Coastal aquaculture and development - planning for sustainability

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Executive summary

There has been steady growth in the economic significance and impact of aquaculture related activities in coastal areas of the developing world since the FAO published 'Guidelines for the Promotion of Environmental Management of Coastal Aquaculture Development' (Barg, 1992).

In parallel with this growth, a large number of integrated coastal management (ICM) programmes and projects or co-management initiatives have attempted to balance the needs and interests of the wide range of stakeholders with national policy objectives or international guidelines for sustainable and responsible practice.

The sustainable development of the aquaculture sector requires technical information and improved awareness linked with a framework for coordination that comprises suitable policy, legislation and institutions.

Institutional issues cross-cut policy, management, enforcement and compliance and are now seen as a major constraint (or opportunity) for promoting the adoption of existing technical knowledge and expertise. These constraints are strongest in developing states where the management capacity represented by the structures, political will and the resources available to the relevant agencies is often very limited.

There is now greater awareness of the need to identify sustainable institutional arrangements for pro-poor development and of the potential use of alternative planning tools. Several ICM principles and related tools offer opportunities for accommodating aquaculture within the broad range of economic activities and development objectives in coastal areas.

The social and environmental issues associated with aquaculture in the coastal area are well documented but the destruction caused by the Indonesian tsunami in December 2004 has also highlighted a need for long-term and contingency planning with respect to threats associated with climate change or other catastrophic events.

This discussion paper presents an overview of aquaculture management and planning in the context of coastal areas in the developing world. The purpose is to outline common themes and management issues and the options derived from empirical research and national or regional experience.

1. Introduction

Aquaculture as the cultivation of fish, molluscs, crustaceans and aquatic plants (FAO, 2000) provides an increasingly significant proportion of food production globally. The sector has represented the greatest growth of all food production systems in the last two decades and an estimated 10% yearly increase in output is likely to bring productivity to a predicted 47 million tonnes in the year 2010 (Pedini and Shehadeh, 1997). Significantly, the greatest contribution to total production and the greatest rate of uptake of aquaculture activity is in the developing world. More than 82% of the total global yield in 1999 was produced by developing countries (GESAMP, 2000) and growth rates between 1984 and 1995 were six times higher than that from developed countries (Rana, 1997; Tacon, 1996). In turn, over 50% of global production originates from coastal and brackish water systems providing seaweeds, molluscs, crustaceans and finfish[1].

Several factors have fuelled this increase. National and international support to small scale aquaculture in the developing world has focussed on the contribution to national and global food security and to the provision of pro-poor employment and trade but independent commercial operations now represent a huge proportion of aquaculture activity and to current trends in growth. Improved processing and transportation has resulted in globalisation of the market and new commercial operations have evolved to meet growing demand. This diversity of coastal aquaculture activities, and so wide ranging management objectives, represents a major problem for planning and management (Hambrey and Southall, 2002).

1.1 Management constraints in the development context.

Approximately 95% of the world's tropical coastal systems are under the jurisdiction of developing countries and about 70% of the world's coastal zone is included within developing states or nations in transition from a centralized to a market economy (Sorensen, 2002). The developing world includes a large proportion of globally significant habitats (coral, sea grass systems, mangrove, lagoons etc.) and associated species assemblages that are extremely sensitive to pollution or over-exploitation and that may be protected under global directives.

Many developing countries face extreme social and economic obstacles to achieving rational and sustainable management in the coastal area, however, and these are exacerbated by the prevalence of poverty. The population growth rate in coastal areas is significantly higher than in inland areas and the majority of this growth is represented by the poor and vulnerable often directly reliant on activities associated with the natural resource base. Demographic change can be particularly pronounced in the urban context and development demands in coastal cities bring increased economic activity and associated externalities from industry and settlement.

Many countries lack the capacity to monitor change in coastal areas or to enact policy that can safeguard the long-term viability of these areas. These limitations are confounded by technical constraints and the lack of financial resources but the key

[1] Following Sorensen and McCreary (1990) the term 'coastal' is used here to mean any land influenced by the sea, the water column and the seabed extending to the continental shelf. The term 'coastal aquaculture' thus includes land-based, brackish water and maritime aquaculture practices.

constraints are often institutional ones. The constraints to achieving integrated management of coastal areas in the developing world have been discussed by Sorensen (2002) and Christie et al. (2005) and are developed further below:

1) D*emographics* – poverty can work against collective and long-term management and planning. Limits to long-term planning and participation may also stem from high rates of migration and labour mobility, conflicts associated with ethnicity, diversity in livelihoods activities associated with the resource base and so divergent management objectives.

2) *Institutional features* – many of the formal institutions relevant to ICM are isolated, poorly-funded and with limited expertise or power. These institutions were sometimes developed during previous donor projects or policy fads and may still rely on foreign expertise. Other agencies may have a purely sectoral focus with little motivation or incentive for horizontal or vertical collaboration and linkage. Pronouncements associated with decentralisation are likely to lag behind the changes required for regional planning or co-management. Agencies with the power to implement change may not operate transparent decision-making processes while other relevant stakeholders may not possess the knowledge to challenge the system.

3) *Information base* – it is unlikely that adequate monitoring of change (associated with pollution, ecology, economic activities such as aquaculture and related socio-economic factors) is in operation, reducing the scope for informed decision-making. It is unlikely that tenure and land use is clearly defined or mapped.

The diversity of interests in the coastal area, and the complex mosaic of rights and economic activities, makes conflict one of the greatest challenges to integrated management (Davos et al., 1997). Coastal areas exhibit all those characters that make natural resource conflicts especially difficult to manage: high levels of scientific uncertainty, multiple interests, high economic stakes, complex spatial issues such as transnational impact, overlapping institutional responsibility and the management constraints associated with common property resources (MacNaughton and Brune, 1997).

Rijsberman (1999) suggests that most coastal conflict is associated with some, or a combination of, the following:

- Chronic social, economic or environmental changes that reach a threshold (such as the influx of labour from immigration, loss of habitat or the impact of pollution)
- Changing social preferences and perceptions of what constitute acceptable management practice
- Externally initiated and large-scale initiatives
- Sudden rise of a new activity such as tourism or aquaculture.

The challenges to achieving any degree of integrated management are significant in both developing and developed countries but the prevalence of poverty and the pace of social and ecological change represent additional barriers in the development context (Olsen and Christie, 2000).

1.2 Aquaculture, integrated coastal management and development

Over the last three decades, international expert consultations such as the Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) have sought to elaborate the most pressing policy and management requirements for sustainable aquaculture. Broadly, these issues relate to technical issues or functions of coordination. With respect to technical functions, it is important that appropriate practice is promoted, that ecological impacts are properly understood and that meaningful systems of monitoring and evaluation are operating. However, the role of coordination in the multi-stakeholder setting of coasts and the role of legislation in creating the right setting for aquaculture development have dominated much of the discussion in the last decade. This emphasis has mirrored the growth of interest in the institutional context of natural resource management generally and the question of where, and with whom, management rights and responsibilities should be situated. Positive experiences of decentralised management in the agriculture sector during the 1980s have since fed into fisheries and broader rural development initiatives in the developing world. Co-management, where responsibility is devolved to relevant stakeholders within a government-supported structure and legislative framework, appears to have worked well in some cases for integrated management (see Section 3.3).

The need for better management and planning of aquaculture in the coastal context is widely acknowledged. Growth in coastal aquaculture has tended to occur incrementally through piece-meal and short-term commercial ventures rather than as a result of strategic planning and this has implications for the environmental and social performance of the sector. The constraints to sustainable coastal aquaculture development are associated with: 1) the inability to realise the full potential of aquaculture options and to benefit poorer sections of society; 2) the vulnerability of the sector to water quality and other uses and users and; 3) unregulated growth where rapid expansion has caused negative environmental and social impacts (GESAMP, 2001).

In the developed world, a combination of relatively strict planning procedures and regulations, assessment by investors themselves, and the demands for sustainability by consumers has helped ensure some level of control over the impact and growth of the industry. However, enterprise-specific regulation is capital intensive and reliant on government agencies with the capacity to review and challenge new activity. What is needed in the development context are processes that enable integrated and rational management in the coastal zone and that allow strategic planning given existing constraints in capacity.

Key guiding principles and priority areas for aquaculture management in the coastal context have been identified by GESAMP (1991) and elaborated by Barg (1992) and GESAMP (2001). The following distils the core requirements:

General Principles

- Adherence to international declarations and obligations such as the Rio principles (the precautionary approach, polluter pays etc.), especially Chapter 17 of Agenda 21 and the FAO Code of Conduct for Responsible Fisheries (FAO, 1995).

- Properly planned and managed coastal aquaculture can contribute to national development goals and international obligations by enhancing economic and social well-being through food production and income-earning opportunities.
- Potentially negative social and environmental effects of aquaculture in the coastal area must be acknowledged and some form of mechanism established to track change and to evaluate performance.
- Management plans should include alternative management strategies or remedial measures should negative change exceeds acceptable limits.

Policy principles

- Rational use of coastal resources to generate products and income policy to minimise conflict with other coastal activities
- Management of aquaculture to ensure minimal adverse impacts including direct and indirect impacts on human health.
- Public involvement and the use of representative organisations
- Use of incentives rather than regulation where appropriate
- Management as an ongoing process of iteration, evaluation and adaptation

Generic policy and management pronouncements such as these are not controversial but operationalising them is problematic or, in some cases, unrealistic. The next section outlines in more detail the technical and coordination tasks required for sustainable aquaculture in the coastal context before focussing on various attempts to improve planning and representation.

2. Technical and environmental issues

The negative bio-physical impacts of aquaculture in the coastal area are broadly associated with: 1) pollution from excessive organic and chemical inputs to the coastal system or; 2) wider ecological impacts associated with loss of habitat, disruption of wild species or loss of ecological function.

Most aquaculture operations produce nitrogen and phosphorous laden waste from faeces or unused food and this contributes to water quality issues such as eutrophication, increased oxygen demand and contamination of water for human consumption. In addition, a range of chemical products may be applied such as disinfectants, biocides, growth and hormone promoters. These chemicals may disrupt other species and wild populations and their longevity in animal tissue can represent an issue for human health, particularly in contexts where urban aquaculture relies on re-cycling domestic waste and supplying urban markets.

Cultured species may threaten the viability of wild stocks directly with genetic dilution from escapees or via competition, predation or as a new vector for pathogens. The greatest threat to biodiversity and ecological function, however, is associated with land conversion from natural or semi-natural habitat to farm units and this has been particularly well-documented with respect to mangrove habitats that provide nursery and breeding grounds for economically significant species.

It is useful to discuss the function and impact of coastal aquaculture activities with respect to Coche's (1982) distinction between extensive, semi-intensive and intensive practice. Seaweed production systems are amongst the more extensive coastal

operations, generally relying on naturally occurring nutrient and with relatively little husbandry requirements during the culture cycle. In some seaweed systems, chemical applications may be applied to control algal pests or predators and inorganic or organic fertilizer may be applied in semi-intensive operations. The potential negative impacts of these systems include disruption of the water flow and sediment recycling, phytoplankton blooms or the introduction of invasive species through transportation (GESAMP, 2001).

Bivalve systems can rely on large areas of the seabed but may have minimal reliance on additional inputs. However, bivalve production has been shown to impact other planktonic herbivores and to have knock-on effects on near shore species assemblages especially where new species are introduced (Chew, 1990). High density operations can produce significant oxygen demand through the decomposition of faeces and, as with some seaweed systems, bivalve cultivation can disrupt waterflow and increase sedimentation.

Shrimp culture is semi-intensive or intensive in nature with relative high husbandry demands and water management requirements. Negative environmental impacts such as salt water intrusion, conversion of mangrove habitat or lower-value production systems like rice paddy and the damaging capture of wild post-larvae are well-documented (for example, Barraclough and Finger-Stich, 1996 and Williams and Khan, 2002). The chemical and organic fertilizers and feeds added to increase production, along with the effluent produced, can lead to excessive nutrient loading and oxygen demand at specific times in the production cycle (Phillips et al., 1993). In addition, organo-pesticides and chemicals used for the pre-treatment of soil and water may have long-term consequences for human health. Mangrove areas cleared for shrimp culture often suffer from sedimentation from upland sources while intensive water management regimes will disrupt alternative land use (especially agriculture) and other downstream ecological functions. Externalities such as these, together with a huge demand for fishmeal may impact on commercial fish stocks and benthic assemblages. The social and livelihoods impacts of shrimp culture are a major concern and remain a key focus of research.

Similar land use conversion issues are associated with the cultivation of finfish in the coastal context, even where the production cycle is relatively extensive (e.g. the culture of herbivorous species in brackish water ponds). In more intensive operations based in cages, pens or tanks, effluent and excessive inputs are likely to increase nutrient loads and biochemical oxygen demand in the surrounding area. Additional negative impacts are associated with chemical treatments and the biological implications of exotic species and the risk of disease in wild populations.

In addition to the bio-physical impacts of these aquaculture systems, several modes of production result in obvious negative social impacts and conflict. Broadly speaking these effects are associated with marginalisation or the denial of access to traditionally-exploited areas and resources leading to conflict.

In summary, the entire range of aquaculture practice in the coastal zone can impact other ecological functions, economic uses and users. Expansion in aquaculture activity, if not accompanied by some increase in regulatory capacity, is likely to increase the severity of these impacts.

Technical options

The environmental impact and economic viability of coastal aquaculture at any level is associated with numerous inter-dependent factors. These will include; siting, species and culture methods, skills and technology, access to capital and markets, legal status and support within integrated management or policy (Barg, 1992).

Cultivated species exhibit broadly understood and predictable demands on the environment and there is now greater awareness of downstream effects associated with escapees, disease and contamination from each method of culture. Appropriate siting will depend on hydrographic and topographic characters that will influence the rate of water re-charging, salinity and the impact of tides, for instance. The substrate will dictate which species and which culture methods can be applied and may influence the extent of impacts on other systems in the coastal area. Better technical knowledge of aquaculture systems can identify the scope for improving productivity and/or reducing environmental impact. Chowdhury et al. (2003) discuss the possible application of the principle of 'environmental capacity' to tropical coastal areas and to aquaculture, focussing on the flow of organic and inorganic inputs and outputs as a means to quantify the need for better practice regarding siting, waste management and feeds (see Hambrey, 2003).

Despite the technical knowledge derived from research there are considerable obstacles to implementing responsible management and practice. In the context of developing world aquaculture, the limitations in skills, knowledge and technical resources may limit the range of production systems that evolve and prevent the emergence of efficient and sustainable operations. Financial constraints (both to government and producer) will limit the degree to which improved practice is promoted and adopted. This will influence the production systems that emerge, the character of land use and conversion, and so sustainability. Fluctuations in the market will also have knock-on effects to sustainability of operations and the rate of abandonment, both for extensive low-input operations and intensive production.

Coastal aquaculture is normally monitored in relation to environmental performance and change. The intention here is that information is compiled and passed on to government stakeholders and others to evaluate improvement or deterioration in the sector's impact and to assess compliance to regulation. The costs of monitoring can be prohibitive and it is important that the purpose and scope of any new monitoring programmes are clearly defined from the outset. Ideally, the broader range of economic activities in the coastal area should be acknowledged and monitoring linked to a long-term and integrated plan for management. In this respect, monitoring should be considered just one of several activities required for successful integration of aquaculture with other sectors and functions in the coastal zone (Box 1).

Technical aspects and coordination are interrelated. The implementation of known best practice and technical guidance to aquaculture activities that operate within acceptable margins will require relevant supportive legislation and institutions, for instance. These technical and coordination constraints are a recurrent theme in the recommendations derived from empirical research and case studies.

Knowledge of context

- Knowledge of socio-economic & environmental benefits, impacts of aquaculture nationally & locally, including awareness-raising.
- Site & project-specific knowledge (species, siting, production cycle etc.)
- Awareness of the multi-stakeholder context of coastal activities.
- Consider negative social (conflict & marginalisation of poor etc.) & health risks.
- Identify factors limiting environmental performance – describing bio-physical, legal & political conditions/requirements & assessment of hazards.

Pollution assessment & monitoring

- Promote rigorous approaches & supportive monitoring schemes with roles for producers.
- Integrate aquaculture-specific monitoring into broader monitoring of coastal zone pollution.

*Apply environmental impact assessment (EIA)**

- Enhance awareness of EIA principles, establish protocol for new proposals in coastal area.

Integrated Coastal Management (ICM)

- Combine efforts & plans of other coastal resource managers through coordination network.
- Encourage participation in management & planning.
- Participate in broader land zoning process for entire coastal area.
- Communicate to other users & stakeholders & work to resolve conflict.
- Link plans to broader national development goals.
- Discourage use of pristine & vulnerable habitat such as mangrove & stipulate restrictions.

Producer level

- Provide information, training & advice to producers.
- Develop waste management practice, alternative feed regimes, improve siting etc.
- Reduce chemical reliance – via health management services, for instance.

Legal framework

- Promote & enforce flexible framework specific to aquaculture but adaptable to different production methods.
- Legislation should emphasise access & environmental protection.
- Stipulate requirements for EIA, waste discharge etc. & apply incentives/deterrents.
- Apply codes of conduct (transfer of species, food quality & chemical usage).

Box 1. Activity types required for sustainable management of coastal aquaculture (based on Barg (1992) and GESAMP (2001). *EIA is just one of several planning tools. In the context of participatory co-management other tools may be required (see Section 3.2).

Funge-Smith et al. (1996), for instance, highlight how sustainability of penaeid shrimp culture in coastal Thailand is reliant on technical and managerial issues at farm level and planning and integration across the range of stakeholders in partnership with government at other levels (Box 2). In addition, the monitoring of technical aspects of aquaculture practice and farm management can provide the basis for planning and stratifying the provision of services such as extension and the allocation of subsidised inputs. Stevenson et al. (2004) have developed a methodology that identifies five distinct brackish water pond 'types' in the Philippines, for example. In this case, the production systems vary according to scale and intensity (high capital input and monoculture versus extensive and 'generalist' operations) and species (multiple, prawn, large and small milkfish). Stevenson et al. (2004) suggest that deconstructing aquaculture systems like this can provide the basis for comparative studies (and

monitoring) of farm-level performance with respect to environmental, economic and social factors. Such an approach has enabled Irz and Stevenson (2004) to test the relationship between farm size and productivity and to suggest that farm-level differences relate to decision-making and knowledge as much as possible size constraints imposed by national land policy.

Stocking strategies, environmental quality & disease

- Risk-averse strategies by farmers result in overstocking. Paradoxically, this increases the risk of farm failure and disease. Minimising viral disease will require promotion of better pond management to maintain water quality and prevent introduction of pathogens with post-larvae.

Livelihoods and infrastructure

- New shrimp operations can encourage the development of supportive infrastructure but erode the diversity of economic activities. Local economies may be over-dependent on shrimp farming given the risk of failure.

Land ownership issues

- Land with no formal ownership is vulnerable to farm development by influential interest with less concern for sustainability.

Knowledge transfer

- The associated feed and chemical industries can promote change in practice effectively but have vested interests. Promotion of impartial knowledge must compete with these market-oriented advice and change.

Technical and coordination functions overlap – effective promotion of better practice regarding stocking densities and disease management may ideally require a role for government agencies through awareness-raising programmes, technical support or legislation, for instance.

Box 2. Constraints to sustainable shrimp culture in Thailand. The primarily farm-level and technical constraints are also related to institutional capacity and coordination at other levels (after Funge-Smith et al., 1996).

Finally, the obscure property rights and ownership patterns that can characterise coastal areas in developing countries can undermine long-term commitment to responsible site management and the uptake of better practice. In addition, although the importance of both inland and coastal aquaculture is often highlighted in broad policy declarations and national plans, where appropriate legal frameworks do exist to stipulate acceptable practice, there is frequently insufficient capacity or incentive to enact them. The constraints to coordination which hamper ICM also limit prospects for the improved social, economic and environmental performance of the aquaculture sector. In this respect, the experience with ICM and planning has much to offer for improving integration and coordination of the aquaculture sector.

3. Options for enhancing planning and coordination

Although coastal aquaculture activity is very diverse (with respect to species, culture techniques, environmental demands, the range of stakeholders and interests, for instance), it does demonstrate similar characters to other economic activities in the coastal zone. The reliance on ecological services, the externalities and down-stream impacts of activities on other users and its interaction with multiple government agencies is common to other industries. In this respect, aquaculture is another activity that requires accommodating within wider coastal management objectives. The

themes and principles of ICM appear highly relevant to aquaculture and to attempts to bring this activity within broader regional or national management planning and policy.

There are several potential approaches to improve integration of aquaculture related activity with other services and functions of the coastal zone. The approaches represent a spectrum from sector-specific capacity building to cross-cutting and ambitious ICM (see GESAMP, 2001) for a comprehensive discussion of case studies and the strengths and weaknesses of alternative strategies):

Enhanced sectoral management can represent an achievable and realistic short-term strategy and might result in improved practice and new interaction with other sectors. However, this strategy can be constrained by the lack of horizontal integration with other agencies.

Zoning as the allocation of space for alternative economic activities has been a successful management tool in the developed world e.g. the Great Barrier Reef Marine Park, Australia. Protected areas may be established in an attempt to safeguard key species or used in conjunction with buffer zones to limit fishing effort. Shoreline exclusion zones are intended to limit commercial access to the inter-tidal area and are most commonly used to preserve amenity access in the developed world (Barg, 1992). Zonation relies on a strong enforcement capacity, however, together with a command and control approach reliant on large and reliable data sets. As such, its relevance in the development context has been questioned by some authors (Davos, 1998; cited in GESAMP, 2001).

ICM is an ambitious and long-term objective and there are many bio-physical and institutional constraints to success such as issues relating to scale and externalities. However, there may be greater prospects for applying ICM principles to aquaculture initiatives at the local level. In this context, full participation can be ensured and management decisions made more inclusive and accountable. Some local systems of shrimp-farm planning and management in Thailand, for instance, have been able to encourage integration with the relevant agencies and personnel and demonstrate the benefits of cross-cutting management to a wide range of stakeholders (GESAMP, 2001). In addition, it is possible that sufficient local demand for institutional and political change at higher administrative levels might be generated by these local initiatives from below. To date, most ICM programmes have operated in this way, being ambitious but sub-national in scope (Sorensen, 2002). The following summarises the requirements for achieving integrated coastal management and the realistic options for achieving improved management in the developing world (drawing from GESAMP (2001) and Olsen and Christie (2000)).

3.1 Integrated coastal management

Sorensen (2002) defines integrated coastal management (ICM) as a: ‘multidisciplinary process that unites levels of government and the community, science and management, sectoral and public interests in preparing and implementing a programme for the protection and the sustainable development of coastal resources and environments’. It is likely that integrating aquaculture with other activities and ecological services in the coastal area will require a continuous process of consultation, planning and monitoring as proposed by Brown (1997).

Although the diversity of interests and the pace of change in coastal areas represent serious constraints, most planning principles associated with coasts are common to natural resource management, generally. Coastal planning and management requires not only good information management but also the institutional framework and the political will for collaboration and integration.

Sorensen (2002) represents the coastal system and its management as comprising four interacting sub-components: 1) the coastal environment and its resources; 2) economic activities and stakeholders; 3) management tools and; governance issues represented by institutions, laws and political or individual motivation (Figure 1).

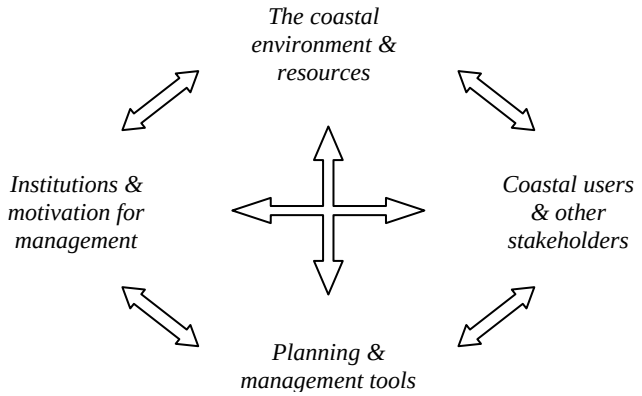

Figure 1. The elements involved in managing coastal resources and economic activity (modified from Sorensen, 2002). Stakeholders are a key component of the coastal system and can interact with the existing institutional and political environment to achieve change through appropriate planning and management tools.

Coastal systems and their resources are obviously affected by the direct, indirect or cumulative impacts of society and users. The term 'motivation' is commonly used in the ICM literature to represent both the demand for specific management interventions targeting a perceived problem (pollution, conflict etc.) or the political and individual's incentive for changing behaviour: 'the motivating issues are the anchor point of an ICM effort because they directly connect to all the programme's components: the goals and objective, the identification of the stakeholders who should be involved in programme preparation and implementation….' (Sorensen, 2002). In turn, both formal government institutions and principal stakeholders might make use of planning tools (see below) and methods of monitoring and decision-making, to inform management choices. This will then affect the coastal resource, and so the position and behaviour of institutions and other stakeholders once again.

Planning for coastal area management is reliant on good information. Firstly, facilitators of the planning process should be well aware of lessons learned or mistakes made in the region and elsewhere. A large bank of literature exists, detailing experiences of implementing integrated management approaches, and it is important that past mistakes are not repeated (see Sorensen 2002, for a review of ICM experience). Information provides the basis for reasoned decision-making and the means to evaluate performance. Unfortunately, coastal areas in the developing world

are often characterised by under-resourced government institutions without the capacity to collect or review the required information. The complexity of these coastal systems and the dynamic flux of changing land use provides special problems to mapping and understanding tenure and management responsibility.

The full range of associated government agencies must be aware of the extent of new demands represented by social and demographic change, water quality issues, industry and the needs of the poor. In addition, as planning in the coastal zone attempts to incorporate the needs of multiple stakeholders, the various interest groups also require a good awareness of management options and issues for informed decision-making. In summary, shared knowledge, at all scales, is one of the key requirements for successful ICM. Internationally, there appears a need for greater exchange of past experience with ICM projects and programmes with the result that new initiatives often fail due to avoidable mistakes at each stage of implementation (Sorensen, 2002).

3.2 Planning tools for integrated management

There is increasing pressure for nation states in the developing world to rationalise and democratise natural resource management, generally. The received wisdom is that truly inclusive planning, based on a sound knowledge base and utilising the participation of the full range of interests, is most likely to result in sustainable and acceptable management arrangements. Greater perceived legitimacy will help ensure compliance to new regulations and the inclusion of all interest groups will avoid negative impacts on less vocal or politically influential users. Several decision-support tools have been applied in an effort to systematically engage with this range of interest groups in a transparent manner and to devise acceptable management options (Table 1).

In the developed world, environmental impact assessment (EIA) has been the principal tool to evaluate individual plans and proposals in the coastal area. EIA requires substantial investment in expertise and may be less relevant in developing countries where the pace of change outstrips the capacity to consider new operations:

> ‘Despite these provisions [a Coastal Environmental Management Plan with set standards and EIA procedure], shrimp farming has developed rapidly and uncontrollably, resulting in self-pollution, disease, user conflict in some areas, and significant mangrove destruction. The failure of these coastal management initiatives relates largely to the difficulties of enforcing registration, and the inability of single enterprise EIA to cope with the problems associated with small incremental, but substantial cumulative impacts. In other words, despite its name, this Coastal Zone Management Plan lacked a strategic approach to planning for aquaculture development, and depended instead on a piecemeal and bureaucratic regulatory approach, which inevitably failed.’
>
> (GESAMP, 2001 after Nichols, 1999; Rohitha, 1997.)

Table 1. The function and character of the various decision-support approaches used in coastal planning (adapted from Pearce and Markandya (1989) and Brown et al. (2002)).

Planning tool		Advantages	Disadvantages
Cost-benefit analysis	Identifies options with greatest net benefits	Provides options on monetary & efficiency basis, resonates with policy-makers	Does not consider distribution of benefits, stakeholder diversity, or include non-quantifiable factors
Cost-effectiveness analysis	Identifies the least cost option for a specific task or decision-maker	Focussed & can use predicted costs of intervention	Does not consider alternative interventions or social costs
Multi-criteria analysis	Uses software to mathematically reconcile different objectives / concerns	Can prioritize management options, attempts to balance multiple interests	Large & good quality data sets required, may represent compromise
Risk-benefit analysis	Compares potential benefits of intervention with risks	Flexible & does not produce definitive, binding decisions	Frameworks are inconsistent & open to interpretation
Decision analysis	Step-wise analysis of choices under uncertainty	Can reflect multiple objectives & acknowledges uncertainty	No clear mechanism of assigning weights to alternatives
Environmental impact assessment	In-depth discussion of social, economic & environmental impacts of options	Requires detailed & thoughtful analysis without reliance on quantification	May not be easy to integrate with quantitative data & open to interpretation
Deliberative inclusionary processes	Typically citizen's fora for public debate of management options	Can communicate a broad range of stakeholder concerns to government	Certain interest groups may dominate, should ideally be granted a planning function by the state
Trade-off analysis	Participatory review of stakeholder concerns to provide best-fit options	Acknowledges stakeholder diversity & provides a basis for their planning input	Interest groups consider options in isolation, limits for consensus
Participatory action planning	Facilitated planning / debate with & between stakeholders at multiple levels	Can create novel options through new linkage & increased mutual awareness	No clear route to policy influence, time-consuming & expensive

The most interesting decision-support tools with respect to aquaculture planning in the development context are perhaps those rather more open-ended processes that can engage with key stakeholders and link to existing policy approaches such as co-management. In the 1990s, non-expert public groups in both the developed and the developing world started to contribute to the decision-making process. These deliberative inclusionary processes (DIPs) include neighbourhood fora, consensus conferences, multi-criteria mapping, public meetings and rapid and participatory rural appraisal (Holmes and Scoones, 2000). DIPs may function with or without the support of the state but are best accommodated within the formal planning process. Whereas DIPs in the developed world may allow direct links to policy formation, similar process in the developing world tend to extract information for deliberation by policy-makers in isolation (Holmes and Scoones, 2000). Despite this, there are examples where government has created the structures for local or regional decision-making and planning within larger programmes of coastal management or fisheries co-management (see below). New donor interest in broader issues of governance and the potential influencing role of civil society organisations, like producer groups, suggests these forms of planning will gain support.

Trade-off analysis develops the approach of multi-criteria analysis to gather feedback from a wide range of interest groups and find best-fit solutions and it has been applied to solve discrete coastal management problems (see Brown et al., 2002). Participatory action planning may have longer-lasting impacts with respect to social capital and collective management, however, and draws from the principles of consensus building and facilitated negotiation (see Bunting and Lewins 2005, for a discussion of peri-urban participatory action planning and implementation (PU-PAPi) in the context of aquaculture development). Tools such as DIPs and participatory action planning can meet the demands of donors and government by including key stakeholders in a systematic and representative manner.

3.3 Co-management

Very detailed and comprehensive plans with specific development prescriptions may be undermined by the sheer power of financial and political/economic interests and this may be a particular problem with those types of aquaculture which may be very profitable such as shrimp farming (Yap, 1996). The institutional and policy context of planning and consultation is key and a supportive framework is required in this respect.

Co-management can exploit the ownership and perceived legitimacy of planning achieved through community participation but can increase coverage and impact via regional or national administrative structures and political support. To date, co-management initiatives have proved successful in achieving both local level management for sustainable aquaculture and broader programmes integrated within existing legislation and policy (see Box 3). These latter are interesting for their potential for up-scaling better aquaculture practice (increasing coverage by replication and using government service providers and agencies at a series of levels) and linking with wider development policy and objectives. Past experience suggests that meaningful coverage and change requires a supportive 'legal corridor' for local and regional institutions to operate (Thao, 1994) and the devolution of rights and responsibilities that in no way contradicts constitutional law (Pomeroy, 1996).

In many countries, collaborative management that proactively attempts to incorporate the needs of diverse stakeholders but links with existing political processes and institutions is perhaps the best strategy to achieve support for necessary management change.

> 'The generation of social and environmental benefits that are equitably distributed among constituencies is a key factor in ICM process sustainability. Participatory processes, while challenging to manage and under growing scrutiny, remain the most effective manner to engage broad constituencies and ensure that benefits match expectations. The scaling up of many local initiatives in the Philippines and Indonesia is well underway and warrants ongoing support and monitoring. Attention must be paid to legal and institutional frameworks that support integrative planning on local and national scales.'
>
> (Christie et al., 2005)

Example 1: A project strategy to inform & influence policy (source: Akester et al. 2004)

The Support to Brackish Water and Marine Aquaculture (SUMA) project has worked with the Vietnam Ministry of Fisheries since 2000 in an attempt to attempt the promotion of sustainable brackish water and marine aquaculture for communities in five coastal Provinces in Vietnam. The project strategy has several strands but a technical research component is intended to develop new systems of benthic aquaculture to guide local management schemes and influence policy. Local stakeholders have had positive experiences testing the viability of sea cucumber (*Holothuria scabra*), seaweed (*Kappaphycus alvarezii*), abalone (*Haliotis asinine*), otter clam (*Lutralia philippinarum*), hard Clam (*Meretrix meretrix*), sea urchin (*Tripneustes gratilla*), green mussel (*Perna viridis*) and trochus (*Trochus niloticus*) species. After participatory meetings with local communities of the Diep Son Islands (Khanh Hoa Province) an area was selected for the co-managed aquaculture of these species. The management scheme used a system of zonation ranging from a 'no take area' to a more intensively managed aquaculture area. The project realised that the community management plans required political acknowledgement and legal support for legitimacy and resilience. In particular, the community management groups require control over the sea bed at critical points in the culture cycle. To date, these alternative production methods have helped reduce destructive fishing practices and helped supplement livelihood opportunities for poor coastal communities.

Dissemination and information exchange is a key part of the project's overall strategy to influence wider practice and it is intended that SUMA will work through the Network of Aquaculture Centres in Asia-Pacific (NACA) to help link stakeholders with similar needs. Networking between research institutions, producers and processors/exporters in the region is expected to harmonize efforts to achieve sustainable aquaculture and to increase spread of sustainable co-management practice.

Example 2: The role of supportive institutions & policy (source: Escober and Jacinto, 2006)

The conversion to fishponds for milkfish and shrimp culture has been the major cause of mangrove habitat loss in the Philippines since the 1960s. Mangrove destruction was partly a function of foreign investment and national policy in aquaculture but more recently an inability of government to implement policies designed to safeguard this habitat. Although a policy shift in the 1990s included fishery and forestry laws to prohibit conversion, approximately 1000 hectares continued to be lost yearly. According to Escober and Jacinto (2006) this failure was largely attributable to the centralised character of the Department of Agriculture (DA) and the Department of Environment and Natural Resources (DENR) and their inability to link with Local Government Units to coordinate their activities. The DA's Bureau of Fisheries and Aquatic Resources (BFAR) has since established the Aquaculture for Rural Development (ARD) programme in consultation with the business sector, research institutes and non-government organisation. The aim is to attempt to move the onus from "aquaculture" development to "aquaculture for rural development" and to focus on simple technologies with community management input such as a shift from rice-fish culture to giant freshwater shrimp (*Macrobrachium rosenbergii*), catfish and tilapia culture in urban areas and the establishment of protected seaweed cultivation zones.

Despite these commitments to sustainable practice, the various components of ARD have struggled to become established or to gain wide local support for several reasons. In some cases, markets for new cultured species may be poorly developed and management zones may be poorly-defined. Escober and Jacinto argue that rather than developing new aquaculture programmes, what is needed is the proper enforcement of existing law prohibiting mangrove conversion together with fundamental change to legislation affecting ownership and incentives for management. These latter might include limits to the size of fishponds and the length of leases. In order to inform decision-making, they argue, these formal changes would require national commitment to mechanisms for proper mapping, licensing and overall monitoring of change. In summary, the co-management of aquaculture here requires a supportive framework or "legal corridor" to achieve desirable change and sustainable management.

Box 3. Aquaculture co-management as pilot activities to influence policy and as national strategy. Various forms of co-management exist at a range of scales but meaningful coverage and influence depends on supportive legal and institutional structures.

4. Rehabilitating aquaculture and planning for impacts of climate change

The catastrophic impact of the Indonesian tsunami in December 2004 has highlighted the vulnerability of millions of people living in coastal areas in the developing world. The immediate impact was the loss of more than 300,000 lives but basic infrastructure and livelihoods opportunities have also been destroyed in large areas of the region. It is estimated that the livelihoods of 1.5 million people dependent on fisheries and aquaculture are now at risk. FAO (2005) state: 'latest estimates from India, Indonesia, Maldives, Myanmar, Somalia, Sri Lanka and Thailand combined put the cost at US$520 million. This relates to 111 073 fishing vessels destroyed or damaged; 36 235 engines lost or damaged beyond repair; 1.7 million units of fishing gear destroyed; and US$200 million of damage to infrastructure (such as aquaculture operations, fishing infrastructure, and harbours).' The Indian states of Kerala, Tamil Nadu, Pondicherry and Andhra Pradesh have suffered severe damage to their fish and shrimp hatchery sectors, Thailand has lost much of its floating cage, shrimp and shellfish capacity and Aceh experienced extensive destruction of hard engineering structures including fish ponds. The damage translates to immediate hardship and short to medium-term impacts on national capacity. Thailand's aquaculture-related export is expected to be down 75,000 to 80,000 tonnes in 2006, for instance (Wetlands International, 2005).

In the short-term, the reconstruction of this infrastructure and additional support to the aquaculture sector must work along collaborative lines so that re-development is perceived appropriate and is widely supported. Rehabilitation should be consistent with international and regional agreements and guidelines:

> 'Rehabilitation activity should positively contribute to the agreements and guidelines on: poverty alleviation and food security contained in the Millennium Declaration, the ASEAN Resolution & Plan of Action adopted by the Millennium Conference; the BIMSTEC declaration; the principles of sustainable development of fisheries and aquaculture outlined in the FAO Code of Conduct for Responsible Fisheries (CCRF); NACA Principles for Sustainable Aquaculture; SEAFDEC Regional Guidelines for Responsible Fisheries in Southeast Asia and the recently agreed UNEP principles for tsunami reconstruction.'
>
> (FAO, 2005)

A major focus will be the supply chain and ensuring that trading and marketing can continue or that new markets might be established, building capacity in quality assurance, handling and processing. Preserving or redeveloping capacity for international markets will have positive and long-term consequences for local livelihoods. More generally, national and NGO support to the redevelopment of the sector provides an opportunity to establish new infrastructure and processes better integrated, less environmentally damaging and less prone to conflict.

A key priority for the reconstruction of the fisheries and aquaculture sector will be the proper coordination of the vast array of donor and NGO agency strategies and objectives. International donor support to multi-sectoral rehabilitation, including the reconstruction of aquaculture structures, and the livelihoods oriented activities of international NGOs that have stressed technical capacity and income generation can work in unison but will require thoughtful partnership. Phillips and Budhiman (2005)

stress the need for national, donor and NGO plans and activities to be situated at the appropriate geographic level and for open communication and experience-sharing to be a component part of reconstruction efforts. In the case of Indonesia, Phillips and Budhiman (2005) suggest a process of planning that links national policy and community-level objectives, implemented by teams at district level. Implementing strategies comprise a major component of the FAO consortium to restore shattered livelihoods in tsunami-devastated nations (CONSRN). Although the focus here is the consolidation of physical, financial, environmental, social and human capital for fisheries and aquaculture, the need for sufficient policy and institutional support is also highlighted (see FAO, 2005a). Strengthening fisheries and aquaculture management institutions, it is argued, will both ensure the development of realistic strategic plans and avoid past constraints to sustainable practice. To this end, although the mechanisms for releasing funds have not been well organised since the tsunami, the wide range of agencies have appeared successful in achieving a level of collaboration, allowing coherent planning and the sharing of experience (FAO, 2006).

FAO (2005b) suggest that planning and new development in the aquaculture sector:

- Is based on environmentally sound management practices that do not pollute, damage habitats or cause long-term irreversible harm, including use of feed that is taken from sustainable sources and seeds that are raised in environmentally sound hatcheries or taken from sustainable fisheries.
- Adopts technologies and farm management practices that are appropriate to rural people with limited resources that minimize the impacts of aquaculture on other users of the coastal environment.
- Adopts an array of appropriate technologies and farm management practices, including those suitable to people with limited resources, which minimize impacts and which support: democratic farmer organisations; marketing, processing manufacturing of inputs and outputs; fair trade and markets, international and regional partnerships and; wide-scale communication, facilitation of dialogue and sharing of experiences.

The tsunami should influence policy and planning procedure in the future and globally given the increasing body of evidence for climate change and so coastal vulnerability. Wetlands International (2005), for instance, highlight the need to incorporate mangrove and other coastal habitats as ‘bio-shield’ buffer zones to protect land from rising sea-levels and the likely increase in catastrophic events linked to global warming. Mangrove rehabilitation projects such as those conducted in Vietnam may become normal components of holistic risk management. Coastal planning should also incorporate a predictive element, identifying those areas and livelihoods most vulnerable from environmental shocks and so managing risk.

With the apparent long-term trends in climate change policy and planning for sustainable management in coastal areas should attempt to build in the capacity to adapt to change, new threats or opportunities. The IISD (2003) have developed a framework for building in resilience to climate change that links the livelihoods approach to Holling’s (2001) notion of an adaptive cycle. Holling suggests that the capacity to manage change relates to: 1) the scope and ability for adaptive change; 2) the degree to which the components of ecological and human systems can be controlled and; 3) the resilience of the system in the face of change. In the context of a

livelihoods-based planning approach this would require first understanding the vulnerability and current coping strategies of stakeholders at risk from catastrophic events or trends and the obstacles to more complete adaptation, such as the inability to enact policy, for instance. The next stage would be to consider the legal, institutional and political context more closely to identify how adaptation strategies are currently developed and can be better supported in future. Finally, in the light of this analysis and a process of participation, a 'climate change adaptation strategy' would focus on reforms and investment that would add resilience through 'both structural and non-structural measures, and the financial means and the institutional changes necessary'. Aquaculture and fisheries interests in coastal areas are obviously vulnerable to climatic change and economic shocks through globalisation but several of the features of the coastal area in the developing world (the pace of social and environmental change, issues of governance etc.) make such forward planning less realistic. Despite this, donors are most likely to continue supporting integrated programmes those do promote resilience and adaptability by identifying alternative practice and markets.

5. Synthesis

Demands for increased participation by donors, and as often outlined in national policy, places great emphasis on finding the 'right' mode of consultation and planning. Although 'the expressions of coastal change are generally consistent worldwide' (Olsen and Christie, 2000), suitable planning and management tools and approaches will be locale-specific, depending on factors such as pre-existing institutional capacity, regional and national development priorities and the character of current practice and associated demands on the environment. In this context and with respect to aquaculture, local initiatives or enhanced sectoral support may be more likely to result in immediate and needed change than ambitious ICM projects or policy. Larger ICM programmes may be most relevant in situations where aquaculture is still in the early stages of growth and where the technical capacity and institutional and legal setting are sufficient to accommodate such an approach.

Barg (1992) suggests first focussing on the key constraints to coordination and management including: 1) the state of aquaculture expertise and technology, 2) socio-economic conditions, 3) institutional and regulatory weaknesses, 4) access to resources, and 5) the coastal setting and its capacity to absorb aquaculture-related activity. Muir and Baird (1991) stress simplicity, equity, institutional capacity, fair distribution of costs and rationality based on scientific foundations.

Partnership and collaborative planning between government agencies, research institutes, business and primary stakeholders could meet each of these management requirements. Political commitment would seem key to up-scaling good planning and management practice and experiences from smaller-scale co-management or ICM-type initiatives and aquaculture projects. Although producer organisations and other direct stakeholders have an important role to play, the function and responsibility of government should be stressed so that existing legal instruments and institutions are used to back and legitimise the collaborative planning process. Planning for the management of risks associated with the global market and climate change will require flexibility, identifying opportunities for alternative modes of production and management that can lend resilience to coastal areas and maintain the viability of their economic and environmental functions.

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