance found no major health hazard related to pathogens from seafood farmed in Thailand and Viet Nam that are supplied to EU citizens. A significant reduction in the use of antimicrobials for shrimp in Thailand was noted, when not too long ago, shipments from both countries were returned or burned. This indicates two things: the sector has become more environmentally and socially responsible, and the management mechanisms — command and control, market-based, and voluntary or self-management — have become more effective.

The Southeast Asian region has had a long history of capacity development in aquaculture and allied sciences through various arrangements, among which had been scientific collaboration in inter-regional projects. This has provided a firm foundation for further cooperation in Science and Technology (S&T) between the ASEAN and other regions, and among the AMSs. The source of much of the research manpower is mainly the universities followed by government R&D institutes and in some countries, the industry, *e.g.* Thailand's CP Foods, Indonesia's CP Prima.

Linkages of the three main players, *i.e.* academic/scientific-industry-government, have strengthened the industry and provided a mechanism for collaborative action in the diagnosis of industry problems and search for, management of the development, and promotion of the solutions to industry problems. This tripartite cooperation at the national level has been enriched and bolstered by: (i) collaborative assistance — through multilateral and bilateral cooperation — of centers of excellence in other regions that have included the EU, USA, Oceania, as well as Japan and other Asian countries; (ii) technical assistance from regional indigenous organizations and international development assistance agencies; and (iii) intra-ASEAN cooperation under various technical cooperation frameworks.

Aquaculture Resources in the ASEAN

The physical resources available for aquaculture have been slowly and steadily declining from numerous pressures, *i.e.* conversion to other uses, domestic, agricultural and industrial demand on freshwater supply, and degradation of the water and soils. But there remains a significant coastal resource that could be tapped for mariculture with such systems as cage culture and the integrated multi-trophic aquaculture or IMTA (Sorgeloos, 2014).

Land and Water Resources

Among the AMSs, Indonesia has the longest aggregate coastline in the world and 55 % of the ASEAN coastal resources, followed by Philippines with 20 % and Myanmar with 8 %. Coastal length can indicate the potential resource available for aquaculture production. In terms of inland area, Indonesia has likewise large resources with 42 % of the ASEAN resources followed by Myanmar with 15 % and Thailand with 12 %. But a better indicator of potential than available land is the availability of renewable freshwater resources per square kilometer per year. On this, Indonesia has 32 % of the ASEAN's followed by Myanmar at 18 %, Viet Nam 14 %, and Malaysia 9 %. Against the current levels

of exploitation, Indonesia also has a very large potential for further freshwater aquaculture development.

Species and Systems

WorldFish (2011) had noted that the region has a diverse mix of aquaculture systems and species. After seaweeds (mainly grown in Indonesia and the Philippines), catfish constitutes the largest species group making up about 15 % of the total production, much of it by Viet Nam. Marine shrimps and freshwater prawns, carps, and other finfish also made up a large proportion with 13 %, 12 % and 11 % of the total production, respectively. Tilapia is the number one freshwater species cultured in Thailand and the Philippines. The other important freshwater species are the clarias catfish and snakehead (*Channa* sp.). Indonesia and Malaysia also have a significant production. Green mussels and oysters are important in Thailand and the Philippines, and blood cockle (*Anadara* sp.) in Malaysia. Myanmar has significant production of the Indian major carps, especially rohu (*Labeo rohita*). Cambodia has been growing snakehead (*Channa* sp.) in freshwater cages, and tilapia and some carps in earthen ponds. Marine culture species in Cambodia are the Asian sea bass (*Lates calcalifer*) and some grouper species. Other species in the ASEAN, which are seldom recorded include the spiny lobster, *Panulirus ornatus*, grown in shallow coastal water pens from wild seeds in Viet Nam and the Philippines, ornamental fishes and aquarium plants (a significant industry geared for export in Malaysia, Thailand, and Indonesia with Singapore usually as the assembler and shipper to destination markets), and amphibians (frogs and soft-shell turtles in Thailand and Indonesia). Trout has been introduced in Viet Nam as well as sturgeon, although trout production is yet minimal and sturgeon is concentrated in a single production site in northern Viet Nam (Le Thanh Luu, *pers.comm*.).

Ponds and off-bottom (cage) culture constitute the most common production systems with 44 % and 38 % of all systems, respectively. Nearshore cage culture of marine finfish is significant in Indonesia, Thailand and Viet Nam as well as in Malaysia and Philippines. Cage culture of milkfish, a staple species along with tilapia, is expanding in the Philippines. Cobia (*Rachycentron canadum*) was introduced and caught on rapidly in Viet Nam although there is a small production in southern Thailand much of it from demonstration cages of the Department of Fisheries.

Shrimp and reef fishes (mostly grouper) are the high-value species, where shrimp is internationally traded and reef fishes are mostly traded in the regional markets, the bulk going to China. Shrimp production in Thailand, Viet Nam and Malaysia suffered a setback starting 2011 with the outbreak of Acute Hepatopancreatic Necrosis Disease (AHPND). Thailand for instance saw its yearly production plummet from approximately 600,000 tons in 2010, before the widespread outbreaks of EMS/AHPND caused a drop, to 250,000 tons in 2013. Recovery, mostly aided by innovations in technology and practices, has been steady.

Structure

The ASEAN aquaculture is mostly market-oriented although pockets of subsistence type farming could be seen in some remote areas in Lao PDR, the northern and hilly regions of Viet Nam, Myanmar and Indonesia. Timor Leste, which lies in the Southeast Asian region, has mostly family-run subsistence culture of tilapia and carps but its seaweed culture is export-geared. While the sector features a few large vertically integrated, *i.e.* CP Foods/CP Aquaculture in Thailand and ALSONS Aquaculture in the Philippines, and horizontally integrated, *e.g.* CP Prima Indonesia, industrial operations, its most significant feature is the domination by small-holder producers and mostly small- to medium-scale enterprises handling the products after the farm gate. Feed and veterinary supplies come from large national, regional and multinational operations but seed supply is mostly from small- and medium-sized hatcheries. Integrators, processors and exporters are medium to fairly large operations. Indeed, livelihood opportunities along the aquaculture value chain are aplenty, and the demand for farmed aquatic products is increasing.

Prospects for Development

Among the top 15 aquaculture producers in the world, four are AMSs, *i.e.* Indonesia, Thailand, Viet Nam, and the Philippines (SOFIA, 2014). The region will experience continued growth in seafood production and demand. Forecasts based on current population trends, and maintaining annual per capita consumption of 30.1 kg/year, predict 2.4 million MT of additional demand by 2020 and 5.0 million MT by 2030. Aquaculture is expected to be a major supplier to meet this demand as the volume of wild catch continues to stagnate. Future demand depends partly on population growth, but primarily on the fact that wealth and urbanization will continue to increase. Helping meet higher demand is an increasingly efficient marketing mechanism. The growing middle class in the ASEAN is where the demand for fish will rise significantly. The ASEAN demand for meat will also increase, which will bring its own environmental demands. In this respect, fish have an important advantage over livestock because they are more efficient at converting feed into biomass. Aquaculture has clear benefits in this respect over meat production (WorldFish, 2011), and aquaculture systems emit much less greenhouse gas than livestock husbandry systems.

Issues and Concerns

This encouraging picture notwithstanding, the potential of aquaculture to contribute further to livelihoods, food security and income is increasingly at risk from various forces sweeping the sector. The rapid growth of aquaculture itself

has raised concerns over the environmental sustainability of that growth. Central to these are the demands aquaculture places on biophysical resources (such as feed and seed) and on the environment from its discharges or wastes (WorldFish, 2011). Even if more resources are potentially available, expansion is not unlimited, markets and profitability cannot always be guaranteed, standard production models cannot be applied everywhere, and growth could move fast beyond the reach of the poor. On top of the concerns over resource sustainability are those that come under the broad ambit of environmental and social responsibility. These are reflected in the requirements for certification of aquaculture products, eco-labels, tighter food safety and environmental standards, and recently, fair labor and employment practices, and assurance of decent work along the value chain.

Conflicts and competition over common resources are old concerns. Competition with suppliers of other similar products or different product forms that satisfy the same consumer need is not new. Then, there is the occasional economic and financial crisis. All these are now exacerbated and amplified by the hazards from climate change and variability. Brought down to the practical level — from the standpoint of an aquafarmer — these concerns are essentially production and marketing risks. Amid such circumstances, the Thirty-fifth Session of the Asia-Pacific Fishery Commission in May 2018 in Cebu, Philippines identified two sets of challenges that confront fisheries and aquaculture governance (**Box 1**), and recommended a number of regional strategies and actions to address these concerns. The capability of the ASEAN to support these strategies and actions is also assessed in this article.

Box 1. Challenges in the development and use of planning management tools to aquaculture governance

I. On the development and use of planning and management tools

1. Lack of established laws and regulations or weak implementation of existing regulations in supporting the adoption of the tools
2. Lack of common recognition of the need to adopting the tools at different levels of government authorities
3. Insufficient financial support and human capacity
4. Difficulties in adapting the tools to different culture systems and environments, and to multi-species culture systems

II. On institutional support to the enforcement of laws and regulations

5. Lack of strong political will and institutional support to enforce established laws and regulations
6. Limited concerted efforts at regional, national and local levels to strengthen aquaculture regulations and governance
7. Inadequate institutional and financial support, and human capabilities at national and regional levels
8. Lack of good understanding to the importance aquaculture regulations, Ecosystem Approach to Aquaculture (EAA), and zonal development among policy makers and stakeholders.
9. Inadequate inter-sectoral collaboration in regulating and planning the aquaculture industry

The ASEAN aquaculture needs to be ever more economically efficient, and environmentally and socially responsible in production, management, processing, and marketing to stay economically viable, be socially relevant, and remain competitive. These are underpinned by innovation, and the relationships among these basic components of sustainable development as illustrated in **Box 2**, which also shows the linkages between the three pillars of development and the institutional support needed to foster social, economic and ecological responsibility.

Capacities

The capacities of the AMSs in terms of governance and pursuing innovations have also been assessed. **Governance** comprises a policy framework, a strategy and plan, laws, enabling regulations, implementing guidelines, and administrative machinery. This set of command and control mechanisms for governance is complemented and usually enhanced by three other instruments: the market, voluntary or self-management arrangements, and stakeholder participation. In assessing the capacity for **innovations**, some indications were used, *i.e.* from breeding and genetic improvement, health management, product safety and quality assurance, production systems improvement, and post harvest including product transformation.

Governance capacity in the ASEAN: a broad assessment

Two sources provide the basis of this assessment (**Box 3**): (1) "Commercialization of Aquaculture Development in Southeast Asia" conducted by the Food and Agriculture

Box 2. Relationship among the four basic components of sustainable development

SOCIAL	ECONOMIC	ECOLOGICAL
Social stability and equity are requisites of a conducive climate for investments in economic development and environmental management	Economically developed communities tend to pay more attention to and allocate resources for environmental improvement, where economic development in turn fosters social stability and could encourage equity	Healthy and resilient ecological systems can better support economic development and contribute to social resilience
INSTITUTIONAL		
Effective governance underpins and fosters social accountability, responsible and orderly economic growth, and environmental responsibility		

Organization of the United Nations (FAO) and the Network of Aquaculture Centres in Asia-Pacific (NACA) from 2003 to 2005 (Hishamunda *et al*., 2009); and (2) brief overview of the aquaculture development status of each AMS. Every country has a policy on aquaculture, a national strategy and plan as well as the administrative machinery for regulation, management and development. Even in some countries where aquaculture is still governed under a Fisheries Act, specific policy and programs have been drawn for aquaculture development. The fisheries development strategy and plan of Cambodia has a prominent emphasis on aquaculture development and its role in food security and poverty alleviation in rural communities.

Box 3. Broad assessment of governance capacity in the ASEAN

Legislative and regulatory framework. In Thailand, aquaculture is administered under a Fisheries Act. By recognizing aquaculture explicitly as a legitimate activity, Myanmar, with its 1998 Aquaculture Act, encouraged illegal operations to be registered, increasing the number of registered legal farms. Even without specific legislations all countries in the region regulate aquaculture. However, lack of capacity and cost of monitoring limit the effectiveness of such regulations. Preservation of mangroves is among the policy targets in all the countries (except Lao PDR). In Malaysia, there is no aquaculture law that controls aquaculture development, except for the 1990 Fisheries (Marine Culture System) regulations that relate to net cages and mollusk culture in the marine environment. Under the 1985 Fisheries Act, the Minister of Agriculture is responsible for aquaculture regulations, and since land and inland waters are under state jurisdictions, planned new regulations are proposed to state governments for adoption and enforcement, which include the requirement that all aquaculture farmers must obtain a license and a permit. In Thailand, farms already operating in mangrove areas can continue but no new leases are granted. Viet Nam gives no official leases for mangrove areas. Viet Nam has promulgated a Law on Investment (59/2005/QH11) regulating investment activities – in all sectors including aquaculture -- for business purposes; defining the rights and obligations of investors; providing guarantee of lawful rights and interests of investors; and encouraging investments with incentives.

a. ***Zoning.*** Indonesia and Malaysia impose zoning for aquaculture management. In Indonesia, for land use planning there are aquaculture integrated zones, where only in particular zones can certain species be farmed, and where technical knowledge is disseminated to fish farmers, all of whom are growing the same species. Zoning in Malaysia is under federal jurisdiction and applied only to marine areas. The Philippines has established more than 60 Mariculture Parks for small investors in cage culture since 2001. Viet Nam has adopted a safe aquaculture zone concept and designated several shrimp growing areas as safe aquaculture zones.

b. ***Aquaculture leases and permits.*** Property rights provide security to investors and reassurance to lenders. In the Philippines, property rights are well established, but, in Myanmar, there are conflicts due to scarce resources in the public domain such as marine waters or land. Changes in land use regulations in Myanmar permitted rice fields in the seasonally saline areas of the delta to be converted into shrimp farms, resulting in dramatic expansion of shrimp farming in the coastal areas. In Cambodia, there are few regulations controlling freshwater aquaculture, but operations beyond a (small) size require permits and licenses to operate in its coastal areas. Malaysia's aquaculture investment zones (AIZ) are the basis for large farms obtaining a Temporary Ownership of Land, which can be on a 30-year lease, and renewed annually. Here, no license is required to run a land-based farm but a permit is required for cage culture in marine waters, and the new regulations require a license to run all aquaculture farms and permission to construct a building. In Myanmar, leases can be for 30 years, renewable for land beyond a certain distance from the waterline. The Philippines has used leases as a policy to stimulate aquaculture, with mixed results. Viet Nam provides long leases for aquaculture and also guarantees a rapid response to license applications.

c. ***Water regulations.*** As a common resource its allocation among competing users can be critical to the development of aquaculture. When shrimp diseases struck the region in the early 90s, the late King Rama IX initiated the development of a marine irrigation project in Kung Krabaen Bay to protect the shrimp industry which was then concentrated along the Gulf of Thailand (eastern coasts). Here, centralized seawater supply drawn one kilometer from the shoreline, clean and not likely to be polluted by shrimp farm effluents, is provided. In Myanmar, aquaculture has been hampered by the government's priority towards agriculture so that in the allocation of water, agriculture has priority over aquaculture. In the Philippines, one cannot dam flowing water for exclusive private use without a permit or license from a national agency mandated to regulate water use. Full payment is required even if the irrigation water is merely diverted to a fishpond and returned to the irrigation canal. In Thailand and most other AMSs putting up any structure in open water areas, such as fish traps and fish cages, requires a permit from the local or regional unit of the national fisheries agency. In Indonesia, Philippines, and Thailand, local government units have full authority over coastal waters up to what is considered national waters, which in the Philippines is 15 km from the coastline.

d. ***Environmental policy and regulations.*** Government policies are often reactive rather than proactive in nature. A classic case is the government policy towards aquaculture development in mangrove areas. Early movers in shrimp farming, such as the Philippines and Thailand, allowed unrestricted development at considerable environmental cost. Both countries have since followed a more cautious approach to brackishwater farming, with an emphasis on environmental and social sustainability. Most countries have recognized the dangers of uncontrolled development, and restrict coastal access through zoning or through setting up of maximum limits. In Indonesia, an Environmental Impact Assessment (EIA) is required for farms of 50 ha or more in brackishwater areas, and for larger farms in lakes and in marine waters, and a Code of Conduct with producer organizations has been promoted. In Malaysia, there is also a voluntary code of conduct. The 1998 Law in Myanmar, not only promoted aquaculture by reducing land disputes, but also encouraged more sustainable practices, and another law conserves the oyster fishing grounds. The Philippine Government has imposed a total ban on any further development of the remaining mangroves, and mangrove reforestation is being encouraged. In Viet Nam, the government sets no ceiling as to the area of public land that can be applied for and developed, but the area granted is based on an approved business plan and presumably the financial capability of the applicant.

Box 3. Broad assessment of governance capacity in the ASEAN (Cont'd)

e. ***Policies and regulations on aquaculture products and contaminants.*** Standards of quality and hygiene, labor regulations, animal welfare and GMOs, can and have been used as non-tariff barriers. For exports, these regulations must be complied with, although domestic markets increasingly demand them as well.

- In Indonesia, policies are based on the FAO Code of Conduct, where seed is inspected for quality according to ISO 9000 standards. All imported fish must have a health certificate and there are provisions planned for GMOs. The Fish Quality and Processing Development supervises the provincial laboratories for fish inspection and quality control, which are responsible for certifying the end product according to Hazard Analysis and Critical Control Point (HACCP) and the Integrated Quality Management Program of 2002.
- The Malaysian Government has taken a number of steps to ensure that products sold domestically are safe and that fish exported meet with international standards. A Fish Inspection and Quality Control (FIQC) system has been implemented. Health Certificates are issued by the Health Ministry, and an Inspection Certificate by the FIQC in accordance with the Codex Alimentarius.
- In Myanmar, there are some regulations for environmental issues but there are no regulations for farmed fish.
- Thailand assures the quality and safety of its aquaculture products, and controls chemical use in aquaculture through a Chemical and Drug Quality Control Board with a traceability procedure, and a Fisheries Products Quality Control Board with registration, inspection, and enforcement.
- Viet Nam's HACCP-based farm level Safe Quality Food Standards specifically for pangasius farming aims to develop full traceability of pangasius from "egg to export". Developed by the National Fisheries Quality Assurance and Veterinary Directorate in partnership with the Swiss auditing company Societe Generale de Surveillance (SGS), the system was built on SGS's Safe Quality Food Standards based on the HACCP system (Bush *et al.*, 2009).
- Viet Nam provides an example of a comprehensive regulatory framework for the responsible management of the animal feed (including fishfeed) industry with Decree No. 39/2017/ND-CP issued on April 4, 2017. The Philippines and Thailand have long had in place feed standards and regulations reinforced by better management practice guidelines that assure the production and sale of efficient, quality and safe feed products, at reasonable cost, and used effectively for better FCR and low environmental impacts.

f. ***Voluntary management mechanism.*** The past 18 years have seen a widening spread and adoption of self-regulatory mechanisms, foremost of which are Thailand's Code of Conduct and Good Aquaculture Practice, followed by better management practice guidelines for specific commodities and systems such as pangasius in Viet Nam, cage culture of grouper and other reef fishes in Indonesia, and a better management guidebook for local governments in the Philippines to manage environmental impacts of aquaculture. The primary driver of this surge was aquatic animal diseases, and was precipitated when scientists made clear to farmers the link between disease and the environment. Subsequent reinforcement came from consumer preferences transmitted through trade and advocacies from various entities (NGOs, mass media, governments) representing the interest of consumers.

g. ***"Green tax and polluter pays" schemes.*** Eco-labels are beginning to take hold, particularly in Thailand but tax on pollution or a green tax is not used, because it is often seen as a tough measure for most developing countries and usually politically unacceptable. A study on coastal zone management in Krabi, Thailand showed that a combination of incentive-based tools such as green taxation and non-incentive-based tools such as coastal land use zoning (based on the carrying capacity of receiving waters) optimally led to economically and environmentally responsible shrimp farming (Pongthanapanich, 2006). Under the Code of Conduct standard for shrimp farming in Thailand, which is based on the polluter pays principle, a farmer is required to set aside a certain area (around 10 % of the total production area) for sludge and waste water treatment before these are discharged into the environment. In a way, this is a cost to farmers as the area taken by the treatment pond is subtracted from the production area.

The role of government is more enabling than pro-active in the Philippines where aquaculture is largely left to (partially regulated) market forces, and where private entrepreneurship has been the main force behind aquaculture development. In Indonesia, Malaysia, Thailand, and particularly Viet Nam, the governments are actively promoting the sector through incentives and other policies. In Cambodia and Myanmar, aquaculture was viewed as a minor contributor to food self-sufficiency, thus, was subordinated to agriculture or to capture fisheries, but both countries have explicitly recognized the role of aquaculture, clarified land tenure to avoid conflicts, and reassured private investors. The result has been an expansion of registered farms and output.

Cambodia has formulated an Aquaculture Development Plan under its National Strategic Development Framework, which focuses on small holders, poverty alleviation and food security. In Brunei Darussalam, fisheries including aquaculture are seen to contribute to the diversification of the national economy from the oil and gas sector. In Singapore, the Agri-Food & Veterinary Authority as the national authority for aquaculture development and sector management, even as it manages aquaculture farms through the issuance of farm licenses, also carries out scientific studies in quality seed production for the local industry and shares the technology with other members.

Capacity for innovation: indicative assessment

Assessment of the capacity for innovation, especially for the whole region, will always be fraught and peppered with generalities and broad qualifications. **Table 1** provides some examples at the regional and national levels, and from public and private sector initiatives. A number of these have had or continue to have technical collaboration with and financial assistance from external organizations.

Table 1. Selected innovations in various segments of the aquaculture value chain

Area	Achievements	Participating Entities
Breeding and genetic improvement	Broodstock development and genetic improvement shrimp	Consortium of CP Aquaculture, Mahidol University (CENTEX Shrimp/BIOTEC), Department of Fisheries (DOF) Thailand, shrimp associations
	Artificial breeding and hatchery of marine shrimp *Penaeus monodon*	SEAFDEC Aquaculture Department (SEAFDEC/AQD), Philippines
	Freshwater prawn (*Macrobrachium* spp.) artificial spawning and breeding	National Inland Fisheries Institute (NIFI), DOF Thailand
	Artificial breeding, mass seed production of giant river prawn	DOF Malaysia and DOF Thailand
	All female production of giant freshwater prawn	Aquaculture Department, Faculty of Fisheries, Kasetsart University, Thailand
	Cross breeding of African catfish and indigenous catfish, mass seed production	A farmer in Thailand; Aquaculture Department, Faculty of Fisheries, Kasetsart University, Thailand
	Artificial breeding (breakthrough) of river catfish	NIFI, DOF, Thailand
	Milkfish broodstock development and induced breeding	SEAFDEC/AQD with assistance mainly from the International Development Research Centre (IDRC) Canada, and Japan International Cooperation Agency (JICA)
	GIFT Tilapia	WorldFish with collaboration from Philippine institutions
	All male tilapia	Asian Institute of Technology (AIT) Thailand, Freshwater Aquaculture Center (FAC), Philippines,
	Saline tolerant tilapia	National Inland Fisheries Technology Center (NIFTC), Philippine Bureau of Fisheries and Aqiatic Resources (BFAR) with French scientists' collaboration
	Improvement of seed stocks of *Eucheuma*/ *Kappaphycus* seaweeds	Marine Science Institute (MSI) of the University of the Philippines (UP) and SEAFDEC/AQD Philippines
	Development of Food Grade Carrageenan and manufacture of refined carageenan	Seaweed Industry Association of the Philippines; DOF, Thailand; Colloid manufacturers from US, France, Denmark clustered in Cebu City, Philippines
	Domestication and breeding of Mekong River fish species; hatchery development and seed production	Living Aquatic Resources Research Center (LARReC), Lao PDR in collaboration with Agricultural Research Centre for International Development (CIRAD), France and the Mekong River Commission
	Breeding of Arowana, culture and promotion in international aquarium trade	Department of Fisheries Malaysia (DOF Malaysia); private sector
	Artificial breeding and mass seed production of grouper Asian sea bass	Malaysia, Singapore, Indonesia, and Thailand
Aquatic animal health management	SPF (specific pathogen free) shrimps in Thailand	Science-Industry-Government consortium; Thailand
	EUS (epizootic ulcerative syndrome in fish) identification of causal organism, control	Aquatic Animal Health Research Institute of DOF, Thailand, with assistance from Department for International Development (DFID) of UK
	Fish disease diagnostic kits	Universiti Pertanian Malaysia (patented)
	Identification of organism causing early mortality syndrome (EMS) in shrimp, development of PCR-based detection protocol	CENTEX Shrimp, Mahidol University in association with National Chen Kung University, Taiwan; DOF, Thailand in association with Tokyo University of Marine Science and Technology, Japan
Product safety and quality assurance	Traceability system and requirements (*e.g.* Good Aquaculture Practice Program, Movement Document) for traded aquatic products, biotoxin monitoring, food safety control management (*e.g.* GMP, HACCP) and cold chain management requirements for seafood products to ensure freshness and safety	SEAFDEC Marine Fisheries Research Department (SEAFDEC/ MFRD) Singapore; Agri-Food & Veterinary Authority (AVA) of Singapore, DOF of Thailand
Environmental management	The development of TROPOMOD model, adapted from DEPOMOD/MERAMOD, to predict environmental impacts from aquaculture in the tropics, which has been validated for milkfish and tilapia, and marine brackish and freshwaters.	Philippines under the project Mitigating Aquaculture Impact in the Philippines (PHILMINAQ) funded by EU. Partners were two European institutions, MSI of UP, and BFAR

Table 1. Selected innovations in various segments of the aquaculture value chain (Cont'd)

Area	Achievements	Participating Entities
	Development and adoption of a better management practice for managing aquaculture and its impacts by Local Governments	This is probably the first case of a BMP guide adopted and used by local government's area management, in ASEAN.
Farming systems and production facilities	VAC system (in Vietnamese refers to *vuon, ao, chuong* which means garden/ pond/livestock pen) for crops, fish and livestock	Viet Nam
	Floating cage culture — mechanized and using Norwegian-type cages for grouper and other finfish;	DOF Malaysia
	Manufacture of circular floating cages using local materials	Private entrepreneurs (Philippines)
Post harvest, processing and product transformation	Comminuted products, product development from fish by-products, training and advisory to food industry	SEAFDEC Marine Fisheries Research Department, (SEAFDEC/ MFRD) Singapore INFOFISH, Malaysia; Agri-Food & Veterinary Authority (AVA) of Singapore
	Value addition: enhancing nutritional value of fish products Waste utilization for pharmaceuticals	AIT Thailand
	Ready-to-eat products (esp. sushi products for the Japanese market)	Private fishery product processing industry, Thailand; National Food Institute, Thailand;
	Smoked and deboned milkfish, canned products from milkfish (for local and export markets)	BFAR, UP College of Fisheries, and the private sector (ALSONS Aquaculture), Philippines
	MUZE - Multi Stream Zero Effluent process of extracting seaweed based compounds	On pilot scale, Indonesia (Dr. Ian C. Neish, *pers.comm.*)

Major Players in Aquaculture Research including Main Clusters and Research-Industry Links

The ASEAN region is endowed with academic, research and development, and technical institutions with expertise in various areas of aquaculture education and research. Many of the national institutions have established problem-based or more durable institutionalized collaborative working arrangements with several regional indigenous organizations (NACA, INFOFISH, Mekong River Commission, SEAFDEC) and international organizations like WorldFish, FAO, UNEP and IUCN, various donor and technical assistance agencies from Australia, Canada, EU, Japan and North America, and global industry, and professional associations such as the World Aquaculture Society, Asian Fisheries and Aquaculture Forum, and Global Aquaculture Alliance, among others. In addition, there are national institutions especially the universities that have been strengthened through various means of cooperation through graduate study and research fellowships in European, Australian, New Zealand, American, Japanese, and other Asian universities; exchange of faculty and scientific staff; special attachments by senior scientists from other universities (in Europe, Australia, America, Japan and other Asian countries); and collaboration between scientists in various projects. These modes of capacity building for scientific personnel — in many cases along with facility upgrade — have built up a strong S&T capability in the ASEAN. Universities forge linkages with industry even as some of their highly trained researchers and technologists find jobs in the industry.

Linkages for R&D in Aquaculture: Examples

A number of alliances and linkages in S&T have facilitated the search and design of solutions to the aquaculture industry problems, bannered by capacity building. A review of 12 ASEAN-EU Collaborative Projects (just ended or ongoing in 2014, which therefore does not include the recently initiated Myanmar Sustainable Aquaculture Project or MYSAP of EU and Germany's GIZ) identified 12 areas of capacity building.

These are: (1) Governance of the Sector; (2) Resource and Environmental Management; (3) Health Management; (4) Certification against Trade-related Standards (safety/quality, environmental and social); (5) Post-harvest and Processing; (6) Market Access and Trade; (7) Value Chain Management; (8) Climate Change Adaptation and Resilience; (9) Higher Productivity and Income; (10) Sustainable Intensification; (11) Livelihood Improvement of Small Farmers; and (12) Social Responsibility, which includes gender equity, food and nutrition security, and poverty alleviation. Some of these categories, such as Market Access (as the outcome

of health management, certification and post-harvest) and Social Responsibility (as the end result of almost all the other areas), can be argued to be the outcomes of a number of related categories.

Opportunities for Research Excellence, Cooperation and Innovation

A national aquaculture innovation system would provide the opportunity for sustained cooperation in research and the utilization of research results for the management and development of the sector. It could comprise two sub-systems: (a) Consortium - industry players are organized into a consortium to enable a continuing (as opposed to *ad hoc*) diagnosis of industry problems and search for their solutions, whose membership includes S&T institutions, Policy and Regulatory bodies, and the industry, and features the credibility endowed by science-based evidence to the processes and products of the sector, thus considerably strengthening efforts to better inform buyers and consumers; and (b) Industry association or federation — professionalized, broadly representative of all stakeholders with close links to professional and scientific resources, *e.g.* the Federation of European Aquaculture Producers or FEAP at the regional level, ASEAN Seafood Federation and the ASEAN Seaweed Industry Club at the regional level, the Seaweed Industry Association of the Philippines and the Thailand Shrimp Association at the national level, and the Vietnamese Fisheries Association to represent a very broad national membership (government, industry, academia), are examples of the industry groups that could be strengthened and infused with scientific and professional programs. These two sub-systems are not mutually exclusive; the association or federation could be the organized industry partner in the consortium. Either model would effectively marshal science-industry-government cooperation for addressing a set of problems in an integrated manner.

Opportunities for Strengthening R&D Capacities, Sharing Results of Aquaculture S&T

There are several not mutually exclusive modes for strengthening R&D capacities and sharing of the results of research and technology development. These could be done through: farmer-researcher cooperation; technical cooperation among ASEAN countries, international institutions; National Agricultural Research Systems; public-private partnerships; industry, professional and scientific forums; aquaculture innovation cluster composed of academic/scientific institutions, regulatory and management agencies, private industry and farmers' associations, farmers' and producers' federations; and the ASEAN (Fisheries Working Group) for regional policy and program formulation, among others. Scientific collaboration from other regions in key areas of competence that complement those of the ASEAN in strengthening regional and national capacities for R&D and development of innovative products and systems should also be established. Basic research could be done in partner institutions, the result of which could then be brought to the ASEAN for applied, adaptive and farming systems research.

Policy Recommendations

The policy recommendations, shown in **Box 4**, are aimed at strengthening the S&T capacities in the ASEAN to support

Box 4. Policy recommendations for strengthening S&T capacities in the ASEAN

1. Encourage and facilitate the formation of aquaculture S&T innovation clusters to solve specific problems (such as diseases of shrimp) or address the industry's value-chain issues from the biological to the physical to the technical, and economic and social aspects;
2. Form S&T networks of excellence in inter-disciplinary research and development, with a key regional institution and national centers linked to it and to each other;
3. Assure start-up funding for S&T initiatives in aquaculture within the ASEAN by ASEAN participants which is predictable and sustainable, and set up an ASEAN Sustainable Aquaculture S&T Advancement Fund;
4. Formalize within the ASEAN Secretariat (working with the ASEAN Foundation) a mechanism akin to an investment center, that would identify, screen, and endorse for funding proposals of regional or sub-regional scope for investments in research and technology development; and
5. Promote an integrated approach to S&T that is multi-stakeholder, multi-disciplinary, and covering the entire range of application of scientific result from policy to implementation.

More details about this **article** could be found in the **review** *ASEAN Research Landscape in Aquaculture: Opportunities for Investments and Cooperation in Science and Technology* carried out by the author in June-August 2014 under the Regional EU-ASEAN Dialogue Instrument (READI), a four-year (2011-15) initiative that supported the ASEAN-EU policy areas including science and technology. The review was supervised by *Alex Degelsegger* of the Vienna-based Center for Social Innovation, then a senior consultant for the Science and Technology Component of READI. Altair Asesores of Madrid Spain, the lead firm of a consortium that implemented the project, facilitated the commissioning of the review, the result of which was uploaded on the READI website in 2015. Highlights were found in *http://readi.asean.org/readi-2011-2015/news/155-asean-research-landscape-in-aquaculture-opportunities-for-investments-and-cooperation-in-science-and-technology* although the page has been discontinued. However, copies of the review including its three Annexes could be sent to anyone interested and upon placing requests to: *pete.bueno@gmail.com*. Regional policies are suggested to support, institutionalize within the framework of regional integration – embodied by the ASEAN Economic Community -- and sustain the S&T initiatives in tackling complex and dynamic issues.

the management of aquaculture development in the ASEAN and institutionalizing a mechanism for cooperation in S&T among the AMSs.

References

APEC-NACA-DEAKIN University. (2000). Report of the Expert Consultation on Aquaculture Education in the Asia-Pacific Region. NACA, Bangkok, Thailand; 239 p

AquaMarkets. (2003). Report of the Seminar-Consultation on Accessing and Fulfilling Market Requirements of Aquatic Products, Manila, Philippines, 2-6 June 2003. NACA, Bangkok, Thailand; 337 p

ASEAN Economic Community. *http://www.asean.org/communities/asean-economic-community*

Bailly, Denis and Rolf Willmann. (2001). Promoting Sustainable Aquaculture through Economic and Other Incentives. ***In***: RP Subasinghe *et al*. (eds). Proceedings of the Conference on Aquaculture in the Third Millennium. NACA, Bangkok, Thailand and FAO, Rome; pp 95-120

Bush, S.R., Nguyen Tri Khiem and Le Xuan Sinh. (2009). Governing the Environmental and Social Dimensions of Pangasius Production in Viet Nam: A Review. Aquaculture Economics and Management, 13:4, 271-293

FAO. (2005). Regional Review on Aquaculture Development. 3. Asia and the Pacific – 2005. FAO Fisheries Circular No. 1017/3. Rome. FAO. 97 p

Hall, S.J., A. Delaporte, M. J. Phillips, M. Beveridge and M. O'Keefe. (2011). Blue Frontiers: Managing the Environmental Costs of Aquaculture. The WorldFish Center, Penang, Malaysia

Hishamunda, N., Bueno, P. B., Ridler, N and W.G.Yap. (2009). Analysis of Aquaculture Development in Southeast Asia, a Policy Perspective. FAO Fisheries and Aquaculture Technical Paper 509. FAO. Rome. 69 p

Madan M. Dey and Mahfuzuddin Ahmed. (2005). Aquaculture — Food and Livelihoods for the Poor in Asia : A Brief Overview of the Issues." J. of Aq Economics and Management, 9: 1-10

Morakot Tanticharoen, T.W. Flegel, Watcharin Meerod, Uthaiwan Grudloyma and Nuchjaree Pisamai. (2008). Aquacultural Biotechnology in Thailand: The Case of the Shrimp Industry. Int. J. Biotechnology, Vol. 10, No. 6; pp 588-603

Pongthanapanich, Tipparat. (2006). "If Thai shrimp were taxed, how much should it be?" Aquaculture Economics and Management 10(2): 147-162

SEAFDEC. 2017. Southeast Asian State of Fisheries and Aquaculture 2017. Southeast Asian Fisheries Development Center, Bangkok, Thailand; 167 p

Sorgeloos, P. (2014). Final Report: ASEM Aquaculture Platform. Gent Universiteit, Belgium; 40 p

Shrimp News International. *http://www.shrimpnews.com*

Small-scale Seaweed Farming in the Philippines: Factors and Support Systems That Contribute to the Sustainability of the Operations and Towards Food Security and Poverty Alleviation of this Sector of the Society. Case Study under AFSPAN WP 5. July 2014; 5 p

The Impact of Converting Inefficient Low-lying Rice Paddies into Aquaculture for Poverty Alleviation in Bac Ninh, Viet Nam. Case Study under AFSPAN WP 4. July 2014; 9 p

The State of World Fisheries and Aquaculture 2014. FAO, Rome, 224 p

Vo Van Son. (2013). Program Completion Report, Fisheries Sector Program Support Phase II (FSPS 2). Ministry of Agriculture and Rural Development, Viet Nam; 43p

WorldFish Center and Conservation International. (2011). Blue Frontiers: Managing the Environmental Costs of Aquaculture, Policy Brief. The WorldFish Center, Malaysia; May 2011

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