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WORKSHOP ON INTERDISCIPLINARY APPROACHES TO THE ASSESSMENT OF SMALL-SCALE FISHERIES

Rome, Italy, 20-22 September 2005

APPROACHES TO SMALL SCALE FISHERIES ASSESMENT: A REVIEW

Summary

The purpose of this paper is to provide a framework to aid discussion for FAO FishCode STF and WorldFish Center's workshop on interdisciplinary approaches to the assessment of small-scale fisheries. The paper presents an overview of approaches related to:

- Biological Resources
- Community-based Management
- Co-management
- The Sustainable Livelihood Approach
- Ecosystem Approach to Fisheries
- Global Environmental Change and Human Security Approach

Preparation of the document

The present report was prepared by Daniela Kalikoski and Gertjan de Graaf of the FAO FishCode programme. The review in the report serves as background information for the workshop and do not necessarily reflect the views of the Food and Agriculture Organization of the United Nations

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ABBREVIATIONS

CCRF	Code of Conduct for Responsible Fisheries
COFI	Committee on Fisheries
CPR	Common Pool Resource
CPUE	Catch per Unit of Effort
EAF	Ecosystem Approach to Fisheries
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographical Information System
MDG	Millennium Development Goal
MSY	Maximum Sustainable Yield
PPA	Participatory Poverty Assessment
PRA	Participatory Rural Appraisal
PRSP	Poverty Reduction Strategy Paper
SFLP	Sustainable Fisheries Livelihood Project
SLA	Sustainable Livelihood Approach
SSF	Small scale fisheries
TEK	Traditional Ecological Knowledge
TURF	Territorial Use Right to Fisheries
VPA	Virtual Population Analyses
WFC	WorldFish Center

1 INTRODUCTION

1.1 Small Scale Fisheries

1. Globally there are an estimated 30 million fishers of whom at least three-quarters, or 22 million, are engaged in small-scale fisheries (FAO, 2002; Coates 2002). If the fisheries-associated livelihoods, such as marketing and processing, are also included a total of about 88 million people are dependent on small-scale fisheries and associated industries. Adding those infants, children and elderly that depend on these income-earners, as many as 150 million people live in households that depend primarily on small-scale fisheries. A large figure in itself, its significance lies in the extent to which these people belong to the poor and vulnerable sections of population. Globally, it is estimated that there are 1.1 billion people living on less than US$1 per day (the World Bank's global poverty line). If many of the fishery-dependent people were poor, they would represent a significant share of world poverty. Even if the incidence of poverty among the fishery-dependent people was only as high as on average in their respective countries, there would be some 23 million fishery-dependent people living on less that US$1 per day (FAO 2002).

2. The importance of these statistics from a development perspective is re-enforced by the fact that small-scale fisheries provide about half of the world's fisheries production used for direct human consumption; about 1 billion people rely on the sector for their main source of animal protein (Pomeroy and Williams, 1994). In many parts of the world small-scale fishing activities also provide an important means of income generation for the rural poor, including those that only fish occasionally and are not officially recognized as fishers. In addition to the role as a primary support, therefore, fishing also plays a role as an important "safety valve" when livelihood strategies in "non-fishing" (e.g. agricultural) communities are under threat. More generally, small-scale fisheries can also help to maintain a degree of economic (and hence political) stability, particularly for states with a heavy reliance on fisheries resources and where economic options for the populace are few.

3. Within the context of the Millennium Development Goals (MDG), fishing provides an important lever for their achievement, particularly within poor rural areas. Improving the productivity of the natural resource base on which these poor people depend and ensuring pro-poor policies and governance will result in direct benefits in terms of eradicating extreme poverty and hunger (MDG Goal 1). Improving the income of poor fishers will also contribute to achieving universal primary education (MDG Goal 2). In many poor communities, fishing can provide one of their few sources of cash income and when this increases families are more likely to be able to educate their children. The goals to reduce child mortality and improve maternal health (MDB Goals 4 and 5) can also be achieved by improving fisheries productivity. Fish can significantly improve the nutritional status of young children, pregnant and lactating women. It can complement the carbohydrate-based diets (e.g. rice) of the poor, providing an easily digestible source of protein. Fishing is also one of the greatest impacts on aquatic ecosystems, particularly marine, and sustainable fisheries management is therefore key to ensuring environmental sustainability (MDG Goal 7).

4. Historically, development interventions for the fisheries sector have aimed at reducing poverty through accelerated economic growth, improvements in technology and infrastructure and market-led economic policy reform. The limited results of these interventions, however, has led to a re-examination of the causes of poverty, the recognition of the significance of vulnerability and the recognition of the need for new strategies for

poverty reduction. There is increasing recognition that establishing appropriate pro-poor governance and institutions for fisheries management are central to maximizing the contribution of fisheries to poverty alleviation and food security. Pro-poor strategies that include rights-based approaches, co-management regimes and fishing capacity reduction are essential to increase wealth generation from small-scale fisheries for poor communities.

5. The importance of the small-scale fisheries sector to food security and poverty alleviation was recognized by the 25th Session of the FAO Committee on Fisheries (COFI, 2003). Specifically, participants at the COFI meeting recognized that there was a need to better understand the nature, extent, and causes of vulnerability and poverty among small-scale fishers and to improve the information base and monitoring approaches for determining the contribution of the sector to the alleviation of these conditions. The research agenda proposed at the 2003 COFI meeting marks an important shift in approach that could lead to more effective development strategies for the small-scale fisheries sector. In response, FAO has developed Guidelines for Enhancing the Contribution of Small-Scale Fisheries to Poverty Alleviation and Food Security that was made available for review and comments by COFI in March 2005. Further the Strategy for Improving Information on Status and Trends of Capture Fisheries (STF-Strategy, FAO, 2003) recognizes that many small-scale and multi-species fisheries, particularly in developing countries, are not well monitored. They are probably underestimated and consequently not adequately considered in the development of plans and policies for fisheries.

6. Historically, the lack of systematic information on small-scale fisheries in developing countries has contributed to a lack of attention from a policy and management perspective. Indeed, most national fisheries policies and development strategies largely ignore small-scale fisheries issues or lead to situations unfavorable to this sector. For example in Vietnam, Neiland and Béné (2003) highlight the fact that regardless of the reliance of hundreds of thousands of households on coastal small-scale fisheries, its value has yet to be reflected in national policies. In a recent global review of 281 national policy papers, including 50 poverty reduction strategy paper (PRSPs) and/or interim PRSPs, it was found that in only a small number of countries were fishing communities included among the target groups and the fisheries sector accorded an explicit role in poverty reduction and food security (FAO-SFLP, 2004). A review of the national Poverty Reduction Strategies in West African countries (FAO-SFLP 2002) showed that small-scale fisheries were rarely or poorly taken into account, even though they produce over 1 million tones in catch and provide livelihoods for over 7 million fishers in the region. Improved information alone is not sufficient to reverse this situation, it must be accompanied by governance and institutional changes. However, without the necessary information any new policies that are developed (and the management measures adopted to implement them) are likely to be ineffective or, worse still, detrimental.

1.2 The need for a new approach to small-scale fisheries assessment

7. As discussed by Vasconcellos and Cochrane (2005), developing countries are among the countries with the poorest systems of fisheries monitoring by state inferred from the quality of the reported fisheries statistics. These authors argue that this reflects problems with the assessment, monitoring and surveillance of fisheries, mostly small-scale, in situations of limited data and information. The availability and quality of information on fisheries in these countries are often considered so poor, that it is very difficult not only to draw conclusions but also to formulate sound policies for responsible fisheries management. It is exceptionally

difficult to obtain accurate information on the biological, social and economic characteristics of small-scale fisheries. Their catches are landed in various and isolated places scattered along the coast. In addition, the multi gear and vessels and the numerous different species landed complicates any accurate assessments. There is a consensus by innumerous researchers and institutions with large experience in small-scale fisheries that assessments and monitoring in small-scale fisheries management no longer can be done without the involvement and participation of fishing communities (World Bank, 1991).

8. Most of the stock assessment tools available today were developed with a focus on temperate areas where large fishing fleets exploit a small number of species that form large stocks. As a consequence, conventional assessment approaches usually focus on single species and are very data intensive. Moreover, such approaches focus largely on the biology of the resource. Although the economics of the fishery may also be considered to some degree, little or no attention is paid to the socio-economic needs of fishers, the social structure and culture of fishing communities or to the institutional dimensions of management (Jentoft, 2000; 2004). This deficiency tends to limit the capacity for collaboration between research and fishing communities and to weaken the institutional linkage between fisheries science and management.

9. In contrast to their larger scale counterparts, small-scale fisheries are often multi-gear and target multiple species with small stock sizes - features that limit the utility of conventional assessment approaches. Further complication is added by the participation of both part-time and full-time fishers, the presence of numerous, often isolated, landing sites and varying market chains. Thus, even if conventional approaches were appropriate, collection of data and the monitoring of small-scale fisheries are often unfeasible for developing countries because they do not have the necessary financial and human resources.

10. Further challenges emerge with the growing imperative to implement an ecosystem approach to fisheries management (FAO, 2003), particularly for small-scale fisheries in coastal tropical areas, characterized by high biological diversity and by intense competition over the use of coastal ecosystems with other sectors, such as tourism, aquaculture, urban and industrial development. Moving the focus of assessment from the exploited resources to the whole range of ecosystem components and processes that affect, or are affected by, fishing increases immensely the data requirements for management.

11. As highlighted above, small-scale fisheries play a key role in providing food security, alleviating poverty and reducing vulnerability. Food security has been defined in the World Food Summit in 1996 as the condition when “all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life”. Poverty is a multidimensional state characterized by low income, poor health, low literacy levels, under-nutrition, inadequate housing and living conditions, and by cultural and political marginalization. The two are intimately related. Vulnerability is also multi-faceted and involves, for instance, climatic and other natural events that lead to yearly and seasonal fluctuations in stock abundance and poor catches; economic factors, such as fluctuations in market price and variable access to markets; policy factors affecting use rights and control over aquatic environments and resources; occupational factors such as the dangers of working at sea; over fishing and environmental degradation (at land and sea) that causes further increase in vulnerability.

12. The root causes of poverty, food insecurity and vulnerability in small scale fisheries are also multidimensional. For example, over fishing can constrain resource availability and increase variability, while lack of access to capital, limited alternative employment opportunities and lack of appropriate technologies for fish harvesting and processing can constrain the sector. One of the most important factors influencing small-scale fisheries, however, relates to governance and policy issues over access to, and control over, resources, markets and the distribution of benefits obtained from fishing (COFI, 2003, 2005).

13. Unfortunately, few methods to assess fisheries within the context of food security, poverty and vulnerability are available, despite them being urgently needed. As stressed by COFI in 2003, the assessment of the causal factors of poverty and vulnerability for small-scale fishing communities is vital if effective fisheries-specific strategies for food security and poverty alleviation are to be developed. To obtain this understanding an interdisciplinary approach that goes beyond conventional "stock assessments" is required. This approach must be based on theories and methodologies that integrate biological understanding (at both the exploited species and ecosystem level), social, economic and institutional/governance aspects of the fisheries. It also requires better use of available primary data from living standard measurement surveys and other national socio-economic household surveys through techniques such as poverty mapping.

14. The objective of this working paper is to present an overview of approaches and methods applied by different disciplines and in different context for the assessment of small scale fisheries.

1.3 The structure of the working paper "WHY-WHAT-HOW"

15. In reviewing the number of documents it became clear that not all authors/experts are using a similar approach for, or have similar definition for information obtained through assessments. For sake of conformity the structured approach as presented in FAO Guidelines for the routine collection of capture fishery data (FAO, 1999) was used to make a linkage between approaches, methods and data needs. Therefore three questions were addressed under each approach:

Why the information is needed. Information is always related to specific questions and objectives. It can be related to general policy or management objectives such as "*aquatic resources should be managed in a sustainable way*" or to specific topics to be addressed, such as for example; *Can we successfully implement a co-management system?*; *Are there conflicts between fishery sub sectors ?; Will fish production meet food security requirements in the medium term ?*, etc.

The second question to be addressed will be: **What** information is needed to reach the objective and for each specific variables or indicators selected.

The third question to be addressed will be: **How** the information needed to reach the objective is obtained Different approaches/strategies and methods (structured interview, Participatory Rural Appraisal, direct measurement, etc) are discussed.

Throughout the document the question "Why, What and How" is used as a guiding principle.

2 BIOLOGICAL RESOURCE MONITORING

16. The aim of fisheries assessment is to establish the status of the resource and to determine the levels at which it may be exploited. Scientific fisheries assessment most likely started in the 19th century: *"In the second half of the 19th century the North Sea plaice fisheries were in a poor state. Increasing fishing effort was not resulting in larger catches, catch-per-unit effort was falling and the average weight of plaice in the catches was declining. It was showing all the signs of what, in today's terms, is called "over-fishing"*. However, fisheries had collapsed in the past without it initiating research. But the same factors that were leading to over-fishing, industrialization and advanced technology were also providing the money to pay scientists to investigate the reasons for the collapse. As a result numerous public enquiries were held, mainly in Great Britain, to collect information which would provide an answer to the question of why the North Sea plaice stocks had declined and to determine what could be done to rectify the situation (Holden and Rait, 1974).

17. As interactions between fish stocks and fishing are not directly visible therefore studying the state of the stocks and the effect of fishing in quantitative terms must be based on more or less simplified mathematical models.

18. Russell (1931) was the first who provided a simple mathematical expression for the development of fish biomass incorporating growth, mortality and recruitment:

$$S_{i+1} = S_i + (A + G) - (C + M) \qquad (1)$$

Where:

S_i is fish stock biomass in year i
A is the annual sum of the initial weights of all recruits
G is the sum of the growth in biomass of individuals already recruited to the stock
C is the weight of all fish caught
M is the weight of all fish died from natural causes.

19. The essential aspect of the fish stock dynamics described by Russell, was that stock biomass had gains (recruitment and individual growth) and losses (natural and fishing mortality) (Haddon, 2001).

20. Russell's initial work resulted in the development of number of fisheries models applied the last decades. The majority of the models can be grouped in *"Holistic models"* and *"Analytical models"* The simple holistic models use fewer population parameters than the analytical models, they consider a fish stock as a homogeneous biomass and do not take into account, for example the length or age structure of the stock The analytical models are based on a more detailed description of the stock and they are more demanding in terms of quantity and quality of the input data. On the other hand as compensation they are also believed to give more reliable prediction (Sparre and Venema, 1998). The most commonly used holistic models are the *Surplus Production models* or *Biomass Dynamic models* (Schaefer and Fox models) and commonly used analytical models are the *Population dynamic models* (Yield per Recruit, Virtual Population Analyses, Thompson and Bell models).

21. However before launching a model it should be realized that the abundance of certain stocks depends very much on environmental factors (Sharp and Csirke 1984) which are beyond control of any human interference. In such case the predictive value of any fisheries model is nil.

2.1 Surplus production models[1]

2.1.1 The basics

22. The objective of the application of surplus (harvestable) production models is to determine optimum level of fishing effort, which is the effort that produces the maximum yield (MSY) that can be sustained without affecting the long term productivity of the stock.

23. Surplus (harvestable) production models are the simplest analytical methods available that provides a full stock assessment. They are relatively simply to apply partly because they pool the overall effect of recruitment, growth and mortality into a single production model. The stock is considered solely as undifferentiated biomass, that is, age- and size-structure, along with sexual and other differences, are ignored.

24. Surplus production models and Maximum Sustainable Yield (MSY) are based on the theory of density dependent growth of biomass (*g(B)=dB/dt*) described by the sigmoid logistic growth curve:

$$g(B) = \frac{dB}{dt} = r_m B.\left(1 - \frac{B}{B_\infty}\right) \qquad (2)$$

B_∞ is the theoretical maximum biomass that can be attained also known as carrying capacity, which is mainly determined available food and space. The parameter r_m is the intrinsic rate of natural increase in biomass.

However, in this equation biomass loss due to fishing is not yet included, this is done by including the catch or yield in the equation;

$$g(B) = \frac{dB}{dt} = r_m B.\left(1 - \frac{B}{B_\infty}\right) - Y \qquad (3)$$

When biomass does not change (*dB/dt=0*), then the surplus production is equal to the yield and the stock is said to be in equilibrium. Assuming ***equilibrium***, Schaefer (1954, 1957) developed one of the first surplus production models demonstrating a theoretical link between stock size and expected catches.

Under equilibrium conditions when *Db/dt=0* , Yield can be expressed from equation 3 as:

$$Y = r_m B.\left(1 - \frac{B}{B_\infty}\right) \qquad (4)$$

From basics fisheries equations Yield can also be expressed as:

[1] Taken/derived from King, 1995, Sparre and Venema, 1998, Haddon 2001 and Larsen *et al*., 2003

$$Y = F.B \qquad (5)$$

Further

$$F = q.f \qquad (6)$$

Whereby F is the fishing mortality, q is the catchability and f is the fishing effort. Y/f is equivalent to CPUE and combining equation 5 and gives:

$$B = \frac{CPUE}{q} \qquad (7)$$

Substituting equation 7 in equation 4 gives:

$$Y = f.(CPUE) = r_m\left(\frac{CPUE}{q}\right)\left[1-\left(\frac{\frac{CPUE}{q}}{\frac{CPUE_\infty}{q}}\right)\right] \qquad (8)$$

or

$$CPUE = CPUE_\infty - \left(\frac{qCPUE_\infty}{r}\right)f \qquad (9)$$

Which is a straight line with a slope $b=(-CPUE_\infty.q/r)$, and intercept $a= CPUE_\infty$; that is a line of the form $CPUE = a + bf$, where a and b are constants. Thus *providing* the basics of the "Schaefer curve", with a direct relation between "fishing effort" and "CPUE" Multiplying the CPUE with fishing effort f provides yield and gives $Y = af + bf^2$ suggesting that yield is related to fishing effort by a symmetrical parabola.

25. Being rather simply to apply, the Schaefer model and later versions (Pella and Tomlinson 1969, Fox 1970, Schnute, 1977) have been extensively used in the last decades. However as any model which tries to describe biological complex interaction through mathematic also the Surplus production models encountered serious constraints.

2.1.2 Constraints of Surplus Production models

26. **Equilibrium**. One of the basic assumptions of Surplus production models is **equilibrium** (equation 4). i.e. for each level of fishing effort there is an equilibrium sustainable yield. The stock is assumed to be at some equilibrium level of biomass producing a certain quantity of surplus production. If the fishing regime is changed the stock is assumed to move immediately to a different stable biomass with its associated surplus-production. However fish stocks are rarely in equilibrium and nowadays it is even argued that ecosystems are in a constant and ever changing stat of non-equilibrium due to considerable variation of variables external to the system. Assuming equilibrium and applying surplus production models consistently overestimate sustainable yield and can lead to the collapse of the stocks (Boerema and Gulland, 1973; Larkin, 1977; Hilborn, 1979).

27. An ad hoc solution is to use the weighted average of a number of years fishing effort for each year instead of just observed effort for that year. However, developments continued and Surplus production models no longer need the assumption of equilibrium to be fitted (Haddon, 2001). The most common approach nowadays is the use of observation error estimation and fitting with least squares or maximum likelihood methods.

28. **CPUE reflect relative** abundance **of fish stock.** All fishing gears are species and size selective: especially in multi species small scale fisheries where one type of gear may catch a set of species, while another gear or the same gear used in a different way or different area may catch another set. This means that all fishing gears are only able to catch a certain portion of the total (multi species) fish community present. The use of catch rate as index of abundance of a fish stock is therefore complicated by the selectivity of the gear and is only valid under the assumption that all specimens within a (multi-species) stock at some stage during their life become part of the fishable stock.

29. **Multi species and relative** abundance**.** Surplus production models are mainly developed as single species models and it can be doubted whether the dynamics of aggregated species in a multi species fisheries is similar to that of a single species. Problems are certainly encountered if the fishers operating a single gear switch from target fish due to economic reason this would lead to a decline in cpue of the not preferred species and an increase of the cpue of the preferred species irrespective of the relative abundance of both species.

30. A second example is replacement under exploitation of one species by another. This replacement restricts the use of the MSY concept as effort increases and the "mining" of one species after another proceeds, does not necessarily lead to parabolic plots of "catch" on "effort" but rather to flat tipped curves with no discernable maximum (Pauly, 1994, Hoggarth *et al.*, 1999) In such replacement fisheries slow growing and late maturing species (K strategists) are often replaced by fast growing and early maturing species (r-strategists) (Pauly 1994, de Graaf, 2003, de Graaf *et al* 2001) and this phenomenon stresses the importance of following individual species in a multi-species fisheries.

31. **System variability or** human **impact only.** Surplus production models are mainly based on the assumption that human intervention i.e. fishing or fishing effort is the **only variable** influencing the ecosystem/biomass. However, over the years a number of experiences, especially in inland fisheries indicated that this concept is too rigid as other abiotic factors such as water level, water temperature proved to be an important impact on biomass and consequently cpue (de Graaf and Ofori Danson, 1997, de Graaf, 2003, Larsen *et al*, 2003). If the other variables are not considered as only minor "disturbances", but as factors that may alter the dynamics of the ecosystem in a significant way, then one cannot *a priori* say how changes in fishing effort will affect the eco system, since the effect of fishing effort will vary according to the state of the abiotic variables (Larsen *et al*, 2003). Multivariate analyses and modeling is therefore an important tool in catch and effort analyses.

32. **Changes in catchability.** The major assumption in the use of surplus production models is that the relation between catch rates and stock biomass is constant ($C/f=qB$ or $C=q.f.B$). This relationship implies that the catchability coefficient q remains constant through time. Catchability also called gear efficiency or fishing power depends on biological and technological factors (Larsen *et al*, 2003).

Biological factors include:

- Fish availability on fishing ground, migratory behavior
- Fish behavior towards fishing gear
- Size, shape and external features of the fish

Where some of these factors again are depending on season, age, environmental and other factors.

Technical factors include:

- Gear type, design, colour and material
- Gear position duration and handling
- Experience of fisher

Where again these factors are depending on biological changes.

33. The catchability coefficient or probability of a fish being caught is therefore a composite and very complicated factor. Conceptually, however, "*fish catcability*" implies primarily changes in fish behavior, whereas "*fishing efficiency*" indicates changes in fishing practices or in relative fishing power. As fishers tend to improve continuously their fishing gear and fishing practices it means that fishing efficiency increases through time.

34. So even if the nominal fishing effort f (no of fishing days, number of boat days, no of hooks set, no of meters of gill net set) can be followed, which is not always that easy, then changing catchability makes application of standard surplus production models over long data sets still complicated, with a risk of systematical over estimation of abundance.

35. This is why "*fishing effort*" is often replaced by "Fishing mortality" For the latter Csirke and Caddy (1983) developed a Surplus production model based on fishing mortality in stead of fishing effort. This model is a good alternative for standard surplus production models. However, the major disadvantage is the data requirements as fishing mortality or total mortality has to be estimated annually. The latter is normally done through the application of length or age based stock assessment programmes (growth, age, catch curves, cohort analyses).

36. A second approach is to compare catch rates from commercial and research fishing where the catchability of the research fishing is kept constant from year to year:

$$\frac{CPUE_{fishery}}{CPUE_{research}} = \frac{q_{fishery}}{q_{research}} \qquad (10)$$

This method requires several years of data in order to detect relative changes in the efficiency of the commercial fishery. This lag time, before eventual changes are discovered, will lead to over estimation of stock size if the commercial efficiency or fishing power is rising.

37. A third alternative is to define catchability q as a variable and add them in fitting procedures in non-equilibrium surplus production models (Prager 1994, Haddon, 2001).

2.1.3 Conclusions

38. After being relatively unpopular in the 1980s Surplus production models continued to progress and due to its relatively small data requirement they are most likely the major tool for the resource assessment of small scale multi-species fisheries. The present status of the models and its applicability is well provided by Haddon (2001).

39. "Now that surplus-production models have moved away from their equilibrium-based origins they provide a useful tool in the assessment of stocks for which there is only limited information available. Their simplifying assumption implies that any conclusions drawn from their outputs should be treated with caution. Nevertheless, given the constraints of only considering the total stock biomass, they can provide insights as to the relative performance of the stock through time. Surplus production models have now surprising flexibility and can be used in risk assessment[2] and to produce management advice that goes well beyond the old traditional performance indicator notion of MSY and F_{MSY}.

2.2 Dynamic models[3]

2.2.1 The basis

40. These types of models are based on population dynamics whereby the total number of fish, their survival, natural and fishing mortality and growth is followed over time. It would be too exhaustive to provide the mathematical approaches for the different models, but in general they are based on/derived from a number of standard classical equations:

Population size: Exponential decay $N_{t0} = N_0 e^{-(F_t + M_t)t}$

Catch: Baranov catch equation $C_t = \frac{F_t}{F_t + M_t} N_t \left(1 - e^{-(F_t + M_t)}\right)$

Growth: Von Bertalanffy growth curve $L_t = L_\infty . \left(1 - e^{-K(t - t_0)}\right)$

Stock Recruitment: Beverton & Holt $R = \frac{S}{a + bS}$, Ricker $R = aSe^{-bS}$

41. The most commonly used dynamic fisheries models are: stock recruitment models, yield per recruit models and population dynamic models (VPA, cohort analyses and Thompson & Bell models).

2.2.2 Stock Recruitment models

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[2] through Baysian statistics/modelling

[3] Taken/derived from Gulland, 1983; King, 1995; Gayanilo and Pauly, 1997; Sparre and Venema, 1998; and Haddon 2001

42. An important type of over fishing is **recruitment over-fishing,** which occurs when a stock is fished so hard that the stock size is reduced below the level at which it, as a population, can produce enough recruits to replace those dying naturally or by fishing. Recruitment over-fishing can not continue for long and is usually a precursor to stock collapse.

43. Theoretically one would expect the correlation between the number of recruit and the stock size to be reasonable, the larger the number of reproductive individuals in a stock, the larger the number of offspring. However, this is not that clear, the success of recruitment is also related to a large number of environmental variables and as a consequence drawing stock-recruitment relationships is extremely difficult. This even resulted in the dangerous belief that stock-recruitment relationships can be ignored unless there is clear evidence that recruitment is not independent of stock size.

44. Due to the difficulties for stock-recruitment relations related to data collection and analyses most likely it will be difficult to apply them in small scale fisheries. However, they are mentioned as they are important in sophisticated simulation models.

2.2.3 Yield per Recruit analyses

45. In classical fisheries management the major parameters which can be controlled directly is the amount of fishing or its resulting fishing mortality, and the way fishing is distributed on different sizes of fish as measured by the age at first capture (t_c).

46. If considered that recruitment is constant, then calculating the yield from a recruited year class is straightforward if reasonable estimates of growth and natural mortality are available. With the estimates the question can be addressed what pattern of fishing (changing fishing effort or changing mesh size) will give the greatest yield from the year class that has just been recruited. These Yield per Recruit approaches have been developed by Beverton and Holt (1957) and are based on the following assumptions:

- A steady-state stock structure; that is the total yield in any year from all age classes (all pseudo cohorts) is the same as that from a single cohort over its whole life span.
- Recruitment is constant but not specified.
- The fishing and natural mortalities are constant once the recruits enter into the fishery (exploited phase).
- All fish are born on the same day.
- There is complete mixing within the stock.
- Gear selection through knife edged selection curve (all fish older then t_c in contact with fishing gear have equal probability of capture).

Under these assumptions the classical Yield per Recruit depends on:

- Growth, von Bertalanffy: Max weight W_∞, growth parameter K and age at zero length t_o
- Age of first capture (t_c)
- Fishing Mortality (F) and Natural Mortality (M)

Yield per Recruit is expressed as:

$$Y/R = F \exp\left[-M\left(t_c - t_r\right)\right] W_\infty \sum \frac{U_n \exp\left[-nK\left(t_c - t_0\right)\right]}{F + M + nK}$$

Where U_0=1, U_1=-3, U_2=3 and U_3=-1

47. The yield per recruit can be expressed either as a function of fishing mortality, F, keeping the age at first capture constant, or as a function of t_c, keeping F constant. For both cases Yield per Recruit will reach a maximum. An alternative is changing simultaneous F and $t_{c,}$ which will provide isopleths plots.

48. Major constraints of Y/R models are;

- The assumptions that recruitment, fishing mortality and natural mortality are constant. This is inherent to the set up of the model which in principle is a simple version of Thompson and Bell models, in the latter recruitment and length or age related fishing and natural mortality can be incorporated.
- The Y/R curve is very sensitive for high natural mortalities, this as at high natural mortality fish will soon reach the age where losses due to natural mortality exceed the gain due to growth, as a result the Y/R curve does not have a maximum With the high temperature in tropical water where most of small scale fisheries takes place, natural mortalities are high (Pauly, 1980) and this phenomenon will be encountered often which makes application of Y/R methods risky.
- The basic inputs for Y/R models are growth, natural mortality, fishing mortality and age as first capture, or basic parameters obtained from stock assessment programmes. In here lies the major constraint of the application of Y/R models as estimation of these parameters in a multi species, multi gear fishery is a large undertaking.

2.2.4 Population models

49. The earlier mentioned surplus production models treat the stock as an undifferentiated biomass, and by lumping growth, reproduction, mortalities, survival into one production unit, dynamic interactions between these processes are ignored. In the more sophisticated dynamic models the different aspect are treated separately and then combined in an overall predictive model. The overall models seem to be complex, but most of them still can be developed by using combined spreadsheets and if well designed they can even provide more dynamic outputs if compared with the outputs of standard software such as FISAT II or LFDA.

50. Population models can be age-based or length based, in general it is believed that age based models are somewhat more accurate if compared to length based model (FAO, in press) But length based models have the advantage that data collection is easier and cheaper, and this will certainly the case if small scale fisheries is considered.

51. The development of dynamic population models usually implies two steps; (i) Estimation of the values of different variables and then (ii) combining the different variables in a predictive model. However, in should be realized that the different variable can be combined in a number of ways varying to simple prediction systems to more complex complete population dynamic models.

Estimation of growth

52. Growth is estimated through seasonal or non seasonal version of the von Bertalanffy growth curve based on age readings or **length frequency distributions obtained from non selective gears.** Estimating the growth parameters from length frequency distribution has to be done with specialized software such as FISAT II or LFDA.

Estimation of natural and fishing mortality

53. The total instantaneous mortality rate of a fish population consists of natural mortality (M) and fishing mortality (F). The estimation of natural mortality is most likely the most difficult one and often forgotten/ignored.

Natural mortality can be estimated through:

- Empirical formula of Pauly (1980) based on growth parameters K and L_∞ and the ambient water temperature.
- Plotting the annual value of total mortality Z against fishing effort. Whereby Z is obtained from catch-curves, Beverton and Holt mortality equation for mean length or Wetherall plots.
- Munro's approach using probability of capture data (Munro, 1984; Moreau (1988).

54. A disadvantage of the methods is that natural mortality is constant and irrespective of size, methods to describe natural mortality with an allometric relationship are provided by Peterson and Wroblewski (1984); McGurk 1986 and Lorenzen 1996.

55. A second disadvantage is that recruitment is assumed to be constant and initial strength of recruitment for each cohort is ignored.

56. Estimation of total mortality trough a catch curve is mathematical straightforward but it has some practical complications. A catch curve is based on the assumption that age composition of the sample represents the age composition of the stock. As a consequence samples for a catch curve have to be obtained from non selective gears. Even in the case of small scale fisheries independent surveys could be organized for this, but still the bottleneck will be that the estimated fishing mortality is the sum of the fishing mortalities caused by the different gears used by the small scale fishers, which can not be separated. It becomes even more complicated a stock is targeted by small scale as well as by industrial fisheries. These problems can be overcome by applying cohort or Virtual Population Analyses (VPA).

Estimation of mortality and recruitment through Cohort or Virtual Population analyses

57. Virtual Population Analysis (VPA) and cohort analysis is based on the catch equation of Baranov and use the number of fish caught during fishing operations to estimate historic fishing mortality and numbers in a cohort of fish. The idea behind it is to analyze what can be measured, the catch, in order to calculate the population that must have been in the water to produce this catch. The total landings of a cohort in its lifetime are a first estimate of the number of recruits from that cohort. It is, however, an underestimate because some fish must have died from natural causes. Given an estimate of natural mortality M we can do a backwards calculation and find out how many fish belonging to a cohort were alive year by

year and ultimately how many recruits were there. At the same time the fishing mortality (F) is estimated for each sampled gear.

58. VPA or cohort analyses is straightforward and can be applied to multi-species, multi-gear small scale fisheries, a prerequisite is that reliable data on total catch for each species and each gear are available. VPA further requires a reasonable estimate of growth parameters for the different species.

Predictive Thompson and Bell models

59. A Thompson and Bell model is the converse of a VPA; a prediction of the development of a fishery given the assumptions on future recruitment and values of fishing effort, expressed in terms of size (age) specific fishing mortality and gear selectivity. In other words it predicts the effect of changing fishing effort on future yields.

The Thompson and Bell model has to important assumptions:

- The fishing pattern has no influence on recruitment.
- Biological interactions among species can be neglected.

60. An important aspect of the T&B model is that it allows for the incorporation of the value of the catch. Therefore the model has become the basis for the development of so called bio-economic models, which are important for prediction needed for management decisions.

61. T&B models are straightforward and if data from VPA analysis are available they can be applied to small scale, multi-species, multi-gear fisheries and can encompass. Multi species, multi gear T&B models or Bio-economic models if combined with financial/economic data, do not require special software as the can be easily build in spreadsheets (de Graaf, 2002.).

2.3 New developments

2.3.1 The use of traditional ecological knowledge

62. The term fishers' knowledge (used here interchangeably with Traditional/Local Ecological knowledge (TEK/LEK) refers to the cumulative body of knowledge, practice and beliefs, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings with one another and with their environment (Berkes 1999; Neis and Felt 2000). TEK contains empirical and conceptual aspects, is cumulative over generations, and is dynamic, in that it changes in response to socio-economic, technological and other changes (Berkes, 1999).

63. As pointed out by Berkes and Folke (1998), TEK/LEK could play an important role in fishery assessment because local level institutions usually learn and develop capabilities to respond to environmental feedback faster than do centralized agencies. Berkes *et al* (2001) demonstrate that qualitative indicators of change can often be based on readily available fishers' knowledge of the catch trends, their observations of ecology and fish behaviour, and other information resulting from years of practical experience. It is at these smaller scales that

local knowledge about nature can be applied in daily life. A problem related to the centralization of data collection is that valuable information from the resource may be delayed or lost because of the mismatch in scale (Holling *et al*. 1998; Folke *et al*., 1998).

64. Many studies demonstrate that fishers' knowledge can provide valuable information about the relationship between fishers and the local environment, and about the characteristics of practices, tools and techniques that underlay a more sustainable pattern of resource use (Berkes, 1999; Neis and Felt, 2000; Haggan *et al*., 2003; Neis and Haggan, 2005). Examples of methods used in TEK/LEK are presented in Annex 2.

65. There are already many initiatives towards complementary use of scientific and traditional local ecological knowledge around the world that seeks to develop collaborative assessment and management of small-scale fisheries. Wilson (2003) mentions the Fishermen and Scientist Research Society composed by 156 fishers and 42 scientists that collaborate in the fisheries research activities. Community-based management, co-management, sustainable livelihoods are all approaches that emphasizes the need for collaboration and complementarities among scientific research and fishers' knowledge. There have been excellent examples of alternative ways fishers can contribute their knowledge and create management models that are effective for their community and for the species that they fish. In Brazil a few studies have reported different aspects of fishers knowledge, including their understanding of the environment of Pantanal wetlands (Calheiros *et al.*, 2000). Fishers in many coastal areas and in the Amazon river have a nomenclature system for fish species, usually classifying useful species in a detailed way. The classification of fish is influenced by their ecology and behaviour. The use of fishers knowledge in deciding about optimal fishing strategies of coastal islands (Begossi, 1992; 1996), in the management and assessment of fisheries in the Amazonian floodplain (Castro, 2000; Isaac *et al.*, 1998), in coastal fisheries of North-eastern Brazil (Cordell and McKean, 1992; Christensen *et al.*, 1995; Barbosa and Hartman, 1997), and in coastal lagoons in southern Brazil (Seixas and Berkes, 2000; Kalikoski and Vasconcellos, 2005) have been key for sustainable management of the resources. In Australia, Traditional Ecological Knowledge plays an important role because indigenous communities are increasingly valuing and protecting their knowledge as intellectual property. This involves strict controls of access and use, and adherence to culturally appropriate research ethics and methods (Faulkner and Silvano, 2003). Fisher's knowledge research in the Mekong River in Asia, a very complex system that supports one of the most important freshwater fisheries in the world, has been essential to identify migratory and reproductive habits of 50 important fish species and the distribution ranges for another 120 species Fishers' knowledge can provide information that is vital for management, and help develop hypotheses that focus future research (Poulsen, 2003). Research on fisher's knowledge in the seahorse fishery in the Philippines was key to estimating seahorse abundance, habitat quality and their livelihoods as in decline, and proposed a number of solutions. Meewig *et al* (2003) conclude that through participatory approach involving seahorse fishers playing a role in designing applied fisheries research, and in developing management plans for their fishery.

66. Berkes' approach to assess small-scale fishers' knowledge (1999) focuses on several levels of analysis that are consistent with the description of traditional ecological knowledge as a "knowledge-practice-belief complex" (Figure 1). Berkes (1999) warned that distinctions between the levels of management systems and institutions are sometimes artificial, and although the four levels are hierarchically organized, there are often feedbacks between the

knowledge levels such that worldviews may themselves be affected by changes occurring, for instance, with the collapse of a management system. They are the following (Berkes, 1999):

- knowledge of nature: related to the local knowledge of the animals and ecosystems, such as the behavior and habitat of fish, and the timing of fishing seasons;
- knowledge of resources management system: local environmental knowledge to devise an appropriate set of practices, tools and techniques for resource use;
- knowledge of social institutions: the set of rules-in-use to co-ordinate the management of the resources;
- knowledge of world view: the system of belief (e.g. religion, ethics) that "shapes human-nature relations and gives meaning to social interactions".

67. This frame of reference refers to the manner in which local residents perceive, use, allocate, transfer, and manage their resources.

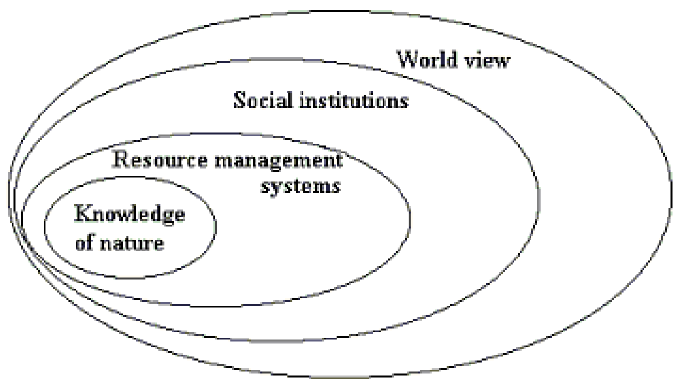

Figure 1: Levels of analysis of traditional ecological knowledge (Berkes, 1999).

2.3.2 Ecosystem Analysis Methods

68. Attention during the last decades has been given to the development of ecosystem analysis methods centered on the representation of trophic interactions in aquatic food webs. The available methods can be grouped into three general types (Walters et al., 1997; Lehodey, 2001; Shannon et al., 2004); .

- **Whole ecosystem models**: models that attempt to take into account all trophic levels in the ecosystem, including Ecopath with Ecosim and other bioenergetic trophodynamics models;
- **Dynamic multispecies models or Minimum Realistic Models**: models restricted to represent a limited number of species most likely to have important interactions with a target species of interest, including MSVPA and MSFOR; MULTSPEC; BORMICON; SEASTAR; GADGET; and Individual-based Models (IBM);
- **Dynamic System Models**: models that attempt to represent both bottom-up (physical) and top-down (biological) forces interacting in an ecosystem, including Individual-based Models (IBM), SEPODYM, etc.

69. The implementation of some of these models have been hampered by the high data requirements, the difficult parameterization, the high degree of expertise required from the modeler, and the overall lack of transparency in the estimation procedures (Walters et al., 1997). Of these models, Ecopath with Ecosim, is the most widely used because of its capacity to represent simple and complex food webs, multiple fishing fleets, its relative simplicity, and because it can incorporate diverse sources of information, a characteristic that makes it more suitable for data-limited settings than the other ecosystem methods. Ecoptah with Ecosim relies on the truism that for each group in the system, and to any time period, the total biological production of a stock must balance the sum of the losses to predation, other sources of mortality, fisheries catches and losses to adjacent systems. By expressing this relationship as differential equations the provides dynamic biomass predictions of each group as affected directly by fishing and predation, changes in food availability, and indirectly by fishing or predation on other groups with which a given species interacts (Walters et al., 1997). The model also allows a simple representation of the spatial dynamics of species and fisheries by accounting for movements of biomass and fishing effort across a grid map of the ecosystem (Walters et al., 1999).

2.3.3 GIS

70. Another interesting development for small scale fisheries is the application of Geographical Information System (GIS), especially related to spatial structured surplus production and modeling of fishing effort.

71. Corsi (2000) developed a model to investigate the behavior of surplus production models in conditions of varying stock densities. The basic assumption behind the analyses is that the slope (b) of the Schaefer curve remains constant with different ecological zones whiles the intercept (a) changes with these zones. The model is still in its theoretical stage but its merits for small scale fisheries could be studied.

72. A second application could be the use of GIS in effort modeling in data limited situations. The method is based on the classical 'Friction of distance' approach to generating fields of action around home ports. Caddy and Carocci (1999) applied the model to artisanal fisheries in the Mediterranean while Payet[4] (2002) applied the approach to artisanal tuna fisheries in the Seychelles and its application to small scale fisheries should be further investigated.

2.4 Assessment framework

73. There are a number of policy guidelines and international instruments underpinning the assessment and management of small-scale fisheries including:

- UN Convention on the Law of the Sea (UNCLOS).
- FAO Code of Conduct for Responsible Fisheries (CCRF).

[4] Spatial distribution of fishing effort in the Seychelles schooner fishery, Brighton Symposium on GIS in Fisheries (Not entered in the proceedings)

- Convention on Biological Diversity (CBD).
- Chapter 17 and 18 of the United Nations Conference on Environment and Development (UNCED).
- The Johannesburg World Summit on Sustainable Development (WSSD).
- The FAO strategy for Improving Information on Status and Trends in Captured Fisheries (FAO STF strategy).

74. Precautionary management is the core of the Code of Conduct for responsible management and the Code advises:

7.5.1. States should apply the ***precautionary approach*** *widely to conservation management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment. The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures.*

7.5.2. In implementing the precautionary approach, States should take into account inter alia, ***uncertainties*** *relating to the size and productivity of the stocks, reference points, stock condition in relation to such reference points, levels and distribution of fishing mortality and impacts of fishing activities, including discards, on non target and associated or dependent species, as well as environmental and socio economic conditions.*

75. The FAO STF strategy addresses especially small scale fisheries:

"States, relevant intergovernmental and non governmental organizations, and financial institutions should recognize that many small scale fisheries and multi species fisheries, particularly in developing countries are not well monitored and awareness needs to be raised on the importance of monitoring these fisheries. They are probably underestimated and therefore under-represented in current fisheries status and trends information and consequently they are not adequately considered in the development of plans and policies for fisheries".

"States should participate in and support the development of cost-effective methods for acquiring and validating data on small scale and multi species fisheries, including rapid appraisal methodologies and other approaches for data poor situations and participatory processes that closely associate the fishers and their organizations to the data collection schemes. Regular surveys at appropriate frequencies rather than continuous monitoring may be more feasible, particularly for some inland and small scale fisheries".

76. Taking the major aspects into consideration then an assessment should include; biological, ecological, economic and social issues, should explicitly consider uncertainty, and should be appropriate for small scale fisheries and developing countries. Within the context of appropriateness of monitoring systems Nielsen and Dengbol (2001) provided a direction:

"A minimum set of criteria for fisheries assessment methodologies in a development context is that the knowledge base for fisheries must be valid for all stake holders and it must be feasible to produce this knowledge on sustainable bases within the economic means of society. This set of criteria will exclude most methodologies presently applied in the North Atlantic or elsewhere in relation to industrialized fisheries in industrialized countries. There is a need to identify and develop methodologies which rely on observations which can be made at low costs and reflect resource system features which can be recognized and accepted

by both fishers and researchers. This points to using indicators rather then complex assessments as produced by full models of processes".

Box 1: Biological assessment key characteristics

Objective: Sustainable resource management.
Mechanism: Through data collection, analysis and estimation of key indicators.
Framework: Based on international agreements and assessments should encompass precautionary approaches and uncertainty.
Assessment: Based on relatively simple biomass models or on more complex population dynamic models.

3 COMMUNITY BASED APPROACH

77. In the last decades, facing the failure of conventional resource management systems, several researchers have been investigating the links between social systems and ecological systems in order to improve natural resource management (Berkes and Folke, 1998; Holling *et al.*, 1998). As a result, an emphasis on institutions and property rights as the mediator of the interaction between society and nature has become crucial for small scale fisheries management (Ostrom, 1990; Hanna and Munasinghe, 1995).

78. Fundamental to understanding the complexities of natural resource management is the fact that people form institutions (rules and rights) around the resources they exploit (North, 1990). Assessing fisheries institutions, i.e. the "set of rules actually used (the working rules or rules in use) by a set of individuals to organize repetitive activities that produce outcomes affecting those individuals and potentially affecting others" (Ostrom, 1992) and that in turn guide management (Ostrom, 1990) becomes crucial for dealing with the sustainability of the resources and the empowerment of fishing communities livelihoods. Institutions play a pivotal role in environment/human relationships (Young, 1999). The importance of understanding and studying institutions stem from the fact that "they are often behind the causes of environmental problems and hence they play an important role in solving these problem*s*" (Young, 1999, 5). Deficient institutional arrangements frequently cause large-scale environmental problems, such as severe depletion of living resources which result from unrestricted access to global commons (Young, 1999, O'Riordan and Jordan, 2000). Conversely, institutional arrangements play a role in solving environmental problems, as in cases where international regimes intensions are intended to prevent environmental problems, such as the creation of limited-entry regimes to avoid the ravages of unsustainable harvesting of living resources (O'Riordan and Jordan, 2000).

79. Findings in the common pool resources literature suggest that many of the associated fisheries' crises [such as the tragedy of the fisheries commons] may be seen as problems of failure to control access to the fisheries resources, and to enforce internal decisions for collective use (McCay and Acheson, 1987; Fenny *et al*., 1990). A key issue on governing the commons[5] relates to the ability of developing institutional arrangements that enhance the likelihood that individual incentives lead participants toward sustainable use rather than imprudent uses (Ostrom *et al*., 1999). In a condition of scarcity and competition over the resources, fishers' stewardship for resources is an important yet difficult issue to achieve. Where stewardship for resources exists it is in the best interests of those who control it not to over fish. As put by Johannes (1981, 64) in this case "self-interest thus dictates conservation". Users must be interested in the sustainability of the particular resource so that expected joint benefits will be worth trying (Ostrom *et al*., 1999). Therefore, solving fisheries Common Pool Resources (CPRs) problems' involves two distinct elements that are important to the stewardship of the resources:

- i) restricting access, and
- ii) creating incentives for users to invest in the resource instead of overexploiting it (Ostrom *et al*., 1999, Orensanz *et a*l., 2005).

80. A fundamental incentive to conservation relies on the fact that many institutions involve a range of property rights to common pool resources (Ostrom, 1990) including

[5] Fish resources are often referred to as a common pool resource (CPR) in which exclusion is difficult and resource use involves subtractability (Berkes and Folke, 1998)).

common-property (or community-based management) regimes, where user groups hold the rights and responsibilities for the use of fisheries (Berkes and Folke, 1998) in a self-governance of fisheries. Figure 1 exemplifies the wide range of stakeholders participation in the governance of natural resources, with limited participation in traditional top down management through governmental regulations toward a share of management functions and decision power between government and resource users in co-management regimes to the other side of the range community based management (Figure 2).

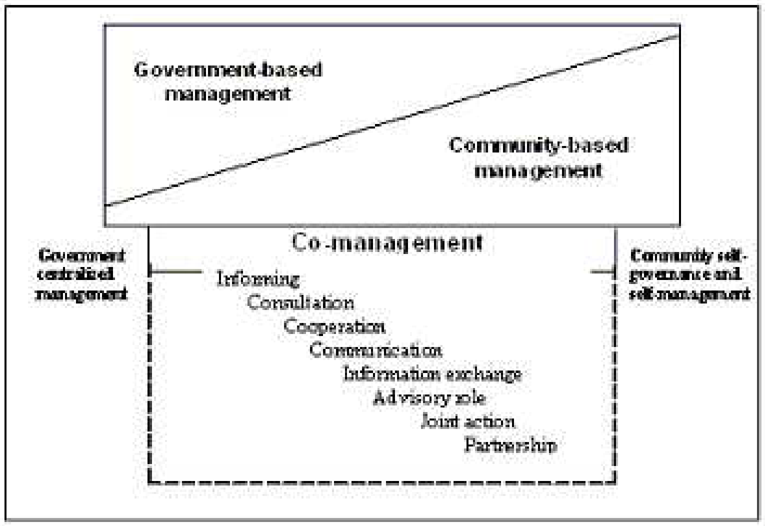

Figure 2: Hierarchy of management arrangements from government-based management, co-management and community-based management (after Berkes 1994)

81. As long as property rights to resources remain open no one knows what is being managed or for whom, and any incentive to conserve will disappear because there is no guarantee that the benefits of any management action will be accrued by the same individual or group that practices conservation (Ostrom, *et al.*, 1999). Limiting access alone can fail if resource users compete for shares that may become depleted unless incentives or regulations that involve use rights delegation to communities prevent overexploitation (Ostrom *et al.*, 1999).

82. Many scholars emphasize the importance role of use rights in fisheries (Charles, 2002). Charles (2002, 153) affirms that “indeed, it seems apparent that if both the use rights held by fishers and the responsibilities undertaken by those fishers are clearly identified and widely accepted, success in achieving responsible fisheries will be that much more likely in the future”.

3.1 Assessment framework

Many CPR’s studies use the Institutional *Analysis and Development* (IAD) framework, developed by scholars at Indiana University, and largely tested worldwide, as an appropriate analytical framework for assessing different common pool resources, such as fisheries. The framework is used to study the origin, maintenance and performance of collective actions toward CPRs. Central questions of the theory of common-pool resources are related to the erosion, survival and adjustments of community-based management systems and how they can increase ecosystem resilience (Ostrom 1990, Ostrom, 1994, Berkes and Folke 1998). In other words it studies if local users are effective managers of the smaller resource systems they depend upon for living (Ostrom, 1995). The assumption is that users managing their own resources learn about the unique aspects of a local ecology (the diversity of local environmental conditions, fish behavior, migration, spawning areas and seasons, among others) and can fit rules to these local circumstances that lead to culturally accepted norms and equitable resource use and access distribution. The IAD framework provides the factors that are relevant to small-scale fisheries assessments (Ostrom *et al.*, 1994) (Figure 3):

1 the attributes of the Biophysical world/resource,
2 the attributes of the communities, and
3 the existing management structure (institutions and organizations) that defines what is required, prohibited, and permitted (rules-in-use) in regard to resource use.

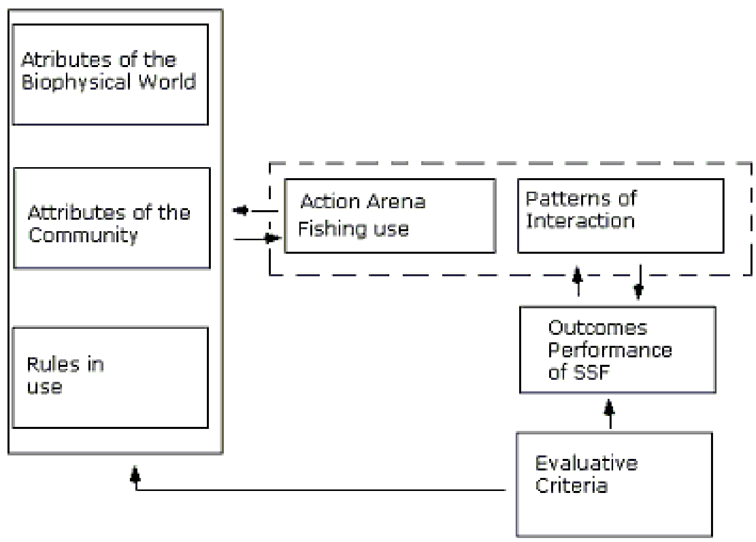

Figure 3: Institutional Analysis and Development framework (Adapted from Ostrom *et al*., 1994).

83. **The attributes of the biophysical world** relate to the range of ecological opportunities and constraints affecting the production systems. Individual strategies' of resource use are shaped by the attributes of the ecological environment, such as spatial and temporal distribution and abundance of the resource, productivity, and resilience of the system.

84. **The attributes of the community** influence the perceptions and ability of individuals to define their own strategies of resource use. Individuals are organized in different levels (household, community, and region) and are influenced by the different sets of incentives presented at each level.

85. **The rules-in-use of the system** (institutions) are prescriptions that are actively in work and intermediate the use of the resources, creating opportunities/limitations for achieving certain goals in fisheries management.

86. Resource attributes, community attributes, and rules-in-use affect individuals differently according to their personal features, such as preferences, identity, and assets (knowledge, access to information, technology endowment) (Ostrom *et al.,* 1994, Berkes and Folke, 1998). Therefore, the pattern of behavior generated through those factors is filtered by individual differences, which can lead to different outcomes. According to evaluative criteria, the outcomes affect the ecological, social, and institutional setting where the social arena takes place, leading to a new round of outcomes (Ostrom *et al.,* 1994, Berkes and Folke, 1998).

87. The IAD framework accounts for the dialectics between social and ecological systems in which small scale fisheries regimes emerge. According to Ostrom (1990) the following seven design principles are key to explain most of the robust institutions while the eight principles is associated to the largely more complex cases:

1) Group boundaries are clearly defined.
2) Rules governing the use of collective goods are well matched to local needs and conditions.
3) Most individuals affected by these rules can participate in modifying the rules.
4) The rights of community members to devise their own rules is respected by external authorities.
5) A system for monitoring member's behavior exists; the community members themselves undertake this monitoring.
6) A graduated system of sanctions is used.
7) Community members have access to low-cost conflict resolution mechanisms.
8) For CPRs that are parts of larger systems: appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

88. These principles can be translated into criteria to assess the community’s capabilities to organize for collective action and manage their resource base in a sustainable and resilient fashion. and should be one of the major issues to be addressed before community based management is put into action. Other objectives of assessment could be:

- determine the success of managing resources over time;
- evaluate the cross-scale institutional aspects of small-scale fisheries;
- explain successful common property resource regimes
- provide a description of the interactions between social and ecological systems;
- evaluate right systems.

89. Use rights are crucial in the pursuit of responsible fisheries, use rights already exist in many fisheries; if use rights do not exist, or current rights are ineffective, an appropriate system must be developed and implemented (Charles, 2002).

Box 2: Community based approach's key characteristics

Objective: Solving fisheries Common Pool Resources problems.
Mechanism: Restricting access and create incentives or regulations that involve use rights to communities.
Framework: IAD framework study origin, maintenance and performance of collective actions towards CPR.
Assessment: Understanding why community based management was successful or failed.

4 CO-MANAGEMENT APPROACH

90. The literature on co-management theory, or power-sharing between government agencies and non-government groups (Pinkerton, 1989; Jentof and McCay 1995), as well as the field of participatory research (Campbell and Salagrama, 1999; Berkes, 2000; Jentoft, 2000a; Jentoft, 2000b; O'Riordan, 2003), whereby scientists and fishermen and other community members collaborate in various dimensions of fisheries research and management is very relevant to inform the assessment of small scale fisheries.

91. Pomeroy and Berkes (1997, 466) define fisheries co-management *"as the sharing of responsibility and authority between the government and the community of local fishers to manage a fishery"*. Although the spectrum of co-management arrangements varies, the essence of co-management as defined by Pinkerton (1989) is the involvement of fisher’s organizations and fishing communities in management decision-making through power sharing: sharing both between government and locally-based institutions, and among differently-situated fishers (Pinkerton, 1989). It represents a way to decentralize decisions, delegate rights and roles to community and move towards implementing a joint decision-making process.

92. One important aspect of co-management relates to the fact that it does not challenge the authority and responsibilities of the agencies of the state” (Jentoft and McCay, 2003: 300). Incentives to decentralize fisheries management in recent years have created opportunities for co-management initiatives around the world (Geheb and Sarch, 2002; Wilson *et al.*, 2003; Kalikoski and Satterfield, 2004; Pinto da Silva, 2004; Cunningham and Bostock *et al.*, 2005; Orensanz *et al.*, 2005). Co-management’s emphasis on multi-stakeholder partnerships is a strong alternative when managing resources under complex conditions, and when significant power imbalance across stakeholders exists. A key ingredient in the success of such initiatives is the government’s willingness to share power when devising and enforcing rules. Finally, co-management has the capability of improving the knowledge base of resource management by combining different types of knowledge, traditional and scientific, rather than assuming away the merits of one or the other (Pomeroy and Berkes, 1997; Pinkerton, 1989).

4.1 Assessment framework

93. Co-management regimes have been studied now for approximately 20 years. Co-management is usually created out of crisis (Pinkerton, 1989) as an institutional response to a resource overexploitation and/or collapse directly affects fishing livelihoods, their food security and vulnerabilities to poverty. Co-management and community-based management approaches have played an important role for such changes in the field of fisheries assessment and management. Both approaches focus on the resource user rather than on the resource itself (Berkes *et al.*, 2001). Co-management approaches guide us on the importance of evaluating the cross-scale link of institutions within fisheries in which small scale fisheries assessment should be conducted in at least two levels of influence (sensu Berkes *et al*., 2001; Pollnac, 1998; Pomeroy *et al.*, 2001): the ***supra-community*** and the ***community levels***.

94. ***Supra-community*** conditions are external to the community and include government's role in legitimising fisheries decisions and willingness to share power and authority on small-scale fisheries assessment, management and monitoring without eroding local-based institutions and knowledge.

95. ***Community*** conditions affecting the success of fisheries co-management include the local physical and the social environment. Issues such as *property-right*s, *power relations*, f*ishers' participation in some functions of fisheries management*, particularly in "the right to make decisions about how, when, where, and how much fishing will occur" (Pinkerton, 2003) are key for both empowering fishing livelihoods and protecting fish resources.

96. These issues have shown to be extremely relevant to understand the complexities that influence small-scale fisheries needed for successful transition to co-management and should be included in the agenda for small scale fisheries assessment.

The key elements for appropriate assessments are:

4.1.1 Property-rights

97. Defining boundaries over resources is a way to deal with the issue of property rights. As stated by Ostrom (1990), the definition of boundaries can be thought of as a first step in organizing for collective action. Ostrom discusses that "as long as the boundaries of the resources and/or the individuals who can use the resource remain uncertain, no one knows what they are managing or for whom" (right to what, right for what, for whom, against whom). Lack of comprehension on property rights' issues (e.g. delimitation of boundaries and rights to exclude outsiders from the use of resources) will make difficult to maintain life support systems and resource users livelihood. As pointed out by Pinkerton (2003) the first time that the term co-management was used was in the late 70's when US tribes won in court the recognition of their access and withdrawal rights to fish allocation.

98. The basic and probably universal factor of environmental regimes in fisheries is the limitation of access to the resource (Scudder and Conelly, 1985). Without some kind of access limitation, a productive fishery sooner or later attracts enough fishermen to render it unproductive (Gibbs and Bromley, 1989; Grima and Berkes, 1989). Many current crisis faced by small-scale fisheries relates to the historical problem of access limitation – or the lack of it. Devolution of territorial use rights to fisheries (TURFs) is an important incentive for small-scale fishers.

99. Lessons from co-management studies have shown that "it is analytically useful to distinguish the core aspects of co-management arrangements which creates these opportunities, and to array rights and duties within an analytical framework which permits us to distinguish different levels of power and necessary bundles of rights permitting a co-management system to be effective" (Pinkerton, 2003).

100. Pinkerton (2003) emphasizes that not much progress can be made in co-management approaches unless collective choice rights are exercised. This involves user participation in assessment, management and monitoring systems that define:

- access (who can fish),
- territories (where to fish),
- season (when to fish),
- fishing practices (how to fish) and
- quotas rights (how much fish is allowed and who has the right to have it).

101. This involves transcending co-management boundaries towards cross-scale fisheries governance (Kalikoski *et al*., 2002, Pinto da Silva, 2004). This applies to both resource use of migratory and sedentary species.

4.1.2 Scale and scope

102. Co-management studies have shown that assessment of small-scale fisheries have to consider issues of scale. This relates to finding ways to protect not only the fish stocks as it has been the issue of concern by many studies but also their habitats. There is little point in planning the enhancement of stocks if in the process the community cannot protect its environment and the habitats on which the stocks depend for spawning and nursery (Pinkerton, 1999; Young, 1999). Lee (1993) attributes the problem of resource over-exploitation to a mismatch of scales between institutions and ecosystems, therefore assessments must focus on understanding institutional fits/misfits, i.e. the (in)congruence between rules on paper and rules in-use and the characteristics of the fish resources (Pinkerton, 1989; Ostrom 1990; Kalikoski *et al*, 2002; Folke *et al*., 1998). Spatial mismatches occur where the boundaries of management do not coincide with the boundaries of the ecological entity (Lee, 1993). Temporal mismatches are often discussed in reference to time horizons of planners and politicians (short) relative to environmental and social changes (long) (Lee, 1993). Functional mismatches are mismatches of scope and relate to functional attributions sharing and responsibilities between government and user-groups (Jentoft and McCay, 2003).

4.1.3 Representation and power

103. Jentoft (2003) suggest that question on representation is a key one to be addressed in small-scale fsheries assessment. Successful outcomes from any participatory approaches to fisheries that seek to improve the conditions of resources while empowering fishing communities have to address some of the following research questions(Jentof, 2003):

- Who can legitimately claim to be recognized as a user or stakeholder?
- In what capacity should users and stakeholders be represented (as a member of a particular interest group, a local community or concerned citizens)?
- How much involvement?
- And finally how representation should be done?

104. It is often pointed out that government managers are reluctant to share authority, and small scale fisheries are usually under complex conditions, multiple interests, and power imbalance situations (Pomeroy and Berkes, 1997). Therefore social assessments must provide the answers on how representation, equal opportunity, respect and support for user in fisheries governance, accountability, and the presence of mechanisms to deal with conflict-resolution all affect fishing livelihoods.

4.1.4 Role of science and local knowledge

105. Small-scale fisheries have succeeded when there are mechanisms in their structure to revisit rules and regulations and provide user groups with an opportunity to input into rule-making as identified in successful fisheries governance systems worldwide (Pinkerton, 1989; Ostrom, 1990; Pinkerton, 1999; Pinkerton, 2003). Using fisher's knowledge in the design of local rules that mediate the use of resources, for instance, has been proved to be an efficient way to empower local communities as it gives them a voice into the process and it creates a mechanism for inclusion because it provides a concrete basis for their involvement.

106. One of the strongest aspects of fisheries co-management that differentiates it from other models of participatory management is the knowledge of the environment that fishers have. Indeed, as put by Pomeroy and Berkes (1997) *"it is the complementarities between such local knowledge and scientific knowledge that makes co-management stronger than either community-based management or government management".*

107. Jentoft and McCay (2003) alert, however, that while many of these issues have been "fully exhausted" and the framework for analysis have been well documented in the literature, there is also a "need to focus more on the political ecology of fisheries management" (Jentoft and MacCay, 2003:302) that could help identifying and dealing with the struggle to shift systems of governance given different levels of preparedness, willingness, interests and power of people and institutions to make such a shift. Historically, small scale fisheries worldwide have shown failures in decentralised community-based regimes because such informal local-based small-scale regimes were easily eroded by external factors, i.e. unable to deal with access control of outsiders, internal pressures to behave opportunistically by taking advantage of new technologies, and external pressures due to market incentives and governmental policies (e.g. Kalikoski and Vasconcellos, 2005). By relying on a system of economically driven policies, centralised management approaches disregarded the sustainable resource use practices by small-scale fishers and drove many resources to over-exploitation and collapse (Johannes 1981; Berkes 1999; Castro, 2000; Seixas and Berkes, 2000).

108. Jentoft and McCay (2003) indicate that assessment from social scientists should focus on the evaluation of the influence of the state and market on the organization of civil society that are essential to management. They propose the following questions:

- -" To what extent are current state based, market based an co-management systems eroding community?. What is the precise nature of these impacts and the mechanisms behind them? How are they experienced at the community level? And What can be done to restore communities that have suffered from these impacts?" (Jentoft and McCay, 2003)

109. These authors also propose that assessment should also focus on the extent that participatory approaches to management, such as fisheries co-management, work under less ideal circumstances (e.g. in situations that the integrative qualities of communities are missing) (jentoft, 2000b). This is related to the issue of social cohesion that has been shown to be an important pre-condition supporting co-management (Pinkerton, 1989). In an international comparative study of user participation in fisheries management, Jentoft and McCay (1995) conclude that specific patterns of user participation reflect the broader institutional patterns and practices that prevail in each country. The cost of ignoring the importance of social cohesion or of removing its functions generates a disruption of the

resources management process. For local control to exist, it is imperative that the integration of the community be restored as showed by Jentoft (2000a;b). The dilemma is that the more disintegrated communities are, the more difficult it is to achieve a successful co-management process (Jentoft, 2000a;b). Jentoft and McCay (1995) argue that to work, institutions must have the support of resource users, but this support is often not in place before property rights regimes are implemented. The restoration of communities and the introduction of co-management through the delegation of regulatory powers must go hand in hand as part of a coordinated plan. Co-management institutions must be designed with social integration in mind, and users must be involved in their creation (Jentoft and McCay, 1995).

Box 3: Co-management key characteristics

Objective: Sustainable management of resources.
Mechanism: Sharing of responsibilities and authority between government and the community of local fishers to manage a fishery through decentralized decisions, delegation of rights and rules to communities and implementation of joint decision making process. Co-management is an alternative management scheme under complex conditions when significant power imbalance exist across stakeholders.
Framework: Evaluate the cross-scale link of institutions within fisheries in which small scale fisheries assessment should be conducted.
Assessment: Should be conducted in at least two levels of influence, the *supra-community* and the *community levels* and address cross-scale linkages in fisheries governance.

5 SUSTAINABLE LIVELIHOODS APPROACH

110. The Sustainable Livelihoods Approach (SLA) focuses on improving the understanding of the livelihoods of poor people and its overall goal is to eradicate poverty focusing on both actual poverty and vulnerability to poverty (Horemans, 2004; DFID, 1998). The SLA assesses poverty under a multidimensional and complex phenomenon, which is not possible to reduce its understanding to a single or a few indices for its measurement and representation (Lewis, 2004).

111. The livelihoods of the poor are the central focus of the SLA. As defined by Chambers and Conway (1991) a livelihood "comprises people, their capabilities and their means of living, including food, income and assets. Tangible assets are resources and stores, and intangible assets are claims and access. A livelihood is environmentally sustainable when it maintains and enhances the global assets on which livelihoods depend, and has net beneficial effects on other livelihoods. A livelihood is socially sustainable which can cope with and recover from stress and shocks, and provide for future generation….sustainable livelihoods are those that can avoid or resist stresses and shocks and/or that are resilient and able to bounce back".

112. The SLA provides the means for an action research approach because it presents a framework for studying and understanding the multidimensional complexities of poverty while it sets a set of practical guiding principles to act towards addressing and overcoming poverty (DFID, 1998). Within the SLA, poverty is addressed as a "complex phenomenon which encompasses, alongside low income, other concepts such as illness and lack of education, social exclusion, entitlement failure vulnerability and political powerlessness" (Béne, 2004, pg: 79). This concept brings into the equation other key issues such as the institutions that govern fisheries and their relations to access rights (Neiland and Béné, 2004). This shift of approach to poverty is essential if one wants to understand why many of developing counties are rich in resources while most of their populations starve to death. This new definition shows that poverty in fisheries is not systematically related to the state of the resources but appears instead to be strongly conditioned by social-institutional mechanisms (Béne, 2004; Neiland and Béné, 2004). Sectoral approaches do not work (e.g. technology) and correct diagnosis of development constraints is crucial for successful policies interventions. Neiland (2004) elaborate this further arguing that fisheries are capable of generating significant wealth but the distribution and use of this wealth, through particular socio-institutional arrangements that determines the incidence of poverty within fisheries in many countries.

113. As well put by Béne (2004) preserving the fish stocks may be necessary, but not sufficient condition for poverty reduction. This author argues that the factors which shape people's command over these resources (essentially their social positions and the institutional arrangements governing the access to and the use of the resources, i.e. the management systems) play a more critical role in determining people's poverty (or symmetrically wealth) than pure economic or biological considerations. Therefore approaches to small-scale fisheries assessment that look at poverty must go beyond the evaluation of economic and biological aspects of the fisheries activities. Focusing only on variables such as low income of fisheries (associated to catches) and exploitation of resources (associated to open-access regimes in fisheries (Béne, 2004) have been proven to be inefficient in providing the necessary information on combating poverty alleviation, maintaining human security and guaranteeing resources sustainability.

114. In the SL approach there is a key shift from the traditional focus on financial aspects of poverty to a multidimensional one. It draws on the degrees of access or entitlement to resources that reflects their local influence or the level of support derived through their network of social and family ties. The concept of social capital is therefore a potential for those vulnerable to poverty. In terms of implementation and evaluation SL approach puts strong emphasis on participation (Lewis, 2004).

115. One of the underlying principles of the SL approach is that it should be operationalised in a participatory manner through the involvement of local peoples in conducting participatory assessment. To achieve this end, it builds on participatory rural appraisal (PRA) and participatory poverty assessment (PPA). Participatory Poverty Assessment has been developed as an instrument for including the perspectives of the poor in the analysis of poverty and the formulation of strategies to deal with it. As explained by Chambers and Conway (1991) "*…under the rubrics of rapid rural appraisal (RRA) and participatory rural appraisal (PRA), a battery of participatory methods has been developed which enable them to do more of the analysis themselves. Their criteria vary, fitting and reflecting local conditions and aspirations…Professional assessments will always be needed, but the more poor rural people themselves play a part in making assessments, the more they will be empowered; and the more policies and practices support their priorities, so the more they will be enable to achieve for themselves the sorts of sustainable livelihoods they want and need* ".

116. This means learning from and building upon the established area of participatory development. The SL approach encourages users to :

- promote people's achievement of their own livelihood objectives. There is no prejudgment about what these are - they must be 'established' through participatory activities.
- build upon people's strengths. Again, this is only possible if participatory methodologies are used to establish who has access to which types of capital and how this is affected by the institutional, social and organizational environment.
- seek to understand, through participatory analysis, the effects of macro policies upon livelihoods.
- negotiate with local people which indicators will be used to show impact. This idea of 'negotiation' implies much more intensive communication and dialogue than if the objective were simply to 'consult' people about indicators.

117. Although the SLA is increasingly considered as pragmatic yet flexible in application, it is based in some key guiding principles (DFID, 2001; Horemans, 2004):

118. **Focusing on people**: SLA starts with an analysis of people's livelihoods and how these have been changing over time. The assumption is that elimination of poverty will be achieved only if external support recognizes the socio-economic, cultural and ethnic diversity of communities, focuses on what matters to people and works with them in such a way to fit in with their current livelihood strategies, social environment and ability to adapt. The importance of cross-scale is identified, i.e. the recognition that it is important to work not only at village level but also at higher levels, in the sense of engaging the participation of policy makers for example. In this sense the following should be taken into account:

- fully involvement of communities and a respect for their views;

- acknowledgment of the diversities of affected groups by development programmes and seek the understanding of the factors that influence their livelihoods and participation in those programmes;
- awareness that the impact of policy and institutional arrangements upon people/households and upon the dimensions of poverty;
- awareness of the importance of influencing different policies and institutional arrangements so they promote the agenda of the poor; and
- provide the means to support people to achieve their own livelihood goals (though taking into account considerations regarding sustainability).

119. **Being responsive and** participatory: Poverty reduction efforts are more likely to be effective when poor people are closely involved in identifying and addressing livelihood priorities. The SL approach builds upon participatory approaches, i.e. processes of analysis, planning and action should be fully participatory, whether the projects under consideration focus at a local level or at a higher, policy level. In this sense outsiders need processes that enable them to listen and respond to the poor.

120. **Working at various** levels: SLA recognizes that institutional arrangements can shape and constrain the livelihoods strategies that people can follow. It recognizes that there is an essential link between peoples daily lives and the social, economic and institutional macro-context to which people both respond and shape, therefore poverty elimination can only be achieved by working at multiple levels. That means "to ensure that micro level activity informs the development of policy and an effective enabling environment and that macro level structures and processes support people to build upon their own strengths" (Horemans, 2004).

121. **Working with partners**: the effectiveness of the SLA is largely dependent upon building strong partnerships with both the public and the private sector.

122. **Being dynamic**: livelihoods and the factors shaping them are constantly changing. Flexibility is a core aspect of the SL approach. Because people's livelihoods are subjected to constant change, support programmes cannot be set in stone. They must be ready to respond to new circumstances. The SL approach allows to capture and build on the positive aspects of constantly changing livelihoods. This puts us in a better position to try to support positive patterns of change and help people to defend their livelihoods against negative patterns. It is also important to build longer-term commitments to poverty elimination, as the shifting nature of livelihoods means that lasting success in poverty elimination is unlikely to be achieved in a typical project lifetime of 3-4 years.

123. **Holistic**: acknowledgement of people's different needs regardless of where they occur in terms of which sector, location or level. Moreover there is a diversity of participants whose needs, aspirations and capacities will be different. This is an important shift from seeking improvements in form of fisheries production to looking at the full diversity of strategies (Horemans, 2004).

5.1 Assessment framework

124. A number of SLA frameworks have been conceived to guide the analysis of the livelihoods of poor people. The DFID framework (Figure 4) uses the concept of capital assets as a central feature and considers how these are affected by the 'vulnerability context' in

which they are derived, and by ‘transforming structures and processes’ (alternatively labelled ‘policies, institutions and processes’), to constitute ‘livelihoods strategies’ which lead to various ‘livelihoods outcomes’.

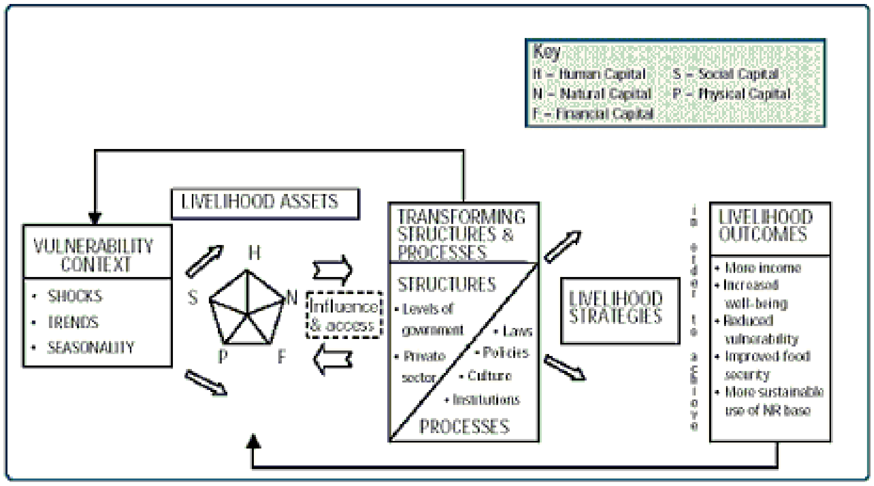

Figure 4: Sustainable livelihoods framework

125. The Sustainable Fisheries Livelihoods Programme (SFLP) is a partnership programme between FAO and DFID and focuses on poverty alleviation in West African artisanal fisheries communities through better governance and improved policies to involve communities in management of the resources on which their livelihoods depend (Horemans, 2004). The objective of this programme is “to reduce poverty in coastal and inland communities by improving the livelihoods of people dependent on fisheries and aquatic resources” (Neiland and Béne, 2004). The SFLP uses a combination of the SLA and Code of Conduct for Responsible Fisheries (CCRF) . According to Horemans (2004) the combination of these two approaches offer a broader range of actions. The SLA offers an approach which can facilitate the application of the Code in ways which support artisanal fisheries communities to achieve, or improve their sustainable livelihoods. Likewise the Code can facilitate the application of the SLA by providing normative guidance related to policies, institutions and processes related to the sustainable use of fisheries and aquatic resources (Horemans, 2004.

Box 4: Key characteristics of sustainable livelihood approach

Objective: Eradicate poverty.
Mechanism: Understand livelihood of poor people by focusing on both actual poverty and vulnerability to poverty.
Framework: Use the concept of capital assets and how these are affected by *vulnerability context* and *transforming structures* and *processes* to constitute *livelihoods* strategies’ which lead to various *livelihoods outcomes*.
Assessment: Implemented in a participatory manner through the involvement of local peoples in conducting participatory assessment. To achieve this end, it builds on participatory rural appraisal (PRA) and participatory poverty assessment (PPA).

6 ECOSYSTEM APPROACH

126. There are different terms currently in use to describe similar approaches, including Ecosystem Based Management, Ecosystem Based Fishery Management, Integrated Management, and the Ecosystem Approach to Fisheries, which is the terminology used by FAO (Garcia *et al*., 2003). They all share the similar understanding that the sustainable management of any economic activity must be based on "sound science, adaptation to changing conditions, partnerships with diverse stakeholders and organizations, and a long-term commitment to the welfare of both ecosystem and human societies" (Kimball, 2001).

127. According to FAO (2003) the development of an Ecosystem Approach to Fisheries (EAF) was motivated by four main aspects (FAO, 2003):

- the increasing awareness that fisheries can affect far beyond the target resources through ecological and technological interactions among fisheries and supporting ecosystems;
- the poor performance of the conventional approaches to fisheries management – focused solely on target resources – and the crises faced by marine capture fisheries in many parts of the world;
- the recognition of the ample range of objectives in society with respect to fisheries resources and marine ecosystems and the value of both in the context of sustainable development; and
- recent scientific advances in highlighting the knowledge and uncertainties about the functional value of ecosystems to human beings, i.e, the goods and services that ecosystems provide.

128. The conceptual basis of EAF resulted from different institutional processes directly associated to the concept of sustainable development, including the UN Conference on Human Environment, the UN Convention on the Law of the Seas, the Convention on Biological Diversity, UNCED Agenda 21, the UN Fish Stocks Agreement, the FAO Code of Conduct for Responsible Fisheries and the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem (Garcia *et al.*, 2003). As put by Garcia *et al*. (2003), "*EAF does not represent a revolution, in the sense of a rupture with the current fisheries management paradigm, but rather a new phase in a process of continuous evolution of fisheries-related institutions*".

129. The overall objective of EAF is "to plan, develop and manage fisheries with the aim to address the multiple needs and aspirations of society, without putting at risk the possibility that future generations benefit from the range of goods and services that can be obtained from marine ecosystems" (FAO, 2003). Still according to FAO (2003) "through an EAF one seeks to balance the diverse objectives of society, taking into account the knowledge and uncertainties relative to the biotic, a biotic and human components of ecosystems and its interactions, and to apply an integrated approach to fisheries within meaningful ecological limits/boundaries". This is translated in a set of principles, including the minimization of effects of fisheries on marine ecosystems, the need to maintain ecological relationships between target and associated species, the compatibility of management measures throughout the distribution area of resources, the application of a precautionary approach and the need to develop governance systems that ensure human well being and equity among people and ecosystems (FAO, 2003).

130. The implementation of EAF is rooted on the explicit definition of management operational objectives, indicators, performance measures and decision rules. In a sense it inverts the habitual priorities of fisheries management by focusing from the beginning on the definition of management objectives and measures rather than embarking directly on extensive data collections and assessment of stocks and ecosystems. The process is carried through consultations with fisheries stakeholders and follows the general steps showed in Figure 5.

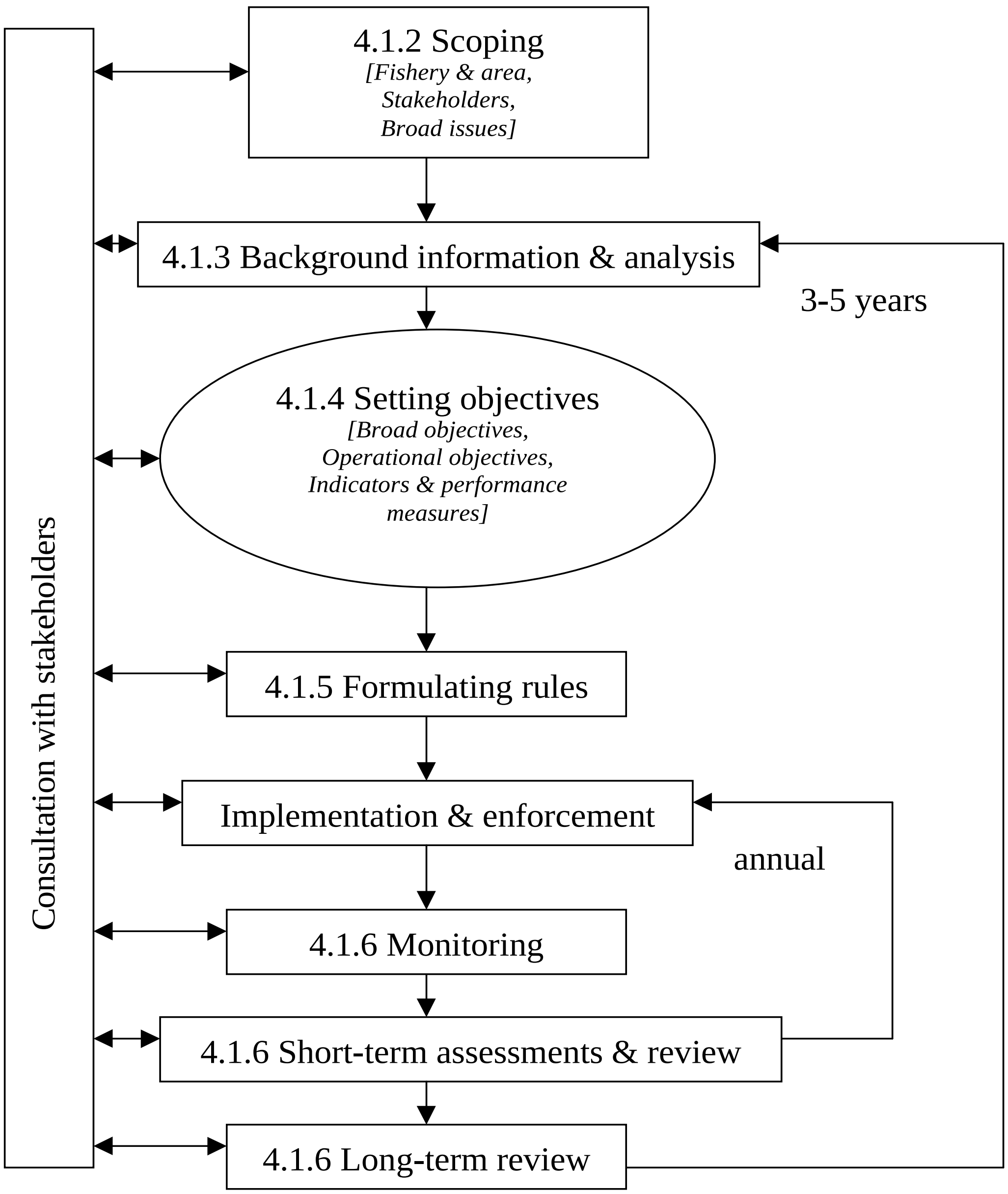

Figure 5. Main steps on the process of implementation of an EAF (source FAO, 2003).

6.1 The Assessment Framework

131. Along the way from higher policy goals to the definition of management operational objectives, indicators and performance measures some type of prioritisation is necessary since a large number of issues can be identified for a fishery but their importance will vary greatly. As the capacity of fisheries management agencies is generally limited by scarce human and financial resources it is important to concentrate on issues that offer the highest risks to the performance of a management system. There are different means to develop operational objectives from higher policy goals. The approach that has been used by FAO is an adaptation of the Australian National Ecologically Sustainable Development (ESD) Framework (Fletcher *et al*., 2005) and focuses on identifying issues that need to be assessed across eight major components of sustainable development, covering various ecological, social, economic and institutional aspects of fisheries management:

- Contributions of the fishery to ecological well-being
    - Target resources: the impacts of fisheries on the species that are the main target of the fishing activity.
    - Non-retained resources: impacts of fisheries on species that are incidentally caught and discarded.
    - General ecosystem: impacts of fisheries on the supporting ecosystem, including effects on habitats and biodiversity.
- Contribution of the fishery to human well-being
    - Indigenous well-being: effects of fisheries on indigenous communities or traditional resource users.
    - Community and regional well-being: effects of fisheries on local dependent communities.
    - Social and economic well-being: contribution of fisheries to food security, employment and income.
- Factors affecting the ability of the fishery to contribute
    - External impacts on fishery: issues that affect the performance of the fishery but are outside of the direct local management control (environmental changes, global markets, etc.).
    - Governance arrangements: management processes and institutional arrangements that affect the ability of the fishery to contribute to human and ecological well-being.

132. It is clear that the transition to an ecosystem approach to fisheries will necessarily broaden the information required for good management, covering a wide range of disciplines. In the specific case of small-scale fisheries, assessments will have to be adapted to situations

of limited data.. On the other hand addressing vaguely defined issues such as ecosystem integrity and biodiversity will be a challenge for both data-rich and data-poor fisheries. Research efforts in this particular field have been directed to the development of quantitative ecosystem models that capture the main processes affecting marine ecosystem dynamics (e.g. Christensen and Maclean, 2004; Butteworth and Plaganyi, 2004) In small scale fisheries, the model approach most likely will encounter similar problems as dynamic stock assessment models have encountered i.e. large data requirements. Thefore, definition of comprehensive, robust and easily-measurable indicators of the status of marine ecosystems (e.g. Daan *et al.*, 2005) could be more relevant for small scale fisheries. Both areas of research are still in their infancy and constrained by the lack of a clear understanding of ecosystem dynamics and lack of theories to explain the behaviour of some of the proposed ecosystem indicators (Parsons, 2005).

133. Fisheries management under EAF will be aimed at achieving a set of agreed objectives and the information needed to support the decision making process will vary according to the defined operational objectives and indicators. Table 1 exemplify the types of data needs of a hypothetical fishery based on different types of objectives. Due to the complex and dynamic nature of the ecosystems in which fisheries operate, there will always be gaps in the knowledge and information required. Under such circumstances managers and stakeholders will need to adopt a precautionary approach and make the best possible decisions with the information available.

Table 1: Examples of possible relationships between fisheries operational objectives, indicators and data needs.

Operational objective	Example of Indicators	Example of data needs
Target resources		
maintain stock biomass above a certain “safe” biological limit	spawning biomass (or any other indicator of stock abundance, such as cpue)	size and age composition; catch per unit of effort; acoustic assessments of biomass
reduce fishing effort	fishing effort	number of boats, fishing time by fishing fleets
Ecosystem considerations		
reduce/minimize discards of non-target resources	Discards by species	amount of discards by species or group of species
reduce the areas of critical habitats impacted by fisheries	area of habitats under effective protection	fishing areas, habitat areas, quantification of habitat impacts by fishing type
Economic		
Increase the contribution of fisheries to the national economy	net economic returns from the fishery	income and costs by fleet; value added to fish products
Increase export of fish products	total export values	destiny of landings; market opportunities and constrains
Social		
Increase job opportunities	employment by sector (capture, processing, etc.)	number of fishers directly involved in the activity; indirect jobs; number of people employed in

		processing sector
decrease vulnerability of fishing communities	income level; dependency on fisheries; human development indicators	employment in the fishing sector; employment in other sectors; social networking and services
Management/Institutional		
Improve enforcement and monitoring capacity	fleet covered by monitoring schemes	frequency of port sampling; proportion of fleet covered by observers
Attain a more equitable representation of stakeholder interests in management	level of stakeholder involvement in management functions (decision making, monitoring, etc.)	stakeholder representation in consultations; number of meetings among stakeholders

Box 6: Key characteristics of ecosystem approaches

Objective: to plan, develop and manage fisheries with the aim to address the multiple needs and aspirations of society, without putting at risk the possibility that future generations benefit from the range of goods and services that can be obtained from marine ecosystems.
Mechanism: The implementation of EAF is rooted on the explicit definition of management operational objectives, indicators, performance measures and decision rules.
Framework: Focus on eight major components of sustainable development, covering various ecological, social, economic and institutional aspects of fisheries management:
Assessment: Multi-sectoral and integrated.

7 GLOBAL ENVIRONMENTAL CHANGE AND HUMAN SECURITY APPROACH

134. Environmental variability affects fisheries in both short and long term. While human systems have developed mechanisms to cope with short term environmental variations (e.g. seasonal calendars), it is the long term component of variability (between years and decades) that is less understood, normally unpredictable and most influential to fisheries sustainability. Special attention has been given to the effect of global climate change and the need for adaptation policies to cope with it. Global environmental change, as defined by the Global Environmental Change and Human Security Project (GECHS) "consists of large-scale natural and human-induced perturbations to the environment, affecting land use and land cover, biodiversity, atmospheric composition and climate" (Lonergan, 2000).

135. As put by Smithers and Smit (1997) "adaptation to climate is relevant to both long term global climate change and to current variability in climatic conditions. In the case of global climate change, adaptation is important as an essential ingredient of any estimate of impacts and as one of the possible response options. For current variability, an improved understanding of individual and societal adaptation not only provides insights for estimating future adjustments, but also helps address current problems of sustainable development in light of variable and uncertain environments".

136. Although conventional models acknowledge, at a theoretical level, the impact of climatic uncertainty on the productivity of fisheries, they have not regularly incorporated climate as a variable that must be considered when making management decisions. Despite improvements in the scientific ability to anticipate seasonal climate variability, debates continue about the roles of specific climatic and oceanographic changes relative to the role of over-fishing (NRC 1999). Thus, the potential role of climate forecasting information in improving management decisions for sustainable fisheries remains a considerable challenge (IRI 2001). Addressing this challenge requires a better understanding of how climatic variability shapes both ecological and socio-economic processes and of the cultural, economic and political dimensions that drive human decisions about the use and management of marine systems.

137. Environmental change causes different types of impacts (social, economic, ecological) which in turn triggers responses from society. This structure differentiates two broad types of responses: mitigation and adaptation. Mitigation involves mechanisms that attempt to alleviate the impacts and also prevent further environmental change (e.g. reduction of greenhouse gas emissions). Adaptation is on the other hand defined by the Intergovernmental Panel on Climate Change (IPCC) as adjustments in human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (Burton *et* al., 2002). According to the authors "climate [environmental] adaptation policies refers to actions taken by the governments including legislation, regulations and incentives to mandate or facilitate changes in socio-economic systems aimed at reducing vulnerability to climate change" (vulnerability is understood here as the degree to which a system is unable to cope with adverse effects of environmental change, being a function of both sensitivity and adaptation).

138. From the perspective of the natural sciences, debates over global environmental change and variability frequently focus on global phenomena and regional averages (NRC

1999). There have been relatively few attempts to incorporate the perspectives and concerns of the people who are directly affected by climatic fluctuations. This is changing fast, however, and, as the scientific capability to predict seasonal climate variability improves and becomes more accessible to stakeholders, the use and usefulness of such information gains increasing attention in social science driven research (Finan and Nelson, 2001). In the case of fisheries, the economic impacts of El Niño events have been well documented in regions where the anomalous warming of sea-surface temperatures (SST) with accompanying increases in sea level atmospheric pressure have been clearly linked to the decline of critical species. Thus, focus on the use of climate forecasts in fisheries to mitigate the impacts of ENSO events has concentrated in those regions of the world, mainly Peru, Ecuador, Australia, and the Pacific Islands, where the skill of predicting SST variations is relatively high (Stern and Easterling 1999). Not surprisingly, in areas where the skill of the forecasts is lower and the variability in the phenomena to be predicted is higher, the use of climate forecasts has not been a critical component of management. Given the high degree of environmental, including climatic, and institutional uncertainty inherent in fisheries, even imprecise information, if appropriately used and communicated, can be of utility to policy makers, industry investors, resource users and other stakeholders. In order to understand the utility of improved climate forecasting skill, however, it is important to understand how society perceives climatic variability, what relevant information is needed to achieve sustainable management of fishery resources, and how this information can be combined and incorporated into already existing adaptation strategies that appear to be sustainable.

139. Berkes and Jolly (2001) extend the concept of adaptation to embrace the responses of communities of resource users to increase the chances of success/survival in a changing climate. The authors differentiate two types of responses: coping mechanisms and adaptive strategies. Coping mechanisms are short term emergency responses to abnormal seasons or years. For instance, in the Canadian Artic the authors identified as short term coping mechanisms of communities of hunters/fishers the switching of species and the where, when and how of hunting. Adaptive strategies are "ways in which individuals, households and communities change their productive capacity and modify local rules and institutions to secure livelihoods"(Berkes and Jolly, 2001). Examples of community adaptations are flexibility in seasonal fishing patterns, network for sharing food and other resources and intercommunity trade. As emphasized by the authors the two types of community's response may overlap over temporal scales and also may evolve into another.

7.1 The assessment framework

140. The goal of adaptation policies is to reduce vulnerability, and climate change research is now shifting emphasis from the assessment of future impacts of climate change to the analysis of the vulnerability of communities to present and future changes. Burton *et al*. (2002) emphasize some key elements of an adaptation research for policy:

- Contrary to the standard climate change policy framework which is focused on the impacts and adaptation to future climate scenarios; there is a shift in emphasis towards analyzing current policy adaptation. "A national government wishing to develop a policy for adaptation to future climate change might best begin, therefore, by assessing current vulnerability to present day climate including its variability and extremes, and the ways that existing policy and development practice serve to reduce vulnerability". To assess current vulnerability the following questions should be addressed:
- What has been the recent experience with climate variability and extremes?

- What economic social and environmental impacts have occurred and how have these been distributed spatially and among socio-economic groups?
- Are there any trends in damages and other impacts, and if so how can they be explained?
- What adaptation policies and measures have been used to reduce vulnerability and how successful have they been?
- What is the extent of adaptation in practice and what are the barriers, obstacles or incentives to adaptation?
- How does public policy affect impacts and adaptation?
- How does public policy with respect to climatic hazards relate to the economic and sustainable development policies and strategies in place?
- To what extent have stakeholders (including those at risk) been involved in the policy development process, and how can this be facilitated?

141. The second aspect of the framework is the design, assessment and prioritisation of policy initiatives and alternatives, taking into account possible future conditions. As suggested by the authors the question in this second step mirror those raised to evaluate current vulnerability:

- In what ways is climate expected to change?
- What are the prospects for economic and sustainable development and how will this affect climate change impacts?
- What are the prospects for adaptation and how much can vulnerability be reduced?
- What are the public policy’s constrains and limitations to adaptation?
- What are the costs of adaptation measures and what benefits can be anticipated?
- How will costs and benefits be distributed?
- What would happen in the absence of public policy reform and innovations?
- How does public policy for adaptation to climate change relate to other natural resource and environmental policies?

142. There are important linkages between vulnerability and human security in the debate about the impacts of global environmental change (GECHS, 1999). According to GECHS human security is achieved when individuals and communities:

- have the options necessary to end, mitigate, or adapt to threats to their human, environmental and social rights;
- have the capacity and freedom to exercise these options;
- actively participate in attaining these options; and
- when these communities are able to challenge the structures and processes that contribute to insecurities.

143. In this respect when analysing the threats to human security of environmental and institutional change one needs to take into account the vulnerability status of communities to these threats. The following list of research questions illustrates some of the goals of the Global Environmental Change and Human Security (GECHS, 1999) program:

- What types of climate change threaten human security?
- How does climate change threaten human security?
- What is the present extent of insecurity?
- Which regions and groups are the most insecure?
- Why are some regions and groups more vulnerable to specific climate changes than others?
- Can we predict future insecurities?

- What strategies are potentially available to cope with the insecurities caused by climate change?
- Why are some strategies selected?
- Why are they effective?
- How can obstacles be overcome?

Box 7: Key characteristics of global environmental change and human security approach

Objective: Sustainable management of natural resources and improvement of livelihood of fishers communities.
Mechanism: Improve the understanding of how climatic variability shapes both ecological and socioeconomic processes and of the cultural, economic and political dimensions that drive human decisions about the use and management of aquatic systems.
Framework: Assess the vulnerability of communities to present and future changes and assess the impact of climatic uncertainty on the productivity of fisheries.
Assessment: Multi-sectoral.

8 SMALL-SCALE FISHERIES ASSESSMENT: THE WAY FORWARD

8.1 Major characteristics of small scale fisheries in relation to assessments

144. As indicated in this document there are a number of assessment approaches and methods which could be applied in small scale fisheries. However, the special characteristics of small scale fisheries make some more suitable than others. Some of the main characteristics and dilemmas important for assessment can be summarized as:

- Small-scale fishers are heterogeneous in all their attributes (social, biophysical, economic and political orientation).
- They target multi species resources simultaneously, they are mainly coastal, non-industrialized, with widely spread coastal population.
- Small scale fisheries can be characterized by high levels of interdependence among fishers. The action of one fisher affects the actions and outcomes of other fishers. These interactions can lead to conflicts among fishers over space (territoriality and quantity of fish (catches), for instance.
- Small scale fisheries can be characterized as a common pool resource in which the exploitation by a given user directly affects the resource availability to other users who are difficult to exclude.
- Due to their often legal open access property regimes small scale fisheries can act as a "last resort".
- Small scale fisheries can have a high mobility in terms of employment and income generation, as a consequence, fisheries can become only one of several income generating activities.
- Usually small scale fisheries management institutions lack appropriate financial and human resources and are fragile or non-existing.
- In a large number of developing countries, institutional and financial capacity are lacking to maintain extensive assessment systems.
- Small-scale fisheries usually lack information or have poor information on (1) landings (weight, value, species composition, etc); (2) auto-consumption and trade; (3) contribution of fisheries to livelihoods; (4) effort; (5) the existence/absence of self-informal local regulation, fisheries administration at local level; and (6) fishing rights (that could be existent, non existent and/or inefficient); among others.
- Policy makers are not always aware of the importance of small scale fisheries due to a lack of proper information available or are influenced by various pressure groups to direct activities towards large scale commercial sector, high priced fisheries products, increasing exports and earning foreign currency.

8.2 Lessons learned in relation to assessments

145. Experiences with the application of the different assessment approaches in small scale fisheries worldwide indicate that any assessment should take into consideration the followings aspects:

- Fishing communities must be involved.
- Appropriate incentives for fishers to participate in data collection and management are essential.

- Involving fishing communities in assessment and management depends on the existence of appropriate institutions that aim to widen the basis of power by enabling participants to define problems from their perspectives and experiences, and to seek solutions which they regard as appropriate and suitable for their culture and aspirations.
- The transition from a top-down management approach to a more decentralized one is essential and a legal framework that allows this is crucial.
- The combination of scientific knowledge with traditional/local fishers ecological knowledge can enhance the efficiency and quality of data collection.
- Resources assessment should rely on observations which can be made at low costs and reflect resource system features which can be recognized and accepted by both fishers and researchers.
- Collaboration between the research institutions, government and the local users requires a matrix of rights and duties, and a way to enforce such an agreement.

8.3 An overall framework for the integrated assessment of small scale fisheries

146. As indicate in the document, the characteristics of small scale fisheries as well as the characteristics of the different assessment approaches and methods have a large number of different features. One of the objectives of the workshop is to develop a preliminary framework for the assessment of small scale fisheries to be tested under different field conditions. To initiate this activity and to provide starting points for discussion a first set up is provided and discussed in the next paragraphs.

8.3.1 Overall international policy frameworks

147. There are a number of overarching international policy frameworks which should provide the basis of the framework, among them:

- Ensure environmental sustainability and eradicate extreme poverty and hunger as provided by the Millennium Development Goals (MDG).
- Sustainable management of natural resources as provided by the FAO Code of Conduct for Responsible fisheries (CCRF).
- Improvement of data needed for policy making and management for sustainable use of fisheries resources within ecosystems as provided by the FAO Strategy for Improving Information on Status and Trends of capture fisheries (FAO Strategy STF).
- The conservation of biological diversity, and the sustainable use of its components as provided by the Convention on Biological Diversity (CBD).

8.3.2 Guiding principles of assessments

148. The collection of data is not an end in itself, but is essential for informed decision making[6], and assessment projects should be developed while considering the following questions (FAO, 1998):

[6] FAO technical guidelines for responsible fisheries 4: Fisheries management, article 2a, FAO 1997)

149. **Why is the assessment needed ?** Data is collected to answer a specific question related to a general policy decision which leads to an action. For example: "The overall policy is to eradicate poverty by 2015, the action could be to enhance the role of SSF in income generation and food production, and the specific question could be: what is the current status of people's reliance on fish-related and non fisheries related activities?

150. **What needs to be assessed ?** Once specific objectives are known, the indicators or variables related to the specific objective are identified and selected. In the example they could include: *Annual income, annual income of fishers per capita fish consumption, poverty profile, vulnerability profile, regional distribution of the indicators/variables* …. It is important that assessment focuses not only on contextual variables (attributes of the resource, the community, institutions and so on) but also captures the structure of small scale fisheries ,the processes' variables (patterns of interactions, outcomes, changing in the status of attributes, etc), in order to acquire the dynamic variables of small scale fisheries. Further the assessment should take into consideration the time horizon of the stakeholders (e.g. (i) medium to long-term, with "slow assessment" for policy development; (ii) short-term, with "rapid assessment" for problem solving, conflict resolution, etc).

151. **How to collect information ?** How to collect the information is addressed in 2 steps:

i) First the strategy for the assessment should be established. The strategy mainly depends on resources and logistics and addresses the spatial and temporal coverage, i.e. Complete assessment in villages, all households or sample based collection of information. Time is a critical element. All the variables can change through time. Biophysical and technological attributes can have a direct affect on outcomes, for example, high levels of fishing effort can lead to overexploitation, regardless of whether or not institutional arrangements are in place.

ii) Once the strategy is known[7] the specific method for data collection can be determined i.e. How should poverty profiles be developed: *through standard questionnaire, Participatory Poverty Assessments or Participatory Rapid Appraisal, for instance.*

This process of linking assessments to policies, which is too often forgotten is visualized in Figure 6.

[7] Available resources and method can sometimes influence the strategy

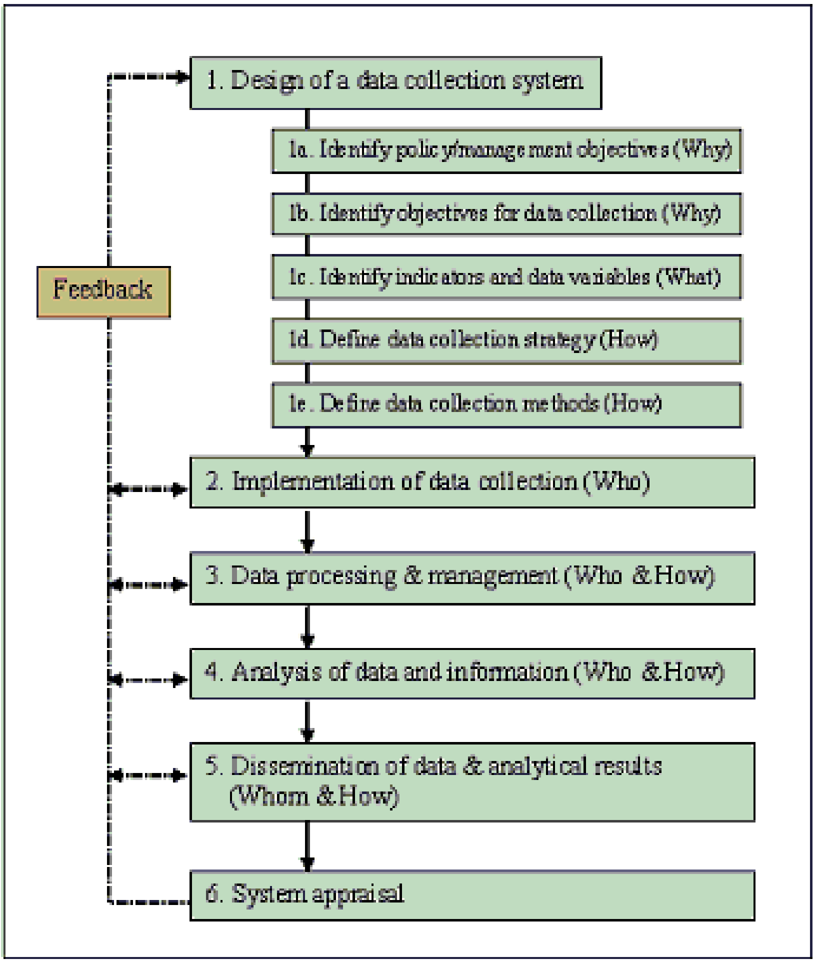

Figure 6: Linking assessments to policies.

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ANNEX 1: TOPICS FOR DISCUSSION

Theme 1: Development of a framework for the interdisciplinary assessment of Small Scale fisheries (day 1).

Two suggested frameworks

152. A general Small Scale Fisheries Assessment framework must be specific enough to offer operational guidance in the field, yet general enough to permit application to widely variable situations. Such a framework should not be a causal model in which data is inputted and an output is generated. Rather, it should be a guide for logically analysing a problem, identify the data needed, selecting methodologies, arranging information, examining relationships among attributes and considering or describing outcomes. A concept of a framework based on "Why, What How" adapted from Ninnes[8] (2003) is presented in Figure 7.

153. From an assessment point of view this concept is straightforward as: The *"Overall Policy"* leads to an *"Action Policy"*, to implement and determine the success/progress of the action policy some assessment will have to be made and the scope of the Action policy will determine the *Variables/Indicators* to be assessed, Spatial, temporal characteristics, available resources and sometimes other specific objectives[9] will determine the strategy of the assessment, and finally for each variable/indicator the specific *method* will be determined.

154. A disadvantage of this framework is that in itself it is not inter-disciplinary or multi-sectoral. i.e. in order to have an integrated assessment the institutions involved have to make the integration beforehand. or afterwards during analysis of the information.

155. The Institutional Analysis and Development Framework (Figure 3, page 21) is in itself more integrated but has one objective only as it is developed for assessing common pool resources.

156. The general set up of the IAD framework, can however be used to make it applicable to overall assessment of small scale fisheries and a set up of such a framework is presented in Figure 8.

[8] Paper prepared for ACFR working party on small scale fisheries, Improving the collection, analysis, and dissemination of information in small scale fisheries, Bangkok, 2003.

[9] For example a participatory approach can be considered as a strategy for data collection but at the same time it can function as a tool of empowerment of fishers communities.

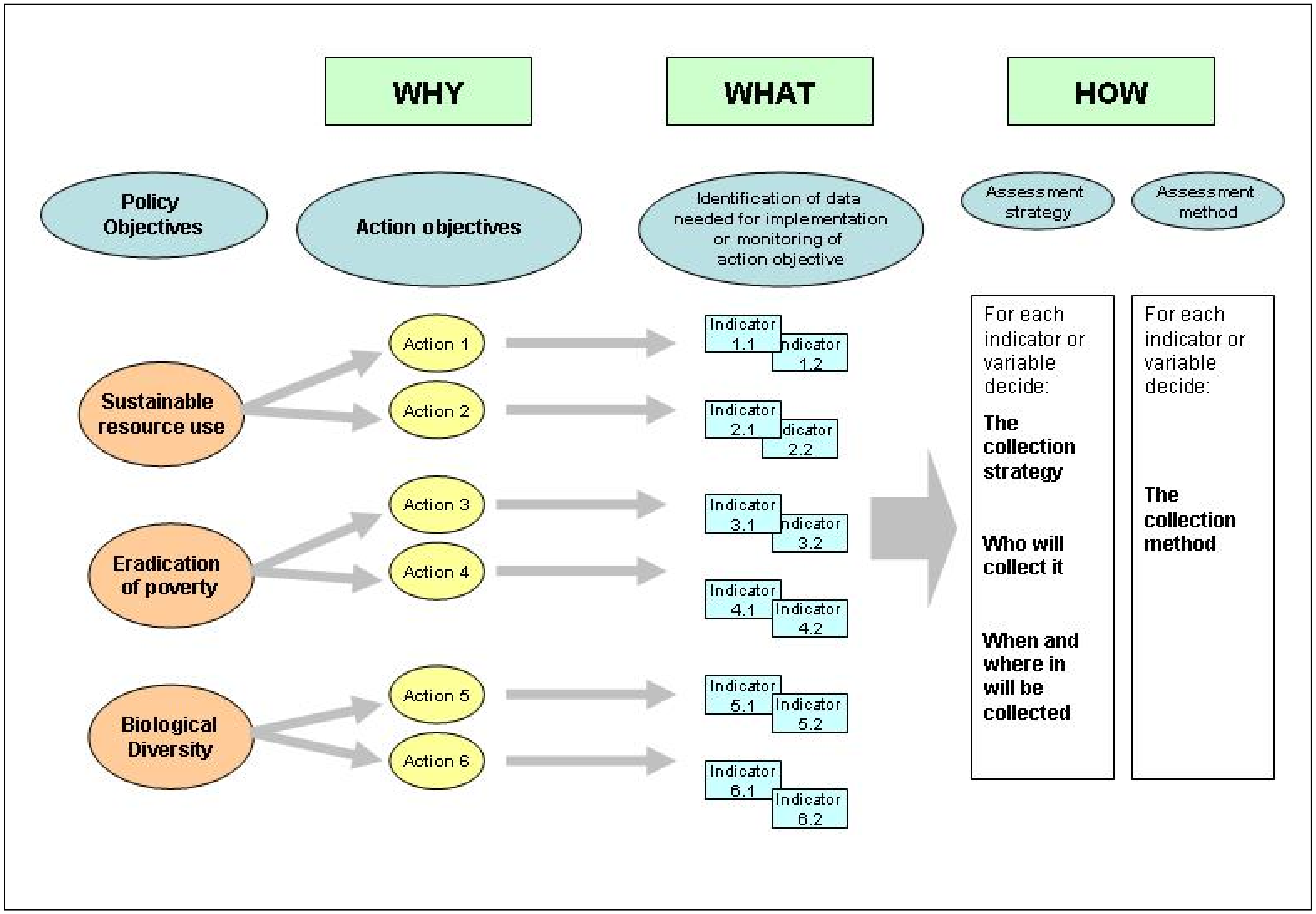

Figure 7: Framework based on “Why, What, How”.

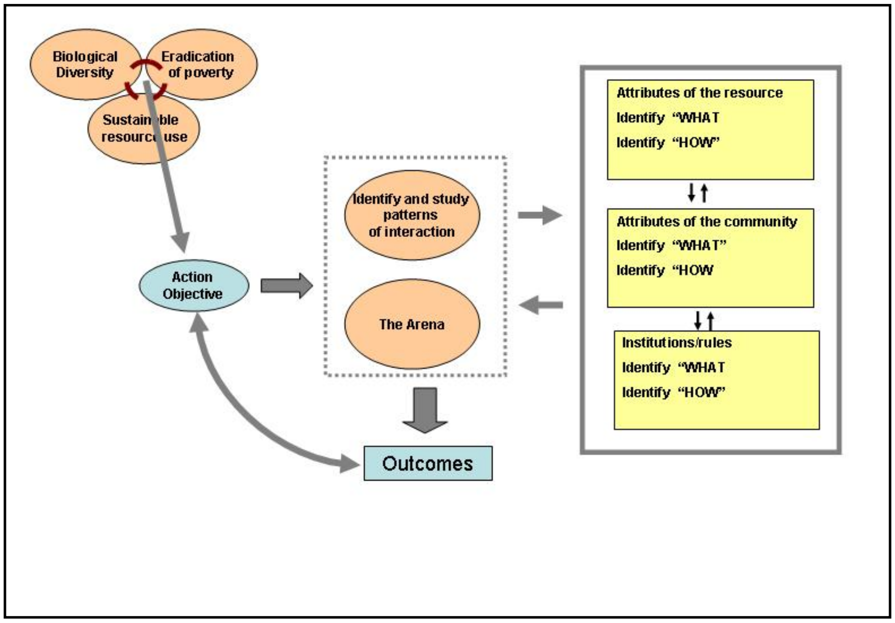

Figure 8: Interdisciplinary framework for data collection and assessment of small-scale fisheries based on IAD

157. During the first day of the workshop the participants are requested to come up with a framework for integrated assessment of small scale fisheries that grasp the specific features of small scale fisheries.

158. Points of attention will be integrating the different approaches, timing (slow and rapid assessments), policy advice characteristics, uncertainties, minimising risks, and cost of assessments.

Theme 2: Identify appropriate approaches, methods and research needs for filling in the gaps (day 2).

Approaches and Methods

159. In order to obtain a more complete overview of the approaches and methods used in assessing small scale fisheries the participants of the workshop are requested to fill in Table 2. beforehand.[10] Under the general umbrella of policy objectives such as sustainable resource use, poverty alleviation, among others, and based on the research/action experiences the participants are asked to indicate the procedures, information needed and constraints/opportunities to conduct an assessment in small-scale fisheries.

160. The results could be used as a basis for discussion during the workshop and more detailed inventories in the future.

161. Where possible special attention should be given to rapid assessment methods

[10] Please use the provided spreadsheet

Table 2: Examples of type of information on inventory of assessment methods used in small scale fisheries

WHY			WHAT INFORMATION	HOW – METHOD	CONSTRAINTS AND SUPPORT REQUIREMENTS FOR METHOD
Policy Objectives	Action Objectives	Objectives of Assessment			
SUSTAINABLE RESOURCE USE	To recover the importance of artisanal fisheries through the creation of a co-management arrangement	A) To understand historical status of resource exploitation	1) Patterns of exploitation	1) open ended interview	
			2) Annual and seasonal variation of exploitation	2) focus groups close ended questionnaires	
			3) Types of resources utilized	3)	
			4) Ways of utilizing resources	4)	
		B) To evaluate viability of introducing co-management arrangement	1) Existence and adequacy of supporting legal framework	1.1 Desk study	
			2) Definition of property rights	2.1 PRA	
				2.2. Questionnaire	
			3) major stakeholders	3.1 PRA	
			4) Power-balance among stakeholders	4.1 PRA	
				4.2 Questionnaire	
SUSTAINABLE RESOURCE USE	Sustainable resource use by small scale fishers	A) To understand status of resources	1) Status and trends of catch	1.1 Catch Assessment survey	
				1.2 Frame survey-Fleet register	
				1.3 effort survey	
			2) Target Species	2.1 CAS	
				2.2 Questionnaire	
				2.3 LEK survey	
		B) To understand the status of	3) Fishing capacity	3.1 Frame survey	
			4) Target area	3.1 Effort survey	
				3.2 Interview to boat owners	

		fishing operations			
ERADICATE POVERTY	To enhance the role of SSF in income generation and food production	A) To understand the status of people's reliance on fish-related activities	1) Level of participation to fishing	1.1 PRA/RRA	
				1.2 Closed questionnaire	
			2) Production assets (fisheries)	2.1 PRA/RRA/PPP	
				2.2	
			3) Access to aquatic resources	3.1	
		B) To understand the status of people's reliance on non fish-related activities	4) Status of non-fishing activities	3.2	
			5) Production assets	4.1	
			6) Access to resources	4.2	

Theme 3: Elaborate on strategy and implementation of a programme to enhance the capacity of individuals and institutes in integrated assessment of small scale fisheries. (day 3).

162. During the last day of the workshop future activities will discussed. The concept paper and the outcome of the first 2 days of the workshop will form the basis of discussion.

ANNEX 2: METHODS FOR ASSESSMENT OF SMALL-SCALE FISHERIES

Common methods for collecting data and information for the assessment of small-scale fisheries are provided below:

1.1. Simple indicators as provided by Froese
In spite of known problems with the collection of CPUE and effort data, they still will remain in the picture as they are relatively easy to collect through sample based or participatory systems. Further in combination with species composition they can provide valuable insight in the status of the resource base.

Froese (2004) presented three indicators based on population dynamic approaches which are presented as examples of simple indicators we are looking for the biological assessment of small scale fisheries:

Indicator 1 can be described as "Let them spawn" and is measured as the percentage of mature specimen in the catch. The target could be to let all (1005) fish spawn at least once before the are caught and be measured by Lc50/Lm.

Indicator 2 can be described as *"Let them grow"* and is measured as the percentage of fish caught at optimum length, i.e. the length where the number of fish in a given unfished year class multiplied with their mean individual weight is maximum and where thus the maximum yield and revenue can be obtained.

Indicator 3 can be described as *"Let mega spawners live"* and is measured as percentage of old, large fish in the catch, i.e. fish of a size larger then optimum length plus 10%.

The indicators as presented by Froese in it self seem simple however collecting the data on small scale fisheries in order to make reliable estimate of the values for the three indicators is not that simple and should also be considered in the selection of appropriate indicators.

1.2. Participatory action research include a full collaboration between researcher and participants in posing the questions to be pursued and gathering data to respond to them (Atkinson and Hammersley, 1994; Reason, 1994).

1.3. Participatory Poverty Assessment is an instrument for including poor people's perceptions and views in the diagnosis and analysis of poverty and the formulation of poverty reduction strategies. PPAs are generally carried out as policy research exercises, linked to governmental policy processes, aimed at understanding poverty and priority poverty reduction actions from the perspective of poor people. More recent PPAs have emphasized their importance in terms of improving the effectiveness of public actions aimed at poverty reduction.

1.4. Poverty Group Profiles
Poverty analysis and food security information systems of small-scale fisheries have been understood through an assessment tools denominated Poverty Group Profiles. According to Pittaluga *et al* (2004) "poverty profiles are analytical instruments that do not have the

intensions of being academic exercises but to provide relevant information to the larger fisheries governance process and generates relevant information at all aspects of poverty at once". In order to accomplish this goal, poverty profiles should provide information on (Pittaluga *et al*, 2004):

- variety of assets that the household has access to;
- laws, policies and regulations and development programs and projects operating in the area that affect the household;
- local attitudes and beliefs;
- external factors such as demographic trends, the conditions of natural resources base and macroeconomic data, and
- the probability of shocks, such as failing commodity prices, drought, conflict or large scale illnesses.

Poverty profiles seek to assess and identify who and how many are the poor artisanal fishers in a given geographical area, their location and the reasons that make them poor or vulnerable to poverty. To make a typology of the fisheries community (i.e. to disaggregate the whole population on the basis of various structures and processes such as ethnic, nationality, religious, age, class and gender issues), the SFLP makes full use of the Food Insecurity and Vulnerability Information Mapping System (FIVIMS) developed by FAO, but within the SL approach focusing not only on food insecurity and vulnerability but also on the various aspects of poverty and vulnerability to poverty (Horemans, 2004).

Poverty profiles can be developed in different levels. The following presents two examples at the application of poverty profiles by the SFLP in two different levels of analysis:

at the national, state, district or water body level to gain snapshot of poverty in fisheries dependent communities and to show the distribution of poverty in that area, its causal factors, dependency of the communities on the fishery, the implicated stakeholders and institutions, the large scale dynamics that could affect the communities the communities and indications of potential areas for action.

Box 5: Poverty profiles at the water body level in Guatemala as highlighted by Pittaluga *et al* (2004) were the following:

National participatory brainstorm session with different stakeholders and poverty specialists in poverty and food security in Guatemala were conducted. The aim was to identify all major groups of people in the country that could be characterized as vulnerable to food security. Their location, sources of livelihoods and potential driven forces of their vulnerability. Session was conducted in a participatory way and information was triangulated with various secondary sources that could validate the results from the brainstorm session (Pittaluga *et al*., 2004). The first part of the session was conducted by applying a set of open-ended questions that aimed to identify those who were extremely poor artisanal fisheries and those who were coming out from the cycle of poverty. The latter part of the session was concerned with the feasibility of actions and looked at the strengths, weaknesses, opportunities and threats faced by the identified groups. Validation of findings were done via individual interviews and focus group interviews with artisanal fishers, women, and key people in the communities in pre-selected sites to cover the diversity of poverty and food insecurity contexts faced by artisanal fishers. Semi-structured questionnaire was conducted using Participatory Rural Appraisals to obtain further information on seasonal patterns, geographical distribution of people and resources and calendars of productive activities by gender. Final validation was conducted with key informants representing institutions that work directly with artisanal fishers to validate the structure of the profile, the correctness of the reported statements and the conclusions drawn.

at the community level to contribute to the process of identifying and formulating community projects and their monitoring indicators. This more detailed aspect would provide information on the various levels and distribution of poverty, its causes, the dynamic nature of poverty in the community highlighting strengths and opportunities for action as well as risks and constraints.

Box 6: Poverty profiles at the community level in South Benin as highlighted by Pittaluga *et al* (2004) were the following:

Participatory brainstorm session at village level was conducted with key resource people complemented by secondary literature review to contextualize findings. The session's objectives were to elicit the communities linkages to other villages and to larger institutional frameworks. Attention was centered on the web of socio-economic relationships that connect, fail to connect and/or prevent to connect the community to other social units, markets and dynamics that are outside the control of the village that is under analysis.
A 5 day Field work within the community was conducted using diverse field techniques such as Participatory Rapid Appraisals tools, open-ended and semi-structure interviews and focus group interviews. The poverty profile underlying questions guided the field work. In addition information was collected to elicit the following:

(i) construction of a scale of poverty based on participatory exploration of local perceptions with linguistic analysis of the terms of indigenous languages;
(ii) classification of local population according to their livelihoods and placing them along the continuum of poverty;
(iii) understanding of social mobility (upward and downward) along the constructed scale;
(iv) understanding of the institutional environment in which small-scale fishers operate;
(v) understanding of the potential areas of conflicts between the different sectors of the community in respect to assessing resources.

1.5. RAPFISH is a flexible non-parametric ordination technique for the rapid appraisal of fishery status in relation to some defined goal or norm (Pitcher and Preikshot 1998; Pitcher and Preikshot 1999; Pitcher and Preikshot, 2001). Ordinations of sets of attributes are performed using multi-dimensional scaling (MDS). Normally this is in two dimensions and the MDS is followed by rotation to an orientation adopted as a convention (horizontal). Ordinations are bounded by reference points that simulate the best and worst possible fisheries using extremes of the all attribute scores, and these hypothetical 'good' and 'bad' fisheries define the extremes and the orientation of the horizontal axis. Fisheries are given a score of 0% to 100% along this axis. A second set of fixed reference points constructed from two half-way scores stabilizes the vertical dimension of the plot. Further constructed reference 'fisheries' with randomly allocated attribute scores define the size of differences among fisheries that might be regarded as significant. Within a field, attributes are chosen to reflect sustainability, and although intended to remain fixed so that different analyses may be compared, attributes may be refined or substituted as improved information becomes available. Most attributes are scored on a ranked scale, for example a five point scale from zero to 4. Intermediate scores are permitted because all scores are normalized before ordination. Scores given to a particular fishery should be justified. Candidate attributes whose extreme scores cannot be unequivocally regarded as 'good' or 'bad' should be dropped from the analysis. Discussion of attributes in a workshop venue makes explicit the values that define a particular field. Separate Rapfish ordinations may be performed using sets of pre-defined attributes in ecological, economic, technological, social and ethical disciplines (or 'fields' or 'components of sustainability'). More fields may be added as required for particular analyses such as the compliance of the State fisheries' regulations with the FAO Code of Conduct for Responsible Fisheries (Pitcher and Kalikoski in preparation).

1.6. Semi-structured in-depth interviewing

As pointed out by Marshall and Rossman (1995) in-depth interviewing is a data collection method largely used in qualitative studies. It can be classified as a "conversation with a purpose" (Kahn and Cannel, 1957:149). The method allows the researcher to explore a few general topics and to help uncover the participant's meaning and perspective, but otherwise respects how the participant frames and structures the responses (Mason, 1996; Kvale, 1996). Semi-structured interviews provide some structure to the interview while at the same time allowing for the flexibility to follow leads and to go in unanticipated directions (Bernard *et al.*, 1994). The most important aspect of the interviewer's approach concerns conveying an attitude of acceptance – that the participant's information is valuable and useful with a fundamental assumption that the participant's perspective on the phenomenon of interest should unfold as the participant views it, not as the researcher views it (Marshall and Rossman, 1995). The main strength of the application of open-ended interviews is related to its usefulness in gathering a wide variety of data across a larger number of subjects quickly. However data are time consuming to analyze. Issues such as lack of cooperation, lack of comprehension and unwillingness to participate may represent limitations and weaknesses of the method and researchers should be aware of these when conducting field work (Gorden, 1992). Interviews are usually done through the face-to-face method. The sampling strategy has to be selected as to cover the full region (e.g. be representative of all fishing communities), all gear sectors, and different age groups (to look at how convergent/divergent they are). Careful attention should be paid to the heterogeneous characteristics of the interviewed sampling population and the wording of the questions should be adapted accordingly. In reporting the findings, interviews highlights based on quotations help to summarize the major points. Also the use of quotations is important to illustrate and bring the local dialogue into perspectives of the various groups.

1.7. Document review

Participant observation, interviewing and quantitative survey should be supplemented with the gathering and analyzing of documents. The specialized approach called content analysis entails the systematic examination of the content of various kinds of documents being examined (Marshall and Rossman, 1995) and it is important to be guided by a common analytical framework to allow comparisons.

1.8. Participation in the setting and direct observation

Participant observation is an important complementary method to assess local conditions and to evaluate small-scale fisheries, for instance as it allows the observation of the practice of implementing co-management processes and the dynamics of a governance system at the local levels in contrast to larges decision making policies (Creswell; 1994; Maxwell, 1996). Participant observation is usually used as one method to allows for cross validation of data from other sources as researcher can fully observe the dynamic of the meetings (in case of co-management forums, participatory rule-making systems, among others) and the behaviour of participants. Participant observation is considered by different authors as an important tool for qualitative research and its use is strongly recommended (Creswell, 1997; Miller and Dingwall, 1997; Marshall and Rossman, 1995).

Participant observation allows the researcher to hear, see, and begin to better understand the participants' perspectives. Through participant observation, the researcher learns about behaviors and the meaning attached to these behaviors. Participant observation can be also an efficient way of building trust between the researcher and the people to be interviewed because through the participation the researcher exposes him/herself into the community and become known by the participants and familiar with the important issues at hand. This may create a bond between the researcher and the target population of the study, which improved the quality of the data gathered.

Observation can range from highly structured, detailed notation of behaviour guided by checklists to more holistic descriptions of events and behaviour (Marshall and Rossman, 1995). In case of assessment of small-scale fisheries issues of representation, power relations, channels of communication, interests, conflicts, inputs from the parties related to management decisions can be all observed and compared with data provided by the interviews and survey.

The researcher takes part in the activities of the fishers to learn by direct observation and experience. Widely used by anthropologists but time-consuming, this is the single most effective technique for understanding and appreciating fishing practices, social organization and informal rules. Especially important for the manager, participant observation reveals if there are institutions for the management of the commons (Berkes 1999). It also provides the insider view on resource abundance/crises, enforcement problems/solutions, and, in general, how the fishers make their livelihood (Jorgensen 1989).

1.9. Survey

More qualitative-type of open-ended and semi-structured interviews, along with document analysis, field observation and literature review, can be complemented with a quantitative closed-ended survey (Fowler, 1993; Singer and Stanley, 1989). Why link qualitative and quantitative data? This linkage enables confirmation or corroboration of data via triangulation; providing richer detail on the theme to be assessed (Creswell, 1994).

The design of the questionnaire is an important step that should be in an iterative and complementary process between researcher and fishers where the researcher should count on the help of fishers to elaborate the questions. Before the completion of its final version, the questionnaire profile to be used in the survey should be evaluated by some small scale fishers. Fishers can then provide inputs to the questionnaire both in terms of content materials and language formats in order to guarantee that the questions are clear, understandable and of interest to the target population. Once this process is completed and adjustments are made to the questions, the pre-testing of the questionnaire should be done (Fowler, 1995).

The target population of the survey depends largely on the objective of the assessment and should be selected accordingly. In case of lack of an adequate sampling frame (in many cases there is no updated list and registration about the whole group of fishers in the study region) the sample population can be selected through the snowball technique (Henry, 1990; Creswell, 1994; Czaja and Blair, 1996). This method permits the development of a more directed study when one wants to analyze a special population and still obtain a representative sample. In this case, information obtained from the different sources, including (1) members of the Fishers Organization, (2) officials from government where fishers obtain their license permit, (3) the captain of the ports where fishers have to register their boats; (4) non-governmental organizations that work directly with fishers in the field; (5) the researchers from the university, for instance.

The timing to conduct surveys have to follow a careful analysis about the best period of the year and the appropriate time of the day for the survey to be carried out and shall be done during closure periods where fishers are at their villages doing work such as fixing their nets, boats, etc. A contact person (e.g. fisher and/or fishermen wives) in each community can be at help to introduce the researchers to the fisherfolk. It is important to clarify the objectives of the research, why they were selected as a potential participant in the project and ask about their feasibility of participating in the survey.

Some points are important to a successful survey accomplishment: (1) research questions should be well developed beforehand, and it works best if inputs and revision are given by contact fishers; and (2) the researcher should devote a considerable time in the field to build trust with the participants.

1.10. Traditional Ecological Knowledge. There are many methods that could be used to assess fishers' knowledge. Berkes *et al* (2001) summarize common methods employed in fisheries research for collecting traditional knowledge. They are described in Table 3, and include seasonal calendars, participatory mapping, transects, local and oral histories, folk taxonomies, ethnographic information and cognitive mapping.

Table 3: Summary of methods used to collect traditional knowledge in small-scale fisheries (based on Berkes *et al*., 2001)

Method	
Seasonal calendars	Usually artisanal fisheries followed a calendar of activities (rules in use) determined by the abundance of different fisheries resources during the year and by the fishing technologies in use. The calendar should be based on the experience of local fishers and include species and seasonal catches. Historical analysis of fishing calendars is important to assess patterns of changes in the calendar (e.g. amount of fishing pressure in a given time over a particular species and/or critical period, changes in technologies).
Participatory mapping	Participatory mapping is a process involving all members of the fishing community. The object is to map aspects of the fishing activity such as areas of importance for the fishery, potential spawning sites, especially diverse or abundant sites, fishing territories by species, season and communities, among others. The use of local names is important. The key aspect in participatory mapping is that it is *participatory*, and the community controls the outcome as well as all stages of the mapping process. All individuals, have the opportunity to join in the making of the maps, both through field surveys, drafting and feedbacks
Transects	Transects involve walking tours (transect walks) through the coastal zone used by a fisher community to observe, to listen, and to identify different resource areas, as well as to ask questions to identify problems and possible solutions. Carried out by skin divers pulled by boats along a predetermined grid, this method can be adapted to conduct rapid surveys of coral reefs and seagrass beds, for example. The various uses of the transect method provide an effective way for an outsider to learn about a local area, its features and its use, and for the local people to explain their point of view to a researcher or manager.

Local and oral histories	Every fishery and fishing community has a historical context that is important in understanding why a group of fishers behave as they do. For example, finding out if a fisher's father and grandfathers were also fishers helps establish the likely depth of that person's knowledge about the fishery, given that traditional knowledge is multigenerational and cumulative. Historical information can provide an account of how things have changed or are changing. Beyond the "living memory," oral history techniques can be used to access information on such events as major hurricanes, and their effect on fishing practices via mechanisms for adaptation.
Folk taxonomies	Taxonomies are generally embedded in local cultural and social systems, and serve various social functions. Folk Taxonomies exist to allow popular identification of classes of objects, and apply to all areas of human activity. They relate to culture's own systems of naming local plants and animals, and include information such as the habits of large mammals. These localised naming systems are called folk taxonomies. Berkes *et al*. (2001) summarize the following steps to identify folk taxonomies (1) identify user groups; (2) using stimuli such as picture books and organisms in the wild (at landings and in the market), to elicit names of fish; (3) for each type of fish named, ask if there are any other types of that fish; (4) cross-validate information with additional informants; using fish (shellfish, etc.) identification books, identify fish by scientific name; (5) photograph fish types that you cannot identify in the field so that experts in the university or fishery department may identify them.
Ethnographic information	Ethnography's aim is describe a group or culture. The particular type of fieldwork that is common in ethnography is called participant observation (a method of collecting data through the observation of a group or organisation in which the researcher participates as a member) and this refers to the researcher living within a group for a period of time and observing how they carry out their normal everyday activities. The key to ethnographic interviews is the willingness to listen. In fisheries, ethnographic information is used to collect the knowledge concerning the resource and harvest, such as numbers, locations, mobility patterns, feeding patterns, and reproduction. Important is to collect this information historically to identify patterns of changes and reasons for identified changes.
Cognitive mapping	Cognitive mapping relates to how we think about space and how those thoughts are used and reflected in human spatial behaviour. In political science, cognitive maps have been used as a qualitative reasoning tool to try to analyse, predict and understand decisions (Axelrod 1976) In researching fishers knowledge, cognitive mapping is useful to indicate the knowledge about distribution of fish, breeding areas, and so on.