2. Contextualizing the framework

This chapter aims to convey the conceptual origins of the IAA framework, to show how it incorporates contemporary thinking in natural resource management, fisheries management and ecosystem governance. It introduces the fundamental principles on which the IAA framework is based in order to justify and enable integration of these ideas in the operational IAA framework, which is then presented in Chapter 3.

CONCEPTUAL ORIGINS

Management of SSF can be improved by an assessment and advice process that better recognizes and understands the complexities, interactions and dynamism of these systems. While some progress has been made in going beyond single-species "classical" fishery science, subsequent approaches do not fully appreciate and integrate the breadth of conceptual work on alternatives. Moreover, management frameworks that highlight these issues, such as FAO's Code of Conduct for Responsible Fisheries (CCRF) and the associated ecosystem approach to fisheries (EAF), as well as more general sustainable development (SD) approaches, are not specifically tailored to SSF. The IAA framework seeks to operate within these overarching normative frameworks to provide a basis for developing operational tools for managers of SSF. Further, this framework provides an approach to SSF assessment that is versatile enough to be relevant for SSF where the value of the fishery is too small relative to the cost of conventional approaches.

Inspired by work in sustainability and management science, the IAA process adopts a systems approach that recognizes SSF as interacting social and natural systems (Holling 1978; Walters, 1986; Gunderson, Holling and Light, 1995; Holling, Berkes and Folke, 2000; Charles, 2001). A systems approach is strongly interdisciplinary. It combines historical, comparative and experimental approaches, it uses qualitative and quantitative methods and it is fundamentally concerned with integrative modes of inquiry and multiple sources of evidence. A systems approach also engages with issues of uncertainty, surprise and threshold effects, and recognizes the importance of cross-scale interactions. A management system is, therefore, expected to cope with multiple perspectives, scales of action and composite effects of change and so needs to be experimental, flexible and adaptive. Rights-based approaches are also central to the principles and processes developed for the IAA framework.

Integrated analyses in cognate disciplines and areas of enquiry, including integrated river-basin management, integrated coastal zone management, integrated rural development, integrated conservation and development, interactive governance and common property resource management, are also adopted and the methodological tools that populate these frameworks borrowed. The theories and conceptual background of the IAA framework are summarized in Table 1. Many of these theories and concepts are themselves interrelated. It is beyond the scope of this document to review all the literature and ideas behind them, but it would be remiss not to acknowledge their influence on our thinking.

Finally, assessment frameworks that have been used to understand specific aspects of a complex system are incorporated. These are not supplanted by the framework presented here but can be used within the IAA process where appropriate. They include conventional stock assessment, environmental impact assessment (EIA), qualitative and quantitative risk analysis and management, rural livelihood assessments and approaches used for understanding and coordinating macroeconomic development (globalization of trade, poverty reduction strategies, pro-poor growth).

While the framework itself aims to enable some flexibility, autonomy and creativity on the part of those implementing the IAA process, the above principles should underpin the various choices made. These include the selection of methods of assessment, the process of their application, the interpretation of findings, the identification of options and the elaboration of advice.

Principles of integration

Shared visions and values

The IAA process aims to develop a vision shared among the stakeholders – a mental model of the facts, issues and solutions – as well as a common set of values and principles as a necessary condition for them to act accordingly. It is important, from the onset, through the scoping and assessment phases, to establish whether common understanding exists of threats, opportunities and objectives of the fishery and the SSF subsector. If this is not the case, it will be necessary to develop a common understanding of the state of the system, its key components with their relationships and dynamics, the roots of the problem and its history and possible solutions. A shared vision is not a prerequisite for action but, where it does not exist, it should be sought as an outcome of the IAA process. The ideal consensus might only emerge fully during the IAA process and possibly only after repeated IAA interventions. For this reason, constructing shared visions and values is an objective of every intervention. This requires formalizing a modus operandi that is multistakeholder, interdisciplinary, participatory (inclusive) and integrates different sources of knowledge, accounting for differing perceptions and values. Tools for conflict resolution and consensus building may be required.

Multiple forms of knowledge

Fishery science and management have co-evolved for more than a century, but as the demand for advice increased in complexity, the incremental process of involvement of additional disciplines led to very segmented visions of the sector. Disciplinary “domains” have tended to remain mutually exclusive, narrowly preoccupied with their respective specializations. Thus, in rough outline, the following viewpoints have come to prevail.

1. Resources: the domain of the fishery biologist
2. Technology: the domain of the gear technologist and engineer
3. Markets: the domain of the economist
4. Environment: the domain of the ecologist
5. Stakeholders and society: the domain of the sociologist
6. Institutions: the domain of fishery administrators, lawyers and political scientists

In contrast, the IAA process should be an integrated undertaking requiring the interaction of knowledge from many domains, whether this is of scientists and bureaucrats trained in different disciplines within the natural and social sciences, or stakeholders with differing experience and perspectives. It aims to move beyond "multidisciplinarity", towards "interdisciplinarity" or "transdisciplinarity". The framework therefore encourages, collaboration between disciplines and between technical specialists and those with other forms of knowledge (experiential, local, traditional, etc.). This facilitates the elaboration of the synoptic assessments necessary for multidimensional advice. This will be better enabled through time by the emergence of a new breed of scientist, manager and/or collaborative team with the capacity to and appreciation for undertaking such comprehensive, interdisciplinary assessments.

The framework recognizes both the potential and the challenge of achieving interdisciplinary science and advisory support. The standard process of data collection, data analysis, diagnosis, advice, monitoring and evaluation offers various steps at which to start integrating across disciplines. Conventionally, the process may have involved

TABLE 1
Theoretical and conceptual origins of the IAA framework

Theoretical and conceptual basis	Selected references
Adaptive-dynamics ecology and systems theory	
Integrated social-ecological systems thinking	Gallopin 2002; Garcia and Charles, 2007
Adaptive management	Folke, Berkes and Colding, 2000; Walker *et al*., 2004; Folke, 2006
Social adaptive learning	Holling, 1978; Walters, 1980, 1986
Non-equilibrium ecology	Berkes and Folke, 2000; Charles, 2001; Hilborn and Walters, 1992
Institutional analysis	
Common-property and collective action	Wade, 1987; Berkes, 1989; Ostrom, 1990; Berkes and Folke, 1998; Ostrom *et al*., 1999; Jentoft and McCay, 2003; Berkes, 2005
Institutions and power	Agrawal, 2003, 2005; Scott, 1998; Oakerson, 1992; Ostrom, 2005
Collaborative approaches	
Participation and deliberative inclusionary processes	Brown, Tompkins and Adger, 2001; Francis and Torell, 2004; Raakjaer-Nielson, 2003; Wilson, Raakjaer and Degnbol, 2006
Multiple knowledge systems	Agrawal, 1995; Blaikie *et al*., 1997; Scott, 1998
Interactive governance	Hersoug, Jentoft and Degnbol, 2006; Bavinck *et al*., 2005; Mahon, McConney and Roy, 2008
Integrated management	
Integrated conservation and development	Brown, 2002; Berkes, 2004
Integrated coastal zone management	
Vulnerability	
Risks, hazards, exposure, sensitivity and adaptive capacity, resilience, human security and social and environmental justice	Capak, 1993
Macroeconomic growth theories of development	
Modernization, structural adjustment, pro-poor growth, food entitlements and food security, poverty reduction, decentralization, strengthening civil society, human rights, wellbeing, development as freedom	Sen, 1999; Corbridge, 2002; Jomo and Fine, 2005; Stiglitz 2006
Rural development theory	
Farming systems analysis, integrated rural development, capitals and capabilities, sustainable livelihoods, participation and empowerment and rights-based approaches, use of local or indigenous technical knowledge	Ellis and Biggs, 2001; Fafchamps, 2003
Rights-based and entitlements approaches	
These ideas underlie many of the approaches above.	

The IAA framework intends to act as a precursor to effective management. This document does not explicitly deal with management structures but develops a process through which challenges and opportunities for management, characteristic of a particular SSF at a particular time, are identified and negotiated. The framework intends to build integrated knowledge in support of responsible SSF management. The IAA process presented here guides the incorporation of multiple conceptual principles expected within IAA implementation. These principles are elaborated below.

FUNDAMENTAL PRINCIPLES

Recent international codes and standards in fisheries, science, good governance and equitable and sustainable development provide a number of principles upon which the IAA framework has been built. Listed as thematic headings, they include the following.

1. Principles of integration
2. Principles of collaboration
3. Principles of transparency and accountability
4. Principles of versatility
5. Principles of adaptability
6. Principles of sustainability

BOX 4
The ecosystem approach to fisheries

During the past decade the concept of an ecosystem approach to fisheries (sometimes also referred to as ecosystem-based fisheries management or ecosystem-based management) has been increasingly used in policy statements by fisheries' management and environmental agencies, both governmental and non-governmental, at the national and international levels. At the same time, there has been widespread confusion regarding what an ecosystem approach actually entails. Perceptions and use of the expression have been very different, ranging from the idea of the need to base management of human activities on a detailed understanding of ecosystem structure and functioning to the perception that the use of marine protected areas (MPAs) is synonymous with EAF. Notwithstanding good progress in many localities, this confusion has significantly hindered progress towards implementation of the approach.

According to FAO (2003),

An ecosystem approach to fisheries strives to balance diverse societal objectives, by taking account of the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries.

The above definition clearly addresses both human and ecological well-being and merges two paradigms – that of protecting and conserving ecosystem structure and functioning and that of fisheries management – that focus on providing food, income and livelihoods for humans. In fact, the application of EAF represents the ultimate effort to implement sustainable development in fisheries, to be achieved through democratic and transparent practices that take account of diverse societal interests and allow participation of stakeholders in the planning and decision-making processes. Issues of sustainability are also linked to the principle of intergenerational equity, also a fundamental principle of EAF (FAO, 2003).

The *FAO Technical guidelines on the ecosytem approach to fisheries* (FAO, 2003) provide a framework for planning and managing fisheries in a way that is consistent with EAF, recognizing the need to consider the wider (ecosystem) context, including the ecological, social and institutional dimensions of the fishery system.

The EAF-based planning process consists largely of examining existing or developing fisheries to identify key priority issues to be dealt with by management in order to be consistent with an ecosystem approach. As the process unfolds, high-level policy goals, which are often too general to be useful in day-today management, are translated into operational objectives and decision rules for actual implementation. A fundamental step in this process is the formal identification with stakeholders of the priority issues to be considered for management, e.g. through a qualitative or quantitative risk analysis (depending on the information available).

The planning process unfolds in a structured way, with reference to three major dimensions of sustainable development, – namely: ecological and social well-being, and the "ability to achieve", which depends on fishery governance capacity as well as drivers external to the fisheries systems.

The process also should be applied in a participatory way, such that it is able to draw upon informal and traditional knowledge and to combine, in a balance that will depend on the type of fisheries and social conditions involved, bottom-up with top-down approaches.

Subsequent steps in the process engage practical challenges of how management can actually deal with the agreed priority issues, including the setting of operational objectives (i.e. targets), determination of the most appropriate management tools, and assessment of costs and benefits of alternative management options.

The EAF-based planning process stands in marked contrast to conventional fisheries management approaches because it is holistic in orientation: it attends to issues and concerns across all dimensions of a fisheries system, and it calls for wide stakeholder participation.

Sources: FAO, 2003; Bianchi, Cochrane and Vasconcellos, in press.

only a few potentially useful disciplines with the synthesis expected at the decision-making level (leaving to the manager the impossible task of blending the various disciplinary advices). It would be more effective if integration occurred earlier on in the process, resulting in integrated advice and information for the stakeholders. This is the minimum requirement for such an integrated assessment. Yet, it is also possible to integrate disciplines earlier, for instance at the level of the analysis and diagnosis (e.g. if hybrid, multidisciplinary models are available) and even at the data collection level, to achieve economies of scale. The appropriate level of confluence of the disciplines cannot be easily prescribed and will depend on the context, the scientific capacity available and the institutions in place, which may or may not enable the process.

It is important throughout processes of knowledge integration to maintain scientific rigour. Rigour does not equate with quantification but relates to respect for agreed enquiry protocols and transparency about assumptions, for example. The UNCLOS requirement for the "best scientific information available" states that assessments should be policy-relevant, rigorous, accurate, precise, documented, verifiable, comprehensive, understandable for recipients and timely. Rigour and quality of qualitative methods highlight criteria such as credibility, transferability, dependability and confirmability (UNEP, 2005). Assessments must also be cost effective. This is particularly so in the resource-poor settings characteristic of many SSF. The need to meet timing requirements and operate within limited resources may lead to trade-offs, however – for example, between timeliness and comprehensiveness or precision. Precision and rigour are not the same, however; it is possible to be rigorous in reporting high levels of uncertainty and in using existing information to best effect.

The uncertainty inherent in resource systems and their assessment can be addressed by broadening perspectives, as is encouraged through the IAA process, from:

- resources to the ecosystem, including people;
- single to multiple disciplines;
- assessing stocks to assessing fisheries, subsectors and cross-sectoral issues;
- dealing with management *sensu stricto* to dealing with the whole range of decision-making, from management to policy development and planning; and
- using exclusively scientific conclusions to using a broad range of information from different origins.

Again, the extent to which broader perspectives can be achieved and integrated with an IAA process cannot be prescribed. It will depend, *inter alia*, on: (i) the type of question faced; (ii) the data; (iii) the "client"; and (iv) the research capacity, among other issues. Importantly, the way the assessment is carried out is central to the success and sustainability of outcomes. Thus, the concept of "rigour" (although seldom articulated as such) in the human part of the IAA process places emphasis, in addition to scientific rigour, on effective participation of target groups in problem identification and solving, on building institutional capacity and on stakeholder ownership of the development process.

Beyond the integration of disciplines and analytical and conceptual approaches within the natural and social sciences, the value of local knowledge is increasingly recognized in the broader natural resource management and development literature:

> *The knowledge of local people…has a comparative strength with what is local and observable by eye, changes over time and matters to people. It has been undervalued and neglected. But recognizing and empowering it should not lead to an opposite neglect of scientific knowledge ... the key is to know whether, where and how the two types of knowledge can be combined, with modern sciences as servant not master and serving not those who are central, rich and powerful, but those who are peripheral, poor and weak, so that all gain.*
>
> (Chambers , 1997, page 205)

The IAA framework for SSF requires the combination of scientific, interdisciplinary knowledge with various forms of "non-scientific" local (indigenous or traditional) knowledge.[3] This document refers to the validation of local knowledge – meaning the differentiation of collective knowledge and group perspectives from individual or elite interests. The IAA process encourages consideration and integration of multiple perspectives, values, experiences and knowledge of both a scientific and 'non-scientific' nature. It is appreciated that the "non-scientific" too can influence decision-making processes and the development of understanding, shared values, legitimacy and appropriate collective action. In practice, there may not be a sharp distinction between "local" and "scientific" knowledge. Scientists sometimes use a kind of "folk knowledge" similar to that used by small-scale fishworkers – they use "rules of thumb", "gut feelings" and rapid observations and experience to make judgments that, because they are "experts" are judged to be "scientific". This process is even formalized as "expert elicitation" and used to inform major global policy processes, such as the likelihood of catastrophic "tipping points" in future climate change, including the melting of the polar ice caps or the loss of the Amazon rainforest (Schellnhuber *et al.,* 2006). Similarly, local knowledge may in fact have multiple sources, with fishworkers now acquiring data through radio programmes, discussion with scientifically-trained extension agents and multiple other pathways of knowledge diffusion. In agricultural development, such "multiple sources of innovation" models of knowledge diffusion have largely supplanted the dichotomous view of knowledge as being either "traditional" or "scientific" (Biggs, 1990). It is increasingly recognized that in the event of a contradiction between collective local knowledge and scientific knowledge, it cannot be assumed that the scientific knowledge is *de facto* correct. For this reason, the IAA framework encourages a view that engages with multiple sources and types of knowledge.

Incorporating local knowledge and different perceptions may provide useful information for creating working hypotheses, structuring models or scouting for options. It is also necessary for the construction of shared visions and values and so will play an important role in the negotiation and, therefore, in the practical outcome of the IAA process.

Principles of collaboration

The IAA framework should be highly participatory. Active participation of stakeholders and other knowledge holders is essential for the application of many of these principles and for ensuring ownership by the community, relevance of the issues and legitimacy of the responses. It helps in empowering the actors, mobilizing people, building-up consensus, improving the knowledge base and identifying expectations and perceptions. The mechanisms put in place in a participative assessment may become useful for other more decision-oriented processes, facilitating decentralization and devolution of responsibilities. Participation contributes to adequate problem formulation and effective solution-finding, facilitating conflict resolution and reducing social and economic risk. It increases equity and transparency, facilitating public scrutiny and auditing. It is also a means necessary to improve scientific understanding and transform it into a broader societal understanding that will inform people's decisions and willingnessness to comply or not to particular courses of action. The concept of participation and its nuances and ramifications are explored in Annex 2.

The degree of participation required for an effective process depends on the nature of the issues to be dealt with. Decisions about a food-safety norm may require less stakeholder participation (and non-scientific intervention) than decisions on where to site a marine protected area or on the introduction of territorial use rights.

---

[3] This issue is both sensitive and controversial and even hedges on the ideological. It is examined in more detail in the section *Stakeholders' roles*.

Active participation is in line with the requirements of the 1990 Arusha Declaration[4] and 1998 Aarhus Convention[5]. In IAA, the assessment constituency and the management constituency may overlap significantly, even given that stakeholders may have different roles in the two interconnected processes. Fishworkers, for example, will be contributors in the assessment process as well as negotiators or deciders in the advisory and decision-making processes.

An important consideration for the application of participatory integrated assessments is that organizers, in the design and preparation of any application, should honestly reveal the potentially diverging interests, conflicting views and possible hidden agendas of expected participants. With this and a skilful moderator, these problems can be managed if identified ahead of time and contingency measures are taken. The key is to prevent the evolution of hostile attitudes towards the participatory process itself. Meticulous preparation can turn this risk into an opportunity by creating group dynamics that transform initial tensions into creativity (Toth, 2001).

Principles of transparency and accountability

The assessment should be transparent, i.e. processes, data, methods, processes, results and interpretations should be documented and easily available. This is particularly important when dealing with uncertainty and multiple sources of knowledge. It also requires a formal recognition of roles and responsibilities in the process. Dissent and concerns should be particularly documented if set aside, with information on the reason for discarding. Together with active participation, transparency and accountability contribute to credibility, legitimacy and trust.

Principles of versatility

By definition, assessments of complex systems should not pretend to be universal (i.e. they are strongly contextual). Nevertheless, the IAA framework can be employed under a variety of management/policy contexts and by any organization. There are a number of governance, economic and research approaches that are available to guide the design of management structures and processes. These vary in their prioritization of different objectives, including collaboration (co-management, community-based management), integration (integrated zone management, integrated conservation-development projects), rights (property rights, human rights) and sustainability (sustainable ecosystem approach, sustainable livelihood approach). In any given country, the institutional architecture of management may differ among, subsectors and individual projects. The IAA framework is designed to be appropriate for assessment and decision-making processes in the entire spectrum of management and policy contexts from sector to individual project. As such, the assessment process is independent from the current management or policy frame.

Indeed, IAA is expected to update and improve the current management or policy frame. The framework can, therefore, be implemented by a range of individuals and

[4] The 1990 Arusha Declaration on Popular Participation in Development was founded on the notion that sustainable development could only be achieved through the full participation of the intended beneficiaries of the development process (Sharp, 1995). It followed from recognition that development projects designed and implemented without the full involvement of the intended beneficiaries have a high failure rate.

[5] The United Nations Economic Commission for Europe Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (in short, the Aarhus Convention) was signed in 1998 and entered into force in 2001. It recognizes citizen's rights to information, participation and justice and aims to promote greater accountability and transparency in environmental management matters. The pillars of the convention are: (i) greater public access to public environmental information; (ii) opportunity for people to express opinions and concerns on environmental matters and ensure that they are accounted for in decision-making; and (iii) public access to review procedures when those rights have been breached and, in some cases, the possibility to challenge violations of environmental law.

organizations, including government agencies, academic institutions, the private sector, local communities or NGOs. To enable this, the IAA process is adequately generic and adaptable to particular contexts. This principle raises three important challenges. First, the term SSF hides a wide range of very different situations in which similar assessment processes and methods might successfully be used but for which generalization of management prescriptions would be dangerous. Second, the whole IAA framework itself, with its approaches to knowledge development, uncertainty, participation and empowerment, is deeply embedded and informed by a range of theories regarding structures and interrelationships in the natural and human subsystems. It is forward-thinking and innovative but based on relatively well-established principles. It is, however, difficult to envisage how it might be used in situations where such concepts might not yet be accepted, e.g. where some of its underlying principles and values, such as the principles of democratic governance, are not yet adopted and implemented. In such areas, emerging ideas relating to resilience-building, empowerment for self-organization, etc. might be a way to enable evolution in the more appropriate directions. Third, the concept of co-evolution of science (or knowledge building) and management, implies that initially similar IAA systems, applied to different situations in an adaptive mode, may evolve differently. Starting from a common framework, evolutionary pathways might diverge.

The IAA framework can thus be employed to increase understanding of problems and issues and clarify pathways to solutions, in many different contexts: in data-poor as well as data-rich situations, whether high or low assessment capacity is available, in a problem-oriented as well as strategic planning mode, in a short-term as well as a long-term perspective, for dealing with local to global issues and under a variety of governance regimes. To achieve this versatility, the framework encompasses a range of qualitative and quantitative approaches of varying cost and difficulty of application. It proposes sophisticated analyses as well as rapid appraisals. It combines scientific knowledge with collective local knowledge. It overcomes shortcomings through iteration and social learning.

Multiple scales of enquiry

The connections between spatial scales (global, national and local levels) have been revealed through research, management practice, industry and market mechanisms and trends in human development. Research has indicated the importance of international and regional programmes and mentoring sources that have progressively replaced colonial research. It is recognized that management practice is subject to the obligations generated at all levels by the international instruments agreed at the highest political levels, often without a clear analysis of their implications at the lower levels. Industry and market mechanisms and norms continue to develop at the global level with the power to disadvantage or eliminate those who cannot adapt (the Hazard Analysis and Critical Control Point [HACCP] system, the International Organization for Standardization [ISO], the Marine Stewardship Council [MSC], etc.). Finally, trends in human development include increased labour mobility, such as movements of people between fisheries and from fisheries into other sectors of the economy. The IAA framework, therefore, needs to be versatile enough to account for cross-scale interactions. It considers the fishery (and the fishery sector) as a complex whole even when the assessment is concerned with a specific issue affecting only part of that whole. The need to deal with cross-scale effects is important, *inter alia,* for looking at:

- transboundary impacts, whether imported (external drivers) or exported (externalities) from the studied subsystem;
- strategic (long-term) implications of operational measures and vice versa;
- interactions between governance systems, at intersectoral level and across jurisdictional scales (from local to global).

Dealing with multiple scales is obviously a challenge as, with finite assessment resources, this will inevitably involve a trade-off between the operational (local) and the strategic (contextual) scales. It will be neither possible nor useful to assess both to the same extent. Part of the solution of the dilemma is in the demand itself. If the initial question is a broad strategic one (e.g. what might be the impact of ecolabelling, or territorial rights in the national SSF sector?) then the focus will be strategic, but some representative case studies, at local level, will be used as "ground truthing". If, on the contrary, the question is local (e.g. conflict with an expanding neighbouring fleet or newly introduced gear), the solution is to focus on the local issue, but open a rapid assessment of the potential consequences of the solutions proposed in terms of, for instance, compatibility with national legislation and the national constitution, possible "domino effects" on other fisheries out of the area, etc. In general, a dual track will be advisable, combining parallel assessments of the global and partial assessment, with the balance between the two being fixed by the nature of the initial request (i.e. the entry point).

In brief, while the scale at which assessment is made is largely imposed by the demand, the framework calls for looking at all relevant scales with an appropriate weighting (in terms of importance, detail, cost of the analyses) depending on the particular issue and context.

As stressed by Lebel (2006), scales are not politically neutral. The capacities and interests of the different stakeholders vary greatly with scale. The fleet scale (as opposed to vessel scale) is preferred by industry for confidentiality. The scale at which a coherent assessment can be made (because of data density or model limitations) may not be the most pertinent scale for operational management. Power holders prefer the scale (local, national or global) at which they can influence the outcomes. The implication is that integrated assessment and advice will need to find the best scale combination or compromise for the issue and mix of stakeholders concerned.[6]

Principles of adaptability

Addressing complexity and uncertainty

Acknowledging the complexity of social-ecological systems, including SSF, has various implications:

- loss of universality (reduced transferability of experience);
- increased uncertainty;
- multiple and scale-dependent points of view and cross-scale issues;
- non-linearity of relations between components;
- non-applicability of equilibrium and reversibility concepts;
- delayed responses to action;
- remote control and feedbacks;
- possibility of unexpected evolution (surprises) and of self-organization; and
- risk of organizational failure if thresholds are reached

Under these conditions, the risk of ineffective action is high. The IAA framework must therefore accept complexity, knowledge limitations and an element of uncertainty. In line with the precautionary approach to fisheries, the IAA process will identify and explicitly assess the consequences of uncertainty on the robustness of the advice. The assessment should be repeated with a frequency dependent on the level of risk. Such risk should be explicitly assessed, for example using qualitative or quantitative participative risk assessment procedures. It should specifically look for potential errors in model structure and interconnections, unexpected effects of external drivers or internal feed-back loops. It should ensure that risk is duly communicated to managers and stakeholders and progressively reduced through adaptive learning processes.

[6] Fanning *et al.* (2007) elaborate extensively on scale issues and linkages, largely in response to SSF governance issues.

The complex, even chaotic, behaviour of fish stocks led Wilson *et al*. (1994) to suggest that there could never be sufficient information to manage fisheries on a numerical basis. Instead of controlling "how many' fish are caught (e.g. by specifying total allowable catches [TACs]), they suggested that the best alternative was to develop fishing restraints that affect "how, when and where, fish are caught", to ensure that core ecosystem functions that support fisheries productivity are preserved. Wilson *et al.* (1994) reviewed examples of what they termed "parametric management" from fisheries around the world and suggested that many "traditional" management systems that had successfully sustained fisheries were based on such parametric controls, which include protection of spawning and nursery areas, limited access, closed seasons and size limits. These management measures are often based on local or indigenous knowledge (Ruddle, 1994).

A modern extension to the idea of addressing the inherent uncertainty of fisheries systems and implementing the precautionary principle in fisheries management is the development of networks of marine reserves (e.g. Lauck *et al*., 1998). Here is a management tool that does not depend on numerical fisheries stock assessment to balance conservation and resource extraction. Their use as a management tool does, however, require a wider assessment process, which encompasses many of the principles and processes outlined in this document.

Thus, in a context of high uncertainty, assessment advice should provide clear indications about directions, which are robust to uncertainty, as opposed to dubious predictions about targets. Participative elaboration of long-term scenarios should be preferred to model-based equilibrium models. Sources of variability, such as "decadal" cycles and recruitment levels, should be studied to improve short-term forecasting.

Complexity should be taken into account with all its implications, maintaining a balance between two dangerous extremes: the illusory facility of oversimplification and the unnecessary burden of over complication (Holling, 2000; Garcia and Charles, 2007).

Adaptability, flexibility and information asymmetries

SSF, particularly in a developing country context, present a particular management challenge. In many cases, even if governments had sufficient understanding of the complex and dynamic ecological, social and economic factors affecting aquatic resources to devise rules (which they do not), it would still be difficult and costly to enforce them (e.g. Baird, 1996). For this reason, more collaborative approaches (e.g. co-management) may be required whereby authority and responsibility are shared among a diversity of stakeholders (e.g. Berkes *et al*., 2001; Garaway and Arthur, 2004). Experience indicates that while fishers often have a wealth of time and place knowledge, they often have less understanding about the dynamics and biological limits of the fishery (e.g. Anderson and Mees, 1999). On the other hand, external agencies and researchers often have an understanding of some of the larger scale biophysical, political, economic and social processes and factors affecting the fishery, but lack knowledge of the specifics (Garaway *et al*., 2006). The framework addresses information imbalances, with stakeholders learning from each other in order that management and policy decisions are built upon a common understanding among all stakeholders.

The complex and dynamic nature of SSF has led also to an emerging interest in applying the principles of adaptive management within a co-management setting, bringing together multiple stakeholders to participate in the management process, using management as an experiment from which all stakeholders learn (e.g. Garaway and Arthur, 2004; Olsson, Folke and Berkes, 2004; Armitage, Berkes and Doubleday, 2007; Armitage *et al*., in press). In complex, dynamic systems, while some uncertainties can potentially be addressed prior to identifying a management strategy, others, such as the response of key variables to change, cannot. Adaptive management recognizes this and seeks to identify appropriate policies and management strategies through processes of experimentation aimed at reducing key uncertainties (Rondinelli, 1993; Lee, 1993; Holling, 1987; Walters, 1986). In this way management can be used to learn more about the resource system at the same time as it is being managed, with management actions subsequently being refined based on learning. Experimentation may be of two types, both based on examining variation in management actions and outcomes temporally or spatially.

Variation in management may come about through naturally occurring variation in the systems (allowing passive experimentation), e.g. comparing the outcomes from different protected area policies in different locations. Alternatively it may come about through deliberate changes to management actions to create variation (as active experimentation) and "probe" the fishery system (Charles, 1998). In terms of learning, active experimentation, where the variation and contrast in treatments are more controlled, is likely to produce results more quickly (Peterman and McAllister, 1993; McAllister, Peterman and Gillis, 1992; Collie and Walters, 1991; Sainsbury, 1988) but is much less applicable to the human aspects of the system (Garaway and Arthur, 2004).

An important element of complexity and uncertainty perspectives is the idea of social-ecological system resilience (as an inherent system property), which infers resilience of valued ecosystems (not resources) and reduced vulnerability of communities supported by them. Enabling the accumulation of resilience within SSF, with the minimum input of public resources, is a primary aim of management. The IAA process therefore addresses uncertainty, vulnerability and risk in the context of resilience as a system outcome.

Principles of sustainability

The task of IAA assessment is to assist decision-makers and stakeholders in their efforts to achieve sustainability despite changing requirements and environments. There are numerous definitions of sustainability (e.g. World Commission on Environment and Development [WCED], FAO) and the Code of Conduct for Responsible Fisheries lays down the fundamental implications in each area of activity of the fishing sector (catching, processing, trade, management, etc.). The definition of sustainability is relevant for assessment inasmuch as it indicates the broad direction in which SSF should be guided when assessing impact and alternative options. For the purpose of this framework, it is agreed that sustainability requires both the well-being of people and the health of the ecosystem and stresses with Berkes and Folke (2000) that sustainability implies not challenging ecological thresholds that will negatively affect ecological and social systems. Other evaluative criteria for assessing performance and options could include efficiency (in terms of Pareto-optimality) and equity (Oakerson, 1992), as well as poverty alleviation, empowerment of disadvantaged groups and food and livelihood security. One difficulty is that while there is some agreement on ecological sustainability criteria, there is less agreement on economic criteria and even less agreement on social and cultural criteria (Berkes and Folke, 2000, page 21).

As with many complex and value-laden processes, overprescription is counterproductive. It suffices to distinguish four broad principal components of sustainability (e.g. Charles, 1994):

1. Ecological sustainability – dynamic maintenance (and *a priori* rebuilding) of the resource base so as not to foreclose future options for its use.
2. Socio-economic sustainability – the maintenance and positive evolution of livelihood-related benefits from the resource, for those who depend on it.
3. Community sustainability – the ability of groups of people to maintain social structures that enable equitable sharing of livelihood benefits from resource use.
4. Institutional sustainability – the maintenance of suitable financial, administrative and organizational capability in the long term.

SYNTHESIS

This chapter has provided the conceptual background of the IAA framework. The framework benefits from the development of new conceptual and analytical tools in ecosystem governance, fisheries management, natural resource management and alternative development. From these, fundamental principles have been identified, which informed both the design of the IAA process and should continue to inform its implementation. The IAA framework is presented in the following chapter.