ASEAN RESEARCH LANDSCAPE IN AQUACULTURE: OPPORTUNITIES FOR INVESTMENTS AND COOPERATION IN SCIENCE AND TECHNOLOGY

Pedro B. Bueno
Abstract

An analysis of the capabilities for, accomplishments in, and priority needs for aquaculture management and development is made. Twelve R and D projects in which EU or an EU donor government collaborated with ASEAN were broadly assessed of their contribution to 12 capacities for aquaculture management and development by matching their objectives and actual outputs with the capacities. The outcome of this exercise and a review of other past and present programmes of national, regional and international organizations in aquaculture research and development were the basis for identifying research areas and opportunities for cooperation among ASEAN members and between ASEAN and EU in science and technology. Recommendations for regional policy are proposed. One of these was inspired by a discussion on social innovation at the EU & ASEAN Consultation on Aquaculture held in Jakarta on 25 - 26 August 2014, in which a summary of the provisional findings of this review was presented.

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ASEAN RESEARCH LANDSCAPE IN AQUACULTURE: OPPORTUNITIES FOR INVESTMENTS AND COOPERATION IN SCIENCE AND TECHNOLOGY

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Summary

The growth of aquaculture in ASEAN is reflected in this graph (each country's production and trends are in Annex 1). It represents food fish only; the curve would be steeper yet if the seaweed outputs of the Philippines and Indonesia, the latter having become the largest carrageenophyte producer in the world, were included. Among other developments, this growth should be sustained by science and technology. And the need to produce more and better with less resources, including time, strongly points to an urgent mission for S & T, which is to propel aquaculture towards a knowledge-based industry. Noteworthy is that ASEAN is a net exporter of a number of aquaculture commodities: marine shrimp and freshwater prawn, reef fish especially groupers, pangasius catfish, tilapia and even milkfish. Indonesia and the Philippines are the largest exporters of carrageenophytes and their semi-refined extracts. It is undoubtedly an important player in the global effort to fill the looming gap between demand and supply of seafood.

Fig 1. Growth of ASEAN aquaculture

Source: Fisheries Information and Statistics Service, FAO.

This is the trajectory that is envisaged for S&T in this review. It starts with a description of the aquaculture development status and priorities of the ASEAN. It then reviews the management capacities for aquaculture development and illustrates the capacities for research and technology development in the region. The analysis narrows down to the

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general and specific contributions of recent ASEAN-EU collaborative programmes (12 projects were reviewed) to the region’s capacities for aquaculture management and research. Placing the results of the review in the context of (a) regional aspirations, (b) regional aquaculture development priorities and (c) global priorities and advocacies on the role and directions of aquaculture development, a number of priority areas for research are identified. The research priorities reflect persistent problems, emerging issues, and repeated hazards that surface now and then — whose nature are complex because many of them pose multiple risks (biological, natural, ecological, economic, social). As such they would be best addressed by an interdisciplinary approach. A set of regional policies is recommended to support, institutionalize within the framework of regional integration (embodied by the ASEAN Economic Community), and sustain the science and technology initiatives to tackle the complex and dynamic issues.

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 SEAT project for instance found no major health hazard related to pathogens from seafood farmed in Thailand and Vietnam to EU citizens and a significant reduction in the use of antimicrobials for shrimp in Thailand, when not so 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. On a broader sectoral context, ASEAN 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 between ASEAN and EU and among ASEAN members. The source of much of the research manpower are the universities followed by government R and D institutes and in some countries, industry. Thailand’s CP Foods and Indonesia’s CP Prima are examples. Linkages of the three main players (academic/scientific-industry-government) have strengthened 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 partnership at the national level has been enriched and further bolstered by (i) the collaborative assistance — through multilateral and bilateral cooperation — of centers of excellence in other regions that have included the EU, USA, Oceania, as well as other Asian countries, (ii) technical assistance from regional indigenous organizations (RIOs) and international development assistance agencies, and (iii) intra-ASEAN cooperation under various technical cooperation frameworks.

Indications if not evidence of a firm foundation for ASEAN innovativeness in support of the aspirations for the region — particularly competitiveness and the sustainability of small-scale and resource-challenged farmers from whose farms around 80 percent or more of the aquaculture output of ASEAN is produced — are provided by this review. These are: (i) a long list, with brief description of their mandates and capacities, of the four types of entities with science and technology functions related to aquaculture development in or operating in the region, (ii) a list of research and development activities that have addressed capacity building in 12 areas of aquaculture management and development2, (iii) examples of product, technological, and systems innovation that have been created under various institutional cooperative arrangements (the list hints at a dearth of social innovation in the

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The priority issues that are suggested for basic, disciplinary, interdisciplinary, applied, adaptive, on-farm and action research were sifted from the various project outcomes, recommendations, as well as those contained in policy advisories. These have been whittled down to this list. The research topics meant to strengthen the management of aquaculture, classified under 12 areas of aquaculture management and development are:

- **Health**: vaccine development; immuno-stimulants and probiotics and disease control strategies — cost/benefit assessments
- **Feed and nutrition**: replacing fish meal and oil with locally sourced plant-based ingredients
- **Genetics**: breeding for (a) growth and economic efficiency (basic objectives), (b) development of strains that require less lipids (to reduce dependence on fish meal and oil), (c) disease resistance (in the wake of repeated onslaught of diseases); and (d) temperature tolerance (for climate change adaptation).
- **Food safety**: food safety/hygiene awareness — cost/benefit assessments
- **Processing**: converting waste into useful products, by-products utilization, value addition to aquaculture products, enhancing nutritional property of products.
- **Rural development/livelihoods enhancement**: alternative use — for aquaculture — of marginal land except mangrove, and livelihood capitals/farm business management.
- **Biosecurity**: interdisciplinary assessments to ensure that the social, technical, economic and institutional aspects of disease control strategies are considered and that measures are in place to ensure they are feasible and adaptable in the future. Approaches that enable the interactive participation of stakeholders throughout product value chains; and a comprehensive cost-benefit analysis of different production strategies incorporating treatment costs, yield gains, risk reduction and costs of inaction.
- **Biodiversity**: interdisciplinary assessments to ensure economic and social change associated with aquaculture development has no adverse impact on biodiversity, and that the consequences for all stakeholders are considered and where necessary appropriate safeguards and mitigation measures implemented.
- **Environmental responsibility**: research to mitigate the adverse impacts of aquaculture on itself and on the environment as well as the impact of other sectors on aquaculture. Research should also be looking for ways that aquaculture can contribute to or enhance some of its positive contributions to the environment. Seaweed for instance absorbs nutrient discharges to coastal waters and integrated systems convert what could otherwise be waste into food or material. Energy efficient farming systems and better management practices that increase the efficiency of inputs especially feed — or those that do away with artificial feed — are invariably benign on the environment.
- **Social responsibility and value chain management**: an integrated research programme that covers the value chain to (i) infuse social responsibility throughout the chain (ii) increase efficiencies along the chain and (iii) create decent work at each node in the chain.

There will be elements of a problem that require basic research. Such research could be done in the EU institutions with the appropriate expertise and facilities. The result would then be brought to ASEAN for applied, then adaptive, then farming systems research and extension by the appropriate ASEAN institutions, preferably with further EU collaboration.

Interdisciplinary as well as inter-sectoral research programmes should be built around the current global priorities and advocacies for aquaculture development. Among these global advocacies are Blue Growth or Blue Economy and Sustainable Intensification of Aquaculture, Value chain management and, along the value chain, decent employment. The others are geared to production systems such as fully controlled culture systems (aquaponics and recirculation systems) and integrated multi-trophic aquaculture.

One important indication from the review of the “landscape” is the dearth of social
innovation. Product, process and systems innovation are important for industry growth and generally economic development. Social innovations will enable the creative application of resources and technology to anticipate and address old and persistent and new and emerging technological, economic and social issues. This is a critical gap for Science and Technology investments to fill. This could be an area where indigenous and traditional knowledge of farmers and farming communities are meshed with science-based knowledge and information technology to devise solutions to problems that might otherwise be intractable or keep coming back in a different guise.
1. Introduction: Overview of Aquaculture Development in ASEAN

ASEAN is globally an important aquaculture region, in two ways: as a producer and supplier of aquaculture products and a market for aquaculture products (with a population of 600 million), production inputs, and professional and technical services. The members, Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Thailand, Singapore and Vietnam together produced in 2012 some 11.3 million tonnes, around 17% of the world total. Indonesia dominates the aquaculture production of the ASEAN region with a yearly production of 3.85 million tonnes, followed by Vietnam, Philippines and Thailand with 2.50, 2.41 and 1.37 million tonnes respectively. The latest available figures, by country, including Timor Leste, are found in Annex 1. The five-year period from 2006 to 2011 saw a rapid increase in production particularly in marine and freshwater environment (Fig 2).

Figure 2. ASEAN Aquaculture production by environment

This rapid mariculture production has been primarily from Indonesia (Fig 3) with the large increase in seaweed production; in 2011 it was over 5 million tonnes (wet weight), from 197,300 tonnes in 2000. This is followed by the Philippines, also largely pushed by its production of seaweeds.

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Increase in brackishwater production during the same five-year period (2006-11) was also led by Indonesia followed by Vietnam, Thailand and Malaysia (Fig 4).
The exploitation of freshwater resources is highest by Vietnamese aquaculture at more than 8 kg per km² water largely owed to the highly intensive pangasius culture (Fig 5).

Figure 5. Exploitation of freshwater resources for aquaculture (tonnes/km²)

1.1. Land and Water Resources

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). But there remains a significant coastal resource that can be tapped for mariculture with such systems as cage culture and Integrated Multi-Trophic Aquaculture or IMTA. Among ASEAN members Indonesia, with the longest aggregate coastline in the world, has 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 ASEAN resources followed by Myanmar with 15% and Thailand with 12%. But a better indicator of potential than available land is available renewable freshwater resources per square kilometer per year. On this, Indonesia has 32% of ASEAN’s followed by Myanmar 18%, Vietnam 14% and Malaysia 9%. Against current levels of exploitation, Indonesia also has a very large potential for further freshwater aquaculture development.

1.2. Species and systems

The ASEAN region has a diverse mix of aquaculture systems and species. After seaweed (mainly grown in Indonesia and the Philippines), catfish constitutes the largest species group and made up 15.3% of the total production, much of it by Vietnam (in 2008). Marine shrimps and freshwater prawns, carps and other finfish also made up a large proportion with 13.2%, 11.6% and 10.7% of the total production respectively. Tilapia is the number one freshwater species cultured in Thailand and the Philippines. The other important freshwater species are

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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*) 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 seabass (*Lates calcarifer*) and some grouper species. Other species in ASEAN, which are seldom recorded are spiny lobster, *Panulirus ornatus*, grown in shallow coastal waters pens from wild seed as in Vietnam and the Philippines, ornamental fish 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 Vietnam as well as sturgeon. But trout production is as yet minimal and sturgeon is concentrated in a single pilot production site in the North6.

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 Vietnam as well as in Malaysia and the 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 Vietnam; there is a small production in southern Thailand much of out from demonstration cages of the fisheries department

Shrimp and reef fish (groupers, mostly) are the high-value species. Shrimp is internationally traded and reef fish are mostly traded in the regional markets, the bulk of which goes to China. Shrimp production in Thailand, Vietnam and Malaysia suffered a set back starting 2011 with the outbreak of the early mortality syndrome (EMS), also called the Acute Hepatopancreatic Necrosis Disease (AHPND). Thailand for instance saw its yearly production plummet from approximately 600,000 tonnes in 2010 before widespread outbreaks of EMS/AHPND caused a drop to 250,000 tonnes in 2013.7 A big and slow-subsiding flood in 2011 further trimmed overall output of mostly freshwater fish.

1.3. Structure of the sector

ASEAN aquaculture is mostly market-oriented although pockets of subsistence type farming would be seen in some remote areas in Laos, the northern and hilly regions of Vietnam, Myanmar and Indonesia. (Timor Leste, which belongs to the Southeast Asian region and will likely become a member of ASEAN has mostly family run subsistence culture of tilapia and carps but its seaweed culture is export-geared.)

While the sector features such large vertically integrated (i.e., CP Foods/CP Aquaculture and ALSONS Aquaculture, Philippines) and horizontally integrated (CP Prima Indonesia) industrial operations, the most significant feature of the sector in ASEAN is the domination by small-holder producers and mostly small to medium 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 hatcheries. Integrators, processors and exporters are medium to fairly large operations.

Overall, there are plenty of livelihood opportunities created along the aquaculture value chain. The demand for cultured aquatic products is also increasing.

6 Personal communication with Dr Le Thanh Luu, Director, International Collaborating Centre for Aquaculture and Fisheries Sustainability www.ICAFIS.org; former director, RIA 1 Vietnam

7 Shrimp News International http://www.shrimpnews.com
1.4. Prospects

By 2012 total world production of foodfish from aquaculture had reached 66.6 million metric tonnes from 49.9 million MT in 2007 (including plants, the total in 2012 was more than 90 million MT). Among the top 15 aquaculture producers in the world in 2012 were Indonesia, Thailand, Vietnam and the Philippines. ASEAN 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 tonnes of additional demand by 2020 and 5 million tonnes by 2030. Aquaculture is expected to be a major supplier to meet that new demand as wild catch continues to plateau. 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. As ASEAN wealth continues to grow, demand for aquatic products will follow suit. The growing middle classes in the ASEAN region are where demand for fish will rise significantly. The ASEAN demand for meat will also increase, which will bring with it its own environmental demands. In this respect, fish have an important advantage compared to livestock because they are more efficient at converting feed into biomass. Therefore, aquaculture has clear benefits in this respect over meat production for human consumption (WorldFish, as cited). And, arguably, most systems of farming fish emit less greenhouse gas than livestock husbandry systems.

2. Concerns, Aspirations and Capacities

The encouraging picture portrayed above notwithstanding, the potential of aquaculture to contribute further to livelihoods, food security and income, is increasingly at risk from various forces and influences now 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 (inputs including land, water and feed) and on the environment from its discharge or wastes (WorldFish, as cited). 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 may move beyond the reach of the poor.

On top of the concerns for 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, ever 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 are not new. Then there is the occasional economic and financial crisis. All these are now exacerbated and amplified by the hazards from climate variability. Brought down to the practical level — from the standpoint of an aquaculture farmer — these concerns are essentially production and marketing risks.

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2.1. Basic goals of a farmer

Development plans invariably stress that the farmer is both the reason for and the central player in rural development. At the risk of putting theory before evidence, let us consider what a farmer’s basic goals could be. These are suggested:

• Higher yield
• Lower costs
• Better economic returns
• Less risk

In addition, she must satisfy the basic demand of the consumer for a product that is safe, at a price that is affordable, and supplied in enough quantities at a time they are needed in the form and state that are desired. On top of these, society requires her to produce without polluting the surroundings, without exploiting farm workers, if any, and as much as possible without tampering with other living things in the wild. Other conditions are in the horizon that include keeping the fish in comfort. At the very least, they add to production and marketing costs. A worse effect comes from the limited awareness of fish farmer groups of the various standards required by consumption markets, which could drive them out of supply chains.

2.1.1. Staying in business. Society’s interest in keeping the farmer in business is to be able to continuously enjoy her products. Reciprocally, it is in the farmer’s interest to satisfy what society requires. In this light, helping the farmer stay in business is a social responsibility. But apprehension had been expressed that the increasing number and stringency of market requirements could drive the poor, small farmers — unable to comply with all these requirements — out of farming. In addition, difficult access to capital and the high capital requirements for certain technologies and farming systems either make it difficult for the poor to enter or could eventually marginalize the poor farmers (Dey, M. et.al. 2005). These two factors of high capital needed to adopt technologies and high cost of compliance with market requirements raise the specter in ASEAN (where more than 80% of fish farmers are small) of hundreds of thousands of displaced and unemployed farmers, or farmers turned laborers in what used to be their farms now consolidated by some corporate giant.

2.1.2. Sustainability and making a profit. Farming can only be sustainable if the farmer wants to keep on farming. There is no plausible reason in a democratic environment for any farmer to want to keep on farming other than to benefit from it. Making a profit is nothing to make excuses about. To paraphrase a management guru, the late Peter Drucker: A farmer who succeeds in business, who earns a profit to pay for production costs, for his family’s living and their future security is a responsible farmer. The farmer who is not responsible fails to make a profit and fails in farming, or makes profit by taking short cuts, the cost of which end up being paid by society.

2.1.3. Empowerment and reward. In this regard, a sustainable aquaculture program should emphasize and strengthen the system of support that enables the farmer to play a stronger and active role in the social and economic processes that impact on his livelihood. This means empowering her and assuring that for staying in business, she is justifiably rewarded.

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2.1.4. Competitiveness in the market place. Between satisfying the farmer’s objectives and meeting the demands of the consumer stands an economic mechanism called the market. Its function is to make compatible the goals of the producer on one hand and the needs of the consumer on the other. Globalization however has raised the question as to whether the market alone can enable this compatibility, without distorting its mechanism to favor the farmer, as with a subsidy. As market distorting gratuities are discouraged, the acceptable way to go is for farmers to have a better capacity to comply and compete.

2.1.5. Empowerment through organization and innovation. This underlines the importance of farmers being organized, a means of empowerment. Being organized to attain economy of scale and acquire a stronger power to transact with suppliers and buyers is seen as essential to the survival of small and poor producers in developing countries where the market chain is usually fragmented. It is also necessary for larger producers. But being organized is not a sufficient condition to compete in the global market place, much less simply access the market. The product has to possess the necessary attributes for which a consumer is willing to pay. In essence all of the required attributes for a product to compete can be endowed by innovation, which comes in two basic forms: on the product and in the process. Just as important, innovation enables the product to be produced, transformed and brought to the consumer with technical and economic efficiency. And with resource constraint and biotic and abiotic impacts facing almost every industry and economic sector, innovation can push the limits to productivity and mitigate or avoid the impacts. These are largely endowed by technological innovations. Facilitating the creation, development and application of technological innovations is probably the most important type of innovation — social. The contribution of S and T to the efficiency of social processes and effectiveness of social and economic transactions is enormous, although, as an aside, the social sciences often take the backseat behind the natural and biological sciences.

2.1.6. Doing more with less. Another reality facing farmers is having to do more with less. One trend identified by a NACA/FAO workshop almost 10 years ago that reviewed aquaculture development in Asia was the continuing intensification of aquaculture.\(^{11}\) This is a short simple statement that embodies a complex train of events and linked factors. What it simply indicates is that farmers, to reach their basic goals of producing and earning more, will now have to do with less: less land, less freshwater, less or probably inferior biological resources, probably less financial resources. Almost ten years from that assessment, sustainable intensification of aquaculture is being advocated by FAO. This will require a good dose of innovativeness to manage the tricky task of attaining technical and economic efficiency amidst strained physical and financial resources.

To sum up 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. All these are largely underpinned by innovation.

2.2. ASEAN Aspirations

By 15 December 2015, full economic integration envisaged in the Vientiane Action Programme shall have come into reality with the formal establishment of the ASEAN Economic Community (AEC). As with EC, the AEC shall aspire to be (a) a single market

and production base, (b) a highly competitive economic region, (c) a region of equitable economic development, and (d) a region fully integrated into the global economy.¹²

This ASEAN members’ aquaculture development strategies, as expected, are aligned with these regional aspirations (see Annex 1).

Does the sector have the capacity to address these concerns, meet the challenges and realize the aspirations?

2.3 Capacity of the sector: an analysis of the strengths, weaknesses, gaps

There are two core capacities needed to manage the development of an economic sector:

• Governance, so that essentially the development of the sector is geared to the goals of society, that its development is so directed towards those goals, and that its growth is orderly.

• Innovativeness, so that the sector is governed with utmost effectiveness and efficiency in the application of resources, and so that the producers have the ability to supply products in the quantity, reliability and form that always meet the market requirements, anticipate demand, and better yet, create demand.

Governance and innovativeness are linked: good governance provides a favorable environment as well as direct encouragement for science and technology to flourish. In turn innovations — in addition to enhancing progress and welfare with new products, systems and processes — support and facilitate better governance.

2.3.1. Governance mechanisms

This comprises a policy framework, a strategy and plan, acts or 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.

a. The policy framework addresses issues of equity and strategy including: principles for use and allocation of the public domain (water bodies such as rivers, lakes, reservoirs, coastal and offshore areas and freshwater resources); any socially required balance between small-holder and large-scale aquaculture; coherence with other policies and strategies such as those on poverty alleviation, industrial development, water and land use, rights of indigenous peoples, or regional priorities; environmental sustainability, including mitigation of social and environmental externalities; clear definition of the roles of the public and private sectors; sector leadership and coordination; and fiscal regime for aquaculture.

b. A national aquaculture plan and strategy mainstreams aquaculture into key planning and policy instruments such as poverty reduction strategies, foreign direct investment policies and rural development strategies. A national plan creates an attractive investment climate and inter-agency coordination. This is to overcome the dynamic nature of a growing industry where public authority is dispersed across sectors, agencies and disciplines.

c. The regulatory and administrative regime draws on the policies to set out the rights and obligations of fish farmers. The regime may specify among others: obligation to acquire permits or licenses to establish a farm based on physical planning including zoning and safeguarding sensitive ecosystems and critical habitats; measures to protect the environment, including EIAs and audits; environmental monitoring and internalizing the cost

of environmental impacts (i.e. polluter pays); control and enforcement mechanisms and penalties or means to redress damage; formal processes for stakeholder consultation with involvement of civil society organizations; standards for aquaculture practices and animal health and certification systems for the health and safety of aquaculture food products and the quality of seeds and feeds.

d. Market instruments. One such instrument is the market incentive, which works by the producer bearing the cost of polluting or not polluting the environment: in the first instance, a tax is imposed on pollution with the collected tax to be used to either clean up the pollution or compensate society for the damage caused by the pollution; in the second instance the farmer pays for the cost of abatement of pollution so that no pollution is imposed on society. As it affects private cost and benefits, its purpose is to induce individuals or firms to change their behavior to more socially desirable alternatives.

Another is the eco-label, which takes into account the attributes embodied in the products other than price, quality and safety. These other attributes relate to environmental, economic, social and ethical values or objectives such as fair trade, support to small farmers, discouraging child and forced labor, health-related properties such as being organic, and environmental and ecological-related attributes. Eco-labeling gives the consumer the opportunity to express her concerns through the choice of products. Such preference is expected to result in price or market share differential between eco-labeled products and those products that do not qualify for eco-labeling or whose producers chose not to seek an eco-label. The potentially better price or increased market share, or both, provide the incentive to seek certification for an eco-label.13

e. Self regulation and co-management. Faced with increasing difficulty with and costs of regulating aquaculture activities, increasing importance is given to voluntary arrangements and co-management practices. Their practical application is in the adoption of best management practices, codes of conduct and codes of practices by farmers and industry. Certain features of voluntary and co-management arrangements automatically remove the need for such usual government functions as monitoring of compliance with rules and regulations and imposition of penalties for violations.

f. Stakeholder participation. This mechanism is based on pluralistic structures, political legitimacy and consensus. It assumes that greater information and broader experiences make it easier to develop and implement policies and plans, new initiatives can be embedded into existing legitimate local institutions, there is less opposition and greater political support, local capacities are developed, and political interference is minimized. The State is one of the major stakeholders, not THE dominant stakeholder. It also highlights a fundamental role of governance, which is to ensure that basic rights of individuals and the welfare of the public take precedence over that of interest groups. This is not a strong suit in ASEAN reflected in the weak co-management mechanisms that have been designed and tried in a number of countries.

2.3.2. Governance capacity in ASEAN: a broad assessment

Two sources provide the basis of this assessment: (1) “Commercialization of Aquaculture Development in Southeast Asia” which was conducted by FAO and NACA from 2003-5, with the participation of experts from Cambodia, Indonesia, Malaysia, Myanmar, Philippines and

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Vietnam, and this reviewer\textsuperscript{14}; and (2) Annex 1, which provides a brief overview of the aquaculture development status of each ASEAN member. The scan has yielded this broad and rough assessment:

a. 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 under a Fisheries Act, as in Thailand, specific policy and programmes are drawn for aquaculture. 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.

b. The role of government is more enabling than pro-active in the Philippines where aquaculture is largely left to (partially regulated) market forces. Private entrepreneurship has for many years been the main force behind aquaculture development, with governments adopting a laissez-faire approach. In Indonesia, Malaysia, Thailand and particularly Vietnam 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. It was subordinated to agriculture or to the capture fisheries. But both countries have explicitly recognized the role of aquaculture, clarified land tenure thus avoiding conflicts, and reassured private investors. As a consequence, there has been an expansion of registered farms and output. Cambodia has formulated an Aquaculture Development Plan under its National Strategic Development Framework. It focuses on small holders and on poverty alleviation and food security. In Brunei, fisheries including aquaculture are seen to contribute to the diversification of the national economy from the oil and gas sector. Singapore’s Agri-Food and Veterinary Authority is the national authority for aquaculture development and sector management. Even as it manages aquaculture farms through the issuance of farm licenses it also carries out scientific studies in quality seed production to supply the local industry and contribute the technology to other members.

c. Legislative and regulatory framework. Some countries lack legislation specific to aquaculture. As 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. This move increased the number of registered legal farms. Even without specific legislation all countries in the region regulate aquaculture. However lack of capacity and cost of monitoring, limit the effectiveness of regulations. Preservation of mangroves is among the policy targets in all the countries (except Laos and Singapore). In Malaysia, there is no aquaculture law to control aquaculture development, except for the 1990 Fisheries (Marine Culture System) regulations that relate to net cages and mollusc culture in the marine environment. Under the 1985 Fisheries Act the Minister of Agriculture is responsible for aquaculture regulations. Land and inland waters are under state jurisdiction so planned new regulations are being proposed to state governments for adoption and enforcement. Among the new regulations is 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 available. In Vietnam there are no official leases for mangrove areas.

d. Zoning. Indonesia and Malaysia include zoning for aquaculture management. In Indonesia, for land use planning there are aquaculture integrated zones. Only in particular zones can certain species be farmed. Such zoning also aims to encourage dissemination of technical knowledge among farmers, all of whom are growing the same species. Malaysia has zoning under federal jurisdiction, applying therefore only to marine areas. The Philippines has established more than 60 Mariculture Parks for small investors in cage.

culture since it started the programme in 2001. Vietnam under a DANIDA project adopted a safe aquaculture zone concept and designated several shrimp growing areas as safe aquaculture zones.

e. 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 that are 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. This resulted in a dramatic expansion of shrimp farming in the coastal areas. In Cambodia, where there are few regulations controlling freshwater aquaculture, operations beyond a (small) size require permits; in coastal areas licenses are required for any operation. 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. No license is required to run a land-based farm but a permit is required for cage culture in marine waters. However new regulations require a license to run all aquaculture farm and permission to construct a building. In Myanmar, leases can be for 30 years renewable for land beyond a certain distance form the waterline. The Philippines has used leases as a policy to stimulate aquaculture, with mixed results. Vietnam provides long leases for aquaculture; it also guarantees a rapid response to license requests.

f. Aquaculture water regulations. As a common resource its allocation among competing users such as other fish farmers, or agriculture, can be critical to the development of the sector. When disease struck in the early 90s Thailand’s shrimp farms, which were concentrated along the Gulf of Thailand (southeastern coast), the King initiated the development of a marine irrigation project in Kung Kra Baen Bay in an effort to save the industry through a new development model. The project provided centralized seawater supply drawn one kilometer from the shoreline where the water is clean and not likely to be polluted by shrimp farm effluents. In Myanmar aquaculture has been hampered by the government’s priority towards agriculture. 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. In the Philippines full payment is required even if the irrigation water is merely diverted to a fishpond and returned to the irrigation canal. Intertidal areas cannot be titled. In Thailand and most other countries in Southeast Asia the right to put 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, the Philippines and Thailand local government units have full authority over coastal waters up to what is considered national waters, which is 15 km from the coastline in the Philippines.

g. Environmental policy and regulations. Government policies are often reactive rather than proactive in nature. A classic case is government policy towards aquaculture development in mangrove areas. A broad conclusion from the mangrove issues is that 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 brackish water 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 maximum limits. In Indonesia an Environmental Impact Assessment (EIA) is required for farms of 50 ha or more in brackish water, and for larger farms in lakes and in marine waters. A Code of Conduct with producer organizations was promoted. In Malaysia there is a voluntary code of conduct. The 1998 Law in Myanmar, not only promoted aquaculture by reducing land disputes, but also encouraged more sustainable practices. Another law conserves oyster fishing grounds. The Philippine government has imposed a total ban on any further development of the remaining mangrove. Mangrove reforestation is being encouraged and is
a recent beneficiary of a large grant for mangrove reforestation. In Vietnam, the government sets no ceiling as to the area of public land that can be applied for and developed. The area granted is based on an approved business plan and presumably the financial capability of the applicant. Table 1 is a summary of the policy and measures to manage environmental impacts in the region.

### Table 1 Environmental Policies and Tools used in ASEAN

<table>
<thead>
<tr>
<th>Policy goal</th>
<th>Measures and Tools</th>
<th>Countries</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid or reduce pollution</td>
<td>EIA Environment compliance certificate, Plans for farm filtration sinks for pond discharge</td>
<td>All countries except LaoPDR</td>
<td>Thailand’s COC (code of conduct) requires setting aside ponds to discharge waste water.</td>
</tr>
<tr>
<td></td>
<td>Chemical use and Drug Quality Control Board-Registration/inspection/enforcement, Farm level HACCP; Traceability; Feeding regulations</td>
<td>All countries</td>
<td>Still mostly enforced through regulations. But feed management at the farm level is increasingly part of the better management practice guides being developed for some systems and species (shrimp, marine fish culture in cages, pangasius)</td>
</tr>
<tr>
<td>Coastal planning</td>
<td>Green belt; Zoning; Rent Mariculture Park; Integrated Coastal Zone Management</td>
<td>Indonesia, Thailand, Malaysia, Philippines</td>
<td>Zoning in Malaysia and Marine Parks in the Philippines are also policies for encouraging and protecting investments</td>
</tr>
<tr>
<td>Mangrove protection</td>
<td>Ban on cutting of A class forest, No farming in mangroves</td>
<td>Thailand, Indonesia, Philippines, Myanmar</td>
<td>Mixed results due to strain on enforcement resources. Co-management has enhanced protection; also aqua-silviculture in Indonesia and southern Vietnam have helped conserve mangroves.</td>
</tr>
<tr>
<td>Water quality</td>
<td>Regulation of maximum discharge, Recirculation Filtration (biological, physical)</td>
<td>Indonesia, Thailand, Malaysia, Philippines, Singapore, Vietnam</td>
<td>Thailand’s shrimp sector pioneered in using filtration and recirculation. Farms under the COC are required to set aside filtration ponds for waste water discharge.</td>
</tr>
</tbody>
</table>
h. 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 met. They are increasingly demanded by the domestic market.

- In Indonesia policies are based on the FAO Code of Conduct. Seed is inspected for quality according to ISO 9000 standards. There are also feed inspections and standards based on species (shrimp, catfish, common carp river eel and frog). All imported fish must have a health certificate and there are provisions planned for GMOs.
- Fish Quality and Processing Development supervises the provincial laboratories for fish inspection and quality control, which alone are responsible for certifying the end product according to HACCP and the Integrated Quality Management Program of 2002. Among the main points in the latter program are: a) each processing unit has to possess a Processing Cleanliness Certificate; b) the person in charge of the processing unit has to possess a fish processing certificate; c) each fishery export facility has to apply the program based on HACCP and; d) every fishery export must possess the Integrated Quality Certificate or Health certificate issued by the laboratories for fish inspection and quality control. Only heath certificates issued by these laboratories are acceptable for exports to the European Union. When chloramphenicol and nitrofurans became a concern for exports to Europe all shrimp exported from Asia to Europe were subject to antibiotic analysis in the port of entry. Indonesian shrimp was checked with the Rapid Alert System. This policy was followed by the USA and Canada. There is zero tolerance for chloramphenicol.
- 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 in Malaysia as well as a network of Fish Health and Quarantine Centres. Health Certificates are issued by the Health Ministry, and an Inspection Certificate by the FIQC. This is in accordance with Codex Alimentarius. Quarantine Centres, at all main entry and exit points, implement regulations on the international trade of live fish, thereby controlling fish disease. In Myanmar, while there are some regulations for environmental issues there are no regulations for farmed fish.
- Thailand has one of its objectives for 2020 assuring the quality and safety of aquaculture products. It controls chemical use in aquaculture through a Chemical and Drug Quality Control Board with a traceability procedure. It also has a Fisheries Products Quality Control Board with registration, inspection, and enforcement. The purpose is to maintain HACCP standards. These regulations on drug and chemical use are driven by standards set by importing countries.
- Vietnam’s HACCP-based farm level Safe Quality Food Standards specifically enforced for pangasius farming in Vietnam aims to develop full traceability of pangasius from “egg to export”. It was developed by the National Fisheries Quality Assurance and Veterinary Directorate in partnership with the Swiss auditing company Societe Generale de Surveillance (SGS) and was built on SGS’s Safe Quality Food Standards based on the HACCP (Hazard Analysis and Critical Control Point) system.\footnote{Bush, S.R., Nguyen Tri Khiem and Le Xuan Sinh.2009. Governing the Environmental and Social Dimensions of Pangasius Production in Vietnam: A review. Aquaculture Economics and Management, 13:4, 271-293.}

Table 2 is a summary of the policy and regulatory tools for assuring safety and quality of aquatic animal products and health of farmed aquatic animals.
Table 2. Food safety and quality policy and tools used in ASEAN

<table>
<thead>
<tr>
<th>Policy goal</th>
<th>Measures and Tools</th>
<th>Countries</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensure fish quality and safety</td>
<td>Fisheries Products Quality Control Board: Registration/inspection /enforcement HACCP (farm and processing) and Good manufacturing practices Chemical use/Drug quality Feed quality inspection and control; ban on antibiotics and chemicals Traceability Movement certificate Farm accreditation Fish health certificates</td>
<td>Thailand, Indonesia Philippines Malaysia Myanmar Cambodia Vietnam Singapore</td>
<td>There are now numerous standards that are being adhered to or complied with depending on the destination of the product. Some of these have to be enforced and usually enforcement is limited.</td>
</tr>
<tr>
<td>Reduce risk of disease</td>
<td>Early warning Quarantine Seed quality assurance Control on movement of live aquatic animals Feed quality tests Breeding for SPF seed PCR and other tests</td>
<td>All countries</td>
<td>FAO, NACA, SEAFDEC, ASEAN Fisheries Working Group, APEC, and OIE have developed regional aquatic animal health and biosecurity strategies that have included strengthening of policy and regulations, as well as capacity building.</td>
</tr>
</tbody>
</table>

i. Voluntary management mechanism

- The past 15 years have seen a widening spread and adoption of self-regulatory mechanisms. Foremost of these are Thailand’s Code of Conduct and Good Aquaculture Practice. This has been followed by better management practice guidelines for specific commodities and systems such as pangasius in Vietnam, cage culture of grouper and other reef fish in Indonesia, and a better management guidebook for local governments in the Philippines to manage environmental impacts of aquaculture, and others. The primary driver of this surge was disease, and this 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.

j. “Green tax and polluter pays” schemes

- Eco-labels (as described in the previous section) 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 evidence 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.\textsuperscript{16}

- However, the Code of Conduct standard for shrimp farming in Thailand is based on the polluter pays principle: it requires a farmer 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.

2.3.3. Capacity in innovation, an indicative assessment

An assessment of this capacity especially for a whole region will always be fraught, peppered with generalities and broad qualifications. This section attempts to do so anyway by using some indications from breeding and genetic improvement, health management, product safety and quality assurance, production systems improvement and post harvest including product transformation. The table provides examples at regional and national levels 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 3. Selected innovations in various segments of the aquaculture value chain

<table>
<thead>
<tr>
<th>Area</th>
<th>Achievements</th>
<th>Participating entities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breeding and genetic improvement</td>
<td>Broodstock development and genetic improvement shrimp</td>
<td>Consortium of CP Aquaculture, Mahidol University (CENTEX Shrimp/BIOTEC), Department of Fisheries, shrimp association</td>
</tr>
<tr>
<td></td>
<td>Artificial breeding and hatchery of marine shrimp P. monodon</td>
<td>SEAFDEC Aquaculture Department, Philippines</td>
</tr>
<tr>
<td></td>
<td>Freshwater prawn (Macrobrachium) artificial spawning and breeding</td>
<td>Department of Fisheries' National Inland Fisheries Institute, Thailand</td>
</tr>
<tr>
<td></td>
<td>Artificial breeding, mass seed production of giant river prawn</td>
<td>DOF Malaysia and DOF Thailand</td>
</tr>
<tr>
<td></td>
<td>All female production of giant freshwater prawn</td>
<td>Aquaculture Department, Faculty of Fisheries, Thailand</td>
</tr>
<tr>
<td></td>
<td>Cross breeding of African catfish and indigenous catfish, mass seed production</td>
<td>A farmer in Thailand; Aquaculture Department of the Faculty of Fisheries, Kasetsart University, Thailand</td>
</tr>
<tr>
<td></td>
<td>Artificial breeding (breakthrough) of river catfish</td>
<td>National Inland Fisheries Institute, DOF Fisheries, Thailand</td>
</tr>
</tbody>
</table>

\textsuperscript{16} Pongthanapanich, Tipparat. 2006. If Thai shrimp were taxed, how much should it be? Aquaculture Economics and Management 10(2): 147-162.
<table>
<thead>
<tr>
<th>Project Description</th>
<th>Implementing Agencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milkfish broodstock development and induced breeding</td>
<td>SEAFDEC Aquaculture Department, Philippines; with IDRC Canada, JICA assistance (Filipino, Canadian, Japanese and Indian scientists collaboration)</td>
</tr>
<tr>
<td>GIFT Tilapia</td>
<td>World Fish (then ICLARM) with collaboration from Philippine institutions</td>
</tr>
<tr>
<td>All male tilapia</td>
<td>AIT Thailand, Freshwater Aquaculture Center, Philippines,</td>
</tr>
<tr>
<td>Saline tolerant tilapia</td>
<td>NIFTC, BFAR, Phil with French scientists' collaboration</td>
</tr>
<tr>
<td>Improvement of seed stocks of Eucheuma/Kappaphycus seaweed</td>
<td>Institute of Marine Sciences of the Univ of the Phil and SEAFDEC Aquaculture Department, Philippines</td>
</tr>
<tr>
<td>Development of Food Grade Carrageenan and manufacture of refined carageenan</td>
<td>Seaweed Industry Association of the Philippines; Department of Fisheries; Colloid manufacturers from US, France, Denmark clustered in Cebu City, Phil</td>
</tr>
<tr>
<td>Domestication and breeding of Mekong River fish species; hatchery development and seed production</td>
<td>LARReC, Laos; with collaboration from CIRAD (France), and the Mekong River Commission</td>
</tr>
<tr>
<td>Breeding of Arowana, culture and promotion in international aquarium trade</td>
<td>Department of Fisheries, Malaysia; private sector</td>
</tr>
<tr>
<td>Artificial breeding and mass seed production of grouper; Asian seabass</td>
<td>Malaysia, Singapore, Indonesia</td>
</tr>
<tr>
<td>Malaysia and Thailand</td>
<td></td>
</tr>
<tr>
<td>Aquatic animal health management</td>
<td>SPF (specific pathogen free) shrimp in Thailand</td>
</tr>
<tr>
<td>Science-Industry-Government consortium; Thailand</td>
<td></td>
</tr>
<tr>
<td>EUS (epizootic ulcerative syndrome in fish) identification of causal organism, control</td>
<td>Aquatic Animal Health Research Institute of the DoFisheries, Thailand, with assistance from DFID</td>
</tr>
<tr>
<td>Fish disease diagnostic kits</td>
<td>Universiti Pertanian Malaysia (patented)</td>
</tr>
<tr>
<td>Identification of EMS (early mortality syndrome in shrimp) causal organism, development of PCR-based detection protocol</td>
<td>CENTEX Shrimp, Mahidol University in association with National Chen Kung University, Taiwan; DoFisheries, Thailand in association with Tokyo University of Marine Science and Technology, Japan</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Product safety and quality assurance</strong></td>
<td>Movement document for traded aquatic products</td>
</tr>
<tr>
<td><strong>Environmental management</strong></td>
<td>The development of TROPOMOD model, adapted from DEPOMOD/MERAMOD, to predict environmental impacts from aquaculture in the tropics. Validated for milkfish and tilapia, and marine brackish and freshwaters. Development and adoption of a better management practice for managing aquaculture and its impacts by Local Governments</td>
</tr>
<tr>
<td><strong>Farming systems and production facilities</strong></td>
<td>VAC system (Crops, Fish and Livestock)</td>
</tr>
<tr>
<td><strong>Post harvest, processing and product transformation</strong></td>
<td>Floating cage culture — mechanized and using Norwegian-type cages for grouper and other finfish; Manufacture of circular floating cages using local materials</td>
</tr>
<tr>
<td></td>
<td>Comminted products, product development from fish by-products, training and advisory to food industry</td>
</tr>
<tr>
<td></td>
<td>Value addition: enhancing nutritional value of fish products Waste utilization for pharmaceuticals</td>
</tr>
<tr>
<td></td>
<td>Ready-to-eat products (especially sushi products for the Japanese market)</td>
</tr>
<tr>
<td></td>
<td>Smoked and deboned milkfish, canned products from milkfish (for local and export markets)</td>
</tr>
</tbody>
</table>
2.3.4. 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 World Fish, FAO, UNEP and IUCN, various donor and technical assistance agencies from Australia, Canada, EU, and North America, and global industry and professional associations such as the World Aquaculture Society, Asian Fisheries and Aquaculture Forum, Global Aquaculture Alliance and others.

Table 4 lists and describes the mandates and areas of competence of five regional indigenous organizations in ASEAN (AIT, NACA, INFOFISH, MRC and SEAFDEC), four international agencies, the World Fish Center, FAO (FAO RAP), UNEP and IUCN, 34 national fisheries/aquaculture international agencies management agencies, academic institutions, R and D organizations, and some private entities that have prominent roles in aquaculture technology development and promotion, and three other institutional arrangements. A brief identification of the major players and description of some of the research industry links follows the tabular list.

Table 4. Institutions in the field of ASEAN aquaculture management, development, research and education

<table>
<thead>
<tr>
<th>Institutions/Organisations</th>
<th>Areas of Excellence/Competence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indigenous Regional Organisations</td>
<td></td>
</tr>
</tbody>
</table>

17 Sources of information for this section are Dr. C.V. Mohan, Senior Scientist, WorldFish; Dr. Eduardo Leano, Coordinator, Aquatic Animal Health Programme, NACA; APEC-NACA-DEAKIN University, 2000. Report of the Expert Consultation on Aquaculture Education in the Asia-Pacific Region. NACA, Bangkok 239p; and a web search. 239p.
1. **Asian Institute of Technology, Bangkok**

   Specialises in engineering, advanced technologies, and management and planning. Its aim is to "promote technological change and sustainable development" in the Asia-Pacific region, through higher education, research and outreach. Has produced over 500 graduates (MSc & PhD) in the field of aquaculture/fisheries, and trained over 1,000 government officials and private company managers/entrepreneurs from Bangladesh, Cambodia, India, Laos, Malaysia, Nepal, Thailand, Vietnam and several others from African, American, Australian and European countries. The short-term training courses help update knowledge on recent developments in the field and provide opportunities to acquire specific skills. A wide range of training courses are taught by the experts in the field of Aquaculture and Aquatic Resources Management and also external resource persons. It has outreach programmes in Vietnam, Cambodia and Thailand. Post graduate studies and research in aquaculture and related fields usually by students.

2. **SEADEC Aquaculture Department, Iloilo, Philippines**

   The range of aquaculture research, technology development, training and outreach of freshwater, brackishwater and marine finfish, crustacean, mollusc and seaweed species and systems. Shares technology and knowledge with the rest of ASEAN and Japan through training and information and researcher exchanges.

3. **SEAFDEC Marine Fisheries Research Department, Singapore**

   Research, training and industry advisory service in fish post-harvest technology, processing and food safety and quality. Provides technical advisory services to food industries in ASEAN, training of personnel in post-harvest and processing and quality control.

4. **INFOFISH, Kuala Lumpur, Malaysia**

   Market information, market access of fishery products. Conducts market studies and promotes product development and market access. Provides advisory service to processors and exporters and to governments. Membership includes government agencies and private industry.

5. **Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand**

   Promotes expansion of sustainable and responsible aquaculture through technical cooperation among member (19) and participating governments (associate member is the Secretariat of the Pacific Community to represent the Pacific Island Countries) Coordinates, initiates, brokers, manages research, training, information exchange. Programmes include aquatic animal health management, which is a flagship programme; farming systems; genetics; training and education; and information. It has had collaborative programmes of a wide range of development and donor organizations, NGOs, Industry organizations, and academia.
5. Mekong River Commission, Fisheries Programme, Vientiane, Lao PDR

The MRC Fisheries Programme includes a project on Aquaculture of Indigenous Mekong Fish Species which focuses on the development of techniques for propagation of indigenous Mekong fish species for culture and stocking of water bodies. It aims to assist line agencies, other relevant organizations and users to develop and implement indigenous Mekong fish species culture systems for aquaculture, stocking and mitigation. It plans to increase the number of indigenous species bred specifically for fisher farmers' use through continued development of breeding and husbandry techniques for selected species and using genetic techniques to identify stock differentiation within certain species. It facilitates information sharing between countries.

International Organizations and Agencies

1. World Fish Centre with HQ in Penang, Malaysia

As a CGIAR institution its mandate is to conduct upstream research and capacity building of National Agricultural Research Systems to strengthen the global and national efforts to combat poverty and food and nutrition insecurity.

2. UNEP

In Asia Pacific, UNEP operates through its Regional Office for Asia and the Pacific and works in 41 countries in the region. Work is on six cross-cutting thematic priorities:

- Climate change
- Disasters and conflicts
- Ecosystem management
- Environmental governance
- Harmful substances and hazardous waste
- Resource efficiency — sustainable consumption and production
- Environment Under Review

At the sub regional level in Southeast Asia, the UNEP Southeast Asia subregion consists of eleven countries: Brunei Darussalam, Cambodia, Indonesia, Lao People’s Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, and Vietnam. There are two intergovernmental organizations, the Association of Southeast Asian Association and Mekong River Commission. It also has an important cooperative programme called the Greater Mekong Sub-region Economic Cooperative Programme.

UNEP has a project “Enhancing South-South Cooperation - Building the Capacity of Developing Countries to Promote Green Economies”. One component is to support the transition towards a resource-efficient, low-carbon economy.
### 3. IUCN

The IUCN Asia Regional Office (ARO) provides coordination and support for the region. The Country Offices and The Ecosystems and Livelihoods Group (ELG) implement the IUCN Programme and Strategy in collaboration with project partners, and with its state and NGO members. It has developed a series of publications for aquaculture governance:

- “Interactions between Aquaculture and the Environment,” addresses finfish and shellfish culture, dealing mostly with finfish aquaculture, and specifically cage culture.
- “Aquaculture Site Selection and Site Management,” seeks to provide the reader with a full set of parameters and ideas to reflect upon and apply to aquaculture site selection and site management.
- “Aquaculture Responsible Practices and Certification” brings into focus several interesting issues for discussion, such as marketing or management support for certification, and the voluntary versus mandatory approach to sustainability certification.

IUCN and UNDP have been running the Mangrove for the Future project for 7 years and have recently received funding from SIDA for a new 4-year phase ([www.mangrovesforthefuture.org](http://www.mangrovesforthefuture.org)).

### 4. FAO RAP

The Regional Office for Asia and the Pacific now has 46 member countries. It has adopted FAO’s corporate strategic objectives into five Regional Strategic Priority Areas:

- strengthening food and nutritional security
- fostering agricultural production and rural development
- enhancing equitable, productive and sustainable natural resource management and utilization
- improving capacity to respond to food and agricultural threats and emergencies
- coping with the impact of climate change on agriculture and food and nutritional security.

Within the above regional priorities, the core functions of RAP are:

- providing perspectives, trend monitoring and assessments
- capacity building and technical support
- policy assistance and advice to subregions
- building partnerships and alliances
- strengthening information, knowledge and statistics
- developing international instruments.

FAO RAP has been involved with a number of important aquaculture studies including, recently, the development of a toolbox for aquaculture to improve the planning and management of aquaculture in Asia and the Pacific.
<table>
<thead>
<tr>
<th>National</th>
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<tbody>
<tr>
<td>1. Brunei Department of Fisheries</td>
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<tr>
<td>2. Royal Agriculture University of Cambodia, Phnom Penh</td>
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<tr>
<td>3. Marine Aquaculture R&amp;D Centre, Sihanoukville</td>
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<td>4. Gondol Research Institute for Mariculture, Bali</td>
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<td>5. Freshwater Aquaculture Centre, Sukabumi</td>
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<td>7. Coastal Aquaculture Centre, Lampung, Sumatra</td>
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<td>8. Fisheries University, Jakarta</td>
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<td>9. Institute Pertanian Bogor</td>
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<td>10. Agency for Marine and Fisheries Research Development</td>
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<td>11. CP Prima Indonesia</td>
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<tr>
<td>29. Coastal and Inland Fisheries Research Centres of the Department of Fisheries, Thailand</td>
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<tr>
<td>30. Department of Fisheries - Inland, Coastal, Fish Inspection and Quality Control, Feed, Genetics, and other divisions, Bangkok</td>
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<tr>
<td>31. Research Institutes of Aquaculture (RIA) 1,2 and 3, Vietnam</td>
</tr>
<tr>
<td>32. University of Fisheries, Nha Trang, Vie</td>
</tr>
</tbody>
</table>
33. Can Tho University, Can Tho, Vie  
College of Aquaculture and Fisheries. Research areas are in Aquatic biology and physiology, Aquatic resources and environment, Fish nutrition and feeding, Aquaculture technology, Aquatic pathology, Aquatic animal genetics, Fisheries economics and management. Has linkages and collaborative projects with a wide range of institutions and organizations in Asia, Oceania, Europe, USA and regional and international institutions and agencies such as NACA, FAO, EU. It is a founding member of the ASEAN Fisheries Education Network” (ASEAN-FEN).

34. Hanoi University  
Has a Faculty of Animal Science and Aquaculture; collaborates in training and research with other Vietnamese universities and the RIAs.

Foundations, Non-Profit organisations, International NGOs

<table>
<thead>
<tr>
<th>1. Asian Coastal Resources Institute-Foundation (Prince of Songkhla University in southern Thailand)</th>
<th>CORIN-Asia Foundation is a non-profit organization registered under Thailand law that works on coastal, wetlands and river basin management in the region in partnership with the CORIN-Asia group. Several years of professional experience in empowering human resources by translating local problems into opportunities. The focus is to build local capacity to sustain their livelihood and improve coping mechanisms to changes in their environment. CORIN-Asia has five separate organizations in the Mekong region which include Thailand, Vietnam and Cambodia. CORIN-Asia Foundation coordinates the group’s work at the regional level in partnership with other CORIN institutions established in Vietnam (CORIN-Asia Vietnam), Cambodia (CORIN-Asia Cambodia) and Northeast Thailand (CORIN-Asia Mekong) as well as with the Marine and Coastal Resources Institute (MA-CORIN) of Prince of Songkhla University, Thailand. CORIN-Asia also has its presence in Indonesia. It is undertaking a research initiative aimed at creating CORIN-Asia in Myanmar. CORIN-Asia was a partner in the project Sustainable management of ecosystem services for aquaculture production in the Mekong Delta.</th>
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<tr>
<td>2. Partnerships in Environmental Management for the Seas of East Asia (PEMSEA)</td>
<td>A partnership arrangement involving various stakeholders of the Seas of East Asia, including national and local governments, civil society, the private sector, research and education institutions, communities, international agencies, regional programmes, financial institutions and donors. It is the regional coordinating mechanism for the implementation of the Sustainable Development Strategy for the Seas of East Asia. It organized the Workshop on Addressing Food Security through Sustainable Aquaculture in 2009.</td>
</tr>
</tbody>
</table>
The list includes several national institutions especially the universities that have been strengthened over the years through various means of cooperation: graduate study and research fellowships in European, Australian and American, Asian/other ASEAN universities; exchange of faculty and scientific staff; special attachments by senior scientists from other universities (in Europe, Australia, America, other Asian countries such as Japan), 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 science and technology capability in ASEAN. At the national level, the universities have forged linkages with industry even as a number of their highly trained researchers and technologists find jobs in the industry.

### 2.3.5. Linkages for R and D in Aquaculture: examples

The section provides examples (not exhaustive, not even extensive but illustrative) of alliances and linkages in science and technology that have facilitated the search and design of solutions to aquaculture industry problems:

| **3. WWF** | The WWF Coral Triangle Programme has been in operation for over 15 years to  
| | • Support improved governance of the Coral Triangle  
| | • Build a sustainable live reef food fish trade  
| | • Promote sustainable tuna fisheries  
| | • Finance marine protected area for the future  
| | • Create an international marine protected area network for turtles and reduce turtle by-catch in Indo-Pacific region  
| | • Reduce the impacts of climate change and tourism  
| | WWF was an early pioneer in implementing Fisheries Improvement Projects (FIPs) as a tool for creating positive change in fisheries management through whole-of-supply-chain engagement. Evidence of the growing interest in FIPs can be seen in the new “ASEAN Fisheries Improvement Project (FIP) Protocol” process now underway and led by the ASEAN-US MARKET project following a recommendation by the ASEAN Public-Private Task force for Sustainable Fisheries and Aquaculture. The Task force aim is “to define a regional FIP protocol/standard that reflects the realities facing fisheries in ASEAN while meeting the key elements of credibility for the definition and management of the standards, as well as address the environmental impacts and social issues.” This objective is driven by the ASEAN push to harmonise standards and protocols across ASEAN countries for fisheries and aquaculture by 2015, when AEC is slated to be formed. |
| **4. Wetland Alliance** | Established in 2006, the Wetland Alliance Programme (WAP) is jointly managed by four organizations: WWF, WorldFish Center, Asian Institute of Technology (AIT) and the Coastal Resources Institute of the Prince of Songkla University (CORIN). Funded by the Swedish International Development Cooperation (SIDA), WAP operates in four lower Mekong countries, and aims to build capacity of local change agents to improve management of wetlands, and to improve livelihoods of the poor living around wetlands. |

The list includes several national institutions especially the universities that have been strengthened over the years through various means of cooperation: graduate study and research fellowships in European, Australian and American, Asian/other ASEAN universities; exchange of faculty and scientific staff; special attachments by senior scientists from other universities (in Europe, Australia, America, other Asian countries such as Japan), 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 science and technology capability in ASEAN. At the national level, the universities have forged linkages with industry even as a number of their highly trained researchers and technologists find jobs in the industry.

### 2.3.5. Linkages for R and D in Aquaculture: examples

The section provides examples (not exhaustive, not even extensive but illustrative) of alliances and linkages in science and technology that have facilitated the search and design of solutions to aquaculture industry problems:
1. A national innovation system dedicated to the marine shrimp culture industry was established in Thailand in the early 1990s: a consortium of private (CP Aquaculture), academic (Mahidol University’s CENTEX/BIOTEC), government (DoFisheries) organizations. Its programme began with broodstock development and genetic improvement of the indigenous species, black tiger shrimp *Peneaus monodon*, expanding to the breeding of high health shrimp (SPF), health management that broadened into biosecurity, feed and nutrition, and food safety. The CENTEX of Mahidol University is the scientific resource. This is cited as an example of a research-industry link. The consortium has since ceased to exist as a formal group but the informal ties remain, usually linked up again for joint action by an emergency. This is illustrated by the massive work on the latest disease of marine shrimp, the EMS or AHPND. The program later transmuted into the Shrimp Genetic Improvement Center for development of genetically selected, Specific Pathogen Free (or SPF) *P. monodon*, operated jointly by the Thai National Center for Genetic Engineering and Biotechnology (BIOTEC) and Prince of Songkhla University in cooperation with CENTEX and the Faculty of Science of Mahidol University. The facility is located at Chaiya in Surat Thani Province.

2. The Epizootic Ulcerative Syndrome or EUS in freshwater finfish had bedeviled both fish farmers and fishers of wild fish in the late 80s and early 90s (spreading through Southeast Asia and South Asia). Its causal organism was identified through a concerted effort among Asian fish disease scientists led by the ones working in the Aquatic Animal Health Research Institute (of Thailand’s DOFisheries). The regional programme — focused on the syndrome and the environment — was initiated by an FAO and DFID (then the Overseas Development Agency) collaborative assistance to the region with laboratory work and capacity building work centered in AAHRI. The regional programme continued under the Network of Aquaculture Centres in Asia-Pacific (NACA), in partnership with FAO and the OIE (World Animal Health Organization) even as the AAHRI received further capacity building assistance from DFID. The strong R&D capacity built for EUS earned AAHRI an accreditation as OIE’s world reference center for EUS.

3. Very recently, scientific collaboration between Mahidol University (CENTEX and its Public Health Department) and Taiwan’s National Chen Kung University of Taiwan with participation from Kasetsart University’s Faculty of Fisheries (through its Aquaculture Business Research Centre), DOFisheries Thailand’s Marine Shrimp Culture Research and Development Institute, and funding and other material support from numerous entities in Thailand including government authorities and industry groups, and in Taiwan (including academic and industry), cracked two problems posed by the Early Shrimp Mortality Syndrome (Acute Hepatopancreatic Necrosis Disease): identifying its causal organism in Thailand and developing a PCR-based detection method as a diagnostic tool. This illustrates among others the effectiveness of marshaling science-industry-government cooperation to focus on a problem. More important, it points to the need for an institutionalized (in contrast with ad hoc or project-driven) linkage of the major players in an industry to address the broad, specific, old but persistent as well as new and emerging issues. The industry collaboration would cover not only the scientific nature of the problem but the policy, regulatory, management and capacity building aspects.

4. The Seaweed Industry Association of the Philippines provides a modest example of this kind of industry collaboration. SIAP developed research linkages with the University of the Philippines, Aquaculture Department of SEAFDEC and international research and development agencies to develop a food grade colloid extract from the carageenophyte species (*Kappaphycus* and *Eucheuma*), promote it for food industry applications and

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18 Personal communications through email exchanges with Prof. Timothy Flegel, Faculty of Science, Mahidol University, Bangkok tim.flegel@gmail.com.
developed the industrial capacity to process the refined form and use it for food and cosmetic products. Just as important, it lobbied against a non-tariff barrier imposed by the US on the Philippine Natural Grade carrageenan product form, and succeeded. Science based argument and evidence, which were accepted and endorsed by Codex Alimentarius, was the technical tool of the lobby. The Association’s membership includes the various local associations of farmers and the processors. Farmers are organized and provided assistance in production loans, technical advice, better seed, seaweed drying and on-site pre-processing, and marketing by the Industry and the government.

One private corporation whose operation comprises seaweed farming, processing and export of processed products has also established a foundation to assist small seaweed farmers. It has developed a corporate structure that includes farmers as stakeholders of the company. This is cited as an example of a social innovation.

5. A possible example of an institutional innovation is the development and adoption of a better management practice guidebook for use by Local Governments in managing the impacts of aquaculture. This was developed under the EU project PHILMINAQ in the Philippines. The institutional innovation makes use of another innovation which the project also developed: a model which predicts the impact of aquaculture on the environment, and which the scientists and technicians use to provide technical advice to local government authorities.

6. In Malaysia, two universities — the University Putra Malaysia and the University Sains Malaysia — have developed innovations in health management and aquafeed, respectively. UPM has patented a handy kit for fish disease diagnosis that farmers and farm technicians can easily use. USM has developed feed formulations using the waste from and by-products of palm oil processing.

7. In Vietnam, the Can Tho University has a central educational and scientific role in the development of a sustainable aquaculture, especially as it is located in the heart of the aquaculture-rich South. The University maintains linkages for various programmes with numerous local, ASEAN, South and North Asian, Oceania, European and American scientific, academic and development organizations. An example is the development of a Better Management Practice guide for pangasius aquaculture in association with NACA, AqASEM, FAO, and the Fisheries department and research institutes of aquaculture.

8. Indonesia’s Gondol Research Institute for Mariculture (GRIM) on Bali Island perfected the artificial breeding of the humpback grouper and other reef fish species that are of high value. It has been working on broodstock development and spawning of the yellow fin tuna with assistance from the Australian Centre for International Agriculture Research (ACIAR).

9. LARReC of the Lao PDR, with collaboration of CIRAD and under the Mekong River Commission aquaculture programme, has been working on the breeding of wild-caught and domesticated broodstock of some indigenous Mekong River species and spawning them to produce seed for stock enhancement (release into the water bodies) and aquaculture. Hatchery techniques for the target species were also developed.

2.3.6. Research and Development projects and their contributions to the capacity of the sector for management and development

This section identifies and describes the areas in the building of capacity for aquaculture

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19 Personal communications with Maximo Ricohermoso, founder of the SIAP, president of the ASEAN Seaweed Industry Club and proprietor-manager of the MCPI corporation and chairman of the Dating-bayan Foundation, Cebu City, Philippines.
development and management to which 12 collaborative projects between EU and ASEAN have contributed. Six of the projects are supported by donor agencies from EU countries (Netherlands, Danish International Development Agency, Spanish Agency for Cooperation in International Development or AECID, Norwegian Agency for Development and the German Federal Enterprise for International Cooperation or GIZ), three projects under FP6 and three under FP7. The list, titles, objectives and achievements of the projects (or in the case of AFSPAN, its work package objectives and two case studies), short descriptions, dates of effectivity, partner institutions, and beneficiary ASEAN countries appear in Annex 2.

A summary of the contributions to various management and development areas in aquaculture or related to aquaculture is provided in Table 5. There are 12 areas of concern for capacity building in the list: (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 if indirect result of almost all the other areas), can be argued to be the outcome of a number of the other categories. These were listed as distinct categories based on a scan of the objectives and achievements of the various projects that had activities that directly address market access or social responsibility].

Table 5. The contributions of 12 ASEAN-EU Collaborative Projects to 12 capacities for aquaculture development and management in ASEAN.

<table>
<thead>
<tr>
<th>Area</th>
<th>Projects</th>
<th>General and specific contributions</th>
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<tbody>
<tr>
<td>1. Governance of the sector</td>
<td>1. RESCOPAR (Netherlands, Indonesia and Vietnam)</td>
<td>Research to understand the interactions and feedback between decision-making processes at different socio-political and spatial levels and how these affect the use, management and conservation of living aquatic resources. Research on global and local governance in CZM in the Mekong Delta, Vietnam;</td>
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<td></td>
<td>2. RFLP (Spain, Cambodia, Indonesia, Vietnam, Timor Leste)</td>
<td>Co-management of coastal fishery resources enhanced the management of common fishing grounds. It improved the wild seed resources for culture.</td>
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</table>
| **3. PHILMINAQ**  
(Philippines) | A Joint Administrative Order was agreed by the Department of Agriculture, Department of Environment and Natural Resources, and Department of Interior and Local Government clarifying roles and jurisdiction of agencies for the environmental management of aquaculture. It was supported by the “Guidebook for Local Government Units (LGUs) for planning, managing, and controlling aquaculture development” and a “Better Management Practice Manual for LGUs.” Development of a Geographic Information System (GIS) database of aquatic ecosystems and sensitive habitats and a GIS database for planning aquaculture development  
Use of modeling for zoning |   |
| **4. ASEM Aquaculture Platform FP6** | Dialogues on rational use of natural resources; reconciling multiple demands on coastal zones, food safety, ‘food security’ and ‘Aquatic farming systems’. The platform sought to reconcile ecological and socioeconomic demands and introduced concepts of sustainability in aquaculture development in both regions |   |
| **5. SEAT** | More than 20 peer reviewed articles; key policy messages from 10 published articles. |   |
| **6. AFSPAN** | The 9 Work Packages combine to provide governments guides to analyse the contribution of aquaculture to development. Work package 8 will synthesize results to provide policy guidance and better coordinating arrangements between countries and donor and development partners for investments. |   |
| **7. EMMA and AQUAPARK** | Build capacity for the site selection for Mariculture parks and optimization of production. Provided guidelines to improve the management of existing mariculture parks; reorganization of existing aquaculture areas into parks; GIS based methods to identify new area; and tools for government to plan responsible and sustainable cage culture. |   |
| **2. Resource & Environmental management; pollution control** | **1 RESCOPAR**  
Research on trade-offs in coastal fisheries production, mangrove structure and extent and shrimp-culture in Ca Mau province, Vietnam: a spatial modeling approach;  
Research on marine protected areas, shrimp farms and coastal fisheries |   |
<table>
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<tr>
<th>Project</th>
<th>Description</th>
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<tr>
<td><strong>2. FSPS 2</strong>&lt;br&gt;(DANIDA, Vietnam)</td>
<td>Safe Aquaculture Zone was developed as a management tool to encourage responsible farming, reduces disease, pollution risks and social risks.</td>
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<tr>
<td><strong>3. PHILMINAQ</strong></td>
<td>Improved monitoring and modeling of aquaculture impacts on the environment. BMP included better feed management practice. Capacity building of fisheries bureau and its technology center for environmental management of aquaculture.</td>
</tr>
<tr>
<td><strong>4. EMMMA and AQUAPARK</strong></td>
<td>Investigated the impacts of aquaculture on the environment and developed predictive models and recommended ways to mitigate impact. The project trained Government staff in the operation of the monitoring equipment, analysis of data collected and the use of models for predictive assessment of impact and estimation of safe carrying capacity.</td>
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<tr>
<td><strong>5. SEAT</strong></td>
<td>Findings contribute to on-going international dialogues and media interest in links between aquaculture and marine conservation. Current practice suggests that environmental and human risk assessment is required for continued success of Asian aquaculture; studies point to low comparative impacts but identify need for monitoring to re-assure consumers. Analysis found unnecessary and resource intensive use of marine ingredients in farmed seafood. Reuse of pond sediments: values for shrimp and pangasius pond sediment investigated with local stakeholders.</td>
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<tr>
<td>3. Aquatic Animal Health Management</td>
<td><strong>1 RESCOPAR</strong> Research on spatial spread and virulence development of White Spot Syndrome Virus in cultured shrimp, Ca Mau, Vietnam; Research in disease transmission of White Spot Syndrome Virus in cultured shrimp, Ca Mau, Vietnam;</td>
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<tr>
<td><strong>2. AqASEM 2009</strong></td>
<td>Fostered partnerships between Asia and Europe to improve cultured aquatic animal health and welfare and to address issues of major economic or environmental significance and concern to both regions including diagnosis, preventative measures and treatments.</td>
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</table>
| 3. SEAT | Found significant reduction in the use of antimicrobials for shrimp in Thailand
Need for improved farmer knowledge of cost-effective and safe use of different chemicals |
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<tr>
<td>4. Certification: Food Safety, Quality, Environmental and Social Standards</td>
<td>1. Compliance to EC Directive 2003/858/EC (Philippines) The project enabled the Philippines to reach the required level of food safety by 2006. Evidence: inspection by the European Food and Veterinary Office. The project developed and promoted a HACCP applied to the culture stage (rather than the processing stage)</td>
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<tr>
<td>2. ASEM Aquaculture under FP6</td>
<td>ASEM contributed to aquatic food safety objectives by providing sound research results, by creating a forum for experts and policy-makers, and disseminating knowledge up to policy levels as well as down to farmers.</td>
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<tr>
<td>3. AqSEM 2009</td>
<td>Supported the dialogue on the development of aquaculture certification schemes, and incorporation of science-based information from Asian and EU partners into the formulation of certification, and associated food safety and legislation; provided guides for addressing certification that benefits both small farmers and the larger ones.</td>
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</table>
| 4. SEAT | Food safety and occupational health
- Evidence for a lack of any major health hazard related to pathogens from seafood farmed in Thailand and Vietnam to EU citizens
- Significant reduction in the use of antimicrobials for shrimp in Thailand
- Requirement for improved farmer knowledge of cost-effective and safe use of different chemicals |
| 5. Post harvest and processing | 1. SEAT Processing by-products and sustainability:
- By-products/non-edible fractions often exceed 50% of harvested yields
- Better linkages to livestock production would leverage win-win scenarios |
| 6. Market access; trade | 1. Compliance to EC Directive 2003/858/EC (Philippines) Inspection by the European Food and Veterinary Office showed that by 2006 the Philippines has achieved compliance. |
| 2. AqASEM 2009 | It fostered a constructive dialogue between the European and Asian stakeholders in pangasius farming, processing and trade. Showed that BMPs can improve market access. |
| 3. SEAT | Quality and brand  
- Removing off-flavor in tilapia from export value chains used as a prioritized issue to improve sector reputation  
- Dialogue with processing sector and regulatory authorities  
- Major emergent issue in EU-based recirculation aquaculture system |
| 4. AFSPAN | Work Package 7 aims to understand the global trade in and markets for aquaculture products, focusing on small-scale producers. The package will review the effects of global trade and markets on enabling or preventing aquaculture from achieving its food security objectives. It will identification of successful species, production systems and countries, as well as the aggregate factors that drive the development of the culture of the species. It will investigate how, for some products, a crisis actually leads to improved practices. Shrimp farming in particular holds several examples of this scenario and similar cases can also be found for several other species. Research will be carried out on how benefits are distributed in the local society and to what extent this distribution depends on the community structure. |
| 7. Value chain management  
1. SEAT | Win-win-local stakeholders efforts align with standards developers  
Modernization of integrated food production |
| 8. Climate change adaptation and resilience  
1. RESCOPAR (Indonesia and Vietnam) | Understanding the ecological, social and political dynamics underlying processes of change and possible threats to the resilience of mangrove forested coastal ecosystems. |
<p>| 2. Integrated coastal and mangrove forest protection in the Mekong provinces for adaptation to climate change (Vietnam) | More than 6,000 households with over 27,000 individuals have been reached with disaster prevention activities. There has been a long-term reduction in the vulnerability of 650 ha of agricultural land. |
| 3. PHILMINAQ | From a disaster response perspective, the project showed that a series of disastrous risk events to an industry and with threats of its recurrence with even more severity can be an opportunity to leverage a well supported and planned scientific response. |</p>
<table>
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<tr>
<th>4. AQUACLIMATE</th>
<th>The project developed future scenarios based on the predicted climate changes in 2020 and 2050; assessed the potential adaptive measures for different aquatic farming systems and prioritized better management practices, suggested codes of practice and improved methodologies for such systems. It has provided information for investments in research, technology development and transfer, public education, training, infrastructure and systems, markets, financial and other support services for the poor farmers and aquatic resource users.</th>
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<tr>
<td>2. Integrated coastal mangrove forest protection in the Mekong provinces for adaptation to climate change (Vietnam)</td>
<td>Aquaculture in Bac Lieu Province: expected increase in income of USD 400 per harvest and hectare</td>
</tr>
<tr>
<td>3. AqASEM 2009</td>
<td>Supported the application of Integrated Multi-Trophic Aquaculture (IMTA). A modified IMTA called Vertical MTA was proposed for Singapore. The seaweed, abalone, and shellfish model could find applications in the Philippines and Indonesia, which have extensive seaweed production areas but with hardly any integration. BMPs confirmed that BMPs can improve productivity, profitability, product quality and access to credit and markets.</td>
</tr>
<tr>
<td>10. Sustainable Intensification of aquaculture</td>
<td>1. FSPS2 (Vietnam)</td>
</tr>
<tr>
<td>2. EMMA/AQUAPARKS</td>
<td>Development of Better Management Practices for cage operators (and translated into Tagalog) Improved mooring system for more exposed sites. Optimization of Mariculture Park cage production layout using the TROPOMOD predictive model. Socio economic survey to analyze the positive and negative perceived or verifiable impacts of implementing Mariculture Parks Analysed the economics and economic benefits of mariculture parks.</td>
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<td>Project</td>
<td>Description</td>
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<tr>
<td><strong>3. AqASEM 2009</strong></td>
<td>Case studies of IMTA models in China and application of IMTA in ASEAN</td>
</tr>
<tr>
<td><strong>11. Livelihood improvement of small farmers</strong></td>
<td></td>
</tr>
<tr>
<td><strong>1. RESCOPAR</strong></td>
<td>Decision-making and change in coastal fish-based livelihoods in Ca Mau, Vietnam. Decision-making and livelihoods in East Kalimantan, Indonesia.</td>
</tr>
<tr>
<td><strong>2. Compliance to EC Directive 2003/858/EC (Philippines)</strong></td>
<td>The farmers who were excluded from export markets due to their poor hygiene practices began to follow the example of those who already improved their practices. The whole industry voluntarily modernized itself. The main reason for this seems to be that many perceive EU accreditation as a quality label, even those who did not export to the region.</td>
</tr>
<tr>
<td><strong>3. FSPS 2 (Vietnam)</strong></td>
<td>Around 43,000 farmers (exceeding the target of 40,000) exited from poverty in the project provinces.</td>
</tr>
<tr>
<td><strong>4. RFLP (Indonesia, Cambodia, Vietnam, Timor Leste)</strong></td>
<td>Aquaculture was promoted as an alternative and complementary livelihood to fishing. Production of products derived from aquaculture (such as seaweed-based snack and food items) was successfully promoted in Nusa Tenggara Timur, Indonesia among women entrepreneurs; grouper and catfish production in Cambodia and Vietnam; and seaweed culture in Timor Leste.</td>
</tr>
<tr>
<td><strong>5. Integrated coastal and mangrove forest protection in the Mekong provinces for adaptation to climate change of GIZ (Vie)</strong></td>
<td>Pilot introduction of a local fish species for aquaculture. Direct support was provided to 500 farmers on 1,500 hectares during these activities.</td>
</tr>
<tr>
<td><strong>6 PHILMINAQ</strong></td>
<td>Development of Better Practice Guidelines for small scale cage and pen operators; Promoted awareness of sustainable production that focuses on culture practices including feeding and health management,</td>
</tr>
<tr>
<td><strong>8. AFSPAN</strong></td>
<td>Work package 4 provides a better understanding of the role of aquaculture systems, scale, enterprise structure and institutional arrangements in improving rural livelihoods.</td>
</tr>
<tr>
<td><strong>9. SEAT</strong></td>
<td>Promoting roles for poorer value chain participants</td>
</tr>
<tr>
<td>12 Social responsibility, gender equity, food security and poverty alleviation</td>
<td>1. RFLP (Cambodia, Indonesia, Vietnam, Timor Leste)</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>2. AqASEM 2009</strong></td>
<td>Empowering vulnerable stakeholder groups to (i) share country experiences and best practices regarding poverty eradication and gender issues (ii) increase knowledge and skills in gender analysis and gender mainstreaming (iii) identify strategies to promote appropriate technologies and greater women participation for vulnerable groups and (iv) develop action plans towards empowering poor farmers and women in aquatic food production</td>
</tr>
<tr>
<td><strong>3. SEAT</strong></td>
<td>Food safety and occupational health Evidence of lack of any major health hazard related to pathogens from seafood produced in Thailand and Bangladesh to EU citizens.</td>
</tr>
<tr>
<td><strong>4. AFSPAN</strong></td>
<td>Research under Work Package 5 will be used to develop an analysis of the key assets and institutional factors required for aquaculture to develop rapidly, sustainably and equitably, and will likewise identify the factors that have made — and will make — aquaculture development deviate from these ideals.</td>
</tr>
</tbody>
</table>

Work Package 6 on Nutrition contributes to the understanding of how aquaculture products are (or have failed to be) integrated into and targeted by nutritional programmes aimed to improve nutrition in food insecure populations, in general, and specifically in vulnerable population groups. Best practices will be analysed to give recommendations for how aquaculture can be made an integral component of interventions to alleviate poverty and improve food and nutrition security.

A summary of these contributions — which reflects the development collaboration “landscape” — is provided in Table 6. The summary table indicates the following:

- Most of the projects have components that contribute to improving the livelihoods of small farmers, followed by Governance, and then by Resource and Environmental Management. This reflects not only the deliberate aim at improving livelihood of farmers by the projects but the consequence of their outcomes inevitably impacting on farmers practices that improve productivity and income.

- The 3 projects under FP7 have broader remits than previous ones; and all three addressed market access and trade, which coincides with the period when the issues related to food safety standards assumed increasing prominence in trade.

- Risk management was not directly addressed by any of the projects, although this would have been included in the projects on climate change or those that had components that addressed hazards from climate change such as RESCOPAR, PHILMINAQ,
AQUACLIMATE, EMMA/AQUAPARKS and the GIZ project in Ca Mau Vietnam on mangrove. The production and marketing risks faced by farmers are also addressed by the projects that sought to promote better management practices (production risk) and those that aimed at improving processes and product quality and enabling farmers to understand and comply with certification standards (marketing risk).

- The conclusion from the Compliance to EU Food Laws project under FP6, in the Philippines, that “even the small farmers whose products were not for export effectively complied with the food laws in their production processes because they considered EU accreditation as quality label” carries these implications: (a) small farmers need not be marginalized by certification standards, (b) the conclusion supports the AqASEM 2009 recommendation for finding ways to achieve a balance between continuous improvement and market access for small holders while maintaining credibility of certification, and (c) offers some answer to SEAT’s concern of giving a fair deal to the poorest groups in the seafood value chain.

- A positive finding of SEAT is not finding evidence for any major health hazard related to pathogens from seafood farmed in Thailand and Vietnam to EU citizens, and as a corollary, a significant reduction in the use of antimicrobials for shrimp in Thailand.

- There is a promising scope for adaptive research in ASEAN — with the abundant coastal resources and long coastlines — to introduce and promote the IMTA models that have been documented in China.

Table 6. Summary of contributions to 12 distinct capacity building areas in ASEAN aquaculture of 12 collaborative projects between EU and ASEAN.

<table>
<thead>
<tr>
<th>Projects/Areas</th>
<th>1 GOV</th>
<th>2 REM</th>
<th>3 AAHM</th>
<th>4 CERT</th>
<th>5 PHP</th>
<th>6 MARK</th>
<th>7 VCh</th>
<th>8 CLIM</th>
<th>9 HP&amp;I</th>
<th>10 SIA</th>
<th>11 Live</th>
<th>12 SR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. RESCPAR - Netherlands</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td>2. FSPS2, DANIDA</td>
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<td>X</td>
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<tr>
<td>3. RFLP- AECID</td>
<td>X</td>
<td></td>
<td></td>
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<td>X</td>
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<tr>
<td>4. Mangrove for CC resilience Vietnam - GIZ</td>
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<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>5. Compliance to EU food laws FP6</td>
<td>X</td>
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<td></td>
<td>X</td>
<td>X</td>
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<td></td>
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<tr>
<td>6. PHILMINAQ FP6</td>
<td>X</td>
<td>X</td>
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<tr>
<td>7. EMMA/AQUAPARK (NORAD)</td>
<td>X</td>
<td></td>
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<td>X</td>
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<td>8. AQUACLIMATE (NORAD)</td>
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<td></td>
<td>X</td>
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<tr>
<td>7. ASEM Aqua FP6</td>
<td>X</td>
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<td></td>
</tr>
<tr>
<td>8. AqASEM 09</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td></td>
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<td></td>
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<tr>
<td>9. SEAT FP7</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>10. AFSPAN</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>No. of projects</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>9</td>
<td>4</td>
</tr>
</tbody>
</table>
3. Opportunities for capacity building in 12 management and development areas

The indications from the preceding section (Tables 5 and 6), the information and views from several experts from ASEAN and EU (provided to the consultant through face to face interviews and/or remote communications by email, Skype and telephone), a number of reports and publications (cited in various sections) such as the UK-Southeast Asia Aquaculture Workshops on Fish and Shellfish Health and Nutrition (March 2014), Blue Frontiers, reports of the FP7 projects, FAO strategic statements, and others are synthesized into a list of opportunities for capacity building in the same 12 areas. The information and views offered by and discussed with experts appear as Annex 3.

Table 7. Suggested researchable issues in support of capacity building

<table>
<thead>
<tr>
<th>Capacities for management and development</th>
<th>Suggested research areas and researchable issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Governance of the sector</td>
<td>• Feasibility of establishing a Seaweed Center of ASEAN.</td>
</tr>
<tr>
<td></td>
<td>• Assessments of ecological and social carrying capacities</td>
</tr>
<tr>
<td></td>
<td>• SOPS for movement of live food finfish within ASEAN</td>
</tr>
<tr>
<td></td>
<td>• Green tax</td>
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<td></td>
<td>• Aquaculture safety zones</td>
</tr>
<tr>
<td></td>
<td>• Innovation clusters</td>
</tr>
<tr>
<td></td>
<td>• Cost-benefit studies/feasibility studies of proposed projects</td>
</tr>
<tr>
<td></td>
<td>• Investigate funding model for regional Aquatic Animal Health Reference Laboratory in Asia.</td>
</tr>
<tr>
<td>2. Resource and environmental management</td>
<td>• Environmental impact prediction</td>
</tr>
<tr>
<td></td>
<td>• Revised assessment of integrated production systems to optimise resource use efficiency and address safety concerns</td>
</tr>
<tr>
<td></td>
<td>• Better management guides for local farms by local governments (adaptation study)</td>
</tr>
<tr>
<td></td>
<td>• Fish meal/oil replacement using local ingredients</td>
</tr>
</tbody>
</table>
3. Aquatic animal health management

- Work towards the development of vaccines, probiotics and immuno-stimulants
- Development of harmonized diagnostic procedures and approaches to risk assessment
- ASEAN shrimp Good Aquaculture Practice
- ASEAN Aquatic Animal Disease Control Center
- BIMP-EAGA harmonized quarantine for fish
- Cost-benefit assessments of improved biosecurity
- Comparative assessment of legislative frameworks in EU with those in ASEAN.
- Combining biosecurity strategies with sociological research for engaging farmers and industry at all levels.
- Development of reliable diagnostic tests
- Broadly participatory research on disease control strategies, aquatic animal movements and cost benefit analysis of alternative disease control strategies

4. Certification: safety/quality, environmental, social

- Labor and employment
- Traceability - feed from by-catch
- HACCP applied to culture

5. Post harvest and processing

- Waste utilization
- Value addition (pharmacological, nutritional)
- Enhancing nutritional properties of products

6. Market access

- Standardization of processes and products
- Counter negative campaign vs. carrageenan with scientific research
- Need to maintain competitiveness of Thailand in EU market due to loss of tariff preference (due to the imminent lifting of the GSP) of Thai aquatic product exports in EU
- Need to maintain aquatic product image of quality
- Need to develop superior value added products
- Value chain management
- Business-to-business platform for trade and investment negotiations

7. Value chain management

- Reducing inefficiencies along the input supply chain and farm to market chain
- Enhancement of livelihoods at each node in the chain
- Decent employment along the chain

8. Climate change resilience and adaptation

- Aquaculture insurance
- Vulnerability assessments
- Selective breeding for disease resistance and temperature tolerance within cultured stocks

9. Higher productivity and income

- Breeding and genetics
- Feed and nutrition
- Health management
- On farm performance improvement
- Integrated farming
- Value addition
- Marketing strategies
3a. Opportunities for research excellence, cooperation and innovation

The examples cited in the foregoing section strongly suggest that a national innovation system focused on aquaculture can provide the opportunity for achieving a sustained cooperation in research and the utilization of research results for the management and development of the sector. It could comprise these two subsystems:

a. Consortium - organize industry players into a consortium to enable a continuing (as opposed to ad hoc) diagnosis of industry problems and search for their solutions. Membership includes S & T institutions, Policy and Regulatory bodies, and Industry. One important feature of this arrangement is the credibility endowed by science-based evidence to the processes and products of the sector. This would considerably strengthen efforts to better inform buyers and consumers.

b. Industry association or federation — professionalized, broadly representative of all stakeholders with close links to professional and scientific resources. An example is the FEAP at the regional level, but there is no close equivalent to FEAP in ASEAN. The 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 both scientific and professional programmes.

The two arrangements are not mutually exclusive; the association or federation can be the organized industry partner in the consortium. Either model would effectively marshall science-industry-government cooperation for addressing in a holistic and integrated manner a problem or a set of problems.

Scope. The industry collaboration would cover not only the scientific nature of the problem or problems but the policy, regulatory, and management framework for problem-solving and, when a solution is devised, for applying it in production/processing/marketing.

Social research. Social science research should take a prominent role at both ends of the problem: (i) at the diagnosis and characterization of problems when it is imperative to assess

| 10. Sustainable intensification of aquaculture | • Adaptation of China’s IMTA models in ASEAN  
• Breeding and genetics  
• Health management  
• Feed and nutrition  
• Recirculation aquaculture system  
• Low-energy systems  
• Waste reduction; waste conversion to useful products |
|-----------------------------------------------|
| 11. Livelihood improvement                      | • Management of livelihood capitals by farmer groups  
• Use of marginal lands for aquaculture of high value species  
• Enterprise development and management |
| 12. Social responsibility                       | • Labor and employment in the sector  
• More positive image of carrageenan for public perception  
• Group certification  
• Co-management of culture based fishery resources  
• Study of the true cost of poor food safety/hygiene on ASEAN consumers |
the opinions, needs and socio-economic circumstances of the producer, farming household, and community and (ii) at the application of the solution when it is crucial to determine if and how the proposed solution fits into their circumstances and goals.

4. **Researchable issues based on current regional priorities and global advocacies**

Table 7 identifies a lengthy list and a wide range of research issues. A short list is identified here based on two basis: current industry priorities and global advocacies.\(^\text{20}\)

**4.1. Priority issues for basic, disciplinary, interdisciplinary, applied, adaptive, on-farm and action research.**

**Health**
- Vaccine development
- Immuno-stimulants and probiotics
- Disease control strategies — cost/benefit assessments

**Feed and nutrition**
- Replacement of fish meal and fish oil with locally sourced plant-based ingredients

**Genetics**
- Selective breeding for (a) growth and economic efficiency (basic objectives), (b) development of strains that require less lipids (to reduce dependence on fish meal and oil), (c) disease resistance (in the wake of repeated onslaught of new diseases); and (d) temperature tolerance (for climate change adaptation).

**Food safety**
- Food safety/hygiene awareness — cost/benefit assessments

**Processing**
- Converting waste into useful products, by-products utilization, value addition to aquaculture products, enhancing nutritional property of products.

**Rural development/livelihoods enhancement**
- Alternative use — for aquaculture — of marginal, low productive land except mangrove (for instance there are 17.5 million rai or almost 2 million hectares of sodic soils in Thailand and likely more in Cambodia, Laos, Myanmar and Vietnam; all other ASEAN countries would have marginal lands
- Livelihood capitals/farm business management

**Biosecurity**
- Interdisciplinary assessments to ensure social, technical, economic and institutional aspects of disease control strategies are considered and that measures are in place to ensure they are feasible and adaptable in the future. Approaches that enable the interactive participation of stakeholders throughout product value chains. Comprehensive cost-benefit analysis of different production strategies incorporating treatment costs, yield gains, risk reduction and costs of inaction.

**Biodiversity**
- Interdisciplinary assessments to ensure economic and social change associated with aquaculture development does not have adverse impact on the environment and biodiversity, and that the consequences for all stakeholders are considered and where

\(^\text{20}\) The short list is further informed by FAO’s State of World Fisheries and Aquaculture 2014, and Blue Frontiers: Managing the Environmental Cost of Aquaculture. Policy Brief, 2011;
necessary appropriate safeguards and mitigation measures implemented (Note: this is addressed in a broader way by AFSPAN).

Social responsibility and value chain management
- An integrated research programme that covers the value chain to (i) infuse social responsibility throughout the chain and (ii) increase efficiencies along the chain:
  - production and supply of inputs — seed, feed, chemicals, credit, labor
  - production — resource and environmental management, health management, feed and nutrition, good practices, being associated (collective action), employment, and gender equity
  - marketing — middle-men’s role, rent seeking, group marketing, labor and employment, gender equity
  - transformation of product — good manufacturing practices, gender equity, creation of rural (cottage or medium scale) industries, labor and employment

4.2. Current global priorities

The current global priorities and advocacies require interdisciplinary or even inter-sectoral (aquaculture/fisheries-agriculture-forestry-commercial/industrial) approaches. Research programmes could be built around these priorities:
- Sustainable Intensification of Aquaculture
- Blue Growth
- Value chain development and management — reducing inefficiencies, creating values, and generating more opportunities for decent livelihood
- Fully controlled aquaculture systems: recirculation aquaculture systems, aquaponics.
- Integrated Multi-Trophic Aquaculture
- Climate change resilience and adaptation: genetics, biodiversity, social resilience, diversification of livelihood opportunities
- Interactions, both positive and negative, among the four sectors in terms of use of resources, flow of materials, labor, and wealth.

The above research areas are organized in Table 8 to show which ones support the 12 areas for capacity building of management and development of the aquaculture sector. Some areas would support more than one sector management capacity:

Table 8. Which priority research areas support what capacity for management and development

<table>
<thead>
<tr>
<th>Researchable Issues/Management &amp; Development Capacities</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. An integrated research programme</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>2. Interdisciplinary assessments – Biodiversity</td>
<td>X</td>
<td>X</td>
<td></td>
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<td></td>
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<tr>
<td>3. Interdisciplinary assessments – Biosecurity</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>4. Alternative use — for aquaculture — of marginal, low productive land except mangrove</td>
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<td></td>
<td></td>
<td>X</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Livelihood capitals/farm business management</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>6. Converting waste into useful products</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>7. Food safety/hygiene awareness — cost/benefit of</td>
<td>X</td>
<td>X</td>
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</tr>
</tbody>
</table>
Management and development capabilities (represented by nos. 1-12 in above table)

<table>
<thead>
<tr>
<th>No.</th>
<th>Activity</th>
<th>Xs</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.</td>
<td>Selective breeding for various attributes</td>
<td>X</td>
</tr>
<tr>
<td>9.</td>
<td>Replacement of fish meal and oil with plant-based ingredients</td>
<td>X</td>
</tr>
<tr>
<td>10.</td>
<td>Vaccine development</td>
<td>X</td>
</tr>
<tr>
<td>11.</td>
<td>Immuno-stimulants and probiotics</td>
<td>X</td>
</tr>
<tr>
<td>12.</td>
<td>Disease control strategies — cost/benefit assessments</td>
<td>X X</td>
</tr>
<tr>
<td>13.</td>
<td>Fully controlled aquaculture systems</td>
<td>X</td>
</tr>
<tr>
<td>14.</td>
<td>IMTA</td>
<td>X</td>
</tr>
<tr>
<td>15.</td>
<td>Interactions among fishery, forestry, agriculture and commercial/industrial sectors</td>
<td>X X</td>
</tr>
</tbody>
</table>

5. Opportunities for strengthening R&D capacities, sharing results of aquaculture S&T

There are several but not mutually exclusive modes for strengthening R&D capacities and sharing the results of research and technology development:

1) Farmer-Researcher cooperation through various means such as on-farm research, farming systems research, which involves the farmer as member of the research team. Innovative farmers could show the researchers a thing or two even as their participation might spur them to innovate by merging their traditional knowledge with the scientific knowledge that the researchers bring to her awareness.

2) Technical cooperation among ASEAN countries: coordination of research, information and technology and expert exchange and the adaptation or adoption of technology under the framework of the regional indigenous organizations (RIOs), NACA, INFOFISH, Mekong River Commission, Southeast Asia Fisheries Development Center as well as the Asia-Pacific Fisheries Commission and FAO’s Regional Office for Asia and the Pacific.

3) International institutions: World Fish, on upstream research and strengthening of national agriculture research systems. FAO/APFIC, for catalytic projects for sector management and development and guidelines for sustainable development and responsible aquaculture. They work with regional indigenous organizations (RIOs) or directly with national research institutions through National Agricultural Research Systems or NARS.
4) National Agricultural Research Systems — applied, adaptive and farming systems research, adaptation of new technology to national socio-economic and agro-ecological conditions and their promotion to the industry.

5) Public private partnerships — joint investments in research projects, infrastructure, and technology development and capacity building geared to enterprise development and management.

6) Industry — complement government efforts in trade negotiations (i.e., business-to-business negotiations) and professional and scientific forums.

7) An aquaculture innovation cluster composed of academic/scientific institutions, regulatory and management agency, private industry and farmer associations such as the model exemplified by the shrimp cluster in Thailand\textsuperscript{21} and referred to in Section 2.3.5 (page 36).

8) Farmer associations, producers’ federations — promotion, adoption of innovations, improvement of capacities of members for management and mitigation of production and marketing risks; take part in formulation of policies and programmes on S & T, or offer policy recommendations to government.

9) ASEAN (Fisheries Working Group): regional policy and programme formulation; coordination and promotion of regional S&T initiatives, review of regional science and technology investments in aquaculture.

10) EU: scientific collaboration in key areas of EU competence that complement ASEAN’s for the strengthening of regional and national capacities for R and D and development of innovative products and systems that provide mutual benefit. Basic research could be done in EU institutions, the result of which can then be brought to ASEAN for applied, adaptive and then farming systems research under EU-ASEAN cooperation.

6. Policy Recommendations

These recommendations are aimed at (i) strengthening the Science and Technology capacities in ASEAN and EU to support the management of aquaculture development in ASEAN, (ii) institutionalizing a mechanism for cooperation in S&T among ASEAN members; and (iii) reinforcing the framework of cooperation in S & T between ASEAN and EU that would generate mutual benefits:

1. READI S & T could focus on key scientific issues that would facilitate the usually broader Horizon 2020 programmes. Place a strong emphasis on research that results in social innovations.

2. Encourage and facilitate the formation of aquaculture S and 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.

3. Form S&T networks of excellence in interdisciplinary research and development, with a key regional institution and national centers linked to it and to each other. This could be a joint programme of AqASEM and READI S & T.

4. Assure start-up funding for S&T initiatives in aquaculture within ASEAN by ASEAN participants which is predictable and sustainable: Set up an ASEAN Sustainable Aquaculture Science and Technology Advancement Fund.

5. As a corollary to “4,” formalize within the ASEAN Secretariat (working in collaboration with the ASEAN Foundation) a mechanism akin to an investment centre. The mechanism would identify, screen, study and endorse for funding proposals of regional or subregional scope for investments in research and technology development.

6. Maintain the ASEM Aquaculture Platform under Horizon 2020 with a focused scope on science and technology addressed to the needs of the small farmers in ASEAN and the needs of education, technology and support service providers in both ASEAN and EU.

7. Promote an integrated, holistic approach to S & T that is multi-stakeholder, multidisciplinary, and covering the entire range of application of scientific result from policy to implementation.
7. References and other sources of information

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B. Experts

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