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Adoption of aquaculture assessment tools for improving the planning and management of aquaculture in Asia and the Pacific

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FOREWORD

Fisheries and aquaculture are today one of the primary sources of protein for the world's population. Globally, fish provides about 3.0 billion people with almost 20 percent of their animal protein intake and 4.3 billion people with about 15 percent of their animal protein intake. Capture fisheries and aquaculture supplied the world with about 148 million tonnes (154 million tonnes in 2011) of fish in 2010 valued at US$217.5 billion, and play a crucial role in food security and in providing livelihoods for millions of people.

Global capture fish production has been stagnant since the 1990s. Rapid aquaculture development contributed the major part of the increased fish production in the last two decades. The contribution of aquaculture to global fish production increased to 40 percent in 2011 from 13 percent in 1990. It is estimated that aquaculture supplied 47.6 percent of total food fish supply for the world population in 2011. The fast growth of aquaculture production has been largely resulted from intensification benefited from progresses in culture technologies and management practices and increased level of input use and expansion of culture areas. While meeting the increasing demand of people for fish, the sector's rapid growth has been accompanied by an array of problems, including biosecurity and related food safety issue, conflicts over use of natural resources, and impacts on the environment. These problems are mainly due to the poor planning, governance and management practices.

With the growing global population and change in people's eating habit for healthier diet, global fish demand will continue to increase in the coming decades. It is estimated that the world will need additional 23 million tonnes of aquatic animal food from the current level just to maintain the current fish consumption level. With the stagnant capture fish production, such increasing fish demand has to be met by the further growth of aquaculture sector in a sustainable manner. Long-term sustainability of aquaculture sector can only be achieved with informed planning and effective management.

Various aquaculture assessment tools (AATs) have been developed and introduced to Asia and the Pacific region for supporting informed planning and effective management of aquaculture sector. Due to the differences in sectoral development stage, national capacity and other factors, extent and effectiveness of adoption of aquaculture assessment tools vary greatly across the countries in the region. An appropriate strategy developed based on good evaluation of adoption of aquaculture assessment tools is an important step to promote sustainable development of the sector through wider and more effective adoption of aquaculture assessment tools in Asia and the Pacific region, which contributes over 90 percent of the world aquaculture production.

This publication is the product of a regional study supported by FAO and implemented through the cooperation with the Network of Aquaculture Centres in Asia-Pacific (NACA) and APFIC, which focused on situation assessment of adoption of aquaculture assessment tools in 10 major aquaculture producing countries in Asia and the Pacific and development of regional strategy for promoting the wider and more effective application for improved planning and management of aquaculture sector in the region. This publication is expected to provide the member governments, various stakeholders and professionals with the up to date information on current adoption of aquaculture assessment tools in the region and a good reference for developing their strategy and action plan to promote the application of the assessment tools and contribute to sustainable development of aquaculture sector in their countries.

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PREPARATION OF THIS DOCUMENT

This publication is the output of a regional reviews study on current status of adoption of common aquaculture assessment tools in Asia and the Pacific and a subsequent regional expert workshop, which were supported by FAO and implemented through the cooperation with the Network of Aquaculture Centres in Asia-Pacific (NACA) and the Asia-Pacific Fishery Commission (APFIC). The study was implemented as an outcome of a regional workshop on "Strengthening assessment of fisheries and aquaculture in the Asia-Pacific region for policy development", held in Yangon, Myanmar, 4-6 October 2011.

The regional review study was carried out during the first half of 2012, which included ten important aquaculture countries in Asia and the Pacific, namely Australia, Bangladesh, China, India, Indonesia, Republic of Korea, Myanmar, Nepal, Thailand and Viet Nam. The regional study was collaborated by NACA and the FAO Regional Office for Asia and the Pacific (FAORAP). Invited experts from the participating countries conducted or led the country study and prepared a country review paper following the guidelines jointly developed by FAORAP and NACA.

A Regional Expert Workshop on Adoption of Common Aquaculture Assessment Tools in Asia and the Pacific was convened jointly by the FAORAP and NACA from 3 to 5 July 2012 in Pattaya, Thailand. Experts from nine countries (Australia, China, India, Indonesia, Malaysia, Philippines, Republic of Korea, Thailand and Viet Nam), representatives from Southeast Asian Fisheries Development Center-Aquaculture Department (SEAFDEC-AQD), World Organisation for Ananimal Health (OIE Tokyo), European Union (EU), Sustainable Ethical Aquaculture Trade (SEAT) Project and the FAO and NACA working team participated in the workshop.

All the country study papers were presented at the workshop and commented by the experts. The country study papers were then revised by national experts following the recommendations from the workshop discussion and NACA-FAO review team. All the country papers were edited for the final publication.

The regional synthesis report was drafted based on the country papers. The report attempts to present a regional picture on adoption of AATs, discuss common issues and constraints and recommend a regional strategy to promote wider application of the tools for aquaculture planning and management in the Asia-Pacific region. The draft report was presented and discussed at the expert workshop and was finalized by the NACA-FAO working team.

ACKNOWLEDGEMENTS

The completion of the publication was attributable to the joint efforts of all the country review authors and NACA-FAO working team. Much gratitude is due to the country review authors who made their best efforts in preparing the country papers and revised them following the suggestions of the editorial team. Special thanks are given to Ambekar Eknath, Director General of NACA and NACA Secretariat staff who supported the regional study and expert workshop in various ways. Great thanks are towards Ramesh Perera (Department of Agriculture, Fisheries and Forestry, Australia), Jesper H. Clausen (University of Copenhagen) and other expert workshop participants for their valuable contributions to the workshop and towards the preparation of this publication. Special thanks are due to Kesara Aotarayakul for her assistance in the publication of the document.

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1. REGIONAL SYNTHESIS

1.1. Background and rationale

At the 31st Session of the Asia-Pacific Fishery Commission (APFIC) held in Jeju, Republic of Korea, from 6 to 8 September 2010, the need to strengthen fishery and aquaculture management in the region was highlighted. As part of APFIC's goals to support dialogue and improve understanding of key fisheries and aquaculture issues of common interest to the Asia-Pacific region, the 31st Session of APFIC endorsed the convening of an APFIC regional consultative workshop on "Strengthening Assessments of Fisheries and Aquaculture in the Asia-Pacific Region for Policy Development and Management".

APFIC convened this regional workshop in Yangon, Myanmar, from 4 to 6 October 2011. The workshop considered how to help developing standards for environmental impact assessments (EIAs) and footprint-type activities to support ecosystem approaches to aquaculture sector management. In particular, the workshop addressed how such assessment methods might be tailored to the characteristics of fisheries/aquaculture within the region (especially considering the needs of small-scale fisheries) in order to facilitate the sharing of learning experiences and contribute to increased use of lower cost assessment tools.

The workshop noted that the initial focus of national planners in many countries of the region was primarily upon aquaculture development to increase production, earn foreign exchange, create employment and generate livelihoods. Aquaculture development was often not effectively regulated during the early stages of sector development. The predominantly small-scale and traditional nature of production hampered planning and management, and moreover, sustainability was not generally a priority. In many countries, regulatory frameworks could not keep pace with the speed of technology and trade development in aquaculture, and the majority of countries had no policy or regulatory framework mandating use of assessment tools.

However, it was only when excessive and unsustainable resource exploitation was linked to disease outbreaks, population collapses and environmental damage that countries began to face scrutiny over these and other problems associated with aquaculture development (e.g. human and animal welfare, food safety and social inequality). Attention shifted towards addressing the challenge of developing assessment tools and regulatory frameworks.

Nevertheless, national aquaculture strategies have only been developed within the past decade. These strategies increasingly allow and mandate the use of assessment tools, following a shift from production-driven planning towards more responsible aquaculture development with a focus on sustainable production systems. There are numerous drivers for the use of such tools in aquaculture:

- market forces and trade requirements;
- food and feed safety issues;
- compliance with national requirements and regulatory frameworks;
- compliance with international agreements and requirements;
- long-term sustainability of the sector;
- concerns of civil society; and
- emerging issues such as climate change and new diseases.

Growing interest in more holistic approaches to planning and management, such as the Ecosystem Approach to Aquaculture (EAA), further heightens the need to promote and develop regionally relevant tools to support aquaculture planning and management.

Currently, such tools are not uniformly applied across the region. It is therefore important to gain an appreciation of the current status of awareness and understanding of the range of available tools, the in-country capacity to apply each tool, the extent to which they are applied in practice, and the legal basis for implementation and enforcement. Such information provides a basis for national and regional-level recommendations that can strengthen the application of relevant tools and contribute to development of a resilient and sustainable aquaculture sector across the Asia-Pacific region.

Based on limited case studies and discussion, the Yangon workshop recommended initiation of a regional process with the following aims and objectives:

- evaluate the status of the use of various aquaculture assessment tools in planning and management for sustainability in the region;
- evaluate the usefulness or effectiveness of existing tools for aquaculture development and suggest possible modifications for applicability in the region; and
- develop a regional program to support implementation of aquaculture assessment tools in Asia-Pacific, within a broader regional approach to ecosystems.

Following the recommendation of the APFIC regional consultative workshop in Yangon, the FAO Regional Office for Asia and the Pacific (FAORAP) allocated resources to support the collaborative regional activity with the Network of Aquaculture Centres in Asia-Pacific (NACA) to promote the wider application of aquaculture assessment tools (AATs) for sustainable aquaculture development. This enabled FAO, NACA and APFIC to jointly organize a regional evaluation study to evaluate levels of adoption of existing aquaculture assessment tools, convene a regional workshop and develop a regional strategy to promote wider application of aquaculture assessment tools in Asia-Pacific. The specific study objectives were as follows:

- assess the status of the use of various aquaculture assessment tools in selected countries in the region by conducting a regional evaluation study on adoption of existing aquaculture assessment tools in the Asia-Pacific region;
- produce eight to ten country reports and a regional synthesis document on application and constraints to adoption of aquaculture assessment tools in Asia, evaluating the applicability and effectiveness of existing tools and suggesting options to strengthen their applicability in the region;
- convene a regional workshop to discuss implementation issues in the adoption of aquaculture assessment tools, develop recommendations at national and regional levels, and formulate a regional strategy/action plan to promote wider application of aquaculture assessment tools in Asia-Pacific; and
- produce a FAO/NACA/APFIC publication on the regional study.

Overall, by developing a regional strategy and plan of action promoting the wider application of aquaculture assessment tools, and by sharing country-level experiences and lessons in their application, the study and workshop aimed to provide a foundation and benchmark for further regional follow-up actions in strengthening aquaculture planning, governance and management, that will contribute to the overarching long-term goal of sustainable aquaculture production.

1.2. Scope of study

The importance of promoting responsible and sustainable aquaculture practices at national and local levels is widely recognized. In developing national programs and activities to promote aquaculture to support rural development, planners, policy makers and managers are expected to consider a wide range of issues in addition to those directly related to productivity. These include environmental, social, animal health and welfare and food safety issues as well as empowerment of small-scale farmers. A range of aquaculture assessment tools (e.g. import risk analysis, environment impact assessment, residue inspection, and certification) has been developed and applied to support the development of responsible and sustainable aquaculture.

Aquaculture assessment tools may be broadly considered to include methods, guidelines and processes used for planning, development, management and decision-making. The level of application ranges from the farm to national policy level; some tools are also guided by international agreements and instruments. AATs may be classified by function as follows:

- tools for assessing risks in aquaculture (e.g. pathogen risk analysis, food safety risks, genetic and ecological risks);
- tools for assessing risks in international trade (e.g. IRA);
- tools for assessing impacts (e.g. EIA);
- tools for assessing governance (e.g. codes of practice)
- tools for management (e.g. BMPs, GAPs, certification); and
- tools for socio-economic assessments.

The above tools may be supplemented by generic communication, information and guidance tools. The present study focused on aquaculture assessment tools that are relevant for aquaculture planning, development and management, within the overall context of the guidance offered by the FAO Code of Conduct for Responsible Fisheries (CCRF). The tools suggested to be included for the country study are as follows:

- import risk analysis (IRA);
- health certification and quarantine;
- disease surveillance and early warning system;
- environment impact assessment (EIA) of aquaculture operations;
- ecosystem approach to aquaculture (EAA);
- ecological risk analysis (genetics and biodiversity);
- food safety (e.g. residue testing, traceability);
- aquaculture development (e.g. spatial planning/zoning based on carrying capacity);
- production process (e.g. public and private certification);
- social impact assessment;
- input quality assessment and monitoring;
- management tools (e.g. BMP/GAP); and
- other tools (e.g. life cycle analysis, greenhouse gas emissions, carbon footprint studies).

The tools are designed to address identified major risks for aquaculture development, intensification and sustainability, as indicated in Figure 1 below.

Risk	Tool
Market closure due to residues	• Residue testing/monitoring • Record keeping • Traceability
Market loss due to CA failing evaluation by importing country	• Self-evaluation – PVS
Production closures due to environmental concerns (pollution)	• EIA; zonation • Carrying capacity limits • Environmental monitoring
Production loss due to trans-boundary diseases	• HC; Quarantine; Surveillance; Emergency response; farm-level biosecurity
Marginalization of small farmers caused by burden of compliance with certification requirements and market loss due to trade barriers	• In-country public certification schems; group certification

Figure 1 Sustainability: risks and tools

Whilst certain tools are designed for farm-level application, others are intended as policy instruments, whilst one ('Ecosystem approach to aquaculture') may be considered as an overarching philosophy guiding the use of individual specific tools. EAA has been defined as follows[1]:

> *"An ecosystem approach to aquaculture (EAA) is a strategy for the integration of the activity within the wider ecosystem in such a way that it promotes sustainable development, equity, and resilience of interlinked social and ecological systems".*

Thus, within the overall paradigm of the ecosystem approach, individual tools can be broadly classified as instruments for planning or management, according to the typology presented in Figure 2 below.

Ecosystem Approach

Planning

- Aquaculture development (e.g. spatial planning/ zoning based on carrying capacity)
- Environment Impact Assessment (EIA) of aquaculture operations
- Ecological risk analysis (genetics and biodiversity)
- Social impact assessment
- Other tools (e.g. life cycle analysis, greenhouse gas emissions, carbon footprint studies)

Management

- Import Risk Analysis (IRA)
- Health Certification
- Quarantine
- Disease surveillance/EWS
- Food safety (e.g. residue testing, traceability)
- Production process (e.g. public and private certification)
- Input quality assessment and monitoring
- Management tools (e.g. BMP/GAP)

Figure 2 Typology of tools in aquaculture

In order to develop a coherent and coordinated approach, a regional management framework was discussed during the regional workshop for implementation of national and regional actions. The workshop participants discussed the fundamentals of such a framework, in terms of themes, purpose of tools, and institutional arrangements for implementation. The proposed regional framework is shown in Figure 3, which depicts the range of aquaculture management tools grouped according to four themes, consistent with FAO's four pillars of certification: biosecurity, food safety/quality, animal health and welfare, and environmental and social impact.

A regional management framework requires clear categorization of the tools in terms of the three identified components of public sector oversight as identified by workshop participants; namely, tools applied for:

- planning for aquaculture development;
- managing aquaculture activity; and
- managing post-harvest activity.

The diagram also suggests how tools might be mapped to their respective points of application along the supply chain, from 'pond to plate', whilst also linking specific tools to government agency/ies) that should carry responsibility for their implementation.

[1] FAO (2008) *Building an Ecosystem Approach to Aquaculture*. Proceedings of an FAO/Universitat de les Illes Balears Expert Workshop, 7-11 May 2007, Palma de Mallorca, Spain. Aquaculture Management and Conservation Service of the FAO Fisheries and Aquaculture Department and the Universitat de les Illes Balears in Spain.

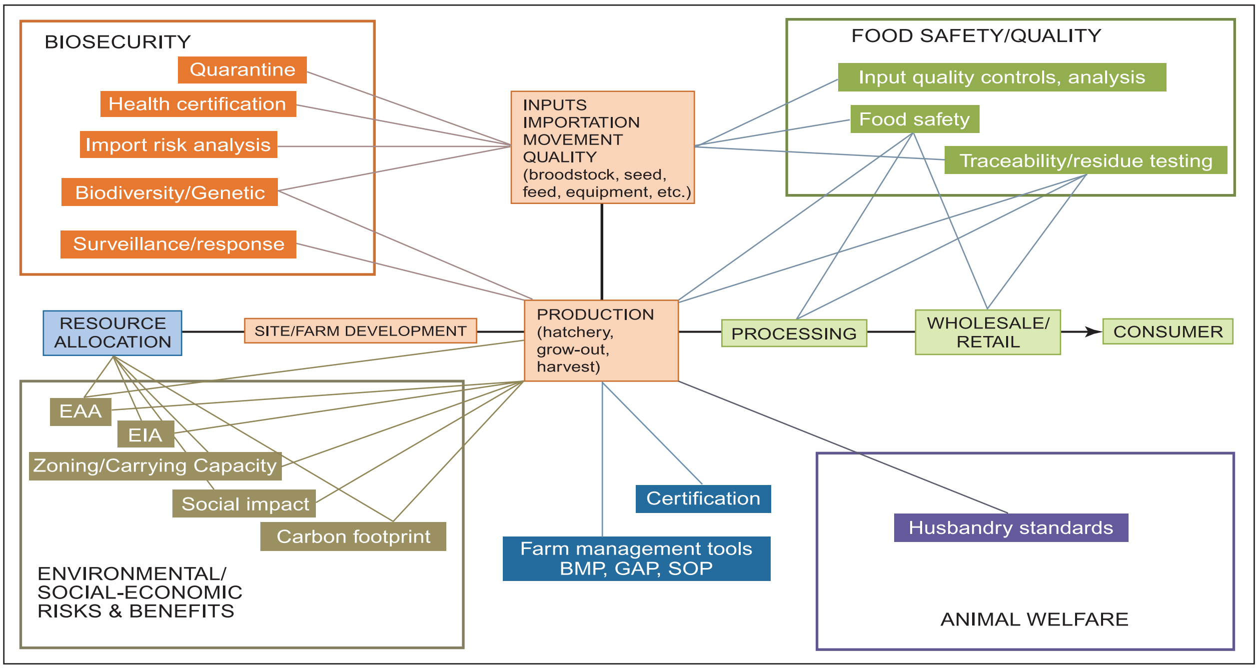

Figure 3 Proposed framework for implementation

1.3. Methodology and framework for evaluation

In conducting each country study, the national-level expert teams followed a common methodology jointly developed by FAO and NACA, which included:

- review existing information (published and unpublished literature, reports, websites);
- identify all stakeholders who have used, or could potentially use AATs (including institutions dealing with aquaculture products or issues, but not directly involved in the activity, e.g. trade, environmental organizations, etc.);
- design an elicitation method (e.g. questionnaire targeting individuals from each identified stakeholder institution, or focus group with representatives from key institutions) to establish perceptions of the level of awareness and capacity to implement AATs, and to generate feedback on perceived usefulness of AATs (pros and cons) and measures that might enhance their adoption and effectiveness;
- design a set of benchmark criteria (or indicators) against which the effectiveness and usefulness of AATs can be measured and apply it to the information and data collected; and
- on the basis of the previous tasks, recommend national and regional actions for promoting adoption of AATs (addressing the issues and constraints identified).

The country assessments selected for evaluation by national level experts, or teams thereof, focused upon four key aspects of AATs application. An evaluation framework was developed for use by each country (shown in Table 1 below) to evaluate the four main dimensions (awareness, capacity to implement, extent of use, and legal basis) according to common criteria. However, it is important to note that since assessment at national level is ultimately the result of subjective 'expert opinion', caution must be exercised in drawing cross-country comparisons.

Table 1 Evaluation framework for AATs

Aspect	Level/extent	Score
Awareness about the tool	***None***	0
	Fair – Only policy-makers and scientists at national level	1
	Moderate – Policy-makers, scientists, at provincial level	2
	Good – All stakeholders at local level except farmers	3
	Excellent – All	4
Capacity to apply the tool	***None***	0
	Fair – Only policy-makers and scientists at national level	1
	Moderate – Policy-makers, scientists, at provincial level	2
	Good – All stakeholders at all levels except farmers	3
	Excellent – All stakeholders	4
Extent of use in the country	***Never used***	a
	Used in some projects	b
	Used only at national level	c
	Used at provincial level	d
	Used at all levels	e
Supporting legal instruments	***Yes***	4
	No	2
	Under development	0

The combined results of the national-level evaluations for the four aspects are summarized in the following sections.

1.4. Awareness, capacity, implementation and legal status

Overall levels of awareness, capacity to implement, actual level of usage and legal status are presented in this section. The country responses were scored following Table 1: Evaluation framework for AATs. The results, tabulated for each tool in Appendix A, summarize the overall status of implementation of each tool, showing the number of countries for each level of each of the four criteria, together with a weighted total score (maximum score = 32). Using the combined scores, overall performance across the eight countries is discussed below, according to the four commonly-defined criteria.

1.4.1. Awareness about AATs

Overall levels of awareness of the AATs are shown in Figure 4 below. Using the weighted scores for awareness of each tool, adjusted for missing data, the graph illustrates the range in awareness for the 15 assessed tools, from ‘None’ to ‘Excellent’.

Figure 4 shows highest reported awareness across the region for health certification, quarantine, residue testing/monitoring, record keeping, management tools and input quality assessment. Lowest awareness scores were reported for the ecosystem approach to aquaculture, ecological risk analysis, social impact assessment and life cycle assessment.

However, the responses showed considerable variation in level of awareness for specific tools among the eight countries. Whilst awareness of quarantine and input quality assessment was consistently high across all countries, import risk assessment, disease surveillance, spatial planning/zoning and production process showed wide variability in awareness across the countries surveyed.

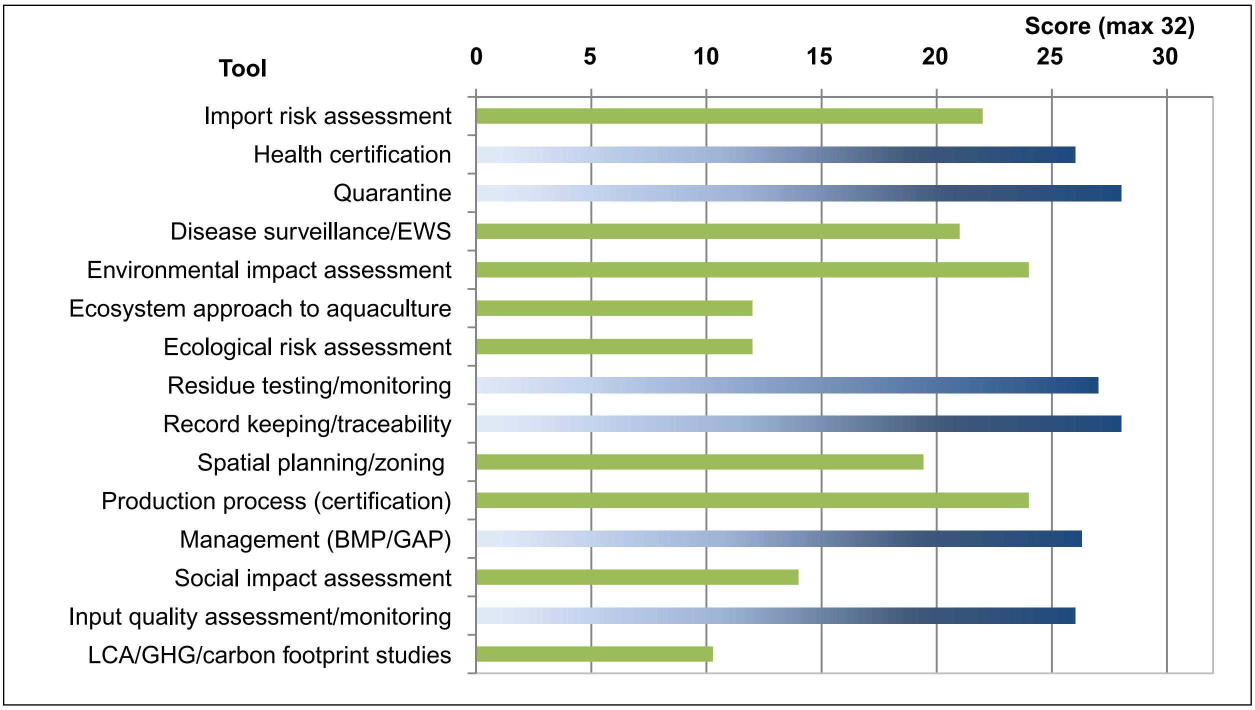

Figure 4 Awareness of AATs (all countries)

1.4.2. Capacity for application

Capacity to implement each AATs was scored according to Table 1, and the combined results are summarized in Figure 5.

In general, implementation capacity follows the same pattern described for awareness of tools, although assessments of capacity are uniformly lower than those of awareness. As for awareness, Figure 5 highlights the widely diverging capacity among countries to implement individual tools.

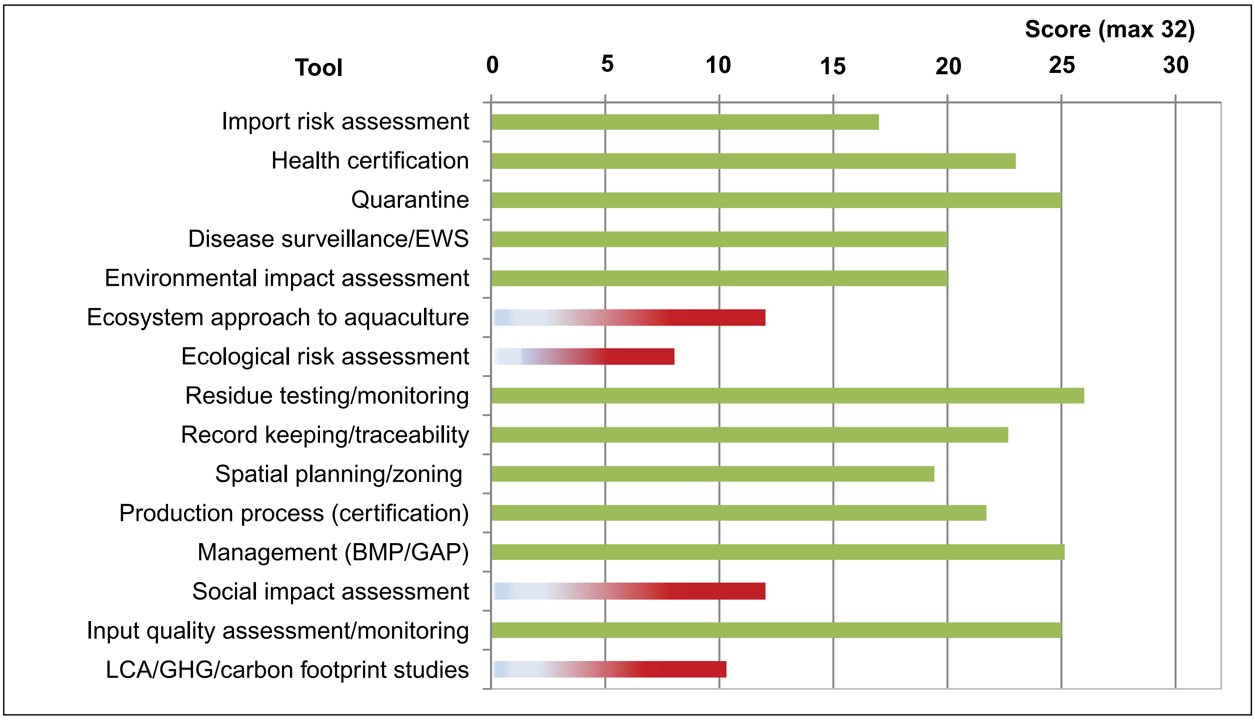

Figure 5 Capacity for implementation (all countries)

The highest implementation capacities were reported for quarantine, residue testing, management tools and input quality analysis, whilst the weakest capacities for implementation were reported for applying the ecosystem approach to aquaculture, ecological risk assessment, social impact analysis and life cycle analysis and associated tools. Greatest variability was shown for production process and spatial planning tools.

1.4.3. Implementation of tools

Figure 6 highlights the wide range in level of application of AATs across countries, reflecting the different aquaculture species/systems and sector development across the region. Wide variations are also evident in the prevailing policy and regulatory environments, resource endowments, technical capacity and legal/institutional frameworks of the eight countries studied.

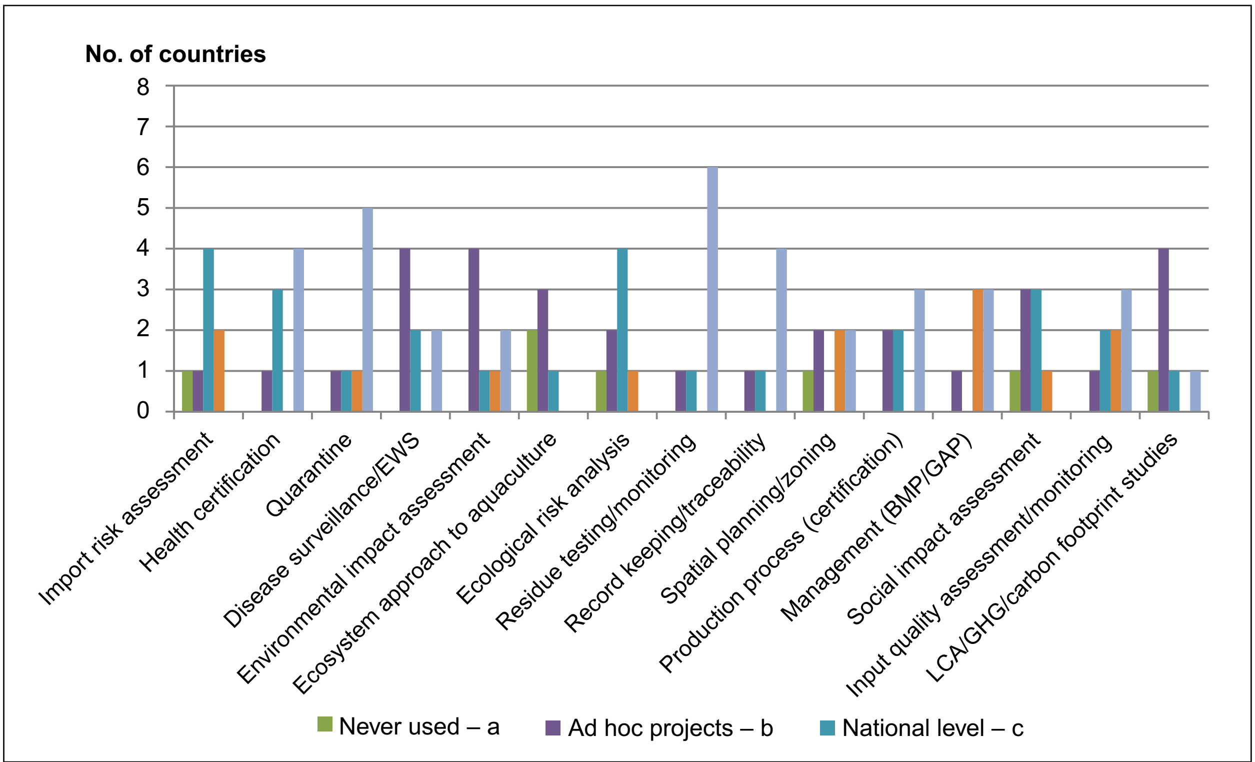

Figure 6 Implementation of AATs across the region

Overall, countries reported a tendency to focus on export commodities rather than all aquaculture systems. It is also evident across the region that implementation tends to target larger operations, with arbitrary cut-off thresholds for farm size, below which farms are exempted from compliance requirements. Examples include the following:

- mandatory EIAs for farms over 50 ha (Malaysia);
- effluent controls on farms over 1.5 ha (Thailand); and
- infrastructure support for intensive/semi intensive farms >10 ha, or extensive farms >50 ha (Viet Nam).

In the absence of comprehensive empirical data to inform policy-making, selection of these thresholds appears to be based on pragmatism and resource limitations rather than ecological or environmental principle. Given the predominantly small-scale of operations across the region, the widespread practice of exemption of small farmers from statutory control requires review, especially since larger farmers may in some cases avoid regulation and the compliance burden entirely by subdividing their operations into smaller plots. It is evident from the divergence in levels of application that there is significant scope for broadening application of AATs from their current levels.

1.4.4. Legal status

The application of AATs depends strongly upon the status of supporting Acts, decrees, and regulations. Without statutory mandate, voluntary adoption (especially at the production level) is not incentivized, and generally limited. Figure 7 shows the combined level of legal support for the AATs across the eight countries studied, including all levels of legislation, from Acts of Parliament and Presidential decrees, through to subsidiary measures such as Ministerial decrees and pursuant rules and regulations.

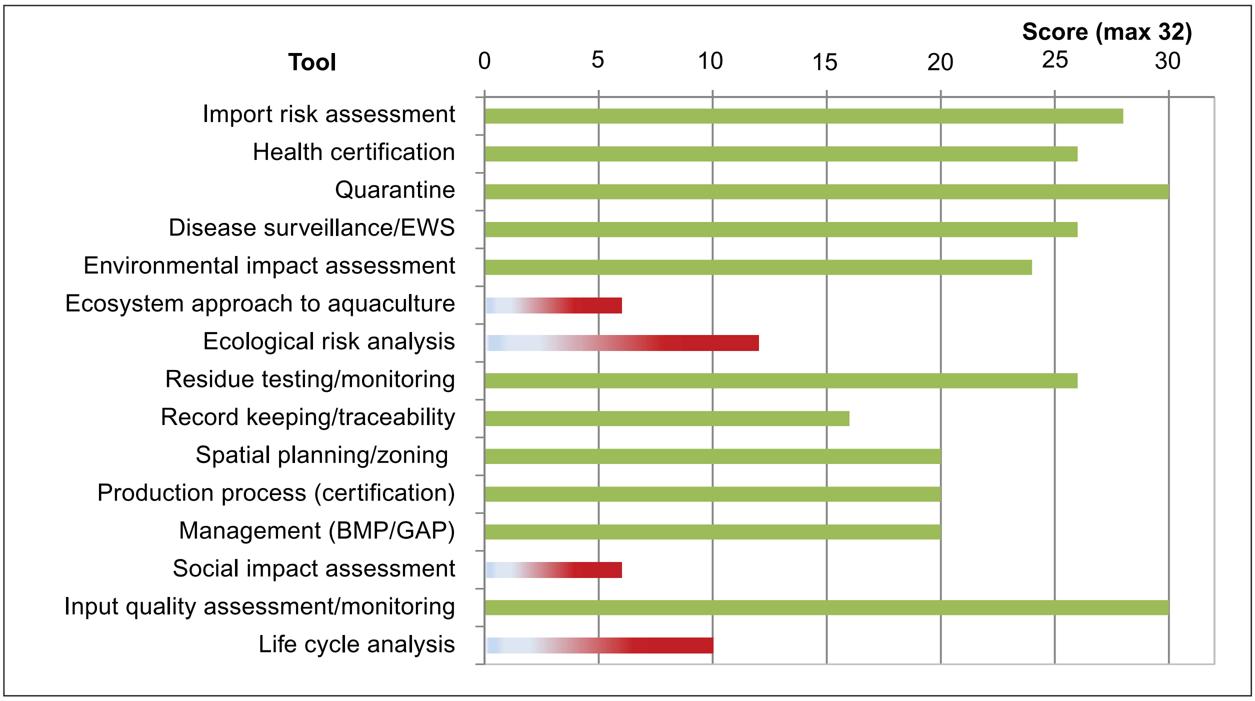

Figure 7 Legal status of AATs (all countries)

The data illustrate the broad divergence in the legal mandate for implementation and enforcement of the tools. Some, such as quarantine and input quality assessment and monitoring have long been mandated as integral functions of responsible State agencies, with full legal backing for implementation and enforcement.

However, adoption of other tools, particularly those that have emerged only relatively recently, remains voluntary. In the absence of legal mandate or official budgetary support, adoption by state institutions remains generally weak and fragmented. Moreover, for some tools such as social impact assessment and life cycle analysis, the substantial anticipated budgetary burden for enforcement serves as a major disincentive to adoption.

Finally, countries also reported regulatory conflicts that may constrain adoption. Such conflicts may arise between legislative acts or between State, provincial and local levels.

1.5. Issues and constraints in application

The eight countries surveyed reported a range of issues and constraints concerning application of AATs at national level. These issues were further discussed at the regional workshop (3-5 July 2012, Pattaya, Thailand). Overall, the most important constraints to adoption of AATs were reported as follows:

1. Lack of awareness of the tools and incentives for AATs adoption on a voluntary basis. Long term benefits are not apparent to producers or industry.
2. Legislative/regulatory issues (lack of primary and subordinate legislation, weak institutional mainstreaming, and conflicts between State and provincial legislative requirements.

3. Ineffective integration between different agencies with responsibilities linked to planning and management.
4. Financial constraints, including inadequate budget allocations, lack of clarity on recovery mechanisms and prohibitive costs of stock destruction and containment.
5. Lack of capacity and technical skills to apply tools.
6. Lack of buy-in by producers wary of regulatory controls and potential increased costs; long term benefits may not be immediately apparent to industry/producers.
7. Lack of empirical scientific data to underpin and validate tool design and effective use.
8. Lack of standard methodologies or regional minimum requirements (e.g. carrying capacity, genetic risk analysis).
9. Limited access to technical information (including language barriers).
10. Lack of implementation capacity (technical skills, manpower, budgets, logistics).
11. Smaller farmers are often excluded from control for practical reasons, using arbitrary farm size thresholds or other justifications.
12. Focus on control of exported produce creates risk of a two tier system.
13. Confusion over competing certification schemes.

Table 2 summarizes specific issues reported by each country in the country reports or during the regional workshop.

Table 2 Issues and constraints as reported, by country

Country	Issue/Constraint
China	• Lack of legal grounding of assessment tools, and long time to establish legal provisions • Lack of awareness of tools, particularly at farmer level • Compatibility of certification schemes: costs of farm planning and management are increased by compliance burden created by multiple certification schemes • Lack of resources (technical/budgetary/facilities) for monitoring and supervision • Uncertainty over responsibilities of public and private sectors – who pays for AATs?
India	• Majority of tools developed and validated for specific limited geographical application. Lack of scientific validation of the majority of AATs for large-scale application • Institutional mandates or capacity often do not allow large-scale application • Risk of deliberate misuse of tools such as LCA to over-estimate environmental impacts of aquaculture, especially in the use of extrapolations and untested assumptions to arrive at final estimates. • Lack of trained human resources for data collection and monitoring • Challenges in collection from farmers of data not directly related to production. This hampers the creation of a large dataset for validation and large-scale application • Need to strengthen regulatory environment and institutional framework for implementation and enforcement • Farm-level acceptance hampered by perceived lack of relevance to productivity improvement
Indonesia	• Lack of budget for implementation • Lack of cooperation among state agencies responsible • Lack of awareness of benefits of AATs among officials • Poor law enforcement results in inconsistent application of AATs, e.g. destruction of contaminated produce • Dominance of small-scale producers hampers efficient implementation • Lack of understanding of AATs implementation among small-scale producers, especially in issues relating to ecological risk analysis, traceability and social impact assessment.

Table 2 Issues and constraints as reported, by country *(continued)*

Country	Issue/Constraint
Republic of Korea	• Need to standardize sampling/measurement protocols across many monitoring institutions. • Interpretation of EIAs is difficult-each location is complex and unique • Legal framework and standards implementation for safety and quality assurance are not comprehensive • Legislative framework for safe, responsible and sustainable aquaculture, esp. with regard to control of aquatic animal diseases is incomplete, and enforcement is inconsistent • No law to limit genetic risk e.g. from inbred farmed species • Need to minimize feed-driven pollution from use of unprocessed feed, and ensure higher feed standards, esp. with respect to unsafe levels of pesticides, biological, physical and chemical contaminants and adulteration • Ecological risk of biological invasions/alien species • Need low-cost automatic monitoring of HABs
Malaysia	• No legal basis for many AATs. • Lack of public awareness of AATs • Lack of budgetary allocation and institutional support for implementation • Lack of human capacity, expertise and skills for implementation • Lack of documentation such as handbooks, practical guidelines or reference texts for stakeholders • Potential for conflict between jurisdictions of federal and state government.
Philippines	• Lack of applicability of AATs to small farmers • Resistance to technological advancement by small-scale 'traditional' farmers • Lack of training and capacity building for scientists, regulators, policy makers • Lack of investment in laboratory facilities and analysis capacity • Lack of access to credit for small farmers • High fees imposed further reduce acceptance at farmer level, especially for small-scale farmers.
Thailand	• Lack of awareness of AATs among policy-makers and scientists • Insufficient legislative/regulatory framework to support effective AATs implementation • Need effective AATs to prevent/control TBDs caused by introduction of exotic species • Gap in knowledge on potential impacts of climate change on inland aquaculture to support zoning/spatial planning tools • Gap in knowledge on potential environmental impact of intensive inland aquaculture development to support EAA • Lack of budget, as well as human and technical capacity to enforce food safety legislation, especially at farm level • Improved food safety mechanisms needed at farm level • Need benchmarking to increase credibility of govt certification system and resolve issues related to multiple certification schemes.
Viet Nam	• Inadequate legal and enforcement framework (e.g. for AATs such as spatial planning/zoning, Ecosystem Approach to Aquaculture, social impact assessment) • Lack of budget and competent human resources • Low awareness of tools among stakeholders • Whilst some tools are routinely applied, others, such as EAA, spatial planning, social impact assessment, and carbon footprint studies have only recently been introduced and are not well understood or implemented. A review of the application of the ecosystem approach, studies of carbon footprint/greenhouse gas emissions, and spatial planning in other sectors, and their potential utility in the aquaculture sector is needed • Need training and technical guidelines for effective tool application. Such guidelines for tool application should be specifically designed for priority aquaculture systems • Assess whether environmental assessment tools applied in other sectors can be used in aquaculture • Form-filling is often too cumbersome • Confusion over certification schemes.

1.6. Recommendations

The study has highlighted the expectation that aquaculture will assume greater significance as a supplier of fish for food, particularly in Asia, where population growth, economic development and declining capture fish supply will inevitably impose increasing demands on aquaculture production to meet consumption growth. However, the regional workshop noted that issues related to biosecurity, food safety, environmental and social impact/protection, and animal welfare can only increase in their significance, both to ensuring ecological resilience and sustainability in the sector, and also to ensure compliance with the highest ethical standards. Governments and the aquaculture sector therefore must address as a matter of urgency the common challenge of sustaining supply against a background of increased competition for land and water from other sectors, as well as increasing constraints on resource inputs such as marine feeds.

AATs form an integral basis for continued sustainability of the aquaculture sector. The study identified legal, structural, technical and financial challenges to adoption of AATs, pointing to the need for action on a broad front to enhance the resilience and sustainability of aquaculture production across the Asia-Pacific region. In order to address constraints to adoption identified in the country studies and further elaborated during the regional workshop, the workshop agreed upon a series of follow-up recommendations to be applied at national and regional levels.

The regional workshop concluded that in order to improve the application and coverage of the range of tools available for aquaculture planning and management, there was a need for support at both national and regional levels in key areas. These were categorized and formulated as national- and regional-level recommendations for actions to encourage adoption of the tools and enhance their cost-effectiveness. These national and regional level recommendations are presented below.

1.6.1. National level recommendations

At national level the workshop noted that in-country action to improve the use of the tools and their effectiveness should prioritize the following:

1. **Scoping of the national aquaculture sector** using an EAA approach to prioritize areas where tools are required, and to identify key issues to be addressed using specific planning and management tools. This should include special consideration of the implications of AATs for small farmers;
2. **Review national legislation and regulatory implications** and consider upgrading relevant provisions to incorporate priority AATs. New legislative and regulatory measures and mechanisms could be informed by lessons from development of similar tools used in the animal health sectors across the region;
3. **Integrate pollution control and environmental protection** with aquaculture development planning, and set limits for carrying capacity, zoning limits and/or total capacity limits;
4. **Undertake an institutional review** to enhance coordination among competent national agencies in the key areas of food safety, environmental management and biosecurity, in order to strengthen integration and coherence in support of sector management to minimize adverse impacts;
5. **Examine how national competent agencies could benefit** from effective use of services and oversight mechanisms to ensure effective support for sustainable development of the aquaculture sector;
6. **Explore opportunities for public-private partnerships (PPPs)** in providing services to the planning and management of the sector (e.g. private testing systems, quarantine, EIA, certification, quality testing, etc.);
7. **Develop appropriate training modules** and deliver training in the use of specific tools at national and local levels, as relevant. Such training could include development and use of an aquaculture ‘toolbox’ on context-specific tool implementation, outline of tool functions and decisions that can

be made as a result of application, case studies of tool application, and examples of limits and carrying capacities for different systems;

8. **Launch an awareness-raising communication strategy** to sensitize policy-makers, regulatory agencies, businesses and farmers to the need for, and application of tools and their benefits to the sector. The strategy should incorporate pilot projects to demonstrate effectiveness, supported where possible by FAO/NACA and private sector expertise;
9. **Solicit additional funding and technical support** for national-level TCPs at high level meetings such as COFI.

1.6.2. Regional level recommendations

The workshop concluded that in order to improve the application and coverage of the tools for aquaculture planning and management, key support will also be required at regional level, as follows:

1. **Initiate a regional process to evaluate the use of various aquaculture assessment tools now being used in the region:**
    - Evaluate the usefulness or effectiveness of existing tools for aquaculture development and suggest possible modifications for applicability in the region;
    - Review the adoption rates of various assessment tools by different countries;
    - Develop generic guidelines (e.g. for marine spatial planning) for use by countries in the region in order to encourage implementation of assessment tools;
    - Conduct a cost-benefit analysis of the use of assessment tools and develop mechanisms for sharing benefits through the supply chain from producers to consumers;
    - Compile an online country-wise database of legislation, including case studies of adaptation of existing legislation (e.g. amending livestock laws) or specific new acts/laws, e.g. overhaul and specific inclusion of EIA, or regulatory power on effluents).

2. **Once tools are identified and available, initiate measures to build capacity and widen adoption:**
    - Develop a manual of case studies and best practice of application of tools for practitioners/ policy-makers;
    - Develop a comprehensive series of training course modules on tools for aquaculture planning, assessment and management;
    - Develop a regional training course for use by training institutions. These training materials would include generic guidelines for adaptation to national- and local-level requirements.

3. **Collate an aquaculture planning and management toolbox for the region:**
    - The toolbox would be based on existing source materials as well as case material from country-specific applications, and would be made available as an online resource;
    - There are opportunities to learn lessons from parallel development of animal health systems in the region as well as EIA or other tools from other sectors;
    - A regional process will be required to build consensus in order to harmonize the minimum requirements and methodologies for implementing the tools.
4. **Promote/encourage networking for information sharing:**
    - Document success stories and lessons in best practices in tool application, as relevant to the regional context;
    - Undertake a specific review focusing on how tools for planning and management may benefit or marginalize small-scale producers, and what additional practical measures at both regulatory and enforcement levels might contribute to enhancing small farmer inclusion.

5. **Develop a regional support programme:**
   - This could be implemented within the framework of NACA, noting that these capacity development and information-sharing needs are relevant to three NACA core themes (health, food safety, sustainable aquaculture), and adopting a broader regional approach to ecosystems training programs;
   - Prioritize efforts to seek regional support, including a request to FAO for regional TCP support;
   - Draw the identified need for capacity-building to the attention of the NACA Governing Council and APFIC 32^{nd} Session;
   - Encourage member countries to consider raising this regional need at the FAO Sub-Committee on Aquaculture and the FAO Committee on Fisheries;
   - Support the development/revision of national aquaculture strategies so that appropriate assessment tools are included in the national planning/development programs of countries.

1.7. Towards a regional management framework and action plan

Whilst the recommendations of this study contribute towards establishing the place of AATs as management tools and operational procedures within the context of the range of institutional frameworks/systems needed to effectively manage the ecologically sustainable development of aquaculture, they represent only a first step towards a coherent and effective regional approach. Recognizing that the range of management tools identified is not exhaustive, it will, for example be necessary to incorporate a comprehensive database of the full range of planning and management tools available for managing sustainable aquaculture. NACA can play a central role in developing such an approach in concert with the national competent authorities and other stakeholders.

2. COUNTRY REPORT: PEOPLE'S REPUBLIC OF CHINA

Application of aquaculture assessment tools in China

Yuan Xinhua[1] *and Jing Xiaojun*[2]

2.1. Introduction

China has a long history of aquaculture. However, large-scale production only began after its founding in 1949. Following economic liberalization during the 1980s, China's aquaculture industry grew dramatically, with production rising from 1.23 million tonnes in 1979 to 38.28 million tonnes in 2010. China has emerged as the world's largest aquaculture producer, contributing 61.4 percent of global production.

Aquaculture has overtaken capture fisheries as the major fishery activity in China, accounting for 71.26 percent of total national fisheries production. The total aquaculture area increased from 2.854 million hectares in 1979 to 7.645 million hectares in 2010. At 4.41 million hectares, China also has the world's largest freshwater aquaculture area. Guangdong, Hubei, Jiangsu, Hunan and Anhui are the major production areas, with over 140 species of aquatic living organisms cultured. Farmed shrimp, eel, tilapia, shellfish and seaweed account for about 50 percent of national seafood exports in terms of value.

The rapid development of aquaculture has not only contributed to improved food supply, but has also generated employment and income. In 2010, the total fishery population was 20.81 million, with a traditional fishing population of 7.47 million. Fisheries (including aquaculture) employed 13.99 million people in related sectors, and the fisheries sector contributed about 9.3 percent to total agricultural GDP.

2.2. Institutional and legal framework

Aquaculture operations are governed by legislation on water body utilization, seed production, feed and farm management for achieving food safety, environment and sustainable aquaculture development.

In addition to national-level legislation, several state laws govern aquaculture planning and management. Licensing and monitoring, aquatic products production and quality control are under the responsibility of the Ministry of Agriculture, while environmental issues are the responsibility of the Ministry of Environment.

There are three major laws on aquaculture planning and management in China: the Fishery Law, Environmental Protection Law and the Law of the People's Republic of China on the Entry and Exit Animal and Plant Quarantine.

- **Fishery Law of the People's Republic of China.** The Fishery Law, enacted in 1986, was amended in 2000 and 2004 by the State Congress. It represents the main legislative instrument governing capture fisheries, aquaculture, fishery resource conservation and stock enhancement.
- **Environment Protection Law of the People's Republic of China.** This law, enacted in 1989, covers water, air, land, ocean, wild life, urban and rural area.
- **Law of the People's Republic of China on the Entry and Exit Animal and Plant Quarantine.** This Law was enacted to prevent infectious or parasitic diseases of animals, diseases, insect pests, noxious weeds and other harmful organisms from spreading into or out of the country, protecting the production of agriculture, forestry, animal husbandry and fishery as well as human health, and promoting development of foreign economic relations and trade.

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2.3. Summary of aquaculture planning and management tools (APMTs) application in China

Based upon the findings of the evaluation study, a summary of the status of adoption of aquaculture planning and management tools (APMTs) in China is provided in Table 3 below. Standard analysis criteria were used to evaluate each of the four dimensions, as follows:

Table 3 Summary of APMT Application in China

Tool	Level of awareness[1]	Level of capacity[1]	Extent of use[2]	Supporting legal instruments[3]
Planning Tools				
Aquaculture development-spatial planning/zoning (e.g. based on carrying capacity)	d	b	d	Yes
Environment impact assessment (EIA) of aquaculture operations	d	d	d	Yes
Ecological risk analysis (genetics and biodiversity)	d	d	d	Yes
Social impact assessment	a	a	b	No
Import risk analysis (IRA) for introducing new species for aquaculture	d	d	d	Yes
Others: life cycle analysis (LCA); greenhouse gas (GHG) emissions, carbon footprint studies	a	a	a	No
Management Tools				
Risk analysis	a	b	b	Yes
Health certification	d	d	e	Yes
Quarantine	d	d	e	Yes
Disease surveillance and early warning system	d	d	d	Yes
Residue inspection and monitoring	d	d	d	Yes
Record keeping and traceability	d	d	d	Yes
Input quality assessment and monitoring	d	d	d	Yes
Production process (e.g. public and private certification)	c	c	b	Yes
Farm management tools (e.g. BMP/GAP)	d	d	e	Yes

Notes:

1 Levels of awareness/Capacity: ***a*** **–** policy makers and scientists at the national level; ***b*** **–** policy makers, scientists, at the provincial level; ***c*** **–** all stakeholders at local level except farmers; ***d*** **–** all

2 Extent of use: ***a*** **–** never used; ***b*** **–** used in some projects; ***c*** **–** used at national level; ***d*** **–** used at provincial level; ***e*** **–** used at local level

3 Supporting legal instruments: Yes; no; under development.

2.4. Application of existing aquaculture assessment tools: Case studies

The Chinese government places high priority on the development and management of aquaculture. In order to keep pace with technological development and rapid sector growth, the government has developed a legislative framework to regulate aquaculture development, and has mandated use of a number of evaluation tools to monitor operations. Some international standards have been adapted to Chinese conditions, including aquaculture certification to satisfy the requirements of international and domestic markets.

Based on a practical assessment of current aquaculture practice in China, the government has encouraged adoption of a number of planning and management tools according to priority. Application of critical and important tools is compulsory, while others remain voluntary or are under research or pilot demonstration. Some high-priority tools are also mandated by local legislative bodies or by the National Congress.

2.4.1. Import risk analysis (IRA)

Import risk analysis (IRA) is used by import authorities to identify any threat posed by import of live aquatic organisms or their products to human health and the country's aquatic resources. IRA is usually undertaken by the Competent Authority (CA) for the importing country. In China's case, the CA is the State Administration of Quality Supervision, Inspection and Quarantine. However, risk analysis is also required for individual operators intending to import live aquatic organisms into their farm or site. IRA performs a critical preventive role; the ecological and economic consequences arising from an inadequately performed IRA can be potentially disastrous. IRA thus finds widespread use in the practice of animal quarantine, and provides a transparent and scientific basis for decision-making.

The State Administration of Quality Supervision, Inspection and Quarantine Bureau approved a regulation on the risk warning alerts and rapid response to entry-exit inspection and quarantine, which came into force in 2001. Chapter II, Article 7 appoints the State General Administration of Quality Supervision, Inspection and Quarantine as the agency responsible for IRA. Chapter III, Article 8 states that the State General Administration of Quality Supervision, Inspection and Quarantine of Entry and Exit will implement risk warning measures for goods imported according to the type and extent of identified risks. Risk management provisions for entry of animals and animal products have been in force since 2003. Additionally, Chapter III, Article 11 of the regulation states that risk assessment is required if any risk factors are identified in the entry of animals, animal products, animal genetic material, animal-derived feed, biological products and animal pathological materials.

In 2003, the Risk Analysis Research Center was set up by the Quality Standards and Testing Institute of the Chinese Academy of Agriculture. In May 2007, the National Agricultural Product Quality Safety Risk Assessment Committee was established by the Ministry of Agriculture. In 2009, a National Food Safety Risk Assessment Committee was established by the Ministry of Health, followed by a Risk Assessment Center in 2011.

With continuing diversification of farmed species, increased trade of aquatic products, and disease outbreaks at home and abroad, there is an urgent and growing need to strengthen China's IRA operating mechanism to effectively address the associated risks. There are lessons to be learned from the occurrence of Taura syndrome virus diseases linked to importation of *P. vannamei* seeds (Lei et al., 2002) and infectious pancreatic necrosis virus from rainbow trout imports (Hu et al., 2012).

Despite its importance to the industry, relatively little research attention has been given to this field in China, as compared with the USA and Europe. Recent research has focused on typical pathogenic microorganisms, forecasting, risk assessment of *Vibrio parahaemolyticus* in oysters, and quantitative modeling for *Vibrio parahaemolyticus* aquatic risk assessment. Good correspondence was found between the prediction models and actual disease outbreaks (Zhang et al., 2005). There is therefore a need for further study of quantitative risk assessment techniques to predict and quantify aquatic microbiological hazards (Kang, 2004).

Since the 1990's, China's exports of aquatic products have repeatedly encountered technical barriers to trade with the European Union (EU) and other countries (Ji, 2006). Food safety regulations directly restrict export of aquatic products from China, causing not only huge economic loss but also seriously damaging the reputation of China's aquatic products in the international market (Bao, 1997). Thus there is a need to recognize that IRA of aquatic products sometimes becomes used as a technical barrier to trade by some countries, established as a means of protecting domestic interests.

2.4.2. Health certification

Legislation covers the administration of entry-exit inspection and quarantine, and health certificates are mandatory for transboundary movement of aquatic products to ensure quality and safety of aquatic products. Certificates are issued by authorized private sector commodity inspection companies. Article IX of the

People's Republic of China Law on Import and Export Commodity Inspection (amended to Article XI) stipulates that the consignee or agent, approved by the commodity inspection authorities, must submit a declaration of the commodity to inspection authorities. Customs clearance of the consignment will be completed by showing the approved commodity inspection documents, including the health certificate. In 1996, inspection regulations on export of aquatic products were issued by the State Import and Export Commodity Inspection Bureau. Chapter V, Article 19, states that commodity inspection certificates shall be issued by the Director of the Bureau or the Director of Veterinary Inspection. Certificate issuance is based on examination of the quality, export country, the original record of the contract (e.g. letter of credit) and original test records of microbiological, physical, chemical and microbiological tests. Guidelines for export inspection and quarantine of aquatic products state that inspection should explicitly satisfy import country requirements, with every batch to be inspected.

In 2004, the European Union announced the lifting of the import ban on Chinese shrimp, farmed fish and other animal-derived food. China took immediate measures to ensure that produce inspection as well as packaging and labeling requirement were in full compliance with EU requirements, to ensure continuity of shrimp exports to EU. However, Italy, France, Greece, Spain, Portugal and other countries later issued a new requirement for aquatic health certificates issued by China's inspection and quarantine authorities, stipulating that Europe-bound aquatic health certificates can only be used for customs clearance if they are written in the relevant language. The State Administration of Quality Supervision, Inspection and Quarantine has adopted the 2004/4l4/E resolution issued by the EU and provides a downloadable certificate format to satisfy the new requirements of the EU veterinary health certificate. Currently, the State Import and Export Commodity Inspection Bureau provides a variety of health certificate formats for different countries, to ensure full compliance and avoid economic losses from rejection at the destination port, and the wider impact of import bans.

2.4.3. Quarantine

Quarantine is a risk management facility. In China, aquatic quarantine is mainly used for cross-province trade in aquatic products, and for import and export of aquatic fingerlings and aquatic products. The quarantine departments are also responsible for quarantine of aquatic fingerlings and aquatic animals produced in each region, and are tasked with prevention and control of aquatic animal epidemics in aquaculture and fishing, and the elimination of infectious diseases and parasites. The quarantine system provides a robust mechanism for monitoring and controlling the spread and prevalence of domestic aquatic animal diseases, and also safeguards farmer incomes. The system is key to maintaining trust and credibility of Chinese produce in the international market, thus contributing to global competitiveness (Jiang et al., 2005; Huang and Jiang, 2008).

The State Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) is responsible at national level for inspection and quarantine for import and export of aquatic products; thus entry-exit inspection and quarantine agency of the region fall under the jurisdiction of AQSIQ. At county and district levels, aquatic disease prevention stations are responsible for quarantine of aquatic fingerlings and fish trade within the municipality.

Procedures for quarantine of aquatic products and fry in China are described below.

The quarantine system for import and export of aquatic products and seed is prescribed by the *Import and Export of Aquatic Products, Inspection and Quarantine Supervision and Management Measures*. The consignee first establishes a system for maintaining records of aquatic products import and sales, and is required to submit official inspection and quarantine certificates from the exporting country or region. The imported aquatic products must be stored in refrigerated warehouses or specified facilities approved by the inspection and quarantine authorities. Site inspection and quarantine are carried out by supervision and sampling checks; the clearance certificate is then issued by the customs inspection and quarantine agency. Fish farms producing for export must also meet specific health requirements. Quarantine of aquatic fingerlings and aquatic products of export aquatic farms in provinces, municipalities, counties and districts are conducted by the respective aquaculture disease control centres and aquatic disease prevention stations. The quarantine method is similar across different regions, including quarantine facilities, laboratory examination, airport checkpoints and quarantine and market quarantine.

The legislative framework for the aquatic quarantine system in China is well established at both state and regional levels. In 2011 a new regulation on import and export of aquatic products, inspection and quarantine supervision came into force. According to the fish seed management measures issued by the Ministry of Agriculture, aquatic fingerlings must be inspected and quarantined by legally qualified inspection and quarantine authorities before reproduction and releasing. In Tianjin, the People's Congress Standing Committee issued the Tianjin fisheries management regulation in September 2005. Chapter I, Article 12 stipulates that aquatic fingerlings must pass through inspection and quarantine before sale and release, and must meet State and Municipality quality standards. It is also prohibited to stock harmful aquatic animals and plants on farms or in natural water bodies. Article 13 requires fisheries authorities (in accordance with the Law on Animal Epidemic Prevention and other relevant provisions) to organize and implement measures for prevention of epidemics and quarantine of aquatic animals and their products; and to strengthen technical guidance on aquaculture production, pathogen monitoring and investigations on a regular basis, reporting major epidemics to the local government and higher level fisheries authorities.

Quarantine for aquatic products and seed is key to aquaculture development in China, and is of fundamental importance to sustainable development of the sector. In 2005, there were 25 aquatic product exporters and 14 registered aquatic animal farms exporting to the Republic of Korea. Six exporting enterprises failed quarantine inspection and were suspended from exporting; the export permit of one enterprise was cancelled altogether. The system has helped raise industry standards and significantly improved the quality and image of exported products. From 1997 to 2005, Tianjin Binhai International Airport quarantine office carried out quarantine inspection on 3 000 batches of seedlings of more than 50 varieties, valued at RMB 2 billion, including marine and traditional freshwater aquaculture fish, shrimp, crab, shellfish, and ornamental fish species. Pathogen detection and infection rates showed a downward trend; concurrently, quality of aquatic seed has showed steady improvement (Chen, 2007).

2.4.4. Disease surveillance and early warning system

Disease monitoring and early warning systems are vital to prevention, treatment and containment of disease epidemics. In 1999 China launched a pilot project on aquaculture disease forecasting, and in 2001 implemented the program nationwide to provide accurate information for disease prevention and control. Today, aquaculture disease forecasting has become an integral part of aquaculture management (Xiao et al., 2005; You, 2010). Aquaculture disease monitoring and early warning monitoring is carried out by observation of culture species in the corresponding aquaculture environment. A relatively robust aquaculture disease monitoring and early warning systems has since been established, overseen by the Bureau of Fisheries of Ministry of Agriculture. Counties and districts report their monitoring records from aquaculture disease forecasting points on a monthly basis and provide summaries to provincial stations for collation and reporting to the national station. Monitoring results are disseminated to farmers through newspapers, television and other media, or via early warning mobile messages from district and county stations. Farmers can also receive technical guidance for reducing risks of epidemic diseases. In addition, many researchers are involved in research on aquaculture disease monitoring and early warning, including disease diagnostics and digital disease monitoring systems.

Aquaculture disease monitoring and early warning methods vary across the regions, depending upon the needs and local situation. Classical immunological diagnostic methods used include immunoprecipitation (immunodiffusion, immunoelectrophoresis, etc.), immune agglutination test, labeled antibodies and immuno-PCR technology. Polynerase Chain Reaction (PCR) detection technology has also been applied through a commercialized test kit (Chen et al., 2010). Colloidal gold immunochromatography is simple in principle and application using a rapid test strip, without the need for specialized skills or equipment, and has recently been tested in China (Wang et al., 2010). The LAMP method is used to detect aquatic animal parasitic infections, such as mucus parvum (*Myxobolus cerebralis*), as well as Cryptosporidium parasites which cause proliferative kidney disease (PKD) (Zhang et al., 2010). Gene chip technology has been applied as a diagnostic technique, but is still at the initial stage (Ou, 2012). In addition to the above techniques, there are many monitoring and early warning approaches, including the use of a computer network as a platform at the Shanghai Aquatic Disease Control Center. Since 2003, the centre connects aquatic disease control departments in the city and districts using digital images and transmission equipment for acquisition of aquatic information, diagnosis and early warning and forecasting. Aquatic disease experts can make a diagnosis via digital images of symptoms transferred online. Intensive information systems can now give early warnings for water quality, fine feeding, decision-making and disease early warning in intensive aquaculture farms. Nevertheless, in many under-developed areas, the early warning information feedback process is relatively slow, and is mainly undertaken by field technicians or by laboratory monitoring. Early warnings and forecasts are released by the Aquaculture Technology Extension Stations, which provide predictions of epidemics and stipulate preventive and control measures to be taken.

In 2011 the Ministry of Agriculture issued a regulation covering primary aquatic animal epidemic prevention stations, including basic building requirements and specifications, supplementing the Act on Animal Epidemic Prevention. In recent years, Shaanxi, Fujian and other provinces have developed contingency plans for prevention, containment and control. Urumqi's Agriculture and Animal Husbandry (Veterinary Office) established seven forecasting stations for implementing a unified system for monitoring, involving monthly reports on aquaculture disease epidemics throughout the year. (Dang et al., 1992).

By 2008, the national monitoring system covered over 80 farmed species and more than 150 diseases, with a monitoring area of about 5 percent of the country's total aquaculture area. In that year, over 5 000 datasets were collected and analyzed each month. In 2010, under the joint efforts of the disease monitoring station on aquatic animals and plants in Shandong Province, the province has established more than 200 conventional monitoring points, 70 provincial-level direct reporting points and 5 pilot-level disease prevention and control stations. By 2010, 36 kinds of diseases and hazards were monitored throughout the year.

Since its introduction the monitoring and early warning system has yielded significant improvements (Yue et al., 2011). Compared with 2009, in 2010 there were no reported disease incidences for 10 farmed species. Cases with unknown etiology fell to 4 in 2010 from 15 in 2009. In 2011, Shaanxi Province further increased its monitoring efforts, with a total of 26 aquaculture disease monitoring points and a monitoring area of about 10 120 mu. In 2011, 5 species were monitored, including grass carp, common carp; and 15 kinds of aquaculture disease were reported.

In conclusion, the epidemic monitoring, early warning and diagnostic prevention and control systems are not fully implemented in some more remote areas of the country. The institutional framework and technical capacity at local levels are still relatively weak, and they cannot adequately meet the industry's needs for early warning of diseases, forecasting, and epidemic prevention and control. Thus China needs to further strengthen the aquaculture disease monitoring and early warning network system, as well as to conduct more research on aquatic disease monitoring methods including rapid diagnostic technologies, and to provide more timely and effective information for early warning and prevention.

2.4.5. Environmental impact assessment (EIA)

Aquaculture production without consideration of the environment presents a serious risk of adverse environmental impacts. Examples include the unfettered aquaculture development in Gaoyou Lake during the late 1990s. In Jinhu County, pen culture in Gaoyou Lake began in 1998, and by 2002 had expanded exponentially to occupy 8 000 km^2 of the lake. The rapid and unregulated over-expansion of pen culture severely impacted the aquatic environment in Gaoyou Lake (Hu et al., 2011). In 2007, an outbreak of blue algae in Taihu Lake (caused by eutrophication attributed to intensive pen culture) seriously damaged livelihoods and the local economy. To address such concerns, EIA of aquaculture in China has been made a mandatory requirement.

The revised Marine Environmental Protection Law of the People's Republic of China came into force on 1 April 2000. Chapter II, Article 14 states that the National Ocean Administration is responsible for survey, monitoring and surveillance of the marine environment. Pursuant measures were subsequently introduced for implementation by the relevant departments of the National Marine Environmental Monitoring Network, which regularly conducts evaluations of the quality of the marine environment, and publishes a report on marine surveillance. Moreover, Chapter III, Article 28 of the Law requires the State to promote ecological aquaculture production methods. EIA is mandated for new construction, renovation, expansion of mariculture installations. The Environmental Impact Assessment Act was adopted in 2002; Chapter II, Article VIII states that departments of State Council and governments above district level are responsible for organizing EIA and approval of plans for industry, agriculture, animal husbandry, forestry, energy, water conservancy, transportation, urban construction and tourism. In 2008, amendments to the Water Pollution Prevention Law of the People's Republic of China came into force. Chapter 3, Article 17 states that new construction, renovation, expansion, construction projects and other water sports facilities which directly or indirectly discharge pollutants to the water, shall carry out an EIA.

EIAs for aquaculture project development are supervised by the relevant departments of the State Council, the local People's Governments above district level and include other agencies at central and local levels. EIA reports are reviewed by a panel of representatives from the government and outside experts. Institutions entrusted with providing technical services for EIAs must be approved by the Environmental Protection Administration under the State Council. EIAs of existing aquaculture systems are mainly carried out through investigation and monitoring the farm water inlet and outlet system, water quality and feed, cultured species, aquaculture patterns, e.g. aquatic feed components and stability in the water have significant impact on water quality. Research continues into identifying critical indicators for cost-effective EIA methodologies (Luo et al., 2008).

2.4.6. Ecological risk analysis (genetics and biodiversity)

Inadequate attention has been given to ecological risk assessment and prevention in aquaculture, resulting in adverse ecological impacts that are sometimes irreversible. The Millennium Ecosystem Assessment found that about 20 percent of freshwater fish species have been included on the threatened or endangered species list just in the past few decades (Zhang, 2008). There is therefore a need to build ecological impact assessment and prevention into the process of aquaculture development, not only to strengthen ecosystem resilience, but also to safeguard the sustainable development of aquaculture.

Ecological risk assessment of aquaculture includes evaluation of genetic diversity of aquaculture organisms and the impact of farming activities on biodiversity of the local ecosystem. In China, ecological risk assessment has not yet been widely adopted and no guidelines have been established. In June 1994, the Environmental Protection Committee of the State Council endorsed publication of the China Biodiversity Conservation Action Plan, which addresses threats to inland freshwater ecosystems, declines in important wetland, marine and coastal species, habitat loss and depleted marine fishery resources. Implementation of, and compliance with the Action Plan are the responsibility of the Coordination Group for the Convention on Biological Diversity and its information exchange mechanisms. Relevant agencies have established biodiversity management bodies based on operational needs. Some provincial governments have also established their own coordination mechanisms for biodiversity conservation. However, China has yet to establish a formal ecological risk assessment system for aquaculture and thus no legal mandate exists for the tool.

Nevertheless, field research in this subject continues, and the study of genetic diversity for many species has provided a scientific basis for cultured species (e.g. Meng et al., 2007; Wang et al., 2011; Xiao et al., 2011). Also, the ecosystem model has been established to study the impact of species introduction on ecosystem and biodiversity (Wang et al., 2004; Wang et al., 2007). With the rapid development of aquaculture and its potential ecological impacts, as the world's largest aquaculture country, there is an urgent need for China to establish an effective system for ecological risk assessment of aquaculture as a basis for decision-making by responsible agencies.

2.4.7. Residue testing and monitoring, record keeping and traceability

Ensuring the safety of aquaculture products is vital to protect human health, safeguard livelihoods in the aquaculture sector and promote China's international trade in aquaculture products (Liu et al., 2008). China has been pro-active in establishing a regulatory framework whose scope covers the entire process of aquaculture activities, including culture environments, aquaculture seed delivery, water disinfection, fish disease prevention and control and related chemical drugs use, processing, ecological management and safety, safety measures in feed and feeding (Chen et al., 2009), inspection and quarantine of aquatic products, aquaculture monitoring and early warning systems.

Safety risk assessment for seafood was adopted only recently in China. Chen Yan has assessed *Vibrio parahaemolyticus* (Vp) distribution in raw oysters in Fujian (Chen and Liu, 2004). Liu Xiumei and others also identified Vp in retail seafood and monitored the organism in four coastal provinces (Zhejiang, Jiangsu, Guangdong, Fujian) from September to December 2003 (Liu et al., 2005). Shen Xiao-Sheng monitored the major shellfish farming area in Zhejiang, to make an accurate evaluation of food safety risks for the region's marine shellfish in August 2003 (Shen et al., 2005). Although these studies provide important basic data for future risk assessment, there is no nationwide risk assessment system for seafood safety hazards.

In regard to aquaculture drug residue testing and traceability, detection and monitoring of drug residues in aquatic products have been widely adopted in domestic and international trade of aquatic products, and are a key area of concern for inspection and quarantine processes. Its purpose is to detect residues of harmful substances in aquatic products and prevent under-qualified products from entering the market and causing adverse impacts on consumer health. Drug residue surveillance and monitoring of aquatic products is the responsibility of the Ministry of Agriculture and State Administration of Quality Supervision, Inspection and Quarantine. The Ministry of Agriculture and State Administration of Quality Supervision, Inspection and Quarantine have set up aquatic drug residue detection and monitoring centres and aquaculture drug residue testing laboratories at municipality and regional levels. Drug residue testing for aquatic products has already attracted commercial attention; a number of private testing laboratories now offer drug residue detection services.

To enable timely identification of suspect batches, both upstream and downstream along the supply chain, China has launched a number of pilot traceability demonstrations in key fishing areas, where seafood quality and safety can be traced back to the original producers. These initiatives have been well received and are being extended. In 2006, China launched a cooperation project (Chill-On) to test key technologies and traceability systems for aquatic products. The project aimed to implement microbiological risk assessment and supply chain analysis in aquatic products enterprises, and establish a cost-effective traceability system to improve product safety and quality (Zhang et al., 2009). Radio Frequency Identification (RFID) is also increasingly used in identification and traceability of aquatic products (Li et al., 2007) and supply chain management platforms have been established that utilize the combined findings of information technology and traceability studies.

Drug residues in aquatic products arise mainly from antibiotics, disinfectants and water conditioners in aquaculture process and other sources. Detection methods for residues of drugs and chemical toxins include colorimetry, fluorescence, detection of immunological techniques, high performance liquid chromatography (HPLC), atomic absorption spectrometry (AAS), gas chromatography (GC), ultraviolet absorption spectroscopy (UV), infrared absorption spectroscopy (IR), nuclear magnetic resonance spectroscopy (NMR), inductively coupled plasma atomic emission spectrometry (ICP-AES), and mass spectrometry (MS). Any sample found to contain residues exceeding the prescribed standard is to be handled in accordance with relevant laws and regulations. Nevertheless traceability systems for aquatic products remain at an early stage of development in China.

China has published many laws and regulations on the aquatic food safety. Hazard Analysis and Critical Control Points (HACCP) system was introduced and applied in 1991 by the Fisheries Bureau of Ministry of

Agriculture. Experts were sent to participate in seminars on HACCP organized by the Food and Drug Administration (FDA) and National Oceanic and Atmospheric Administration (NOAA). In 1993, the National Fishery Product Quality Inspection Center held its first seafood HACCP training courses to introduce HACCP principles for aquatic products, covering quality assurance technology, aquatic hazards and control measures. In 1996, the Ministry of Agriculture promulgated the industry standards for five aquatic products, and large-scale HACCP training activities started as preparation for implement. At present, approximately 500 aquatic export enterprises have been awarded HACCP certification.

There is also a broad legislative basis covering drug residues detection and monitoring in aquatic products. In 2003, the aquaculture quality and safety management provisions was deliberated and adopted by the 18th executive meeting of the Ministry of Agriculture and entered in force on 1 September 2003. Chapter IV, Article 20 stipulates that the Ministry of Agriculture is responsible for formulating the national aquaculture products drug residue monitoring plan and for organizing implementation activities. Fishery administrative departments at local people's governments (above county level) are responsible for monitoring drug residues in farmed fish in their respective administrative areas. Article 21 provides that aquaculture units and individuals shall be subject to sampling and testing for drug residues in farmed fish by the fishery administrative departments of the people's government at or above county level.

In 2002, the Ministry of Agriculture, the State Administration of Quality Supervision, Inspection and Quarantine jointly issued the 'Aquatic drug residues special rectification program: Control fish drug residues in aquatic products', 'Aquatic toxic and hazardous substances list', 'Guidelines for the use of drugs in fisheries' and a number of regulations on aquatic drug residue regulations and requirements. These aquaculture quality and safety regulations entered into force in 2003. Chapter III, Article 12 provides that aquaculture units and individuals should keep records of aquaculture production, including farmed species, seed sources and growth, feed sources and feeding and water quality changes. Aquaculture production records must be kept for at least two years after sale of each batch of aquatic products. In December 2007 the State Administration of Quality Supervision, Inspection and Quarantine implemented special provisions for implementation of electronic supervision of product quality management, which called for mandatory use of electronic monitoring codes on product packaging before they are allowed for sale. This initiative had a major impact on pre-packaged food manufacturers, and set new administrative licensing and market access conditions (Liu, 2006).

In the past, China's aquaculture industry has suffered serious impacts arising from residue issues, including the EU's ban on imports of Chinese shrimp and other aquatic products in early 2002 following to detection of chloramphenicol residues (Lin et al., 2011). Learning from such lessons, China's aquatic drug residue testing program has made considerable progress, supported by the enactment of a range of legislative and regulatory provisions. The measures have contributed significantly to enhancing the safety and quality of China's aquatic products. Moreover, traceability systems have recently been established by some aquaculture companies. For example, the traceability system of Dalian Zhangzidao Fishery Group Co., Ltd. for sea cucumber has been recognized in the international market, and significantly boosted the corporate brand and sales in both domestic and export markets (Huang et al., 2011).

Overall, China's aquatic products today are safe, with an inspection pass rate of aquatic products for export as high as 99 percent. However, with improving living standards, growing health consciousness, and increasingly stringent food safety standards set by importing countries, aquatic food safety issues are attracting increasing attention (Ji et al., 2006; Li, 2006; Li et al., 2007).

2.4.8. Spatial planning/zoning based on carrying capacity

Chinese aquaculture exhibits the greatest diversity of cultured species and farming systems in the world. However, the sector's rapid and continuing expansion has been accompanied by environmental impacts such as water pollution, and product quality was affected as stocking densities continued to increase (Liu et al., 2009). Ecological imbalance was caused by intensive management; when exploitation of natural resources exceeded the environmental carrying capacity, negative effects were sometimes catastrophic. In particular, cage aquaculture in some bay areas resulted in frequent oxygen depletion of the waters, with the resulting ecological impacts causing huge economic losses. Given the large-scale of development, environmental degradation, shrinking resources and economic losses have emerged as a serious environmental threat to the sector's development (Bartley et al., 2007).

To address these concerns, aquaculture planning and zoning is increasingly based on environmental carrying capacity. Aquaculture environmental carrying capacity evaluation is carried out on the basis of a spatial planning and zoning plan, managed by the Bureau of Fisheries, Ministry of Agriculture, in cooperation with the aquaculture planning authorities at provincial, district and local levels, as well as the inland water and marine administrative authorities.

Since 2002, an aquaculture permit system has been implemented to ensure sustainable and regulated development of aquaculture projects. These requirements apply both to pond aquaculture, inland open waters and coastal aquaculture. Use of marine and inland waters for aquaculture activities is subject to approval by the local people's governments as well as the county level fishery administrative departments responsible for processing applications. Applicants are subject to site inspections to verify site demarcation and other compliance issues before an operating permit is granted.

There is increasing interest among researchers in exploring new ways to improve carrying capacity and refine planning methods, in order to optimize the environmental performance of aquaculture operations whilst ensuing a safe, sustainable supply of high quality aquaculture products to meet market needs. Implementation of the permit system has resulted in significant improvements in animal health, environmental protection and operator awareness of food quality and safety issues. Such measures have resulted not only in limiting environmental loads, but also in increased production efficiency. In 2006, fisheries production in medium-sized reservoirs reached 2.5 million tonnes, an increase of 25 percent over the previous year. In addition, innovative farming methods helped further reduce the negative environmental impact of aquaculture.

2.4.9. Production process – public and private certification

The production process is certified by an official certification body or officially recognized certification body as the outcome of a continuous review of production activities. Aquaculture certification programs provide guiding principles defined by the scope of the respective scheme. The scope of private certification may often be associated with key issues, particularly: a) animal health and welfare; b) food quality and safety; c) environment; or d) social responsibility.

China has not yet enacted specific legislation mandating certification of aquaculture products or processes. Aquaculture certification is mainly a response to international laws and regulations, such as the following:

- World Trade Organization (WTO) Technical Barriers to Trade Agreement (on the standard preparation, adoption and application of laws and regulations);
- WTO Health and Phytosanitary Measures (SPS) Agreement;
- International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) Guide 59: Code of Good Practice for Standardization (1994);
- International Organization for Standardization (ISO) Guide 62: General Requirements for Bodies Operating Assessment and Certification/Registration of Quality Systems (1996);
- ISO/IEC Guide 65: General Requirements for Bodies Operating Product Certification Systems (1996);
- International Society and Environment Recognition and Label Alliance (ISEAL).

Certification has been widely adopted by China's shrimp farm operators. Legal requirements include business license, aquaculture license, land certificate (lease or concession agreement), land use tax, construction permit, water permit, the protection of the mangroves, emissions permit and landfill permit. The parties involved in the construction of farms are responsible for all necessary documentations for construction and operation of equipment (Lou, 1983).

In addition to compliance with internationally recognized third party certification schemes for exported aquaculture products, China is currently implementing various government-initiated certification schemes for domestic trade, including non-hazardous food, "green" food and organic food. At present, all such schemes are voluntary. Aquaculture certification is typically operated at provincial level and the standards and procedures are always consistent. A national centre for aquaculture certification has been established to coordinate aquaculture certification at national level.

2.4.10. Social impact assessment (SIA)

Social impact assessment (SIA) refers to the analysis, monitoring and management of social impacts, both negative and positive, arising from proposed interventions (policies, projects, plans, engineering works) or any process of social change. The primary goal is to ensure that proposed activities maximize sustainability and equity in the human environment. The purpose of SIA in aquaculture is to predict and control potential adverse social impacts of aquaculture operations, to maximize beneficial impacts and promote sustainable development of the sector.

SIA includes collection of baseline data, development of evaluation indicators, definition of sphere of influence, identifying key stakeholders to assess the program, and recommendation of options to mitigate negative impacts. SIA uses time-period comparison as a basis for analysis, to investigate historical precedents, establish pre-and post-project status, and propose options for addressing social impacts identified.

As yet, no specific regulatory requirements have been established for SIA in aquaculture. In China, the subject is still in its early initial stages of introduction and research, and there is no substantive application. Given the scale of aquaculture in China, there is an urgent need to address the needs to mandate SIA, in order to minimize the potential for adverse social impacts and facilitate sustainable development of aquaculture.

2.4.11. Input quality assessment and monitoring

Aquaculture inputs provide the material basis for aquaculture, including seed, feed and feed additives, drugs, water quality improving agents, and other environmental maintenance agents. However, the discovery of drug residues in food have emerged as a primary and widespread health concern both nationally and globally, and their occurrence is closely associated with input quality management. Therefore, enhancing management of aquaculture inputs through continuous source control has become a key issue to be addressed by aquaculture administrators at all levels. Currently, China can only ensure strict monitoring of inputs for large-scale export-oriented production and processing enterprises.

Following discovery in 2005 of excessive levels of malachite green residues in aquaculture exports to the Republic of Korea, the State Administration of Quality Supervision, Inspection and Quarantine decided to suspend farmed fish exports nationally as a preventive measure. Aquaculture farms involved in exports were obliged to obtain approval by the local entry and exit inspection and quarantine bureau as well as full implementation of testing of fish from fry to adult for export by the Entry-Exit Inspection and Quarantine Bureau. Farms that failed to meet the product quality monitoring requirements would be banned from exporting.

In 2002, nationwide quality inspection centres were established by the National Aquatic Product Quality Inspection Center. Six farmed species were subject to mandatory checks for residues of chloramphenicol and furazolidone, banned for use in aquaculture. These were shrimp, eel, tilapia, crab, grass carp and crucian carp. Drug residue tests were also required for exported products. In recent years, increasing public and official awareness of this issue has driven fishery administrative departments in many provinces to impose increasingly stringent requirements for management of aquaculture drugs, fish feed and other aquaculture inputs. Research continues to optimize input levels including use of aquaculture drugs (Shen and Fei, 2004; Yu, 2009).

However, despite the high level of awareness and concern, responsible departments have yet to adopt consistent, uniform implementation procedures nationwide. Some municipal governments have set up input management offices or imposed other arrangements to centralize input markets and facilitate control and management. Inputs are assessed and those that fulfill agreed quality criteria are recommended for use by aquaculture operators; farmers are also warned of products that fail to comply. Jiangsu Province has launched a fishery drugs market access system, in which distribution of fishery drugs within the province must be registered at a specified fishery drugs distribution unit. Aquaculture drug retailers need to be registered at the local fishery administrative or technical extension station. Market access permits are suspended if substandard products are found at the point of sale. On the manufacturing side, GMP is a compulsory requirement for all manufacturers of aquaculture drugs and chemicals.

Production and introduction of aquatic seed must comply with the Fisheries Law of the People's Republic of China and the aquatic seed management regulation issued by the Ministry of Agriculture. Superior varieties and breeds of aquatic animals should have obvious morphological characteristics and economic traits, and the quality must comply with prescribed standards. New species to be introduced from other countries are subject to strict quarantine to avoid introduction of pathogens and aquatic animals. Seed production conditions and facilities must also comply with prescribed technical operation guidelines for aquatic seed production. The government has published standards for animal feed in China, including the *Feed Hygiene Standard (GB13078-2001), Safety Limits for Fish Feed of Pollutant-free Food Production (NY5072-2002), Fishery Drug Use Guidelines for Pollution-free Food Production (NY5071-2002)* and *Standardized Management Protocol for Marine Cage Aquaculture at Exportation Bases*.

China is the world's largest aquaculture producer, and product quality and safety are taken as the top priority. Nevertheless, there is need for strict and consistent implementation of aquatic input quality assessment and monitoring, in order to address the challenges of managing the large numbers of aquaculture farmers and the diversity of production systems and farmed species.

2.4.12. Management tools – GAP

Good aquaculture practices (GAP) is a set of operational standards for aquaculture production. It is an effective management tool for optimizing aquaculture practices and improving product quality and safety, whilst contributing to environmental integrity and social equity. Development and implementation of GAP has attracted increasing attention across the country and is by now widely adopted. Some provinces have published rules and regulations on implementing GAP, adapted to local aquaculture conditions, mainly focused on standardized pond construction and aquaculture disease control.

In July 2010, Jiangsu Provincial Bureau of Oceanic and Fishery officially released its standard for aquaculture pond construction, introducing standards for freshwater aquaculture ponds, including detailed requirements for pond shape, area, dyke width, slope, depth, slope protection, as well as management, buildings, supporting facilities, environmental requirements etc. (Jiangsu Province, 2010). In 2007, China's major fisheries provinces launched a program to promote prudent aquaculture drug-use practices, disseminating relevant scientific knowledge and good management practices to aquaculture village and fish farmers in the countryside. The program was strongly supported by the Bureau of Fisheries of the Ministry of Agriculture, the relevant fishery administrative department in charge of the Aquaculture Technology Extension Station, and received active cooperation from aquaculture drug manufacturers.

In 2004, preparation and formulation of the China GAP standard began; China GAP was based on the EUREPGAP standard and adapted to comply with conditions and regulatory requirements in China. A series of national standards of good agricultural practices GB/T 20014.1-11 were formally implemented from

May 2006. The *Good Agricultural Practice (GAP) certification and implementing rules (trial)* was released in early 2006, followed in 2007 by *Good Agricultural Practice (GAP) Certification Implementation Rules (Trial)* (CNCA-N-004: 2006). The second batch of China GAP Series came into force in 2008, and was named as GB/T 20014.13 ~ 24-2008.

Legislative support is based primarily on the Fisheries Law of the People's Republic of China; Article 36 states: "The people's governments at all levels should take measures to protect and improve the ecological environment of fishery waters, prevent and control pollution, supervise and manage the ecological environment of fishery waters and investigate fishery pollution accidents in accordance with the relevant provisions of the Marine Environmental Protection Law and Water Pollution Control Act of the country."

Local governments have introduced management regulations pursuant to this provision. For example, Article 9 of the Jiangsu Province Fisheries Management Regulation states that seed production must meet quality standards in order to comply with national or provincial regulations on seed production and technical operation. The regulation also requires regular replacement of brooder stocks, use of pure strain parents in hybridization, and those hybrids and their seed should not be released in natural waters or used as breeding parents. Any organization or individual involved in the aquatic fingerling business must also carry the required quality and quarantine certificates.

China GAP also needs to take into consideration the wide range of aquaculture practices, and diversity of culture species, systems and diverse farm environments. The GAP framework is divided into basic standards for farms, and sets standards by type (pond aquaculture farming, in-door aquaculture, cage culture, pen culture and tidal zone, hanging and sowing culture), species production standards (tilapia ponds, eel ponds, shrimp ponds, flatfish factory farming, yellow croaker cage culture, and Chinese mitten crab fence culture).

China GAP employs the HACCP principles for identification, evaluation and process control of the entire aquaculture process, equipment and facilities on farm, aquaculture inputs (fingerlings, aquaculture drugs and chemicals, vaccines, fish feed), aquaculture management (aquaculture program, fry rearing, transfer management, hygiene management, disease control, dead animal disposal, drug residue control, harvest, hygiene in icing, packaging and transport, animal welfare, disaster prevention, etc.) and environmental protection aspects for the general requirements. Special requirements are based on the characteristics of the different culture environment and farming methods (Li, 2012).

China's aquaculture industry has a long history and for decades has ranked the world's top aquaculture producer. China has issued almost 600 fishery laws and regulations on fisheries management at different levels. However, enforcement needs to be further strengthened with awareness raising, capacity building and resource allocation to ensure rigorous, consistent and effective implementation.

2.4.13. Life cycle analysis, greenhouse gas emissions, carbon footprint studies

In addition to those discussed above, a number of other aquaculture assessment tools have been developed to address the emerging issue of the impact of aquaculture on climate change. These include life cycle analysis (LCA) and studies of greenhouse gas emissions and carbon footprints of operations. Because aquaculture generates large quantities of greenhouse gases, mainly carbon dioxide. Appropriate management techniques are required to minimize emissions in order to mitigate climate change impacts of aquaculture, and to meet international carbon tariff requirements through introduction of low-energy, low-carbon farming methods.

Although LCA in aquaculture has been extensively studied, standard research procedures and legal norms have yet to be established in China. In terms of greenhouse gas emissions and carbon footprints, despite the high priority attached by the international community to the problem, China's aquaculture legislative framework has yet to address these issues.

However, the findings of research on low-carbon-based aquaculture have been incorporated to some extent into strategic planning processes in order to assess financial feasibility of low energy consumption and low emission farming enterprises (Luo et al., 2011). The CO_2 emissions of Chinese aquaculture has been estimated at approximately 988×10^4t, or 0.17 percent of the country's total annual CO_2 emissions. Furthermore, CO_2 emissions from freshwater ponds (the dominant production system) were found to account for 73.8 percent of total aquaculture emissions.

Targeting aggregated greenhouse gas emissions and carbon footprints from all industry sectors, the government has mandated a target 40-50 percent reduction in CO_2 emissions per unit of GDP, compared with 2005 levels as a baseline (Shi et al., 2008). Facing potentially high carbon tariffs for export of aquatic products, China's aquaculture industry is likely to encounter many challenges; it will thus be important to act on all levels to promote development and adoption of low-carbon aquaculture practices in China. Thus there is a need for research to focus on energy-saving technologies and CO_2 reduction in freshwater pond aquaculture.

2.5. Issues and constraints in the application of tools

Many assessment tools have been used and applied in China's aquaculture. While some tools are still at the research or development stage, some are recognized as mandatory tools. A number of issues and constraints hamper wider application of the assessment tools, as outlined below.

2.5.1. Legal status of assessment tools

The protracted legislative process results in long delays in incorporating assessment tools into relevant laws and regulations. The process can be fast-tracked only if the importance of the tools to sustainable development or for market compliance is recognized at political level. Wider adoption of APMTs can only be expected when supported by legislation at state or local levels.

2.5.2. Awareness of assessment tools

Awareness of aquaculture planning and management tools is still low at grass-root management and farmer levels. It will therefore be important to improve awareness through education, training and public advocacy.

2.5.3. Compatibility of certification schemes

The many available private certification schemes increases the overall cost of aquaculture planning and management for operators, who must often apply for multiple certifications. It is therefore important to study the certifications and their compatibilities. If certification schemes can be recognized as mutually compatible, they will be more widely adopted by farmers and the management authority, especially for international trade.

2.5.4. Monitoring and supervision

After evaluation and certification, there is an increasing need for monitoring and supervision of farm practices, imposing a major ongoing burden on authorities in terms of manpower and financial resources. It is therefore necessary to explore more efficient means for post-certification monitoring and supervision at operator level.

2.5.5. Responsibilities of public and private sectors

With increasing awareness of the importance of resource conservation and sustainable development, APMTs are increasingly adopted around the world, imposing major demands on financial resources and human capacity. The funding responsibility should be shared between the public and private sectors, suggesting a need to explore modalities for equitable cost-sharing between public and private sectors. Such a balance would limit increases in production costs (which would be translated into higher consumer prices) whilst allowing the public sector to fulfill its statutory responsibility for safeguarding food safety, trade and livelihoods, social equity and environmental integrity. Therefore, the public and private sector should work as public-private-partnerships to promote adoption of APMTs.

2.6. Recommendations and way forward

2.6.1. At national level

The review finds that in China, many APMTs have been adopted in aquaculture planning and management, resulting in significant contributions to improved long-term sustainability and resilience of the sector. However, in order to fully benefit from the application of APMTs in China, the following actions should be taken at national level:

- Promote awareness of APMTs among stakeholder groups;
- Further strengthen the legal support and implementation mechanisms for aquaculture assessment;
- Speed up the national plan for wider adoption of aquaculture assessment tools;
- Strengthen capacity building programs for adoption of APMTs;
- Strengthen monitoring and inspection of aquaculture operations.

2.6.2. At regional level

China has learned much from the lessons and practices of other countries in research and application of APMTs. The rapid pace of technological advancement, combined with the sector's wide diversity across countries as well as capacity to adoption aquaculture planning and management tools, means that countries need to collaborate in research and adoption of APMTs. Regional collaboration is needed to support national-level efforts to promote adoption of APMTs for informed planning and management. In particular, the following areas should be prioritized for regional interventions:

- Establish a regional platform for exchange and information sharing on APMTs;
- Develop and disseminate practical guidelines or a toolbox on existing aquaculture assessment tools to support and facilitate country-level adoption;
- Provide support to national-level agencies on capacity-building and implementation mechanisms for thirty party certification;
- Initiate a regional program on AATs research and knowledge generation in the region;
- Promote adoption of AATs along the aquaculture value chain in the region.

2.6.3. The way forward

To progress in promoting adoption of aquaculture assessment tools, there is an urgent need to build synergies between national and regional initiatives. National governments should fully recognize the necessity of adopting relevant aquaculture management tools and demonstrate political will by supporting the national capacity and operational capability, and by mobilizing the necessary resources. For their part, international and regional organizations such as FAO and NACA should provide technical assistance to the member countries, e.g. through regional collaboration in developing and disseminating an 'AATs adoption toolbox' including updated scientific knowledge and promoting the sharing of experiences and lessons learnt by different countries in adopting AATs. External support for capacity development is also needed for most countries in the region. There is also a great need to promote public-private partnerships in promoting the adoption of aquaculture assessment tools in the region.

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3. COUNTRY REPORT: INDIA

Status of adoption of aquaculture planning and management tools for sustainability in India

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3.1. Introduction

Fish production in India has shown enormous growth during the last 20 years with the major contribution from inland aquaculture. In 1991-1992 total fish production stood at 4.16 million tonnes, with marine production at 2.44 million tonnes and inland production at 1.71 million tonnes. In 2010-2011, production almost doubled to 8.29 million tonnes, comprising 3.22 million tonnes from marine and 5.07 million tonnes from inland production. According to FAO (Fishstat, 2012), freshwater aquaculture production in India in 2010 reached 4.5 million tonnes with 94 percent contribution from carps. Brackish water aquaculture production consisted of shrimps (112 100 tonnes) and fish (28 420 tonnes). *Penaeus monodon* contributed about 86 percent while *Litopenaeus vannamei* and Indian white shrimp contributed 14 percent. Mariculture in India is still in its infancy, with total production of 18 000 tonnes of green mussel and oyster.

Commercial aquaculture production in India is based on only a few farmed species – in freshwater the Indian major carps and exotic carps account for 94 percent of total production. *Pangasius hypophthalmus* alone contributes nearly 5 percent. Similarly, among the brackish water cultivable species only *P. monodon* and *L. vannamei* contribute substantially to total production. Among brackish water fishes, commercial seed production technology is available only for sea bass and pearl spot. Though some breakthroughs have been achieved in seed production of other important cultivable species (e.g. of mullet, milk fish, groupers and cobia), technology development is still in the early stages. Grow-out culture of these species therefore remains dependent on wild seed availability.

India's marine food exports in 2011-2012 reached 855 737 tonnes, with a total value of Rs. 16 477 crores (US$3.3 billion). The growth over the last year was 5.24 percent in quantity and 27.72 percent in value. Frozen shrimps contributed 22 percent of the total quantity of marine food exports which was about 50 percent of the total value. Shrimp production from aquaculture during the period has increased to 216 500 tonnes which was 61 percent more than the shrimp aquaculture production in 2010-2011. The estimated value of shrimp produced during the year was Rs. 4 073 crore (US$814.6 million), a 32 percent increase over the previous year (SEAI, 2012).

Considering the country's aquatic resources, the aquaculture industry has recognized the potential for substantial improvement in aquaculture production and productivity. However, continuing intensification has raised environmental concerns. Moreover, with increasing awareness of food safety, control of antibiotics and other residues in aquaculture products has attracted increasing concern. In order to address environmental and food safety concerns, Aquaculture Planning and Management Tools (APMT) assume an increasingly critical role. Increasing the area under culture, choosing suitable sites, integrating aquaculture under Integrated Coastal Zone Management (ICZM) Plans, ensuring environmental protection through EIA and carrying capacity estimation can be achieved if APMTs developed in India are effectively used. There is also scope for applying APMT tools effectively employed in other countries.

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3.2. Institutional and legal framework

At national level, the Division of Fisheries, operating under the Department of Animal Husbandry, Dairying and Fisheries (DAHDF), Ministry of Agriculture (MoA) is responsible for planning, regulating, and monitoring the sector's development. DOF also funds the majority of the country's development programs related to fisheries and aquaculture. Almost all State governments have a separate Ministry for Fisheries or a separate wing under the Ministry of Animal Husbandry, responsible for oversight of fisheries and aquaculture at state level. The Division of Fisheries of the Indian Council of Agricultural Research (ICAR) undertakes R&D in aquaculture and fisheries through eight research institutes. Also, the Marine Products Export Development Authority (MPEDA), under the Ministry of Commerce, promotes coastal aquaculture in addition to its primary role in promoting aquatic product exports. The Ministry of Environment and Forests enforces regulations for environmental conservation where these are relevant to responsible aquaculture development.

India is a federal republic, subdivided into 28 states and seven union territories. According to the Indian Constitution, the state legislatures have the power to make laws and regulations with respect to issues including land, water, fisheries and aquaculture, as well as the preservation, protection and improvement of stock and the prevention of animal diseases. Essentially, this legislation must be seen in their broader context in order to gain a full picture of the legislative and regulatory framework for aquaculture. The major Acts and other legal instruments currently in force in India in relation to the APMTs are listed as follows:

- Indian Fisheries Act (1897)
- Livestock importation Act (1898) amended in 2001
- Coastal Aquaculture Authority Act (2005)
- Environmental Impact Assessment Notification (1994)
- Environment (Protection) Act (1986)
- Water (Prevention and Control of Pollution) Act (1974)
- Coastal Regulation Zone Notification No. SO 114 (E) (1991)
- Biological Diversity Act (2002)
- Export (Quality Control and Inspection) Act (1963)
- Export of Fresh, Frozen and Processed Fish and Fishery Products (Quality Control and Inspection and Monitoring) Rules (1995)
- Export of Live Fish (Quality Control, Inspection and Monitoring) Rules (2002)
- Andhra Pradesh Aquaculture Seed (Quality Control) Act (Act No. 24 of 2006).

Further details are available in the overview of Indian legislation related to aquaculture (FAO, 2012; Howarth et al., 2012). (Acts are those items passed by the Parliament or State Legislature, whilst notification and rules are those framed by the respective Ministries).

3.3. Summary of APMTs application in India

Based upon the current evaluation, a summary of the status of adoption of aquaculture planning and management tools (APMTs) in India is provided in Table 4. Standard analysis criteria were used to evaluate each of the four dimensions, as follows:

Table 4 Summary of APMTs Application in India

Tool	Level of awareness[1]	Level of capacity[1]	Extent of use[2]	Supporting legal instruments[3]	Remarks
Health					
Import Risk Assessment (IRA)*	c	b	c	Yes (3.2)	IRA carried out for introduction of *L. vannamei; P. hypophthalmus*, tilapia
Surveillance*	b	b	b	No	Surveillance in Andhra Pradesh for emerging diseases by NBFGR & CIBA
Health Certification of imported stocks*	d	b	c	Yes (3.2)	Checking health certification given by other countries for imported stocks of *L.vannamei*, tilapia & rainbow trout
Quarantine*	d	a	c	Yes (3.2)	Routinely in use since 2009 for Importation of SPF *L. vannamei*
Environment					
Environmental impact assessment (EIA)*	b	b	b	Yes (3.3, 3.4, 3.5, 3.6)	Mandatory requirement for CAA registration of large farms
Impact of aquaculture	a	a	c	Yes (3.3, 3.5, 3.7, 3.8)	Tool developed by CIBA for assessing impact of aquaculture on mangroves, nutrient loading in source water, soil and drinking water salinization
Life cycle analysis (LCA)*	a	a	b	No	Validation of tool ongoing for brackish water aquaculture by CIBA
Ecology					
Biodiversity-genetic risk analysis*	a	a	b	No	Validated by NBFGR for Indian Major Carps
Ecological risk assessment of invasive alien species*	a	a	c	Yes (3.8)	Used in clearing of proposals for introduction of alien species by the Exotics Committee, Ministry of Agriculture
Planning					
Decision support system to identify potential sites for brackish water aquaculture development*	a	a	b	No	Developed and validated for identification of potential sites for brackish water culture (CIBA) and mariculture (CMFRI)
Carrying capacity assessment of source water bodies – Decision support software*	a	b	b	No	Developed and validated by CIBA for assessing carrying capacity of creeks to support shrimp farming
Social impact assessment	b	b	d	No	Used by researchers as input into many APMT, in policy and planning exercises to increase stakeholder involvement

Table 4 Summary of APMTs Application in India *(continued)*

Tool	Level of awareness[1]	Level of capacity[1]	Extent of use[2]	Supporting legal instruments[3]	Remarks
Economic impact – Disease loss assessment*	a	b	b	No	CIBA study to quantify loss due to shrimp diseases
Aquaculture produce trade assessment	b	c	d	Yes (3.11)	Used by researchers and as input for policy documents
Management					
Food safety standards	c	c	e	Yes (3.9, 3.10, 3.11)	Mandatory requirement for pre-harvest residue testing in shrimp culture for shrimp exports
Input assessment (seed, feed, medicines)	d	e	d	Yes (3.3, 3.12)	In culture of *P. monodon* and *L.vannamei* seed quality testing is extensively used; a mechanism for feed and medicines is currently being set up
Application of HACCP*	b	c	e	No	Seafood processing plants
Better management practices (BMPs)	e	c	e	No	Extensively adopted by farmers
Interactive tool for training extension personnel on BMPs	a	b	b	No	Developed by CIBA for use by extension personnel
Cluster farming certification	a	c	b	No	NaCSA is developing this tool
Organic certification	a	c	b	No	MPEDA provides organic certification of freshwater shrimp; MPEDA is developing national guidelines for organic shrimp, carp and mussels.

* Due to the nature and purpose of these tools, the capacity and the extent of use is limited to the level of policy makers and scientists at national level

Legislation: Though the subject covered in APMT is indicated in the legislation identified, for many of the tools, specific rules have not yet been framed

Notes:

[1] Levels of awareness/capacity: ***a*** – policy makers and scientists at the national level; ***b*** – policy makers, scientists, at the provincial level; ***c*** – all stakeholders at local level except farmers; ***d*** – all

[2] Extent of use: ***a*** – never used; ***b*** – used in some projects; ***c*** – used at national level; ***d*** – used at provincial level; ***e*** – used at local level

[3] Supporting legal instruments: Yes; no; under development

3.4. Application of tools

3.4.1. Import risk assessment

Risk analysis has been adopted in recent years as a tool to manage aquatic animal health. The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) stimulated global adoption of risk analysis to investigate disease risks associated with international trade. In 2003, India's Ministry of Agriculture granted permission to two firms for the import of the Pacific whiteleg shrimp, *L.vannamei* SPF broodstock on a pilot scale. On review of these introductions and based on extensive stakeholder consultations, the Ministry decided that an Import Risk Assessment (IRA) was warranted prior to allowing large-scale introduction of *L. vannamei* for aquaculture in India.

The IRA was conducted in 2007 by a committee comprising representatives of the Central Institute of Brackish Water Aquaculture (CIBA) and Chennai and National Bureau of Fish Genetic Resources (NBFGR), Lucknow. Precedents had already been established by the IRA of *P. hypophthalmus*, which had been permitted for introduction and culture in India, following an IRA conducted by NBFGR. Similarly, for tilapia, a committee constituted by the Ministry of Agriculture evaluated the risks and developed guidelines for its culture.

As an input for the IRA for *L. vannamei*, CIBA carried out a rapid survey on adoption of biosecurity protocols by Indian shrimp farmers. The IRA was based on this information, combined with a review of the status of *L. vannamei* culture in Southeast Asian countries, and a critical evaluation of the experience of pilot-scale importation and culture of *L. vannamei* by the two licensed firms.

The IRA identified five possible import scenarios for SPF *L. vannamei,* as follows:

1. Unrestricted import (high-risk);
2. Pilot scale tested, restricted imports with quarantine facilities at the importers' facility (high-risk);
3. Quarantine facilities under public sector – unrestricted culture (moderate-risk);
4. Quarantine facilities under public sector, with restriction on culture practices (low-risk);
5. Establishment of SPF multiplication centre cum quarantine under public-private partnership with restricted permits for culture (low-risk).

The IRA concluded that the low-risk scenarios (4) and (5) were considered most suitable for Indian conditions. Based on the findings, a regulatory framework for introduction of *L. vannamei* under the two recommended low-risk categories was formulated, along with specific guidelines for hatcheries and farms. The recommendations were adopted and a new legislative framework for the low-risk scenarios for import of exotic shrimp species for aquaculture in India was implemented in 2009 following approval by a committee chaired by the Coastal Aquaculture Authority (CAA), which regulates coastal aquaculture activities.

Subsequently, following three years of experience, the system for quarantine and import of *L.vannamei* was reviewed and the regulatory guidelines modified to include a public-private partnership for implementing quarantine regulations. Under the modified guidelines, two consortia have been awarded permits to set up quarantine facilities based on designs to be approved by the competent authority. Operations will be overseen by a designated quarantine officer and the screening of pathogens will be supervised by government scientific staff.

The main lesson learned in the process of developing the IRA and developing and implementing the guidelines is that in such issues, differing stakeholder perspectives can be addressed using a science-based approach to IRA, leading in this case to a successful outcome.

3.4.2. Disease surveillance and early warning system

Surveillance is a mechanism applied to collect and interpret data on the health of aquatic animal populations, to accurately describe their health status with respect to specific diseases of concern. Targeted surveillance to prove absence of infection by specific pathogens may be used to reinforce inconclusive general (passive) and/or historic evidence (FAO, 2004).

No extensive surveillance has been carried out in India. However, NBFGR and CIBA have carried out investigations on emerging shrimp diseases. Recently NBFGR organized a national consultation on surveillance, in collaboration with the Ministry of Agriculture and NFDB. The consultation aimed to develop a national-level surveillance program for aquatic animal diseases.

Economic losses from disease represent a comparatively neglected area in regard to overall economic assessment of aquaculture. Briggs et al. (2004) estimated losses due to disease in shrimps at US$1 billion. During 2006-2008 CIBA conducted a disease loss assessment in India. A total number of 1 142 shrimp farms from nine states were surveyed using simple random sampling major diseases considered were white spot syndrome virus (WSSV), loose shell syndrome (LSS) and the combination of WSSV with other diseases such as LSS, and also included other bacterial and fungal diseases. The economic loss caused by diseases was quantified in terms of price loss attributable to low quality, productivity loss per hectare, production loss from the nation, income losses and corresponding loss of employment in terms of man-days. The study aimed to draw attention to the urgent need to allocate adequate budgets to aquatic animal health research and to attract the attention of policy makers and development departments towards aquatic animal health management.

The impacts of disease incidence include both market-based and non-market effects. For example, market-based impacts may include partial or complete destruction of produce, with consequent loss in total production, employment, sales and income. Non-market effects include environmental consequences and psychological effects suffered by the individuals involved.

The study found gross annual national losses estimated as follows:

- A national loss of 48 717 metric tonnes of product or about 30 percent of present shrimp production occurred due to diseases;
- In terms of national income an amount of Rs. 1 022.1 crores (US$204.4 million) was lost due to diseases on shrimp farms;
- In terms of farm level employment 2.1 million man-days were lost due to shrimp diseases in the country. As the sample size for these cases were not large, the actual losses could be even higher.

The extent of losses caused by disease needs to be communicated to farmers, development agencies and policy makers in order to ensure that adequate attention is paid to disease prevention and disease management at farm, region and national levels. The exercise needs to be repeated periodically to monitor changing disease risks and for shaping policy initiatives to reduce total production losses.

The key message from the disease loss assessment is that the production loss is huge, and that there are also multiple unreported infections. Large-scale epidemiological investigations along with economic loss assessment are required to quantify these losses and design remedial measures at all levels.

The limited efforts made with regard to surveillance and efforts to develop a national level surveillance program highlight the magnitude of the task, which will require a large number of dedicated manpower and budget, and will necessitate close coordination among all agencies involved.

3.4.3. Health certification of imported stocks

The tool described here refers only to health certification given to confirm the health status of imported stocks to prevent transboundary diseases. Importation of exotic shrimps and fishes is regulated by a high-level committee under the chairmanship of the Joint Secretary (Fisheries), DAHDF, MoA. Detailed guidelines have been developed for importers, and inspection and health certification of imported stock is entrusted to the various ICAR Fisheries Research Institutes, according to the species under consideration for importation. In India, health certification has been applied to marine shrimp broodstock (Pacific white shrimp, *L.vannamei*) and seed, which are currently imported from overseas Specific Pathogen Free (SPF) facilities via aquatic quarantine.

For other species such as tilapia and rainbow trout, imported for research or pilot scale introductions, the health certificate given by the country of export is accepted, based on quarantine and pathogen tests carried out by the importing institutions within India. During trial introductions of *L.vannamei* on three occasions when proper health certification from other countries was not produced or on testing of pathogens when the results did not tally with the health certificates, those stocks were destroyed.

With the continuing efforts of CAA and the fisheries institutes in the country, health certification of imported broodstock and seed of Pacific white shrimp can be considered as success stories in preventing import of exotic pathogens while at the same time ensuring increasing shrimp production. The main lesson learned is that when the capacity to check for exotic pathogens is available and is put to use, it can be effective in arresting the spread of transboundary diseases.

3.4.4. Quarantine

As discussed above, introduction of exotic organisms for aquaculture carries a risk of introduction of exotic pathogens. To specifically avoid such transfer of pathogens, aquatic quarantine is an essential measure. Imported stock is retained and checked for the presence of listed pathogens. The stock is then returned to the importers after ascertaining it is free of all listed pathogens.

Aquatic quarantine facilities established for the purpose of the import of *L. vannamei* are operated by Rajiv Gandhi Centre for Aquaculture (RGCA) under the overall control of the Animal Quarantine Officer of the Department of Animal Quarantine and Certification Services, Ministry of Agriculture. Quarantine of *L.vannamei* is technically monitored by a committee constituted by the Ministry of Agriculture under the Chairmanship of the Coastal Aquaculture Authority (CAA) with members from Central Institute of Brackish Water Aquaculture (CIBA), Rajiv Gandhi Centre for Aquaculture (RGCA), Marine Products Export Development Authority (MPEDA), National Fisheries Development Board (NFDB), Ministry of Agriculture, and Animal Quarantine Officer. Based on guidelines developed by CAA, shrimp hatcheries must be registered; only registered shrimp hatcheries are permitted to import the exotic shrimp and to use the quarantine facility for obtaining import clearance.

The initial inputs for developing the guidelines and Standard Operating Procedure (SOP) for quarantine facilities were provided by CIBA, based on its review of experience in other countries and taking into consideration actual practice followed by hatcheries and farms in India. These were then evaluated by a technical committee before they were officially notified by the Ministry of Agriculture.

In the absence of any provisions under the Fisheries Act (1897), quarantine of *L.vannamei* is implemented under the provisions of the Livestock Importation Act (1898). The Ministry of Agriculture had developed guidelines for the operation of aquatic quarantine and notified this under the Livestock Importation Act (1898, amended in 2001). The Animal Quarantine Officer has overall charge of the aquatic quarantine operation, and modification to the SOP can be effected only with the approval of the technical committee and official endorsement of the amendment by the Ministry of Agriculture.

Successful introduction of disease-free SPF broodstock of *L. vannamei* has been achieved and since 2009 has been continuously operating, leading to a substantial increase in shrimp production over the past three years. For freshwater ornamental fishes a separate aquatic quarantine is being constructed under the oversight of the Ministry of Agriculture.

India's successful implementation of quarantine can be attributed to the development of clear implementation guidelines, the presence of a practical, functional mechanism, the strength and coordination of the institutions involved (CAA, RGCA and CIBA) and the cooperation of the industry itself. Based on the successful operation of the quarantine under the public-private partnership arrangements, the capacity of the government's existing quarantine facilities is also being expanded.

3.4.5. Environmental impact assessment (EIA)

Environmental impact assessment (EIA) must be conducted prior to start of aquaculture operations in a new area, or when there is a move to significantly increase the intensity of operation throughout an existing culture area. EIA is a prerequisite for effective environmental management and decision-making. EIA for aquaculture in the country has been applied mainly to shrimp farming.

CAA regulates shrimp farms and prevents construction of farms on agricultural land, in mangrove or other sensitive areas. EIA is mandatory for farms larger than 40 ha. State Pollution Control Boards are responsible for implementation of EIAs by the aquaculture units. CAA can issue or reject/cancel the operating license of any farms failing to comply with an EIA report. However, with more than 90 percent of Indian farmers holding farms less than 2 ha in size and no new large farms currently under development, in practice the EIA is rarely applied.

CIBA has conducted assessments of the environmental impact of shrimp aquaculture, with four major endpoints for investigation: (i) effect of shrimp farm discharge water (effluent) on the receiving water bodies (creek); (ii) impact on adjacent lands (soil salinization); (iii) impact on ground water quality and drinking water sources (salinization of freshwater resources) and (iv) impact on critical habitats such as mangroves and agricultural lands.

For the first three endpoints, impacts were evaluated by comparing changes in the water column and sediment as well as physico-chemical and biological characteristics at varying distances from the culture centre, considering the temporal variations in the cultivation site in some cases or by comparing the impacted area with a control site. To study salt intrusion from shrimp farms, soil samples were collected in triplicate from villages adjoining the farms at a distance of 0 m, 50 m, 100 m, 250 m and 500 m. Soil samples at each distance were collected at the surface, 50 cm and 100 cm depths, and analyzed for soil texture (sand, silt and clay), pH and electrical conductivity. Water samples from existing drinking water wells in the study area (shrimp farm) and from wells adjacent to the farming area were analyzed for total dissolved solids (TDS) and chloride. Information was collected on depth of the water column, use of water (stagnant or not), and the existence of any alternative arrangements for supply of drinking water in villages.

With regard to impacts on mangroves, CIBA has developed a methodology using remote sensing and ground truth using geographical information system (GIS) data to develop time series data that can clearly identify the role of aquaculture development on land use patterns. Site-specific assessments of the impact of aquaculture on mangroves have been conducted in the major shrimp growing states of Tamil Nadu, Andhra Pradesh, and Gujarat. The methodology includes use of multi-spectral satellite data (LISS III data and TM data), various image processing techniques, ground truth verification, identification of dense and sparse mangroves overlay analysis and quantification of changes in and around mangroves. Image processing techniques and GIS tools are coupled with water quality assessment to understand aquaculture impacts on mangroves.

The Coastal Aquaculture Authority Act (2005) prohibits conversion of mangrove forests to shrimp farms. The Forest Department of states where farms are located must certify that mangroves are not converted to construct shrimp farms in order to endorse the granting of the licence by CAA.

Impact assessment studies have so far indicated that aquaculture is not contributing significantly to soil and water salinization, and that shrimp farm discharge water has had no significant negative impacts on the receiving water bodies. Moreover, assessments of change detection with regard to mangroves has revealed that aquaculture has not led to adverse impact on mangroves; in fact, according to Jayanthi et al. (2007) the area under mangroves has increased in all shrimp-growing coastal states except Andhra Pradesh; areas developed for aquaculture are located away from mangrove reserve forests. While carrying out ground truth studies to verify the findings, the influence of other factors which affect the quality of mangroves became evident; in some places the felling of mangroves had created conditions of high salinity which had adversely affected the mangroves.

Monitoring is an essential integral part of the EIA procedure in any shrimp culture regulation program or coastal zone management plans. The environmental monitoring program (EMP) is a planned, systematic and repeated collection of environmental data to meet specific objectives and environmental needs. In order to improve the quality of EIAs, the National Registration Board for Personnel and Training (NRBPT), a member of the Quality Council of India, launched a scheme for registration of EIA consultant organizations. Registration under this scheme is based on the organization's resources, technical expertise, and experience.

This tool proves factual information to help address the general misconception that shrimp farming has negatively impacted the environment and mangroves; it also serves as an effective monitoring tool to ensure that aquaculture operations do not cause such adverse impacts.

3.4.6. Life cycle assessment (LCA)

Life cycle assessment (LCA), also known as life cycle analysis, is a structured, comprehensive and internationally standardized tool used to evaluate the global impact of different processes within production systems and the full value chain on the environment, and is important in evaluating the potential contributions of such processes to climate change. LCA is powerful decision support tool, complementing other methods to help make consumption and production more sustainable. By identifying hotspots along the supply chain, remedial action can be designed into the process in order to mitigate climate change impacts; this might include exploring the possibility of carbon sequestration to make aquaculture more eco-friendly. Thus, LCA can facilitate implementation of comprehensive and integrated ecosystem approaches to manage aquaculture and to adapt to, and/or mitigate climate change.

The Central Research Institutes, CIBA and the Central Institute of Freshwater Aquaculture (CIFA) currently use LCA as a research tool to evaluate impacts in brackish and freshwater commodities, respectively. Once this output is validated, legislative provisions will be required in order to mandate implementation of farm-level measures to minimise emission of greenhouse gases (GHGs) from aquaculture production systems.

Use of large quantities of inputs (e.g. manure, fertilizers, feed, therapeutics and other inputs aimed at increasing production), transportation, aeration and motor pumping have made modern aquaculture operations highly energy-intensive. In this context, the vast area of aquaculture ponds in the country is a significant source of GHG emission that may cause considerable impacts on climate; it is therefore essential to evaluate alternative systems in terms of their total emissions; this task can be accomplished using LCA. The impact of any aquaculture production system can be quantified according to impact categories such as global warming potential, eutrophication, acidification, ozone layer depletion, and ecotoxicity. The analysis displays the contribution from specific inputs (materials) and also the processes contributing to each impact category. Eco-labeling of products has proceeded at a slow rate in many countries, but where it has been adopted there has been an almost automatic requirement for LCA inputs.

The key lesson learned so far is that the software available for LCA studies is based on the European database and may not be appropriate for use in tropical conditions with mixed aquaculture farming systems. Therefore as the study progresses, there may be a need to identify modifications required in the LCA approach so that the estimates are more reliable and appropriate to the Indian context.

3.4.7. Biodiversity – genetic risk analysis

Introduction of alien species or alien stocks of native species carry potential for genetic contamination as a result of escapes from the aquaculture facility and subsequent breeding with wild populations of native interspecifics or conspecifics. Under this scenario, introgression of exotic genomes could impair the adaptive capacity of wild populations of native species. During the process of domestication for seed production or when specific selection programs are undertaken, the resulting stock acquires a different genetic makeup and life history traits in comparison to their wild conspecifics. If these stocks escape from aquaculture farms or if used for ranching they can contaminate wild populations. The risk that such escapees of the alien species/stock pose through genetic introgression into wild stocks depends upon their capacity to mature and interbreed with native species, the proportion of escapees with respect to the size of the recipient population, and the capacity of the resulting progeny to flourish in the wild.

NBFGR has worked on the population structure of 20 fish species of importance to aquaculture and conservation, and has developed baseline genetic profiles of wild populations which may be used for evaluating genetic introgression in wild populations. The studies also showed that in Indian major carps (IMC), genetic interrogation occurs due to mixed breeding practices adopted in hatcheries. During field sampling of wild populations, some cases of IMC F_1 hybrids have been detected. Although analyses of wild populations have so far not indicated large-scale introgression, this risk can not be ruled out. Until now, hardly 10 generations could have passed since IMC aquaculture became totally dependent on hatchery bred seed, but the recent programs to stock rivers and reservoirs may show negative impacts in future, particularly in the rivers under the Indo-Gangetic plains, where IMCs are indigenous. In a population genetics study of *Cirrhinus mrigala* from eleven populations, the different allele frequencies in samples from Bhagirathi (lower reaches of the Ganga River) indicated the possible influence of farm escapes (Chauhan et. al., 2007). This indicates the potential for genetic introgression due to escape of hatchery-bred seed. Other Institutes including CIFA, CIBA and Central Marine Fisheries Research Institute (CMFRI) have developed genetic markers for many of their candidate species; such markers will be valuable in future attempts to elucidate the potential for genetic introgression.

The demonstration of genetic contamination risks has raised awareness among researchers about the risks posed by alien stocks and the practice of mixed breeding. The potential risks have influenced decisions on proposals for introduction of alien stocks. However, no specific guidelines have been developed, although draft guidelines proposed for accreditation of hatcheries, at present under consideration by the Ministry of Agriculture, take into account practices that can cause genetic introgression.

The application of genetic markers to track genetic contamination in mixed-bred hatchery stocks has been validated with Indian major carps. However, its application with regard to the potential impact of ranching hatchery-reared stock has yet to be validated. The impacts may take several generations before they become apparent. However, since the theoretical risk is known to exist, adoption of the precautionary principle, i.e. of ranching with seed of wild broodstock collected from the specific river, will contribute to minimizing such risks.

3.4.8. Ecological risk analysis of invasive alien species

When an alien species is introduced for aquaculture, there is a possibility that the species could become established in the wild due to escapees. When the alien species population reaches a certain level, ecological processes may be influenced, and native species endangered. The two key factors to be considered are the capacity of the exotic organism to reproduce in the wild, and its potential to become invasive.

As part of its mandate, NBFGR studies non-native species that have been introduced into India, and species that are likely to be introduced. Following introduction of the African catfish *Clarias gariepinus* into India by farmers, field surveys revealed the presence of juveniles of *C. gariepinus* in paddy fields, indicating that this species was reproducing in the wild (Singh and Lakra, 2011). Moreover, the carnivorous feeding habit and plasticity in the diet of this species suggest it could adapt and compete with native species. NBFGR informed the Ministry of Agriculture, which issued an order for destruction of stocks held in hatcheries. The Ministry's order was contested in the High Court of Kerala but was upheld. Occurrence of the highly carnivorous piranha (*Pygocentrus nattereri*) was reported in aquaria in Kerala (Gopalakrishnan and Ponniah, 1999). Being native to tropical humid South America, the species had strong potential to breed and establish populations in natural water bodies in Kerala, and cause serious damage to native species (Gopalakrishnan and Ponniah, 1999). In view of its high potential to cause a major ecological catastrophe and based on information provided by NBFGR, the Ministry of Agriculture declared the piranha a banned species.

Information on the biology of most fish species and their potential for invasiveness is readily available via global online databases such as the following:

- FishBase (http://www.fishbase.org);
- DIAS (http://www.fao.org/fishery/dias);
- ERNAIS – European Research and Management Network on Aquatic Invasive Species (http://www.reabic.net/ERNAIS.aspx)
- REABIC – Regional Euro-Asian Biological Invasions Centre information system (http://www.reabic.net).

Such databases facilitate ecological risk assessment for individual species using available tools to quantify the invasive nature of a species (Copp et al., 2005). Where interactions with native species cannot be estimated based on available information, controlled experiments can assess the capacity of the animal to reproduce and establish in the new environment (Hart et al., 2012). This may typically be necessary for ornamental fishes because they are based on extensive selection or hybridization and biological information on the species/stocks to be imported is often not available.

Modeling the habitat suitability of alien aquatic species through spatially explicit mapping such as ensemble models is an increasingly important risk assessment tool that can provide insights into the locations and environmental conditions that may promote the future spread of invasive fish (Poulos et al., 2012). Habitat modeling also facilitates identification of key environmental variables influencing invasive species distribution.

Proposals to introduce an alien aquatic species are evaluated by a committee constituted by the Ministry of Agriculture under the Chairmanship of the Joint Secretary (Fisheries) with the research institutions (CIFA, CIBA, CMFRI and NBFGR) and organizations including MPEDA as members. The Ministry of Agriculture entrusted NBFGR with developing a national strategy (Ponniah and Sood, 2002) and guidelines (Ponniah et al., 2002) on introduction of alien species, and two documents were prepared on these topics. The guidelines outline the process to be adopted for submitting proposals to introduce alien species, compiling the data, and conducting a risk assessment to screen proposals. The research institutes are asked to give recommendation as to the potential risk that the species proposed for import could become invasive. Based on literature survey and expert advice a final decision to permit or reject the proposal for introduction is then made by the committee.

Based on these procedures, proposals for importation of ornamental fishes and for broodstocks of tilapia species were cleared for two pilot level screening trials. The proposals of research institutions for introducing alien species for research purposes also must follow the same process; clearance was given to CIFA for introduction of stocks of tilapia and to Directorate of Coldwater Fisheries Research (DCFR) for introduction of rainbow trout for research. Based on the deliberations of the committee, a list was issued of exotic ornamental species considered as no risk; listed species could be cleared for regular import without requiring additional scrutiny.

Understanding the process adopted by other countries would help India in upgrading its own system (National Invasive Species Council (NISC) of the USA – http://www.invasivespecies.gov/).

3.4.9. Carrying capacity assessment of source water bodies - Decision support software

The concept of sustainable development is closely linked to the carrying capacity of ecosystems. Most environmental assessment guidelines require analysis of the relationship between new developments and ecosystem carrying capacity (ECC). The key to sustainable development of shrimp farming is to stay within the "carrying capacity" (CC) of the environment. Codes of conduct and codes of practice refer to carrying capacity either explicitly or implicitly. The FAO Technical Consultation on Policies for Sustainable Shrimp Culture (Bangkok, December 1997) recommended that research should be undertaken to determine the CC of coastal ecosystems for shrimp culture with an emphasis on application of this knowledge to local areas. The International Principles for Responsible Shrimp Farming (IPRSF) also advise against locating new shrimp farms in areas that have already reached their CC for aquaculture (FAO, 1998). In shrimp aquaculture the CC of a water body can be used to estimate the maximum area under shrimp farming that can be accommodated without excessive water quality degradation. In relation to the water body receiving the discharge water from shrimp farming the CC can be defined in terms of the maximum nutrient loading which can be assimilated by the water body without exceeding permissible levels. This self-limiting density (i.e. the number of ponds that can be operated sustainably) must be quantified as a basic management parameter; however, its estimation requires detailed field studies and modeling (Chen et al., 2011).

CAA, as the nodal agency for regulating shrimp farming, indicates in its guidelines that the type of culture system and the level of intensification permitted should be clearly defined for each zone, based on the CC of the zone, in order to prevent excessive nutrient loading in the ecosystem (CAA, 2001). CIBA has developed decision support software to estimate the maximum allowable shrimp farming area for a particular location, based on the carrying capacity of water bodies estimated from the nutrient loading from shrimp farms and other nearby wastewater discharge sources. The software evaluates CC using mathematical models to determine the concentration of important parameters that result from a given level of waste loading, dilution rate and flushing time of the water body.

The methodology involves preparation of satellite data, mapping of land resources, ground truth verification, elimination of non-permitted areas from the land resource map, mapping of soil texture, drainage patterns and transport network, and GIS analysis using a site suitability index for brackish water aquaculture. The sites for development of brackish water aquaculture were classified into three groups: highly suitable, suitable and moderately suitable. This method has been evaluated for Nellore and Krishna Districts of Andhra Pradesh and for Nagapattinam District of Tamil Nadu.

The site suitability index classifies sites into different categories. The weighting assigned to each criterion varies according to the species requirement, technology used for site selection and culture type. Sites designated as highly suitable will require lower investment due to proximity to water source, good drainage and availability of transport facilities.

The tool will facilitate identification of unutilized waste lands for development of coastal aquaculture and improved livelihoods for coastal communities. At the same time the tool will help safeguard the environment. Aquaculture development at national level is also possible by identifying suitable sites for aquaculture development in all coastal states using multi land objective allocation criteria which aim to avoid any conflicts in the subsequent years among different stakeholders.

Area recommendations for shrimp aquaculture were made taking into account the rules of the Coastal Regulation Zone (CRZ) notification (1991), the CAA guidelines and the supportive capacity of the ecosystem. Case studies were conducted to validate the mathematical model in Andhra Pradesh and Tamil Nadu, where water was discharged wither from shrimp farms alone, or from both shrimp farms and paddy fields. CC assessment of four major source water bodies surrounding Polekuru Island in East Godavari District, Andhra Pradesh (AP) that were source and sink for waters from shrimp farms revealed that of the total 2 000 ha developed area, 1 300 ha could potentially be used for culture without impairment of water quality. For the CC assessment in three zones of Mogalthur Drain, the source for shrimp farms and sink for discharge waters from shrimp farms and paddy fields in West Godavari District, Andhra Pradesh, and the model indicated that deterioration of water quality was due to industries in Zone 3. A total area of 822 ha was recommended for culture out of 922 ha area developed. On the Vellar and Upanar Rivers located near to the Pichavaram Mangroves in Tamil Nadu, the recommended area for shrimp farming based on the CC was 275 ha and 96 ha, respectively. The studies indicated that there is no necessity for monthly sampling in the study area with shrimp farming as the only major activity; it is sufficient to sample only during the critical month. Based on these studies, the tool can be readily customized and applied to determine the CC of other water bodies.

CIBA has presented the tool to Andhra Pradesh and Gujarat State Governments and has indicated that it would offer its services to the state governments to implement the tool as well as offer consultancy services for large aquaculture projects.

The key lesson learned while validating the tool through different case studies is that CCs are highly site dependent and change with time, species and intensity of culture. The distribution of critical regions within a water body (well circulated areas or poorly circulated areas) and the resultant CC will vary with the hydrodynamic conditions. Hence, CC assessments have to be undertaken on a regular basis for all the critical water bodies.

3.4.10. Social impact assessment tools

Many participatory assessments such as Participatory Rural Appraisal (PRA), Socio-economic and Gender Analysis (SEAGA), Stakeholder interactions, economic impact assessment of aquaculture interventions, adaptations to extreme climatic events and market and value chain assessment have been undertaken to assess social impact of aquaculture operations. In-depth quantitative analysis was not possible for most of these applications, and the qualitative data generated only descriptive statistics.

CIBA has conducted numerous socio-economic studies on key issues in brackish water aquaculture since its establishment in 1987. MPEDA has also conducted some studies on land use issues. CIBA, NFDB and CAA have also conducted many stakeholder consultations to assist in drafting guidelines and recommendations for the Ministry of Agriculture in regard to policy-making for aquaculture. Fisheries research institutes and colleges have also used these tools for socio-economic assessment of aquaculture in the country. Many of the findings of such studies have been used by policy-makers as well as by planning and research agencies, and have formed the basis of a number of support schemes for aquaculture farmers, designed by MPEDA and NFDB. However, most such tools result in a qualitative assessment and there is a need for methodological refinement in order to generate quantitative data.

3.4.11. Aquaculture produce trade assessment tools

Out of approximately 8 million metric tonnes of fish produced annually in India, an estimated 90 percent is sold in domestic markets. Only high-value items from either capture or culture are exported. With imposition of WTO regulations, a range of international trade issues have surfaced. Assessment tools such as Price Spread, Nominal Protection Coefficient (NPC), Revealed Comparative Advantage (RCA) and Domestic Resource Cost (DRC) have been applied by many socio-economic researchers both in India and abroad to analyze Indian seafood exports, particularly for the shrimp trade. Value chain analyses have also been attempted.

These tools have been applied in analysis of international trade of aquaculture produce by researchers at CIBA, CMFRI, the National Centre for Agricultural Economics and Policy Research (NCAP), the Indian Agriculture Research Institute (IARI), Central Institute of Fisheries Education (CIFE), Indian Institute of Foreign Trade (IIFT), Indian Institute of Management (IIM) and Central Institute of Fisheries Technology (CIFT), as well as at fisheries and agricultural colleges across the country.

Most analyses were based on data on species and port-wise exports from published data sources such as the periodical reports of MPEDA and the Commercial Intelligence and Statistics unit of the Commerce Ministry. Indices such as DRC used other supporting figures on cost items from published survey results or surveys specifically carried out by individual researchers.

The findings of many of these studies have been used by policy-makers in India and by planning and research agencies abroad. CIBA has given assistance to NFDB in designing many support and subsidy schemes based on the research findings. The application of these tools has been possible since all export data are available in the public domain. If data on farm gate prices and markets can be collated and also be made available in the public domain, then the accuracy and effectiveness of these tools can be further enhanced.

3.4.12. Food safety standards

In India, the main focus of food safety standards is to ensure that practices followed at hatcheries and farms do not lead to contamination of produce, and that produce is in conformity with national and international standards and regulations such as FAO/WHO *Codex Alimentarius*. Food safety standards require control over the use of drugs and chemicals in aquaculture, traceability and record keeping, hygienic conditions of aquaculture facilities and operations, monitoring, and worker training.

The CAA, MPEDA and ICAR Institutions such as CIFT are involved in setting guidelines and for implementation of seafood safety regulations. From 2003-2006 ICAR conducted an evaluation of seafood safety through its implementation of a 'National Risk Assessment Program for Fish and Fish Products for Domestic and International Markets'. In 2003, the Ministry of Health and Family Welfare issued Gazette notifications on permissible limits of chemicals and enteropathogenic microbes, which serve as benchmark in assessing seafood quality in the country.

The Ministry of Commerce and Industry has also issued notifications, setting maximum residue limits for antibiotics, heavy metals and pesticides in fresh, frozen and processed fish and fishery products and issued a list of prohibited antimicrobials and chemicals in aquaculture in 2001. Moreover, MPEDA implements a national program on residue control planning, which includes monitoring and control of residues such as antibacterial substances, dyes, aflatoxins, pesticides, and heavy metals at all stages of seafood production.

3.4.13. Input quality assessment

Seed and feed are the primary inputs in aquaculture production. In addition, during the last two decades since the outbreaks of white spot syndrome in farmed black tiger shrimp (*Penaeus monodon*) in India, probiotics, antibiotics and other chemicals were introduced. Use of such inputs has gathered pace in line with growth in black tiger shrimp production (there are more than 300 registered hatcheries across India). Ideally, input quality assessment should begin with the health of broodstock, notwithstanding confidence in their status as being free from pathogenic viruses due to rigorous testing using PCR and RT-PCR based methods. PL quality assessment involves five main areas: Gross examination, microscopic examination, stress test, *Vibrio* test and PCR screening. Health quality assessment is a continuous process in hatcheries until PL are sold to shrimp farms. Assessment of the health status of PL includes screening for pathogenic viruses, examining them for physical deformity, phototactic activity and feeding behaviour indicated by fecal strings, and recording of data.

Currently, a limited number of government-approved antibiotics and chemotherapeutic agents are used for prevention and treatment of infectious aquatic diseases. In BMP-certified hatcheries, antibiotic usage is avoided. Adverse effects associated with their use include development and spread of antimicrobial-resistant human pathogens as a consequence of low-level environmental exposure to antimicrobial agents.

Fisheries research institutes and universities engaged in research in freshwater, cold water, brackish water, and marine fisheries have developed expertise in assessing aquaculture inputs such as seed. However, quality assessment of other inputs such as probiotics and chemicals has yet to be addressed, although CAA is currently developing guidelines on the quality of probiotics and their usage in Indian aquaculture.

In regard to feeds, CIBA, in consultation with stakeholders, has also developed draft guidelines for CAA on feed quality. Based on extensive consultation, draft guidelines on feed quality have been prepared by a committee chaired by NBFGR and submitted to the Ministry of Agriculture. The CAA Act has standard-setting provisions for all inputs used in brackish water aquaculture. A high-level committee chaired by the Fisheries Deputy Director General of ICAR has been constituted by the Ministry of Agriculture, charged with developing a comprehensive plan for regulation and use of 'aquaculture medicines'. The committee is considering a system that would help in evaluating claims relating to content and efficacy made by manufacturers of probiotics and aqua medicines. All eight fishery institutions and a number of Fishery Colleges have technical capacity for assessing quality of inputs used in aquaculture. The development of a framework for assessment of input quality in aquaculture has been initiated and is ongoing. Seed quality testing, now implemented routinely at farmer level, has contributed to increasing production and profit margins for farmers.

Assessment of input quality for shrimp seed is well-established in India, and is implemented directly by shrimp hatchery operators. The measure has led to substantial productivity gains and increased national production. However, quality assessment tools and guidelines for other inputs, currently under development, also need to be implemented. Quality assessment of seed was widely accepted by farmers since they could see immediate economic advantage. Similarly, successful adoption of quality assessment of feed and medicines will largely depend on acceptance by the stakeholders.

3.4.14. Application of HACCP

Hazard Analysis and Critical Control Points (HACCP) is a process that identifies potential hazards (the critical control points or CCPs) in any operation and focuses upon strict management and monitoring of these CCPs to maximize product safety. Important potential hazards associated with aquaculture are: a) microbial pathogens of public health importance; b) bacterial pathogens of aquaculture species (e.g., shrimp); and c) drugs and chemicals.

In 1995 the Ministry of Commerce issued Gazette notifications adopting HACCP principles in order to maintain the highest quality standards for fish and fishery products as required by importing countries such as USA, EU member states and Japan. The Ministry of Health and Family Welfare (Department of Health) under the Central Government, after consultation with the Central Committee for Food Standards, issued notifications under the Prevention of Food Adulteration Rules in 2003 on permissible levels of chemicals and microbes in fish and fishery products, which largely conform to EU standards. A compendium of orders issued by the Ministry of Commerce providing guidelines on limits of chemicals, antibiotics and microbes for fresh, frozen and processed fish and fishery products is available online (http://www.eicindia.gov.in/eic/notification-main.htm). CIFT has the mandate and expertise to provide training and implementation of HACCP principles in seafood processing plants. The HACCP team verifies the process of aquaculture production process and its compliance with the principles defined to achieve high standards of food safety.

CIBA (Chennai) in collaboration with CIFT has trained 45 personnel involved in shrimp hatcheries and aquaculture grow-out sectors in application of HACCP to produce shrimp free from potential bacterial pathogens and safe for human consumption. The training has created awareness among aquaculturists, especially the more progressive farmers, on the benefits of adopting HACCP principles in shrimp hatcheries and grow-out culture for producing shrimp free from pathogens and chemicals of concern to human health. However, despite the legislative and capacity-building support, HACCP application remains in its early stages in Indian aquaculture.

3.4.15. Better management practices (BMPs)

In recent years, the sustainability of aquaculture has been questioned in view of a range of environmental and social concerns. However, adoption of appropriate management strategies depending on the site's environmental characteristics, system of culture, type of management and the needs of the local population will contribute to sustainable development of shrimp farming. Globally, these management strategies are stated variously in the form of Codes of Conduct, Guidelines and Better Management Practices (BMPs) issued by various agencies. Though voluntary in nature, they can also be used as a basis for regulation or certification.

Due to wide variation in site characteristics, 'standard' BMPs may often need tailoring to specific locations. In India BMPs were formulated during 2000-2002 through a cooperative program between the MPEDA and the Network of Aquaculture Centres in Asia-Pacific (NACA) with a focus on control of shrimp diseases. This initiative also led to the formation of the National Centre for Sustainable Aquaculture (NaCSA), which focuses on the specific needs and challenges faced by small-scale farmers. NaCSA is now organizing aquaculture societies to improve information exchange and resource-sharing among group members, disseminating technologies and information on better farming practices, sustainable and judicious use of natural resources to produce safe and sustainably farmed shrimp, scampi and fish for export and domestic markets. CIBA has carried out investigations on BMPs to provide a scientifically robust basis for improve the performance of BMPs.

Farmers show a strong interest in following BMPs that address the disease problem. However, it is essential that BMPs should also address environmental and food safety issues which are important for sustaining shrimp aquaculture production in the longer run.

3.4.16. Interactive training tool for extension personnel on BMPs

BMPs are formulated by many national and international organizations to promote sustainable and productive shrimp farming. Many institutions are developing guidelines for on-farm application BMPs, and in terms of regulation, state governments can make use of existing legislative support in implementing BMPs related to environmental sustainability.

However, it is not feasible to train all aquaculture farmers directly in the application of BMPs. There is therefore a need to train government extension personnel so that they in turn can train farmers. An expert system for extension personnel on BMPs has been developed by CIBA as a communication tool for technology dissemination, extension and capacity building for knowledge management in brackish water aquaculture. Extension personnel from State Fisheries Departments and organizations such as NaCSA could make use of this expert system as an interactive training tool.

The system's effectiveness as a tool for knowledge dissemination has already been validated in terms of knowledge gain among the extension personnel (36 percent) and outgoing fisheries graduates (48 percent).

The expert system has advantages over traditional methods, since it is well accepted by field-level workers, is easy to operate, cost-effective, rapid and interactive. The tool's ten main menus give a complete picture of BMPs to be applied in shrimp farming. The tool will help fisheries extension personnel update their own knowledge and assist them in training farmers. The tool explains the entire sequence of shrimp farming, from site selection, biosecurity protocols, water and soil, feed and disease management to harvest and post-harvest management. There is scope to increase application of BMPs by farmers if extension personnel adopt this user-friendly expert system.

3.4.17. Group certification

In order to facilitate adoption of BMPs by small-scale shrimp farmers Aqua Societies were established by NaCSA, providing small farmers with a louder and unified voice in addressing production and marketing challenges. With quality as a key determinant of price, certification is a means for farmers to realize higher prices and improved market access. Presently there are many private certification programs, each with distinct and defined standards. However, almost 90 percent of India's aquaculture farmers are small-scale operators, and certification for individual farmers is prohibitively expensive as well as impractical.

MPEDA, NaCSA and NACA have therefore developed simple group certification guidelines that will help farmer groups to access the certification program of their choice. To be eligible, the 'aqua farmers' societies must have legal status through registration with relevant authorities. Registration with the Registrar, Societies (State Registration), CAA and MPEDA is a statutory requirement.

Group certification is intended for groups of affiliated farmers operated under such a legal entity. The certification is issued in the name of the aqua society, with the cost shared by all members. Compliance with the certification standards both by individual members and collectively by the Aqua Society is mandatory for group certification. Group certification is dealt with in two phases-first, the formation and functioning of aqua societies, and secondly, procedures to be followed for attaining group certification.

Pilot testing of group certification was conducted out during 2010 at three NaCSA societies and draft guidelines were revised later in October 2010, taking into account lessons learnt from the pilot testing.

This tool is important for small-scale farmers to realize premium prices for their produce in export markets. Credibility of certifying program and standards, lack of enforcement and monitoring, difficulties in implementing absolute traceability, the relatively higher cost of certification and responsibility at both individual and collective level represent the main constraints encountered in the group certification programs.

3.4.18. Organic certification

With growing health consciousness of global consumers, the demand for organically produced food is increasing. Many consumers are prepared to pay a premium for organic produce, perceived as good for health, tastier and produced in an eco-friendly manner.

MPEDA/NaCSA, Naturland Germany and Indocert have joined with farmer groups in implementing the Indian Organic Aquaculture Project (IOAP), with technical collaboration from the Swiss Import Promotion Programme (SIPPO), Zurich, Switzerland. The project, which started in 2007, covered organic production of brackish water shrimp *P. monodon* (tiger shrimp) and the fresh water giant prawn, *Macrobrachium rosenbergii* (scampi), initially in the States of Kerala, West Bengal and Andhra Pradesh. SIPPO extended technical assistance through its consultant, BLUEYOU, which conducted several training programs and demonstrations of organic tiger shrimp and scampi culture in Kerala and Andhra Pradesh. MPEDA implemented the programme in West Bengal with the support of SIPPO technicians. Under the MPEDA financial assistance programme, organic shrimp farmers received a subsidy of 50 percent on the costs of organic seed, feed and inspection/ certification fees, subject to a maximum of Rs. 50 000/- (US$50) per ha. This assistance was provided for three consecutive crops of scampi/black tiger shrimp. The project followed organic aquaculture standards stipulated by the certifying body Naturland. M/s INDOCERT was the inspection agency for the programme.

CIBA has also developed a low-input and low-cost farming technology based on organic principles. APEDA, following a series of technical consultations with MPEDA, CIBA, CIFA and CMFRI has developed national organic farming guidelines for tiger shrimp, carp and mussel and these guidelines are expected to be notified.

Though the project generated considerable interest among stakeholders, organic production was not adopted on a large-scale among shrimp farmers due to the low permitted maximum production level (800 kg/ha), and inadequate availability of certified organic inputs. The APEDA initiative partly addresses the first issue, since the organic shrimp farming technology developed by CIBA sets a higher maximum level of production.

3.5. Issues and constrains in application

- Nearly all the tools have been developed/modified by research institutes and validated for a limited geographic area with a limited number of trials. These institutes have neither the mandate nor the capacity to cover large geographic areas. However, where linkages between research institutes and regulatory or development agencies are strong, tools have been applied on a larger scale.
- There is a danger that some tools, such as LCA, may be used to portray aquaculture as environmentally damaging, if extrapolations and untested assumptions are made to arrive at the final estimate.
- Many of the APMTs require a very large dataset collected from different regions of the country. Availability of trained work force and resources suitable for this task is limited.
- Most of the tools aim by definition to protect the environment or address food safety and are not directly related to increasing production. Farmer motivation to adopt such tools is therefore low, which hampers farm-level data collection for validation and large-scale application.
- Where tools are seen by farmers to be essential for increasing production (such as evaluation of shrimp PL quality), farmers themselves have endorsed the tools and have adopted them routinely in their operations.
- Within India's regulatory and developmental framework, the state carries sole responsibility for implementing various aquaculture assessment and management tools, and this has been a difficult process. One major success has been the wide acceptance and effectiveness of risk assessment and quarantine of *L.vannamei,* which was made possible by establishing a robust institutional framework, and by the government's ability to build consensus and cooperation among all stakeholders in adopting these tools.
- Where legislation is present, further work on rules and guidelines need to be developed and appropriate institutional frameworks for applying them need to be developed.

3.6. Recommendations

3.6.1. At national level

1. Regulatory agencies need to recognize the importance and potential of these tools and build mechanisms for their large-scale application.
2. Tools such as EIA and Carrying Capacity Evaluation should be made mandatory prior to development of new areas, and if small-scale farmers are involved, the designated state agency should undertake this work.
3. When development agencies fund large projects, they can stipulate mandatory use of tools related to environmental sustainability.
4. The application of some tools such as surveillance area estimation and disease loss assessment are hampered by lack of resources and trained manpower. The government should identify institutions to carry out the work and allocate the necessary resources.
5. Existing legislation should be explored to establish whether by appropriate framing regulations, rules or guidelines, application of APMTs can be mandated under such existing provisions.
6. Research institutes that have developed APMTs need to increase awareness among policy-makers and other stakeholders on the potential benefits of their application.
7. Successful cases of application of the tools such as import risk assessment and quarantine of *L. vannamei* need to be highlighted so that different institutional players see the benefits of such tools and the need for better coordination.

3.6.2. At regional level

1. Successes and failures in large-scale application of each tool should be critically evaluated to understand the underlying factors; such an analysis will help countries learn from each other.
2. Legal and institutional mechanisms are essential elements for successful application of APMTs and many tools can employ the same legal/institutional mechanisms. However, developing workable legal and institutional frameworks is one of the most challenging tasks. Specific attention could therefore be given at regional level to help the countries in this regard.
3. In applying many of the APMTs, there are gaps in the data; the feasibility of using other tools such as Bayesian modeling or simulations should be examined and capacity in these approaches could be developed.
4. Greater use of databases including FishBase and DIAS should be encouraged and incorporated into relevant aquaculture tools.
5. The fragmented information available on aquaculture tools needs to be complied as a manual, and capacity building programs implemented at regional level.

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4. COUNTRY REPORT: INDONESIA

Application of aquaculture assessment tools in Indonesia: A Country Review

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4.1. Introduction

Indonesia comprises more than 17 500 islands with a total population in 2010 of almost 239.9 million (World Bank, 2012), making Indonesia the world's fourth most populous country. As an archipelagic country, capture fisheries and aquaculture are the main source of income for coastal communities. Indonesia's aquaculture production has shown strong growth in recent years, from 3.8 million tonnes in 2008 to 4.7 million tonnes to 6.3 million tonnes in 2009 and 2010, respectively (Table 5). In 2011 total production increased further to approximately 7.9 million tonnes.

Table 5 Aquaculture production 2008-2010 (tonnes)

No.	Main Commodities	2008	2009	2010
1	*P. monodon*	134 930	124 561	125 519
2	*L. vannamei*	208 648	170 969	206 578
3	Seaweed	2 145 060	2 963 556	3 906 420
4	Tilapia	291 037	323 389	464 191
5	Pangasius	102 021	109 685	147 888
6	Catfish	114 371	144 755	242 811
7	Carp	242 322	249 279	282 695
8	Gouramy	36 636	46 254	56 889
9	Seabass	4 371	6 400	5 738
10	Grouper	5 005	8 791	10 398
11	Milkfish	277 471	328 288	421 757
12	Others	293 328	232 638	407 040
	Total	**3 855 200**	**4 708 565**	**6 277 924**

Source: Indonesia Aquaculture Statistics, 2011

The Ministry of Marine Affairs and Fisheries strategic plan for 2010-2014 has set a fish production target of 22.39 milion tonnes in 2014- more than double the 10.06 millions tonnes achieved in 2009. In that year, 55 percent of the total catch (5.2 million tonnes) came from capture fisheres, whilst 45 percent (4.7 million tonnes) was produced by aquaculture. It is projected that by 2014, capture fish production remain at approximately 5.5 million tonnes whilst aquaculture's share in the total catch will show strong growth to more than 16.8 million tonnes by 2014. The aquaculture sector is thus set to play an increasingly important role in Indonesia's economy, and by 2014 is expected to employ around 13.8 million people, either directly or indirectly. Per capita protein intake from fish will also increase from 30 kg/year (2009) to around 38.67 kg/year by 2014.

The main aquaculture species are shrimp (*Penaeus monodon* and *Litopenaeus vannamei*), seaweed, seabass (*Lates calcarifer*), grouper (*Chromileptes* spp.), milkfish (*Chanos chanos*), tilapia (*Tilapia niloticus*), Pangasius

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(*Pangasianodon hypophthalmus*), African catfish (*Clarias geriepenus*), common carp (*Cyprinus carpio*), and giant gourami (*Osphronemus gourame*). Seaweed tops the list, followed by milkfish and shrimp.

The major aquaculture systems used in Indonesia are pond culture (brackish water and freshwater culture), cage culture (marine and fresh water aquaculture) and pen culture (flood plain areas). The brackish water pond culture system is widely used for cultivating shrimp (traditional, semi intensive and intensive systems), milkfish (traditional and polyculture systems) and seaweed. In freshwater, pond culture systems are used for intensive culture (e.g. running water systems for common carp and tilapia, and traditional and semi-intensive culture for common carp, tilapia, java barb, pangasius, African catfish and freshwater prawn). Meanwhile, the cage culture system in freshwater is preferred for tilapia, common carp, pangasius, giant gourami, leptobarbus in reservoirs and lake, and in marine aquaculture for rearing grouper, seabass and pompano.

Fish broodstock and seed for growout culture are produced by private hatcheries operating at small, medium and large-scales) as well as government hatcheries at central, provincial and district levels. Quality of seed produced by these hatchery units is guaranteed under the standard of Indonesian Good Hatchery Practices (IGHP), also known as CPIB (*Cara Pembenihan Yang baik*).

Indonesian aquaculture products are mostly destined for the domestic market, whilst the majority of shrimp output is exported to USA, Japan, and the European Union. Seaweed is exported to China, Republic of Korea, Viet Nam, Philippines, and Hong Kong SAR, tilapia to USA and the EU, and grouper to Hong Kong SAR, Singapore, China and Malaysia.

4.2. Summary of APMTs application in Indonesia

Table 6 below provides a summary of responses for the four criteria evaluated, for each tool.

4.3. Planning tools

4.3.1. Import risk analysis (IRA)

Import risk analysis (IRA) is a process to analysis the risks presented by importation of aquatic animals or aquatic products which could potentially introduce and spread pathogenic agents into the country. IRA plays an important role in Indonesia's biosecurity protection of aquatic natural resources, human health, and the aquaculture sector. Based on the Aquatic Animal Health Code the IRA comprises 4 components: hazard identification, risk assessment, risk management, and risk communication (Rodgers, 2001). Hazard identification is a process for identifying the suspect pathogenic agent, while risk assessment assesses the likelihood of introduction and spread of the pathogenic agent, the risk to aquatic natural resources and human health as well as the sustainability of the aquaculture sector. Risk assessment comprises 3 components: release assessment, exposure assessment, consequence assessment, and risk estimation. Risk management is carried out to reduce risk to an acceptable level, designated as the "Appropriate Level of Protection" (ALOP). There are 4 components of risk management: risk evaluation, option evaluation, implementation, and monitoring and review. Risk communication is the interactive exchange of information on risk among risk assessors, risk managers, decision makers, and other stakeholders both in the source of origin and destination country.

IRA has been mandated in Indonesia since July 2011, with the issuance of Regulation No: PER.16/MEN/2011 of the Minister of Marine Affairs and Fisheries, which was also referred to as the Aquatic Animal Health Code.

The scope of the Aquatic Animal Health Code includes hazard identification and characterization, risk assessment, risk management and risk communication for importing fish and aquatic products. This regulation has been socialized since 2011 to both central and local governments (provincial and district levels) and aquaculture businesses for production of ornamental and food fish. Due its recent introduction, only limited

Table 6 Summary of APMTs Application in Indonesia

Tool	Level of awareness[1]	Level of capacity[1]	Extent of use[2]	Supporting legal instruments[3]	Remarks
Planning Tools					
Aquaculture development-spatial planning/zoning (e.g. based on carrying capacity)	a	a	a	Yes	National regulation
Environmental impact assessment (EIA) of aquaculture operations	a	a	a	No	–
Ecological risk analysis	a	a	a	No	–
Social impact assessment	a	a	a	No	–
Import risk analysis (IRA) for introducing new species for aquaculture	a	b	c	Yes	Ministry Decree No. 16/MEN/2011
Others: LCA, GHG, carbon footprint studies	a	a	b	No	–
Management Tools					
Risk analyisis	a	b	c	Yes	CODEX, EU regulation
Health cerification	d	b	c	Yes	OIE, National regulation
Quarantine	d	b	d	Yes	OIE, National regulation
Disease survelilance and early warning systrem	d	a	b	Yes	OIE, National regulation
Residue inspection and monitoring	d	d	e	Yes	International/national regulation
Record keeping and traceability	d	d	e	Yes	National regulation
Input quality assessment and monitoring	d	d	e	Yes	Indonesian national standard
Production process (e.g. public and private certification)	d	d	e	Yes	Private certification: ACC, BRC, Organic product, ASC.
Farm management tools (e.g. BMP/GAP)	d	d	e	Yes	Indonesian national standard, certification

Notes:

[1] Levels: **a –** policy makers and scientists at the national level; ***b* –** policy makers, scientists, at the provincial level; ***c* –** all stakeholders at local level except farmers; ***d* –** all

[2] Extent of use: ***a* –** never used; ***b* –** used in some projects; ***c* –** used only at national level; ***d* –** used at provincial level; ***e* –** used at local level

[3] Supporting legal insturments: Yes; no; under development

information is available on implementation. Institutions responsible for implementation include the Directorate General of Aquaculture, Fish Quarantine and Inspection Agency (FQIA), Ministry of Marine Affairs and Fisheries, local government at provincial and district levels, and a group of experts from universities and research agencies.

The legal basis supporting this tool includes the following:

- Law No. 16 (1992) concerning Animal, Fish, and Plant Quarantine;
- Law No. 31 (2004) concerning Fisheries, as amended by Law No. 45 (2009);
- Government Regulation No. 15 (2002) concerning Fish Quarantine; and
- Government Regulation No. 54 (2002) concerning Fisheries Business.

The government anticipates that implementing this tool will help protect Indonesia's aquatic biodiversity, human health and ensure sustainability of the aquaculture sector.

4.3.2. Aquaculture development – spatial planning/zoning

Accurate estimation of carrying capacity is the most important factor in improving quality of management decision-making of resource allocation on fish farming. The Indonesian Government has prioritized this theme in the wake of past problems arising from over-exploitation. The Fisheries Act No. 45 (June 2009) and Chapter 18 of Act No. 31 (2004) give the Government powers to regulate utilization of water and land for aquaculture activities in order to ensure quantitative and qualitative availability of water for aquaculture purposes. Implementation of spatial planning/zoning under local government authority control is covered by Article 3 of Chapter 18.

Subsequently in 2010, the Ministry of Marine Affairs and Fisheries issued Law No. 30/MEN/2010 concerning the 'Management Plan and Zoning of Aquatic Conservation Area', requiring management plans and zoning to be based on carrying capacity in order to maintain the sustainability of natural resources and aquaculture practices.

In 2011, Decree No.: 127/DJ-PB/2011 for spatial planning/zoning was also issued by the Director General of Aquaculture. Its purpose was to provide additional guidance for implementation of spatial planning/zoning to ensure efficient and effective utilization of water and land for aquaculture. The scope of the guideline covers planning, utilization, control of natural water resources and land, and monitoring of their utilization.

Notwithstanding the legal mandate, in practice implementation of this regulation is limited by lack of awareness among local government policy-makers and relevant stakeholders. Research on carrying capacity for marine farming in the Awarange Bay zone, South Sulawesi was reported by Rahmansyah (2005). The survey evaluated the biophysical quality of Awarange Bay to determine zones suitable for development of milkfish marine farming. Carrying capacity was predicted based on available dissolved oxygen, oxygen consumption rate of milkfish, and the waste load of total phosphorus entering the bay both from fish cages and other activities surrounding the bay. Estimation of carrying capacity was made using the estimated balance of dissolved oxygen for Awarange Bay, the maximum allowable annual fish production per unit area, the capacity of the local environment to absorb the nutrient load, and the minimum sitting depth of milkfish cages. Awarange Bay has approximately 28 ha suitable for marine fish farming, with a carrying capacity of 36 tonnes fish biomass per hectare. Maximum annual fish production ranges from 1.3 to1.6 t/ha, while capacity of the environment to absorb nutrient loads (both total nitrogen and total phosphorus) is about 6.762 tonnes TN and 3.077 tonne TP, respectively. The sitting depth of milkfish cages are more than 8 m to minimize benthic impacts that have actually been used for regulating marine farming sites. Assuming an individual cage size of 8 m^3 with a productivity of 0.25 t/cage, the total maximum number of cages allowed to operate in Awarange Bay is less than 144 units.

A study on carrying capacity in Cirata and Jatiluhur Reservoirs for cage culture, reported by MMAF (2007), showed that the carrying capacity of the Cirata reservoir was 69 720.3 tonnes/year and 104 009 tonnes/year for Jatiluhur reservoir. Nevertheless, actual production exceeded these levels, threatening the sustainability of the local natural environment. Planning zones based on carrying capacity is thus critical in order to maintain sustainability of natural resources and aquaculture practices.

4.3.3. Environmental impact assessment (EIA) of aquaculture operations

Environmental impact assessment (EIA) is defined as 'the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decision being taken and commitment made' (FAO, 2009). EIA serves two main purposes: to inform a consenting or licensing decision; and to identify mitigation measures which will minimize any possible environmental impacts. In Indonesia, EIA is most commonly applied to intensive culture of finfish such as salmon, and to support proposals for large-scale shrimp farm development.

In 1999 the Indonesian Government issued Regulation No. 27/1999 concerning EIA. Its scope included a requirement to evaluate the expected environmental impact of aquaculture operations, develop an environmental management plan, and include appropriate mitigation measures and monitoring. However, awareness of IEA for aquaculture is mainly limited to policy-makers and researchers, and there is a lack of information and research on EIA conducted at research centres and universities.

Although EIA in aquaculture is not widely implemented in Indonesia, this does not mean that environment impacts are neglected. Indonesia has applied the principle of sustainable aquaculture development for many years, acknowledging environmental concerns such as cumulative impacts on water and sediment quality, introduction of alien species, excessive use of chemical and antibiotics, production intensity and technology use. Research on assessing waste load from a 84 m^2 milkfish marine cage farming into the surrounding environment was reported by Rachmansyah et al. (2003), resulting in a mass balance model which is used to estimate the rate of waste load for cultivated milkfish. The assessment was based on data on feed, fecal and carcass proximate analysis as well as feed conversion ratio, nutrient retention, digestibility, fish biomass and total mass of particulate organic matter. The farm discharged 43.6 kg nitrogen, 31.0 kg phosphorus and 148.4 kg carbon per tonne of milkfish produced. The model thus assists in developing cost-effective feed management regimes whilst minimizing nutrient loads from milkfish farms.

Monitoring and evaluation of the environmental impacts of aquaculture operations is undertaken by government officials as well as inspectors on behalf of private certification programs, on both large and small-scale farms. In order to implement EIA in aquaculture, the government and policy-makers should promote the concept to relevant institutions and stakeholders and enact appropriate legislation covering implementing agencies, standard procedures, and technical guidelines. This will provide a firm platform for effective implementation of EIA in aquaculture.

4.3.4. Ecosystem approach to aquaculture

The Ecosystem approach to aquaculture (EAA) is a strategic approach to integration of the activity within the wider ecosystem in such a way that it promotes sustainable development, equity, and resilience of social and ecological linkages. This definition essentially follows the ecosystem-based management approach proposed by the Convention on Biodiversity (CBD) and also follows the recommendation of the FAO Code of Conduct for Responsible Fisheries (NRCP) (FAO, 2009a).

EAA is based upon three key principles: a) Aquaculture should be developed in the context of ecosystem functions and services with no degradation of these beyond their resilience capacity; b) Aquaculture should improve human well-being and equity for all relevant stakeholders; c) Aquaculture should be developed in the context of (and integrated with) other relevant sectors. Three scales/levels of EAA application have been identified: a) Farm; b) Water body and its watershed/aquaculture zone; c) Global, market-trade scale (FAO, 2009a).

The EAA concept is well appreciated by policy-makers and fisheries researchers in Indonesia, and is implemented mainly by the Ministry of Marine Affairs and Fisheries, working in collaboration with local government and other stakeholders. Based on the three key principles and three levels of EAA, the Indonesian government piloted an Integrated Aqua-business Centre Zone (IACZ) or "Minapolitan" concept, with the aim of facilitating sustainable aquaculture, incorporating provisions for production, local economic growth, food security and food safety, access to markets and minimization of environmental impact, in compliance with Government Regulation No. 23, 1997 concerning environmental management.

The IACZ concept was developed to take into account the aquaculture supply and value chain, including backward and forward linkages, and is implemented in more than 100 districts around Indonesia within the 2010-2014 Plan.

4.3.5. Social impact assessment

To date, no regulations concerning social impact assessment have been promulgated in Indonesia. Although awareness and concern over social impact is increasing both within government and with the general public, Indonesia has yet to implement any initiatives to assess the social impacts of aquaculture.

4.3.6. Others (LCA, GHG emissions, carbon footprint studies)

Indonesia is highly vulnerable to climate change, and the impact of climate change is a growing concern. The Indonesian Government has issued numerous policy documents and initiated planning as well as capacity building measures to support climate change adaptation and mitigation strategies. These measures include the following:

- Action Plan for Mitigation and Adaptation on Climate Change (Ministry of Environment Affairs, 2007);
- Indonesian Climate Change Sectoral Roadmap (Ministry of National Planning Affairs, 2010);
- Second National Communication and Country Report (Ministry of Environment Affairs, 2010);
- National Action Plan for Climate Change Adaptation (National Assembly of Climate Change, 2011); and
- Indonesian Adaptation Strategy: Improving Capacity Building to Adapt to Climate Change (Ministry of National Planning Affairs, 2011).

However, despite the fact that the aquaculture environment is exceptionally susceptible to ecological impacts triggered by climate change (e.g. in terms of disease epidemics), relatively little research has been initiated in Indonesia to evaluate potential qualitative and quantitative impacts. A number of analyses of weather anomalies and their influence on fish spawning and fish diseases have been conducted. For example, the work of Prihad et al. (2010) provides a useful example of LCA in the Indonesian context, reporting on 'Potential Environment Impact Assessment on Cage Culture System by Life Cycle Assessment in Cirata Reservoir'). The findings demonstrated and quantified the significant environmental impact of the cage culture system on the water body, depending on feed, cage materials used and species cultured. Nevertheless, overall, LCA in aquaculture is limited in application and there remains a low level of awareness at policy level and among other stakeholders.

It will therefore be important for Indonesia to strengthen research in this area, since implementation of LCA, assessment of greenhouse gas emissions and carbon footprint studies offer useful new avenues and tools to protect the country's aquaculture resource.

4.4. Management tools

4.4.1. Risk analysis

So far risk analysis is conducted to evaluate the significance of laboratory testing results such as the residue monitoring program. The analysis is mainly based on EU regulation and CODEX guidance. The purpose of the analysis is to determine the level of compliance with residue and contaminant limits for aquaculture products as listed in the National Residue Control Plan (NRCP).

4.4.2. Health certification

Health certificates have been used to control movement of live fish and fisheries products to be exported or imported. Health certificates for fish and fisheries products (for human consumption) are based on inspections related to food safety (antibiotics, proscribed chemicals, heavy metal residues and microbial) within the processing plant, also following import market requirements. Certificates are issued by the Fish Quarantine and Inspection Agency (FQIA), Ministry of Marine Affairs and Fisheries to exporters of fish and fisheries products when the products are in compliance with international standards and market requirements. The scheme guarantees that certified fish and fisheries products fulfill the requirements for Food Safety and Quality Assurance for human consumption. The main institutions responsible for health certification are the FQIA and Fisheries Services Offices at provincial level.

The legal basis for this tool includes the following as relevant to fisheries and aquaculture products:

- Law No. 31, 2004 concerning fisheries, as amended by Law No. 45 (2009);
- Minister of Marine Affairs and Fisheries Regulation No. PER.01/MEN/2007, amended by Ministry of Marine Affairs and Fisheries Regulation No. PER.019/MEN/2010 concerning Control of Food Safety and Quality Assurance;
- Head of Quarantine Agency FQIA Regulation No. PER.03/BKIPM/2011 concerning Technical Guidelines on Implementation of Food Safety and Quality Assurance.

HACCP has been implemented and fish and fisheries products are fully traceable following the *Codex Alimentarius* international standard. The health certification process for fish and fish products (for the protection of fishery resources from dangerous pests and diseases of fish) is based on the following legislation:

- Law No. 16 (1992) concerning Animal, Fish, and Plant Quarantine;
- Government Regulation No. 15 (2002) concerning Fish Quarantine;
- Regulation of Minister of Marine Affairs and Fisheries No. PER.05/MEN/2005 concerning Fish Quarantine Actions for the Exportation of Carriers of QPDF;
- Regulation of the Minister of Marine Affairs and Fisheries No. PER.20/MEN/2007 concerning Fish Quarantine Actions for the Entry of Carriers of QPDF from Overseas and from One Area to Another within the Territory of the Republic of Indonesia, and refers to the international standard of the OIE (Aquatic Animal Health Code).

Health certificates for fish and fish products are issued following inspection of carriers of QPDF and/or certain pests and diseases of fish (PDF) as well as laboratory analysis and on-farm monitoring to meet market requirements of importing countries. This is considered highly important to Indonesia because it may help avoid rejection of fish and fisheries products exported to other countries. The tool thus increases confidence among importing countries.

4.4.3. Quarantine and inspection service

The scope and purpose of fish quarantine and inspection services is to prevent entry and spread of QPDF into, within and out of the territory of the Republic of Indonesia, control of quality and safety of fishery products, and to fulfill the requirements of the quality management system. The requirement applies to any individual or private company intending to export any fish or fisheries product or transport within the country. The Indonesian Government now has 47 Fish Quarantine and Inspection (FQI) Technical Implementing Units, with facilities located at air and seaports serving as exit/entry points for exports and imports in 33 provinces, organized as follows: Main Regional Office of FQI (2), Regional Office of FQI Class I (7), Regional Office of FQI Class II (5), Station of FQI Class I (18), Station of FQI Class II (14), and Regional Office of FQI Standard Examination (1) located in East Jakarta.

The health certificate forms part of documentation requirements required before import or export can take place. Quarantine-listed diseases refer to OIE-listed diseases for fish and new fish diseases with potential to cause outbreaks and economic loss. Fish quarantine actions, and control of quality and safety of fish and fishery products are conducted by quarantine inspectors and quality control inspectors, based on the quarantine law and regulations.

The operations of the Fish Quarantine and Inspection Authority are supported by government legislation as follows:

- Law No. 16 (1992) concerning Animal, Fish and Plant Quarantine;
- Law No. 31 (2004) concerning Fisheries amended by Law No. 45 (2009);
- Government Regulation No. 15 (2002) concerning Fish Quarantine;
- Decree of Minister of Marine Affairs and Fisheries, No. KEP.41/MEN/2003, concerning Establishment and Revocation of Fish Quarantine Area;
- Regulation of Minister of Marine Affair and Fisheries No. PER.11/MEN/2011 concerning Fish Quarantine Installation;
- Regulation of Minister of Marine Affairs and Fisheries No. PER.20/MEN/2007 concerning Fish Quarantine Actions for the Entry of Carrier of QPDF from Overseas and from One Area to Another within the Territory of the Republic of Indonesia;
- Regulation of Minister of Marine Affairs and Fisheries No. PER.29/MEN/2008, concerning Requirements for Importation of Live Fish;
- Regulation of Minister of Marine Affairs and Fisheries Number: PER.25/MEN/2011 concerning Organization and Working System of Fish Quarantine and Inspection (FQI) Technical Implementing Units;
- Regulation of Minister of Marine Affairs and Fisheries No. PER.05/MEN/2005 concerning Fish Quarantine Actions for the Exportation of Carrier of QPDF;
- Decree of the Minister Marine and Fisheries Affairs No. KEP.53/MEN/2010 concerning Designation of Entry and Exit Places of Carrier of QPDF;
- Decree of Minister of Marine Affairs and Fisheries No. KEP.03/MEN/2010, concerning Kinds of QPDF, Their Categories and Carriers;
- Minister of Marine Affairs and Fisheries Regulation No. PER.01/MEN/2007 as amended by Minister of Marine Affairs and
- Minister of Marine Affairs and Fisheries Regulation No. PER.19/MEN/2010 concerning Control of Food Safety and Quality Assurance;
- Minister of Marine Affairs and Fisheries Regulation No. PER.15/MEN/2011 concerning Control of Quality and Safety of Fishery Products for the Importation into the Territory of the Republic of Indonesia; and

- Minister of Marine Affairs and Fisheries Regulation No. PER.10/MEN/2012 concerning Fish Quarantine Additional Obligations.

The fish quarantine and inspection system aims to provide a guarantee that fish and fish product exports and imports are free from QPDF, and/or meet the requirements of safety and quality assurance, as stipulated by buyers from importing countries.

4.4.4. Disease surveillance and early warning system

Surveillance is the systematic ongoing collection, collation and analysis of information related to animal health and timely dissemination of information to those who need to know so that action can be taken (Corsin et al., 2009). Two approaches are adopted in Indonesia, namely passive surveillance whereby the laboratory receives samples from fish farmers or private companies, and active surveillance in which laboratory officers collect samples from aquaculture ponds.

The system for surveillance and monitoring of fish diseases aims to cover 33 provinces, with the government providing a facility for online reporting of the results of regular surveillance and monitoring by provincial fisheries services to the Directorate General of Aquaculture and Provincial Fisheries Service Offices. Monitoring officers have been appointed at Central Government and local government agencies responsible for monthly fish disease monitoring of freshwater, brackish water and marine aquaculture. The results are reported via the Fisheries Services at district and provincial levels, through to the Directorate General of Aquaculture at Central Government level. The final collated data are used by policy makers for improving fish disease management.

In addition, surveillance and monitoring data are sent to OIE as part of a Quarterly Report to the Network of Aquaculture Centres in Asia-Pacific (NACA). Institutions involved in surveillance and monitoring are the Directorate General of Aquaculture and Provincial and District Fisheries Service offices and Fish Quarantine and Inspection Agency (FQIA).

The legislative basis for Indonesia's disease surveillance operations and early warning system is provided by the following instruments:

- Law No. 16 (1992) concerning Animal, Fish, and Plant Quarantine;
- Law No. 31 (2004) concerning Fisheries amended by Law No. 45 (2009);
- Government Regulation No. 15 (2002) concerning Fish Quarantine;
- Regulation of Minister of Marine Affairs and Fisheries No. PER.13/MEN/2007 concerning Surveillance and Monitoring System of QPDF; and
- Decree of Director General of FQIA No. KEP.460/BKIPM/XII/2011 concerning Technical Guideline of Integrated Fish Quarantine Actions Based On In Line Inspection in Fish Production Units and Raisers.

An effective disease surveillance and early warning system is a key tool to mitigate the potential for fish disease outbreaks and ensuing production and economic loss in the aquaculture sector. This tool helps reduce the potential for fish disease outbreaks in the region and economic losses for the aquaculture sector as a whole. However, additional capacity-building measures are needed, especially at provincial level, in terms of more provincial fisheries staff in order to enhance standards and efficiency in implementing the surveillance and early warning system.

4.4.5. Residue inspection and monitoring

In today's free trade era, Indonesian aquaculture products face various competitive challenges, both in terms of product quality and production efficiency. The most important challenge for fishery products, as for all food products, is food safety. Increasing public awareness towards food health and safety requires all aquaculture stakeholders to focus on quality for domestic as well as export produce. Quality improvement of fish products is aimed primarily to provide a guarantee of food safety, from raw feed materials to finished products that are assured to be contamination-free in accordance with market requirements. A System of Quality Assurance and Safety of Fishery Products (SQASFP) has been established as a preventive effort conducted from pre-production to distribution level in order to generate high quality fishery products that are safe for human health. SQASFP activities implemented by the Directorate General of Aquaculture include: (1) GAP Certification; (2) Hatchery Certification; (3) Fish Feed Registration; (4) Fish Drug Registration; and (5) Residue Monitoring. SQASFP is overseen by the Ministry of Marine Affairs and Fisheries as Competent Authority.

Residue monitoring focuses on residue levels in finfish such as tilapia and milkfish and shrimp such as tiger shrimp and whiteleg shrimp. Implementation follows the National Residue Control Plan (NRCP) as prepared every year by the Directorate General of Aquaculture as the Competent Authority. Fish samples are taken from ponds in target area by the monitoring team, and the sample analyzed at residue testing laboratories. A broad range of substances are monitored, divided into two groups. Group A includes stilbene, salt and ester steroids, chlorampenicol (CAP), nitrofuran (AOZ, AMOZ, SEM, AHD) and nitromidazol. Group B includes antimicrobial substances such as anthelmintics, organochlorine compounds including PCBs, heavy metals, mycotoxin and dyes, in line with EU legislation CD 96/23. Indonesia has 10 accredited laboratories for residue testing and residue confirmation, located in Jakarta, West Java, Central Java, East Java and Lampung provinces, with 17 target areas designated for sampling: Aceh, North Sumatera, South Sumatera, Lampung, Banten, West Java, Central Java, East Java, West Kalimantan, South Kalimantan, East Kalimantan, West Sulawesi, Central Sulawesi, South Sulawesi, Southeast Sulawesi, Bali and West Nusa Tenggara.

The following regulations have been established as a foundation for the Quality Assurance and Fish Products Safety System:

- Law No. 31 (2004) concerning fisheries, amended by Law No. 45 (2009);
- Government Regulation No. 28 (2004) concerning Nutritious Food and Quality Safety;
- Regulation Decree of Minister of Marine Affairs and Fisheries No. PER.01/MEN/2007 regarding the Control of Quality Assurance System and Safety of Fishery Products;
- Decree of Minister of Marine Affairs and Fisheries No. PER.02/MEN/2010 regarding Fish Feed Supply and Distribution;
- Ministerial Regulation No. PER.02/MEN/2007 concerning Fish Drug Residues, Chemicals, Biological Substances and Contaminants in Aquaculture;
- Ministerial Regulation No. 019/MEN/2010 concerning the Control of Food Safety and Quality Assurance System; and
- European Legislation of CD 96/23 EU.

The tool has thus far been effectively applied in Indonesia; for the past three years (since 2009) there have been no RASFF (Rapid Alert System for Food and Feed) alerts for antibiotics in aquaculture products exported to European member countries. Given that this tool is a key pillar of the country’s strategy to ensure safety of domestic and exported aquaculture products, the capacity of accredited laboratories to run a valid residue testing program is crucial to generating reliable and timely results. Currently, the significant budget resources required to operate the scheme constrain its overall effectiveness, and budget allocations should be increased to reflect the requirements and strategic importance of the residue testing system. Capacity building is also needed to ensure sufficient technical personnel for monitoring and evaluation.

4.4.6. Record keeping and traceability

Farm record keeping is a requirement for qualification for Indonesian Good Aquaculture Practices (IGAP). IGAP-certified fish farms must maintain full records of all farm operations, noting field activities classified by farm/tank/container and by production process. Recording is adjusted to the needs of each farm, but must may record the following components as a minimum:

- Seed (quantity, hatchery, output test, spreading date);
- Feed (quantity/hour/day, type, producer, batch);
- Water quality (DO, pH, salinity, nitrates, plankton, etc.);
- Use of chemical and biological materials;
- Records of fish disease incidence;
- Harvesting records (date, quantity, buyer).

Documents and record keeping applied by grow-out operations are certified by the competent authority of IGAP. Documentation and record keeping is also required as part of Indonesian Good Hatchery Practices (IGHP) in order to assure consistency of seed quality, as objective proof of production process implementation and in facilitating traceability and information access related to production processes. The required IGHP documentation is compiled as a Standard Operational Procedure (SOP). Forms and records applicable to the hatchery unit cover the following:

- Broodstock management;
- Seed management;
- Water management;
- Live food management;
- Feeding management;
- Management of use of fish drugs;
- Management of use of chemical materials;
- Water quality examination (heavy metal and other water quality parameters);
- Broodstock and seed health examination;
- Biosecurity management;
- Seedling environment sanitation;
- Management of seed harvest;
- Management of seed packaging and distribution.

Record keeping and traceability are interconnected as a component within the Guideline for IGHP and IGAP as stated in Ministerial Decree No. KP. KEP.02/MEN/2007 on Good Aquaculture Practice. The tool is supported by central and local government agencies (at provincial and district levels) and is verified by auditor teams monitoring hatcheries, nurseries and grow-out farm operations. It is considered an essential basis for tracing the source of any problems arising from non-compliance with declared safety and quality standards detected downstream in the supply chain.

4.4.7. Input quality assessment and monitoring

Input quality assessment and monitoring are designed to ensure compliance with mandatory national and international standards and market requirements and are prioritized by the government.

The National Standards Body (NSB) was established as the national institution responsible for drafting the Indonesian National Standards (INS) procedure for products and production processes. The Ministry of Marine Affairs and Fisheries has also established a Technical Committee (TC) which oversees 3 Sub Technical Committees (STC) responsible for capture fisheries, processing and marketing, and the aquaculture subsector, respectively. The STC for the aquaculture sector is responsible for drafting the INS for fish seed development, aquaculture infrastructure, fish health and environment, and for grow-out systems. The BSD's standard code, manual and guidelines comply with international standards such as ISO and *Codex Alimentarius* as well as relevant national regulations. So far, a total of 147 INS aquaculture sector control points have been authorized for broodstock and fish seed (79), grow-out culture (34), fish feed (12) and fish diseases test methods (22).

Compliance with these INS items is currently voluntary; nevertheless, in practice farms and laboratories must reach compliance in order to achieve high qualification grade certification under the IGAP and IGHP programs, as well as laboratory operation based on ISO 17025 accreditation. Accordingly, many farms apply the INS items as a means of ensuring production to high quality, safety and environmental standards. Inspection and audits are conducted on a regular basis to monitor compliance.

4.4.8. Production process

Competent process production management is critical to produce high quality produce that meets market requirements. Production process standards have been established by private sector organizations such as the British Retail Company (BRC), Aquaculture Stewardship Council (ASC), and Aquaculture Certificate Council (ACC). The purpose of such certification is to produce products with specific attributes related to consumer demand in destination markets, such as products that are free of residues from antibiotics or chemical substances, or are environmentally friendly, or meet criteria related to social or environmental responsibility. These certification programs are developed and implemented by the private sector, and are especially relevant to shrimp farming systems. For example, in Indonesia organic black tiger shrimp certification has been available since 2000, as reported by Wongso (2005), in Sidoarjo, West Java. In this system, a traditional integrated mangrove-aquaculture polyculture system produced milkfish and black tiger shrimp without artificial aeration, artificial feeding or medication. Shrimp was harvested within 105-120 days after stocking, while milkfish were harvested in 7-12 months. More than 256 farms covering more than 2 500 ha are registered as members of organic certification groups, exporting organic shrimp products to Japan.

ACC certification has been implemented since 2007 in integrated shrimp farms and hatcheries by 23 companies, meeting quality standards and market requirement for export to USA, Japan and Europe. Meanwhile BRC certification has been applied by private shrimp farms in East Kalimantan since 2009, exporting mainly to the United Kingdom. BRC certification specifies aquaculture operations must produce at low density, without chemicals or artificial feeding. Government agencies have no involvement in these privately operated certification schemes. A limited number of aquaculture farms were certified by BRC due to lack of capability of the farm in terms of the facility, capital, joint collaboration and access.

Due to the many certification schemes introduced by both government and the private sector, there is considerable confusion among growers as to how to comply with multiple certification requirements. Farmers often lack the facilities and capital to meet these compliance burdens.

4.4.9. Farm management tools

Indonesian Good Aquaculture Practices (IGAP)

In accordance with Government Regulation No. 28 (2004) concerning Safety, Quality and Food Nutrients, application of Good Aquaculture Practices is regulated by the Decree of the Minister of Marine Affairs and Fisheries No. KEP.02/MEN/2007 regarding Indonesian Good Aquaculture Practices (IGAP). Indonesian GAP is adapted from the Good Aquaculture Practices (GAP) standard, widely considered as a benchmark for food safety requirements of importing countries (particularly European Union member countries). The IGAP scheme obliges fish farms to maintain and/or cultivate as well as harvest fish in a controlled environment, focusing on standards of sanitation, fish food, drugs and chemical and biological materials used during the production process. All stages in fish farming should take into account sanitation and control in order to prevent contamination of aquaculture products from food safety hazards including bacteria, biotoxins, heavy metals and pesticides, as well as residues of prohibited materials (antibiotics, hormones, etc.). The purpose of Indonesian GAP to provide better management guideline on aquaculture activities in order to produce high quality products from sustainable and environmentally friendly aquaculture operations. The granting of IGAP certification to aquaculture operators offers a guarantee to buyers that the operation's products conform with food safety requirements and are safe for human consumption.

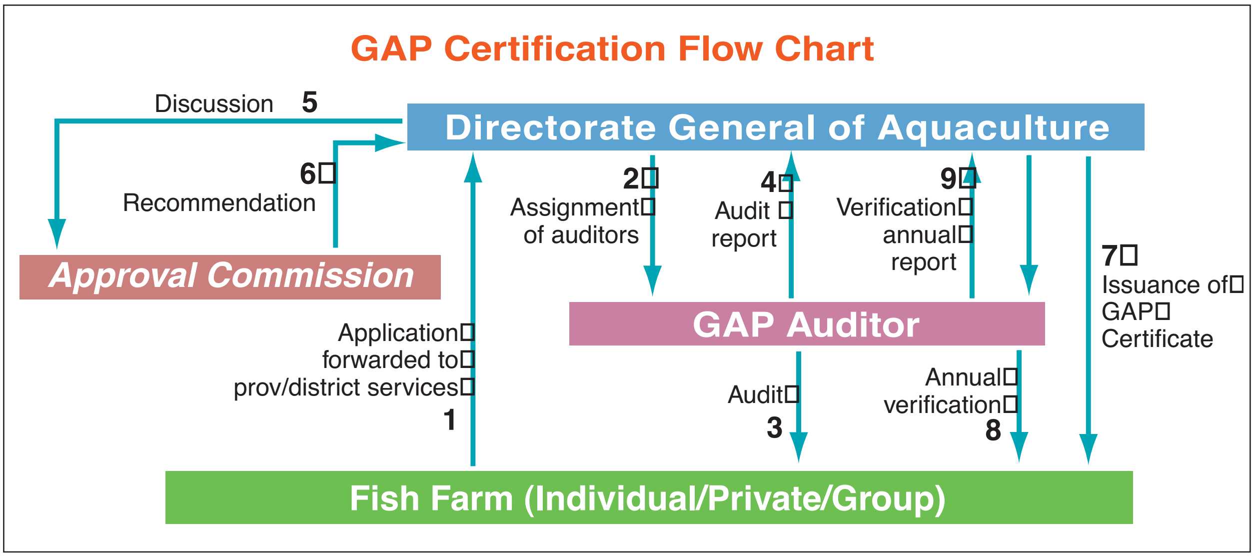

Figure 8 Indonesia GAP Certification Flow Chart

The IGAP certification procedure can be summarized as follows:

1) Application for IGAP certification by the fish farm to the Directorate General of Aquaculture;
2) Appointment of evaluation team;
3) Document and field evaluation;
4) Report of evaluation result;
5) Discussion by approval committee;
6) Recommendation from approval committee to the Directorate General of Aquaculture;
7) Issuance of GAP Certificate;
8) Periodical evaluation (supervision) and verification.

The Indonesian GAP certification implemented to individual farms, farmer groups and aquaculture companies. The number of certified farms has increased year by year as shown in Table 7.

Table 7 Number of IGAP-certified farms (2004-2011)

No.	Province	2004	2005	2006	2007	2008	2009	2010	2011	Cumulative
1	Individual	–	1	–	17	31	52	164	1 010	1 275
2	Farmer group	3	5	2	3	1	16	94	180	304
3	Company	8	12	12	45	29	59	57	51	273
4	Number	11	18	14	65	61	127	35	124	1 852

Indonesian Good Hatchery Practice (IGHP)

In order to ensure a sustainable and competitive aquaculture sector, best practices need to be applied from the hatchery stage. High seed quality contributes to fast growth, uniformity, high survival rate, adaptability to the aquaculture environment, freedom from parasites, immunity against disease and efficient feed conversion. In 2010 Indonesia had 25 243 hatchery units for freshwater, brackish water and marine fish species, and 61 units for seaweed seedlings (Directorate Seed Development, 2011).

The IGHP standard specifies good hatchery practices for spawning, hatching, and larva/seed maintenance in a controlled environment, including use of technologies to meet biosecurity, traceability and food safety requirements. The IGHP standard covers feasibility requirements, production processes (including biosecurity), personnel management as well as documentation/record keeping. Details of the process for obtaining IGHP certification are provided below.

Certification Procedure: Certification enhances buyer and consumer trust in seed quality. A seedling unit may apply for certification after meeting the following prerequisites: a) applying Good Hatchery Practices; b) employing a Quality Control Manager; and c) keeping comprehensive quality control documents. After submitting the IGHP application, the technical manager in charge of the seedling unit must undergo quality control training. The following stage concerns SOP for documentation and quality of the hatchery unit. When all documents are complete, the seedling unit may submit the application for certification, according to the following steps:

- ***Submission of Application.*** The application is sent to the Directorate General of Aquaculture c.q. Directorate of Seed Development with copy to Fisheries Services Office Provincial level as local authority, enclosing: a) application form for IGHP certification; b) general data for the seedling unit; c) flow of seedling process; d) list of facilities; e) list of human resources; f) list of SOP/IK; and g) list of records kept.
- ***Conformity Evaluation.*** The seedling unit will then be evaluated through field audit performed by the Auditor Team for Fish Seedling Quality. The Auditor will perform conformity evaluation in accordance with IGHP requirements. The conformity evaluation covers the following: a) Feasibility requirements for fish farm; b) Production process; c) Personnel management; and d) IGHP documentation and recording.
- ***Certificate Issuance.*** The hatchery unit is graded according to the criteria: very good, good, fair, and fail.
- ***Monitoring and supervision.*** An annual surveillance plan aims to ensure that seedling units consistently comply with IGHP standards, using the same process as the certification inspection. The IGHP certification of any hatchery found to be non-compliant is suspended, and revalidated only when the operation can prove it has rectified the error and is once again in compliance.

4.5. Issues and constraints in application of tools

A number of specific issues and constraints were identified at various levels, including the following:

- Low public awareness of the tools and their benefits. As a result application of AATs is generally not widespread among all stakeholder groups. Where AATs are applied, implementation may frequently be suboptimal.
- Weak enforcement of existing legal provisions has resulted in inconsistency in application of AATs. For example, seized produce suspected of containing residues beyond permitted levels often cannot be destroyed as required.
- The prevailing small-scale of operation of aquaculture farming hampers effective dissemination of information, compliance and enforcement.

4.6. Recommendations and way forward

4.6.1. National level recommendations

- Improve the capacity of small-scale fish farmers to adopt and apply AATs effectively, especially those that are related to environmental and socio-economic issues;
- Whenever possible, make use of technical support and budgets allocated by international funding sources such as FAO *Technical Cooperation Programme* (TCP) and the European Union Technical Support Programme;
- Enhance cooperation between the DG of Aquaculture and research institutes to develop and apply assessment tools, and especially to develop expertise in the ecosystem approach to aquaculture (EAA), ecological risk analysis (genetic and biodiversity), traceability, social impact assessment, life cycle analysis, and studies of GHG emissions and the carbon footprint of aquaculture operations.

4.6.2. Regional level recommendations

- NACA and the FAO Regional Office for Asia and the Pacific (RAP) should whenever possible help member countries to improve their capacity to develop and apply AATs according to need;
- NACA and FAO assistance to the member countries is required, especially in seeking solutions pertaining to the cost implications in development and application of AATs;
- The way forward is to promote wider adoption of AATs to support responsible and sustainable intensification of aquaculture development;
- NACA and FAO should assist in facilitating market access for members countries that have implemented the AATs in order to increase the value-added of their products;
- NACA and FAO should promote efforts to involve all relevant stakeholders in aquaculture chains as well as prevent use of AATs as technical barriers to trade.

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5. COUNTRY REPORT: REPUBLIC OF KOREA

Application of Aquaculture Assessment Tools: Republic of Korea

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5.1. Introduction

5.1.1. Development of Korea's aquaculture sector

Korea's aquaculture dates back to seaweed production in the 17 century (National Academy of Sciences, 2009). During that period, cold-tolerant seaweed, laver (*Porphyra* sp.) was first cultured along the sheltered southern coasts of the Korean peninsula, mostly for family consumption and/or local markets. Significant expansion in aquaculture began during the early 20th century (National Academy of Sciences, 2009), with rapid growth in production from 127 tonnes in 1918 to 2 447 tonnes in 1937 and further to 2 723 tonnes in 1942.

The success in seaweed aquaculture led to further diversification to other aquaculture species, but still primarily through small-scale production systems. However, during the 1960s production of laver, brown seaweed *Undaria* sp., and kelp *Laminaria* sp. became more industrialized, with 1970 production levels increasing to 43 285 tonnes. Seaweed aquaculture subsequently found a new and important role in bioremediation of coastal waters; further intensification followed, boosting production to 858 659 tonnes in 2009 for *Porphyra* spp., *Undaria* sp., *Caulerpa* sp., *Laminaria* sp., *Hizikia fusiformis*, *Monostroma* sp., and *Codium* sp. Advances in seaweed aquaculture technologies paved the way for more advanced systems for other species, utilizing long lines for shellfish in 1970s and pen systems for finfish during the 1980s.

These systems continued to develop, and improved aquaculture management technology including hatchery seed production for a variety of marine species drove rapid expansion in the sector. Annual aquaculture production excluding seaweeds increased from 80 773 tonnes in 1970 to 473 060 tonnes in 2009. Geographically, the southern coasts of the Korean Peninsula provide favourable sites for aquaculture activities in terms of warmer temperatures, natural shelters from high surface water energy, and easy access. Consequently, around 90 percent of total Korean aquaculture production is concentrated in these coastal areas. Table 8 provides a comparison of recent expansion in Korean aquaculture relative to global aquaculture.

In response to continuing intensification of coastal aquaculture over time, academics and local communities began to advocate government regulation of aquaculture operations. The first aquaculture regulation related to oyster farming, through designation of suitable areas for oyster culture. This later led to aquaculture guidelines in the designated area (called the "Blue Belt"), an area highly protected from anthropogenic pollutants and favourable for oyster growth.

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Table 8 Comparison of global and Korean aquaculture and their utilization

Production/utilization	Year					
	2004	2005	2006	2007	2008	2009
Inland production						
Capture Fisheries G*	8.6	9.4	9.8	10.0	10.2	10.1
Capture K*	–	–	–	–	–	–
Aquaculture G	25.2	26.8	28.7	30.7	32.9	35.0
Aquaculture K**	0.025	0.024	0.025	0.027	0.029	0.030
Marine production						
Capture G	83.8	82.7	80.0	79.9	79.5	79.9
Capture K	1.57	1.64	1.75	1.86	1.95	1.84
Aquaculture G	16.7	17.5	18.6	19.2	19.7	20.1
Aquaculture K	0.41	0.44	0.51	0.61	0.47	0.47
Utilization						
Human consumption G	104.4	107.3	110.7	112.7	115.1	117.8
Non-food uses G	29.8	29.1	26.3	27.1	27.2	27.3
Per capita food supply G (kg)	16.2	16.5	16.8	16.9	17.1	17.2
Per capita food supply K (kg)	41.1	39.9	43.5	42.1	42.1	39.1

Units: million tonnes (M/T) unless otherwise stated
**G and K stand for Global and Korean, respectively*
***Quantity of inland production covers a total of aquaculture and catching production*

However, as intensification of the sector continued as a result of the focus on productivity, negative impacts also became evident. It was found that prolonged intensive aquaculture activities in a given location resulted in decreased productivity over time. Intensification also brought attendant environmental impacts, which frequently led to friction with other traditional industries and adjacent land uses. In some locations, aquaculture caused harmful algal blooms, outbreaks of pathogenic agents, biological pollution and introduction of alien strains/species for aquaculture. The significant decline in production from 376 683 in 1990 to 293 420 tonnes in 2000 may well be attributable to the over-intensification and loss of balance in management.

The need for more robust regulation was particularly evident in the case of finfish aquaculture, which was established on the southern coasts. Significant parts of the pen facilities for finfish were aggregated in highly sheltered waters, which, in turn, brought serious local problems, mostly attributed to self-pollution. Release-recapture and release for wild stock enhancement is one of the focal points of Korean aquaculture. Hatchery-seed release ensures significant recapture (Kojima, 1995), but at the same time it can damage coastal ecosystem integrity unless done appropriately (Munro and Bell, 1997). Therefore, criteria for production and release technology for the hatchery-seeds were mandated (NFRDI Hatchery-Seed Release Order 437 (2008); MIFAFF Notice 2010-2 (2010)).

5.1.2. Adoption of AATs in Korean aquaculture

Over the last decade, the Republic of Korea has seen a paradigm shift in aquaculture production from maximizing productivity to its present focus on enhancing environmental sustainability and human safety in aquaculture operations. The government has been requested to establish a comprehensive administrative framework in support of these new priorities. The new regulations are intended to support aquaculture operations that combine reliable and safe production of aquatic products with environmentally friendly practices that do not compromise ecosystem integrity. In this regard, the priority concerns of EIA in aquaculture are environment, pathobiology/quarantine, and food safety. Genetic issues are also emerging, but at present remain a comparatively minor parameter for EIA. MIFAFF has taken a central role in establishing the framework, with the cooperation of its key research institute, NFRDI. EIAs are collectively governed by MIFAFF and implemented throughout the country with different foci and intensities following location-specific aquaculture methodologies and culture intensity. This is because Korean aquaculture is highly location-specific, with the southern coasts dominating total production.

The Basic Environmental Policy Act (1990) identifies the objectives and directions for actions for environmental preservation and protection. A number of other laws have been enacted including the Water Quality Conservation Act (1990), the Nature Environment Conservation Act (1991), and the Act on Assessment of Impacts of Works on Environment, Traffic, Disasters and Population (1999). These acts contain general directions for EIA, but are not specific in terms of fisheries and aquaculture. The Fisheries Resources Protection Act (1953) defines jurisdictional waters for the purpose of conservation and management of fisheries resources. A more comprehensive Fisheries Act as an amendment in 1990 described the utilization plan and licensing for aquaculture. The Aquaculture Ground Management Act was legislated in 2000, aiming at improving the productivity and introducing a system of sabbatical years for ecosystem-based aquaculture practice. The Culture-based Fisheries Promotion Act promulgated in 2002 further details the ecosystem-based aquaculture approach, in which the framework is to be updated on a five-year basis to introduce newly accepted methodologies and approaches under the ICZM framework.

For EIA of pathology, disease inspectors and veterinarians from the Aquatic Organism Disease Inspection Association (AODIA), a private organization financed by government, monitor farmed animals on both a regular and *ad hoc* basis. These *ad hoc* monitoring are undertaken when disease outbreaks are anticipated, or when requested by farmers. The monitors of AODIA work in collaboration with NFRDI via the responsible branch station or Regional Aquatic Animal Disease Control Institute (RAADCI) for further assessment. NFRDI, a comprehensive fisheries research institute equipped with state-of-the-art instruments for EIA, is the final decision maker and reporter to MIFAFF, if necessary, in recommending government action at national level (Figure 9).

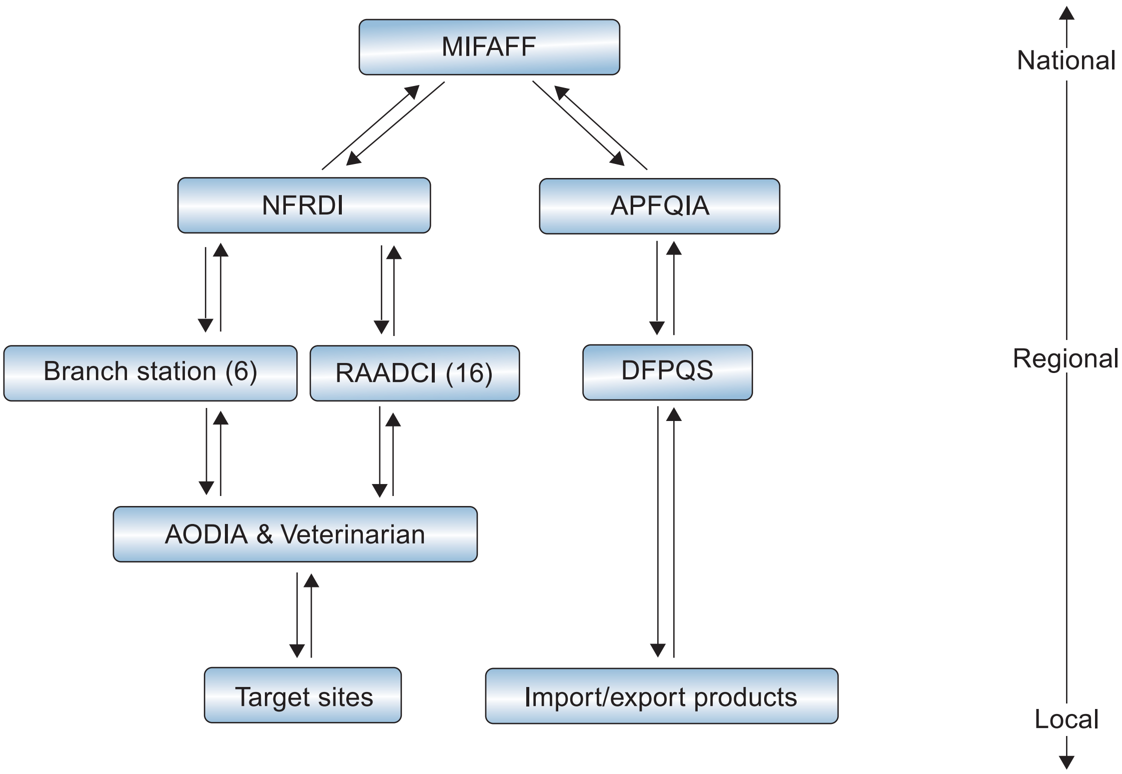

Figure 9 Schematic drawing for EIA for disease monitoring and quarantine procedure

(Figures in parenthesis indicate the number of stations or organizations under NFRDI).

Figure 9 also explains the system for quarantine of species for aquaculture and fisheries products to be imported and exported. Inspection takes place in two steps, the first for food quality and safety and the second for quarantine. These functions are overseen by the Department of Fisheries Products Quality and Safety (DFPQS) and the Animal, Plant and Fisheries Quarantine and Inspection Agency (APFQIA), respectively. Products that fail to reach the standards prescribed by government EIA are rejected for import or export.

5.2. Summary of AATs application in the Republic of Korea

Table 9 summarizes application of AATs in Korean aquaculture. The grading criteria for the level and extent are based on the NFRDI standard.

5.3. Case Studies in Application of AATs

5.3.1. Environmental impact assessment (EIA)

In 2000 the government issued a regulation for freshwater aquaculture, prohibiting installation of any new aquaculture facilities in public freshwater bodies. However, freshwater aquaculture accounts for less than 1 percent of total aquaculture production, mostly in recirculation and private ponds. Therefore, EIA in the Republic of Korea prioritizes marine aquaculture operations.

The purpose of EIA is to ensure that aquaculture activities maintain key ecosystem integrity, balancing production with environmental preservation and also to produce safer aquatic foods. In general, because the physico-chemical and biological parameters in the waters can often exacerbate the damaging effects of pollutants, it is necessary to monitor all the potential elements as part of an integrated model. Local government extension services took on this responsibility, making use of remote-sensing systems with automatic data transfer to mobile devices of farmers to provide early warning and reference.

EIA and monitoring related to aquaculture are mainly the responsibility of the Ministry of Food, Agriculture, Forestry and Fisheries (MIFAFF) with a number of branch institutes and organizations dealing with establishment of regulatory requirements, practice, effectiveness, and potential improvement of EIA and monitoring technology in aquaculture operations. The National Fisheries Research and Development Institute (NFRDI), under the auspices of MIFAFF, has nationwide branch institutions, research centres and related stations, and plays a key role in data measurement, monitoring, analysis and assessments, upon which EIA regulations, guidelines and best aquaculture practice are established. The regulations and guidelines are updated on a 5-year basis, highlighting aquaculture practice in terms of sustainability and food safety in an integrated coastal zone management (ICZM) framework. Data assessments are also summarized in forms appropriate for aquaculturists. The data are also available for public reference, and for use by researchers.

EIA applied to aquaculture includes direct monitoring of organic and inorganic matter in waters surrounding aquaculture facilities for shellfish, seaweeds, finfish, and others (including tunicates) cultivated in Korean waters. Monitoring of indirect or potential pollutants is concurrently measured, both in grow-out waters and remote waters. The Republic of Korea's HACCP regulation stipulates Sanitation Standard Operating Procedures (SSOP) with which aquaculturists must comply. According to SSOP, key water quality factors for aquaculture are as follows:

a) Critical environmental parameters should be determined prior to system operation;
b) Once in operation, depending on estimated water quality, key parameters should be monitored at least once a year or for each crop if it is less than a year; and
c) Parameters to be monitored should include biological and chemical measurements which are scientifically acknowledged as having a correlation with verified hazards for human safety or the environment.

Table 9 Summary of AATs Application in the Republic of Korea

Tool	Level of awareness[1]	Level of capacity[1]	Extent of use[2]	Supporting legal instruments[3]	Remarks
Pathogen/Disease					
Import risk analysis (IRA)	d	d	b, c, d	Yes	Extent of use is national, but not yet strictly enforced
Health certification	d	d	c, d, e	Yes	
Quarantine	d	d	c, d, e	Yes	
Disease surveillance and early warning system	d	d	c, d, e	Yes	
Environment					
Environment impact assessment (EIA)	d	a	c	Yes	Legislated but not yet strictly enforced
Ecology					
Ecosystem approach to aquaculture (EAA)	d	a	c	Yes	Legislated but not yet strictly enforced
Ecological risk analysis (genetics and biodiversity)	d	a	b	Under development	
Food Safety					
Residue inspection and monitoring	d	d	c	Yes	
Record keeping and traceability	d	d	c	Yes	
Planning					
Spatial planning/zoning based on carrying capacity	d	a	e	Yes	Legislated but not yet strictly enforced
Management					
Production process (e.g. public/private certification)	d	d	c	Yes	
Management tools (e.g. BMP/GAP)	d	d	d	Yes	
Social impact assessment	a	a	b	Under development	
Quality					
Input quality assessment and monitoring	d	d	d	Yes	
Other Tools					
LCA/GHG emissions, carbon footprint studies	a	a	b	Under development	

Notes:
[1] Levels: ***a*** – policy makers and scientists at national level; ***b*** – policy makers and scientists at provincial level; ***c*** – all stakeholders at local level except farmers; ***d*** – all
[2] Extent of use: ***a*** – never used; ***b*** – used in some projects; ***c*** – used at national level; ***d*** – used at provincial level; ***e*** – used at local level
[3] Supporting legal instruments: Yes; no; under development

SSOP criteria for water quality for aquaculture are listed in Table 10 below.

Table 10 SSOP criteria for water quality for aquaculture in HACCP regulation

Measurement	Marine Lower than (mg/L)	Freshwater Lower than (mg/L)
Chemical oxygen demand (mg/L)	2.0	4.0 mg/L
Total coliform group (count of total coliform group)/100 mL	1 000	500
Total nitrogenous matter	0.6	–
Total phosphorus matter	0.05	0.04 mg
Cadmium (Cd, 0.1 mg/L)	0.01	0.005
Lead (Pb, mg/L)	0.05	0.05
Mercury (Hg, mg/L)	0.0005	None (detecting limit, 0.001 mg/L)

Source: National Environmental Policy Act

The scope and intensity of the environmental assessment are location-specific. Generally, the elements assessed are COD, total coliform count, total nitrogenous matter, total phosphorus, levels of Cd, Pb, Hg in the coastal waters of major farming areas (for finfish, shellfish, seaweeds, and other invertebrates) and coasts in the vicinity of the culture areas (Table 11). In some locations, trace elements and persistent organic pollutants are measured both from the receiving environments and cultured animal flesh.

Table 11 NFRDI routine items and frequency of environmental monitoring in waters surrounding aquaculture facilities for general environmental monitoring

Item	Contents	Frequency
Water quality	Temperature, salinity, transparency, pH, DO, Chl-a *a*, SS, DIN (NH_4, NO_2, NO_3), DIP, SiO_2, COD	Every two months
Pollutant in sediment	Grain size, sediment, COD, AVS, IL Heavy metals (Cu, Pb, Zn, Cd, Cr, Total Hg, As) Residual organic pollutants (PCBs, TBT, PAHs, pesticides, dioxin/furan)	Annual
Pollutant in organism	Heavy metals (Cu, Pb, Zn, Cd, Cr, Total Hg, As) Residual organic pollutants (PCBs, TBT, PAHs, pesticides, dioxin/furan)	Annual
Phyto-Plankton	Species composition, abundance	Every two months

A total of 233 assessment sites are established at 52 locations throughout the country: 16 locations (110 sites) for shellfish farms, 7 locations (21 sites) for finfish, 6 locations (28 sites) for seaweeds, and 5 locations (21 sites) for tunicates, 2 locations (21 sites) for specific coasts managed by local communities, and 16 locations (47 sites) for open coastal areas.

The EIAs for the locations are based on assessments of environmental elements and biological indicators such as appearance of bio-indicators (isopods) and early reproductive life stages (sea urchins and other indicator finfish). The EIA also focuses on maximization of the ecosystem's carrying capacity in terms of both production carrying capacity and ecological carrying capacity. Besides the assessment in the given locations, EIAs are also being practiced for designing re-location of farming facilities where decreases in farming efficiencies are evident or anticipated. Monitoring of the impact of these measures contributes important scientific data as a basis for establishing an ecosystem based approach to aquaculture.

5.3.2. Food safety

Antibacterial are used in finfish aquaculture during the hatchery and grow-out phases of production. During the expansion of finfish aquaculture in the Republic of Korea, use of antibacterial was often not managed responsibly. Frequent overdosing by farmers resulted in resurgence of antibacterial-resistant pathogens, which in turn needed more potent antibacterial dosages to regain control. Moreover, bioaccumulation of residues of antibacterial drugs in fish flesh presented an additional public health risk. The Korean government established a national regulation (the Culture-based Fisheries Promotion Act, 2002) dealing with standard use of antibacterial for fish farms, following the standards set by FAO, World Health Organization (WHO), and the International Office of Epizootics (OIE).

The emergence of drug-resistant pathogens can lead to major problems in regard to the patho-ecology within the given ecosystem, since the pathogens are fully exposed to the open water ecosystem in which the finfish pens are located. Given the prevalence of live fish consumption in the country, irresponsible use of antibacterial represents a significant public health threat. Human consumption of live fish containing significant levels of antibacterial residues frequently generates a number of adverse side-effects. Increasing recognition of the verified and potential risks associated with such drug residues in fish products has led to total bans on use of some antibacterial in fish for human consumption, particularly for fish for live consumption.

The Korea Food and Drug Administration (KFDA) has updated its regulation on responsible use of anti-bacterial for fish for human consumption (KFDA Notification No. 2008-78, 8 December 2008; KFDA Notification No. 2009-56, 15 July 2009; KFDA Notification No. 2012-1, 20 January 2012). The new rules set new guidelines for maximum residue limits (MRLs) for those antibacterial with known risks. The regulations also updated the list of banned chemical substances in aquaculture to include chloramphenicol, known to pose significant risks to human health even at low concentrations. The chemicals identified by KFDA's Notifications are under the control of the Animal, Plant and Fisheries Quarantine and Inspection Agency (APFQIA). APFQIA (Notification 2011-20) issues licenses for use of the chemicals listed by the KFDA's Notification and monitors responsible use and residual concentrations (Table 12).

In regard to food safety, the Law for the Quality Management of Agricultural and Fishery Products includes the Fisheries Product Quality Control Act (Inspection of Fishery Product and Re-inspection) which designates the concerned anti-bacterial such as oxytetracycline (OTC), erythromycin, amoxicillin, and others, and their permitted maximum residue levels (MRL) in the harvested fish (Table 13).

Table 12 Chemical treatment and withdrawal period for aquaculture animals

Chemical	Target animal	Withdrawal period (day)	Suggested SD usage
Florfenicol	Yellowtail, Trout Ayu Eel	5 14 14 7	Lower than 10 mg/kg body weight/day by oral in diet
Flumequine	Yellowtail Flounder Trout Carp Crucian carp Eel	8	Lower than 20 mg/kg body weight/day by oral in diet
Oxolinic acid	Yellowtail Trout Carp Eel	16 21 28 25	Lower than 30 mg/kg body weight/day by oral in diet Lower than 20 mg/kg body weight/day by oral in diet Lower than 10 mg/kg body weight/day by oral in diet Lower than 20 mg/kg body weight/day by oral in diet
Oxolinic acid	Eel Ayu	25 14	Bathing 5 g/tonne water Bathing 10 g/tonne water

Table 12 Chemical treatment and withdrawal period for aquaculture animals *(continued)*

Chemical	Target animal	Withdrawal period (day)	Suggested SD usage
Oxytetracycline	Yellowtail Eel Trout Sea bream Flounder Rockfish Carp Catfish	20 20 30 20 40 20 20 20	Lower than 50 mg/kg body weight/day by oral in diet
Formalin	Flounder	100 degree day $= \frac{100}{\text{Temp (°C)}}$	Bathing in 100-200 ppm for an hour
	Egg (Trout, Salmon)		Bathing 1 000-2 000 ppm for 15 min

Source: QIA Notification 2011-20.

Table 13 Maximum residue levels of permitted antibiotics

Antibiotics	Maximum Residue level (mg/kg)	Target Animal
Oxytetracycline, Chlortetracycline, Tetracycline	0.2	Finfish, Crustaceans Abalone
Spiramycin	0.2	Finfish, Crustaceans
Flumequine	0.5	Finfish, Crustaceans
Oxolinic acid	0.1	Finfish, Crustaceans
Enrofloxacin, ciprofloxacin	0.1	Finfish, Crustaceans
Doxycycline	0.05	Finfish
Amoxicillin	0.05	Finfish, Crustaceans
Ampicillin	0.05	Finfish, Crustaceans
Sum of sulphonamides (14 species)	0.1	Finfish
Norfloxacin	ND	Finfish, Crustaceans
Ofloxacin	ND	Finfish, Crustaceans
Pefloxacin	ND	Finfish, Crustaceans
Colistin	0.15	Finfish, Crustaceans
Lincomycin	0.1	Finfish, Crustaceans
Erythromycin	0.2	Finfish, Crustaceans
Cefalexin	0.2	Finfish
Florfenicol	0.2	Finfish
	0.1	Crustaceans
Josamycin	0.05	Finfish
Kitasamycin	0.2	Finfish
Nalidixic acid	0.03	Finfish
Difloxacin	0.3	Finfish, Crustaceans
Clidamycin	0.1	Eels, Flounders
Praziquantel	0.02	Rockfish
Tiamulin	0.1	Finfish
Trimethoprim	0.05	Finfish, Crustaceans
Gentamicin	0.1	Flounder, Trout, Carp
Neomycin	0.5	Finfish, Crustaceans
Antibiotics without SD usage	0.03	Any target species

Source: KFDA Article 2012-1.

5.3.3. Harmful algal blooms (HAB)

Marine pollution resulting from intensive human activities including aquaculture, both on and near the coasts, has been identified as a cause of harmful algal blooms (HAB) periodically affecting the Republic of Korea's coastlines. Of the algae blooms, *Cochlodinium polykrikoides* in particular presents serious risks due to their direct impact on local ecosystem integrity and other aquaculture animals, and indirectly due to their human toxicity. HAB's have caused enormous economic damage to the aquaculture sector. From 1993 to 2007, *C. polykrikoides* blooms reached up to 20 000-48 000 cells mL^{-1} over a 79 km^2 area that included intensive aquaculture activities, causing economic loss of US$117 million due to mortality and production losses of economic fish and shellfish.

Since the enormous *C. polykrikoides* bloom-driven mass mortality in 1995, which caused economic damage estimated at US$60 million, the Korean government established the HABs Emergency Centre under NFRDI, charged with monitoring, mitigation and control of HABs in accordance with MIFAFF Notification (No. 1996-655), an amendment of Notification No. 2008-22. Table 14 summarizes the modified notification.

Table 14 Regulation for mitigation of HAB (Notification No. 2008-22 of MIFAFF)

Monitoring	HAB warning	Organization	HAB control
No. of stations: >70 Period: Mar.~Nov. Frequency: Monthly (Weekly during HAB) Item: HAB species, Environmental factors	Attention, Alert, lift: See Table 15	NFRDI and local fisheries agency: Report HAB occurrence to MIFAFF minister	Clay dispersal: >1 000 cells mL^{-1} of *C. polykrikoides* Certification criterion for suitability of clay: See Table 3

The HABs Emergency Centre is responsible for monitoring of HABs and mitigation of fisheries damage. It monitors HABs during the critical months from February to November at various coastal locations. Before occurrence of HABs, they are monitored once or twice per month depending on the situation. Once blooms are reported, monitoring frequency is increased to more than once per week. Monitoring parameters include cell density of harmful algae, dominant phytoplankton/zooplankton, chlorophyll a, water temperature, salinity, pH, dissolved oxygen (DO), transparency, nutrients (total nitrogen, total phosphorus, etc.), and others such as wind, rainfall, typhoon, etc.

Red Tide information is regularly uploaded to the internet homepage of NFRDI (http://www.nfrdi.re.kr/redtideInfo). Both conventional and molecular approaches are used to monitor and identify HAB species. Composition and frequency of harmful algae are monitored with the aid of microscopic observation and molecular tools such as species-specific real-time PCR for *C. polykrikoides* and toxic dinoflagellates (Park et al., 2009; 2010). Use of real-time PCR can compensate for the drawbacks of microscopic observation and enables accurate, reliable and high throughput quantification of target HABs. This method is useful to detect and quantify morphologically similar toxic species, of small cell size (ca <10 µm) and currently this detection method is used for monitoring of HABs along with microscopy.

In 1979, the U.S. Food and Drug Administration (FDA) advised "monitoring of shellfish farms affected by paralytic shellfish toxin (PST) producing algae", i.e. PST monitoring on shellfish. Paralytic shellfish poisoning (PSP) is caused by accumulation of *Alexandrium* spp. that produces PST and occurs in the spring. Since 1980, PSP has occurred almost every year with occurrences of *Alexandrium* spp. Since that year, PST monitoring has been undertaken by the food hygiene division of NFRDI once per month for mussels/oysters. Monitoring of PST in sea squirt/warty sea squirt/Manila clam has been conducted since 2010.

NFRDI issues four types of messages alerting the public to the threat of HABs, depending on the density of harmful algae (Table 15), viz. (1) appearance, (2) concentration or density watch (e.g. >300 cells mL^{-1} of *C. polykrikoides*, >1 000 cells mL^{-1} of *K. mikimotoi* and >500 cells mL^{-1} of *Gyrodinium* sp. over 12~79 km^2

area), (3) warning (e.g. >1 000 cells mL^{-1} of *C. polykrikoides*, >3 000 cells mL^{-1} of *K. mikimotoi* and >2 000 cells mL^{-1} of *Gyrodinium* sp. over >79 km^2 area) and (4) lifting. These messages are delivered in near real-time to HABs-related organizations and fishermen by fax, telephone, internet and smart-phone. Once HABs occur and come into proximity to aquaculture farms, rapid or emergency management is essential to protect these fish. Clay dispersion is currently the prime mitigation technique to directly kill HABs species in the Republic of Korea. Clay is dispersed (200~400 g/m^2) around aqua-farms when HAB cell densities reach the warning level. NFRDI surveys the effectiveness of clay dispersal to remove HABs and suitable levels that may be safe to use in the sea. Suitability of clays for use in HAB removal in coastal waters depends on particle size, cohesiveness and stickiness of the clay.

Table 15 Regulation for HABs warning (Notification No. 2008-22 of MIFAFF)

Warning class	Scale	Cell density (cells mL^{-1})
HABs attention	Over radius 2~5 km (12~79 km^2) and potential fishery damages	• *Chattonella* spp.: over 2 500 • *Cochlodinium polykrikoides*: over 300 • *Gyrodinium* sp.: over 500 • *Karenia mikimotoi*: over 1 000 • Other dinoflagellates: over 30 000 • Diatom: over 50 000 • Mixed blooms: over 40 000 cells (over 50%) of dinoflagellate
HABs alert	Over radius 5 km (79 km^2) and fishery damages	• *Chattonella* spp.: over 5 000 • *Cochlodinium polykrikoides*: over 1 000 • *Gyrodinium* sp.: over 2 000 • *Karenia mikimotoi*: over 3 000 • Other dinoflagellates: over 50 000 • Diatom: over 100 000 • Mixed blooms: over 80 000 cells (over 50%) of dinoflagellate
Warning lift	HABs are no longer present, no risk to fisheries	

Since removal efficiency of HABs varies with the type of clay, and the safety of additives is largely unknown, criteria for safety and selection are required for clays or any materials before they are permitted for sea dispersal. In 2004, certification criteria and procedures (Notification No. 2004-63 of MIFAFF) for substances to control HABs were announced to provide a guideline for suitable clays or substances in the Republic of Korea (Table 16). According to the Notification, substances proven to be practical and safe for marine environments and organisms can be only used in the sea, and so far about 170 types of clay have proven suitable for dispersal.

Table 16 Certification criteria for suitability of clay to use on the coasts (Notification No. 2004-63 of MIFAFF)

Analysis item	Certification criterion	Analysis criterion	Note
Removal efficiency	Over 80% removal efficiency	Removal efficiency at 1% clay concentration within 10 min	Allow to use over 70% removal efficiency clay considering practicability
Particle size	Below 20% of >0.125 mm size particle	Analyze particle size ratio after sedimentation and melting of over 1 kg clay with seawater	–

The major minerals in Korean clays are 50~65 percent silicon, 16~24 percent aluminium, 4~9 percent iron, 0.6~2.5 percent magnesium and 5~15 percent other minerals. NFRDI showed that removal efficiency within 10 minutes for 98 clays collected from various locations of the Republic of Korea varied from 32 to 98 percent. The average efficiency was 71 percent and half of them exceeded 80 percent efficiency. Clays with over 80 percent removal efficiency are considered suitable for use because these clays can effectively reduce *C. polykrikoides* density from the HAB warning level 1 000 cells mL^{-1} to the watch level 300 cells mL^{-1}. Clays of over 70 percent efficiency are also considered usable as this is the average efficiency in the Republic of Korea. Clays of over 80 percent efficiency mostly contain less than 20 percent particles over 0.125 mm in size; thus clays with a lower ratio (<20 percent) of particles over 0.125 mm in size are desirable.

5.3.4. Disease control and quarantine

Fish health management aims to manage and control the parameters known to provoke outbreaks of diseases that not only cause economic damage to aquaculture operations, but also threaten ecosystem integrity and human health. Recently, opportunistic invasion of foreign pathogens has been occurring more frequently, in line with increasing volumes of international fish movement and trades.

The Ministry of Food, Agriculture, Forestry and Fisheries (MIFAFF) promulgated the Aquatic Animal Disease Control Act (2008) to establish a comprehensive system for control of infectious diseases in aquatic animals, mainly using quarantine of pathogenic agents, and to preserve ecosystem for wild life. Figure 10 shows the structure established under the 2008 Aquatic Animal Disease Control Act. In the system, the two organizations, National Fisheries Research and Development Institute (NFRDI) and Animal, Plant and Fisheries Quarantine and Inspection Agency (APFQIA) are responsible for domestic quarantine/disease control and/the related quarantine measures, respectively. Two divisions of NFRDI, Aquatic Life Disease Control Division and Pathology Division, a department of APFQIA, have 6 subdivisions and 5 stations throughout the country.

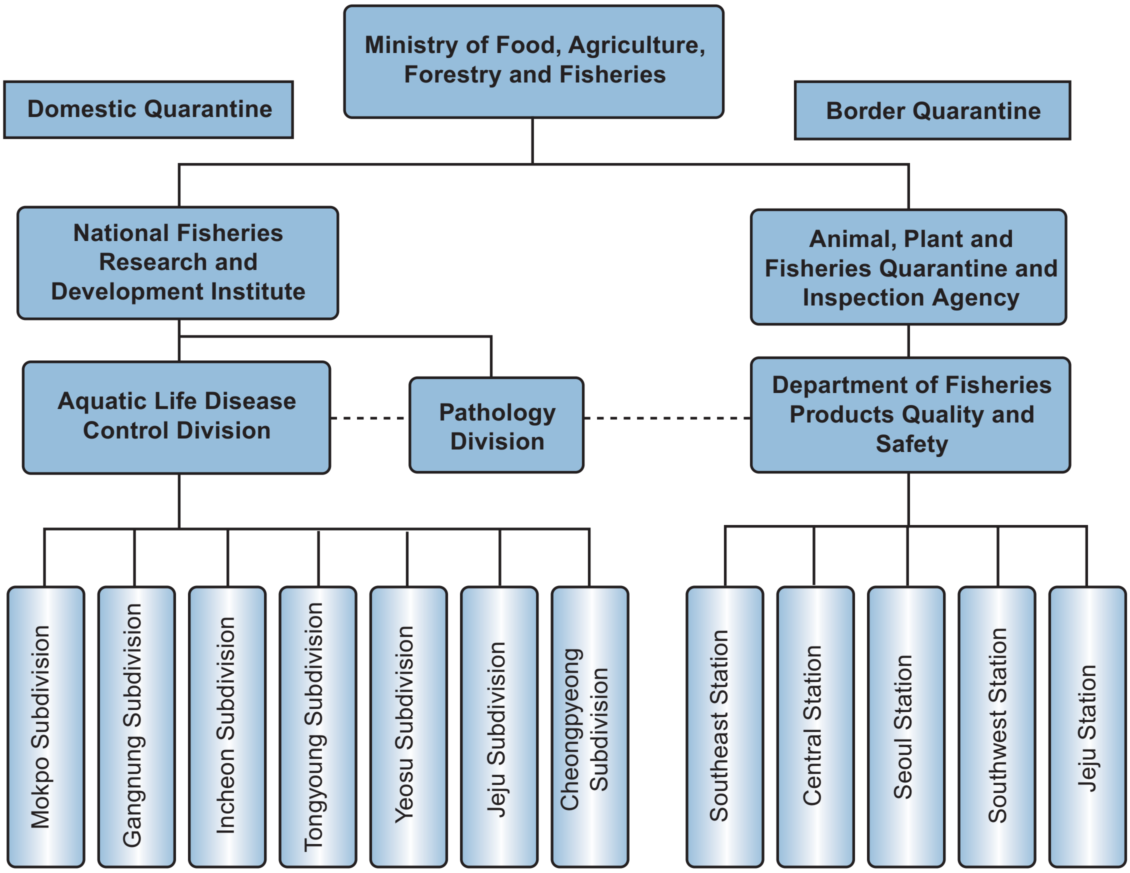

Figure 10 Quarantine and disease control structure

(Established under the Aquatic Animal Disease Control Act, 2008)

Under the Aquatic Animal Disease Control Act, the domestic quarantine sector covers the overall concept of aquatic life disease control, and thus covers the work of border quarantine in a broad sense. In this regard, NFRDI is responsible for surveillance, aquatic life disease diagnosis, disease investigation and control, and pathology research for 20 designated diseases (Table 17).

Table 17 Pathogens of 20 designated diseases and their hosts

Pathogen	Host		
	Finfish	**Shellfish**	**Crustacean**
Virus	Red sea bream iridoviral disease, RSIVD	Infection with abalone herpes-like viruses	White spot disease, WSD
	Viral haemorhagic septicaemia, VHS	White spot disease, WSD	Yellow head disease, YHD
	Infectious salmon anemia, ISA		Taura syndrome, TS
	Koi herpesvirus disease, KHVD		Infection hypodermal and haematopoietic necrosis
	Spring viremia of carp, SVC		Infection myonecrosis
	Epizootic haematopoietic necrosis, EHN		White tail disease
Fungus	Epizootic ulcerative syndrome, EUS		Crayfish plague, *Aphanomyces astaci*
Parasite	Gyrodactylus salaris	Infection with *Perkinsus marinus*	
		Infection with *Bonamia ostreae* or *exitiosa*	
		Infection with *Marteilia refringens*	
Bacterium		Infection with *Xenohaliotis californiensis*	

The Pathology Division of NFRDI is equipped with state-of-the-art instruments for pathology research, and is the lead organization working on high level pathobiology of aquatic organisms. It formulates and provides key information necessary for surveillance, quarantine, and control of concerned diseases. It also conducts research on vaccine development, aquatic medicines, and other related topics.

Surveillance is the first step in the aquatic animal disease control system, and is carried out by 250 university-trained surveillance agents, licensed in quarantine and disease control. Approximately 10 000 first-step surveillance sites have been designated nationwide, including target surveillance aquaculture facilities, key fishing ports, fish markets, game fishing sites, and so on. The 250 surveillance agents monitor clinical signs in the fish at the 10 000 first-step surveillance sites. Fish from suspect sites are subsequently subjected to further diagnosis in the next step.

Border quarantine focuses primarily on prevention of invasion of domestic environments by foreign pathogens. Infectious diseases of aquatic life that present risks in regard to international trade in aquatic life are legally designated under the Aquatic Life Diseases Control Act (2008). Aquatic life forms can be traded with the attachment of a health certificate issued by APFQIA for import.

Since the Aquatic Animal Disease Control Act (2008) excludes disease control and quarantine for aquatic plants, MIFAFF is currently modifying the Act to include aquatic plant monitoring and quarantine within its scope. The amendment is expected to be implemented in 2012.

Release and recapture is another form of aquaculture in the Republic of Korea. Hatchery seeds to be released into open coastal waters are strictly quarantined prior to release. Any hatchery seeds suspected or diagnosed as infected are normally destroyed; alternative measures involve isolation, movement limitation and disinfection. All these procedures are carried out by an independent agency, the Infectious Disease Inspection Agency for Releasing Aquatic Animals.

5.4. Issues and constraints in application

In implementing its strategy of systematizing the data collection and analysis process, NFRDI faces significant challenges, especially because data must be collected from many local-level institutions by a large number of monitors responsible for monitoring and evaluation of diverse sites. There is thus a significant challenge in synchronization and standardization of measurements in order to create a scientifically valid and reliable database. In practice, this has been one of the most difficult goals to accomplish. At the same time, animal responses to environmental parameters are complex and multi-factorial, and may be influenced by other known or unknown parameters, sometimes with synergistic or exacerbating effects. Management factors also play a key role affecting EIA results. Biological responses of farmed animals are affected by quality and quantity of feed, existence of food competitors and other biotic and abiotic factors.

As mentioned earlier Korean aquaculture production is highly location-specific, with the southern coasts of the Korean peninsula dominating aquaculture production. Whilst the zoning can be a positive factor for EIA assessment, long-term intensive aquaculture activities at a given location can result in loss in physiological viability both for farmed and wild species in the ambient waters. Changes in animal physiological viability together with genetic fitness should therefore be taken into account as parameters in EIAs.

Aquaculture activities should be managed to ensure food safety through compliance with relevant national or international standards and regulations. This is particularly important for consumers of raw aquatic products. Although a number of Acts are already established or are under consideration covering both safety and quality issues concerning aquatic products, quality aspects remain under discussion and are opposed by some producers who resist new quality legislation that may impact on costs and total production.

Feed-based aquaculture inevitably induces accumulation of organic and inorganic matter in the ambient waters. Therefore, aquaculture standards should include provision for minimizing or avoiding feeds-driven pollution using scientifically determined and agreed methods. Additionally, aquaculture feedstuffs should not contain unsafe levels of pesticides, biological, chemical and physical contaminants or other adulterated substances. In Korean aquaculture, even though a greater percentage of aquaculturists now use pellets for finfish, unprocessed foods are still used by some local finfish aquaculture operations.

Established legal frameworks are in place or are under development to ensure safe, responsible and sustainable aquaculture in the Republic of Korea, particularly with respect to food safety and aquatic animal disease control as part of ecosystem integrity. Although legislation provides rigorous control and enforcement in some areas, other aspects remain weakly controlled or enforced. A small number of operations still routinely violate mandatory standards, especially in regard to safe use of veterinary drugs and chemicals in aquaculture.

Additionally, aquaculture can be a source of risk from biological invasions in a number of ways. Adverse effects on biodiversity have been reported, including decline or elimination of native species through competition, predation, or transmission of pathogens, and disruption of local ecosystems and ecosystem functions. Field data confirm that genetic diversity within and between farmed and wild strains is evident. This is particularly significant for the population of the flounder *Paralichthys ovlivaceous*, one of the most important farmed finfish in the Republic of Korea. Captive seed strains of flounder have been maintained for decades in the Republic of Korea. As a consequence, the potential genetic impact of the release hatchery-reared fish on wild fish stocks is a growing concern even though most of the farming facilities are land-based. This is because most hatchery stocks typically show reduced genetic variability or narrowed gene pool; any escape into wild populations therefore presents risks. To date this is not covered by any legislation, although a new regulation is currently under development.

The current nationwide HABs monitoring system with more than 70 sampling stations based on monthly or weekly survey frequencies is highly laborious and time consuming. One promising strategy is to employ automated equipment such as environmental sample processors (ESP) which effectively enable identification of HABs species and/or algal toxins. Once HABs occur in or around aquaculture facilities, they can damage farmed animals physically and chemically. Numerous HAB mitigation methods have been examined in the Republic of Korea, yet clay dispersion is recognized as the most practical method. Due to effectiveness and practicability of clay, clay dispersal has become a key part of Korean management scheme. Although clay has been successfully applied to control *C. polykrikoides* blooms, there are still several problems and limitations. Over the past 13 years, from 1 000 to 97 000 tonnes of yellow clay were dispersed each year. Even though no side effects have been reported, use of clay may nevertheless cause long-term adverse impacts. At the same time, clay dispersal is ineffective in controlling paralytic shellfish poisoning (PSP) caused by accumulation of fish/shellfish poison toxins produced from toxic algae.

5.5. Recommendations and way forward

Despite technological advances, overall aquaculture production in the Republic of Korea has remained stagnant for the last decade. As long as demand for high quality seafood remains strong, continuing improvements, interventions and investments will be required to ensure a high degree of environmental sustainability and economic viability in the sector. Aquaculture will continue to dominate production due to the continuing decline in marine fish stocks.

Aquaculture must address several challenges in order to move towards sustainable production. Key efforts have been given to successful introduction and management of integrated aquaculture to minimize environmental pollution, one of the main factors leading to breakdown in sustainability of aquaculture operations. Implementation of the ecosystem approach to aquaculture development is expected to help reconcile the human and environmental objectives of sustainable development.

In the last decade, integrated usage of the coastal zone has also attracted increased attention. Recent advances in the development of offshore aquaculture systems coupled with improvements in their technology management has enabled much more systematic management of aquaculture. It is anticipated that integrated coastal zone management (ICZM)-based aquaculture will play a significant role in the introduction of future aquaculture frameworks in which offshore aquaculture for finfish, integrated multi-trophic aquaculture (IMTA) for eco-based inshore aquaculture as well as land-based recirculating aquaculture are highlighted.

There have been many efforts to publicize the conceptual framework for ICZM-based aquaculture. However, many aquaculturists remain primarily oriented towards production. The multiple parameters affecting sustainability are considered from a short-term perspective rather than considering the effects that multiple impacts in one or several variables might cause. In this regard, the sense of responsibility of individual producers will remain an important driver of sustainability, along with technology development and systematic EIA. Extension efforts to promote wider public awareness on responsible aquaculture, for both the industry and the general public, will therefore be essential, alongside technical improvement.

All EIA data generated are currently being loaded into the NFRDI Info System in compliance with MIFAFF EIA regulations which are scheduled to be open to public access (www.nfrdi.re.kr). To obtain more reliable, realistic and robust information, increased replication of assessments are recommended covering wider areas with the aid of a state-of-the-art automated assessment system, including real-time measuring systems. At the same time, it is also recommended to increase accessibility in homes by means of the web and mobile services.

Finally, there are many known and unknown factors that might influence ecosystem integrity, but which are not currently covered by legislation. Examples include issues relating to genetic modification and endangered species, both of which are vulnerable to irresponsible aquaculture practice and that need to be addressed through more effective legislation.

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6. COUNTRY REPORT: MALAYSIA

Application of Aquaculture Planning and Management Tools (APMTs) in Malaysia

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6.1. Introduction

The development of commercial aquaculture in Malaysia came relatively recently compared with most of its neighbours. Beginning with small-scale freshwater fish culture in the 1920s, the industry expanded into cockle and shrimp culture in the 1930s. A pilot project for commercial marine finfish culture was initiated in the early 1970s; more recently, Malaysia's aquaculture sector has seen a remarkable development of farming of ornamental fish, aquatic plants and seaweeds.

Aquaculture adopted by local farmers is mainly based on traditional farming methods such as fish stocking into former mining pools, bottom culture for cockles, raft culture for oysters and mussels, floating cage culture in sheltered or enclosed water bodies for finfish as well as earthen pond culture for shrimps and crabs. However, since the late 1990s, modern technologies have been introduced, including open-sea cage culture and tank culture using re-circulating aquaculture systems (RAS). However, wider adoption of such technologies is expected to take sometime due to higher levels of required expertise and investment.

By 2010, there were 10 383 ha of cockle farms, 285 540 m^2 of mussel raft culture, 364 908 m^2 of oyster raft culture, 1 988 744 m^2 of marine and brackish water floating cages, 7 722 ha of brackish water ponds and 182 097 m^2 of tanks for marine aquaculture throughout Malaysia. In addition, there were 1 311 ha of ex-mining pools and 53 ha of pens for freshwater fish stocking, 5 025 ha of freshwater ponds, 472 446 m^2 of freshwater cages, 398 186 m^2 of concrete tanks and 21 236 m^2 of canvas tanks for freshwater aquaculture. Besides that, Malaysia has 965 ha of ornamental fish farms and 7 940 ha of seaweed farms. The statistics also indicate a total of 26 291 fish farmers, of whom 19 946 farmers (75.87 percent) are involved in freshwater aquaculture and the remaining 6 345 farmers (24.13 percent) engaged in brackish water aquaculture.

The most important freshwater aquaculture species are Javanese carp, common carp, grass carp, big head carp, giant freshwater prawn, black tilapia, red tilapia, river carp, freshwater catfish, goby, eel, river catfish and giant snakehead as well as a few other species. On the other hand, the main species cultivated in marine and brackish water aquaculture are Asian seabass, mangrove red snapper, milkfish, grouper, golden snapper, Hawaiian white shrimp, tiger prawn, mud crab, red tilapia, red snapper, cockles, mussels, oysters, seaweeds and some other species. Based on production volume, seaweeds, cockles, white shrimp, seabass and tiger prawn represent the major cultured species for marine and brackish water aquaculture while freshwater catfish, river catfish, red tilapia, black tilapia and giant snakehead were the major species for freshwater aquaculture.

In 2010, total aquaculture production in Malaysia reached 581 048 metric tonnes valued at RM 2 798.74 million (US$888 million), an increase of 28.02 percent and 23.36 percent from the previous year in volume and value, respectively. Major production was from marine and brackish water aquaculture activity which contributed a total of 217 757.37 metric tonnes (37.48 percent) valued at RM 1 955.24 million (US$620 million, 69.86 percent) followed by seaweed with 207 892.40 metric tonnes (35.78 percent) valued at RM 83.16 million (US$26.4 million) and freshwater aquaculture with 155 398.63 metric tonnes (26.74 percent) valued at RM 760.34 (US$241.1 million, 27.17 percent).

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Malaysia's aquaculture sector faces several common challenges. Some of the biggest relate to access to land and water resources, access to adequate feed (fishmeal, fish oil and low-value/trash fish), access to capital, access to markets, greater capitalization and diversification of production systems and species, environmental management, rising energy costs, human resource development, research and development needs, information and communication technologies and networking, sound policies, governance and government support.

Aquaculture production will need to expand significantly over the coming years in order to bridge the increasing gap between demand and supply for fish and fishery products due to increasing actual demand and the declining contribution from capture fisheries. Thus, it is imperative to ensure and enhance sustainability of aquaculture practices both in water bodies and on land. Application of APMTs offers an important approach to address many of these issues, especially those related to environmental impacts and sustainability of aquaculture operations.

6.2. Institutional and legal framework

In Malaysia, fisheries activities are governed under the Fisheries Act 317 (1985). Inland fisheries and aquaculture are regulated by the state authorities while marine fisheries and aquaculture fall under the purview of the federal government. The Department of Fisheries Malaysia (DOF) is responsible for developing and expanding marine and inland aquaculture. During the Third National Agriculture Policy (DPN3) covering the period from 1998 to 2010, an Aquaculture Industry Zone (AIZ) development program was introduced to encourage integrated expansion of commercial scale aquaculture activities.

The Malaysian Government also introduced the National Agro-Food Policy (2011-2020) to boost the country's agro-food industry and enhance its contribution to economic development. The policy's objectives are stated as follows:

a) Ensure food security and food safety;
b) Increase the competitiveness and sustainability of the agro-food industry;
c) Increase incomes for agricultural entrepreneurs.

In order to accommodate the policy, the Government established the Malaysian Quarantine and Inspection Services (MAQIS) to protect the country's agriculture from threats of pests, diseases and contamination. MAQIS incorporated quarantine, inspection and enforcement services covering plants, animals and fish.

In regard to the aquaculture component of the policy, the DOF responded by establishing the Fisheries Biosecurity Division to be responsible for Sanitary and Phytosanitary (SPS) requirements, mainly to ensure food safety as well as to prevent disease outbreaks in aquatic animals.

Malaysian legislation, standards and guidelines supporting the application of APMTs include the following:

a) Fisheries Act 1985 (Act 317)
b) Environmental Quality Act 1974
c) Malaysian Quarantine and Inspection Services Act 2011
d) Malaysian Standard Good Aquaculture Practice (GAqP) – Aquaculture Farm – General Guidelines (MS 1998: 2007)
e) Malaysian Aquaculture Farm Certification Scheme
f) Guidelines for Good Aquaculture Practice.

Malaysia also refers to other regional and international standards as follows:

a) CODEX Alimentarius
b) World Organisation for Animal Health (OIE)
c) FAO Technical Guidelines for Responsible Fisheries
d) ASEAN Guidelines on Development of Standard Operating Procedures for Health Certification and Quarantine Measures for the Responsible Movement of Live Food Finfish
e) ASEAN Shrimp GAP.

6.3. Summary of APMTs application in Malaysia

The evaluation is based on the evaluation framework and criteria stipulated in Table 18.

6.4. Case studies on AATs application

6.4.1. Import risk analysis (IRA)

IRA was introduced to complement sanitary and phytosanitary (SPS) measure in Malaysia. IRA comprises two major sections-ecological risk analysis and pathogen risk analysis. Ecological risk analysis focuses on the invasiveness and pest potential of the species to be introduced and considers the likelihood of its escape and/or release into the natural environment as well as the nature and extent of any potential ecological impacts such escape or release may cause. Meanwhile, the pathogen risk analysis examines potential risks due to pathogen introduction along with the movement of the new species, identifies hazards (pathogens) requiring further consideration, and recommends ways to reduce the risk of their introduction to an acceptable level. IRA is conducted prior to introduction of the new exotic aquatic animal species into the country.

IRA is conducted by the Technical Working Group (TWG) on the Introduction of Alien Species into Malaysia. The TWG operates under the Fisheries Biosecurity Division, DOF and is empowered under Section 40 of the Fisheries (Amendment) Act (2011), together with the Fisheries (Fish Disease Control Compliance for Exports and Imports) Regulation (2012). The tool aims to prevent imports of high risk aquatic animal species in order to protect native species and conserve aquatic biodiversity.

6.4.2. Health certification

Health certification is an SPS requirement to ensure the trading of disease-free aquatic animals and food that is safe for human consumption. Health certificates are issued for live aquatic animals, aquaculture products and aquatic animal feed materials based on importing country requirements. A health certificate is also required for importation of live fish into the country. Health certificates are issued by the Competent Authority of the exporting country and must conform to national requirements. Consignments are inspected at the entry point before being released into the country. The health certificate provides a declaration that the products have been inspected and verified by the relevant competent authority and conform to the hygienic and pathogenic standards imposed by that country. It is used by DOF, Malaysian Quarantine and Inspection Services (MAQIS) and other stakeholders.

The health certificate is also crucial to export activity. During exportation, inspection will be conducted by the competent authority and a health certificate issued prior to export. Implementation of this tool is underpinned by the Fisheries (Fish Disease Control Compliance for Exports and Imports) Regulation (2012).

6.4.3. Quarantine

Quarantine is also a crucial SPS measure established to prevent entry of pathogens into the culture system. Live aquatic animals that are imported, exported or obtained from other parts of the country are quarantined. This tool is applied primarily by DOF and MAQIS. Based on current practice, live aquatic animals are

Table 18 Summary of APMTs Application in Malaysia

Tool	Level of awareness[1]	Level of capacity[1]	Extent of use[2]	Supporting legal instruments[3]	Remarks
Planning Tools					
Aquaculture development-spatial planning/zoning (e.g. based on carrying capacity)	***b***	***b***	***d***	**No**	Government policy for aquaculture development
Environment impact assessment (EIA) of aquaculture operations	***c***	***c***	***b***	**Yes**	– Limited to farms exceeding 50 ha – Catchment areas
Ecological risk analysis (genetics/biodiversity)	***a***	***a***	***c***	**Yes**	Incorporated into IRA
Social impact assessment	***a***	***a***	***c***	**No**	Socioeconomic aspect (standard of living; income)
Import risk analysis (IRA) for introducing new species for aquaculture	***a***	***a***	***c***	**Yes**	For importation of new species into the country
Others e.g. life cycle analysis (LCA), greenhouse gas (GHG) emissions, carbon footprint studies	***None***	***None***	***a***	**No**	General study on climate change (impact, mitigation, adaptation)
Management Tools					
Risk analysis	***None***	***None***	***None***	***None***	Covered under IRA and EIA
Health certification	***c***	***c***	***c***	**Yes**	For import and export control
Quarantine	***c***	***c***	***e***	**Yes**	Requirement for import and export
Disease surveillance and early warning system	***c***	***c***	***c***	**Yes**	Disease control and commitment towards WTO/OIE
Residue inspection and monitoring	***c***	***c***	***e***	**Yes**	National monitoring program for aquaculture residue
Record keeping and traceability	***c***	***c***	***e***	**Yes**	Part of the certification program (SPLAM, SAAB, FQC)
Input quality assessment and monitoring	***c***	***c***	***c***	**Yes**	Broodstock, seed, feeds
Production process (e.g. public/private certification)	***c***	***c***	***c***	**Yes**	Certification program (SAAB, SPLAM, FQC)
Farm management tools (e.g. BMP/GAP)	***b***	***b***	***d***	**No**	Government development policy (MS 1998: 2007-voluntary basis)

Notes:

[1] Levels: ***a*** – policy makers and scientists at the national level; ***b*** – policy makers, scientists, at the provincial level; ***c*** – all stakeholders at local level except farmers; ***d*** – all

[2] Extent of use: ***a*** – never used; ***b*** – used in some projects; ***c*** – used at national level; ***d*** – used at provincial level; ***e*** – used at local level

[3] Supporting legal instruments: Yes; no; under development

required to be quarantined for certain periods of time, depending on species, and to be monitored for any clinical signs during the quarantine period before being released for export or stocking into the aquaculture system. This tool is supported by the Fisheries (Fish Disease Control Compliance for Exports and Imports) Regulation (2012) and the Malaysian Quarantine and Inspection Services Act (2011). By applying this tool, the Competent Authority (CA) can continually update its knowledge of fish diseases, clinical signs and refine its database on fish diseases and their occurrence.

6.4.4. Disease surveillance and early warning system

The basis for development of this tool is to complement the SPS requirements. A disease surveillance program is conducted for aquatic animals (shrimp, ornamental fish, and food fish) to control disease outbreaks and emerging diseases in the country. DOF is the main implementer of this tool. Active surveillance is conducted on certain OIE-listed diseases on a regular basis, covering KHV, SVC, WSSV, IHHNV, TSV, YHV, IMNV, bacteriology, parasitology. Meanwhile, the stakeholders are responsible for informing the CA when there is an incident of mass mortality on the farm. This program is supported under the Fisheries (Fish Disease Control Compliance for Exports and Imports) Regulation (2012).

This tool helps providing the CA with updated information on disease status at any administrative or geographical level, preventing disease outbreak and enhancing the knowledge and competency of the CA. However, close coordination between the CA and researchers is important for effective application.

6.4.5. Environmental impact assessment (EIA) of aquaculture operations

EIA was developed for environmental protection and to reduce land use conflicts among stakeholders. EIA is mandatory for proposed development of land areas exceeding 50 hectares for aquaculture, and for catchment areas and enclosed water bodies. EIA is an important tool for sustainable aquaculture development, and is implemented by public and private organizations proposing large-scale aquaculture operation. EIAs are performed by appointed independent consultants. The EIA report is submitted to the Department of Environment Malaysia (DOE) for approval.

In Malaysia, EIA is underpinned by the Environmental Quality Act 1974 which is currently enforced by the DOE. Project development and operation must comply with guidelines provided by the DOE in order to reduce environmental impact, minimize social conflict and maintain the sustainability of the aquaculture operation.

6.4.6. Ecological risk analysis (genetics and biodiversity)

This tool has been incorporated as a component of Import Risk Analysis (IRA).

6.4.7. Residue inspection and monitoring

Residue inspection and monitoring is also part of the SPS requirement. Malaysia has established two monitoring programs, the Aquaculture Residue Monitoring Plan (ARMP) and SPS Aquaculture to monitor chemical residues in aquatic animals (finfish and shrimp for human consumption) for export. Currently, both are implemented primarily by DOF as the Competent Authority. Sampling and analysis are conducted for chemical residues (nitrofuran, chloramphenicol, malachite green, stilbene, steroids, etc). Stakeholders are also required to send samples for analysis (part of the 'own check' procedure). This tool is supported under the Fisheries (Quality Control for Export to the European Union) (Amendment) Regulations (2010), the Food Act (1983) and Food Regulations (1985).

This tool ensures that aquaculture products for both export and local markets are safe for human consumption, and that products destined for export comply with importing country requirements. The tool contributes to reducing the number of consignment rejections at the border post of the importing country and ensuing economic losses.

6.4.8. Aquaculture development – spatial planning/zoning

The Malaysian government's policy is to develop aquaculture in a structured manner to ensure sustainability. The Department of Fisheries (DOF) identified potential areas for aquaculture operation, which were allocated as Aquaculture Industrial Zone (AIZ) for commercial aquaculture operations. The purpose of the AIZ is to facilitate a large-scale integrated approach to aquaculture as well as to minimize adverse impacts on other industries and vice versa. The list of AIZ is updated periodically.

DOF first identifies the proposed AIZ and requests the approval of the respective State Government. Following approval, DOF will produce a prospectus for promotion to private sector stakeholders. Interested parties may then approach DOF for advice and apply for the area of concern from the State Government. Finally, DOF provides letters of support for land application, basic infrastructure and technical assistance to the stakeholder. Nevertheless, there is no specific legal underpinning for application of this tool.

Application of AIZ contributes to increasing aquaculture production, providing expedited approval of land use permits for aquaculture activities, and reduced likelihood of conflicts over land usage. Meanwhile, cooperation between federal and state governments in terms of land usage for aquaculture purpose is also important. Besides that, promotion of AIZ is also important to raise awareness of aquaculture operators on responsible and environment friendly aquaculture practices.

6.4.9. Record keeping and traceability

This tool is the basis for audit and verification for all aquaculture facilities registered and approved under the DOF, and provides assurance that the facility complies with the standards and conditions set by DOF. Aquaculture operators are required to prepare and retain their operational records (e.g. feeding, stocking, harvest, treatment, pest control, etc), supplier guarantee, workers' medical reports and other information required for traceability. Implementation of this tool is supported under the Fisheries (Quality Control for Export to the European Union) (Amendment) Regulations (2010). The tool helps ensure that aquaculture farms are managed professionally and are organized so they are able to provide farm-level data to facilitate the DOF's ongoing monitoring process.

Application of this tool means that the CA is able to trace back any consignments of non-conforming product. It is however important to raise awareness among aquaculture farmers of the importance of proper record keeping.

6.4.10. Production process (e.g. public and private certification)

This tool is developed to facilitate market access for Malaysian aquaculture products. DOF offers certification (e.g. SAAB, SPLAM, and Fish Quality Certificate (FQC)) for aquaculture facilities (farms, cages, importer/exporter premises) that conform to the standard set by DOF. The certification provides assurance to buyers that certified aquaculture products are safe for human consumption and disease-free. The aquaculture facility will be inspected and audited before granting certification. Subsequently, surveillance audits are also conducted during the validity period to ensure the farm maintains compliance with the standard; when renewal becomes due, re-certification audits are conducted to re-evaluate the farm for renewal of the certificate.

This tool is supported under the Fisheries (Quality Control for Export to the European Union) (Amendment) Regulations (2010). The tool contributes to increased confidence among buyers, particularly in export markets, and thus contributes to market access as well as directly to food safety and quality.

6.4.11. Social impact assessment

This tool was developed mainly to identify and pre-empt potential social conflicts among resource users, and is included as a criterion in the aquaculture farm certification program. Evaluation of the social impact of aquaculture operations is based on needs and takes into account socio-economic indicators such as the number of farmers, farm area per farmer, incomes, standard of living, level of education and contribution to the national economy. As well as its value in analysing specific situations, the tool can also make an important contribution to the process of strategic planning for the country's aquaculture development. This tool is mainly applied by regulators such as DOF as well as other government agencies and ministries. DOF appoints an independent consultant to conduct the study, and study outcomes are incorporated as an integral component of planning and policy-making. Nevertheless, as yet, there is no legal underpinning for application of this tool.

6.4.12. Input quality assessment and monitoring

This tool is based on the principles of Good Aquaculture Practice and the certification program established by the DOF. An official control program for imported and locally produced aquaculture feed, seed and broodstock has been established to ensure that imported feeds are safe for feeding and that seed and broodstock are disease-free.

Imported aquaculture feed must be accompanied by a guarantee letter from the supplier. A monitoring program (sampling and analysis) is also conducted by DOF to ensure that feedstuffs on the market are free from prohibited substances. Meanwhile, DOF also conducts assessments for imported seed and broodstock, based on documentation provided by the exporting party. Onsite verification may also be conducted at the exporter's establishment if deemed necessary. An official control program for local hatcheries is also in place. This tool is supported by the Fisheries (Quality Control for Export to the European Union) (Amendment) Regulations (2010) and the Animal Feed Act (2009).

6.4.13. Farm management tools (e.g. BMP/GAP)

This tool was also developed to facilitate market access for Malaysian aquaculture products. Aquaculture farms are managed according to Malaysian Standard Good Aquaculture Practice (GAqP – MS 1998: 2007) which includes stocking, feeding, culture practice, water management and other aspects. The purpose of this tool is to increase sustainability and competitiveness of Malaysia's aquaculture products in both domestic and international markets. The tool is applied by the DOF and targets private sector aquaculture operators.

GAqP is incorporated into the aquaculture certification scheme offered by DOF. MS 1998: 2007 (GAqP); guidelines for good aquaculture practices in various aquaculture systems have been published and distributed to the private sector by the DOF. It is a voluntary scheme and as yet there is no legal support for its implementation. Farms that comply with the MS 1998: 2007 (GAqP) will be certified under Malaysian Aquaculture Farm Certification Scheme (SPLAM) and Certificate for Good Aquaculture Practice (SAAB) by DOF.

6.4.14. Others: life cycle analysis (LCA) greenhouse gas (GHG) emissions, carbon footprint studies

These tools are currently not applied in Malaysia.

6.5. Issues and constraints in the application of tools

The following issues and constraints were identified during the assessment:

- Not all tools are supported by legislation. Most are currently implemented on a voluntary basis and rely much on the awareness, cooperation and sense of collective responsibility of aquaculture operators. Application of the tools may be enhanced by the establishment of legal mandates.
- Lack of public awareness: mass media gives little emphasis to the importance of these tools. Promotion programs should be conducted more systematically through mass media, training, etc.

- Lack of institutional support in terms of budget contributions. In some cases implementation of the tools is not prioritized by the related bodies.
- Lack of human capacity, expertise and skills to implement the tools.
- Lack of guidelines or handbooks on the tools for reference by aquaculture operators.
- Overlapping jurisdiction over the resources between the federal and state government.

6.6. Recommendations and way forward

6.6.1. At national level:

- ***Legislation and regulation:*** Currently, there is only one regulation, namely the Fisheries (Marine Culture System) Regulations (1990) which governs the marine culture system operating in the sea and lagoons. The regulation on aquaculture is at its final stage of development and is expected to be gazetted soon. This legislation on aquaculture will be important in governing application of APMTs and should be expedited.
- ***Certification:*** There is a need to consolidate all voluntary certification programs to improve clarity and reduce the compliance burden for aquaculture farmers.
- ***Awareness and promotion:*** In order to increase public awareness, the Government and the DOF should give increased priority to promotion through seminars, road shows and mass media to educate the public on the importance of APMTs.
- ***Strengthening institutional support:*** The Ministry of Agriculture and Agro Based Industry Malaysia (MOA) have established Malaysian Quarantine and Inspection Services (MAQIS) as well as the Fisheries Biosecurity Division under DOF to support application of APMTs. However, the government should place greater emphasis on capacity building for the staff of these organizations in order to strengthen institutional support.

6.6.2. At regional level:

- ***Cooperation and collaboration*:** All member countries in the region should increase cooperation to address regional problems such as illegal transboundary movement of exotic and invasive aquatic animal species between countries.
- ***Exchange of information:*** Networking among stakeholders in the region should be encouraged in order to promote cooperation and exchange of information on application of APMTs. This activity could be coordinated and facilitated by regional bodies such as NACA and SEAFDEC.
- ***Capacity building:*** Capacity building programs for stakeholders and government extension staff will be important in order to upgrade their knowledge and skills on application of APMTs. The programs could be coordinated and organized by NACA and other regional bodies.
- ***Handbook:*** A handbook on application of APMTs should be developed by the regional body for used as a guideline by stakeholders and government officers.

6.6.3. Way forward

Application of APMTs should be made mandatory to promote wider adoption for responsible and sustainable aquaculture development as well as sustainable intensification. Where possible, this could be expedited through legal or regulatory amendments to incorporate APMTs into existing national regulations and international standards.

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7. COUNTRY REPORT: PHILIPPINES

Aquaculture assessment tools: Philippines

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7.1. Introduction

The Philippine archipelago comprises 1 700 islands, with 42 027 barangays or communities as the smallest Local Government Unit (LGU) within 1 497 municipalities, 137 cities and 80 provinces. The island group is divided into three (3) major clusters of geographical and ethnic boundaries – Luzon, Visayas and Mindanao which are further subdivided into fifteen (15) administrative regions. Bounded on the north by the Babuyan Channel, on the south by the Celebes Seas, the Pacific Ocean on the east and the South China Sea on the west, the country possesses a total coastline of 34 289 km, longer than the United States. Endowed by vast marine and inland resources comprising swamplands, lakes, rivers, reservoirs and estuarine areas, the fisheries sector plays a vital role in the agro-fisheries economy of the country, contributing at least 2.0-2.4 percent of total GDP at current and constant prices.

Aquaculture contributes almost 50 percent of the country's total production of 2.5 tonnes of fisheries products, valued at US$1.97 billion in 2010. The sector comprises 226 298 registered operators (according to the 2002 national census) including freshwater, brackish water and mariculture production. Among the major aquaculture species produced in 2010, seaweeds ranked top at 1.8 tonnes, followed by 349 432 tonnes of milkfish, 258 840 tonnes of tilapia and 50 928 tonnes of shrimps/prawn and 85.5 tonnes from minor farmed produce.

Aquaculture in the Philippines incorporates three distinct resource environments, freshwater or inland aquaculture, brackish or estuarine farming and sea farming or mariculture. There are at present forty-one (41) known farming technology practices being employed in the industry, ranging from state-of-the-art capital-intensive systems to traditional small-scale farming systems. Farming systems and level of intensification vary according to stocking density and farming environment.

In 2010, farmed seaweeds by far remained the top export commodity next to tuna fisheries. Other cultured species such as crustaceans and finfishes including ornamental fish were also among the country's top aquaculture exports. Trade in aquaculture products is generally stable in the local market, yet there are trade practices and imbalances which remain unresolved in the various domestic settings. Increasing costs of farm inputs including fuel prices are key factors. Trade concerns linked to management, sustainability and food safety are complicating issues under GATT and TBT, SPS and HACCP, which significantly affect local production in the aquaculture industry.

Full development of the potential of the aquaculture sector has yet to be accomplished in view of a variety of problems ranging from lack of availability of high-quality brood stock/fry/fingerlings, limited access to credit by small farmers, high input costs, data gaps, local and international market access constraints, lack of private sector participation, food safety and quality constraints, lack of appropriate aquaculture information management systems, inadequate regulatory frameworks and lack of focused research and protocols on environmental degradation, and climate change impacts. Hence, a proper assessment of the key tools needed in aquaculture is timely and relevant to resolving these current and emerging issues.

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7.2. Institutional and legal framework

Application and adoption of aquaculture planning and management tools (APMT) in the Philippines are mandated by national legislation which is periodically updated and amended over time due to changing trade and market pressures, calls for modernization, technology advancements and changes in the ecosystem and farming environment. The legal basis of assessment tools in aquaculture rests with the Philippine Fisheries Code of 1998, a Republic Act providing for the development, management, and conservation of fisheries and aquatic resources, integrating all laws pertinent thereto.

7.3. Summary of APMTs application

While most of the APMTs require some degree of compliance with existing national regulations and international trade agreements or protocols, overall current implementation of the APMTs covered in this study at country level can be classified in terms of voluntary and obligatory instruments. Thus, whilst a given tool may appear to be a regulatory procedure requiring legislation, most of the tools as currently applied do not compel aquaculture producers to comply with the tools at all levels of production. This is particularly the case for small- and/or medium-size enterprises (SMEs). The tools mostly target large-scale commercial producers, especially those engaged in production for export.

A country level summary of the current status of application of aquaculture tools is presented in Table 19. The table shows the actual activities in aquaculture where specific tools are applied congruent to frontline services rendered or extended by the Bureau of Fisheries and Aquatic Resources (BFAR) in the aquaculture sector. Most of the common tools applied appear in terms of registration, certification, monitoring, assessments, evaluation, inspection, clearances, accreditations, analysis, permits, implementing rules/regulations, training and information.

7.4. Case studies in application of AATs

7.4.1. Registration and accreditation

Certification for Hazard Analysis and Critical Control Points (HACCP) Recognition/Accreditation – This assessment tool has general application, not only to farm level producers but also as a compulsory requirement to fish processing plants, IPCS, FVs (refrigerated/non-refrigerated) and for buying stations and auction markets that receive farmed fish and fishery products. The tool requires the issue of LTO by BFAD, GMP, generic GAqP and SSOP under the HACCP plan, a Sanitary Permit from the LGU, together with endorsement of BFAR authorities from the regional/provincial source of commodities. These requirements are outlined in a Fisheries Office Order No. 131 on HACCP recognition application compliant with EU export requirements and non-EU markets. There are no fees required (per EO.564) but the process takes approximately 25 working days. The process is in regular operation and is regarded as an effective regulatory instrument.

In issuing the Certificate of HACCP Approval and the Certificate of Recognition for HACCP, the following procedures apply:

- **Implementation and Certificate of Inspection** – These certification tools are issued once or twice a year and require obligatory inspection of farm facilities, processing establishments and IPCS which do not require fees. Processing takes a day and a half with no application fee. The documentation requirements (i.e. HACCP certificates, etc.) are also prerequisites to product export to EU but are essentially applicable and routinely utilized for domestic market FQAS standards.
- **Registration Certificate of Aquaculture Farms Supplying Raw Materials to EU** – This farm certification tool requires compulsory registration of aqua-farms engaged in raw materials production destined for EU markets, which has to be endorsed by BFAR authorities from the producing province. Prerequisites to the certificate of registration are the obligatory hygiene inspection report, laboratory

Table 19 Summary of application of APMTs in the Philippines

Tool	Level of awareness[1]	Level of capacity[1]	Extent of use[2]	Supporting legal instruments[3]	Remarks
Planning Tools					
Aquaculture development-spatial planning/zoning (e.g. based on carrying capacity)	***d***	***d***	***c, d, e***	Yes	Applied in mariculture park/zonation development plan in inland cages
Environment impact assessment (EIA) of aquaculture operations	***d***	***d***	***c, d, e***	Yes	Required in all aquaculture project development
Ecological risk analysis (genetics and biodiversity)	***d***	***d***	***c, d, e***	Yes	Screening/genetic marking and monitoring of both indigenous and exotic species
Social impact assessment	***d***	***d***	***c, d, e***	Yes	Part of EIA
Import risk analysis (IRA) for introducing new species for aquaculture	***d***	***d***	***c, d, e***	Yes	Screening of introduced species
Others: life cycle analysis (LCA), greenhouse gas (GHG) emissions, carbon footprint studies	***a***	***a***	***b, c***	No	Knowledge and awareness at the national level but rarely applied in aquaculture projects/activities
Management Tools					
Risk analysis	***d***	***d***	***c, d, e***	Yes	Obligatory for import
Health certification	***d***	***d***	***c, d, e***	Yes	Obligatory for both import/export
Quarantine	***d***	***d***	***c, d, e***	Yes	-do-
Disease surveillance and early warning system	***d***	***d***	***c, d, e***	Yes	Regular on-farm monitoring/sampling conducted
Residue inspection and monitoring	***d***	***d***	***c, d, e***	Yes	-do-
Record keeping and traceability	***d***	***d***	***c, d, e***	Yes	Required under HACCP and Organic Aquaculture program
Input quality assessment and monitoring	***d***	***d***	***c, d, e***	Yes	Required under HACCP and GAqP
Production process (e.g. public and private certification)	***a***	***a***	***b, c***	No	Existing but not widely adapted (e.g. ASA for shrimp producers)
Farm management tools (e.g. BMP/GAP)	***d***	***d***	***c, d, e***	Yes	Good Aquaculture Practices (GAqP) being developed/ applied

Notes:

[1] Levels of awareness/capacity: ***a*** **–** policy makers and scientists at the national level; ***b*** **–** policy makers, scientists, at the provincial level; ***c*** **–** all stakeholders at local level except farmers; ***d*** **–** all

[2] Extent of use: ***a*** – never used; ***b*** – used in some projects; ***c*** – used at national level; ***d*** – used at provincial level; ***e*** – used at local level

[3] Supporting legal instruments: Yes; no; under development

analysis of sampled harvested fish products, disease surveillance and monitoring report. There are no fees applicable but processing takes about 21 days. Antibiotic residue analyses are the main regulatory measures controlled via application of these tools upon satisfactory compliance with the above-mentioned requirements.

- **SPF/SPR *Penaeus vannamei* and *Penaeus monodon* Hatchery Accreditation** – This assessment tool requires obligatory facility inspection to ensure compliance with biosecurity measures prior to issue of the accreditation certificate. Hatchery operators must also submit a letter of intent to engage in *P. vannamei*/*P. monodon* fry production using SPF/SPR breeders. In addition, the applicant must submit a business permit, SEC registration, SOP and management system with organizational structure together with the building layout as supporting documents for the application. There are no fees prescribed but the processing takes up to 14 working days. These regulatory measures are compliant with Fisheries Administrative Order 225 on importation of *P. vannamei* broodstock for the culture of off-spring to safeguard diseases outbreaks.
- **Registration Certificate for Live Food Fish Exporters** – This certification tool applies to both farmed and capture fisheries products intended for export. It requires a letter of intent and application of the exporter supported by SSOP, business license from the DTI or SEC registration, plant layout of the facilities, sketch of the location of the holding facilities and laboratory analyses of product samples for export. No fees are required and processing takes up to 17 working days. Facilities inspection is compulsory plus the basic laboratory analyses of sampled live commodities for exports. Certificates of origin and hygiene, registration of facility, report of laboratory test and other supporting documents are also required by the importing country.

7.4.2. Chemical and microbiological tests

Fisheries Product Testing – The tests target both capture and farmed fishery products intended for export submitted by fish processors and exporters for chemical and microbiological testing. The test laboratory requires fish samples of 500-1 000 g packed in fresh-chilled or frozen form and kept in iced clean insulated containers. The tests are used to support certification, industry self-monitoring, BFAR verification and monitoring, and to provide technical assistance. The tests cover physico-chemical analysis, microbial and toxicological examination and physical/sensory examination for fresh/frozen, processed and canned fish and fishery products. Laboratory fees are applicable, and the process takes 7-10 working days. The tests are compulsory under the provisions of FAO 213 and require a sample collection form.

Fish Health Management and Quality Assurance – This laboratory test corresponds to a complete Fish Health Certification from biological, physico-chemical, histopathological, molecular, parasitic, bacterial and drug residue analysis of fish samples of farmed fishes (particularly prawn fry) intended for domestic and export markets. The tests are compulsory for exporters and feed millers, but non-obligatory for farmers supplying domestic markets. The procedures take 3-10 working days, and require samples for analyses and corresponding fees.

Analytical Tests for Marine Biotoxins – The analyses are compulsory for processors and exporters of farmed fishes, shellfish and other fishery products to detect ciguatera fish poisoning (CFP), paralytic shellfish poisoning (PSP), ASP, DSP, TTX, cyanide and plankton, particularly for live farmed and capture fishes which require live fish samples and prior health inspection certificate. The procedures take up to 3 working days from acceptance of samples and require payment of laboratory fees.

7.4.3. Sanitary and phytosanitary tests

Sanitary and Phytosanitary (SPS) clearance to import fresh/frozen fishery products – Obligatory requirements for importers of fresh/frozen/chilled fishery products (farmed and catch fisheries) requiring laboratory analysis for shrimps, EU catch certificate, distribution, processing, canning, production reports and delivery receipts. Import requisites under FAO 195, 205, DA-AO No. 8, Series of 2009, FAO 220 and

BFAR Memorandum Order No. FRQD-2 of 2007 are subject to prescribed certification fees for a 1 day documentation process.

SPS clearance for import of live fishes and fishery products – Compulsory requirements for live fishes and fishery/aquatic products importation (e.g. koi, arowana for ornamental purposes and bangus fry/vannamei PL for grow-out production) requiring SEC/DTI/BIR registration and mayors' permit. Applicants must apply personally and submit ID during application, along with Cites Certifications of species being imported from the country of origin. Prescribed fees apply for SPS clearance issuance, with 1-hour processing. Legal basis: RA 8550; FAO 225, s.2007-2008; Fisheries General Memorandum No. 1-04.

Issuance of health certificates for in-country trans-boundary movement for live shrimps and seaweeds for aquaculture purposes – Health certificates for in-country transboundary movements are required for seaweed farmers, hatchery operators, technicians, sales agents and ancillary industry practitioners. The procedure requires compulsory laboratory analyses, traceability profiles, shrimp fry source and grow-out certificates, as well as BFAR-accredited hatchery compliance certificate. Prescribed fees are applicable, with a maximum 15 hrs processing time.

Health certificates for export of live food fishes and tropical marine ornamental fishes – This is a compulsory requirement for exporters of live food fish (farmed/catch) and tropical marine ornamental fish intended for export. Applications require submission of export declaration, laboratory analysis, registration certificate and invoices. No fees are required and processing takes a maximum 2 working days. The certificate is required for compliance with importing country requirements.

Issuance of sanitary/health certificate for accredited exporters to international markets – This is a compulsory requirement for exporters of fish and fishery products intended for human consumption (except live fishes). Processing takes a maximum of 2 working days and no fees are levied. Required documentation includes pre-shipment inspection report, packing list, product test report issued by BFAR and accredited laboratories with the letter of application for sanitary health certificate issuance. The process flow of certification is illustrated in Figure 11 below.

7.4.4. Export permits and related clearances

Permit for export of fresh/frozen/chilled fishery products – This is an obligatory requirement for exporters of fresh/frozen/chilled farmed/catch fishery products. A permit requires supporting documentation including export declaration, EU health certificate, quarantine certificate, proforma invoice, mayor's permit, and BIR/DTI/SEC registration of exporters with corresponding application for export permit. No fees are levied as per Executive Order No. 554. Processing of applications takes one hour.

Export Commodity Clearance (ECC) – This is a compulsory requirement for exporters of fish and fishery products (farmed and catch, including shell-craft and ornamental shells (except fresh, chilled and frozen products and those exported to EU, which require HACCP accreditation and an assigned EU approval number). There are no fees for the clearance, but documentation is required for non-commercial export (e.g. for personal use, samples for scientific research, etc.) and ECC application form, export declaration, invoice/packing list and product/commodity samples in lieu of on-site inspection of export commodity, together with relevant documents as may be required by the importing countries. Export registration certificates, health certificates, inspection report of holding and packing facilities, LGU certification from source for farmed/propagated or hatchery bred live food fish and crustaceans/live ornamental fish are required by BFAR, including DOH-Quarantine Certificate on laboratory analysis.

Clearance for outgoing fish and fishery products via domestic/international airports – Clearance documents are required at ports of entry/exits of international/domestic airports for shippers, exporters and outgoing passengers engaged or bringing in/out of the country or for inter-country transboundary shipments of all fish and fishery products (catch/farmed, frozen or live). Clearance requires the shipper's commodity

Products Covered: canned tuna, canned sardines/mackerel, sardines in glass jar, fresh/frozen octopus, whole roundscad, fresh/frozen black tiger prawn (whole, headless), fresh/frozen milkfish products (deboned, smoked and marinated, fresh/frozen tuna loins, cuts and steak, pasteurized salted tiny shrimp (shrimp paste), fresh/chilled fish/fishery products and fermented fish (fish sauce or fish paste).

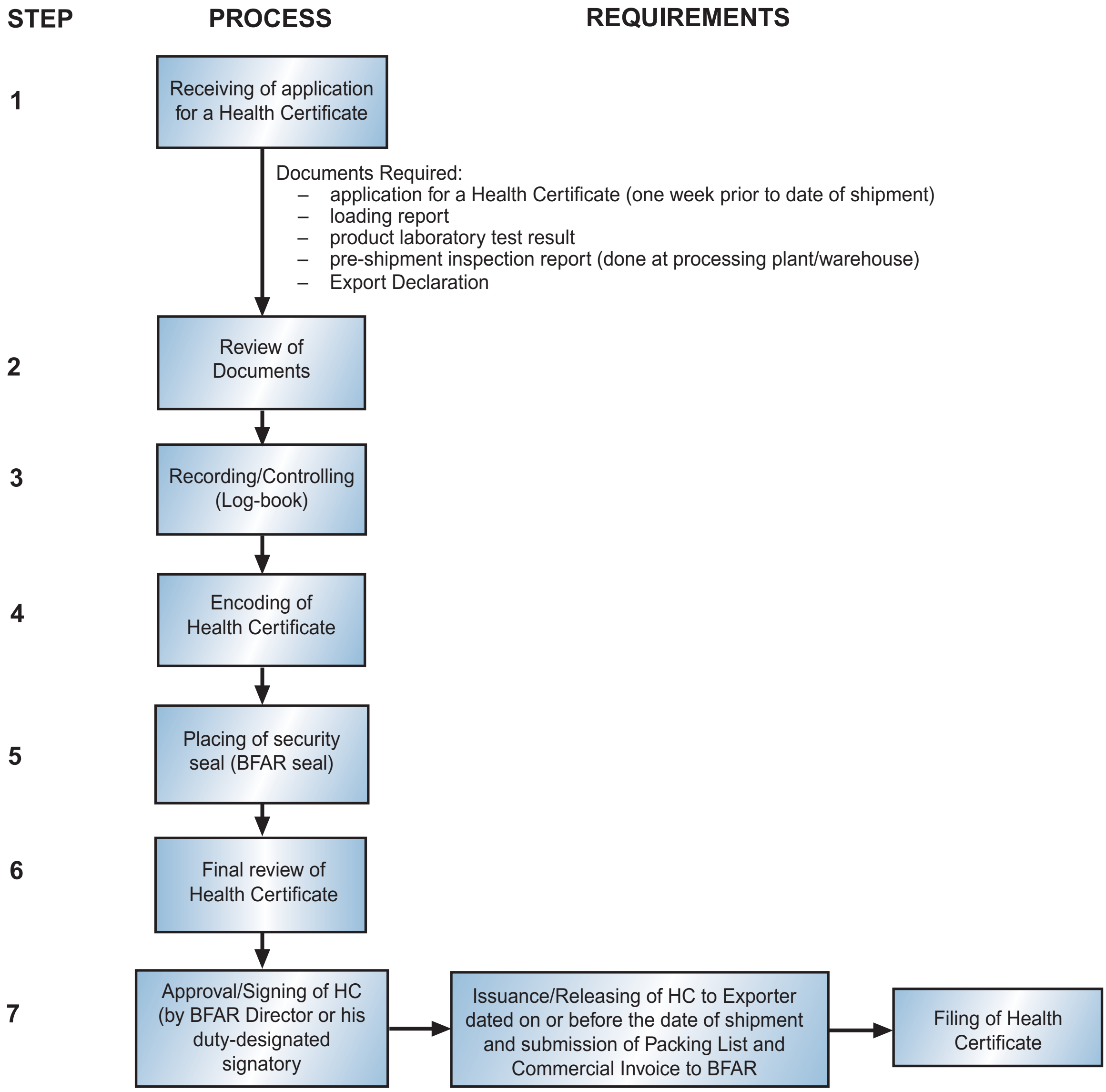


Figure 11 Process Flow for the Issuance of Sanitary/Health Certificate for Fishery and Aquaculture Products

(Issuing Unit: Administrative Support and Product Certification Unit – BFAR, and Regional Product Certification Units)

clearance, export permit, export declaration/invoice, airway bill and other importing country requirements. No fees are levied and applications are processed within one hour before the flight or upon arrival at the airports.

7.4.5. Import permits and related clearances

Inspection/clearance of imported/incoming fish and fishery products via domestic/intl. airports – Fish/fishery products brought in by importers and passengers require compulsory inspection or quarantine procedures at the airport of disembarkation. This requires import permit, aquatic animal health certificate or aquatic products sanitary certificates, Bureau of Customs entry and gate passes, airway bill and corresponding invoices. The inspection and clearing process takes one hour to complete. Fisheries quarantine officers operate on a 24/7 basis at the airport of disembarkation.

Pre-border assessment of compliance for live fish importation – Live fish importation, either for ornamental/aquarium purposes or for propagation, requires the importer to obtain importation documents, referrals from the fisheries regulatory and quarantine division of BFAR and routing slip or referral letter. No fees are levied but the procedure takes one month. Import risk analysis (IRA) and physical inspection of the proposed quarantine facilities are conducted by BFAR quarantine officers.

Assessment of compliance with post-border quarantine measures for imported SPF/SPR *P. vannamei* Broodstocks and *P. Monodon* post larvae – Post-border assessment is required for accredited hatchery operators engaged in the importation of *P. vannamei* broodstock or *P. monodon* seed stocks to comply with quarantine measures for imported SPF/SPR commodities for aquaculture purposes. The procedure takes 15 to 30 days processing without fees, but requires submission of import permit, 2 years' disease-free status certification from the competent authority (CA) in the country of origin, the disease history of the broodstock facility for the period covering the commercialization, laboratory results from authorized diagnostic laboratory, and airway bill. In case of delay, a certificate is also required, issued by the CA present at the airport, confirming that the cargo was not mixed with other cargoes. Appropriate inspection and monitoring of the broodstock/fry and holding facilities are also conducted, with samples taken for laboratory examination for the presence of serious diseases. Commodities testing positive for such diseases and contamination are immediately destroyed.

7.4.6. Licenses and permits

25-year Fishpond Lease Agreement (FLA) – Under the Fisheries Administrative Order 197, any Filipino citizens 21 years of age and above, fisher folk associations or cooperatives, registered SMEs, corporations registered and incorporated under Philippine law with 60 percent of the capital stock or interest owned by Filipino citizens are granted FLAs upon subscription to the scheduled rental fees, provided the following administrative requirements are met:

- Initial – Notarized application; sketch or survey plan of the area under application; certificate of initial available investment capital and certificate from the Forest Management Bureau of DENR that the area applied for is already classified for fishpond development purposes as duly placed under the jurisdiction, management and disposition of BFAR;
- Final – payment of the initial annual rental at PhP1 000/ha or fraction thereof, plus cash bond deposit of PhP100/ha; blueprint copies of the survey plan of the area; copy of the FLA forms duly approved by BFAR; certified copy that the area is not being subleased and that there is no pending judicial conflict filed in court; and Environmental Compliance Certificate;
- Others – In case of transfer of rights involving FLA, copy of deed of sale, deed of waiver for quit claim; deed of assumption of leasehold rights and interests of the Fishpond Area executed by the DBP or any financial institutions/banks where the rights are duly assigned.

Permit for collection of aquatic wildlife for research/scientific purposes – Permits for gathering, catching, gleaning and or collection of aquatic wildlife, whether for breeding, propagation, aquarium observation, demonstration or experimental purposes are likewise required from individual researchers, research institution or conservation organization, students affiliated with local academic institutions for thesis/dissertation research, government agencies conducting research or scientific projects, local academic institutions and NGOs engaged in fisheries/aquaculture research including foreign entities or Filipino citizens affiliated with foreign institutions. Applications must be accompanied by a letter of intent and the research proposal (to include lists of researchers and personnel involved, endorsement letter from the head of the institution, and the specific generic classification of the marine/aquatic animals to be collected from the wild). Inspection of the holding facilities, transport, and handling and collection methods is strictly monitored. Legal basis: RA 9147-Wildlife protection and Conservation Act (joint DENR-PA-PCSD Administrative Order No.1, s.2004).

Fisheries special permit for live aquatic wildlife – A special permit is required for importation, in-country trans-boundary movement, collection, gathering, catching, gleaning of aquatic wildlife for scientific propagation, breeding and other related purposes to corporations/associations/business enterprises, foreign entities or research institutions and NGOs involved in scientific/experimental research of aquatic wildlife. Proper documentation requires letter of intent, legal business documents, export permit from country of origin supported by CITES list as prerequisites to issuance of the permit, in compliance with and pursuant to RA 9174.

7.4.7. Fish farm/hatchery registrations/operations

Section 57 of the Republic Act 8550, otherwise known as the Fisheries Code of the Philippines, requires all fish hatcheries, fish breeding facilities and private fishponds to be registered with the LGUs which prescribe minimum standards for such facilities in consultation with BFAR. BFAR is required to conduct an annual inventory of all fishponds, fish pens and fish cages on private and public land. Moreover, all fishpond, fish pen and fish cage operators must report annually to BFAR the type of species and volume of production in areas devoted to aquaculture.

Production facilities are required to strictly comply with the FAO Code of Practice for Aquaculture, Good Aquaculture Practices and HACCP in aquaculture at the minimum level of compliance. Facilities are subject to regular monitoring, evaluation, inspection and sampling of stocks, especially for products destined for export. Establishments and onward operations of these aquaculture facilities must further conform with Section 12 (Environmental Impact Statement) of RA 8550 requiring all government agencies as well as private corporations, firms and entities intending to undertake activities or projects which may affect the quality of the environment, to prepare a detailed EIS prior to undertaking such development. The preparation of the EIS shall form an integral part of the entire planning process pursuant to the provisions of Presidential Decree No. 1586 as well as its implementing rules and regulations.

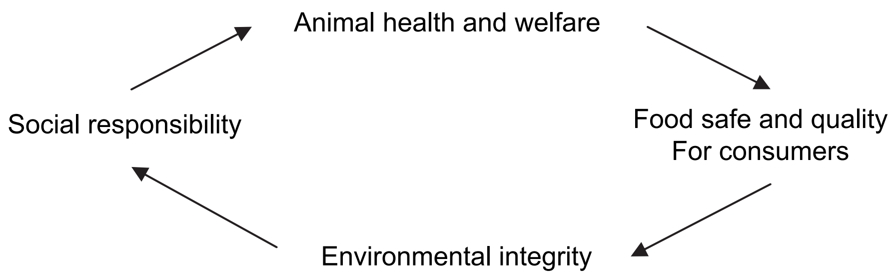
Likewise, Section 13 of RA 8550 requires all persons, natural or juridical, undertaking any development project to first secure an Environmental Compliance Certificate (ECC) from the Secretary of the DENR for review and evaluation. A joint BFAR-DENR inspection and monitoring team conducts pre/post-establishment assessments of these aquaculture facilities and regular evaluation of the aquaculture operations to ensure conformance with all environmental and good practice standards.

7.4.8. Certification, registration and accreditation of organic aquaculture farms, inputs and products

Presidential Decree 10068 mandates compulsory registration of organic aquaculture farms, certification of organic products and farm inputs and accreditation of certifiers engaged in organic aquaculture. The decree includes penal provisions for violations of the above requirements. Farm inspection, monitoring, evaluation and laboratory analysis are mandatory in the documentary process. The standard focuses on minimum requirements for management of aquatic animals and plants in order for the product to be labeled as 'Certified Organic'.

The formulation and implementation of Philippine National Standards on Organic Aquaculture and Good Aquaculture Practices aimed to ensure that aquaculture production processes address the following issues: a) animal health and welfare; b) food safety and quality; c) environmental integrity; and d) and social responsibility.

Development of credible certification schemes will develop verifiable performance indicators for aquaculture systems and practices that can verify compliance with the standard, following the food safety and quality assurance flow as illustrated below:



Within this framework, government (as regulators), producers and suppliers have the following responsibilities:

- Government – Provide education and training at all levels of the supply chain, particularly for small-scale, non-industrialized producers, in order to help them meet basic requirements of hygienic food practices and ensure the industry is able to fulfill its statutory obligations.
- Producers – Through the diligent application of food safety and quality assurance measures, producers must demonstrate the precautions taken to safeguard consumers through transparent documentation of farm operations in compliance with the Good Aquaculture Practice standard.
- Processors/exporters – The final seller is responsible for the safety and quality of the produce sold, and for conducting safety audits of their suppliers of farm produce.

7.4.9. Establishment of mariculture parks/zones

Mariculture parks and zones in the Philippines (see Figure 12) are designed for sea-cage finfish production of bangus, siganids, grouper and red snapper, as well as seaweed farming, aqua-silviculture, mussel farming, oyster culture, and sea ranching of lobsters and seahorses in coral reefs and seagrass areas. Other types of aquaculture may also be introduced via the R&D program of BFAR and other institutions. These zones and/or parks are community-based marina type projects, established in designated municipal waters with the involvement of local fisherfolk and their organizations. Mariculture parks are selected for their diverse and productive environments suitable for commercial mariculture development; their access to existing transport and storage infrastructure, ice plants, BFAR facilities as well as accessibility to input supply and markets.

The legal basis for establishing such mariculture zones is as follows:

- City/municipal ordinance
- Memorandum of Agreement between BFAR and LGU
- Lease agreements
- Environmental compliance certificate (ECC).

Operators may apply to establish a facility within the zone, subject to submission of the following requirements:

- Letter of Intent;
- Business/Operational Plan;
- Application form (3 copies);
- City/Municipal Business Permit;
- Mariculture Zone Lease

Figure 12 shows the location of mariculture parks/zones in the Philippines.

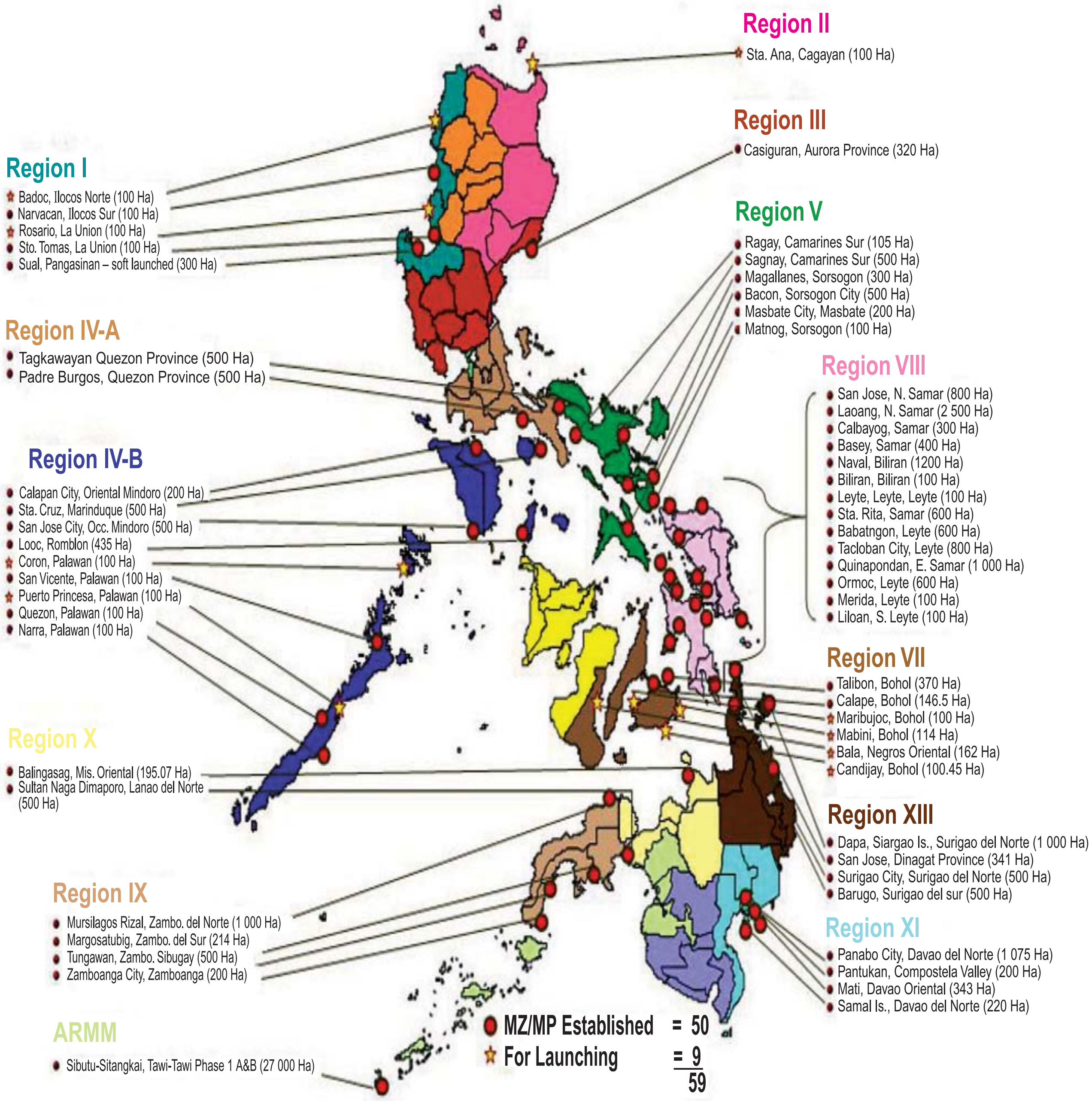


Figure 12 Location of Mariculture Park/Zones, Philippines (April, 2010)

The process of application and registration for lease takes the following steps;

- Filing of application form to the Executive Management Council (EMC) and payment of filing fee;
- Approval of the application by the EMC;
- Issuance of certificate of lease upon;
- Compliance of pre-registration requirements;
- Formal acceptance of the proposed terms and conditions of registration;
- Payment of registration fee.

7.5. Issues and constraints in application of tools

In general, the AATs covered in this report are grounded in regulatory measures supporting existing aquaculture program activities and front-line services delivered by BFAR by virtue of its mandates "to conserve, protect, manage, rehabilitate and regulate aquaculture productivity within ecological limits" for sustainable development and food security.

In practice, compliance of stakeholders with tool implementation is generally good, since all recommended applicable measures (i.e. regulations, guidelines, inspections, monitoring/evaluation) were already subject to prior public consultation and proper planning. The majority of tools support compliance with trade regulations as a requirement of importing countries and WTO agreements, while others support compliance with environmental, food safety, quality and health standards.

The practicality of applying AATs also enhanced the quality of administrative and technical assistance to clients and stakeholders, helping to increase resource productivity, improve use efficiency, and ensure long term sustainability of the country' aquaculture resources. Overall, the assessment tools are considered as beneficial both not only by planners, policy-makers and regulatory agencies that formulated and implement the tools, but also by the regulated sector.

Having enumerated the application of AATs in each of the particular program activities, some redundancies were evident, with many tools interacting or overlapping in their functions. A number of specific issues and constraints during implementation were also identified. It was also noted that most tools focus on medium and large-scale commercial entities, rather than small-scale farmers. Often, resistance towards technology adoption on the part of small-scale producers hampers their development; at the same time, many such producers complain of being neglected or excluded from government support measures.

The fees imposed in the course of application of various tools (e.g. analysis fees, permits, clearances, certification, registrations) are the most frequent reason for complaints from the private sector, which argues that such services should be provided at no cost to the sector, since it represents a major contributor to the national economy. The private sector has called for government subsidy of laboratory analysis fees, improvement and modernization of facilities, processing and documentation procedures. Compliance with mandatory requirements imposes a high compliance burden on producers, and the financial implications mean that only larger-scale producers engaged in product processing and exports can bear such a burden.

On the part of planners, policy-makers, managers and regulators the AATs are viewed as a dynamic process that must evolve to keep pace with technologies, markets and the physical environment. Accordingly, ongoing information updates, expertise upgrading and capacity building needs to be built into the system, for both producers and at the regulatory level.

7.6. Recommendations

7.6.1. At national level:

- Training and capacity building for scientists, regulators and policy makers;
- Modernization of laboratory and aquaculture facilities;
- Credit facilities for farmers;
- Public-private partnerships to enhance competitiveness;
- Inclusion of aquaculture in academic curricula.

7.6.2. At regional level:

- Regional standardization of tools;
- Categorize AATs according to applicable program/projects (e.g. regulatory, management, guidelines);

- Strengthening training and capability building needs;
- Classify which AATs should be made mandatory, and which should remain voluntary.

7.7. The way forward

AATs are formulated and implemented within the framework of the existing national aquaculture program and project activities. A legal framework is required in which to develop appropriate tools, some in the form of agreements (e.g. under the auspices of WTO), compliance with international market regulations (e.g. EC regulations), health and SPS protocols (e.g. OIE-based inspection/monitoring). Others will be subject to country-level regulation by way of national legislation, rules and regulations, Presidential directives and administrative orders.

Greater clarity is needed in areas open to misinterpretation, particularly in regard to application of HACCP, the FAO/Codex and the use of risk analysis and food safety tools.

While most AATs were found to be effective in their respective purpose, constraints such as human capability and incentives such as the absence of clear demonstrations of their benefits and incentives to end-users, remain as key underlying factors hampering further adoption and effectiveness. One priority thrust will be to validate AATs through a cost-benefit study and socio-economic analysis. In this way, the appropriate level of government subsidy, user fees and taxes imposed taxes may be more clearly established. Moreover, such studies will contribute to tool development, and provide rationale for elimination of those found to be impractical or ineffective. Overall, such measures will support the development of a more resilient, sustainable aquaculture sector that can contribute to national food security and meet the needs of producers as well as consumers.

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8. COUNTRY REPORT: THAILAND

Application of Aquaculture Planning and Management Tools for Sustainable Aquaculture Development in Thailand

Putth Songsangjnda[1]

8.1. Introduction

Thailand's capture fisheries continue to show a sharp year-on-year decline. The Department of Fisheries (2011) reported that from 1990-2009 capture fisheries products declined from about 2.5 million tonnes (89.34 percent of total annual production) to 1.9 million tonnes (56.9 percent, Table 20). This crisis is attributed primarily to stock depletion from over-fishing since the introduction of otter-board trawling in 1961 (Department of Fisheries, 2008). In contrast, aquaculture has grown rapidly over the same period from 297 000 tonnes (10.66 percent) to 1.4 million tonnes (43.1 percent), and plays a vital role in supplying fish products to meet both domestic and a growing export demand.

Table 20 Fisheries and aquaculture production for Thailand, 1990-2009

Year	Annual fisheries production (1 000 tonnes)				
	Total	Capture		Aquaculture	
		Amount	% of total	Amount	% of total
1990	2 786.40	2 489.4	89.34	297.0	10.66
1991	2 967.70	2 614.6	88.10	353.1	11.90
1992	3 239.80	2 868.4	88.54	371.4	11.46
1993	3 385.10	2 927.9	86.49	457.2	13.51
1994	3 523.20	3 007.0	85.35	516.2	14.65
1995	3 572.60	3 019.1	84.51	553.5	15.49
1996	3 549.20	2 994.5	84.37	554.7	15.63
1997	3 384.40	2 884.5	85.23	499.9	14.77
1998	3 505.80	2 911.3	83.04	594.5	16.96
1999	3 625.90	2 932.1	80.87	693.8	19.13
2000	3 713.20	2 975.2	80.12	738.0	19.88
2001	3 648.40	2 834.2	77.68	814.2	22.32
2002	3 797.00	2 842.4	74.86	954.6	25.14
2003	3 914.00	2 849.6	72.81	1 064.4	27.19
2004	4 099.60	2 839.6	69.27	1 260.0	30.73
2005	4 118.50	2 814.4	68.34	1 304.1	31.66
2006	4 053.10	2 698.8	66.59	1 354.3	33.41
2007	3 675.40	2 305.0	62.71	1 370.4	37.29
2008	3 204.20	1 873.4	58.47	1 330.8	41.53
2009	3 287.30	1 870.6	56.90	1 416.7	43.10

Aquaculture production has increased in both freshwater and coastal aquaculture environments, yielding an increase in domestic value from 17.356 billion baht in 1990 to 89.87 billion baht (US$2.7 billion) in 2009 (Table 21), with 74.1 percent and 25.9 percent contributed by coastal and freshwater aquaculture, respectively.

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Table 21 Value of fisheries products of Thailand, 1990-2009

Year	Annual value of aquaculture products (million baht)		
	Total	Coastal	Freshwater
1990	17 355.60	14 753.60	2 602.00
1991	23 331.30	20 362.10	2 969.20
1992	29 712.70	26 234.50	3 478.20
1993	37 693.00	33 603.40	4 089.60
1994	45 858.40	40 961.80	4 896.60
1995	46 327.30	41 038.80	5 288.50
1996	48 815.10	42 029.50	6 785.60
1997	56 353.80	50 399.00	5 954.80
1998	68 478.20	61 526.30	6 951.90
1999	78 455.60	70 502.50	7 953.10
2000	101 176.50	92 743.30	8 433.20
2001	77 851.70	68 571.90	9 279.80
2002	67 626.50	56 638.70	10 987.80
2003	60 702.80	47 517.40	13 185.40
2004	68 563.00	49 250.10	19 312.90
2005	69 950.40	49 787.90	20 162.50
2006	75 480.90	55 292.60	20 188.30
2007	73 771.50	52 649.50	21 122.00
2008	78 022.90	55 145.30	22 877.60
2009	89 870.30	66 566.90	23 303.40

The major types of coastal aquaculture include shrimp, fish and shellfish culture including blood cockle, green mussel, oysters and horse mussel, while freshwater aquaculture is dominated by production of Nile tilapia, common carp, common silver barb, snake skin gourami, walking catfish, striped snake head fish, striped catfish, and giant freshwater prawn culture (Department of Fisheries, 2011). Among these, shrimp farming plays a primary role and contributes significantly to international trade and economic growth (Szuster, 2003).

Although aquaculture growth has the potential to meet the fast-growing demand for aquatic foods and contribute to food security and poverty reduction, it is acknowledged that if this is to be accomplished sustainably, improved management will be essential to mitigate major risks before the situation reaches a critical stage. In particular, an FAO consultation has identified four pillars for action: 1) food safety; 2) animal health and welfare; 3) environmental integrity; and 4) social and economic issues (FAO, 2011).

The strict food safety controls imposed by global markets along the entire value chain "from farm to fork" are a recent phenomenon, requiring responses at farm and policy level to control, monitor, verify and mitigate the risks of environmental and social impacts. Other drivers are as follows:

(a) Increasing risks of transboundary diseases attributed to intensification and cross-border movement of broodstock, postlarvae, fry and fingerlings as well as the introduction of alien aquaculture species (Bondad-Reantaso et al., 2005);
(b) Impacts of climate change on fisheries and aquaculture and the need to develop national plans for adaptation and mitigation measures (De Silva and Soto, 2009);
(c) Consumer perception of contamination risks (microbiological and chemical),
(d) Sustainability and environmental risks (damage to the ecosystem, animal welfare, worker rights) (Ernst and Young, 2008).

These factors are driving aquaculture operators as well as national authorities to develop and implement robust aquaculture planning and management tools (APMTs) to ensure that aquaculture development proceeds in a balanced and sustainable fashion.

In this study, the author has selected shrimp farming as the model for evaluation due to its large scale of operation, international trading and history in development of various APMTs to help ensure sustainability. The objectives of this study thus are to assess the present status of the use of various APMTs in shrimp farming and evaluate the applicability and effectiveness of these tools for sustainable aquaculture development in Thailand.

8.2. Institutional and legal framework for aquaculture planning and management

The Department of Fisheries is the core institute responsible for establishing regulatory frameworks and implementation of all the APMTs for sustainable aquaculture development. The Ministry of Natural Resources and Environment is responsible for planning in environmental control, zoning and the national plan of action related to climate change. Universities play a role in research into life cycle analysis (LCA) greenhouse gas (GHG) emissions and carbon footprint studies. The National Bureau of Agricultural Commodity and Food Standards (ACFS) is responsible for standard-setting in aquaculture production systems and food safety, accreditation of certification bodies, food standard control and promotion of standard compliance for farms and food establishments. The Thai Food and Drug Administration (Thai FDA) is responsible for implementation of food and drug laws.

APMTs can be classified into 2 groups: 1) aquaculture planning tools; and 2) aquaculture management tools. The institutions responsible for development of a legal framework and implementation of APMTs in Thailand are shown in Figure 13 below.

Aquaculture Planning

Department of Fisheries, Ministry of Agricultural and Cooperatives
- Aquaculture development-spatial planning/zoning
- Environment impact assessment (EIA)
- Ecological risk analysis (genetics and biodiversity
- Social impact assessment
- Import risk analysis (IRA) for introducing new species for aquaculture
- Others: life cycle analysis (LCA), greenhouse gas (GHG) emissions, carbon footprint studies

Ministry of Natural Resources and Environment
- Aquaculture development-spatial planning/zoning
- Environment impact assessment (EIA)
- Others: life cycle analysis (LCA), greenhouse gas (GHG) emissions, carbon footprint studies

University, Ministry of Education
- Others: life cycle analysis (LCA), greenhouse gas (GHG) emissions, carbon footprint studies

Aquaculture Management

Department of Fisheries, MInistry of Agricultural and Cooperatives
- Risk analysis
- Health certification
- Quarantine
- Disease surveillance and early warning system
- Residue inspection and monitoring
- Record keeping and traceability
- Input quality assessment and monitoring
- Production process (e.g. public and private certification)
- Farm management (e.g. BMP/GAP)

The National Bureau of Agricultural Commodity and Food Standards (ACFS), Ministry of Agricultural and Cooperatives
- Residue inspection and monitoring
- Input quality assessment and monitoring
- Production process (e.g. public and private certification)
- Farm management (e.g. BMP/GAP)

Thai Food and Drug Administration (Thai FDA)
- Residue inspection and monitoring
- Input quality assessment and monitoring

Figure 13 Institutional framework for implementation of APMTs in Thailand

The two categories of tools (planning and management) are discussed in the following two sections.

8.3. Summary of APMTs application in Thailand

An overview of the state of application of APMTs used in shrimp farming in Thailand is provided in Table 22 below.

Table 22 Summary of the use of aquaculture planning and management tools (APMTs)

Tools	Level of awareness[1]	Level of capacity[1]	Extent of use[2]	Supporting legal instruments[3]
Aquaculture development-spatial planning/zoning (e.g. based on carrying capacity)	c	c	d	Yes
Environment impact assessment (EIA) of aquaculture operations	c	b	d	Yes
Ecological risk analysis (genetics and biodiversity)	a	a	b	Yes
Social impact assessment	b	b	c	Yes
Import risk analysis (IRA) for introducing new species for aquaculture	d	c	c	Yes
Life cycle analysis (LCA), greenhouse gas (GHG) emissions, carbon footprint studies	a	a	b	No
Risk analysis	c	c	c	Yes
Health certification	d	c	e	Yes
Quarantine	d	c	e	Yes
Disease surveillance and early warning system	c	c	e	Yes
Residue inspection and monitoring	d	d	e	Yes
Record keeping and traceability	d	d	e	No
Input quality assessment and monitoring	c	b	c	Yes
Production process (e.g. public and private certification)	d	d	e	Yes
Farm management tools (e.g. BMP/GAP)	d	d	e	Yes

Notes:

[1] Levels : ***a*** – policy makers and scientists at the national level; ***b*** – policy makers, scientists, at provincial level; ***c*** – all stakeholders at local level except farmers; and ***d*** – all

[2] Extent of: ***a*** – never used; ***b*** – used in some projects; ***c*** – used at national level; ***d*** – used at provincial level; ***e*** – used at local level

[3] Supporting legal instruments: Yes; no; under development

Overall, the results showed that tools for aquaculture planning were evaluated at the top to medium rankings (moderate/fair), being backed by a certain level of legislative support. Social impact assessment was also evaluated at medium rank, since awareness and implementation capacity for this tool remain only moderate. Tools related to environment, and ecosystem tools such as the ecosystem assessment approach and ecological risk analysis were also evaluated at medium rank; the ecosystem approach to aquaculture is however not backed by any specific legislation. The life cycle analysis (LCA), greenhouse gas (GHG) emissions, carbon footprint studies are emerging as new approaches and are considered as likely future requirements for international trade in order to promote 'green growth' of the aquaculture sector and provide objective indicators of progress. However, there are few studies relevant to Thailand and implementation is still in its early stages, with some projects initiated to develop suitable practical tools for assessment.

Those tools applied for aquaculture management (pathogen/disease management, food safety and production management) were ranked high (excellent or good) for levels of awareness and capacity to apply the tools. Most of the tools are applied at local level, with legislative support. The disease surveillance and early warning system tool was evaluated at medium rank (moderate/fair), whilst input quality assessment was evaluated at medium rank, as indicated by the moderate/fair rankings for awareness and capacity and the wide range of application.

8.4. Aquaculture planning tools

8.4.1. Import risk analysis (IRA)

The development of IBC-DOF also allowed DOF to establish a mechanism analysing the risk of importation of live organisms for aquaculture operations including shrimp. In the case of importation of live non-native whiteleg shrimp (*Litopenaeus vannamei*) to culture in Thailand, the IBC-DOF committee called several technical meetings of shrimp experts to analyze all possible risks, and also funded a study by Mahidol University to assess potential impacts. The study concluded that if legal import was not permitted, illegal and uncontrolled imports would increase, leading to proliferation of new viral diseases such as the Taura syndrome virus (TSV) in Thailand. On the other hand, legal permission to import would provide a regulatory framework for prevention and control of disease. It was therefore proposed to allow imports of specific pathogen free (SPF) shrimp to culture in the nuclear breading centre and use for broodstock. Thus, a regulation was issued to allow import of whiteleg shrimp only from approved certified SPF shrimp suppliers. A national quarantine centre and disease monitoring program were also established. This tool has resulted in major expansion of whiteleg shrimp culture and availability of SPF broodstock and postlarvae in Thailand.

A second case study in import risk analysis for imported shrimp is the regulation to control Infectious Myonecrosis Virus (IMNV). IMNV outbreaks have been reported to cause massive mortality in Brazil and Indonesia, seriously damaging their respective shrimp industries (Senapin et al., 2007). IRA was used by IBC-DOF to evaluate the situation, concluding that importation of shrimp from these two affected countries carried a risk of introduction of IMNV disease into Thailand, where no outbreaks had previously been reported. Therefore DOF initiated emergency action to prevent this transboundary movement. Regulations and customs controls were strictly implemented to prohibit imports of live or dead shrimp and other crustaceans from these two countries into Thailand. In addition, DOF also launched a national program to monitor the status of IMNV infection in shrimp and other crustaceans at farm level. The DOF's ongoing implementation and monitoring program indicate that Thailand currently remains free from IMNV infection in all farmed shrimp.

8.4.2. Spatial planning/zoning based on carrying capacity

In 1998, the Ministry of the Environment issued a Notification of the zoning of a shrimp farming area based on Article 9 of the environmental protection law in order to halt the expansion of shrimp farming into inland areas and prevent ensuing environmental impacts from salt contamination of freshwater and impact on agricultural activity such as rice cultivation. Responding to this Notification, in 2000, DOF announced a policy to cap the total land area allocated for shrimp farming to no more than 76 000 ha (475 000 rai), to ensure sustainable development of the sector.

In 2011 DOF implemented an FAO-funded project "Aquaculture information management system in Thailand: AIMS". The project's objective was to use AIMS to support sustainable aquaculture development. The project collated all available information related to aquaculture for processing and analysis of potential risks based on monitoring and surveillance information as well as carrying capacity models for finfish, shrimp and bivalve culture. Secondary data such as climate, hydrology, monitored environmental data and disease surveillance data were also incorporated in the analysis. The project resulted in planning recommendations based on the carrying capacity of each area/production system.

8.4.3. Environmental impact assessment (EIA)

In 1991 DOF issued a new Notification to mitigate environmental impact from operation of aquaculture facilities, requiring shrimp farms larger than 8 ha (50 rai) to construct a water treatment facility and sludge dumping pond. This was intended to prevent effluent from shrimp farming operations from causing eutrophication of surrounding water bodies.

A Notification of the National Environmental Board (NEB) No. 7 (1994, revised in 2007) sets water quality standards and defines "coastal water" as water seaward of the river mouth or lake, including water surrounding an island in the sea. The standard establishes 6 classes of coastal water and sets criteria for coastal farms. In conducting EIAs, this standard is used as a principal reference for coastal development projects and monitoring of marine pollution (Sompongchaiyakul et al., 2011). Also, responding to the finding that effluent from aquaculture farms contains high levels of organic matter and nutrients that could lead to eutrophication and other adverse environmental impacts, a notification on aquaculture effluent was issued to control and mitigate the environmental impact of aquaculture (Pollution Control Department, 2002).

8.4.4. Ecological risk analysis (genetics and biodiversity)

The Department of Fisheries (DOF) established an Institutional Biosafety Committee (IBC-DOF) in 2006, responsible for ecological risk analysis at national level. The committee evaluates risks associated with introduction of exotic aquatic animals into the country, following the relevant regulations covering introduction of live aquatic organisms, including potential impact on genetics and biodiversity of wild populations. In case adequate scientific information is not available, a restricted permission may be granted by the IBC-DOF specifically for research purposes to be conducted at a credible bio-secure hatchery or quarantine facility.

For example, in the case of requests to introduce blue shrimp (*Litopenaeus stylirostris*) for intensive culture in Thailand, introduction for research purposes was initially permitted. Ultimately, the committee prohibited further introduction of blue shrimp for farming and made further requests for technical reviews on the impact of blue shrimp escapees on ecosystem biodiversity, as well as a review of its potential for transmitting diseases to native shrimp species and crustaceans in Thailand. The reports of such risk analyses must be considered by the committee in evaluating new import requests for large scale aquaculture operations.

8.4.5. Social impact assessment

In shrimp farming, the most important social impact relates to labour/worker welfare. The Department of Labour Protection and Welfare (DLPW), Ministry of Labour is mandated to ensure compliance with labour laws and regulations. A social impact assessment scheme for the shrimp production sector has been introduced by DLPW, DOF and the private sector to develop guidelines for good labour practice in shrimp farming, peeling sheds, and processing facilities. The development of the guidelines incorporates stakeholder participation and consultation. The program will result in the development of a listing of hazardous work in the shrimp production sector, along with prescribed good labour practice. This will provide clarity for operators and strengthen compliance with agreed socially responsible labour practice, sector-wide.

8.4.6. Life cycle analysis/greenhouse gas emissions/carbon footprint studies

This group of tools are at an early stage in their development for the aquaculture sector, and further study is needed to support their application in this sector. The Department of Environmental Science and Faculty of Science, Kasetsart University, Thailand has conducted a research study to explore the potential and limitations of using Life Cycle Assessment (LCA) as the basis for setting eco-labeling criteria in developing countries. The application of LCA was illustrated using the specific case of shrimp aquaculture in Thailand, as a basis for eco-labeling criteria for a typical product intended for export from a developing country. According to the study results, the farming operation appears to generate the most significant environmental impacts of all stages in the life cycle, causing "abiotic depletion and global warming, which arise mainly from the use of energy, and eutrophication caused by wastewater discharged from the shrimp ponds." LCA provides a basis for quantifying a number of important eco-labeling criteria related to the use of abiotic resources and to emissions (Mungkung et al., 2006). A follow-up study is to be conducted in relation to preparation of a Life Cycle Inventory Database to support the LCA project in the seafood industry.

8.5. Aquaculture management tools

8.5.1. Risk analysis

This tool is implemented under the provisions of the Animal Epidemics Act, B.E. 2499 (1956). The Department of Fisheries analyzed the risk of introduction of whiteleg shrimp into DOF-registered hatcheries for breeding and genetic improvement. The main purpose of this analysis was to prevent the spread of transboundary diseases through imports of live shrimp. In the case of whiteleg shrimp, the importer is required to attach an official health certificate for SPF shrimp produced under the biosecurity system, guaranteeing the source is free from the following viral diseases; 1) White Spot Syndrome Virus (WSSV); 2) Yellow Head Virus (YHV); 3) TSV; 4) Infectious Hypodermal and Hematopoietic Necrosis Virus (IHHNV); 5) IMNV and other viruses for at least two years and without any mass mortality within 3 months prior to import. The international airports at Bangkok, Phuket and Had Yai were designated as the only permitted ports of entry. Following import, the imported shrimp must be kept in quarantine at a permitted hatchery until its SPF status is confirmed by laboratory testing and thus presents no risk for its use as brooder. If imported shrimps are found to be infected, DOF has the authority to order destruction of the stock at the quarantine facility. Applying this tool has brought major benefits for the shrimp industry by ensuring a supply of high quality, healthy postlarvae of whiteleg shrimp.

8.5.2. Health certification

DOF has issued regulations requires exporters to declare the health conditions of fish and fishery products in according to international agreements. In general, the health certificate is issued for laboratory tested products that are found to comply with the health standard for export fish and fishery products under the guidelines of the World Organization for Animal Health (OIE) for transportation and trade of dead or live aquatic animals.

In 1987, a regulation was announced requiring declaration of health certificate for export of frozen fish and fishery products. This regulation has been implemented for export of shrimp and shrimp products containing more than 10 percent (by weight) shrimp, except for cooked products. The exporter is required to ensure that the production plant and product are in compliance with the respective standards before the health certificate can be issued.

In 2001, DOF announced an amendment to the 1989 regulation on issuing of health certification for export of living aquatic animals such as shrimps and fishes. Exporters are required to send a number of samples for inspection of disease and clinical signs of disease infection 2-7 days prior to shipment. Many countries including Australia, EU member states, USA, Canada, China and the Republic of Korea are now strictly implementing the controls, using health certification at port of entry as a means of preventing spread of transboundary aquatic animal diseases.

8.5.3. Quarantine

This tool is used in conjunction with health certification to regulate whiteleg shrimp importation. The Department of Fisheries authorizes the Airport Aquatic Animal Inspection Office to quarantine and inspect imported shrimp. The importer is required to declare all documentation including the official health certification for inspection at point of entry. While under quarantine at the fishery quarantine area or other approved private quarantine facility, regular sampling is conducted to test for disease infection and chemical contamination. Quarantined shrimp are released and an import permit issued when import documentation and shrimp condition comply with the regulatory requirement. Non-compliance can lead to legal action and the aquatic animals will either be returned to the exporting country or destroyed.

The quarantine system also applies at private biosecurity hatchery operations, especially shrimp hatcheries. The shrimp must be maintained in quarantine for 3 months prior to introduction into any nuclear breeding centre in order to prevent entry of pathogens into the production system. Using this tool, Thailand had produced 67-72 × 10^{11} PL per year of quality postlarvae of whiteleg shrimp, yielding approximately 600 000 tonnes per year of shrimp to meet domestic and export demand.

8.5.4. Disease surveillance and early warning system

In order to comply with OIE regulations, measures to prevent transboundary diseases resulting from trading of live shrimp have been implemented by DOF since 2004. DOF developed a shrimp farm compartment project for shrimp farmers intending to export live shrimp to Australia. In order to participate in the shrimp compartment project, the farm must comply with several prerequisites, including registration with DOF, certification of good aquaculture practice (GAP) or code of conduct (CoC) for responsible shrimp farming and biosecurity. Under the programme, a regular schedule for disease surveillance within the farm area and buffer zone was set, with shrimp samples tested for viral diseases (WSSV, YHV, TSV, and IHHNV). The farm must also maintain daily records of shrimp health. Farmers are required to report any sign of disease outbreak to DOF. Farms with no disease symptoms and non-detection of the specified viral diseases for a continuous period of two years in both the farm area and buffer zone are deemed to meet the certification requirements of the compartment farm. In order to maintain this status, the surveillance programme is continued to ensure that farm practice remains compliant. There are currently 14 fully certified farms located in 6 provinces, and approximately 40 under the disease surveillance programme.

The tool related to early warning system is used by DOF offices located in all provinces to provide early warnings in aquaculture and fisheries. Local DOF officers are required to monitor and report any evidence of disease outbreak, extreme climate conditions and natural disasters. The DOF then coordinates with other related agencies as appropriate and early warning messages will be sent to aquaculture farmers via national newspapers, television and radio. DOF officers also develop prevention measures, providing technical advice and ensuring that farmers make all necessary preparations in order to minimize production and investment losses for farmers.

8.5.5. Residue inspection and monitoring

Regarding food safety, DOF has set policies and measures to provide an acceptable level of assurance that fish produce are free from contaminants. This is accomplished through frequent monitoring programs and application of preventive measures in fish inspection, using quality management programs based on the Hazard Analysis and Critical Control Points (HACCP) principle. Approved processors reaching compliance are certified by DOF as processing safe, high quality products that meet importing country requirements. The Fish Inspection and Quality Control Division (FIQD) was established for the inspection and monitoring of residues in raw or processing aquaculture products. At farm level, shrimp farms voluntarily enter the farm certification program and operate according to the standard to ensure best practices for food safety are maintained in a responsible manner. This tool has been implemented at all levels in the shrimp industry.

DOF has also implemented a national residue control program for aquaculture products to ensure that seafood products from inland and coastal aquaculture meet safety requirements for exported products. This program is supported by several Acts and Cabinet resolutions: the Fisheries Act (1947), Food Act (1979), Animal Feed Quality Control Act (1982, and amended in 1999), Hazardous Substances Act (1992) and Cabinet Resolutions (1994, 2003). Under this programme, samples of aquaculture products are taken from the farm for laboratory testing for biological contamination and residues of hazardous chemicals, veterinary drugs, etc. Inputs such as feed are also sampled for testing. Non-compliant products and inputs must be re-investigated to establish the source of contamination. In case of discovery of use of prohibited substances, the farm's certification will be immediately suspended.

Pre-shipment inspection is performed to determine product quality compliance with requirements set by importing authorities. Fishery officers collect samples according to sampling plans recommended by the *Codex Alimentarius* Commission. The samples are subsequently analyzed for chemical, microbiological and physical qualities.

8.5.6. Record keeping and traceability

The Thai GAP (TAS 7401-2009) standard considers record keeping as a major requirement with which farmers must comply. Good record keeping contributes to efficient production and allows tracking of problems at every stage of production. Good record keeping is also important in case of production problems such as disease outbreaks. Moreover, on completion of each production cycle, data analysis must be conducted, and farmers most retain those data on farm for a minimum of 4 years from the date of record creation.

DOF has introduced traceability requirements into the procedures for export of seafood products including those from aquaculture, in order to enable the sector to enhance food safety and comply with standards imposed by international buyers. The aquatic animal movement document (MD) and aquatic animal fry movement document (FMD) were introduced in 2002 as tools for traceability in case any exported seafood product does not meet the statutory requirements. The MD is issued to the farmer when shrimp is sold, and the FMD is used to identify the origin of shrimp fry. After sale, the MD document will travel with the shrimp consignment to the processing plant. This document is submitted to DOF when the processor requests documentation (DS-2031, health certificate) for a declaration of the origin of exported shrimp products. DOF requires all offices authorized to issue MDs to enter data using computerized MD online. MD online provides an additional safeguard for processors to check MDs in order to prevent unauthorized use. DOF also uses MDs to directly trace suspect products back to the farm of origin in case of any downstream food safety problems.

Traceability is also an essential tool for tracing the source of disease contamination for certified shrimp compartment farms registered with DOF. Information on compartment farms, surveillance reports, farm production, shrimp movements, trading and export are all linked in a database to facilitate traceability, allowing rapid responses to any food safety or transboundary disease issues.

8.5.7. Input quality assessment and monitoring

Feed regulations protect consumers as well as the regulated industry and help ensure food safety throughout the supply chain. All aquaculture feed mills and commercial aquaculture feeds produced or imported must be registered with DOF. DOF prohibits any feed factory from producing any medicated feed; use of chemicals not yet proven safe for human health is also prohibited. Wholesalers and retailers of aquaculture feeds must apply for a license to sell, based on the authority given by the Ministry of Industry under the Hazardous Substances Act (1992). DOF undertakes four levels of control measures, as follows: 1) Control by specifying requirements for sale, use and discard; 2) Control of label and use instructions; 3) Control of manufacture and sale; 4) Control of import (import of specified chemicals must be approved by DOF).

8.5.8. Production processes

As a leading producer and exporter of aquaculture products, especially shrimps, Thailand has adopted a proactive strategy to secure continuing access to its high-end global markets by strengthening the country's reputation for safe, high quality products. The Thai National Shrimp Certification Scheme for farmed shrimp was developed and in 1998 DOF introduced the Code of Conduct (CoC) for Responsible Shrimp Farming, followed by the Good Aquaculture Practice (GAP) programme in 2000. In 2008, the Thai National Shrimp Certification Scheme underwent a major revision, creating three separate entities responsible for standard setting, accreditation and certification in order to develop aquaculture certification in Thailand in accordance with the FAO Guidelines on Aquaculture Certification.

In 2008 DOF reviewed its own role in certification, with the Aquaculture Development and Certification Center (ADCC) established to serve as a certification body following ISO/IEC Guide 65 in setting up the certification system for Thai aquaculture. In February 2010, ADCC launched a Quality Manual explaining the requirements for compliance with ISO/IEC Guide 65. The manual covers requirements for a certification body (i.e. impartiality, non-discrimination, independence); conditions and procedures for granting, maintaining, extending, suspending, and withdrawing certification; internal audit and management reviews, record keeping, confidentiality, certification body personnel; changes in certification requirements; appeals, complaints, disputes; application of certification; evaluation and reporting; surveillance; use of licenses, certificates and marks of conformity; and complaints of suppliers.

8.5.9. Management tools (BMP/GAP)

In order to extend Thailand's reputation as a producer of safe, high quality aquaculture products, the Thai Agricultural Standard (TAS 7401-2009) on Good Aquaculture Practices (GAP) for Marine Shrimp Farms was established in accordance with the FAO Guidelines on Aquaculture Certification. The standard was issued on a voluntary basis in accordance with the Ministerial Notification of Agriculture and Cooperatives on 29 September 2009 (National Bureau of Agricultural Commodity and Food Standards, 2009). The standard has since been widely applied as a voluntary standard for shrimp farming (National Bureau of Agricultural Commodity and Food Standards, 2009).

GAP stipulates criteria to protect animal health and welfare, and requires that all aquaculture operations be conducted in a manner that assures the health and welfare of farmed aquatic animals by minimizing stress, reducing aquatic animal disease risks, and maintaining a healthy culture environment throughout all phases of the production cycle. The criteria on food safety require that farms implement appropriate national or international standards and regulations including those defined by FAO/WHO Codex Alimentarius. The criteria on environmental integrity focus on environmental responsibility in aquaculture practices. Finally, GAP also includes criteria on socio-economic aspects, requiring that aquaculture operators act in a socially responsible manner, complying with national rules and regulations, taking into consideration the International Labour Organization (ILO) Convention on Labour Rights to ensure that the operation does not jeopardize the livelihoods of aquaculture workers and local communities. Benchmarking was carried out in order to establish equivalence and conformity between the Thai National Shrimp Certification Scheme and the FAO Aquaculture Certification Guidelines. The results of benchmarking found that the Thai Scheme was equivalent to the FAO Guidelines since it conforms to all critical requirements contained in the FAO Guidelines, and more than 90 percent of the major requirements (Prompoj et al., 2011).

8.6. Issues and constraints in application

The findings of the current study indicate that APMTs offer a suite of practical tools to foster sustainable development of Thailand's aquaculture sector. This is particularly the case for shrimps, where a large proportion of total production is earmarked for export. Protection of export revenues is thus a major driving force for adoption. However, effective application of APMTs requires strong legal support, meticulous implementation by the relevant authorities and close cooperation between the public and private sectors. Several generic issues and constraints in the application of APMTs were identified, as follows:

1. Introduction of exotic aquaculture species is increasing in many countries and represents an growing concern. If successful, introduction of whiteleg shrimp for intensive culture could lead to a more resilient and profitable aquaculture sector. On the other hand, a failure to prevent inadvertent transmission of transboundary diseases could result in population collapse and ecosystem impacts (e.g. displacement of native species by escapees). APMTs offer a suite of preventive and control measures designed to minimize such risks and the potentially catastrophic impacts on the ecosystem, livelihoods and the economy.
2. Climate change carries significant but unquantified potential impacts on aquaculture, particularly inland aquaculture. However, there is limited scientific information and relatively little understanding of the potential ecosystem impacts and correspondingly less clarity over prediction and effective warning systems. This represents a major emerging issue for all stakeholders. It is therefore imperative that countries share experiences and urgently undertake research to underpin development of the necessary supporting tools (policy and guidelines) to apply at both national and local levels.

3. Intensive and uncontrolled large-scale aquaculture development could seriously compromise environmental integrity. There is a gap of knowledge relating to appropriate technologies and scientific data to inform policy planning, particularly in regard to zoning of areas suitable for aquaculture. In particular, there is a need to develop an appropriate model for EAA in order to underpin spatial planning and establishment of zones suitable for aquaculture development.
4. Food safety requires strong enforcement on a constant basis, generating a major and increasing workload for monitoring, investigation, and control. Capacity building for relevant agencies is needed to ensure effectiveness of application of food safety tools at local level. In addition, training of farmers on food safety issues is needed in order to establish an effective control mechanism at farm level.
5. Aquaculture certification plays an important role in consumer perceptions of the credibility of the system. The FAO Guidelines for Aquaculture Certification provide important advice in regard to the proliferation of private/national certification schemes; there is a need for benchmarking to reduce duplication of effort and cost in the case of multiple certification schemes.

8.7. Recommendations and way forward

Aquaculture's crucial role in food and nutrition security has been amply demonstrated over the past decade as aquaculture has expanded to replace the deficit caused by the continuing decline in capture fisheries. However, aquaculture must be developed in a sustainable manner. The rapid growth in international trade in live and dead aquatic organisms creates new and sometimes unknown risks that could hamper sustainable aquaculture development and harm the environment. This study indicates that APMTs are important and appropriate tools for policy-makers, regulators and other stakeholders to apply systematically in aquaculture development. Recommendations are offered at national and regional levels, as follows.

8.7.1. National level

APMTs should be systematically developed and evaluated by the legal authority. The results from this study should be reviewed at political level, and action taken to strengthen APMTs application in the following four areas:

1. Awareness of policy-makers and scientists on the role and function of APMTs. Consideration should be given to establishing a coordinated mechanism to support the application of various APMTs. Also, an integrated, holistic approach to APMTs should be adopted at policy level prior to implementation at local level.
2. Capacity building should be given greater attention and resources, to ensure sufficiency of application at all appropriate levels. Equipment, facilities and systems used for APMTs application should be upgraded at all implementation points.
3. Training on application of APMTs should be conducted for relevant personnel in all stakeholder groups, in order to fill gaps in knowledge and understanding of APMTs, including scientific information and underlying rationale of APMTs and its importance for sustainable aquaculture, as well as procedures for application.
4. The legislative and regulatory framework supporting application APMTs should be reviewed and updated.

8.7.2. Regional level

1. Increasing levels of regional level cooperation will be necessary to deal with the growing threat posed by transboundary diseases, driven by increasing intra-regional trade. Mechanisms should be developed for cooperation on APMTs application between trading countries as well as among countries within the Asia-Pacific region.

2. Funding and technical support from bilateral and multilateral donors should be mobilized for the developing countries of the region and allocated to strengthening necessary application of APMTs.
3. Intergovernmental agencies in the region should take a lead role in supporting application of APMTs across the region. Sharing of experiences and lessons learned should be prioritized at both regional and international forums.

8.7.3. Way forward

In conclusion, to promote wider and more effective adoption of APMTs in aquaculture, increased cooperation among countries in the region will be required, combined with support from intergovernmental agencies to explore and build a better understanding of the issues facing aquaculture development and mechanisms for application of APMTs. Legislative frameworks should be established in all countries to support application of APMTs, and periodical evaluation should be conducted to assess progress and address issues and constrains arising during APMTs application at national and regional levels.

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9. COUNTRY REPORT: VIET NAM

Application of aquaculture assessment tools in Viet Nam

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9.1. Introduction

Aquaculture (both freshwater and brackish water aquaculture) has long been traditionally practiced in Viet Nam. It experienced remarkable progress after the economic reforms of the 1980s, and developed rapidly after the year 2000. However, within each farming environment (freshwater and brackish water), production and value are dominated by only a few major cultured species.

Freshwater aquaculture operations are found all over the country in the form of pond culture, cage culture, paddy rice fish culture and fish culture in reservoirs. The Red River delta is associated with the *Vườn Ao Chuồng* (VAC) or gardening-pond-livestock farming model where fish culture is integrated as a component of recycling agri-farming systems. Traditional species introduced to this VAC system include carps and more recently, tilapia. Tilapia and hybrid common carps are promising cultured species, expected by Vietnamese local and national authorities to transform freshwater aquaculture into intensive farming systems. However, to date this expectation has not yet been realized (Tran et al., 2010). In 2010, the total area and production volume of tilapia were just 8 262 hectares and 40 955 tonnes, respectively (VIFEP, 2011).

With favourable natural conditions, the Mekong Delta is famous for various freshwater farming systems, including finfish culture (snakehead, mudfish), freshwater prawn culture, and especially *Pangasius* catfish culture. Though traditionally practiced for many generations in the delta region of Viet Nam and Cambodia, over the last ten years catfish farming has accelerated sharply, making catfish the dominant freshwater farmed fish in terms of production and economic value, leaving other freshwater farmed species far behind. In 2010, the total area and production volume of *Pangasius* catfish were 5 434 hectares and 1 038 256 tonnes, respectively (VIFEP, 2011).

Marine and brackish water aquaculture is also widespread in Viet Nam, involving diversified systems, such as marine fish farming, mollusk farming, seaweed farming, lobster farming, and especially brackish water shrimp farming. Brackish water shrimp farming is still dominated by tiger shrimp (*Penaeus monodon*) culture. Shrimp ponds are common along coastal provinces from the North to the South, but the bulk of production originates in the Mekong Delta. Farmed shrimp is the most important seafood commodity in Viet Nam in terms of cultured area, production, export value and employment in the sector. Together, shrimp and catfish account for more than 50 percent of the country's annual fisheries export revenues, hence they are considered as strategic commodities.

To date, various shrimp farming systems have been developed and practiced in Viet Nam: intensive shrimp farming, semi-intensive, improved extensive farming, traditional extensive, rice-shrimp farming in rotation, and shrimp-forestry farming. However, extensive shrimp farming is the dominant system in terms of farmed area. VIFEP (2011) estimates that about 622 120 ha was devoted to tiger shrimp farming all over Viet Nam in 2010. The ratio of extensive farming to intensive (including semi-intensive) farming to shrimp-forestry farming is 84 to 11 to 5. The popularity of the extensive farming system explains why tiger shrimp dominates other farmed shrimp species in Viet Nam. However, whiteleg shrimps currently have become more common

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and are replacing tiger shrimps on many farms. The total area of whiteleg shrimp farming was estimated at about 22 192 hectares in 2010. The total production volumes of farmed tiger shrimps and whiteleg shrimps in 2010 were 339 473 tonnes and 124 315 tonnes respectively.

Marine fish farming is quite new in Viet Nam. About 11 marine fish species are currently cultured in inshore bays in Viet Nam; the most popular cultured species are grouper, cobia, seabass, and red drum. Marine fish farming is commonly operated by small farmers in form of marine cage farming using simple technological innovations. Some domestic and foreign enterprises have also invested in marine shrimp farming, such as those observed in Khánh Hòa and Bà Rịa-Vũng Tàu provinces, however, as yet these are relatively few in number. According to D-FISH (2011), the number and production volume of marine fish culture cages in 2010 is 70 271 and 22 606 tonnes, respectively.

9.2. Institutional and legal framework

The Vietnamese aquaculture sector is managed by:

- Directorate of Fisheries (D-FISH), through its associated departments including the Department of Aquaculture and the Center for Aquaculture Input Testing, Inspecting and Verifying;
- Department of Animal Health (DAH) and its provincial departments;
- The National Agro-Forestry – Fisheries Quality Assurance Department (NAFIQAD) and its provincial departments; and
- Provincial Department of Agriculture and Rural Development (DARD) through its Sub-Department of Aquaculture.

The three agencies of D-FISH, DAH and NAFIQAD operate under the Ministry of Agriculture and Rural Development (MARD), whilst DARD belongs to the Provincial Peoples Committee (PPC).

In order to manage the aquaculture sector sustainably, a number of policies have been promulgated to cover the use of various tools for aquaculture development, management and planning. The key policies that support application of these tools will be listed and analyzed in later sections. However, as yet there is no direct legal framework for the application of a social impact assessment tool. This tool is assumed to be covered implicitly by relevant policies and supporting regulations for aquaculture development planning and management.

9.3. Summary of APMTs application in Viet Nam

Based in the findings of the evaluation study, a summary of the status of adoption of aquaculture planning and management tools (APMTs) in Viet Nam is provided in Table 23 below. Standard analysis criteria were used to evaluate each of the four dimensions, as follows:

9.4. Application of tools: case studies

In this section a number of case studies of Viet Nam's experience in implementing APMTs were analyzed.

9.4.1. Import risk analysis (IRA) (DAH 2011; NAFIQAD 2012)

Responsibility for conducting import risk analysis was assigned to the following organizations in the Ministry of Agriculture and Rural development (MARD):

- For imported fisheries products: National Agro-Forestry – Fisheries Quality Assurance Department (NAFIQAD).
- For imported exotic aquatic species (living species imported into Viet Nam territory) and imported aquaculture seed: Department of Capture Fisheries and Resource Protection (DECAFIREP), Department of Animal Health (DAH), Department of Aquaculture (DOA).

Table 23 Summary of APMTs Application in Viet Nam

Tools		Level of awareness[1]	Level of capacity[1]	Extent of use[2]	Supporting legal instruments[3]
I. Planning tools					
1	Aquaculture development: spatial planning/ zoning (e.g. based on carrying capacity)	c	b	b	Yes
2	Environment impact assessment (EIA) of aquaculture operations	c	c	c, d, e	Yes
3	Ecological risk analysis (genetics and biodiversity)	a	a	c, d	Yes
4	Social impact assessment	c	b	b	No
5	Import risk analysis (IRA) for introducing new species for aquaculture	c	c	c, d	Yes
6	GHG emissions/carbon footprint studies	b	a	b	Yes
II. Management tools					
1	Health certification	d	d	c, d, e	Yes
2	Quarantine	d	d	c, d, e	Yes
3	Disease surveillance & early warning system	d	d	c	yes
4	Residue inspection and monitoring	d	d	c, d, e	Yes
5	Record keeping and traceability	d	c	c, d, e	Yes
6	Input quality assessment and monitoring	c	c	d	Yes
7	Production process (e.g. public and private certification)	d	c	e	Yes
8	Farm management tools (e.g. BMP/GAP)	d	c	b	Yes

[1] Levels of awareness/capacity: ***a*** – policy makers and scientists at the national level; ***b*** – policy makers, scientists, at the provincial level; ***c*** – all stakeholders at local level except farmers; ***d*** – all
[2] Extent of use: ***a*** – never used; ***b*** – used in some projects; ***c*** – used at national level; ***d*** – used at provincial level; ***e*** – used at local level
[3] Supporting legal instruments: Yes; no; under development

The IRA process is used extensively by agencies within central Government and local authorities, as well as agencies concerned with fisheries import and exports. All organizations and individuals when importing aquatic products and animals into Viet Nam must prepare and submit profiles of the products and animals proposed for importation to the relevant authorities in Viet Nam. The applications will be assessed and evaluated through a formal procedure stipulated by the Viet Nam authorities. Following evaluation, the application to import will either be rejected or approved for importation of the animal/product into Vietnamese territory.

The following policies have been promulgated to support implementation of IRA:

- Circular No. 25/2010/TT-BNNPTNT of the Minister of Agriculture and Rural Development dated 4 August 2010 to regulate inspection, testing and certification for food safety of goods and products from exported animals;
- Circular No. 06/2010/TT-BNNPTNT of the Minister of Agriculture and Rural Development dated 2 February 2010 to regulate the procedures and steps to quarantine fisheries products and fisheries species (including imported and exported fisheries products and species).
- Circular No. 53/2009/TT-BNNPTNT dated 21 August 2009 on regulating exotic aquatic species imported into Viet Nam territory.

To date, the authorities in Viet Nam have controlled and managed introduction of more than 100 species for aquaculture and trading purposes, based on detailed analyses of each species. Imported products from animal sources have also been evaluated and checked following the same process.

However, some difficulties remain in terms of the capacity of responsible agencies to implement this tool effectively. Due to the large volume of fisheries products and fisheries species imported into Vietnamese territory (to date, over 200 000 metric tonnes of fisheries products have been imported) there is a serious constraint on technical capacity and human resources to implement IRA effectively. The need for IRA is predicted to increase significantly in line with increasing trade volumes.

9.4.2. Health certification (DAH 2011; NAFIQAD 2012)

Health certification is applied country-wide for all aquaculture species and seed. These are tested, assessed and certified by the Department of Animal Health (DAH) and the Centre for Aquaculture Input Testing, Inspecting and Verifying (CAITIV), operating under the Directorate of Fisheries (D-FISH). Health certification is routinely used by the CAITIV, the Department of Animal Health (DAH), aquaculture farmers/producers, research agencies and aquaculture logistic companies. The Department of Animal Health (DAH) also issues health certification through its provincial d.partments.

Aquatic animals and aquaculture seeds must be tested and a health certificate issued by the CAITIV and DAH before they can be transferred to other areas for release into aquaculture ponds. Sampling procedures are defined in the regulations. Without the required certification, the owners must not transfer, trade, or release into ponds; violation is publishable by fines or other penalties.

Legislative support for use of the tool is provided under the following instruments:

- Decree No. 18/2004/PL-UBTVQH11 promulgated by the National Assembly dated 29 April 2004 about veterinary medicine;
- Government Decree No. 129/2005/NĐ-CP dated 17 October 2005, defining regulations for violations in the administration of veterinary medicine.

Under the scheme, billions of aquaculture seeds and aquatic species are tested each year and issued with health certification. This tool is considered key to preventing transmission of diseases and outbreaks on aquaculture farms.

Currently, issuance of health quarantine and certification in aquaculture has been assigned to two agencies – the Department of Animal Health (DAH) and the Centre for Aquaculture Input Testing, Inspecting and Verifying, which belongs to the Directorate of Fisheries (D-FISH). A degree of overlap exists in the functions and tasks of the two agencies, and as a consequence, aquaculture farmers/producers, hatcheries and aquaculture seed traders are obliged to undergo duplicate procedures for species health inspections and checking and certifications from the two agencies. The tasks of implementing health inspection and certification should therefore be merged and assigned to a single agency.

9.4.3. Quarantine

Based on Decision No. 1427/Q-BNN-TCCB of the Minister of MARD dated 20 May 2009 and Circular No. 56/2011/TT-BNNPTNT dated 16 August 2011 on state management of aquatic animal health and veterinary medicine, the following agencies have been assigned to manage Viet Nam’s quarantine system:

- DAH: responsible for aquaculture veterinary medicines and imported seeds for aquaculture;
- Centre for Aquaculture Input Testing, Inspecting and Verifying (CAITIV), under the Directorate of Fisheries (D-FISH): responsible for locally produced seeds for aquaculture, local hatchery quarantine;
- NAFIQAD: responsible for aquatic products quarantine.

Thus, DAH and D-FISH control and manage all activities related to seed quarantine (for both imported and locally produced seed), hatcheries and aquaculture species. In addition, certain designated centres and provincial DAHs assist in implementation, the fisheries veterinary divisions of DAH and D-FISH coordinate with these centres to control and manage veterinary testing in aquaculture operations in all provinces. DAH is designated as officially responsible for notifying international organizations such as NACA or OIE of any incidences of aquatic animal disease. In addition, local authorities are also responsible for managing activities within their jurisdiction.

The following policies have been drafted by DAH and promulgated by MARD to regulate quarantine implementation (DAH 2011; NAFIQAD 2012):

- Decision No. 110/2008/QĐ-BNN dated 12 November 2008 of the Minister of MARD to issue a list of animals and animal products to be subject to quarantine;
- Circular No. 06/2010/TT-BNNPTNT dated 2 February 2010 to define the procedure for quarantine of aquatic animals and products;
- Decision No. 29/2008/Q-BNN dated 28 January 2008 of the Minister of MARD to define the functions of NAFIQAD;
- Official document No. 369/TY-KD dated 11 March 2010 to guide quarantine procedures for import, export, temporary import and export, storage and transit;
- Circular No. 25/2010/TT-BNNPTNT dated 8 April 2010 to define responsibilities and authority of the two organizations.

Following promulgation of the above legal instruments, aquatic animals and products have been controlled, especially for imports of tiger shrimp and white leg shrimp from other ASEAN countries and USA. Exported products are also controlled following requests from goods owners or importing countries. DAH carries out testing on the safety of production conditions on aquaculture farms and certifies the quality of products produced from these farms for export. Further, DAH also plays an important role in managing the quality of ornamental fish to large export markets such as the EU.

Following the recent consolidation of the former Ministry of Fisheries (former MOFI) and MARD to form the new MARD, the functions and responsibilities of related organizations under the new structure are under review. Equipment and infrastructure also needs to be upgraded to meet increasing need, in line with increasing volume of trade. The cooperation and support of international organizations will be needed in this regard.

9.4.4. Disease surveillance and early warning system

In 2001 the former MOFI established a centre of environmental early warning and aquatic disease, under the Department of Science and Technology of MOFI (Dang, 2007). Three years later, the Ministry established four regional centres on environmental early warning and surveillance, responsible for monitoring aquaculture development zones.

Currently, MARD takes the lead in operating the national disease surveillance program and early warning system. Assigned regional organizations set up research units within their respective jurisdictions around the country. Data collected are collated and analyzed at the head office, and updated findings posted to the website. Critical information is reported to MARD for issue of decisions, guidelines or early warning alerts concerning significant situations.

Viet Nam's disease surveillance and early warning system is supported by the following legislation:

- Decree No. 33/2005/ND-CP of the Prime Minister dated 15 March 2005, defining detailed regulations pursuant to the Animal Health Law;
- Circular No. 36/2009/TT-BNNPTNT of the Minister of Agriculture and Rural Development dated 17 June 2009 specifying regulations for disease surveillance and prevention for fisheries species;
- Circular No. 52/2011/TT-BNNPTNT of the Minister of Agriculture and Rural Development dated 28 July 2011 issuing regulations for disease surveillance and prevention for cultured shrimps;

- Circular No. 83/2011/TT-BNNPTNT of the Minister of Agriculture and Rural Development dated 9 December 2011 issuing a list of notifiable fish diseases.

As an outcome of the establishment of the surveillance and early warning system which involves monthly sampling, updated news on aquatic diseases is available online to the provinces, local authorities and intensive aquaculture areas nationwide. An ecosystem database has also been developed to assist planning, environmental protection, capture fisheries and protection of resources.

Nevertheless, to date, the system only has sufficient capacity to cover the intensive aquaculture zones, with biodiversity information collected only for marine preservation areas. In addition to these human capacity needs, the lack of official standards, criteria, and basic research also needs to be addressed. Finally, in order to function effectively, there is a need to establish a single specific organization to control and coordinate the system and ensure the effectiveness of nationwide surveillance operations.

9.4.5. Environmental impact assessment (EIA) of aquaculture operations

EIA for aquaculture development planning is mandatory prior to launch of any new aquaculture investment projects that meet the following scale criteria:

- Intensive or semi-intensive aquaculture projects with total aquaculture area over 10 hectares;
- Extensive aquaculture projects with total aquaculture area over 50 hectares;
- Aquaculture operations on sand beaches and dunes with total aquaculture area over 10 hectares.

Thus, prior to commencement of the aquaculture activity, the project owners must conduct an EIA and submit the report to the responsible agencies for evaluation and approval. The project owners will only be permitted to begin work on their projects following official approval of the EIA, either by the Ministry of Natural Resources and Environment (MONRE) or the Provincial People's Committees (PPC), depending on the scale of the proposed development. If the proposed development involves culture activities on over 100 hectares of sand dunes or on over 20 hectares of rice paddy fields or protected forests, the EIA report will be evaluated and approved by MONRE. For other proposed aquaculture operation, EIA reports will be evaluated and approved by the PPCs or relevant ministries.

EIA procedures and scope for aquaculture operations are regulated according to National Decree No. 29/2011/ND-CP dated 18 April 2011 (issued by the Government of Viet Nam) and Circular No. 26/2011/TT-BTNMT dated 18 July 2011 (promulgated by MONRE). Those two policy instruments regulate procedures and scope contents for EIA implementation for all kinds of investment projects, including aquaculture development.

Although both policies have been implemented by relevant agencies, in practice only a few aquaculture projects have been required to reduce or adjust their production scales or change their aquaculture technologies as a result of EIA reports. Furthermore, there is no record of any aquaculture projects that have been blocked or delayed as a result of EIA reports.

Although conducting EIAs for aquaculture projects is costly and time consuming, budgets allocated are often insufficient to conduct an effective EIA. As a result, many EIAs are unreliable and do not provide a high quality of advice for the project owners (for example on how to adjust their aquaculture activities towards mitigating impacts of operations on the environment and ecosystem), or for decision makers. Decree No. 29 and Circular No. 26 require all EIA implementers to consult relevant stakeholders of the projects; both losers and winners have to be consulted. However, this process is often addressed only superficially without meaningful attempts to incorporate community voices.

9.4.6. Ecological risk analysis (genetics and biodiversity)

Ecological risk analysis (ERA) is a new concept in Viet Nam. This tool was first applied in considering requests to allow importation of *Penaeus* v*annamei* shrimp (whiteleg shrimp) into Vietnamese territory for aquaculture. During 2005 and 2006, the Vietnamese aquaculture sector conducted an ERA of whiteleg shrimp before allowing importation for aquaculture. After that, the ERA concept was applied in formulating and implementing Circular No. 53/2009/TT-BNNPTNT dated 21 August 2009 on regulating imports of exotic aquatic species into Viet Nam. In other sectors, this tool has been applied in formulating and enforcing national policies and programs to implement the Cartagena Convention on Biodiversity and to manage genetic modification in animals and plants. The Department of Capture Fisheries and Resource Protection (DECAFIREP), under the Directorate of Fisheries (D-FISH) is responsible for implementing Circular No. 53/2009/TT-BNNPTNT controlling importation of exotic species into Viet Nam.

The above circular also specifies mandatory regulatory procedures. National, provincial and local fisheries management agencies are required to conduct a survey and prepare a list of exotic aquatic species within their respective management boundaries. The list must specify all potentially harmful and harmless species. Owners of exotic aquatic animals are required to prepare descriptive profiles and apply for official permission to possess such animals.

In summary, the institutional and legal support for use of ERA may be listed as follows:

- Circular No. 53/2009/TT-BNNPTNT dated 21 August 2009 on regulating importation of exotic aquatic species into Vietnamese territory;
- Decision No. 212/2005/QD-TTg of the Prime Minister dated 26 August 2005, promulgating biosafety regulations relating to genetically modified animals and plants and products and goods produced thereof.
- Decision No. 79/2007/QD-TTg of the Prime Minister dated 13 May 2007 approving the National Action Plan on Biodiversity towards 2010 and directions for 2020 to implement the Cartagena Convention and Protocol on Biodiversity.

In its most important application to date, the use of ERA to investigate the risks of importation of whiteleg shrimp to Viet Nam has helped the sector adopt a measured approach to risk, enabling the sector to diversify its cultured species. In recent years the whiteleg shrimp has emerged as one of Viet Nam's key brackish water aquaculture species, contributing significantly to the value of exports.

Nevertheless, it is clear that application of this tool to importation of whiteleg shrimp into Viet Nam was not done systematically. The methodology was insufficiently clear and the findings were not widely shared among stakeholders. The lack of definitive information led to some extent to lack of a common understanding among Ministries, for example on the potential benefits of importation of new species for the sector's competitiveness, and potential adverse ecological impacts. Since this tool is still relatively new to Viet Nam, awareness at both national and local community levels remains low. Additional expertise and capacity building are therefore needed, along with standard methodologies.

9.4.7. Residue testing and monitoring

In order to test and monitor residues in aquaculture, in 2001 Viet Nam formulated and implemented a National Program for aquaculture residue testing and monitoring, with the National Agro-Forestry – Fisheries Quality Assurance Department (NAFIQAD) as the focal agency. Residue sampling and testing are implemented on a monthly basis by regional branches of NAFIQAD and PAFIQADs. Each month, the regional branches of NAFIQAD and PAFIQADs collect samples of all aquaculture species (such as cultured catfish, tiger shrimp, whiteleg shrimps, catfish fingerlings, shrimp seeds and other cultured species) and water samples in aquaculture ponds and hatcheries in all provinces to tests for residues. The monthly test results are posted on the NAFIQAD website and are available for open public access.

Residue testing and monitoring of aquaculture products in Viet Nam are mandated by the following legislation:

- Circular No. 55/2011/TT-BNNPTNT of the Minister of Agriculture and Rural Development dated 3 August 2011, on regulations for testing, inspection and certification for fisheries food safety;
- Circular No. 14/2011/TT-BNNPTNT of the Minister of Agriculture and Rural Development dated 29 March 2011 on regulations for inspection of traders and producers of chemicals and medicines for aquaculture;
- Letter No. 357/BNN-QLCL dated 17 February 2012 of NAFIQAD on guidance for fisheries product quality management;
- Decision No. 15/2002/QD-BTS of (former) Ministry of Fisheries dated 17 May 2002 on regulations covering toxic residues in aquaculture products.

The national residue testing and monitoring program for aquaculture has achieved many positive results, and has helped aquaculture producers and farmers upgrade their production practices to enhance food safety. The results of residue testing and monitoring in Vietnamese aquaculture have been accepted and recognized by all seafood importing markets such as EU, USA, Japan and the Russian Federation.

Nevertheless, application of these measures necessitates major financial, institutional and human resource commitments, due to the large number of aquaculture activities and the millions of farms country-wide (both large-scale and small-scale). Therefore, sampling for residue testing and monitoring is not uniformly implemented around the country and efforts tend to be focused mainly on the major aquaculture provinces.

9.4.8. Record keeping and traceability

Traceability tools define principles and procedures for traceability and withdrawal of unsafe products within the fisheries sector. Record keeping and traceability tools are required in many aquaculture-related business activities, including the following:

- Fishing vessels with capacity of over 50 HP
- Fisheries companies
- Chemical producers
- Hatcheries, nursery farms and aquaculture farms
- Ice making factories, processing and storage companies
- Processing vessels
- Mollusc producers and processing companies
- Cold storage and semi-processing factories.

The procedures for fisheries traceability are defined in Circular No. 03/2011/TT-BNNPTNT of the Minister of Agriculture and Rural Development, dated 21 January 2011. This circular stipulates four key requirements:

(1) All fisheries trading and production units must establish a traceability system in the form of ‘one step backward and one step forwards’ to ensure product traceability at any stage of production, processing and distribution;
(2) Enterprises/farms must maintain full and accurate records of all product information and processes, including product coding throughout all stages of the enterprise’ operations;
(3) The aquaculture units/farms must record and provide information to enable identification of: (a) production lots, (b) received product lots, (c) product suppliers and delivery lots, and (d) product receivers;
(4) Aquaculture farms/units must maintain clear separation between received product lots, production lots and delivery lots.

The key policy that supports the use of this tool is Circular No. 03/2011/TT-BNNPTNT of the Minister of Agriculture and Rural Development dated 21 January 2011. Currently, all catfish and shrimp farmers/producers and marine capture fishermen record their production activities to allow full traceability.

The implementation of record keeping and traceability requirements in aquaculture has brought many positive results in the fields of capture fisheries, aquaculture and processing. However, there is still limited awareness and capacity among aquaculture farmers and local fishermen to apply the tools. Many still lack the skills and capacity to keep basic records of their production processes.

9.4.9. Spatial planning/zoning for aquaculture development

Spatial planning and zoning tools for aquaculture development planning have been modified and applied to fit the practical context of Viet Nam. Whilst the zoning tool has been applied in all aquaculture development planning tasks at both national and provincial levels, the spatial planning tool is a relatively new concept in the country, although the Integrated Coastal Management (ICM) tool has been applied in resource management in a number of different provinces, In 2009, UNESCO released international guidelines on "Marine Spatial Planning: A step-by-step approach toward ecosystem-based management". The Viet Nam Administration for Sea and Islands (VASI) has translated those guidelines into Vietnamese and used them as training tools for national and provincial officers in natural resource management and fisheries management. Therefore, this tool of spatial planning is by now well understood by national officers and selected provincial officers.

The zoning tool has been used by different agencies, organizations and individuals related to aquaculture development planning such as the following:

- Vietnam Institute of Fisheries Economics and Planning
- Directorate of Fisheries (D-FISH)
- Department of Agriculture and Rural Development (DARD)
- Department of Natural Resources and Environment (DONRE)
- Ministry of Agriculture and Rural Development (MARD).

In the case of the spatial planning tool, the World Bank-sponsored Viet Nam 5-year Coastal Resources for Sustainable Development Project (CRSD) for the fisheries sector will apply this spatial planning tool as part of Component A of the project[4]. This component provides support for eight provinces within the project's scope to carry out integrated spatial planning of coastal areas and strategic environmental assessments for provincial fisheries sectors. This project is currently under negotiation between the World Bank and the Ministry of Agriculture and Rural Development (MARD).

In Viet Nam, the zoning tool is applied, but does not incorporate estimates of the carrying capacity of the relevant ecosystems in formulating future development plans for the sector. The lack of quantitative justification for zoning plans thus remains a serious deficiency that remains to be addressed.

For the spatial planning tool, the CRSD Project will support its eight project provinces to adopt an integrated spatial planning (ISP) approach in developing their fisheries development plans to ensure consistency in multi-sectoral planning for coastal areas. The process that the project recommends for its provinces to carry out ISP includes 11 steps, which are specified in the project manual.

In terms of the institutional and legal support, zoning is addressed in Decree No. 92/2006/ND-CP dated 7 September 2006 on formulating, approving and managing social and economic development planning. Some clauses and articles in this decree were later amended in Decree No. 04/2008/ND-CP dated 11 January 2008.

[4] The CRSD project comprises four components: (A) institutional capacity strengthening for sustainable fisheries management; (B) Good practices for sustainable aquaculture; (C) Sustainable management of near-shore capture fisheries; and (D) Project management, monitoring and evaluation. Component A supports three activities: (a) Integrated spatial planning of coastal areas; (b) Upgrading of Viet Nam fisheries database; and (c) Conducting policy research.

Although no item of legislation or regulation directly mandates the application of spatial planning tools in aquaculture management, the issue is addressed implicitly via a number of regulations and decrees. In 2009, the government issued Decree No. 25/2009/ND-CP adopting integrated coastal zone management measures for protection and sustainable use of marine and coastal resources. In 2010, another Decree (No. 33/2010/ND-CP) was issued to manage fishing activities by allocating near-shore fishing areas to provincial, district and commune authorities to implement co-management models for coastal resources.

The zoning tool has been applied to formulate development plans for the whole aquaculture sector, and addresses individual key species such as Pangasius catfish and tiger shrimp, as well as hatchery development and marine aquaculture.

In the application of the spatial planning and zoning tools, it is evident that aquaculture development planning still follows the traditional single-sector approach in many provinces. This can frequently lead to inconsistency among sectors due to lack of coordination and information sharing. Integrated spatial planning for sector development, including the aquaculture sector, especially in coastal areas, requires involvement of multiple sectors (i.e. aquaculture, capture fisheries, tourism, rural and urban development, infrastructure, energy, etc.). Such an approach will enhance coordination among industry sectors.

9.4.10. Production process

A number of private and public certifications are available, including SQF 1000, Global GAP, BAP, VietGAP and more recently, ASC. Of these, VietGAP is a public certification and the rest are private certifications. The plethora of aquaculture certification schemes has led to confusion among both producers and consumers. Moreover, the process of certification is costly for aquaculture producers; the majority of Vietnamese aquaculture producers are small-scale operators and for the most part cannot bear the compliance costs. Though the schemes share many fundamental elements, the focus and procedures for each scheme differ.

Aquaculture farmers and producers are encouraged to apply for certification for their aquaculture operations. Third party private certification is voluntary, with the decision made by farmers according to the requirements of buyers in their respective markets. For public certification (VietGAP), a legal basis is provided through legislation (described under 9.4.13 below).

The number of aquaculture operations certified under third party private schemes remains relatively low as mentioned above, mainly due to the high cost of compliance for small-scale operators. Moreover, there is a lack of clarity due to the many schemes available. Currently, over 30 000 tonnes of cultured *Pangasius* catfish have been given BAP certification in several catfish farms; about 100 hectares of cultured catfish farms belonging to aquaculture companies have been given SQF 1000 certification.

More efforts will be required to encourage uptake of certification and address concerns over multiple third party certification schemes and particularly their prohibitive costs for small-scale farmers.

9.4.11. Social impact assessment (SIA)

Despite its important contributions to livelihoods and the national economy, the expansion of Viet Nam's aquaculture sector has brought with it mixed social impacts for households and communities. As the majority of aquaculture operators in Viet Nam are small-scale family farms, social impacts from aquaculture on households or communities are potentially significant.The purpose of SIA is therefore to assess the potential for both negative and positive impacts from aquaculture on households and communities.

However, in contrast to the mandatory provisions for EIA, Viet Nam has no statutory provisions that explicitly require compulsory conduct of SIA as part of the process for granting approval for aquaculture development projects. The tool therefore fins only limited application, mainly by researchers, managers and policy-makers.

According to some studies (see Le Xuan Sinh et al., 2006), the positive impacts of aquaculture on households and communities generally outweigh any negative impacts. Nevertheless, more research is needed as it is likely that SIA will become increasingly stipulated as a requirement by buyers in destination markets.

9.4.12. Input quality assessment and monitoring

Input quality assessment and monitoring has been conducted for many years in the Vietnamese fisheries sector. Recently, this work was assigned to a single agency under the Directorate of Fisheries (D-FISH), namely the Centre for Aquaculture Input Testing, Inspecting and Verifying (CAITIV), founded in 2010. CAITIV is responsible for testing, inspection, verification and issue of permits for production, trading, import and distribution of all inputs used for aquaculture production including seeds, feed, chemicals, bio-products, aquaculture medicines, and other specialty chemicals.

To obtain the required permits, producers, traders and distributors of aquaculture inputs must first submit an application and supporting documentation to CAITIV. On the basis of the submitted documentation, the centre will decide whether or not the input products under consideration require testing or inspection. The centre also makes regular checks on production conditions (equipment, labour, hygiene requirements, etc.) at the premises of the input producers, traders or distributors.

A legal basis for input quality assessment system is provided by the following instruments:

- Circular No. 66/2011/TT-BNNPTNT promulgated in 2011, concerning implementation of regulations on food management for livestock and aquaculture;
- Circular No. 60/2009/TT-BNNPTNT promulgated in 2009, concerning implementation of regulations on agriculture, forestry and fisheries product trading and import/export;
- Decision No. 3/2006/QD-BTS promulgated in 2006, on procedures for registration, distribution and use of chemicals for environmental treatments in aquaculture;
- Circular No. 65/2011/TT-BNNPTNT promulgated in October 2011 issuing a supplementary list of environmental chemicals and products used for environmental quality improvement and treatments in aquaculture;
- Circular No. 62/2011/TT-BNNPTNT promulgated in September 2011, issuing a supplementary list of feeds used for aquaculture in Viet Nam.

Establishment of this specialised centre for input quality management for aquaculture has greatly contributed to improved quality of aquaculture inputs, especially seed, feeds, medicines and other specialty chemicals. However, the scale of the issue is large. With thousands of chemicals used in aquaculture, thousands of distributors, wholesalers and retailers, and over 3 000 hatcheries engaged in producing seeds for aquaculture, effective management of aquaculture inputs will require improvements and reform of the input quality management system, and increased resource allocation both for facilities and human skills.

9.4.13. Management tools (VietGAP)

Based on Global GAP certification, the Vietnamese fisheries sector has developed the VietGAP certification scheme, covering four main themes: food safety, disease mitigation, ecological and environmental quality, and social responsibility/product traceability. VietGAP tool has been applied in tiger shrimp, *vannamei* shrimp, and *pangasius* catfish farming.

Farmers or producers wishing to apply for VietGAP certification must prepare application forms and other relevant documents for consideration by the Provincial Agro-Forestry – Fisheries Quality Assurance Department (PAFIQAD). PAFIQAD are required to work with accredited certification bodies to conduct the assessment and ensure required certification procedures are followed.

Guidelines on how to use VietGAP in aquaculture farms are included in VietGAP Application Decision No. 1503/QD-BNN-TCTS. MARD has promulgated this decision, together with Decision No. 1617/QD-BNN-TCTS on how to apply the VietGAP tool to specific aquaculture models of *Pangasius* catfish and shrimp farms. In addition, MARD also promulgated Decision No. 84/2008/QD-BNN to regulate procedures for VietGAP application and certification in aquaculture, as well as for vegetables, fruits and tea. Currently, the fisheries sector is drafting a specific circular for VietGAP certification procedures in aquaculture activities. The sixth draft of this circular is currently under consultation. As the procedures for VietGAP certification are still in preparation and the lack of accredited certifiers, so far relatively few aquaculture farms (such as *Pangasius* catfish and shrimp farming) have been awarded VietGAP certifications.

VietGAP was developed to accommodate local needs, and is closely linked with the Global GAP certification scheme. Moreover, VietGAP is currently under negotiation to obtain recognition by key export markets. However, awareness of VietGAP and its benefits remains low among aquaculture producers. There is therefore a major need to upgrade communication and training initiatives for aquaculture producers in order to increase uptake of VietGAP certification and clarify issues related to third party private certification.

9.4.14. Greenhouse gas (GHG) emissions/carbon footprint studies

Assessment of emissions of greenhouse gases (GHG) has been conducted in Viet Nam's aquaculture and fisheries sectors. Based on the findings, MARD promulgated a sectoral program on reducing GHG emission levels in the agriculture and rural development sectors towards 2020. The program's scope included the aquaculture sub-sector. This program makes the following observations:

- Aquaculture operators must improve their services and technologies concerning inputs, in order to improve efficiency of feed conversion ratios, identify more effective chemical and bio-based inputs, including drugs, in order to reduce GHG emissions from aquaculture activities in all aquaculture zones. The program's 2020 target for reduction of GHG emissions for the aquaculture sector is 410 000 tonnes of CO_2e (equivalent to 3.17 percent of total predicted CO_2e reduction for the whole fisheries sector by 2020).
- This program requires the aquaculture sector to upgrade culture technologies, technical processes and treatment of waste from aquaculture ponds in order to reduce GHG emissions by 1.21 million tonnes of CO_2e (equal to 9.52 percent of total predicted CO_2e reduction for the whole fisheries sector by 2020).

Decision No. 3119/QD-BNN-KHCN issued by the Minister of MARD on 16 December 2011 approved the Sectoral Program on Reducing GHG emission levels in the agriculture and rural development sector by 2020, to be implemented from 2012-2020. However, at present the tool serves primarily as a research tool at national level, and is not yet used operationally. Despite the 2020 target for GHG reductions, at present there are few data to estimate existing levels of GHG emissions in agriculture and aquaculture that might serve as a benchmark or baseline.

9.5. Issues and constraints in application of tools

As noted in the introduction to this chapter, all of the available tools have been applied to differing extents and at different levels in Vietnamese aquaculture. Some tools have become routinely used; these include EIA, IRA, health certification, record keeping and traceability, residue testing and monitoring, certification, and input quality assessment and monitoring. However, others such as the ecosystem approach to aquaculture, spatial planning, social impact assessment, and GHG/carbon footprint studies are conceptually new to Viet Nam's aquaculture sector, and so far are rarely applied. Moreover, application of existing tools is not systematic due to insufficient budgets, lack of skilled staff, and low awareness of the tools among aquaculture farmers, producers and regulatory agencies. There is thus a need for research, training and capacity building relevant to these tools so that they may be effectively harnessed to contribute to the sector's long-term sustainability.

Of the many aquaculture species cultured in Viet Nam, some have been prioritized as key aquaculture species with high production values and high contributions to export values: these are brackish water shrimps, *pangasius* catfish and mollusks. Given the high cost of AATs application, these key economic species should be prioritized for application of AATs. Technical guidelines for AATs applications should therefore be tailored for each selected aquaculture system.

Although some of the tools have yet to be applied in the context of Vietnamese aquaculture, the ecosystem approach, carbon footprint studies/greenhouse gas emissions and spatial planning have nevertheless been applied in other sectors. In such cases, it will be important to evaluate the in-country experience using these tools in other sectors, and the potential to extend their utility for adoption/adaptation to aquaculture operations.

9.6. Recommendations and way forward

9.6.1. At national level

In order to promote wider adoption of aquaculture assessment tools for sustainable aquaculture development, Viet Nam has first to establish an adequate legislative framework, including supporting regulatory instruments and implementation guidelines. At present, this is absent for many tools such as spatial planning/zoning, the ecosystem approach to aquaculture, and social impact assessment. Secondly, the aquaculture sector itself should dedicate additional resources for tool application and communication. For the new tools, detailed technical guidelines should be developed in order to guide tool implementation. The guidelines should be tailored to the specific needs of each national key aquaculture species.

9.6.2. At regional level

Pilot assessments for tool application in selected countries should be conducted to enhance understanding and arrive at practical, cost-effective solutions in tool application.

Technical support and capacity building at regional level is necessary to promote adoption of the tools, especially the new tools. For some tools with many forms and formats such as certification, support at regional level should focus on how to establish mechanisms for mutual recognition among certification schemes. This would mean that if any aquaculture operation adopts a specific certification, it is automatically recognized by the other participating certifications schemes.

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APPENDIX: Summary of adoption of AATs in countries that participated in the study

Table 24 Number of countries implementing Import Residue Analysis

Import Risk Assessment	Awareness (None = 0; Excellent = 4)	Capacity to apply (None = 0; Excellent = 4)	Extent of application (a to e)		Legal basis (Yes = 2; Under development = 1; No = 0)	
Excellent	2	0	a	1	Yes	6
Good	4	3	b	1		
Moderate	0	3	c	4	Under development	2
Fair	2	2	d	2		
None	0	0	e	0	No legislation	0
Total	8	8		8		8
Weighted scores (max = 32)	22	17		–		28

Table 25 Number of countries implementing Health Certification

Health certification	Awareness (None = 0; Excellent = 4)	Capacity to apply (None = 0; Excellent = 4)	Extent of application (a to e)		Legal basis (Yes = 2; Under development = 1; No = 0)	
Excellent	4	2	a	0	Yes	6
Good	3	4	b	1		
Moderate	0	1	c	3	Under development	1
Fair	1	1	d	0		
None	0	0	e	4	No legislation	1
Total	8	8		8		8
Weighted scores (max = 32)	26	23		–		26

Table 26 Number of countries implementing Quarantine

Quarantine	Awareness (None = 0; Excellent = 4)	Capacity to apply (None = 0; Excellent = 4)	Extent of application (a to e)		Legal basis (Yes = 2; Under development = 1; No = 0)	
Excellent	4	2	a	0	Yes	7
Good	3	5	b	1		
Moderate	1	1	c	1	Under development	1
Fair	0	0	d	1		
None	0	0	e	5	No legislation	0
Total	8	8		8		8
Weighted scores (max = 32)	27	25		–		30

Table 27 Number of countries implementing Disease Surveillance/EWS

Disease surveillance/ early warning system	**Awareness (None = 0; Excellent = 4)**	**Capacity to apply (None = 0; Excellent = 4)**	**Extent of application (a to e)**		**Legal basis (Yes = 2; Under development = 1; No = 0)**	
Excellent	2	2	a	0	Yes	6
Good	2	2	b	4		
Moderate	3	2	c	2	Under development	1
Fair	1	2	d	0		
None	0	0	e	2	No legislation	1
Total	8	8		8		8
Weighted scores (max = 32)	21	20		–		26

Table 28 Number of countries implementing Environmental Impact Assessment

Environmental impact assessment	**Awareness (None = 0; Excellent = 4)**	**Capacity to apply (None = 0; Excellent = 4)**	**Extent of application (a to e)**		**Legal basis (Yes = 2; Under development = 1; No = 0)**	
Excellent	2	0	a	0	Yes	6
Good	5	5	b	4		
Moderate	0	2	c	1	Under development	1
Fair	1	1	d	1		
None	0	0	e	2	No legislation	1
Total	8	8		8		8
Weighted scores (max = 32)	24	20		–		26

Table 29 Number of countries implementing Ecosystem Approach to Aquaculture

Ecosystem Approach to Aquaculture	**Awareness (None = 0; Excellent = 4)**	**Capacity to apply (None = 0; Excellent = 4)**	**Extent of application (a to e)**		**Legal basis (Yes = 2; Under development = 1; No = 0)**	
Excellent	0	0	a	2	Yes	1
Good	2	1	b	3		
Moderate	1	1	c	1	Under development	1
Fair	3	4	d	0		
None	0	0	e	0	No legislation	4
Total	6	6		6		6
Weighted scores (max = 32)	14.7	12		–		8

Table 30 Number of countries implementing Ecological Risk Analysis

Ecological Risk Analysis	Awareness (None = 0; Excellent = 4)	Capacity to apply (None = 0; Excellent = 4)	Extent of application (a to e)		Legal basis (Yes = 2; Under development = 1; No = 0)	
Excellent	0	0	a	1	Yes	3
Good	2	0	b	2		
Moderate	1	1	c	4	Under development	2
Fair	4	6	d	1		
None	1	1	e	0	No legislation	3
Total	8	8		8		8
Weighted scores (max = 32)	12	8		–		16

Table 31 Number of countries implementing Residue Testing and Monitoring

Residue testing and monitoring	Awareness (None = 0; Excellent = 4)	Capacity to apply (None = 0; Excellent = 4)	Extent of application (a to e)		Legal basis (Yes = 2; Under development = 1; No = 0)	
Excellent	5	4	a	1	Yes	6
Good	2	3	b	2		
Moderate	0	0	c	4	Under development	1
Fair	0	1	d	1		
None	1	0	e	0	No legislation	1
Total	8	8		8		8
Weighted scores (max = 32)	26	26		–		26

Table 32 Number of countries implementing Record Keeping & Traceability

Record keeping and traceability	Awareness (None = 0; Excellent = 4)	Capacity to apply (None = 0; Excellent = 4)	Extent of application (a to e)		Legal basis (Yes = 2; Under development = 1; No = 0)	
Excellent	3	3	a	1	Yes	3
Good	3	1	b	2		
Moderate	0	1	c	4	Under development	2
Fair	0	0	d	1		
None	0	1	e	0	No legislation	3
Total	6	6		8		8
Weighted scores (max = 32)	28.0	22.7		–		21.3

Table 33 Number of countries implementing Spatial Planning/Zoning

Spatial planning/ zoning based on carrying capacity	Awareness (None = 0; Excellent = 4)	Capacity to apply (None = 0; Excellent = 4)	Extent of application (a to e)		Legal basis (Yes = 2; Under development = 1; No = 0)	
Excellent	1	1	a	1	Yes	4
Good	3	3	b	2		
Moderate	1	1	c	0	Under development	1
Fair	2	2	d	2		
None	0	0	e	2	No legislation	2
Total	7	7		7		7
Weighted scores (max = 32)	19.4	19.4		–		20.6

Table 34 Number of countries implementing Production Process (e.g. certification)

Production process (e.g. public and private certification)	Awareness (None = 0; Excellent = 4)	Capacity to apply (None = 0; Excellent = 4)	Extent of application (a to e)		Legal basis (Yes = 2; Under development = 1; No = 0)	
Excellent	4	2	a	0	Yes	5
Good	1	3	b	2		
Moderate	0	0	c	2	Under development	0
Fair	2	2	d	0		
None	0	0	e	3	No legislation	2
Total	7	7		7		7
Weighted scores (max = 32)	24.0	21.7		–		22.9

Table 35 Number of countries implementing Management Tools (e.g. BMP/GAP)

Management Tools (e.g. BMP/GAP)	Awareness (None = 0; Excellent = 4)	Capacity to apply (None = 0; Excellent = 4)	Extent of application (a to e)		Legal basis (Yes = 2; Under development = 1; No = 0)	
Excellent	4	4	a	0	Yes	5
Good	1	0	b	2		
Moderate	2	3	c	2	Under development	0
Fair	0	0	d	0		
None	0	0	e	3	No legislation	2
Total	7	7		7		7
Weighted scores (max = 32)	26.3	25.1		–		22.9

Table 36 Number of countries implementing Social Impact Assessment

Social impact assessment	Awareness (None = 0; Excellent = 4)	Capacity to apply (None = 0; Excellent = 4)	Extent of application (a to e)		Legal basis (Yes = 2; Under development = 1; No = 0)	
Excellent	0	0	a	1	Yes	1
Good	2	1	b	3		
Moderate	3	3	c	3	Under development	1
Fair	2	3	d	1		
None	1	1	e	0	No legislation	6
Total	8	8		8		8
Weighted scores (max = 32)	14.0	12.0		–		6.0

Table 37 Number of countries implementing Input Quality Assessment/Monitoring

Input quality assessment and monitoring	Awareness (None = 0; Excellent = 4)	Capacity to apply (None = 0; Excellent = 4)	Extent of application (a to e)		Legal basis (Yes = 2; Under development = 1; No = 0)	
Excellent	3	3	a	0	Yes	7
Good	4	3	b	1		
Moderate	1	2	c	2	Under development	1
Fair	0	0	d	2		
None	0	0	e	3	No legislation	0
Total	8	8		8		8
Weighted scores (max = 32)	26.0	25.0		–		30.0

Table 38 Number of countries implementing LCA, GHG, Carbon Footprint studies

Life cycle analysis, greenhouse gas emissions, carbon footprint studies	Awareness (None = 0; Excellent = 4)	Capacity to apply (None = 0; Excellent = 4)	Extent of application (a to e)		Legal basis (Yes = 2; Under development = 1; No = 0)	
Excellent	0	0	a	1	Yes	2
Good	1	1	b	4		
Moderate	1	1	c	1	Under development	1
Fair	4	4	d	0		
None	1	1	e	1	No legislation	4
Total	7	7		7		7
Weighted scores (max = 32)	10.3	10.3		–		11.4

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