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# Building an ecosystem approach to aquaculture

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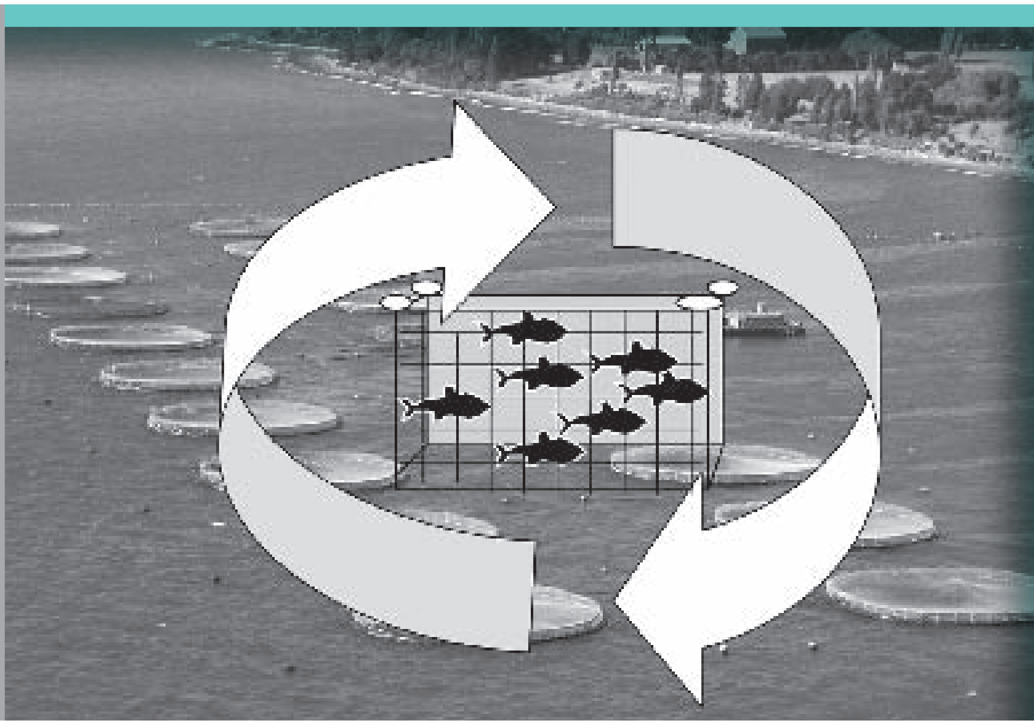

Universitat de les Illes Balears

# Applying an ecosystem-based approach to aquaculture: principles, scales and some management measures

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**ABSTRACT**

As aquaculture growth worldwide involves the expansion of cultivated areas, a higher density of aquaculture installations and of farmed individuals, and greater use of feed resources produced outside of the immediate area, many negative effects are identified when the sector grows unregulated or under insufficient regulation and poor management. The group of experts meeting in Palma de Mallorca to agree on a main framework for an ecosystem approach to aquaculture (EAA) proposes that: *an ecosystem approach for aquaculture 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"*. This definition essentially recaps the ecosystem-based management proposed by the Convention on Biological Diversity and also follows recommendations of the Code of Conduct of Responsible Fisheries (CCRF). Aiming to enhance aquaculture contribution to sustainable development, the EAA should be guided by three key principles: i) aquaculture should be developed in the context of ecosystem functions and services with no degradation of these beyond their resilience capacity; ii) aquaculture should improve human-well being and equity for all relevant stakeholders; and iii) aquaculture should be developed in the context of (and integrated to) other relevant sectors. Three scales/levels of EAA application have been identified and are discussed here: the farm; the waterbody and its watershed/aquaculture zone; and the global, market-trade scale. Additionally some management measures oriented to policy making are proposed considering the above mentioned principles and scales.

## INTRODUCTION

The 1992 Earth Summit in Rio de Janeiro addressed the issue that environmental management policies, with their traditional sectorial basis, were not adequately covering the full impacts of human development and exploitation on the environment. There was a concerted move then to incorporate a more holistic approach to policy decision-making in regard to sustainable development with an ecosystem approach based direction.

Aquaculture growth worldwide invariably involves (with differences amongst regions and economies) the expansion of cultivated areas, higher density of aquaculture installations and of famed individuals, and use of feed resources produced outside of the immediate area. Potential negative effects of aquaculture on the ecosystem often include[1]: (i) increasing demands on fisheries for fish meal/oil, major constituents of carnivorous/omnivorous species feeds, (ii) nutrient and organic enrichment of recipient waters resulting in build-up of anoxic sediments and modifying benthic communities (iii) eutrophication of lakes or coastal zones, (iv) restructuring of biological and/or social environments, (v) release of chemicals used to control water conditions and diseases (vi) competition for, and in some cases depletion of resources (e.g. water) and (vii) negative effects from escaped farmed organisms, often more relevant when exotics. But on the other hand aquaculture can have positive effects on the ecosystem, for example by providing the seed for re stocking of endangered or over exploited aquatic populations. Often as well, aquaculture is negatively affected by other human activities such as contamination of water ways by agriculture or industrial activities.

In an attempt to control inadequate developments countries worldwide have implemented a large number of aquaculture regulations. These have varied from general rules such as banning the utilization of mangroves for aquaculture practices to very specific regulations such as the establishing of maximum production per area, regulations for disease control, use of drugs, etc.

However, these regulations – neither on their own or taken together – provide a comprehensive framework ensuring a sustainable use of aquatic environments. That will happen when aquafarming is treated as an integral process within the ecosystem.

Development of advanced technologies has made production more efficient and facilitated intensification. But often the regulations in place can not guarantee sustainability, especially as most of them focus on the individual farmer and do not consider additive (cumulative) or synergistic effects of many farms on a particular area. Simultaneously, farmers' economic appraisal tends to have a narrow (short-term) view, focused on the more immediate production results. Such appraisals do not include the medium and long term revenues and costs that may be imposed to the farming activity itself and on the rest of the society in the form of a reduced supply of ecosystem goods and services.

An ecosystem approach to aquaculture (EAA) is not a new approach, it is rather an attempt to put together a common framework; the EAA has been in a way practiced since the early stages of aquaculture in small-scale inland aquaculture activities particularly in Asia where the use of poultry wastes (or other organic wastes) are commonly used as feed resources for the culture of carps and other freshwater fish. However, the EAA becomes more difficult and a real challenge in the case of intensive, industrial production but also as a result of the added effect of many small-scale aquaculture.

But equally important, the regulatory structure for aquaculture often does not allow, or facilitate, a production mode/approach that would lead to ecosystem balance. It is not uncommon that nutrient cycling and re-utilization of wastes by other forms of aquaculture (polyculture) or local fisheries, is not allowed, or is discouraged.

An ecosystem approach, like any system approach to management, accounts for a complete range of stakeholders, spheres of influences and other interlinked processes. In the case of aquaculture, applying an ecosystem-based approach must involve physical, ecological, social and economic systems, in the planning for community development, also taking into account stakeholders in the wider social, economic and environmental contexts of aquaculture. Several authors have addressed the need for a system's perspective to the management of this sector (Phillips, Boyd and Edwards, 2001; Muir, 1996; 2005). On the other hand, the first principle for an ecosystem approach, as described by the Convention on Biological Diversity (CBD), is that the

[1] This section takes many elements from *Selected Issues in SOFIA; Sustainable growth and expansion of aquaculture: an ecosystem approach* (FAO, 2007).

objectives of management of land, water and living resources are matters of societal choice (UNEP/CBD/COP/5/23/ decision V/6, 103-106). But, this approach also implies focusing on changing human behaviour and attitudes towards the use of natural resources and considering humans as part of the ecosystems.

In 1995, the Code of Conduct for Responsible Fisheries (CCRF) was adopted by the FAO Council. The CCRF also deals with aquaculture more specifically through Article 9 (FAO, 1995a) addressing many aspects relevant for its sustainable development, but this document only provides a very general framework although some general guidelines to assist its implementation have been developed (FAO, 1997).

During the Palma de Mallorca Workshop[2] a series of papers and presentations plus working group's discussions that continued after the workshop allowed to produce an agreed set of concepts, scales and some management measures for the implementation of an EAA and these are described in the following sections.

## DEFINITION

*The ecosystem approach to aquaculture is a strategic approach to development and management of the sector aiming to integrate aquaculture within the wider ecosystem such that it promotes sustainability of interlinked social-ecological systems.*

This is essentially applying an ecosystem based management as proposed by CBD (UNEP/CBD/COP/5/23/ decision V/6, 103-106) to aquaculture and also following Code of Conduct for Responsible Fisheries (CCRF) indications.

## KEY PRINCIPLES

The EAA can be regarded as "the" strategy to ensure aquaculture contribution to sustainable development and should be guided by three main principles which are also interlinked:

***Principle 1***

*"Aquaculture development and management should take account of the full range of ecosystem functions and services, and should not threaten the sustained delivery of these to society"*

It is only realistic to expect that aquaculture, being a human activity, will lead to some loss of biodiversity or affect ecosystem services to some extent. Odum pioneered the concept of *the ecosystem* making the relationship between human activity and "natural processes" as essential part of this concept (Odum, 1953). Following this author it is useful to distinguish natural from human-dominated ecosystems, in particular farmed or agro-ecosystems. The latter as human dominated are simplified ecosystems to produce food in contrast to a more classical view of natural ecosystems without major human impact (e.g. the classical Tansley (1935) view[3]). Including humans within ecosystems results in changes from their natural state, therefore, we should consider aquaculture i.e. the production system or culture facility be it a cage or pond or other, as an "aqua (cf. "agro") ecosystem", and its surrounding or external environment embedded in the wider ecosystem e.g. a river, reservoir, coastal bay, open seas. This wider ecosystem may vary from essentially undeveloped to heavily modified. In the former case ecological issues are likely to be of greater concern (societal perception) than in the latter case where aquaculture is within an already changed agro-ecosystem.

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[2] The workshop originating these proceedings.

[3] Tansley coined the term *ecosystem* as the interactive system established between all living organisms and their surrounding environment; however his view was one of a rather pristine system with its natural functioning.

Some of these concepts have been applied in Asia where integration of aquaculture and agriculture has a long tradition especially at small-scale production. Nowadays such concepts face greater challenges in other continents where aquaculture is a newer activity and even in the Asian region due to aquaculture intensification (Troell, in press). Indeed they may be especially difficult to apply in intensive large-scale farming worldwide. Integrated aquaculture and more specifically integrated multitrophic aquaculture (IMTA) has been practised in Asia/China since the beginning of aquaculture, this due to their ancient concept of treating effluents and residues from farming practices as resources rather than as pollutants. However in the western world where aquaculture is more recent there is no tradition of using effluents as useful inputs for other production systems and it becomes more difficult to apply the idea of integrated aquaculture and IMTA not even at the small-scale farming.

A key issue here is to define or estimate the resilience capacity or the limits to the acceptable environmental change (Hambrey and Senior, 2007; Hambrey, Edwards and Belton, 2008, this document)[4]. In the case of biodiversity, local declines may be acceptable (e.g. below fish cages) as long as such losses can be compensated and restored, at least at the waterbody scale, in order to preserve ecosystem functions and services. For example after a cage farm operation is halted it is expected that the relevant biodiversity recovers if there is enough *green infrastructure*, that is conservation areas or more pristine areas to provide relevant colonization and restoration.

Many environmental impact assessments (EIA) will touch on these issues and yet the tools to address them are either not well developed or used; a promising one is that offered by risk assessment (RA). Relevant questions remain: How much biodiversity are we willing to loose?, at what scales?, which would be the cost?, and how is this balanced with benefits from aquaculture?. On the other hand, aquaculture effects have to be seen in context by comparing them with those from other food producing sectors such as agriculture and livestock farming. Most terrestrial food producing systems, and especially intensive ones, have been achieved after drastically transforming the landscape, (e.g. clearing native forests, grasslands for agricultural purposes) with permanent impacts on original biodiversity; but we historically grew used to those while aquaculture is a rather new development worldwide. Efforts need to be made in order to permanently monitor aquaculture effects on biodiversity to make sure that such effects do not result in serious/significant losses of ecosystem functions and services. In this respect real values of ecosystem "goods" and services should be integrated into micro and macro environmental accounting.

In summary, developing aquaculture in the context of ecosystem functions and services is a challenge that involves defining ecosystem boundaries (at least operationally), estimating some carrying capacity and holding capacity and adapting farming according to it. This requires to consider ecosystem services to be preserved or guaranteed. With more intensive aquaculture practices some modeling and predicting tools are needed and are becoming available. Mitigation practices which consider ecosystem processes such as integrated aquaculture should be considered more seriously particularly in the intensification process.

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[4] A whole range of terms has been coined or developed to give expression to the idea of limits to environmental change, including *environmental carrying capacity*, *environmental capacity*, *limits to ecosystem functioning*, *ecosystem health*, *ecosystem integrity,* f*ully functioning ecosystems*. All these concepts are more often very difficult to apply in practice because such definitions are subject to human consensual decisions.

### *Principle 2*
### *Aquaculture should improve human well-being and equity for all relevant stakeholders*

This principle seeks to ensure that aquaculture provides equal opportunities for development and that its benefits are properly shared, and that it does not result in any detriment for any groups of society, especially the poorest. It promotes both food security and safety as key components of well being.

Improving human well-being should go beyond the direct contribution of aquaculture (or the attempts to use it for the purpose) to solve hunger especially in the regions where this activity is newer. In these cases its main contribution to local livelihoods comes from the increase in employment opportunities and also from the direct small business, local marketing of products. However often the low interest and consumption of fish by locals (e.g. in some countries in Latin America and Africa) becomes a bottleneck which may prevent the successful development of small/family type of farming in rural areas.

Any new aquaculture project should ensure that well-being of relevant stakeholders, especially rural and poorest groups will improve (or at least will not deteriorate), especially if there are environmental costs. These should be accepted and dealt with when the sector truly provides relevant social benefits. However, presently, the overall social, economic and environmental effects of aquaculture (at different scales) are rarely considered all together to determine the final balance and to decide positively or negatively on a project.

In this context, it would be relevant to define ecosystem boundaries from the social and economic perspectives although it is clearly more difficult to do than for environmental purposes because the extent of aquaculture trade and other indirect effects related to provision of seeds, feeds, services etc.

### *Principle 3*
### *Aquaculture should be developed in the context of other sectors, policies and goals*

This principle recognises the interactions between aquaculture and the larger system, in particular, the influence of the surrounding natural and social environment on aquaculture practices and results. Aquaculture does not take place in isolation and in most cases is not the only human activity – often leading to a smaller impact on waterbodies than other human activities e.g. agriculture and industry. This principle also acknowledges the opportunity of coupling aquaculture activities with other producing sectors in order to promote materials and energy recycling and better use of resources in general. Such integration has existed mostly in Asia. There are indeed many examples of integrated production systems e.g. livestock-fish farming (Little and Edwards, 2003) and fish-rice production (Halwart and Gupta, 2004).

As mentioned above, most terrestrial food producing systems have been achieved after drastically transforming landscapes, but society historically grew used to this while aquaculture is a rather new development worldwide. Therefore worldwide norms and regulations, policies etc. have been made well adapted to agriculture sector but not so much to aquaculture. The later needs an enabling policy environment to grow in a sustainable manner and to be integrated into the agro-ecosystem also minimizing conflict occurrence. Aquaculture can compete for freshwater and for land with agriculture but it can also use agriculture products for feeds. Plans for aquaculture development also need to be included within wider development and management schemes, e.g. integrated coastal zone management (ICZM), integrated water resources management (IWRM). Cooperation and integration of sectors in a better planed landscape particularly caring for water resources could yield greater benefits.

The connection with the fisheries sector is obvious from various perspectives e.g. production of fishmeal from fisheries (a fishery service to aquaculture), aquaculture based fisheries (where fisheries is benefiting from aquaculture) but often such connections are not formally dealt with or operational. Some of the potentially negative interactions deal with the competition for common markets, the potential damage to fisheries from the escaped farmed individuals (e.g. the case of escaped Atlantic salmon in Norway).

On the other hand, terrestrial food production systems and other industrial activities can impact on aquaculture deteriorating water quality and quantity; they can also affect feed's quality and potential safety (Hites *et al*., 2004).

## EXAMINATION OF PRINCIPLES AT DIFFERENT SPATIAL SCALES

The single *farm scale* is easy to picture; this is the relevant and meaningful extent of the farm which could be few meters beyond the physical boundary of the farming structures (in many cases it could be a backyard pond). However the increasing size and intensity of some farms (e.g. large-scale shrimp farming or salmon farming) could have effects beyond farm limits (concession site) extending to the whole waterbody (e.g. a lake).

While in some cases it may be difficult to identify the relevant *waterbody* to which aquaculture, together with other activities, will have an impact should be clear that in inland and coastal aquaculture, in most cases we are talking about *watersheds*. This includes land and inland waterbodies as well as circumscribed coastal areas in the context of the integrated ecosystem. This is or should be an integrated land-water resource management level (ILWRM) and it is clear that this should be a final aim/goal for policy-making.

In some cases these may be within a single country or cross national boundaries e.g. lower Mekong Basin. National or international policy and other issues would often mostly relate to the ILWRM level where the aquaculture system/s are under consideration. The watershed or waterbody scale becomes more difficult to apply (but not impossible) in the case of complex coastal fjords where the watershed boundary or the "common waterbody" becomes relevant e.g. for evaluations of carrying capacity or for the implementation of biosecurity measures.

Another scale may be useful and needed; and that is the *aquaculture zone or aquaculture region*. An aquaculture zone or aquaculture regional level is a scale that even go beyond perceivable ecological boundaries/significance and could be more relevant to social/economic and political issues although there may be some common relevant ecosystem issues for example; diseases, seeds and feeds trade, climatic and landscape conditions etc. However, in practical terms many issues and management measures could be similar at the watershed and aquaculture zone/region; therefore we will consider them together in the following analysis while indicating when an independent view may be needed. For example, offshore and open-seas aquaculture pose a challenge to the "waterbody/watershed" boundary scale while it may be easier to apply the aquaculture zone or regional scale, (e.g. Exclusive Economic Zones).

A major practical problem with the implementation and use of this scale of ecosystem relevance is that often this does not coincide with administrative and even national scales. Therefore the concept of watershed management may require creative approaches and political willingness of different administrative entities. For example it may be the case of the Mekong River and its delta, the Lake Victoria in Africa or the Mediterranean Sea.

The *global scale* refers to the global industry for some commodity products (e.g. salmon and shrimp) but also to global issues such as trade, certification, technological advances, research and education of global relevance etc.

For the above mentioned reasons, the breaking down of principles' implications and issues at each scale are only attempting to exemplify the potential differences and similarities amongst different scales. Clearly there could be a lot of overlapping of issues amongst scales and there could be as well other scales.

### Production scales/farm size

Obviously the proposed principles will have to apply to all production scales and as discussed above the magnitude and effects of ecosystem interactions depend more on the recipient waterbody capacity, structure. In that respect the total production is often more relevant (e.g. the sum of many small farms) therefore regulations should focus more on the recipient body rather than on the farms.

Production scale and intensity are a continuum and it may be a challenge to develop policies for small-scale aquaculture (or "small farmers") [5] when getting to the point of defining it. Some countries have produced definitions based on maximum annual production for a certain area in order to adapt regulations for different farm and productions sizes.

### Temporal scales

These are not directly addressed here but it is clear that in this respect, it may be necessary to permanently apply a precautionary approach due to unknown ecosystem threshold or resilience including the human components. Some external forcing factors such as climate change, climatic variability, population growth, global trade will affect all scales with a temporal dimension adding to the unknown component. Precautionary approach is being included as one of the management measures below.

## SOME OF THE MAJOR ISSUES AT DIFFERENT SCALES

### The farm scale

At the *farm scale*; issues pertaining to *Principle 1* usually have to do with the management practices in the production processes. Most management practices are developed for this scale and most top down regulation measures worldwide apply at this scale. However the ecosystem concept is rarely applied for example for proper site selection for aquaculture farms particularly in open aquatic environments. In general the carrying capacity for one new farm is rarely estimated and one of the problems/ challenges is to define the physical boundaries for such capacity and in some cases conservative approaches are used within environmental impact assessment (EIA) protocols.

Although it may seem less relevant or meaningful to talk about alteration of ecosystem services at this scale, individual large intensive farms often alter local/ site ecosystem functions e.g. the oxygenation of sediments provided by natural bioturbation (this may happen after sharp biodiversity declines).

Another important issue is that farmed species escapees and diseases originate and can be prevented/ controlled at this scale although their effects usually occur at the next spatial scale: the watershed.

Integrated aquaculture usually can take place at this scale and can be a very useful tool to mitigate impacts from excessive nutrient from the farming process out puts while increasing productivity. As mentioned earlier such practices have been common in many places in Asia (Little and Edwards, 2003[5]; Halwart and Gupta, 2004)' where integrated practices often involve individual farms and collectives of farms reaching the watershed scale. A relevant issue is that such integration practices seem to be receding

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[5] There are not globally agreed meanings for "small-scale production" aquaculture and definitions such as commercial and non commercial are being discussed, therefore here we use this term to indicate family-type aquaculture or artisanal aquaculture; one pond, one or two fish cages where workers are the family members/close neighbours and there is minimum use of technology.

especially with aquaculture intensification and although some efforts are been made to keep such systems in place (Troell, in press), more relevance should be given to this matter. One of the main difficulties is that economic assessments and valuation of products of such practices not always consider the "cleaning" benefits of such practices with negative consequences for prices associated with the secondary products.

Regarding *Principle 2* several issues are relevant at the farm scale. In regions where aquaculture is more recent the low interest and consumption of fish by locals could be a bottleneck for the development of family-owned farms and also for the use of the opportunity of increasing protein consumption.

At the farm scale, aquaculture can offer family improvement options and employment opportunities however; returns to owner-entrepreneur (that is the overall profitability of aquaculture) are often unfair. Additionally, working conditions may not always be adequate and there may be gender discrimination and unregulated child labour.

Food safety is a concern that should start at a farm scale, yet for small-scale farming, especially for rural farms often there are no conditions and infrastructures (e.g. refrigeration capability) to implement food safety measures and controls.

When following *Principle 3*, the integration of aquaculture to other sectors may not seem to apply easily at the *farm scale* however a more efficient use of on-site and immediate surrounding resources can take place, examples in Asia are shown above. Integrated aquaculture at the farm scale offers the opportunity to integrate to other sectors such as agriculture also avoiding or minimizing conflicts for resource uses. A problem is that particularly in western countries integrating aquaculture to other coastal activities and multitrophic aquaculture is not facilitated by norms and regulations and often such practices are not even allowed especially in marine coastal areas (Barrington, Chopin, and Robinson, in press). This makes individual aquaculture farms separated from other activities and increases the likelihood of conflicts with other individual users of the coastal zones and aquatic resources.

### The watershed/aquaculture zone scale

Regarding *Principle 1,* while the environmental impacts of a single farm could be marginal more attention needs to be paid to ecosystem effects of collectives or clusters of farms and their aggregate, potentially cumulative contribution at the *watershed/zone scale*, for example the development of eutrophication as a consequence of excessive nutrient outputs. Evaluations and monitoring of the overall effects of aquaculture (plus other sectors) at this scale are rare; a good example of this approach is the Modelling-Ongrowing fish farms-Monitoring (MOM) system in Norway (Ervik *et al.*, 1997) and some pilot initiatives in Ireland (Ferreira *et al*., 2007). Similarly, strategic environmental impact assessments are not common while individual farm oriented EIA are the norm and the base of environmental regulations within the sector.

While it is recognized that aquaculture could have an impact on ecosystem services at the watershed scale, there is scientific debate regarding the resilience needed to preserve essential ecosystem services. However the level of resilience it is a question of societal awareness, and decision (informed by science) must be made considering what is acceptable. Additionally, there is not enough knowledge on methods and approaches to ensure/enhance resilience capacity, for example the amount of "green infrastructure" or conservation areas needed within a watershed to provide the required resilience. Yet, on the positive side, integrated multitrophic aquaculture and various forms of integrated aquaculture are becoming better known for their potential in this respect (Troell, in press; Barrington, Chopin and Robinson, in press). Considering aquaculture within the watershed/aquaculture zone context increases the possibility for integrated aquaculture/farming and could facilitate trade of feeds and seeds.

A very relevant issue is that introductions of alien species or alien genotypes take place at this scale with often relevant impacts on biodiversity in whole watersheds.

Similarly, disease outbreaks take place first at the farm scale but often need a control and management at the watershed scale. Such management and mitigation necessarily require the watershed approach.

When aquaculture activities are not well planned and regulated they can increase inequality at the *watersheds scale*, and in the aquaculture zone, region, therefore violating *Principle 2.* For example some benefits can be felt upstream (would be the case when there is more water and of better quality) but not downstream. Aquaculture can create opportunities for a broad range of resource users; however, often the sector does not offer equitable access to resources and benefits failing to recognise that different stakeholders have different abilities/opportunities to access these.

Increasing equity and well-being simultaneously will not always be possible and over time, the balance between the two will change, and regional and local scale initiatives especially those that promote well-being and equity are often ignored. Ultimately, transfer of benefits from regional, national and other scales should get to locals in which aquaculture takes place.

Regarding *Principle 3*, in general, at the *watershed/zone* scale the integration of aquaculture to other sectors performing and development is difficult, and it does not happen in general. Perhaps Asia has been a special case where the integration as a process seems to start at the farm scale without much planning for integration at the watershed. Although recommended and with theoretical potential, freshwater aquaculture use is seldom planned and developed in conjunction with irrigation and water resources enhancement (Haylor and Bhutta, 1997; Brugère, 2006). Watershed/zone scale activities and initiatives most often are not subsidiary to the wider context of watershed, coastal zone and other integrated management policies and programmes particularly those extending beyond administrative borders (i.e. larger political boundaries or ecosystem functional boundaries).

Networking activities within the aquaculture sector and amongst sectors at the *watershed/zone scale* could be relevant. Integration between different sectors should be facilitated within the ecosystem perspective (for example the trade of feed resources and fertilizers); and increasing connections between agriculture and aquaculture through the trade of soy bean, corn gluten etc. While such trade is mostly market driven the ecosystem consequences should be sought, for example trading products within a watershed makes more sense from the ecosystem perspective than exporting resources beyond the boundaries in order to keep biogeochemical balances.

Geographical remit of aquaculture development authorities (i.e. administrative boundaries) often do not include watershed boundaries and this is a particular challenge. For example; facing climate change threats to aquaculture will require a watershed approach since prevention and mitigation measures need watershed management, e.g. protecting coastal zones from landslides, siltation or just even providing enough water etc.

### The global scale

Under *Principle 1*, core issues at a *global scale* include; pressures on small pelagic fisheries for fishmeal to feed aquaculture; concerns for the unknown biogeochemical consequences of global net transport for elements such as nitrogen, phosphorus and carbon (N, P, C) mostly from the southern hemisphere to the northern hemisphere, partly driven by aquaculture. Other relevant concerns are those related to the global environmental costs of aquaculture in terms of energy, water usage, carbon production etc. Some relevant tools for the comparison of foot prints of food sectors in general are being developed (Bartley *et al*., 2007).

Climate change will affect aquaculture development in the ecosystem context and it is important to consider such effects at global scales (e.g. effects related to fish meal production) and also by regions considering particularities of each (droughts, floods etc.).

Following *Principle 2* at the *global scale* can be challenging. There is a need to improve the well-being of all relevant stakeholders within the context of trans-national aspects of production, markets and other decision-making (e.g. promoting global common standards and social policies/practices for international companies with activities in different countries). However, inequity can grow amongst producers (countries, regions) with very different capacities and technological development particularly regarding the compliance of global standards. Opportunities at the global scale could compromise regional and local opportunities. On the positive side, the global scale offers an opportunity for enforcement of food safety procedures to comply with global market demands.

The development of aquaculture in the context of other sectors, following *Principle 3*, becomes relevant at the *global scale*, when positioning food fish within the global food

TABLE 1
**Summary of guiding principles, scales and major issues under each**

| PRINCIPLES | 1 | 2 | 3 |
|---|---|---|---|
| **SCALES** | **Aquaculture should be developed in the context of ecosystem functions and services (including biodiversity) with no degradation beyond their resilience** | **Aquaculture should improve human-well being and equity for all relevant stakeholders** | **Aquaculture should be developed in the context of other sectors, policies and goals** |
| **Farm** | Better/best management practices implemented at this scale<br>Large intensive farms may significantly alter local/site ecosystem functions<br>farmed species escapes and diseases take place and can be controlled at this scale<br>Integrated aquaculture can be an opportunity for mitigation of environmental impacts | Returns to local farmer are often unfair<br>Aquaculture can offer family improvement options and employment opportunities<br>Working conditions are not always adequate<br>Food safety can often be a concern at this scale especially for small farmers | Use of on-site and immediate surrounding resources more common in Asian countries (e.g. integrated agriculture-aquaculture ) |
| **Watershed/zone** | Environmental effects of clusters of farms are rarely being evaluated<br>Limited knowledge to define ecosystem resilience capacity<br>Diseases and establishment of alien species take place at this scale and could be prevented, mitigated | Unplanned/unregulated aquaculture activities could increase inequity<br>Often different stakeholders have different abilities/ opportunities to access resources and benefits from aquaculture<br>Increasing equity and well-being simultaneously will not always be possible<br>Transfer of benefits from regional, national and other scales should get to the local scale<br>Local scale initiatives promoting well-being and equity are often ignored | Lack of support and/or regulations for integrated aquaculture and multitrophic aquaculture<br>Local scale activities/initiatives most often are not subsidiary to the wider context of watershed, coastal zone management policies and programmes<br>Integration between different sectors are not been facilitated within the ecosystem perspective<br>Geographical remit of aquaculture development authorities' remit (i.e. administrative boundaries) often do not include watershed boundaries |
| **Global** | Increasing pressure on small pelagic fisheries for fishmeal to feed aquaculture<br>Unknown biochemical consequences of N, P, C transport among regions partially driven by aquaculture<br>Climatic change affecting aquaculture development in the ecosystem context | Improving the well-being of relevant stakeholders within the context of trans-national aspects of production, and markets is a challenge and an opportunity<br>Food safety globally enforced due to global markets<br>Development of global opportunities can compromise regional and local opportunities | Fish and aquatic proteins are increasing in world diets, and aquaculture is rapidly increasing its relevance<br>Competition with other food and energy sectors for vegetable proteins (feeds) is increasing<br>Competition for freshwater use with other food sectors will increase |

sector. It is clear that fish and aquatic proteins are increasing in human diets, and aquaculture is rapidly increasing its relevance to fulfil such demand. In parallel and as a consequence, competition with other food and energy sectors for vegetable proteins (feeds) is increasing (e.g. use of corn for bio-fuels), and competition for freshwater use with other food sectors will increase especially under climate change scenarios. Therefore there is a clear need for aquaculture to be integrated with other sectors particularly other food sectors and those using aquatic spaces and aquatic resources at the global scale. The increasing requirements of protein for feeding human population could be a main driver.

Table 1 provides a matrix for easy reference of different issues under at the light of each principle and under different scales.

## SOME MANAGEMENT MEASURES TO ASIST POLICY-MAKING THAT ENSURE ENVIRONMENTAL, SOCIAL AND ECONOMIC SUSTAINABILITY OF THE AQUACULTURE SECTOR

In general and at all levels, policies should be generated from a participatory processes, they should be adaptive, transparent and open to the general public; they must ensure and promote people consciousness of the value of ecosystem approach. They should also reconcile temporal scales facing the fact that aquaculture growth/development and governance capabilities have been moving at two different speeds.

It is also important to consider that management measures should aim to the compliance of the three EAA principles in order to ensure aquaculture contribution to sustainable development, in most cases the management measures proposed below do this and there is also some degree of overlap between them.

### 1. Apply the precautionary approach (PA) /adaptive management (AM)

"Unexpected changes occur"; management should allow to be prepared to deal with them. Some important elements regarding PA and AM have been thoroughly discussed for fisheries and the following paragraph has been adapted from the guidelines for precautionary approach to Fisheries (FAO, 1995b). Management according to the precautionary approach exercises prudent foresight to avoid unacceptable or undesirable situations, taking into account that changes in ecosystems could be slowly reversible, difficult to control and not well understood. A precautionary approach to aquaculture production should involve developing, within management strategies and plans, explicit consideration of precautionary actions that will be taken to avoid specific undesirable outcomes. For example as the overloading of the waterbody's carrying capacity to receive nutrients is a common cause of undesirable outcomes (e.g. losing biodiversity or ecosystem services), a management plan should include estimates of the carrying capacity and mechanisms to monitor and control the filling up of such capacity. Another typical example is that of culturing exotic species or genotypes. Consideration needs to be given to how uncertainty and ignorance are to be taken into account in developing and varying management measures. Plans should be developed or revised to incorporate precautionary elements; adaptive management practices and tools such as risk analysis and geographic information systems could be used.

Adaptive management has emerged as the "best practices" approach to ecosystem management. Adaptive management consciously considers both social and bio-physical systems part of a common system that is constantly changing unexpectedly (Bailey, 2008, this document; Berkes and Folke, 1998). Adaptive management is an iterative process of taking actions, evaluating the consequences of those actions, and adjusting future actions in light of changed conditions.

It may be important to judge if applying a precautionary approach due to unknown ecosystem threshold or resilience could apply at the scale of *watershed and* *coastal zones*. Society may be willing to pay a premium for the preservation of key environmental resources or areas.

Both precautionary approach and adaptive management require using the best, relevant, accurate, recent, available and most reliable information. This should include traditional and scientific ecological and societal data and knowledge to make decisions. *Policy* is informed by knowledge of the role that aquaculture may play in the regional, national and local economies and the social setting. Information is needed on the nature of stakeholders; economic factors related to the activity; details on costs and benefits; the role of aquaculture in providing food and employment; the status of access to, or ownership of, the resource; the institutions involved in planning and decision-making; and the complex interactions that occur within the ecosystem[6].

It is important to promote the capture of existing knowledge to design best sustainable approach to farm production, knowledge on production technologies and species requirements considering the estimation of site carrying capacity or holding capacity. The design and use of simple/inexpensive physical, chemical and/or biological indicators of ecosystem health (Secchi disk, dissolved oxygen, key species etc.) and sustainability at the different levels can be very useful for the latter purpose.

At the same time policies should ensure the dissemination of knowledge on adverse impacts of improper practice and better alternative technologies and better management in general. These management measures are obviously needed at the farmer and at the watershed/coastal zone scale For example, the dissemination of information in coordinate manner is essential for the control of diseases.

The promotion of risk analysis as a tool for farm decisions can ensure wiser decisions guaranteeing more sustainability of the activity. At the same time monitoring programs proportional to the level of risk and extents of impacts to society (levelling/equity among sectors) can be very useful especially at the watershed scale. Such tool can be very useful for the adaptive management process. The promotion of insurance systems (including environmental insurance) when appropriate can be also of help in many cases.

Improved input quality, farm management practices and waste or effluent treatment as well as integrated aquaculture, including integrated multitrophic aquaculture can be promoted as precautionary tools for preventing and diminishing impacts related to excessive nutrient outputs.

It is relevant to promote the PA and AM at the watershed scale as the focus of adverse impacts and assessments and enforce regulations concerning unsustainable practices, ensuring permanent review and implementation of better management at this scale. This requires to consider the influence of all sectors (aquaculture and agriculture industry and other interacting sectors) and to do so it may be necessary to facilitate decentralization of management at the watershed scale. As this may be a great challenge, it may be necessary to go by steps, starting with a certain aquaculture waterbody or cluster of farms, later to go to a portion of the watershed and to finally to be able to manage the whole watershed or coastal zone.

Promoting monitoring programs and use of easy sustainability indicators at the watershed scale is most relevant. Existing management models; hydrodynamic circulation/deposition models and the knowledge of local institutions, universities etc. can be very useful for the estimation of carrying capacity and use of indicators. For example, be aware of local regional particularities when importing technological packages developed in other regions as it may be necessary to develop proper management models or other tools that are more appropriate to specific local characteristics. It may also be relevant to facilitate the acquisition of reliable data/knowledge including the delegating of authority in terms of ecosystem monitoring to

[6] Information requirements for policy-making, adapted from FAO (1995).

general public/industry if needed (final validation of such monitoring should remain within the relevant agency for legitimacy).

At this scale it may also be necessary to facilitate the understanding of competing demands; and use best information for settling multi-user conflicts. Promote certification systems based on best information to differentiate sustainable practices.

At the *global scale*; PA and AM can be promoted through knowledge enhancement and dissemination of risk assessment tools, risk communication (e.g. GESAMP, 2008) and other similar practices to deal with the management of uncertainties. Developing global agreements on better management practices and facilitating dissemination of appropriate information to consumers allowing them to differentiate products according such practices can be also relevant.

Promotion of global sharing of sustainable practices, sustainable technologies particularly for the use of less developed nations and regions can be important. The permanent review, evaluation and improvement of management practices at all scales is at the core of AM recognizing the value and need of new information, new technologies as well as responses of ecosystems to pressures and changes.

**2. Promote appropriate "proactive" and long term goal-aimed research, guided by a participatory process and focusing on ecosystem functioning and services (also using traditional and scientific ecological and societal knowledge)**

Making sure to promote independent research to facilitate compliance of the 3 principles at the farm scale and beyond is at the core of EAA. Of particular relevance is to promote research contributing to the understanding and planning of the production process within the ecosystem framework. At all scales research needs to be interdisciplinary and multidisciplinary and long-term, there is also the need for research on governance/regulation which includes/considers a balanced ecosystem. Governments should have a more inclusive process for decision-making regarding aquaculture and appropriately devolved power at the local scale. Of great relevance is the development of Simulation Models as decision tools at different scales. Research on valuation of ecosystem services which may be undermined by aquaculture are most important in order to properly plan location of farms and aquaculture zones, mitigation measures, maximum production allowances etc.

For the *farm scale* research should focus on developing tools to evaluate externalities of inputs and outputs, to estimate carrying capacity for individual farms, and tools and technologies for improving the feeding process and conversion ratios. It is also very important to promote permanent and proactive research on new species and strains offering enough information for the selection of the right species based on ecosystem functions and market demands, considering species requirements and ecological/nutritional efficiency. Aquaculture rapid development and risks for sudden crash should be avoided/prevented ensuring continuity in following-up in regulation management and reinforcement processes, irrespectively of changes in governments, and authorities in charge.

Although there has been relevant research advances on integrated aquaculture further research is needed to comply with particularities of many regions. Research on the feasibility of integrated multitrophic aquaculture (IMTA) projects is very relevant especially considering the economic and social implications (Barrington, Chopin and Robinson, in press).

At the *watershed scale* research should consider the examination of the most appropriate species to farm, including potentially new species, while closing the life cycles of species of interest could also be important for the diversification of aquaculture within a watershed or at least to keep a wide number of candidate species as an insurance for the sustainability of the sector in the watershed. At this scale, proactive research should also cover health management and biosecurity.

Research should also focus on the considerations of externality costs and socioeconomic implications of alternative development pathways for a locality within a watershed or for watersheds *per se*. Studies should also cover the development and improvement of markets and consumer-awareness, certification and eco-labelling based on an Ecosystem approach.

Research priority should also be given to the development of models to evaluate and simulate cumulative, additive and synergistic effects of aquaculture and other sectors on biodiversity and ecosystem functions thus estimating carrying capacity also considering other users and inputs (e.g. simulation models).

Studies on comparative evaluation of policies and regulations can also be useful both for the watershed and the farm scales. Research should also help to develop regulatory and governance tools and this may involve international initiatives touching on the global scale.

*Global* research should permanently focus on producing more environmentally friendly feeds with ecosystem consideration and global accounting (e.g. lifecycle analysis), it should also prioritize the development of energy and nutrient efficient technologies and safer containment technologies to minimize energy uses, to improve effluent treatment and to avoid escapes respectively. Genetic research of a more open nature, available to all countries and regions, which can produce better and safer strains is and will be most relevant for the world development of aquaculture. Research on health management should also be approached globally or at least regionally. Research on climate change effects, adaptation and mitigation should occur at the global scale but also at the regional and even watershed scale including the interactions with other sectors, e.g. agriculture, forestry.

### 3. Promote sectoral integration when appropriate (e.g. to implement mitigation approaches and to enhance overall productivity)

The promotion of integrated aquaculture including integrated multitrophic aquaculture (IMTA) is a logical way to insert aquaculture in an aqua-system or aqua-agro system where there is proper recycling and full utilization of resources and energy while diminishing risks associated to by-products and increasing productivity of the sites. However, a proper valuation of the externalities in monocultures needs be consider in order to enhance integrated aquaculture.

For the implementation of EAA to be successful, stakeholders must understand and accept the need for this more integrative approach to aquaculture production. This will require a proactive effort by management agencies particularly ensuring effective and appropriate training for all staff having to deal with the changes required for EAA. Scientists and management authorities will need to recognize the value of the knowledge of fisherfolk and aquafarmers, their representatives and communities (particularly regarding the ecosystem). They must also recognize that with the ever-broadening range of stakeholders under EAA, the potential differences in capacity to participate in management will also increase which, if uncorrected, will lead to unbalanced and poor decisions.

Spatial tools could be necessary for organizing and reporting the information so that it can be viewed from single interest or multiple use viewpoints[7]. Integrated coastal zone management plans, in many countries and regions are already in progress and advanced on this subject while some facilitating tools such as geographic information systems (GIS) are becoming more readily available for this purpose.

At the *farm scale* it is necessary to facilitate access to proper technologies and possibly use some form of incentives (see management measure 5). The widespread dissemination

[7] GIS tools are well known for bringing together experts in a variety of disciplines in order to solve complex problems. The capacity to broadly view and spatially analyze competing and conflicting uses exists, but has yet to be fully realized. This could be one of the most important contributions of spatial tools to EAA.

of effective and sustainable traditional technologies; integrating traditional and modern practices; IMTA and integrated crops/livestock/fish should also be considered.

At the *watershed* scale it may be necessary to facilitate integration amongst farmers, and amongst farmer's associations (e.g. mussel farmers and fish farmers) also facilitating integration with fisheries and fisherfolk, with agriculture, recreation, urban and industrial activities and stakeholders. This should also involve research, common resource management, education; etc. Clearly, facilitating decentralization of management at the watershed level can be an important step.

At the *global scale* it is important to promote generation of information with transparency to aquaculture and to other sectors and consumers on the advantages of such integration. It could also be possible to contribute/promote the development of ecolabels and or other certification tools to acknowledge integration and the implementation of EAA.

### 4. Broaden stakeholder participation

Policies must create mechanisms to guarantee farmer (and his family when appropriate), employees and extension agencies the adequate participation. Policy-making and development of norms and regulations must be participatory, timely and transparent.

At the *watershed/coastal zone scale* it is important to facilitate capacity building and empower all stakeholders (particularly those in disadvantage) to ensure equitable participation, this may require mechanisms to guarantee equitable participatory extension, cooperation, research and development.

Another important approach for broadening stakeholders participation is to facilitate (create mechanisms) integrated coastal zone management (ICZM) and management of connected water ways considering EAA and involving stakeholders and institutions in other productive sectors (e.g. Agriculture and Fisheries/Aquaculture, Forestry ministries etc.). GESAMP 68 (GESAMP, 2001) goes in to this subject with some practical guidelines for coastal aquaculture.

Equitable participation can often be triggered by decentralized management measures.

At the *global scale*, connections and cooperation of farmer associations, international institutions, NGOs, IGOs etc can be promoted.

### 5. Implement proper incentives

According to the EAF practical manual (FAO, 2005), "incentives provide signals reflecting public objectives while leaving some room for individual and collective decision-making to respond to them". Different kinds of incentives can be developed in isolation or in combination, as follows:

- improve the institutional framework (definition of rights and participatory processes);
- develop collective values (education, information, and training);
- create non-market economic incentives (e.g. tax mechanisms and subsidies) such as special advantageous licences (for example for integrated aquaculture, polyculture or for implemented better management, etc.); and
- establish market incentives (ecolabelling and tradable property and access rights, e.g. aquaculture concessions).

Incentives work indirectly through affecting those factors that lead to particular individual or collective choices. Market or social forces can be very efficient means to force the global outcome of individual actions towards collectively set objectives". It may be necessary as well to create mechanisms to internalize externalities through advice and development support, training.

Often a very important but simple non market incentive is to implement gradual mechanisms for the compliance of norms, regulations and agreements including aspects of economic assistance to bear especially with initial costs. This needs to go along with a simplification of mechanisms for example for EAA certification or compliance.

Although incentives may tend to focus on the individual farm or farm clusters, some incentives can work at the *watershed scale*. For example the facilitation and promotion of waterbody/watershed certification of EAA compliance, ecolabelling etc. This should involve other stakeholders/sectors and could promote integration and better perception and implementation of the ecosystem approach.

At the *global scale* incentives may de developed by promoting EAA markets with demand for appropriate certification and proper taxation.

### 6. Promote the understanding and inclusion of people/societal values (their context)

Considerations should be made to whom is working at the farm weather a family, children, women, mostly men etc. Such information must translate in adequate working conditions in the farm. There must be also considerations and respects of cultural, ethnic and religious aspects. Such aspects should also be considered when facilitating market conditions. All of this is valid for the *farm scale* as well as for the *watershed/ coastal zone.* At this later scale its may be important to promote consideration and respect of community decisions for development options. Participatory decision processes need to include the different communities, localities even countries which share common watersheds/waterbodies.

Relevance should be given to socio-cultural markets, governance systems and regulatory systems considering historical reasons and present appropriateness.

### 7. Promote education and disseminate information on better practices considering ecosystem based management

At the farm scale it is important to target education and training to the farm stakeholders (farm owners, workers, site managers) focusing on EAA and emphasizing on management-oriented knowledge. The development of collective values and the understanding of externalities of the farming process are very relevant at this scale. The valuation and understanding of ecosystem services has to start at this scale.

At the *watershed scale* it is also relevant to target education to the right portion of the population (aquaculture associations, companies, other relevant sectors e.g. agriculture, industry, general public and policy makers). Orient education to the watershed issues focusing on EAA and promote education fostering integration of sectors.

At the *global scale* the education of consumers and public opinion becomes very relevant. For example the dissemination of scientific-based information on the use of therapeutants, bioavailability of hazardous substances etc. At this scale is also possible to promote education fostering integration of sectors. Education and information on EAA should also target trans-national institutions, global traders, global policy fora etc.

Table 2 provide a matrix to examine various management measures at different scales.

TABLE 2
**Summary of management measures at different scales**

| **1: Apply the precautionary approach (PP) /adaptive management (AM)** | | |
|---|---|---|
| **Farm** | **Watershed/coastal zone** | **Global** |
| • Promote capture of existing knowledge to design best sustainable farming approaches (e.g. production technologies and species requirements considering site carrying capacity)<br>• Disseminate knowledge of adverse impact of improper practice and better alternative technologies<br>• Promote the use of risk analysis as a tool for farm decisions and promote monitoring programs proportional to the level of risk<br>• Promote the design and use of simple/inexpensive physical, chemical and biological indicators of ecosystem health (Secchi disk, dissolved oxygen, key species etc.); and sustainability at the different levels<br>• Promote integrated (INTAQ) or multitrophic aquaculture (IMTA) where appropriate<br>• Promote environmental insurance systems when appropriate<br>• Promote better management practices in general | • Promote regulations which consider this scale as the proper focus when relevant<br>• Ensure permanent review and implementation of better management practices at this scale considering the influence of all sectors (aquaculture and agriculture industry and other interacting sectors)<br>• Facilitate decentralization of management at the watershed/coastal zone level<br>• Promoting monitoring programs and use of easy indicators at this level is most relevant<br>• Consider existing management models; circulation/deposition models; or develop proper management models considering local particularities<br>• Facilitate the acquisition of reliable data/ knowledge<br>• Understand competing demands; and use best information for settling multi-user conflicts<br>• Promote certification systems based on best information to differentiate sustainable practices | • Knowledge enhancement and dissemination of risk assessment tools and other similar practices to deal with the management of uncertainties<br>• Develop global agreements on better management practices<br>• Promote dissemination of appropriate information to consumers allowing them to differentiate products regarding sustainable and unsustainable practices<br>• Promotion of global sharing of sustainable practices, sustainable technologies<br>• Promote certification systems based on best information to differentiate sustainable practices |
| **2: Promote Appropriate "proactive" and long term goal-aimed research, guided by a participatory process and focusing on ecosystem functioning and services** | | |
| **Farm** | **Watershed/coastal zone** | **Global** |
| Research to:<br>• Define the proper species to culture<br>• Estimate externality costs and alternative development pathways<br>• Improve management and especially feed conversion ratios and minimize effluents and wastes<br>• Improve feasibility and promote integrated aquaculture (multitrophic aquaculture / polycultures) at the farm level and at the following scales<br>• Facilitate budget calculations (e.g. Biomass, nutrients, monetary etc.)<br>• Facilitate evaluation of farm carrying capacity<br>• Facilitate the understanding and value of ecosystem goods and services<br>• Carry on studies on comparative regulatory and governance studies | Research to:<br>• Close the life cycle in captivity of many species<br>• Estimate externality costs and socioeconomic implications of alternative development pathways<br>• Evaluate and model cumulative, effects of aquaculture and other sectors on biodiversity and ecosystem functions<br>• Develop tools for evaluating carrying capacity at this scale also considering other users, inputs<br>• Understand and value of ecosystem goods and services<br>• Promote the right species based on market demands, ecosystem functions, species requirements and to facilitate integration with other sectors<br>• Develop, improve markets and consumer awareness/certification and eco-labelling<br>• Develop regulatory and governance tools<br>• To enhance integrated aquaculture practices<br>• To improve biosecurity, health management<br>• Use genetics for better management and increased production | Research to:<br>• Produce more friendly feeds with ecosystem considerations and global accounting (e.g. Lifecycle analysis)<br>• Develop energy efficient farming technologies and the treatment of effluents<br>• Improve health management<br>• Develop safer containment technologies<br>• Develop further integrated aquaculture/integrated multitrophic aquaculture (IMATA)<br>• Improve management in general on genetics for better management and increased production |
| **3: Promote sectoral integration when appropriate** | | |
| **Farm** | **Watershed/coastal zone** | **Global** |
| • Facilitate access to proper technologies<br>• Widespread dissemination of effective and sustainable traditional technologies; integrating traditional and modern practices; IMTA, Integrated crops/ livestock/Fish (IAAS), IMTA | Those measures at the farm level also apply here.<br>• Facilitate integration IMTA (within farm and amongst farmers, prompter farmers associations interactions (e.g. mussel farmers and fish farmers)<br>• Facilitate integration with fisheries and fisherfolk, with agriculture, recreation, urban and industrial activities and stakeholders involving R&D, common resource management, education.<br>• Facilitate decentralization of management at the watershed level | • Must promote connections, cooperation of farmer associations, international institutions, NGOs, IGOs, etc. |

TABLE 2 (Continued)

**Summary of management measures at different scales**

| Farm | Watershed/coastal zone | Global |
|---|---|---|
| **4: Broaden stakeholder participation** | | |
| **Farm** | **Watershed/coastal zone** | **Global** |
| • Policies must create mechanisms to guarantee farmer (and his family when appropriate), employees, and extension agencies the adequate participation | • Facilitate capacity building and empower all stakeholders to ensure equitable participation<br>• Create mechanisms to guarantee equitable participatory extension, cooperation, R&D<br>• Facilitate (create mechanisms) integrated coastal zone management (ICZM) and management of connected water ways considering EAA principles and involving stakeholders and institutions in other productive sectors (e.g. Agriculture and Fisheries/Aquaculture, Forestry ministries etc.)<br>• Facilitate equitable participation by decentralized management measures | • Must Promote connections, cooperation of farmer associations, international institutions, NGOs, IGOs, etc. |
| **5: Implement proper incentives** | | |
| **Farm** | **Watershed/coastal zone** | **Global** |
| • Improve the institutional framework (definition of rights and participatory processes);<br>• Develop collective values (education, information, and training)<br>• Create mechanisms to internalize externalities<br>• Implement gradual mechanisms for the compliance of norms, regulations and agreements including aspects of economic assistance to bear especially with initial costs<br>• Create tax mechanisms, special advantageous licences<br>• Simplify mechanisms for EAA certification or compliance | • Facilitate area-geographic zoning, regulations (Licensing, Certification)<br>• Facilitate and promote waterbody/ watershed certification of EAA compliance, ecolabeling etc. This should involve other stakeholders/sectors and could promote integration and better perception and implementation of the ecosystem approach | • Promote EAA markets with demand for appropriate certification. Proper use of Taxation (int. market) |
| **6: Promote the understanding and inclusion of people/societal values (their context).** | | |
| **Farm** | **Watershed/coastal zone** | **Global** |
| • Considerations should be made to whom is working at the farm weather a family, children, women, mostly men etc. Such information must translate in adequate working conditions in the farm | • Promote the consideration and respects of cultural, ethnic and religious aspects<br>• Ensure proper markets and market conditions<br>• Promote consideration and respect of community decisions for development options<br>• Facilitate participatory decision processes for the different communities, localities even countries which share common watersheds/waterbodies<br>• Relevance should be given to socio-cultural markets, governance systems; regulatory systems considering historical reasons and present appropriateness | • Promote the considerations to socio-cultural markets, governance systems; regulatory systems: historical reasons and present appropriateness taking in account inter regional differences and developing countries/regions needs |
| **7: Promote education and disseminate information on better practices considering ecosystem framework** | | |
| **Farm** | **Watershed/coastal zone** | **Global** |
| • Target education and training to the farm stakeholders (farm owners, workers, site managers) focusing on EAA principles and knowledge-management oriented | • Target education to the right portion of the population (aquaculture associations, companies, other relevant sectors e.g. agriculture, industry, general public and policy makers)<br>• Orient education to the watershed issues focusing on EAA principles and knowledge-management oriented.<br>• Promote education fostering integration of sectors | • Target education to trans-national institutions, policy makers<br>• Promote education of public opinion based on scientific-based information particularly regarding some aquaculture myths, e.g. nutrients are “pollutants”, use of some therapeutants, bioavailability of hazardous substances, etc. |

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## APPENDIX 1

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