

# Sustaining Environmental Integrity in the Midst of Intensified Aquaculture Development

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The escalating aquaculture production from Southeast Asia during the past decades seems inevitable notwithstanding its significant contribution to economic growth and guaranteed food security of the countries in the region. Despite its good prospects, the region's aquaculture sector is being confronted with various issues that should be addressed to enable it to develop sustainably and contribute unceasingly to poverty alleviation in the region. Responsible aquaculture has been practiced in the region as means of easing the crisis in capture fisheries; however, this has to be matched with effective approaches that address concerns on the fishery resources that are deteriorating. Resource enhancement of economically important aquatic species has been considered as one of the effective approaches that would help protect and restore the aquatic resource habitats and stocks, the latter connotes stock enhancement. As could be gleaned from the current scenario of fisheries in the Southeast Asian region, the recurring over-exploitation of common natural resources has affected the livelihoods of fishers and coastal communities. The imbalanced extraction of natural aquatic resources and natural recruitment has worsened through the years and if left unabated could result in the extinction of many of the region's endemic aquatic species.

It is for such consequences that the Aquaculture Department of the Southeast Asian Fisheries Development Center, while intensifying its efforts in developing sustainable aquaculture, is also promoting resource enhancement as these two approaches are expected to enhance the region's fishery resources and food security in view of their perfect roles in improving the productivity of aquatic stocks and status of the natural habitats. Nonetheless, aquaculture techniques have always been used to facilitate the stock enhancement of commercially important, threatened and endangered aquatic species. The National Oceanic and Atmospheric Administration of the USA defines stock enhancement as "restoration aquaculture" or the release of hatchery-bred juveniles of fish and shellfish to the wild, and considers this approach as a management tool to recover depleted stocks due to overfishing and habitat loss. The Food and Agriculture Organization of the United Nations has demonstrated that stock enhancement is a type of culture-based fisheries since part of the life cycle of certain aquatic species is being controlled in hatcheries before the seeds or juveniles are transplanted or released into open waters – freshwater or brackishwater or marine environments – and allowed to propagate or grow on natural foods until reaching harvestable size.

The Philippine-based Aquaculture Department (AQD) of the Southeast Asian Fisheries Development Center (SEAFDEC) is mandated to promote and undertake research on aquaculture relevant and appropriate to the region, encourage human resource development in aquaculture through training and extension, and disseminate and exchange information on aquaculture. In accordance with such mandates, AQD has been carrying out research, technology verification, training and information dissemination on a wide range of aquaculture disciplines, including broodstock management and seed quality improvement; promotion of responsible and environment-friendly aquaculture; diagnosis, prevention and control of aquatic diseases; aquaculture for stock enhancement; and culture of aquatic species under international concern.

The aquaculture commodities covered by AQD include fishes, shrimps, crabs, molluscs, and seaweeds. In addition, AQD also promotes good aquaculture practices and effective management of aquatic resources to support rural development and alleviate poverty. AQD is therefore committed to the sustainable development and the responsible stewardship of aquaculture resources through science-based research and the promotion of appropriate aquaculture technologies and information relevant to Southeast Asia.

## Resource Enhancement for Environmental Integrity

Embracing a highly diverse flora and fauna, the Southeast Asian region possesses a wide variety of aquatic species that have been utilized for human food and trade, subjecting such resources to continuous over-exploitation for decades. As a consequence, many species have been threatened or endangered, and as a matter of fact, some species which are of commercial importance to Southeast Asia have been listed or proposed for listing in the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Such circumstances have regulated capture, collection, trade and utilization of certain species affecting the livelihoods of fishers and the sustainability of fisheries in Southeast Asia, thus, requiring immediate actions toward replenishment of the CITES-listed species as well as over-exploited species, and securing a wholesome ecosystem to support sustainable fisheries for food security and livelihood in the region. In an effort to address such concerns, AQD with support from the Japanese Trust Fund has embarked on a project aimed at restoring the stock levels of some species listed or proposed to be listed in the CITES Appendices and those economically important species in the Southeast Asian region that had

## Box 1. AQD's major programs on sustainable aquaculture development

### Quality Seeds for Sustainable Aquaculture

Success in the sustainable production of aquatic species depends primarily on the availability of quality seed stocks as well as on the optimal husbandry techniques. Thus, AQD pursued various studies to determine the optimal conditions and methods for producing quality seed stocks in sufficient quantities, including methods for stock improvement such as domestication, broodstock management, strain evaluation, and selective breeding or genetic improvement of traditional and emerging freshwater and marine species.

- The **Development of Good Quality Broodstock and Implementation of Proper Stock Management Protocols** focuses on monitoring genetic structures of base populations, establishing husbandry techniques, culturing live food, and developing suitable formulated diets for good reproductive performance of various commodities, e.g. shrimps (*Penaeus monodon*), milkfish (*Chanos chanos*), tilapia (*Oreochromis niloticus*), donkey's ear abalone (*Haliotis asinina*), oysters (*Crassostrea iredalei*), grouper (*Epinephelus fuscoguttatus*), giant freshwater prawn (*Macrobrachium rosenbergii*), and Napoleon wrasse (*Cheilinus undulatus*).
- **Refinement of Hatchery and Nursery Management Methods** has been continued to improve seed stock quality and production of various commodities, e.g. pompano (*Trachinotus blochii*), groupers, sea bass, snapper, milkfish, rabbitfish (*Siganus guttatus*), donkey's ear abalone, oysters, mud crab, seaweeds (*Kappaphycus* spp., *Eucheuma denticulatum*), swimming crab (*Portunus pelagicus*), seahorses (*Hippocampus barbouri*, *H. comes*), silver therapon (*Leiopotherapon plumbeus*), sandfish or sea cucumber (*Holothuria scabra*).
- The **Development of Schemes for Production, Management, Maintenance and Dissemination of Genetically Selected and Improved Stocks** which focuses on selective breeding programs, started with selected crustaceans, i.e. mud crab, shrimps and giant freshwater prawn.

### Maintaining Environmental Integrity through Responsible Aquaculture

This is intended to address issues on the negative impacts of aquaculture on the environment and define strategies on how these impacts could be minimized. Focusing on developing environment friendly-based aquaculture technologies, this project aims to integrate environmental factors in AQD's research activities and promote responsible aquaculture. Thus, studies have been carried out to assess the impacts of aquaculture on biodiversity, and water and sediment qualities in culture areas and adjacent ecosystems both in marine and freshwater systems; develop and promote efficient and suitable environment-friendly culture systems; and conduct biological and ecological studies on species with potentials for resource enhancement.

- **Assessment of the Impacts of Aquaculture on Biodiversity, and Water and Sediment Qualities** has been continued through regular monitoring of the different stations of AQD using the established monitoring systems for water and substrate quality, i.e. at *Igang Marine Station* and surrounding areas, bathymetric profile of the areas and sediment size analyses had been completed while the biodiversity of various ecosystems and near the cage installations had been established; at *Tigbauan Main Station*, sampling of the shore areas around the station had been conducted and publication of a book on the marine biodiversity in Tigbauan, Iloilo initiated; and at *Binangonan Freshwater Station*, a comparison of phytoplankton, zooplankton and fish and other vertebrate diversity in two sites around the station, the East Cove (an aquaculture site) and the West Cove (non-aquaculture site) has been carried out.
- On the **Development and Promotion of Efficient and Suitable Environment-friendly Culture Systems**, experiments were conducted to determine the optimal conditions for the culture of sandfish *H. scabra*.
- **Biological and Ecological Studies on Species with Potentials for Resource Enhancement** had been conducted for species such as the giant clam (*Tridacna gigas*), abalone, mud crab, sea cucumber.

### Promoting Healthy and Wholesome Aquaculture

AQD has been promoting the concept of healthy and wholesome aquaculture as a holistic approach to fish disease management as well as development of cost-effective feeds that optimize production of robust and healthy farmed aquatic commodities with the least negative impact on the environment. Thus, AQD has been putting more focus on R&D in fish nutrition and aquatic animal health management to develop the technologies/good practices and ensure a steady and reliable supply of safe and quality fish beneficial to the public, as well as enhance the capacity and affordability of adopting such practices by a wide range of small-scale fish farmers.

### Adapting to Climate Change Impacts on Aquaculture

This project aims to identify the accompanying changes in the environment brought about by changing climate that affects the aquaculture sector, prepare the sector to the possible effects that these changes may have on aquaculture operations, minimize and mitigate the adverse impacts of climate change on aquaculture, and ensure continued operation of all aquaculture production systems under changing climatic conditions. Thus, studies have been pursued to generate scientific information on the effects of increasing temperature on the susceptibilities of different stages of important tropical aquaculture species like marine fishes, marine invertebrates such as the abalone (*H. asinina*), mud crabs (*S. serrata*); and the acidic conditions and elevated temperature on corals.

### Meeting Social and Economic Challenges in Aquaculture

This project is aimed at developing and implementing social and economic strategies in aquaculture and resource enhancement to secure food and income through stakeholder collaboration.

- **Prioritizing Collaborative R&D in Aquaculture in the Region** has been initiated through studies that enhance understanding of the role of aquaculture in poverty alleviation and in formulating relevant policy recommendations. For freshwater aquaculture, the commodities include the giant freshwater prawn and tilapia, and for brackishwater culture and mariculture, abalone and shrimps.
- **Allocating R&D Resources to Address Emerging Issues** focuses on AQD's efforts to promote eco-friendly aquaculture technologies that could provide socio-economic benefits to stakeholders as well as organizational solidarity and commitment among stakeholders. This includes the potential applications of income-generating but eco-friendly culture technologies such as the integrated multi-trophic aquaculture (IMTA) in milkfish mariculture and socio-economic assessment of highly threatened ecology such as the Napoleon wrasse fishery to complement a study on seed production of this species.

Source: SEAFDEC (2014)



Clockwise from top: sea horses, Napoleon wrasse, mud crab, abalone seeds for release in the wild, sea cucumber, and released abalone  
 been heavily-exploited, as well as promoting resource enhancement for environmental integrity.

Initially, the species identified by AQD for stock enhancement include sea horses (*Hippocampus* spp.) and Napoleon wrasse (*Cheilinus undulatus*) which had been listed in CITES Appendices, and sea cucumber (*Holothuria scabra*), donkey's ear abalone (*Haliotis asinina*), and mud crabs (*Scylla* spp.). Setting its sight towards a holistic resource enhancement project, AQD establishes seed production technologies for the concerned species taking into account

the need to preserve genetic diversity and release procedures that aim to minimize the unintended negative impacts of stock release on the wild populations and the other species. Specifically, release strategies to improve survival of released animals in the wild are being developed by AQD, *i.e.* tagging methods, optimum size-at-release, site selection, conditioning of animals prior to release, and securing shelters (Lebata-Ramos *et al.*, 2015). In order to complement such efforts, socio-economic studies are being carried out as means of identifying the appropriate community-based strategies (Salayo *et al.*, 2015).

Moreover, this AQD project also takes into consideration the environmental capacity since the natural habitats of tropical aquatic life had been rapidly deteriorating due to changing environment brought about by anthropological repercussions and the impacts of climate change. Thus, adaptive measures are being developed by AQD to maintain a healthy environment. This project is therefore expected to establish strategies and guidelines of stock enhancement based on sustainable, responsible and environment-friendly approaches.

In order to bolster the project which focuses on resource enhancement of internationally-threatened and regionally-exploited species, AQD is also undertaking a study that promotes sustainable and region-oriented aquaculture through research and capacity-building initiatives. This study complements AQD's R&D on sustainable aquaculture which comprises five major programs (**Box 1**), namely: Quality Seeds for Sustainable Aquaculture; Promoting Healthy and Wholesome Aquaculture; Maintaining Environmental Integrity through Responsible Aquaculture; Adapting to Climate Change Impacts on Aquaculture; and Meeting Social and Economic Challenges in Aquaculture.

**Box 2. Lessons shared by the Southeast Asian countries on sustainable aquaculture development *vis-à-vis* resource enhancement**

**Aquaculture Development**

- The rapid increase in growth of aquaculture in Indonesia had been achieved because of various factors, such as: (i) enhanced coordination efforts from Government to farmers; (ii) provision of strong technical assistance and Government support (*i.e.* Government conducts empowering activities in each province); (iii) active participation and commitment of key players (*e.g.* government, R&D institutions, private sector, and farmers) to work together.
- The seaweed industry in Indonesia is successful in view of the strong technical support being provided by the Government to the farmers through the following key strategies: (i) empowering the people, especially the farmers near the coastline; (ii) multi-stakeholder involvement (*i.e.* government agencies, private sector and farmers work together); (iii) adoption of cluster approach to empower the farmers, and as a result farmers gain access to technology and bank loans (dissemination of technology and provision of credit facility are facilitated through groups or clusters of farmers).
- Success of Viet Nam in catfish (*Pangasius* sp.) production and increased revenues generated had been attained through cooperation with International Trade Centre (joint agency of World Trade Organization and United Nations). Viet Nam organized a benchmarking workshop which enabled the country to harmonize VietGAP with the globalGAP. To ensure that every catfish farmer in the country follows the VietGAP, human resource development is given the highest priority which involves training those involved in the process of production and certification, *e.g.* lecturers, auditors, farmers. In order that small-scale farmers in Viet Nam meet the requirements of importing countries, especially for its two main commodities exported, *i.e.* shrimps and catfish, the capacity of farmers in applying the VietGAP has been enhanced, and farmers have been encouraged to link together and form groups or companies. Through the farmers' groups, farmers could access to technical support (training) and credit facilities provided by the Government.

**Stock Enhancement**

- Fishes to be stocked should be properly checked for the presence of any viruses or any disease-causing agents especially if the source is from the hatchery where broodstocks are imported.
- Countries that are promoting stock enhancement or restocking should allocate funds for the assessment of the impacts of such activities to wild populations.

Source: SEAFDEC/AQD (2014)

### Box 3. Issues, gaps and opportunities on sustainable aquaculture development *vis-à-vis* resource enhancement

#### Aquaculture Development

- In order that the poorer sector of the society could benefit from aquaculture, a viable business model that is most applicable to the poor and beneficial to them should be developed. This model should take into consideration the methods and species to be produced (*i.e.* it should be site specific) and the resources available to the poor farmers.
- As means of harnessing its potentials, small-scale aquaculture could be developed more in inland waters rather than in brackishwater. Since many national institutions and agencies are playing important roles in enhancing the capacity of small-scale aquaculture farmers, their involvement in formulating aquaculture development plans and policies should be enhanced.

#### Stock Enhancement

- Napoleon wrasse is an endangered species in the Philippines, and in order that this resource in Mindanao (*i.e.* ARMM Region - Autonomous Region in Muslim Mindanao comprising the Provinces of Basilan, Lanao del Sur, Maguindanao, Sulu, and Tawi-Tawi) could be protected from further extinction, cooperation of the local government units and interventions (*e.g.* provision of other livelihood options for fishers) should be enhanced to ensure that the local community would protect the spawning aggregations and prevent from harvesting such resource illegally and indiscriminately.
- On AQD's community-based resource enhancement project in Sagay Marine Reserve (Province of Negros Occidental in western-central of the Visayas, Philippines), the community should be well-equipped and ready to manage its aquatic resources, considering that technical support and capacity building have been provided to them for the last eight years. Since an exit strategy is important and overstaying in the community is not effective, the AQD project should come up with benchmark indicators that will help assess the readiness of the community in managing their own aquatic resources.
- Since genetic monitoring appears lacking in most stock enhancement initiatives in the Southeast Asian region, a strategy that would reduce adverse genetic effects or negative impacts of stock release should be established and adopted by the countries in the region. This would address any potential genetic impacts of hatchery-based resource management.
- On the effects or impacts of stock release during stock enhancement, apart from possible genetic contamination, effects on the carrying capacity of the body of water, including competition should also be considered. Hence, there is a need to bring a balance between genetic and non-genetic (ecological) factors.
- Since most of the species selected for stock enhancement are for export, research institutions and agencies should also give priority to species that are low-trophic, low-value to ensure that benefits could also be gained by the poorer sector of the communities.
- Considering the need to look at what would really benefit the community - sea ranching or mainly restocking only, it is important that apart from knowing what species to use for stock enhancement, the purpose should also be defined and based on an appropriate design, the resource enhancement activity that is most fitting to the communities should be determined.

#### Sustainable Aquaculture and Resource Enhancement

- The aquaculture sector is most often blamed for some irresponsible practices and loss of biodiversity. Thus, greater conscious efforts must be done in managing aquaculture farms to ensure that biodiversity is conserved.
- Findings from any aquaculture and resource enhancement project should include clear policy recommendations, and in order to reach policy-makers, a clear communication strategy should be included in respective projects' plans and designs. Moreover, the target audience should be well defined and should include decision makers or the 'champions'. The importance of having sufficient budget allocated for technology transfer and identifying the team that would facilitate the communications should also be highlighted in the projects' plans and designs.
- Communication strategy should be accompanied by a scenario-setting to convince policy-makers that for some projects the cost and the benefits arising from the investment could be realized only after several years. NGOs could also be tapped in implementing communication strategies (*e.g.* promoting the importance of mangroves to food security and the need to comply with the laws and regulations on mangrove protection).
- On genetics in aquaculture and stock enhancement, considering that a number of stocks had been under domestication for a long time and in the Philippines alone, many new stocks are candidates for domestication, genetic intervention should be taken into account in order that problems encountered in old domesticated species would not constitute the same problems with the new and upcoming species that would inevitably be subjected to long term domestication.
- On alternative protein source or fish meal substitutes (*e.g.* cowpea meal) in aquafeed formulations, the feasibility and cost-effectiveness, particularly when mass-produced, should be determined, while the overall agricultural impacts and other benefits should be assessed.

Source: SEAFDEC/AQD (2014)

## Dissemination of Significant Findings and Sharing of Experiences

Through its project on Sustainable Aquaculture and Resource Enhancement, AQD has continued to assist the Southeast Asian countries in harnessing the full potentials of their resources for aquaculture development while promoting the need to protect and conserve the aquatic environment. In an effort to disseminate the significant findings from the project's activities, AQD with financial support from the Japanese Trust Fund convened the International Workshop on Resource Enhancement and Sustainable Aquaculture Practices in Southeast Asia in March 2014 in Iloilo City, Philippines. The Workshop was aimed at promoting and

augmenting regional initiatives on resource enhancement and sustainable aquaculture practices that would contribute to poverty alleviation, livelihood and food security (Romana-Eguia *et al.*, 2015). The experiences and lessons learned by the Member Countries of SEAFDEC on sustainable aquaculture development and resource enhancement (**Box 2**) were shared during the said Workshop, while various issues as well as gaps and opportunities had also been identified as shown in **Box 3**. The recommendations that were advanced during the Workshop, for the development of sustainable aquaculture and resource enhancement strategies, are summarized in **Table 1**. The status of the activities on sustainable aquaculture development and resource enhancement carried out in the Southeast Asian countries

was also reported during the Workshop, where gaps and issues were identified as well as opportunities for further development. A synthesis of such inputs is shown in **Table 2**.

## Way Forward

From the results of the project on Resource Enhancement of Internationally-threatened and Over-exploited Aquatic Species in Southeast Asia through Stock Release, AQD would establish the strategies as well as guidelines of stock enhancement based on sustainable, responsible and environment-friendly approaches. AQD would also continue to disseminate the significant findings of the project to the Southeast Asian countries through human resource development activities. As envisioned, environment-friendly resource enhancement of economically important aquatic species would eventually be promoted throughout the Southeast Asian region.

Specifically, considering that the findings from the research activities would be useful to local government

unit officers, fisherfolks, researchers and other relevant stakeholders, AQD would continue its effort in bridging the gaps by focusing on the practical levels in order that positive impacts could be generated by the stakeholders that would contribute to the sustainable development of fisheries in the whole Southeast Asian region. While AQD would also continue to promote sustainable aquaculture development through R&D, gaps in this aspect would also be nailed down, to ensure that methods and information available would definitely be useful to relevant stakeholders, especially the aquaculturists, researchers, academicians, and policy-makers. Thus, future activities of AQD would aim to: ensure reliable and sustainable aquaculture production through genetic improvement of commercially important aquatic species and establishment of reliable breeding and mass production techniques for new species for aquaculture; develop environment-friendly feeds from regionally available ingredients; establish management technology of the aquaculture environment taking into account the ecosystem approach to aquaculture; access and analyze the impacts of transfer and adoption of developed sustainable

**Table 1.** Summary of issues and recommendations for the development of sustainable aquaculture and resource enhancement strategies

Issues	Recommendations
<b>Aquaculture</b>	
<ul style="list-style-type: none"> <li>• Decreasing prices of aquaculture commodities/increasing cost of production</li> </ul>	<ul style="list-style-type: none"> <li>• Shift to high value species</li> <li>• Add value to low-priced aquaculture commodities (e.g. adding omega-3 fatty acid)</li> <li>• Identify and prioritize top five high value species to be focused on during the next 5 years</li> <li>• Conduct value chain analysis for different species</li> <li>• Enhance quality control</li> <li>• Apply competitive enhancement for aquaculture products (<i>i.e.</i> quality of products from ASEAN countries for export should be competitive with products from other regions of the world)</li> <li>• Immediately translate/package available technologies which are ready for application and commercialization</li> <li>• Use alternative feed ingredients (<i>i.e.</i> alternative to fish meal and highly digestible ingredients) to reduce cost of inputs</li> <li>• Apply efficient feeding management</li> <li>• Harmonize standards in line with ASEAN integration</li> </ul>
<ul style="list-style-type: none"> <li>• Accumulation of inbreeding in domesticated stocks; loss of genetic ability to adapt to climate change</li> </ul>	<ul style="list-style-type: none"> <li>• Collect relevant existing data, monitor pedigree of aquaculture stocks, bring in more geneticists into relevant activities</li> </ul>
<ul style="list-style-type: none"> <li>• Low technology/lack of technology</li> </ul>	<ul style="list-style-type: none"> <li>• Identify specific technologies that need to be addressed</li> </ul>
<ul style="list-style-type: none"> <li>• Lack of public support/established links between academe/research institutions/private sector</li> </ul>	<ul style="list-style-type: none"> <li>• Increase public awareness on the importance of aquaculture</li> </ul>
<ul style="list-style-type: none"> <li>• Need for more community-based aquaculture</li> <li>• Inadequate extension and capacity building programs for small-scale fish farmers</li> </ul>	<ul style="list-style-type: none"> <li>• Empower small-scale/small-holder farmers to enable them to apply GAqP</li> </ul>
<ul style="list-style-type: none"> <li>• Poor seed quality</li> </ul>	<ul style="list-style-type: none"> <li>• Apply genetic traceability of aquaculture stocks and verifiable certification of seed stocks for aquaculture</li> <li>• Use molecular markers for genetic tracing and certification of seeds</li> <li>• Adopt a system in providing certification for genetic tracing and for stock certification</li> <li>• Establish a system for genetic tracing and data bank for information on various stocks</li> <li>• Contribute to global gene bank for valuable species (international collaboration)</li> <li>• Develop regulatory policies to address inbreeding</li> <li>• Provide verifiable information to allow people the option to choose which stocks to use</li> <li>• Apply for ISO certification to address poor seed quality</li> </ul>

**Table 1.** Summary of issues and recommendations for the development of sustainable aquaculture and resource enhancement strategies (Cont'd)

Issues	Recommendations
<ul style="list-style-type: none"> <li>• Proliferation of invasive species in inland waters</li> <li>• Introduction of exotic species in relation to disease transfer</li> </ul>	<ul style="list-style-type: none"> <li>• Come up with concrete policies/guidelines/regulations on farming of exotic species</li> <li>• Strictly enforce/implement existing policies</li> <li>• Strictly report escapees from farms</li> </ul>
<ul style="list-style-type: none"> <li>• Aquaculture competes with other alternative uses of land and water resources; e.g. conversion of areas for aquaculture to other uses</li> </ul>	<ul style="list-style-type: none"> <li>• Apply zoning for marine aquaculture areas</li> </ul>
<ul style="list-style-type: none"> <li>• Aquaculture waste management</li> </ul>	<ul style="list-style-type: none"> <li>• Apply polyculture systems</li> </ul>
<ul style="list-style-type: none"> <li>• Dependence on the use of antibiotics</li> </ul>	<ul style="list-style-type: none"> <li>• Develop appropriate vaccines</li> <li>• Develop disease resistant strains</li> <li>• Discontinue the use of prohibited antibiotics</li> <li>• Strictly implement GAqP</li> <li>• Use immunostimulants and natural antimicrobials</li> <li>• Use probiotics</li> </ul>
<b>Resource Enhancement</b>	
<ul style="list-style-type: none"> <li>• Inadequate understanding of resource enhancement</li> </ul>	<ul style="list-style-type: none"> <li>• Create core group to establish a common definition/description of resource enhancement</li> <li>• Review the existing guidelines and related instruments</li> <li>• Establish protocols</li> </ul>
<ul style="list-style-type: none"> <li>• Insufficient or limited technical knowledge of local government units (LGUs)</li> <li>• Inadequate consultations with stakeholders, academe</li> </ul>	<ul style="list-style-type: none"> <li>• Enhance Information, Education and Communication for local government units, e.g. through League of Municipalities in the Philippines, community</li> <li>• Identify all groups doing similar work (i.e. on Resource Enhancement) and seek assistance from them (e.g. NGOs, universities, research institutions, national agencies)</li> </ul>
<ul style="list-style-type: none"> <li>• No comprehensive planning and project design</li> <li>• Project implementation is too fast</li> </ul>	<ul style="list-style-type: none"> <li>• Conduct community consultations before project implementation</li> <li>• Provide emphasis in community/participatory research</li> <li>• Adopt careful step by step process of implementation (not skipping crucial steps)</li> </ul>
<ul style="list-style-type: none"> <li>• Project duration is not sufficient</li> <li>• Imposition of donor-driven deadlines</li> <li>• Unclear exit strategy of projects</li> </ul>	<ul style="list-style-type: none"> <li>• Promote project transition that must be smooth</li> <li>• Ensure that implementation must be continuous and evolving</li> <li>• Examine the most logical duration of projects (e.g. Indonesia coral project with 3 phases, 15-year duration)</li> </ul>
<ul style="list-style-type: none"> <li>• Political term-dependent projects</li> </ul>	<ul style="list-style-type: none"> <li>• Enhance coordination with established institutions (e.g. NGOs, stakeholders, academe)</li> <li>• Involve other government agencies (e.g. BFAR and DENR for Philippines, Coast Guard)</li> <li>• Include projects in National or Municipal Economic Development Plan</li> </ul>
<ul style="list-style-type: none"> <li>• Incomplete baseline assessment</li> <li>• Absence of monitoring mechanisms</li> </ul>	<ul style="list-style-type: none"> <li>• Conduct at least one year of baseline information gathering before any intervention is made</li> <li>• Compile scientific information and indigenous knowledge (experience)</li> <li>• Facilitate social preparation</li> <li>• Establish more collaboration with agencies in collection of information</li> </ul>
<ul style="list-style-type: none"> <li>• Absence of impact assessment</li> </ul>	<ul style="list-style-type: none"> <li>• Conduct a follow-up on the same sources of information (from baseline: scientific and traditional)</li> </ul>
<ul style="list-style-type: none"> <li>• Data collection problems</li> </ul>	<ul style="list-style-type: none"> <li>• Empower local communities to gather reliable information</li> <li>• Refer to wiki-type information entry as well as logbook entry</li> </ul>
<ul style="list-style-type: none"> <li>• Political 'stunt act' vs. science-based</li> </ul>	<ul style="list-style-type: none"> <li>• Provide advance information to local government units and agencies about the benefits of projects before implementation</li> </ul>
<ul style="list-style-type: none"> <li>• Location of projects: use of marine protected areas (MPAs) as release sites</li> </ul>	<ul style="list-style-type: none"> <li>• Ensure careful site selection based on carrying capacity evaluation and complete baseline information</li> </ul>
<ul style="list-style-type: none"> <li>• Alternative livelihood and difficulty of coastal fishers to adapt to changes</li> </ul>	<ul style="list-style-type: none"> <li>• Make sure there is no sudden change from existing norm (i.e. types of livelihoods)</li> </ul>
<ul style="list-style-type: none"> <li>• Inadequate sustainable supply of seeds</li> </ul>	<ul style="list-style-type: none"> <li>• Release bigger juveniles instead of larvae</li> <li>• Establish seed production technology</li> </ul>
<ul style="list-style-type: none"> <li>• Seeds (particularly hatchery-bred stocks) and their potential genetic impacts when released in the wild</li> </ul>	<ul style="list-style-type: none"> <li>• Use native/endemic wild broodstocks instead of bred broodstocks</li> </ul>
<ul style="list-style-type: none"> <li>• Seeds as potential carriers of disease-causing agents</li> </ul>	<ul style="list-style-type: none"> <li>• Carry out screening tests</li> <li>• Use disease-free stocks</li> <li>• Conduct quarantine, vaccination, regular monitoring of released animals</li> </ul>

Source: Romana-Eguia et al. (2015)

**Table 2.** Synthesis of the status of sustainable aquaculture development and resource enhancement in Southeast Asia and Japan

Country	Aquaculture/Stock Enhancement Activities	Gaps/Issues	Opportunities for Development
Cambodia	<ul style="list-style-type: none"> <li>Focus is on inland fisheries and small-holder freshwater aquaculture (<i>i.e.</i> floating cage and pond culture, rice-fish culture, fish culture in small-water bodies)</li> </ul>	<ul style="list-style-type: none"> <li>Aquaculture is still relatively new (breeding programs have not yet leveled up)</li> <li>Main constraint is high cost of feeds (commercial pellets are mostly imported)</li> <li>Aquafarmers lack know-how on rice-fish farming</li> <li>Inadequate technical assistance and services</li> <li>Insufficient financial support</li> <li>Weak communication and social networking</li> </ul>	<ul style="list-style-type: none"> <li>Abundance of remarkable genetic resource in terms of 500 freshwater species</li> <li>Many potential aquaculture species</li> </ul>
Indonesia	<ul style="list-style-type: none"> <li>Main species cultured are: shrimps, groupers, seaweeds, barramundi, pearl oysters, crabs, exotic fishes, milkfish, tilapia, common carp, gourami, and freshwater prawn</li> <li>Practices: mariculture, brackishwater aquaculture, inland aquaculture (rice-fish culture systems using giant freshwater prawn)</li> <li>Off-shore farming of barramundi (sea bass) and pompano (with assistance from Norway)</li> </ul>	<ul style="list-style-type: none"> <li>Need more seeds of barramundi</li> <li>Problems on fish health and feeds</li> <li>Inadequate number of extension workers</li> </ul>	<ul style="list-style-type: none"> <li>Aquaculture development is in the upswing and will continue growing</li> <li>To ensure that this will grow sustainably, the Government implements aquaculture integration based on the concept of "Blue Economy"</li> </ul>
Japan	<ul style="list-style-type: none"> <li>Culture of red sea bream, halibut, ayu, Japanese amberjack, rainbow trout, carps, eel, shellfish, sea cucumber, seaweeds and more recently, blue-fin tuna</li> <li>Improvement of stocks/strains through genetics</li> <li>Resource enhancement of Chum salmon</li> <li>Sea ranching of scallops</li> </ul>	<ul style="list-style-type: none"> <li>Sustainability of eel fishery (population is declining)</li> <li>Overall production is decreasing (marine aquaculture production was primarily affected by recent earthquake that hit the country)</li> <li>Instability of business practice in aquaculture due to: low price of aquaculture products caused by overproduction; high cost of production as a result of increase in input costs</li> </ul>	<ul style="list-style-type: none"> <li>The country has instituted a paradigm shift - from sea ranching to resource enhancement</li> <li>Research and technological innovations on larvae and fry production</li> <li>Improvement of culture methods and feed quality</li> <li>80 species are targeted for sea ranching and resource enhancement</li> </ul>
Lao PDR	<ul style="list-style-type: none"> <li>Culture of tilapia in cage, monosex culture</li> <li>Backyard farming</li> </ul>		
Malaysia	<ul style="list-style-type: none"> <li>Pond and cage culture of commercial marine fishes, shrimps, red tilapia, hybrid catfish, giant freshwater prawn; culture of bivalves, green mussel, seaweeds</li> </ul>	<ul style="list-style-type: none"> <li>Low and inconsistent productivity</li> <li>Occurrence of viral and bacterial diseases in cultured shrimps and freshwater fish species</li> <li>Increasing production costs due to high input costs</li> <li>Non-compliance of product quality by entrepreneurs</li> <li>Decline in exports of ornamental fishes</li> </ul>	<ul style="list-style-type: none"> <li>Economic Transformation Programme</li> <li>Enhanced role of aquaculture in food-fish production</li> </ul>
Myanmar	<ul style="list-style-type: none"> <li>Culture of over 20 species of freshwater species, <i>e.g.</i> giant freshwater prawns, carps, tilapias, and catfishes</li> <li>Paddy-cum-fish farming</li> <li>Genetic improvement of rohu (<i>Labeo rohita</i>)</li> <li>Farming of marine fishes (<i>e.g.</i> sea bass, red snapper, groupers)</li> <li>Farming of seaweeds</li> </ul>	<ul style="list-style-type: none"> <li>Marked reduction in production of giant freshwater prawns due to diseases</li> <li>Stock enhancement is practiced but without monitoring of the released stocks, no recapture of stocks is done although there has been no evidence yet of negative impacts</li> <li>The country needs stock enhancement in marine fisheries but there are no technical experts available</li> <li>Need training course on stock enhancement</li> </ul>	<ul style="list-style-type: none"> <li>Poverty alleviation program in livestock, fisheries and rural development sector</li> <li>Government has a development plan for sustainable aquaculture and responsible fisheries in order to support food security and generate income for fisheries communities</li> </ul>

**Table 2.** Synthesis of the status of sustainable aquaculture development and resource enhancement in Southeast Asia and Japan (Cont'd)

Country	Aquaculture/Stock Enhancement Activities	Gaps/Issues	Opportunities for Development
Philippines	<ul style="list-style-type: none"> <li>• Mariculture, brackishwater and freshwater culture of commercially important commodities</li> <li>• Current Government priorities are aquasilviculture and organic aquaculture</li> <li>• Production of high value species</li> <li>• Resource enhancement of internationally threatened species</li> </ul>	<ul style="list-style-type: none"> <li>• Negative impacts of intensive aquaculture</li> <li>• Inconsistent supply of good quality seeds</li> <li>• Disease problems in cultured stocks</li> <li>• Abuse in the use of feeds</li> </ul>	<ul style="list-style-type: none"> <li>• Implementation of Comprehensive National Fisheries Development Plan</li> <li>• Resource enhancement and sustainable fisheries development through countrywide aquasilviculture projects</li> </ul>
Singapore	<ul style="list-style-type: none"> <li>• Coastal farming in floating net cages</li> <li>• Land-based (fish ponds, tanks) farming of tilapia, marble goby, gourami, catfish, snakehead</li> <li>• Ornamental fish farming</li> <li>• Popular marine fishes cultured, e.g. sea bass, pompano, groupers, red snapper, mullets and milkfish</li> </ul>	<ul style="list-style-type: none"> <li>• Problems on fish health and farm management</li> <li>• Inconsistent supply of good quality seeds/fish fry</li> <li>• Reliance on prophylactic drugs which may have negative consequences</li> </ul>	<ul style="list-style-type: none"> <li>• Introduction of Good Aquaculture Practices scheme for food fish farming to help improve the standards of the local aquaculture industry and sustainability through responsible management</li> </ul>
Thailand	<ul style="list-style-type: none"> <li>• Marine and coastal aquaculture</li> <li>• Freshwater aquaculture (mostly tilapias, giant freshwater prawns)</li> </ul>	<ul style="list-style-type: none"> <li>• Disease outbreaks in shrimp farms</li> <li>• High cost of aquaculture feeds</li> </ul>	<ul style="list-style-type: none"> <li>• Milkfish as new species for aquaculture</li> <li>• Implementation of shrimp GAP</li> </ul>
Viet Nam	<ul style="list-style-type: none"> <li>• Marine and coastal aquaculture</li> <li>• Freshwater aquaculture</li> <li>• Shrimp and catfish industries are fast developing</li> </ul>	<ul style="list-style-type: none"> <li>• Disease outbreaks (more recent problem is incidence of Early Mortality Syndrome in shrimps)</li> <li>• High cost of aquaculture feeds</li> </ul>	<ul style="list-style-type: none"> <li>• Widespread implementation of Good Aquaculture Practices (VietGAP)</li> </ul>

Source: SEAFDEC/AQD (2014)

aquaculture technologies to the fisherfolk in the whole region; and sustain the dissemination and demonstration of developed aquaculture technologies.

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