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Challenges in managing inland fisheries — using the ecosystem approach*

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Inland fisheries are an important source of food and livelihood. However, the socio-economic importance of inland fisheries is often undervalued and inadequately addressed in national and international policies for development. Furthermore, while irresponsible fishing can have serious consequences, there are also many outside threats to inland fisheries. The ecosystem approach to fisheries (EAF) strives to balance a diversity of societal objectives, preserving possibilities for future generations to benefit from exploitation of aquatic ecosystems. Implementation of the approach to inland fisheries presents special challenges that arise from multiple uses of inland waters, external pressures, and difficulties in acquiring accurate information. The basic elements of an ecosystem approach include identification of relevant participants, identification of objectives of management and establishment of a monitoring system with appropriate indicators.

Introduction

Reported inland fisheries landings increased steadily from about 2 million tonnes in 1950 to 11 million tonnes in 2010 (FAO 2012a). This growth occurred mainly in Asia and Africa which now account for about 90% of reported landings. Much uncertainty, however, surrounds both the trend and the level of catches due to inaccuracy and/or manipulation of data (FAO 2010).

Inland fisheries contribute about 10%–12% to annual global fisheries production (FAO 2012a). Despite that, the sector is undervalued and often not well addressed in national plans for development (FAO 2010). Inland fisheries are an important supplier of food and income, and provide a diverse set of benefits to many households in rural, often very poor, communities (Smith *et al*. 2005). As food security becomes a major global concern, the role of inland fisheries as food supplier is likely to become increasingly important.

In many parts of the world, inland waters are overexploited (Allan *et al*. 2005, Jia *et al*. 2013) while at the same time many fish populations, for instance in the northern European lakes, are exploited insufficiently (Mitchell *et al*. 2010). Exploitation, however, is often not the main and only factor affecting the state of fish stocks. Factors such as habitat quantity and quality often affect the state of inland fishery resources more than exploitation rates (Arlinghaus *et al*. 2002, FAO 2010). Inland fisheries compete for freshwater resources with e.g. agriculture and hydroelectric power plants, which usually are given significantly higher priorities for development. These

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and growing human populations put strong and widespread pressures on inland fishery resources

The ecosystem approach to fisheries (EAF) strives to balance a diversity of societal objectives, preserving possibilities for future generations to benefit from exploitation of aquatic ecosystems (FAO 2003a, Garcia *et al*. 2003). It addresses both the human and ecological dimensions of sustainability. Implementation of EAF to inland fisheries presents special challenges that arise from multiple uses of inland waters, external influences such as habitat modification, and difficulties in acquiring accurate information. This paper explores the challenges in managing inland fisheries and the basic elements that are required, within the framework of EAF, for the realization of sustainable development in these fisheries.

The socio-economic importance of inland fisheries

In 2008, fish catches from inland waters were worth 5500 million USD while the corresponding figure for inland aquaculture was 61 100 million USD (FAO 2012). These figures are much lower than the value derived from many other uses of fresh water. For instance, the 45 000 large dams generate about 20% of the world's electricity which is worth 5.7 trillion USD (WCD 2000). However, fish often provide livelihood as well as can be an essential source of animal proteins and micronutrients (e.g. Smith *et al*. 2005, Béné 2006, FAO 2010, Welcomme *et al*. 2010). Where commercial inland fisheries are licensed, license fees can generate significant income, at least seasonally, for governments. Products from inland fisheries can also be important commodities.

The inland fisheries sector is extremely diverse and highly dynamic. It includes commercial, small-scale and recreational fisheries, each with a different economic and social structures. The bulk (90%) of inland fish is caught in developing countries where about 61 million people are employed in the inland fisheries sector (World Bank, FAO and WorldFish Center 2010). This number includes people involved in fishing and associated post-harvest activities such as fish processing and trading.

Inland fishers generally catch fewer fish per individual than do small-scale marine fishers. This is mainly because a large number of rural households fish for only a short period of time and often using passive gears (traps, gill nets) (Salmi 2005, FAO 2010).

In developed countries, about 1 million tonnes of fish is caught in the inland waters by about 100 000 fishers, and the total employment in the sector is estimated at about 300 000 (FAO 2010). Although the majority of these people are involved in small-scale fisheries, this sector is technologically more advanced than in the developing countries (Gabriel *et al*. 2005) with higher catches per fisher. For instance, there is a relatively small-scale but active commercial trawling fishery in the lake district of Finland, mainly targeting vendace, *Coregonus albula* (Suuronen *et al*. 1995, Salmi 1998, Turunen *et al*. 1998).

During the last century, in many developed countries the number of commercial fishers decreased considerably and recreational fisheries have become a major activity in the inland waters (Robinson 2001, Dillon 2004, Allan *et al*. 2005, FAO 2010). This change has often been accompanied by a shift in national economics (Salmi and Varjopuro 2001, Arlinghaus *et al*. 2002, Cooke and Cowx 2004). Growing recreational fisheries involves millions of people and generates billions of dollars particularly in developed but increasingly also in developing countries (e.g. Cowx 2002). In many areas, recreational fisheries already provide far greater economic gains than commercial fisheries (Robinson 2001, Whelan and Johnson 2004, FAO 2010). However, recreational fishing is often not just a hobby. Many people still fish to secure food.

Challenges in managing inland fisheries

Lack of data and information

Since 1950, FAO has requested its member countries to report inland fisheries capture statistics as part of their fisheries reporting. The accuracy of reported catch trends, however, is often difficult to assess (Welcomme *et al*. 2004, Welcomme 2011). Large increases of reported catches are relatively common and are often due to deliberate revision of statistics, rather than a sudden change in the status of a fishery (FAO 2010, Garibaldi 2012). Furthermore, recent improvements in the statistical coverage may have contributed to the rapid increase in reported landings particularly since the mid-2000s (FAO 2012). Nonetheless, production in many waters may still be grossly underestimated (FAO 1999, Allan *et al*. 2005, Van Zwieten *et al*. 2011). Significant knowledge gaps exist in species harvested, overall landings and numbers of fishers and associated workers.

The majority of inland fisheries is not licensed, operates at a semi-commercial or subsistence level, and is widely dispersed along the waterbodies (FAO 2010). There are often no centralized landing ports or major markets where data can be easily collected, and a large part of the catch is bartered locally or consumed by the fishers' households. Catch size and composition, gears used and numbers of fishers vary greatly in different seasons. These types of challenges make the data collection both time-consuming and expensive. Furthermore, as few fees or taxes can be levied from these fisheries, in many countries there is little incentive to invest scarce human and financial resources into collecting and analyzing the data. One of the results is that trends in catches become concealed because the data is aggregated across basins and species. Landings are often recorded for some indicative fisheries and these are subsequently extrapolated up to a national level, with large errors occurring when numbers of gears, fishers and households involved are unreliable (FAO 2010). This is often true also in the developed world; for example, inland water catches in the European Union are generally poorly monitored so the overall quality of the data is also poor (Ernst and Young 2011).

It is common in tropical watersheds that landings go completely unreported and have to be estimated from unreliable information sources. Catches are easy to underestimate because the contributions of numerous fisheries on smaller tributaries and water bodies are generally overlooked (Coates 2002). Reported harvests from some major river fisheries alone have been shown to account for only 30%–50% of actual catch (Allan *et al*. 2005, Kolding and van Zwieten 2006). As a result, information on the inland fisheries is so incomplete that it is difficult to trust the trends or to develop appropriate management policies. To improve the situation, alternative approaches to data collection are needed which, besides the traditional catch and effort surveys, should include issues such as population census, consumption studies, market surveys and habitat classification.

Environmental pressures

Inland fisheries suffer from large number of environmental pressures such as deteriorating water quality and fragmentation of habitats. There is a strong competition for freshwater resources from sectors other than fisheries, and demands on fresh water are expected to double by the year 2050 (FAO 2003b).

Loss and degradation of habitat, water abstraction for agriculture, drainage of wetlands, dam construction, pollution and eutrophication, often acting together, have caused substantial decline or change in inland fishery resources (Allan *et al*. 2005, Dudgeon *et al*. 2006, Nguyen and De Silva 2006, FAO 2010). In many waters, ecosystems have been seriously disturbed, usually greatly affecting inland fishers. The loss of spawning grounds and nursery areas has been devastating for many species, especially for those with strict ecological requirements. Nonetheless, these impacts do not always result in a decrease in fishery production, but rather in change in catch composition and value (Allan *et al*. 2005).

Climate change may become the most important factor affecting inland aquatic ecosystems (Bates *et al*. 2008, Barange and Perry 2009). It is likely to result in an increase in variability of environmental conditions including temperature, precipitation and river runoff (Kundezewicz *et al*. 2008), which in turn will impact ecosystems, societies and economics, increase pressure on all livelihoods and food supplies, including those in the fisheries sector (Allison *et al*. 2009, Cochrane *et al*. 2009, FAO 2010). How climate change is going to affect particular fisheries depends largely on the capacity of an ecosystem to adapt to change. In Scandinavia, winter precipitation is expected to increase which in turn is likely to increase acidity of the rivers in the west coast of Finland where large catchment areas are composed of acid sulfate soils (Saarinen *et al*. 2010). This will most probably have a negative effect on the fish stocks and the fisheries in the area.

Inland fisheries in the tropical regions are highly vulnerable to the impacts of climate variability and change (Xenopoulos *et al*. 2005) but there are clear indications of climate change effects also in the boreal freshwater ecosystems (Casselman 2002, Sharma *et al*. 2007, Winfield *et al*. 2010, Keskinen *et al*. 2012). Rainfall is predicted to decrease in many lower-latitude regions. Wetlands and shallow rivers are particularly susceptible to changes in temperature and precipitation; and prolonged droughts will reduce habitat available to the fish. In rivers with reduced discharge, up to 75% of local fish may become extinct by 2070 because of combined changes in climate and water consumption (Xenopoulos *et al*. 2005). Measures implemented to ensure continuous water supply for irrigation and domestic purposes by storing more water will further degrade aquatic ecosystems.

Melting of glaciers will potentially affect river flows and will cause flooding in large catchments leading to changes in flood areas, timing, and duration. As the lifecycles of fish species are closely adapted to the rhythmic rise and fall of the water level, changes to this pattern as well as occasional flash floods may cause losses of eggs and fry (FAO 2010).

Although to date there has been no global assessment of warming of inland waters, moderate to strong warming since the 1960s was recorded in many lakes (Rosenzweig *et al*. 2007). Increased temperatures will affect fish physiological processes and thus their ability to survive and reproduce, thus changing the distribution of species.

Overexploitation and unsustainable use

In spite of the trend of gradually increasing inland catches in the global scale, there has been a reduction in the catches of certain species, apparently due to reduction in population sizes (FAO 2010). There is evidence that overfishing contributes to this decline although it may be largely unrecognized because the decline has often been compensated by a concomitant increase in catches of other species (Allan *et al*. 2005, Jia *et al*. 2013). That is, while there may be no change in terms of gross production, individual species are often seriously overexploited. The decline may have been partly masked by the recent improvements in catch data collection and aggregation of catches, and because the total number of fishers may still be increasing. This may be reflected in the global catches of some major inland-water species groups (reported catches increased remarkably in the 1980s and 1990s, *see* Fig. 1). A contributing factor may also be the fact that an increasing portion of inland catches comes from waterbodies that are stocked with hatchery-produced fish.

Many of the inland fish populations, particularly in the tropical areas, live in extreme environments and are adapted to high mortality (FAO 2010). Such fish communities are highly resilient to exploitation and are capable of persevering even under extreme exploitation levels. However, with increasing fishing pressure large fish will be decimated and this may ultimately result in recruitment failure. In response, the fishers will gradually shift their efforts to other species. As the mean size of individuals and species in the assemblage decreases the fishers will reduce the mesh size of gear they use. This will result in catches mainly consisting of smaller species, with a more rapid life cycle, and often the young of the year (Allan *et al*. 2005). In areas where smaller and shorter-lived species become the main component of the catch and predation is reduced by elimination of larger predatory species, the situation may look good for a while. However, smaller fish are often much less valuable and the situation may ultimately result in further recruitment failures. Furthermore, overfishing of larger fish in a population may eventually change the gene pool towards smaller-sized fish (Fenberg & Roy 2008, Van Wijk *et al*. 2013). This potential problem is generally not recognized and addressed in the fisheries management plans.

In the higher-altitude boreal inland fisheries, often with only a few species inhabiting the

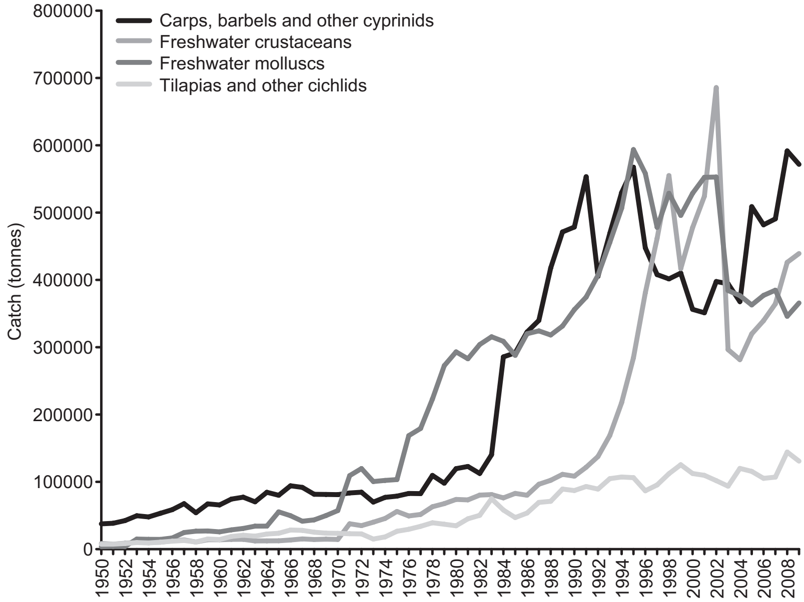

Fig. 1. Catch trends of major freshwater fish species in 1950–2009 (source FAO FishStat+).

water, the fish populations may be less resilient than in tropical waters and the intensity and selectivity of harvesting has the potential to dramatically affect the dynamics of exploited fish populations (e.g. Jonzen *et al*. 2002, Vainikka and Hyvärinen 2012), and may for instance dictate the stock fluctuation (Huusko and Hyvärinen 2005). Fish markets and consumer preferences can influence exploitation. For example, harvesting of the common bream (*Abramis brama*) from many boreal waters for human consumption has a large potential; however, poor consumer acceptance prevents the establishment of markets for this species.

Recreational fishers can significantly contribute to aquatic habitat conservation (e.g. Cowx *et al*. 2010). However, introduction of non-native species that may become invasive can have serious effects on natural habitats and wild fish stocks (FAO 2010). In many lakes and rivers, introduced species are a major threat as their occurrence may change the fish community structure and nutrient cycle. Furthermore, conflicts may arise between recreational and commercial fishers over allocation of catch and access to fishing grounds. Also, recreational fishing mortality rates are often high, particularly close to urban centres, and several waterbodies already suffer from overfishing (Allan *et al*. 2005, Post *et al*. 2008).

Stock enhancement

Stock enhancement, i.e., purposeful release of aquatic species from hatcheries or their transfer between locations in the wild, is widely practiced in inland waters and can keep catch rates high. In many cases, an ecosystem would not be capable of producing that level of catch through natural processes (Welcomme and Bartley 1998). Well-planned and carefully considered stocking programmes can enhance the productivity of waters as well as improve quality and profitability of fishing. Stocking, however, may also create significant risks to natural environment and wild fish stocks. Stocked fish prey on and compete with native fish for food and habitat (Vehanen *et al*. 2009), and can disrupt the food web and alter natural ecosystem processes to the disadvantage of native species. Stocking can spread disease and parasite as well as invasive or unwanted species. Moreover, stocking at levels beyond the habitat's carrying capacity may result in stunted populations and smaller and less valuable catches (Salojärvi and Huusko 1990). In spite of these risks, commercial and recreational fisheries still rely heavily on fish stocking programs to improve catches and associated economic gains (Whelan and Johnson 2004, Arlinghaus *et al*. 2010).

Species introductions

Alien species can increase production and value of inland ecosystems, but they can also have a profound and devastating impact upon an ecosystem (Bartley 2006). One of the best known examples is the introduction of the Nile perch and Nile tilapia in the Lake Victoria: since the introduction of these species about half of the native fish species have either gone extinct or only occur in small populations (Kolding *et al*. 2008). Another risk to wild populations are fish that escaped from fish farms. For instance in a major northern European salmon river, the Teno River, salmon that escaped from coastal fish farms hybridize with wild salmon affecting the genetic composition of the wild stocks (Erkinaro *et al*. 2010).

Lack of sufficient infrastructure

Trade in fish and fish products, especially in developing countries, may be constrained by the insufficient infrastructure. Furthermore, when facilities to keep the cold chain unbroken (e.g. ice plants, cold rooms, refrigerated trucks) are poor or missing, post-harvest losses are high, even up to 30%–40% of the landings (FAO 2010). Lack of investment in post-harvest infrastructure often leads to low quality, and hence low value, of inland fish and fish products. Nonetheless, the situation would likely be even worse if the traditional processing methods such as smoking and sun-drying were not commonly used.

Rising demand for fish and fresh water

According to the projections by the United Nations Population Division, global populations will increase from 7000 million today to 9000 million by 2050. The growing populations will call for significant increases in food production at an affordable price. The need for animal protein, including fish, will increase dramatically. Because most marine fish stocks are already fully exploited or overexploited, it is assumed that fishing pressure on inland fish stocks will increase and there will likely be a rise in destructive fishing methods, such as explosives, poison, electrofishing and dry pumping, that are all capable of killing indiscriminately large amounts of fish (FAO 2010).

Expansion and intensification of inland aquaculture will continue to grow and it will produce more food (FAO 2010). High value species will increasingly come from farms rather than from wild stocks. This may reduce fishing pressure if fishing cannot compete with farmed product.

Demand for fresh water is expected to double by the year 2050. Of the available 3800 km^3 of fresh water in the world, currently agriculture uses 70%, industry extracts another 20% and 10% is for domestic use (Comprehensive Assessment of Water Management in Agriculture 2007). The need for water for irrigation and for domestic purposes will continue to increase dramatically, leading to reduced water availability for fisheries, especially during dry seasons. Furthermore, an increasing demand for energy, including hydropower, will likely lead to further damming of rivers.

Inadequate governance systems

Fisheries policies and regulations have generally shown poor performance, and in many regions inland fishery resources and aquatic environment continue to degrade (FAO 2010). Existing policies generally focus on the allocation of water for irrigation, flood protection, navigation or hydropower generation, and rarely consider fisheries in an adequate manner. Current policies and regulations are largely ineffective in sustaining the quantity and quality of water necessary for inland fisheries. Weak institutions and governance arrangements facilitate illegal fishing and the use of destructive fishing practices as is demonstrated by the globally large amount of illegal and unreported fishing (Agnew *et al*. 2009). Furthermore, when it exists, management of inland fisheries has tended to focus on overexploitation as the primary issue. Actions are typically focused on controlling the access to fishing grounds and on the use of specific fishing practices. They are chiefly guided by ecological and economic rather than social arguments, even though social acceptance and wellbeing are generally considered a prerequisite for successful fisheries governance (Coulthard *et al*. 2011, Salmi 2012). Management of multi-species and multi-gear fisheries, which most inland water fisheries are, is particularly challenging.

Ecosystem approach to fisheries (EAF)

Moving to EAF management

In light of the threats and challenges mentioned above, there exists a great need for policies on inland fisheries to be closely integrated with those of other sectors. In general such policies are lacking, and where present, they may not be easily enforced.

The ecosystem approach (EA) was defined in the Convention on Biological Diversity (UNCBD 1993) as a strategy to achieve the integrated management of land, water and living resources aiming to promote their conservation and sustainable use in an equitable way. Since 1993, countries have taken several steps to promote the use of EA, specifically in case of fisheries (FAO 1995, Fluharty 2005).

The Ecosystem Approach to Fisheries (EAF) is an integrated approach to fisheries management that strives to balance a diversity of objectives (FAO 2003a, Garcia *et al*. 2003, Bianchi and Skjoldal 2008, Fletcher *et al*. 2010). It can be described as a strategy framework that promotes conservation, sustainable use and equitable sharing of ecosystem resources. It involves a transition from traditional fragmented planning and decision making to a more holistic approach to natural resource management. It addresses both the human and ecological dimensions of sustainability, it is participatory, and takes all key factors into consideration and encourages the use of the best available knowledge in decision-making. The approach adopted by FAO explicitly states the importance of taking into account all the essential components of sustainability including the social and economic benefits. The management objectives may be substantially wider than just maximizing fishery production. Aquaculture has also developed a framework for the adoption of the ecosystem approach (Ecosystem Approach to Aquaculture, EAA).

Elements of the ecosystem approach have already been taken into account in traditional management regimes for a long time. More recently, many countries have made important attempts towards application of several of the principles contained in the EAF.

Practical implemention of EAF

Management approaches integrated across sectors become particularly relevant in inland waters where major impacts on fishery resources and ecosystems arise from multiple uses of water resources. An example of a framework for planning and implementation of EAF is presented in Fig. 2 (modified from FAO 2003a and 2005). The framework facilitates developing the EAF management plans, which are the backbone of any ecosystem approach strategy.

The methodology proposed contains elements that are common to those used by any other sector utilizing renewable natural resources, and builds on accumulated experiences of the management of fisheries and aquaculture. It also includes recent insights into sustainability of socio-ecological systems (FAO 2012a). Involving all major players and their knowledge in the process has been found to produce more locally-acceptable solutions (interactive governance; Kooiman *et al*. 2005) but often presents major communication challenges (Varjopuro *et al*. 2008). EAF also tries to make sure that all system components move towards the same and agreed direction. Furthermore, being risk-based, it allows to more effectively address information-poor situations.

One of the considerations in the EAF implementation is the question of who receives the long-term benefits and who pays the short-term costs of EAF. Potential benefits in this case include healthier and more resilient ecosystems, more sustainable use of natural resources, increased long-term output, lower risk of collapses, more abundant stocks, greater employment and income, aesthetic benefits, wider livelihood opportunities, reduced conflicts, positive image of fishing sector, better balancing of multiple objectives, and greater societal benefits;

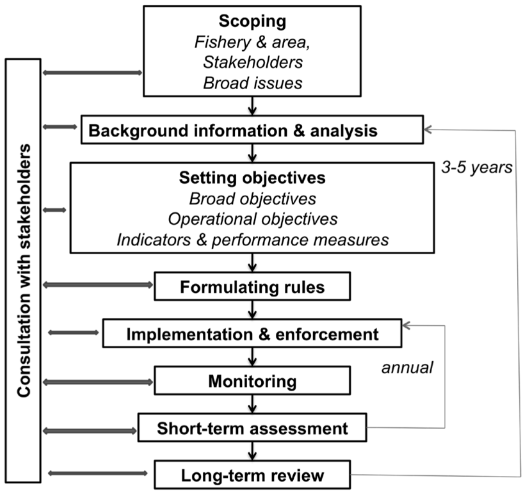

Fig. 2. The EAF planning framework (modified from FAO 2003a).

while costs could include reduced employment if fishers are displaced, and increased cost of management and monitoring.

Lessons learned from applying the EAF

Despite the fact that the term "Ecosystem Approach to Fisheries" has been widely used in many publications, there has been a lack of clear and common understanding of how it addresses the complex problems encountered in many fisheries. Bianchi and Skjoldal (2008) offer a good overview of different aspects of the concept and provide useful examples and experiences from practical implementation. Most examples, however, come from marine fisheries (e.g., Cochrane *et al*. 2008, Fletcher 2008, Hilborn 2011, Tromble 2008, Winsnes and Skjoldal 2008).

Lessons learned from applying a practical EAF framework include recognition that the lack of good governance arrangements, not the lack of ecological data, has been the most commonly identified risk issue in the EAF applications. EAF can be started with whatever level of information is available, with the process helping to determine what additional work is needed. Since EAF is as much about people and policy as it is about ecosystems, the EAF management plan has to enjoy widespread support and credibility among all key interest groups.

FAO has recently published an EAF toolbox that provides detailed guidance on available methods and tools to facilitate application of EAF at all levels, from policy formulation and planning to day-to-day application (FAO 2012b). In developing the toolbox, attention was paid to guiding users through each of the steps of implementing EAF, and assisting them in choosing tools appropriate for their situation. Since EAF focuses on fisheries management in waters where sectors other than fisheries are the main actors, EAF should be nested within an Integrated Water Resources Management (IWRM) framework.

Impacts of EAF to research

Despite the general acceptance of the EAF principles, it is often seen as too complex and difficult to implement because it requires human and financial resources that are usually not available. It is obvious that EAF will add layers of complexity as compared with conventional fisheries management.

To facilitate EAF implementation, research should be expanded to deal with governance, and social and economic factors such as benefits that inland fisheries and fresh waters provide. Assessing long-term ecological and economic benefits and costs of fish stocking and other management strategies would be of high importance. There will also be need for new techniques and approaches aiming at mitigating the impacts of other sectors on aquatic habitats, and new methods to rehabilitate already affected environments.

Conclusions

The Ecosystem Approach to Fisheries is a strategy framework, and its practical application needs to be tailored to the specific ecological, social and cultural conditions in each particular fishery. EAF does not need complete knowledge of an ecosystem and there is no single way to implement EAF. The scale of implementation should be set locally. An EAF process can be kept simple and implemented incrementally from existing measures in fisheries management, but extensive studies of factors affecting fisheries is needed to make it more effective. Where inland fisheries have been supported and well managed, they can play a significant role in generating income and sustaining economic growth. However, the entire concept has to be further clarified and this can be achieved through sharing experiences on implementation as we go along.

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