Information Systems for the Co-Management of Artisanal fisheries

Final Technical Report

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MRAG

FINAL TECHNICAL REPORT

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1. DFID Summary

1.1 Executive Summary

The purpose of this project was to examine the feasibility of developing a generic (generally applicable) Fisheries Information Management System (FIMS) or database to improve the co-management and appropriate development of artisanal fisheries.

Generic information requirements to support the main co-management roles of fisheries departments were identified from literature reviews and case studies of fisheries in Bangladesh and the Turks and Caicos Islands. Generic inputs (fields) to support these requirements were identified from common data fields found in survey forms and databases.

Generic FIMS software to support the co-management roles and corresponding data and information requirements was developed using relational database and systems engineering theory. The system, designed to run under Microsoft ACCESS97, comprises a set of linked reference and survey tables, data entry forms, and predefined SQL queries. The system can store and process of a wide range of data and information collected using common methodologies. All the data and information contained within the database can stratified by more than 5 criteria, spatially referenced, grouped by 40 attributes and either plotted in a variety of formats or exported in Microsoft Excel spreadsheet format. A user manual has been produced to accompany the PISCES software.

The system has been successfully tested using catch and effort datasets provided by the two case study fishery departments, but the extent to which the PISCES system is generally applicable can only be objectively assessed after further attempts by fisheries departments to adopt the system. It is likely that certain elements of the system will be more generally applicable or generic than others. It is likely that outputs that can be explicitly defined including catch and effort, biological, environmental, and control and surveillance data, and information required for international management and reporting responsibilities will all be well supported by the software. Although some customisation will be inevitable, it is estimated that the PISCES software could be installed and working within six weeks compared to six months typically required to develop a bespoke system. Significant initial costs savings are therefore anticipated, although potential long-term maintenance costs remain uncertain. The system is complex and therefore institutional strengthening and training programmes may be required for successful adoption and uptake.

Further development of the PISCES software is required to provide the necessary fields and processing capacity to support the monitoring and evaluation of data relating to conflicts, the maintenance of traditional management practices, environmental data and employment in the harvesting (and processing) sectors. Further work is also required to improve the user interface and error checking functions. The system would also benefit from an expanded range of fields and processing functions for socio-economic data.

Nonetheless, this research has made a significant contribution to the development of improved strategies and plans for the management of capture fisheries important to poor people (RNRKS FMSP Purpose 1). Furthermore, fishery departments from both case study fisheries have expressed keen interest in the system and several requests for software and manuals have already been received including from members of SADC.

1.2 Background

Artisanal fisheries are fundamentally important in the developing world. It has been estimated that between 14-20 million people depend on these fisheries for their livelihoods, and about 1 billion rely on them for their main source of animal protein. Fisheries management is an integrated process involving information gathering, analysis, planning, consultation, decision-making, and the formulation and implementations of rules and regulations to govern fisheries activities to satisfy various objectives. Co-management, where the responsibility for management is shared between the major stakeholders is increasingly recognised as being an effective strategy to redress many of the paradigm failures associated with more conventional 'top-down' approaches to management. However, regardless of the nature of co-management arrangements, effective management relies heavily on processed information from the fishery. Fisheries Information Management Systems or databases provide an efficient means to hold and process information collected from fisheries (Chapter 2).

There are two main approaches to developing a FIMS; either by adapting or customising a commercially available (off-the-shelf) generic system to satisfy local requirements, or by creating a custom system from scratch. Generic systems have lower initial costs, but may be more costly in the long run because of higher maintenance costs. Significant (costly) modifications may also be required to satisfy local requirements. Custom (bespoke) systems are generally more costly to develop and require the continuing involvement of skilled system developers, but can be configured to match closely the data collection strategy so that the system will be more efficient and readily accepted (Chapter 2).

The Food and Agriculture Organisation (FAO) of the United Nations (UN) have developed their own generic FIMS. Although the system has been widely adopted in Africa, mainly for the management of artisanal lake fisheries, it is somewhat inflexible, orientated to the collection of catch and effort data, and contains no functions to support co-management (Chapter 2 & 7).

A wide demand for artisanal FIMS remains. Indeed, MRAG Ltd has received several requests for FIMS from fisheries Departments, particularly in Melanesia (Chapter 2).

1.3 Project Purpose

The purpose of this project was to examine the feasibility of developing a generic (generally applicable) Fisheries Information Management System (FIMS) or database to improve the co-management and appropriate development of artisanal fisheries. In addition to the generic database, other planned project outputs included:

(i) Guidelines and statistical procedures for a generic data collection system to support the FIMS software.
(ii) An evaluation of the cost of implementing the FIMS (both unit costs and national costs at case study sites).
(iii) Training workshops in the use of the generic FIMS and data collection strategy with supporting material/documents.
(iv) A description of the wider utility and applicability of the generic FIMS.

1.4 Research Activities

The outputs described in Section 1.3 were sought through a number of planned activities (Figure 1). It was intended to identify generic information outputs from the FIMS on the basis of a

synthesis of government and community management objectives identified from the literature, company experience and from case studies of two diametrical artisanal fisheries (Volume II).

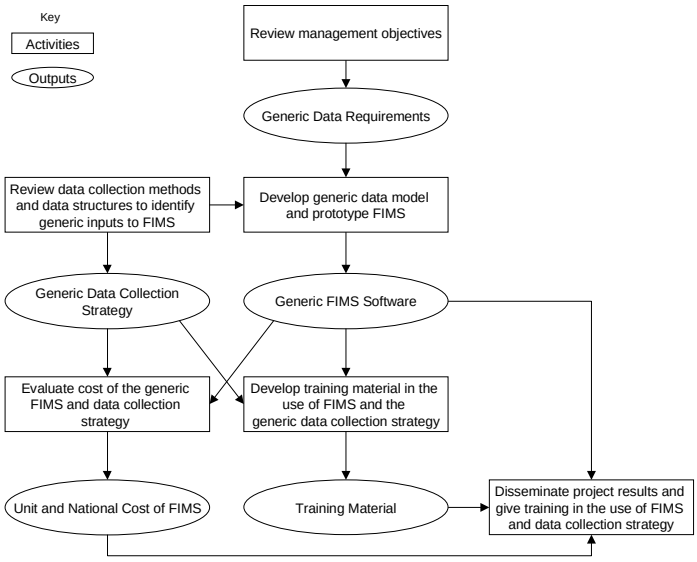

Figure 1 Planned Project Activities and Outputs

The raw data or *inputs* for storing and processing by the database to provide these outputs would be identified from a review of correspondingly appropriate data collection methodologies combined with a review of 'data structures'. This review of data collection methodologies was also intended to provide the basis for developing guidelines and statistical procedures for a generic data collection system to support the database component of the project. The computing hardware requirements for the FIMS software combined with and necessary resources and manpower to support the generic data collection system would then provide the necessary information to evaluate unit costs of the system, as well as the national costs of implementing the FIMS at the case study locations (Figure 1).

Shortly after the project began, it became evident that information requirements (outputs from the FIMS) to support co-management will be governed by more than just management objectives of governments and local fishing communities (Chapter 3). Instead, the information required from a co-management FIMS will be influenced by (i) the nature of the co-management arrangement which will determine which stakeholders are involved in the management decision-making process; (ii) the objectives of these stakeholders; (iii) the basis with which these stakeholders make decisions (eg custom/tradition, empirical or theoretical models, adaptive approaches...etc); (iv) their institutional capacity which will influence the types of decision-making methods and data collection approaches they can employ; (v) the type of management control measures they choose to employ to regulate resource exploitation, and of course: (vi) their preferences and the local conditions under which they operate (Chapter 3).

The continuous spectrum and evolutionary potential of co-management arrangements coupled with the inter-dependence among several of the factors listed above, presented a dynamic and multi-dimensional problem to identifying management information requirements and therefore designing a general database to support co-management (Chapter 3).

As a means of addressing the problem, idealised co-management arrangements based upon the work of Sen & Nielsen (1996) and Hoggarth *et al* (1999) were identified for the three main environmental regimes in which artisanal fisheries commonly operate. These arrangements

effectively match the main stakeholders with the necessary motivation and institutional capacity to the main management roles that are heavily reliant upon data and information (Chapter 3).

It was also necessary to make explicit which of the main stakeholder groups should be the target of the FIMS. It was concluded that government fisheries departments should be the primary targets because they will usually have overall administrative responsibility for the (co-) management of national fisheries resources. They are also the most likely stakeholder group to possess the necessary institutional capacity and resources to formally monitor management performance and therefore are most likely to require such a system. Designing a system that could also support the needs of intermediaries (eg donor-funded projects, NGOs etc) was rejected. It would be impossible to anticipate their diverse range of remits and interests and potentially esoteric monitoring programmes commonly designed to satisfy donor-specified project impact indicators (Chapter 4). In spite of this, several NGOs delegates at the projects' dissemination workshop in Bangladesh believed the FIMS software could effectively be used in support of many of their community project monitoring and evaluation programmes (see later and Chapter 8). It was also concluded that whilst they are the ultimate target beneficiaries of the project, and may in contribute to the data and information contained within it, it would be unrealistic to expect local fishing communities to have any interest, motivation or the necessary institutional capacity to use such a system. Monitoring and evaluation at this level will typically be informal and often based on perception or common knowledge derived from the co-use of the resource under conditions where mutual observations are possible (See Chapter 4 and Project Memorandum Section 15d).

The system was therefore principally designed to support the following heavily-dependent co-management roles of fishery departments at each of the three nested spatial management levels identified as:

(i) Formulation of management plans.
(ii) National monitoring and evaluation, and control and surveillance for management plans for migratory[1] and state-owned sedentary resources[2].
(iii) National policy and development planning including the coordination of sectoral activities.
(iv) National and international management and reporting responsibilities.
(v) Coordination of community management plans to ensure complementarity.
(vi) Evaluation of community management plan performance and feedback of lessons of success and experiences to communities.

1.4.1 Identification of FIMS Outputs

Generic information requirements (outputs) from the FIMS to support these co-management roles were identified from an extensive synthesis of the literature (chapter 4):

Formulation of management plans

The main categories of information required for the formulation of management plans were identified as the stocks or fishery being considered and area of operation of the fishery; information on environments, habitats or locations critical for the life history of the stocks or species; potential catchment influences on the stock; information relating to the fishery; information relating to the fishers and other important stakeholders; the management objectives; decision-making arrangements including rules and regulations; and any external factors that may affect management (Section 4.2).

[1]Migratory resources cannot be effectively managed on a local scale.
[2]These refer to non-migratory stocks that are not managed on a local scale.

National monitoring and evaluation of management plans, and control and surveillance.
Generic information requirements (outputs) from a FIMS to support national monitoring and evaluation activities were identified from a combination of management objectives (and their *status indicators*), technical management models (and their *reference points*) and adaptive management approaches, covering the full range decision-making methods that are employed to evaluate management performance (see above and Chapter 4).

Generic information requirements (outputs) from the FIMS to support biological or resource orientated management objectives, decision-aiding models and adaptive management approaches were identified as catches by species and gear type and corresponding fishing effort by gear type during a specified time period (commonly a year). Other requirements were identified as information to describe the population dynamics of the exploited populations (biological data) derived from the (sampled) catch including: the length or age composition of the catch and their life history characteristics, typically sex, fecundity, and reproductive condition in relation to length, and gonad weight in relation to somatic weight (Section 4.3). Spatially referencing these data and information significantly augments its' value allowing: (i) the development of spatial management models (Section 4.3.3); (ii) the identification of important areas for conservation and management (eg spawning locations or nursery areas...etc); (iii) the examination of the spatial and technical interactions among fleets or fishers, and stocks; and (iv) more effective management if the population dynamics of the stock varies significantly on a spatial scale.

Information requirements (outputs) from the FIMS to support common socio-economic management objectives and decision-aiding models were identified to include costs and earnings stratified by various criteria, economic rent, export revenue by species or product type, numbers of individuals employed in the fishery stratified by sub-sector, income stratified by FEU type, industry diversification data, indicators of food supply or security, information describing the extent and frequency of conflicts, information to monitor the existence/maintenance of traditional management practices or culture, and catch and effort information (Section 4.3.4).

Environmental information was also identified as being an important output from a FIMS, particularly to support the management of fisheries operating in environments sensitive to environmental stress or perturbation. General variables that should be available from a FIMS were identified in Section 4.3.5. Information requirements for control and surveillance were found to typically relate to vessel or gear ownership, identity, communications, fishing power and corresponding licence details (Section 4.4).

National policy and development planning
Information requirements from a FIMS to support national policy and development planning decisions, and reporting responsibilities were examined in Section 4.5. Three main categories of information requirements from the FIMS were identified: (i) resource and fishery related; (ii) socio-economic; and (iii) monitoring control and surveillance.

National and international management and reporting responsibilities.
Required outputs from a FIMS to comply with international management responsibilities including the FAO Code of Conduct for Responsible Fisheries and UNCLOS III were identified. Outputs required for international reporting responsibilities were also identified for the main commissions and conventions including the FAO Regional Fishery Commission; Convention for the International Trade in Endangered Species (CITES), and the Convention for Biological Diversity. However, it was recognised that membership to other regional bodies, agencies and organisations such as Organisation for Eastern Caribbean States (OECS) or the South African Development Commission (SADC) may carry with it additional obligations to supply specific information not required for the above (Section 4.7).

Coordination and performance evaluation of community management plans

Adaptive management is likely to be employed by local communities to achieve their objectives for their own *management unit*. However, identifying the best combinations of management tools and decision-making arrangements to achieve specific objectives by individual communities may take several years of (informal) monitoring and evaluation by the local managers. It was concluded that fishery departments or higher level managers have the potential to significantly accelerate this adaptive learning process by monitoring and comparing spatially, performance among individual management plans. The results and management recommendations arising from this approach can then be disseminated to local level managers via appropriate media such as regular radio transmissions, meetings, posters, workshops...etc. This spatial monitoring and evaluation approach also provides an effective means with which to spatially coordinate local management activities thereby promoting harmony and complementarity and helping to minimise conflicts.

Requirements from the FIMS to support this role were therefore identified as being all the information that is typically contained within a management plan and any other attributes that are believed to affect management performance or outcomes, as well as of course, indicators of management performance.

Co-management attributes and performance indicators were identified on the basis of the Oakerson Framework (Section 3.1), ICLARM's 'Institutional Analysis Research Framework' developed under their Fisheries Co-Management Research Project, DFID's Sustainable Livelihoods (SL) framework, and from inter-disciplinary comparative studies of African lake and coastal fisheries described by Preikshot *et al.* 1998 and Nielsen *et al.*, 1995, respectively.

Performance indicators must be both relevant and palatable to local level managers if effective feedback and adoption of lessons of success are to be achieved. Whilst these indicators should ideally be selected by the local managers themselves, an extensive literature review discovered no documentation describing management performance criteria as selected and applied by the community itself. Nonetheless, it is recommended that these indicators be negotiated in collaboration with the communities themselves. The DFIDs' five main categories of desirable livelihood outcomes were identified as a useful basis with which to negotiate these indicators (Section 4.9).

The FIMS currently includes only a subset of attribute and performance fields for demonstration purposes. Further fields can be added when a commonly agreed or standard set of attribute and performance indicators/measures have been identified or developed (see below).

A statistical framework for identifying patterns or similarities between combinations of attributes (explanatory variables) and management performance indicators was proposed based upon Multi-dimensional Scaling (MDS). Using this framework, lessons of success, described in terms of combinations of attributes and levels of inputs that appear to give rise to desirable outcomes or objectives, can then be feedback to local level managers via appropriate media to help accelerate their own adaptive management activities (Section 6.6).

A DFID funded project ' Interdisciplinary Multivariate Analsysis for Adaptive Co-Management' (R7834) is currently developing, refining and attempting to validate this approach in collaboration with ICLARM, IFM, Reading University, DFID and independent consultants.

1.4.2 Identification of Generic Inputs for the FIMS (database fields)

As explained above, it was intended to identify generic raw data or *inputs* for storing and processing by the FIMS database to provide all the generic requirements (outputs) described above by identifying or formulating a generic data collection system. As a means of attempting to develop such a generic data collection system, factors affecting raw data and their collection and processing were examined in detail in Chapter 5. This included a review of potential sources of data for each required category of requirements, and appropriate data collection tools (eg questionnaires, interviews, direct observation...etc), sampling strata, and the appropriateness of sampling and complete enumeration in relation to the variable or data type in question. It was concluded that it was impossible and wholly inappropriate to design a generic data collection strategy. Effective and appropriate data collection strategies and data processing methods must be designed in accordance with the structure, operations and characteristics of the fishery (the local context), and the available institutional capacity, resources and preferences (see Chapter 5 and Figure 11).

Generic inputs for storage and processing by the FIMS to provide the required outputs were instead identified on the basis of corresponding commonly collected categories of data and information or *generic fields* (Chapter 6). Generic fields were identified by reviewing the types of raw data (example fields) that are frequently collected using commonly employed data collection tools and data sources to provide the main categories of information required from the FIMS.

This approach effectively aimed to develop a FIMS that could support a variety of common data collection strategies as opposed to designing a system around a single generic data collection strategy. In addition to increasing the complexity of the database design (and therefore the time and resources required for it's development), the inability to develop a generic data collection strategy also had the important implications with respect to delivering several of the expected/planned outputs (see later).

1.4.3 Development of the Generic FIMS

The generic FIMS to support the co-management roles and corresponding data and information requirements was developed using relational database and systems engineering theory. Various alternative designs and small working prototypes were examined. User defined stratification across the full range of attributes was achieved through dynamic creation of a series of linked SQL queries. This allowed a whole series of analyses to be partitioned according to values in each or a combination of these attributes. An architecture was developed that allowed the system to be support a variety of different catch and effort sampling strategies. Sample and frame surveys were combined through the use of new methods for common stratification and joining of results via relational operations (Chapter 7).

1.5 Outputs

1.5.1 Achieved Outputs

The project succeeded in fulfilling its primary purpose of examining the feasibility of developing a generic database to support the co-management of artisanal fisheries. Prototype software entitled 'PISCES - **P**roviding **I**nformation for **S**ocio-Economic **C**atch and **E**ffort Fisheries Surveys has been developed to store and process of a wide range of data and information collected using common methodologies to support fundamental co-management roles of fisheries departments described above (Chapter 7 and User manual).

The system, designed to run under Microsoft ACCESS97, comprises a set of linked reference

and survey tables, data entry forms, predefined SQL queries, and plotting and export facilities. The PISCES software can:

- Store details of management plan documents with links to key information fields to aid the (spatial) coordination of inter and intra-sectoral management activites;
- Support the monitoring and evaluation of national management plans on the basis of a range of decision-making methods to achieve common management objectives by providing facilities to store and process:

    - Catch and effort data generated by a range of different sampling or enumeration strategies.
    - Biological data sampled by direct observation at the harvest level.
    - Cost and earnings (income) data collected from fishing units (FEUs) or households.
    - Data to help estimate economic rent from the fishery.
    - Sector diversity data (numbers of target species, numbers of different gears and vessel types).
    - Data to help estimate food supply and average per capita fish consumption.

- Support control and surveillance activities by storing information relating to vessel/fisher registration and identification details and licence/quota information. The system also includes facilities to automatically alert breaches to regulations or licensing arrangements.
- Provide information in support of policy and development planning activities.
- Potentially provide all the information required for international management and reporting responsibilities.
- Support the coordination and performance evaluation of community management plans.

All the data and information contained within the database can stratified by more than 5 criteria, spatially referenced, grouped by 40 attributes and either plotted in a variety of formats or exported in Microsoft Excel spreadsheet format. Several predefined analyses have been included in the PISCES software (see User Manual and Chapter 7).

A user manual has been produced to accompany the PISCES software. This contains sections describing installation, operation, data entry and data analysis.

1.5.2 Outputs not Achieved

Because no single generic data collection strategy to support the software could be identified (see above and Chapter 5) the following remaining planned project outputs were not achieved:

- Guidelines and statistical procedures for a generic data collection system to support the FIMS software.
- An evaluation of the cost of implementing the FIMS (both unit costs and national costs at case study sites).
- Training workshops in the use of the generic data collection strategy with supporting material/documents.

The actual activities and resulting outputs achieved are summarised in Figure 2.

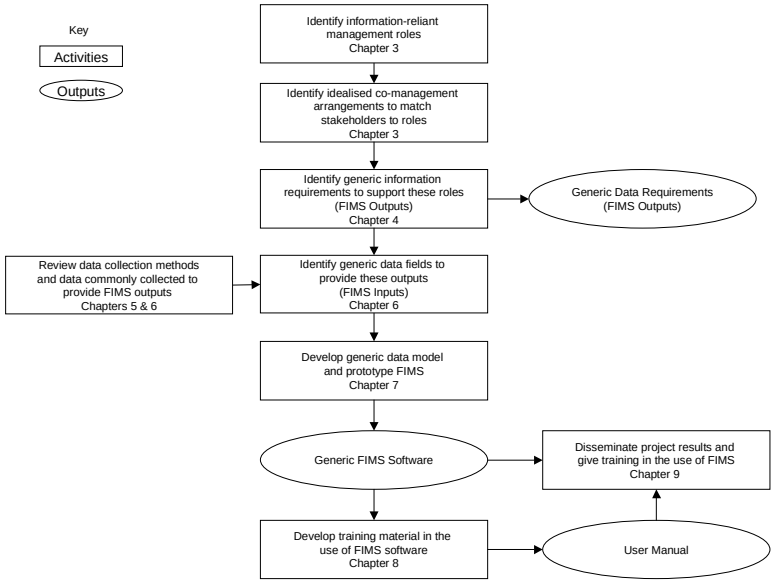

Figure 2 Actual Project Activities and Outputs

1.6 Contribution of Outputs

1.6.1 Contribution of Outputs Towards DFID Development Goals

This research has developed a potentially effective tool to help improve the co-management and appropriate development of artisanal fisheries and has, therefore, made a significant contribution to "...the development of improved strategies and plans for the management of capture fisheries important to poor people" (RNRKS FMSP Purpose 1).

The key question is how generic or general is the PISCES system? It is likely that certain elements of the system will be more generally applicable or generic than others depending upon the specificity of the required outputs and the corresponding range of potential data sources and collection methods.

Outputs that can be explicitly defined including catch and effort, biological, environmental, and control and surveillance data, and information required for international management and reporting responsibilities are all, therefore, likely to be well supported by the software.

Outputs required to support the evaluation of management activities geared towards achieving socio-economic objectives and for policy and development planning purposes are, on the other hand, typically more variable or less explicitly defined reflecting the use of a diverse range of measures, indicators and their proxies, and the wide range of available data collection methodologies and sources. For example, household income and fish consumption data may be monitored either on a routine (monthly) basis by means of a panel survey, or collected during socio-economic baseline/frame surveys. The PISCES software currently does not contain fields or the processing capacity to support the former. Instead fields are provided to record total annual income (from fishing and other activities) and total annual fish consumption generated by annual (ad hoc) surveys. However, fields and data processing facilities provided by the PISCES software for the more explicitly-definable socio-economic data requirements (outputs)

such as income (costs and earnings) by FEU type are likely to be more generally applicable.

Data requirements for policy and development planning purposes are often drawn from the results of frame surveys. Frame surveys are also a very general way of collecting data and information about the fishery to help design data collection strategies, formulate management plans, provide baseline socio-economic and employment data, and indicators of poverty, industry diversification, and food security. The types of data and information collected during frame surveys are highly variable. More than 150 example data fields were identified from the literature ranging from answers to specific questions relating to sector support and infrastructure to data on literacy rates of village members (See Section 6.2.2). Whilst many frame survey fields exist in the PISCES software (via linked reference tables with the FrameTable) to record frame survey data, it is likely that significant changes may have to be made to accommodate further fields and to develop appropriate links and processing functions.

Indeed, it is very likely that additional fields may need to be added and existing broad generic fields re-named in several or all of the tables during installation in order to satisfy local requirements and existing data collection systems. In spite of this inevitable customization process, it is estimated that the PISCES software could be installed and working within six weeks compared to six months typically required to develop a bespoke system. Significant initial costs savings are therefore anticipated, although potential long-term maintenance costs remain uncertain.

Furthermore, whilst the database has been tested using catch and effort datasets provided by the two case study fishery departments (see Volume II), the extent to which the PISCES system it is generally applicable, particularly with respect to accommodating and processing socio-economic data, can only be assessed after further attempts by fisheries departments to adopt the system.

Other factors may influence adoption or uptake, beyond simply its potential applicability and cost-savings. The system as it stands is very complex and demands a high level of understanding of both data collection systems and relational database theory on the part of users (See Chapter 7 and User manual). Institutional strengthening and training programmes may well be required for successful adoption and uptake. Its robustness and reliability may also be important, particularly with respect to long-term uptake. Further testing of the system and error checking is required. Some participants at the dissemination workshop in Bangladesh believed that potential users may resist uptake because they might perceive an off-the shelf system as less desirable that a bespoke system that has been designed for them according to their own specifications and requirements. Notwithstanding these comments, both fishery departments collaborating on the project and members of SADC have expressed keen interest in the system (see below and Chapter 8).

1.6.2 Promotion of Outputs

Distribution of FTR, Software and User Manual

In addition to those required to satisfy DFID's contractual reporting requirements, it is intended, at least in the first instance, to send copies of the Final Technical Report, and the prototype PISCES software and User Manual to the following. Other copies will be made available on request:

DFID, Bangladesh
DoF, Bangladesh
CARE, Bangladesh
CNRS, Bangladesh

ICLARM, Bangladesh
MACH Project, Bangladesh
Fourth Fisheries Project, Bangladesh
EGIS Project, Bangladesh
SUFER Project, Bangladesh
Department for Environment and Coastal Resources, Turks and Caicos Islands
School for Field Studies (SFS), South Caicos.
Lake Uganda Project, DFID
SADC FIMS Project

Publications

No papers have yet been accepted for publication from this report. The following paper has been submitted for publication:

Craig, J.F., Halls, A.S., Barr, J. The Floodplain Fisheries of Bangladesh – A Review. Submitted to *Fisheries Research* October 2000.

The following paper is, at this time, in preparation:

Halls, A.S. and Lewins, R. The Fisheries of the Turks and Caicos Islands and Prospects for Co-Management.

Internal Reports

Two reports describing the case studies conducted in Bangladesh and the Turks and Caicos Islands referred to the main volume and appended in Volume II of this final technical report:

Information Systems for the Co-Management of Artisanal Fisheries. Field Study 1 - Bangladesh. MRAG Ltd, London, 1999, 337pp.

Information Systems for the Co-Management of Artisanal Fisheries. Field Study 2 - Turks and Caicos. MRAG Ltd, London, 1999, 115pp.

Dissemination Workshops

The results of the project were disseminated at the two case study locations between 4th and 19th December 2000 using a combination of workshops, presentations and demonstrations of the FIMS software aimed at target beneficiaries, other stakeholders, and the project's collaborators (Chapter 8).

The workshop in Dhaka, Bangladesh was attended by more than 25 participants representing NGOs, the academic community and international donor and development agencies. Overall, the project results were well received by all participants who expressed an opinion. Representatives of the EGIS project believed that the FIMS would be a valuable tool for the Department of Fisheries (DoF) in Bangladesh, and that the system's implementation should be encouraged.

Many participants supported the concept of learning lessons about (co-)management on the basis of spatial comparisons of standard, commonly-agreed management performance measures/indicators and those explanatory factors (co-management attributes) that are likely to affect performance (Section 6.6). Many participants representing NGOs recognised that whilst the FIMS is primarily aimed at fisheries departments, the system could also be used as a monitoring and evaluation tool to store and process data on local or small scale projects and studies. Most of the participants present requested to receive copies of the Final Technical Report and FIMS software so that they could explore the utility and applicability of the system for themselves in more detail.

A separate presentation and software demonstration was also given to the DoF at their headquarters. This was also well attended and received with many staff also expressing an interest to receive copies of the Final Technical Report and FIMS software. The department also expressed interest in being trained in the use of the software, and thought that the "best bits" of the software should be included in their future database systems.

Dissemination activities in the Turks and Caicos Islands (TCIs) were attended by staff from the Department for Environment and Coastal Resources (DECR) and other Government Departments. Unfortunately, stakeholders from the School for Field Studies (SFS), the processing industry, the Fisheries Advisory Committee (FAC) were not represented (Chapter 8).

The project results and outputs were well received by the participants, particularly those features relating to the automatic system to alert breaches to technical and licensing regulations. The DECR was also impressed by the flexibility of the FIMS with respect to meeting their reporting requirements and provision of data and information for stock assessment purposes. Some participants were sceptical about the appropriateness of co-management in the TCIs because they believe that communities have no interest in conservation and that resource boundary delineation would be problematic. Conditions to support co-management arrangements were believed only to exist in and around Salt Quay, a small, isolated island with few inhabitants and fishers (see Field Study 2 - Turks and Caicos Islands, Volume II). Others, on the other hand, were enthusiastic about the prospects for co-management and felt that the Department should consult the community more with a view to establishing co-management arrangements.

Mark Day, Director, DECR expressed considerable interest in installing the PISCES software in the Department to replace the existing, but no longer functioning, DataEase system (see Field Study 2 - Turks and Caicos Islands, Volume II). He intends to seek DFID development funds for a package to install and customise the FIMS, and to institutionally strengthen and train the Department in the use and application of the software. The prototype version of the PISCES software was installed in the DECR to provide an interim system to replace the DataEase system until a fully developed version of FIMS is installed at the Department.

1.6.3 Recommended Follow-Up Research

Further development of the PISCES software is required to provide the necessary fields and processing capacity to support the monitoring and evaluation of data relating to conflicts, the maintenance of traditional management practices, environmental data and employment in the harvesting (and processing) sectors. Further work is also required to improve the user interface and error checking functions. The system would also benefit from:

(i) some means of simplifying or automating the complex decision-making process surrounding the selection of the appropriate tables in the software for the four main catch and effort data collection scenarios,
(ii) an expanded range of pre-defined queries,
(iii) alternative file export definitions, and
(iv) an expanded range of fields and processing functions for socio-economic data.

The User Manual would also benefit from step-by-step tutorials to guide the user through each database table, feature and function. It is estimated that this further work would require approximately eight man-months of time to complete. No doubt further scope for improvements will be identified on the basis of feedback from users. An *FAO Fisheries Technical Paper* might be an effective medium to further disseminate the results of this research.

2. Introduction

2.1 Background

Artisanal fisheries are fundamentally important in the developing world. It is estimated that between 14-20 million people depend upon these fisheries for their livelihoods, and about 1 billion rely on them for their main source of animal protein (Pomeroy and Williams 1994). At the same time they are also tend to be very complex from resource, technical and institutional perspectives.

The management of artisanal fisheries resources to satisfy various objectives is an integrated process involving information gathering, analysis, planning, consultation, decision-making, and formulation and implementation of regulations or rules to govern fisheries activities.

Until recently, artisanal fisheries management has tended to focus upon maximising resource output using a suite of technical *operational rules* or regulations selected on the basis of deterministic (single-species) biological model-based predictions, set and enforced by a centralised (government) administrative authority.

Particularly in the developing world fisheries, where there is often a paucity of resources and institutional capacity to conduct (and interpret) formal assessments, and monitor and enforce rules and regulations among the widely dispersed resource users, this paradigm often fails to coordinate and restrain resource users, leading to depleted resources, inequity and conflict. Failure may also arise when the technical management models employed to guide decision-making processes are inadequate to capture the dynamic complexity of the fisheries.

Co-management, where the responsibility for resource management is shared between the government and user groups, is increasingly being seen as an effective strategy to redress these paradigm failures and thereby facilitate improved sustainable livelihoods. An adaptive or iterative approach to refining management strategies is often employed where resources and institutional capacity are scare, or where technical deterministic models are likely to fail due to the complexity and dynamic nature of the fishery.

Decision-making for fisheries policy-making, planning and (co-)management, relies largely upon processed information collected, in its raw form, from the fishery. Fisheries Information Management Systems (FIMS) or databases provide a means to hold and process these raw data, and facilitate flows of processed information.

A fundamental requirement of a FIMS is that they must hold all the data as they were collected in their primary, unprocessed form. This allows flexibility in the way the data can be processed (eg filtered, aggregated, sorted, transformed...etc) and ensure that all calculations are reproduced from source data incorporating all revisions. This also means that they should be integrated with the data collection strategy as far as possible (FAO 1999b).

Existing FIMS typically include information collected from the fishery itself but may also contain information required for implementing management instruments or administering the management strategy such as records of vessel details, surveillance information, and other information required for the general administration of the management system. There are two main approaches to developing a FIMS:

(i) Adapting a commercially available (off-the-shelf) system according to local requirements, or
(ii) Creating a custom system from scratch.

Each approach has own advantages and disadvantages. Adapting a commercially available system may have lower initial costs, but may prove costly in the long term because of increased maintenance requirements. Significant modifications may also be required to satisfy local conditions and requirements. These may cripple their intended function. Custom systems, on the other hand, are usually more costly to develop and require the presence and continuing involvement of skilled system developers, but can be configured to match closely the data collection strategy so that the system will be more efficient and easily accepted. Moreover, the use of common terminology and tools (data flow diagrams, task analysis...etc) during the development stage can be mutually beneficial to the design of both the database and data collection system (FAO 1999b).

The FAO have developed an off-the-shelf system for artisanal fisheries called ARTFISH. Although the system has been widely adopted in Africa for artisanal lake fisheries (for which it is particularly well suited), it is somewhat inflexible, largely geared to the storage and processing of catch and effort data, and contains no features to support co-management (Chapter 7).

A wide demand for artisanal FIMS's remains. Indeed, MRAG Ltd has received several requests for FIMS from fisheries departments, particularly in Melanesia. This may reflect limitations with respect to the suitability or adequacy of ARTFISH for the diverse range of fisheries that exist, or simply a reluctance to employ an off-the shelf product for the reasons described above.

2.2 Project Purpose and Other Outputs

As a means of attempting to satisfy this potentially large residual demand for off-the-shelf systems, this project was designed to examine the feasibility of developing a generic off-the-shelf FIMS that can support the (co-)management of a diverse range of artisanal fisheries exploiting both marine and freshwater systems. The project also sought to develop a generic data collection system to support the FIMS, estimate unit costs (and national costs at case study sites) of implementing the system, produce supporting documentation and training material, and conduct demonstration workshops in the use and application of the system.

It should be borne in mind that although fisheries departments are usually the main body responsible for collecting, processing and interpreting data to aid fisheries decision-making, other government departments or ministries may also have an important role in this respect. However, given that it would be impossible to anticipate the range of government structures that may exist among different countries or states and the roles and institutional capacity of their respective departments, the project was restricted to examining the feasibility of a system aimed primarily for use by fisheries departments or ministries.

2.3 Research Approach and Activities

Generic systems usually evolve through experience or on the basis of case studies. The project purpose and outputs were pursued on the basis of a combination of a literature review, company experience, and comprehensive case studies of two widely different fisheries (detailed in Volume II): the inland artisanal fisheries of Bangladesh, and the coastal marine fisheries of the Caribbean Turks and Caicos Islands. Six main research activities were planned:

(i) Identification of generic data requirements (processed outputs).
(ii) Identification of generic inputs (raw inputs/data for processing).
(iii) Development of the generic FIMS and testing with the case study fisheries data.
(iv) Evaluation of the unit costs of implementing the FIMS and the national cost of implementing the system at the case study sites.
(v) Production of training material and supporting documentation.
(vi) Dissemination of project results and training (demonstrations) in the use and applications of the generic FIMS software at the case study sites.

2.4 Institutional Collaborations

With a central project base at the Marine Resources Assessment Group, London, UK, collaborations were established with local research institutions, non-government organisations (NGOs) and relevant government departments and ministries at each case study site (See Field Study Reports 1 & 2 in Volume II of this report) to help identify co-management data and information requirements, provide administrative and fieldwork support, and to help disseminate the results of the project to target stakeholders.

In Bangladesh, formal collaboration was established with the Centre for Natural Resource Studies (CNRS), and CARE Bangladesh. Attempts were also made to establish informal collaboration with the Government of Bangladesh (GOB) Department of Fisheries (DoF). Logistic support and advice was also provided by DFID's Field Management Support (FMS) Office, and the British High Commission.

During the field visit, several other NGOs including; USAID (Dr William Collis); Caritas (Mr Nazmul Alam); ICLARM (Dr Paul Thompson; Mr Manjur Kadir); Proshika (Mr Abdur Rahman); BRAC (Mr Mokkarum Hossain) were visited in order to help identify community management objectives and data requirements.

In the Turks and Caicos Islands, formal collaboration was established with the Department for Environment and Coastal Resources (DECR), Grand Turk. Informal collaboration was also established with the School for Field Studies (SFS) and the Fisheries Advisory Committee (FAC).

2.5 Report Structure

This final technical report comprises two volumes and a software user manual. The main Volume I comprises nine chapters and six annexes. Volume II documents the two case studies conducted in Bangladesh and the Turks and Caicos Islands referred to the main volume.

Chapter 1 of this main volume provides a brief summary of the work, in the format required by DFID for Final Technical Reports. Chapter 2 provides the background and rationale for the study and an overview of the research approach and activities, including details of institutional collaborations, personnel and authorship of this report. Chapter 3 examines in detail how differences among co-management arrangements will influence fishery information requirements. It proposes an idealised co-management arrangement based upon a sharing of management responsibility for discrete 'management units', both spatially and hierarchically. This provides a meaningful basis upon which to develop the generic FIMS. Chapter 4 then identifies generic information requirements (outputs) from the FIMS to support the roles and responsibilities of the main stakeholders under this proposed arrangement including feedback mechanisms. Raw data and how they are processed to provide these data requirements dictate

the design of a fisheries database. Chapter 5 therefore explores how these raw data (inputs) might vary among fisheries, and concludes that this will be dependent upon the data collection strategy which in turn will be dependent upon by local conditions. The design or identification of a generic data collection system/strategy as a means of identifying generic raw data, and thereby the generic database, was therefore rejected. Chapter 6 pursues an alternative means of identifying generic raw data on the basis of common 'data fields' used in artisanal fisheries data collection forms and databases for the main categories of required information. Having identified these fields, Chapter 7 describes the development of the generic datamodel and database and examines the utility and validity of the design using data collected from the case study fisheries. Chapter 8 describes the dissemination activities at the two case study sites. Finally, Chapter 9 summarises the project findings and draws conclusions about the utility and applicability of the system. Recommendations for further work are also discussed.

2.6 Personnel, Authorship and Acknowledgments

2.6.1 Personnel

This research was undertaken by the following personnel:

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Mr Crag Jones (Consultant IT Specialist)
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Mr Saccindra Halder (Director)
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Dr Greg Chapman, (Deputy Coordinator)
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Government of Bangladesh, Department of Fisheries, Dhaka, Bangladesh

Dr Mokkamel Hossain (Director, Community-Based Fisheries Management Project)
Dr Nassurudin Ahmed (Director, Fisheries Resources Survey System, FRSS)
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Department for Environment and Coastal Resources, Grand Turk, Turks and Caicos Islands

Mr Mark Day (Director, DECR)
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Mr Perry Seymour (Fisheries Officer)
Ms Linda Grinton (Database Clerk)

2.6.2 Acknowledgments

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2.6.3 Authorship

This Final Technical Report was written by Dr Ashley Halls, Mr Roger Lewins and Mr Crag Jones. The last two authors were responsible for all the socio-economic and IT sections, respectively, including:

Mr Roger Lewins	3.4	Co-Management
	3.4.1	A Typology for Co-Management
	4.3.2 B	Socio-Economic Objectives, Evaluation Criteria...
	4.3.4 B	Socio-Economic Objectives and Reference Points
	4.9.2	*Common Objectives & Management Performance*.... *Community Management Performance Indicators Negotiated Indicators*
	6.2.6	Socio-economic data
Mr Crag Jones	7	All Sections
	8.2.2	Software Demonstration at CARE
	8.2.3	Presentation and Demonstration at DoF
	8.3.3	One-Day FIMS Software Demonstration
	8.3.4	Interim System training
	User Manual	All Sections

3. FIMS Design Considerations

3.1 A Systems Approach to Design

In line with DFID's Natural Resources Systems Programme Strategy (DFID 1999), a *systems approach* is used here to help identify and address the design issues for a generic co-management FIMS in the development context. By taking full account of the technical, economic, social and institutional issues and their interactions, this approach will ensure an effective and meaningful design of a system to support and promote sustainable livelihoods in the artisanal fisheries sector.

A particularly useful and well established framework for studying common pool resource (e.g. fisheries) systems and their management is the Institutional Analysis and Development (IAD) framework developed by the Workshop in Political Theory and Policy Analysis at Indian University, USA. This framework has theoretical foundations on game theory, neoclassical microeconomics, institutional and transaction cost economics, political economy and public choice. The framework has been widely employed in the fisheries sector as a generic tool for documenting, evaluating and comparing artisanal fisheries management systems and co-management arrangements Berkes (1992); Nielsen *et al*. (1995); Pido *et al*. (1996).

The framework emphasises the relationship between the contextual variables (physical, biological and technical attributes) of the resource system and the institutional setting (decision making arrangements), how these affect patterns of interaction and incentives to cooperate and coordinate, and in turn, how this determines outcomes in terms of efficiency, equity and sustainability (Figure 3). Emphasises is given to the continuous and dynamic nature of the process (Oakerson 1992; Nielsen *et al*. 1995).

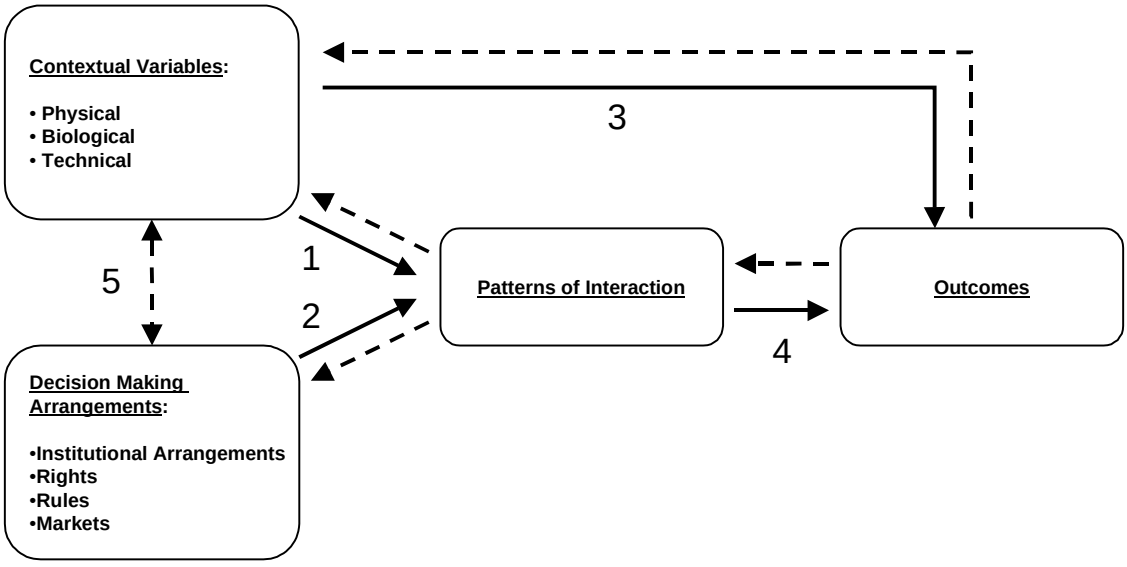

Figure 3 Framework for the analysis of common-pool resource management (adapted from Oakerson (1992) and Nielsen *et al*. (1995))

The following descriptions and explanations draw heavily from Oakerson (1992).

Contextual Variables

The problems of common pool resource management are rooted in the constraints of the physical or biological resource and the available technology to exploit it. These variables directly and indirectly affect outcomes. Important attributes of the resource are (i) *subtractability*: the capacity of the resource base to support multiple users at the same time without reducing the yield of the resource available to all (e.g. how many fishers can fish with using different gear types without affecting each others, or the overall, catch?); (ii) *excludability*: the degree to which the resource permits the exclusion (control of access) to fishers (e.g. migratory and sedentary fish species) and (iii) *divisibility*: the extent or scale to which the resource can be, or should be, divided among fishers without impairing, or to achieve, effective management. For example, migratory fish stocks in lakes are indivisible and therefore may be best managed as an single resource. Lakeshore sedentary resources, however, could be divided into, and more effectively managed in, smaller *management units* (see later). These contextual variables ultimately limit outcomes (arrow labelled 3), independent of human action, but can simultaneously affect them through *patterns of interaction* (arrow 1).

Decision Making Arrangements

Decision-making arrangements are effectively the rules that structure individual and collective choices with respect to the exploitation of the (fishery) resource or *management unit* in order to achieve various management objectives or outcomes. These arrangements specify *who* decides *what* in relation to *whom* and include legal, political and economic factors *(external arrangements*) that will influence decision making. Oakerson sub-divides these arrangements into three hierarchical categories: (i) *operational rules*; (ii) *conditions for collective choice* and (iii) *external arrangements*. *Operational rules* are nested in *collective choice rules*, which are nested in *external arrangements*.

Operational Rules

Operational rules limit exploitation to maintain yield from the resource or meet other objectives agreed through collective choice (see below). In fisheries resource management, these operational rules set out how, where, when and by whom resources may be harvested. These rules have important implications for determining both the outcome of management objectives and the distribution of benefits. For example, banning the use a particular gear type may improve the overall yield from a fishery, but may displace certain groups or users from the fishery. Operational rules also include who should monitor and enforce rules and how, what sanctions will be applied for non-compliance and what information should be collected and exchanged. Operational rules are also the easiest facet of the decision-making arrangements to describe (and change) and therefore usually feature strongly in any prescriptive analysis of a resource system (Anderson *et al*. 1997).

Conditions for Collective Choice

The *conditions for collective choice* determine the rules for *how* decisions regarding the management of the resource are made. That is, who is eligible to make decisions and on what basis are they made. The specific form of these conditions will generally be determined by the cultural or social traditions. In some cases a single individual (eg village head or tribal chief) may hold responsibility for decision making (Anderson *et al*. 1997). In other cases, decisions may be made through a community management committee representing the interests of different stakeholders or ethnic groups, or by the fisheries department of a democratically elected government. In the latter case, decisions regarding the management of the fishery may be made on the basis of technical (theoretical) management models supported by detailed data and information collected through a formal monitoring system. At the other extreme, decision making within traditional or community-based management systems may simply rely on what is perceived to be successful, or on the basis of informal common-knowledge discussions among fishers (see later).

Who is involved in the decision making process is critical for compliance. Individuals not involved in the decision making process are less likely to comply if their aspirations are not represented in operational rules. Compliance may therefore be problematic in heterogenous communities, where consensus is difficult to achieve.

Given their often cultural context, conditions for collective choice normally relate not only to fishers, but to a wider arena and are, therefore, much harder to change than operational rules (Anderson *et al*. 1997).

External arrangements
Management objectives and the set of rules devised to achieve these objectives often cannot be perused or established in isolation of the wider political, legal, and market environment. External arrangements may determine who is eligible to make collective choice or operational rules and the types of rules that are permissible. They may also determine who has collective choice rights.

External arrangements may take the form of international conventions and codes of conduct (eg UNCLOS III, Code of Conduct of Responsible Fisheries) that define management obligations and therefore should be reflected in national and local policies. They may be the legislation necessary to establish the capability of local communities to engage in collective choice (eg the creation of local management committees), the enforcement of operational rules by external officers, or third-party arrangements (eg courts) to resolve disputes between resource users.

Markets arrangements will also be important in determining the economic parameters within which management of the resource is undertaken. For example, the seasonality of fish prices may greatly influence when a fishery might be 'closed' to conserve the resource.

Patterns of Interaction
Patterns of interaction describe the behavior of individuals when faced with the physical, technical and biological attributes of the resource system, and the decision-making arrangements (the rules) employed to govern its exploitation (arrows 1 & 2). Individuals perceived costs and benefits associated with rule compliance will determine their *incentives to cooperate* (or compete) and coordinate (or act alone). Incentives to cooperate may be influenced by many factors; (i) the availability of alternative livelihoods or sources of income; (ii) the opportunity costs associated with fishing; (iii) the effectiveness of enforcement measures and the severity of sanctions for non-compliance; (iv) support for the decision-making arrangements as determined by belief and degree of representation in the arrangements, and (v) the prevalence of free-riders (eg degree of poaching) or inequity in the distribution of benefits that can undermine collective effort (reciprocity) to comply with regulations. As illustrated above, patterns of interaction will also be affected by the biophysical nature of the resource (arrow1).

Outcomes
The patterns of interaction produce outcomes from the resource use (arrow 4). These outcomes include the yield from the resource, the distribution of benefits among stakeholders and the biophysical effects of fishing activities. These outcomes are typically the subject to human monitoring and evaluation, temporally and often spatially typically corresponding to issues of efficiency, optimality, sustainability, amelioration or deterioration and equity, and reflecting management objectives.

The hatched arrows in Figure 1 denotes that dynamic interaction exits among the four attributes. That is, outcomes may change the contextual variables and affect patterns of interaction. The former may occur due to resource depletion or environmental degradation, whilst the latter occurs with learning, causing individuals to modify their *operational rules* or management

strategies to produce better outcomes on the basis of their objectives. Similarly, individuals may employ different technology, such as less destructive fishing gears or invest in stock enhancement programmes that would change the contextual variables. The achievement of dynamic congruence between the decision making arrangements and the contextual variables (arrow 5) in order to achieve desired outcomes or objectives is the essence of fisheries management.

3.2 Fisheries Management - the process, roles and responsibilities

The framework described above usefully identifies the overarching role of fisheries management and effectively demonstrates the complexity of the process. However, at this stage it is also convenient to summarise, in more formal terms, the process of fisheries management and the main roles and functions required to support it.

The fisheries management process has been defined by FAO (1997) as being: "The integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and accomplishment of other fisheries objectives".

The process of fisheries management requires a number of roles to be performed:

1. Setting policies or objectives for each fishery, resource or *management unit* (see later). These must take into account as far as possible, the often conflicting biological, economic and social objectives of the various stakeholders who will be affected by the management of the resource and the overriding objectives of national planning and policy. For example, maximising economic returns from a fishery may be incompatible with maximising employment opportunities. A compromise may be required in order to achieve maximum compliance and cooperation from all stakeholders.

2. Formulation of management plans (MPs) for each fishery, resource or management unit to meet the management objectives. These are formal or informal arrangements between the management authority and other stakeholders which set out:

- Details of the stock, resource or management unit being considered.
- The agreed objectives.
- The decision making arrangements including:
  - (i) Stakeholder roles and responsibilities.
  - (ii) The management strategy - management rules and regulations (operational rules) applied to realise the objectives, including details of monitoring, control and surveillance (see below).
  - (iii) Decisions making methods; criteria upon which decisions and management regulations will be based, evaluated and adjusted as necessary (conditions for collective choice).
- Other relevant details about the fishery.

These management plans effectively serve as a reference and information source for those stakeholders involved in the management of the resource, summarising the state of knowledge of the resource, its environment and the fishery, and the management decision-making arrangements ie who may do what in relation to whom. The development and implementation of management plans for all resources or management units promotes a coordinated spatial approach to management, whereby interactions and externalities among units can be monitored,

evaluated, and ultimately avoided.

The operational management plan may also detail the costs and benefits in order to justify the expenditure on the various components of the management system. Costs may include administration, and staff and capital equipment for monitoring, evaluation, control and surveillance. Benefits are often less easy to quantify, particularly where they result in social or conservation rather than economic returns (Mees 1998).

3. Implementing Management Plans (Monitoring, Control and Surveillance, MCS).
This involves the action and decision-making required to ensure that the management plan is put into operation and operates efficiently. These include monitoring (collecting), collating and analysing the data and information necessary to evaluate the performance of the management strategy in relation to the broader decision-making arrangements and contextual variables, and enforcing the control mechanisms (management regulations that control exploitation by controlling inputs or outputs) through surveillance operations.

4. Reviewing Management Plans
As illustrated in Section 3.1, both the contextual variables and the decision-making arrangements will change with time. This demands that the effectiveness and efficiency of the management plan be regularly evaluated with revisions as necessary. This review process in relation to desired outcomes and objectives forms the basis of adaptive management strategies (see later).

5. Other roles to facilitate and support the management process

Other roles required to facilitate the management process include:

- Develop national fisheries policy and coordinate planning decisions:

National fisheries policy describes the broad directions on how resources are to be utilised and the priorities to be given and criteria by which access to resources is granted. These decisions are made in the macro-policy and macro-economic (multi-sectoral) context and include the coordination of fisheries with other sectors of the economy having an impact on the fishery. It is therefore important that policy and planning decisions are made in the full knowledge of the role of fisheries in the regional, national and local economy, and the implications, costs, benefits and alternatives for use of the resources, before the best policy decisions can be made.

- (Inter-)national reporting responsibilities

The development of effective and efficient national fisheries policy therefore demands information to provide a clear understanding of the position and status of fishing in the regional, national and local levels. This information may include, for example, information on the catch, economic value (export duties, licence fees... etc) and employment opportunities for each fishery, social group or geo-political area. Information is also needed to assure the public at large that resources are managed responsibly and that management objectives are being achieved (FAO 1997). Information may also be required for organisations and conventions such as the United Nations Food and Agriculture Organisation (FAO), Convention for International Trade in Endangered Species (CITES) or Ramsar (Sections 4.6 & 4.7).

- Compliance with International Management Responsibilities

Governments often have international responsibilities for the management of resources. These *external arrangements* often take the form of international conventions and codes of conduct (eg UNCLOS III, Code of Conduct for Responsible Fisheries), which if ratified, define management obligations that should be reflected in national and local policies (Section 3.1).

- Establishment of an appropriate legal and institutional frameworks (conditions for collective choice) for management.
- Conflict Resolution

Fishery managers will often need to resolve conflicts by means of external arrangements (see Section 3.1), either between different fisheries or between fisheries and other sectors that have an impact on the fisheries (eg agriculture, transport, industry... etc).

- Conduct ad-hoc research

In addition to the routine collection of information collected under MCS programmes to evaluate the performance of the management strategy, *ad hoc* research or assessments may be conducted to improve the understanding of the fishery and to help develop management plans.

- Provision of technical advice

A technical understanding of a fishery can be gained through traditional knowledge (often detailed and specific to a particular area) and scientific knowledge gained through *ad hoc* research and MCS programmes. Technical guidance contributes to the assessment of the fishery and the development and implementation of management plans.

- Communication

Effective communication is required to build trust among stakeholders and encourage their continued participation in the co-management partnership. The exchange of information is also important to develop, maintain and improve the fisheries management process. A variety of different mediums of communication exist including meetings, posters, radio transmissions (Muthiah 1991), workshops, newsletters...etc.

3.3 Artisanal Fisheries

Artisanal fisheries are generally characterised by the small-scale use of low technology fishing gear, over a limited range, often, but not always for subsistence needs. This contrasts with industrial fisheries which generally employ higher technology over greater ranges, predominantly for commercial purposes. This division is often subjective, and what is considered artisanal in one country, may be considered industrial in another (Nielson *et al*. 1995).

Artisanal fisheries are mostly associated with developing countries. Developing countries are typically tropical or sub-tropical where species diversity is high and geographical range relatively small. Artisanal fisheries therefore tend to be based upon numerous small stocks and multispecies assemblages inhabiting diverse habitats (Mahon 1997). Some tropical river systems contain more than 200 species of fish and crustaceans with a range of different life histories and migratory behavior (Hoggarth *et al*. 1999). The diverse range of habitats and species are reflected by an equally diverse range of fishing gears and operations. For example, the inland fisheries of Bangladesh are exploited with more than 100 different types of gear (FAP17 1995), many specific to local conditions and (hydrological) seasons of the year. Fishers may be full-time professionals, often working as groups with expensive fishing gear, or only part-time, perhaps working on their own with more simple gear. Part-time fishers may alternate seasonally between fishing and other occupations, such as agricultural labouring. In poor, heavily populated countries where the opportunity costs of fishing are very low, the numbers of fishers can rise to exceptionally high levels (Hoggarth *et al*. 1999). Pomeroy and Williams (1994) estimate that in the developing world, between 14-20 million are directly involved in fisheries (and aquaculture), and about 1 billion rely on protein from aquatic products as their main source of animal protein.

In contrast with many temperate commercial or industrial fisheries, artisanal fisheries therefore tend to be very important from a socio-economic perspective, diverse, complex and dynamic.

3.4 Co-Management - the Search for better methods

The western (temperate) paradigm of fisheries management has tended to focus on maximising resource output using technical *operational rules* or regulations on the basis of quantitative (single-species) biological model-based predictions, set and enforced by a centralised (government) administrative authority. By largely ignoring *patterns of interactions* (fishermen behavior), *conditions for collective choice* and *external arrangements* (and their interactions), this paradigm has often failed to coordinate and restrain resource users, leading to depleted resources, inequity and conflict (Mahon 1997; Pomeroy and Williams 1994).

The failure of this paradigm is particularly prevalent in artisanal fisheries in developing countries; commonly exacerbated by the states paucity of resources and institutional capacity to conduct (and interpret) formal assessments, and monitor and enforce rules and regulations among the widely dispersed resource users. Often, the technical management models employed to guide decision-making process are inadequate to capture the dynamic complexity of the fisheries. Fisheries management experts now recognise that the underlying causes of fisheries resources over exploitation and environmental degradation are often of social, economic and institutional origins.

During the 1960's and 1970's, government and NGOs rural development programmes placed increasing emphasis on the role of the community in fisheries management. The incentives for this approach were numerous but government willingness to devolve difficult or expensive management responsibilities and the local-level desire for empowerment helped fuel the process (Hassett 1994). A huge literature has been developed reviewing past experiences and prospects for community-based management in agriculture, fisheries and forestry, together with a theoretical treatment of the benefits to be derived from a community approach. Frequently cited advantages of community management include:

- Increased sense of ownership encouraging more responsible exploitation.
- Policy and practice are sensitive to local socio-economic and ecological constraints;
- Appropriate and relevant policy is honed by local knowledge and expertise;
- Participation in decision making engenders a collective ownership ethic;
- Increased compliance through perceived legitimacy and local peer pressure; and
- Greater incentives for reliable monitoring via the user.

Community-based development projects often placed an emphasis on consolidating traditional management practices and the accompanying systems of use rights, but with the globalization of markets and increasing pressure on the resource base it was clear that government had a fundamental role to play in co-ordinating initiatives and representing rural needs nationally and internationally.

As the rural development debate of the late 1970's placed greater emphasis on government/resource-user relations, the term "co-management" evolved to represent an idealised balance of rights and responsibilities between the State and stakeholder. Despite lacking a universal definition, co-management became a central theme in much of the fisheries policy literature regarding both developing and developed world scenarios (e.g. Pomeroy and Williams 1994; Phillipson 1996).

An Economic Rationale for Co-management

The study of common property predicts that resources such as fisheries, which are non-exclusive in nature, will suffer from problems of regulation and from subtractability (e.g. Feeny *et al* 1995). By definition, limiting access to the resource is difficult and costly and the behavior of each actor will detract from the welfare or utility of others. Management institutions evolve or are devised to regulate and control access to the resource and prevent an unacceptable dissipation of rent or benefits from the resource. Pomeroy and Berkes (1997) identify three basic regimes for this purpose: a) state ownership and governance where rights are controlled by government on behalf of all citizens; b) communal property where the resource is held by an identifiable group that can exclude others and can self-regulate; and c) private ownership where an individual or corporate body has the right to exclude and regulate resource use. Pomeroy and Berkes accept that overlapping combinations of all three systems are likely to be found but claim that the co-management relationship is based on interaction between a state system and communal system of management.

The rationale and functioning of state ownership and private ownership systems has been elaborated in the "theory of the state" Ostrom (1990) and the "theory of the firm" (after Coase 1937). As Ostrom indicates, in both systems the users are co-ordinated and impelled to maximise collective output from the resource, either through compulsion and coercion by the state or through voluntarily entering a contract with an entrepreneur. With respect to state management these gains and the performance of the fishery may be measured against a variety of predetermined criteria such as maximum economic yield, maximum employment or issues of social equity, while private management success is determined through the market performance of that firm. Ostrom illustrates how both systems suffer from the "problem of credible commitment" whereby the benefit to the actor in cheating within a functioning system will tend to outweigh net gains from compliance. Co-management can be viewed as an attempt to increase the incentive to comply by blurring this fundamental distinction between managers and the managed. Certain management responsibilities, together with their potential local benefits and risks, will have effectively been leased to the users but ultimately the resource will remain *res publica* and the state will hold the veto on any arrangements brokered.

3.4.1 A Typology of Co-management

Sen and Nielson (1996) provide a useful typology of co-management based on the level and mode of communication between government and the resource user (Figure 2). A spectrum exists between paternalistic "instructive" arrangements, with minimal exchange of information between government and user, to "informative" arrangements whereby users are delegated decision making power but inform government of change. Within this gradation Sen and Nielsen identify a "co-operative" mid-point as a desirable goal and loosely define fisheries co-management as:

"..an arrangement where responsibility for resource management is shared between the government and user groups."

A graded treatment of co-management is enlightening because it highlights the range of interactions that might be found and the probability that they will differ from country to country and even between fisheries or *management units*. In addition, while the focus of most co-management literature is the nature and shape of institutional hierarchies within countries, the above model approaches the relationships in terms of pathways and directions of information flow. Co-management might be supported by smoothing this flow of information - both of data and of dialogue or "conferral" information (see Alsop and Farrington (1997)).

Numerous fisheries (or aspects of fisheries) can be considered co-managed according to such

an open definition and these systems of management can be well established. The inshore fishery of Japan is managed on a hierarchical and national system that has evolved gradually from institutional structures delineated during the feudal period (Balland and Platteau 1996). The legitimacy of the fishermen's guild as the body responsible for decisions regarding local access and fishing techniques was codified in law as early as 1719.

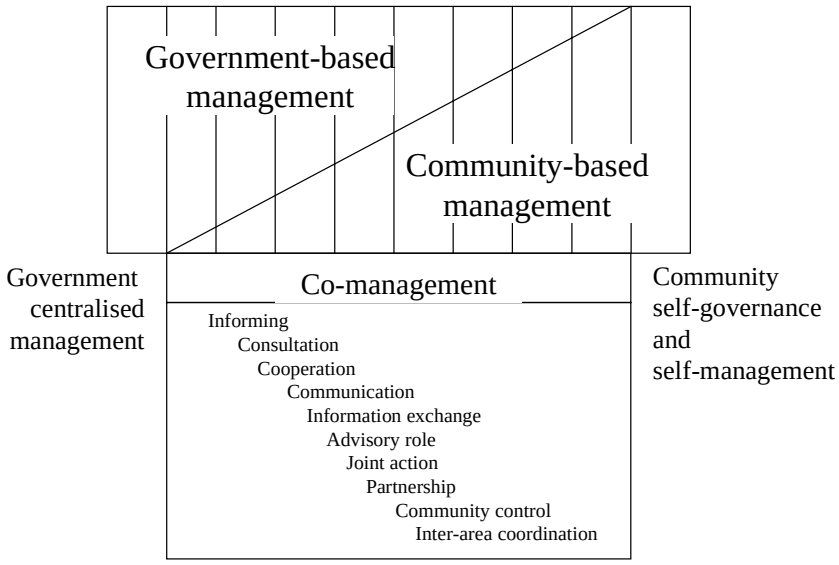

Figure 4 The 'Berkes hierarchy' of co-management arrangements (after Pomeroy and Williams 1994)

3.4.2 Co-Management of Artisanal Fisheries

The range of relationships between government and resource user reflect institutional and bureaucratic arrangements, user representation, political will and ultimately the desirability of partnership. For this reason co-management in the context of artisanal fisheries may involve quite different systems and patterns of interaction from those of industrial fisheries. Whereas these relations in the developed world tend to receive relevant bureaucratic and legal support and are contractual in nature, co-management in the developing world may be locally contained, piecemeal and a more ad hoc process. If politicised and unified user groups are absent, NGOs may play a critical role in articulating and representing local objectives and concerns by reacting to current policy, or through incorporation into national policy frameworks as in Bangladesh and the Philippines, respectively.

The constraints to achieving a co-management process in artisanal fisheries will reflect the current and historic nature of government and bureaucracy in the country in question. Both government and users may have to re-learn their roles and this process will be problematic where a top-down system of patronage has operated. Kuperan and Abdullah (1994) have ranked the prospects for successful co-management in eight south-east Asian countries by incorporating such factors as pre-existing local organisational capacity, ethnic diversity, geographic spread and the distribution of existing marine tenure systems. Significantly, government commitment was considered fundamental and the Philippines ranked first on the basis of that country's national mandate towards decentralisation and the legislation already in

place to support a hierarchical and locally-inclusive frame for management (see Pido *et al* 1995).

3.4.3 Conditions for Successful Co-management

On the basis of research conducted during the last two decades, certain conditions emerge which appear central to developing and sustaining successful co-management arrangements (Pomeroy and Williams 1994):

- Clearly defined boundaries
- Membership is clearly defined
- Group Cohesion
- Organisational capacity exists
- Benefits of participation must exceed costs
- Individuals affected by management arrangements are included in decision-making
- Management rules are enforceable by resource users
- Legal frameworks exist that give users ownership over resources and authority to make management decisions.
- Cooperation and leadership at the community level exist
- Decentralisation and delegation of authority
- Coordination between government and local community.

3.5 Identifying Generic Co-management Information Requirements - a dynamic multi-dimensional problem

3.5.1 What information is required?

Management information is defined here as the information and data required to support management roles and responsibilities in order to achieve the dynamic congruence between the decision making arrangements and the contextual variables described in Sections 3.1 & 3.2. Arguably all management roles require information in one form or another since they all involve or support some form of decision making. However, four main roles, already introduced in Section 3.2, are particularly reliant upon data and information:

(i) The formulation of management plans;
(Ii) The implementation and review of management plans:
Data and information collection (monitoring),
Evaluating the performance of management strategy,
Enforcement of management regulations
(iii) The development of national policy and the coordination of planning decisions
(Iv) (Inter-)national reporting responsibilities.

3.5.2 How might information requirements vary?

The actual information that is required to manage the fishery will depend upon *who* has responsibility for each role and on *what basis* decisions are made. Three major categories of *stakeholders* or individuals, groups, or organisations with an *interest* or *stake* in the fishery (Hoggarth *et al*. 1999) will usually take responsibility for one or more of these roles:

- Government departments eg Department of Fisheries
- Intermediary organisations eg NGOs; donor projects, research institutes etc
- Fisher communities

Government departments will invariably take on the (inter-)national reporting responsibilities, the

development of national policy, and the coordination of planning decisions. However the formulation and implementation of management plans may be undertaken (to some degree or another) by all three stakeholders (Table 1).

Table 1 Potential roles and responsibilities for the main stakeholders of a fishery

Stakeholder	Management role					
				Implementation of MP		
	National Policy & Planning	Reporting Responsibilities	Formulation of MP	Monitoring	Evaluation	Enforcement
Government	✓	✓	✓	✓	✓	✓
Intermediaries			✓	✓	✓	
Fishers			✓	✓	✓	✓

Who actually takes on these respective roles is determined by the position of the fishery on the Berkes co-management spectrum (see above). To illustrate the complexity of the problem of trying to identify generic information requirements, there are more than 1000 combinations of stakeholder roles with respect formulation and implementation of management plans in Table 1 alone even before consideration is given to the type of information that may be employed among and within the stakeholder categories and the extent of their involvement! Moreover, these roles may well change with time as the co-management arrangements evolve.

Potential Variation in data and information requirements

Several factors affect data and information requirements to develop and implement management plans. To begin with, the objectives for the fishery set out in management plans will vary among and within stakeholder groups depending upon their interest or stake in the fishery. Government objectives and policies are usually broad-reaching taking account of international responsibilities and national aims such as the protection of biodiversity, the alleviation of poverty, or the amelioration of landings. Local fisher communities may have more defined objectives such as improved food security or income. These different objectives will demand different information to evaluate the success or extent to which they are being achieved. For example if the management objective was to maximise the catch of fish species X, then obviously it would be necessary to monitor the catch of species X (the outcome) or some proxy or *indicator* of catch such as the availability or price of fish, or the number of fish meals consumed by a villager each week. Similarly, if the objective was to conserve biodiversity, then it would be necessary to monitor the abundance of all fish species or some proxies. What is actually monitored, particularly with respect to proxies or indicators, will therefore also be closely related to management performance evaluation criteria or decision-making method.

The way in which the performance of a management strategy is evaluated, that is decisions about how best the operational rules, decision-making arrangements and contextual variables may be changed, improved, adjusted or enhanced to achieve desired outcomes or objectives, as set out in the MP, will also dictate data and information requirements. Arguably, information on all four of the attributes described above is necessary for this role.

At the simplest level are what may be termed *default* or *status indicators* and their *proxies*. These describe the basic outputs, outcomes or present states arising from a particular management strategy or policy, and can be used to monitor change or trends. Although

measuring and monitoring such simple outputs or outcomes is necessary, they have limited value from an active management perspective. Such basic information cannot, by itself, inform managers whether or not the particular outcome can be improved or increased, or what measures could be taken to make improvements.

To reconcile this problem, decision-makers frequently employ frameworks or models which, in addition to the outcome (outputs), may also include information relating to inputs, and factors affecting both inputs and outputs to improve understanding and decision-making. These may take a variety of forms including (i) cognised (conceptual) models of the fishery[3] developed through perception, reasoning, intuition, or even superstition; (ii) empirical models developed on the basis of experience or *adaptive management*; and (iii) theoretical (technical) models of the fishery. These frameworks and models are expressed verbally, graphically, physically or quantitatively.

The technical models are typically quantitative and often based upon theories of population dynamics and economics (biometric and econometric models) . They attempt to generalize the fishery, often in terms of variables that can be controlled by operational rules or external arrangements(eg allowable fishing effort, mesh sizes, economic (dis) incentives), and outcomes (eg catch or economic rent). In this way they may be regarded as "theoretical laboratories" for exploring interactions in fisheries systems (Padilla and Charles 1994). However, as stated earlier, the utility of technical models from a management perspective is often limited by their failure to take account of *patterns of interaction* (fisherman behavior), *conditions for collective choice* and *external arrangements*, and their ability to successfully accommodate aspects of the contextual variables, particularly environmental affects, which can be both significant and complex in dynamic, heterogenous environments such as floodplain river systems. Many of these technical models demand large amounts of costly information or data generated through research or fishery assessments to estimate their, often numerous, parameters.

The different stakeholders will employ different decision-aiding models or frameworks depending upon their objectives, preferences and (institutional) capacity (their resources, skills, knowledge, motivation and legal rights). Their information and monitoring requirements will therefore vary accordingly. For example, local communities might employ informal cognised models, whilst fishery departments are more likely to have the capacity to collect, collate and analyse data and information to support a more formal technical models. On the other hand, intermediaries, such as NGOs, may have the capacity to employ frameworks such as Oakerson to examine patterns of interaction (fisher behavior) under various conditions for collective choice in order to provide advice to the other main stakeholders on the most appropriate organisational or institutional arrangements to achieve various outcomes.

In reality, it may be necessary or useful to employ a variety of these different models and frameworks together to gain a greater understanding of the fishery and to improve overall decision-making.

The choice of management control measures (Annex 1), to realise the management objectives will also affect data and information requirements, which are often optimised using technical management models. For example, management controls aimed at regulating fishing effort or total catch are often optimised using surplus production type models which have very different data and information requirements to that of age-structured models commonly employed to explore optimal technical regulations such as minimum mesh sizes to limit the age of fish at first capture (see later). Local conditions may dictate which control measures are appropriate and enforceable.

[3]This category would include the Oakerson (1992) framework.

Information is also required to enforce operational rules (management regulations). When enforcement is the role of a fishery department, this information may be quite formal, such as lists or registers of vessels detailing who may fish where with what gear or vessel. Local communities would more likely enforce rules on the basis of common knowledge.

In summary the, information requirements to support the management process will therefore be largely influenced by:

- The position of the fishery on the Berkes spectrum (Figure 2) which will determine which stakeholders are involved in the development and implementation of management plans;
- the objectives of these stakeholders;
- the management control measures;
- their decision-making methods;
- their institutional capacity, and;
- their preferences and local conditions.

The continuous spectrum and evolutionary potential of co-management arrangements, coupled with the inter-dependence among several of the factors identified above, presents a potentially dynamic and multi-dimensional problem to identifying management information requirements and therefore to designing a FIMS.

3.6 Constraining the Problem - a potential solution

In order to provide some basis with which to begin to examine management information requirements for a generic co-management FIMS, there is clearly a need to constrain the independent dimension (variable) - that is, the position of the fishery on the Berkes spectrum.

Sen and Nielsen (1996) suggest that a co-operative mid-point along this spectrum is desirable where responsibility for resource management is shared between the government and user groups. Hoggarth *et al* (1999) propose a co-management system based around this position which effectively matches the main stakeholders, with the necessary motivation and institutional capacity, to the various management roles. This is achieved by sharing management responsibilities for *management units* both hierarchically and spatially. Although the system was originally conceived for the co-management of artisanal tropical floodplain-river fisheries, it's inherent flexibility permits a wider application to other environments and fishery types.

3.6.1 Management Units

Hoggarth *et al*. (1999) sub-divide river systems into four main categories of management unit based upon the spatial interactions between the environment, fishing communities and the fish stocks: (Inter)National Management Areas; Catchment Management Areas (CMAs), Village Management Areas (VMAs) and Intermediate Management Areas (IMAs) (Figure 5). This classification may be extended to the other two main categories of artisanal fishery : large lake[4] and coastal marine fisheries (Figure 6 & 7). For the latter, the CMAs may be replaced by Regional Management Areas (RMAs).

[4]Small lakes are common features of most river systems and can be managed as IMAs. Similar to river systems, much larger lakes, such as the African Great Lakes, may contain several different ecosystems and drain one or more whole catchment areas, with boundaries shared among several different countries.

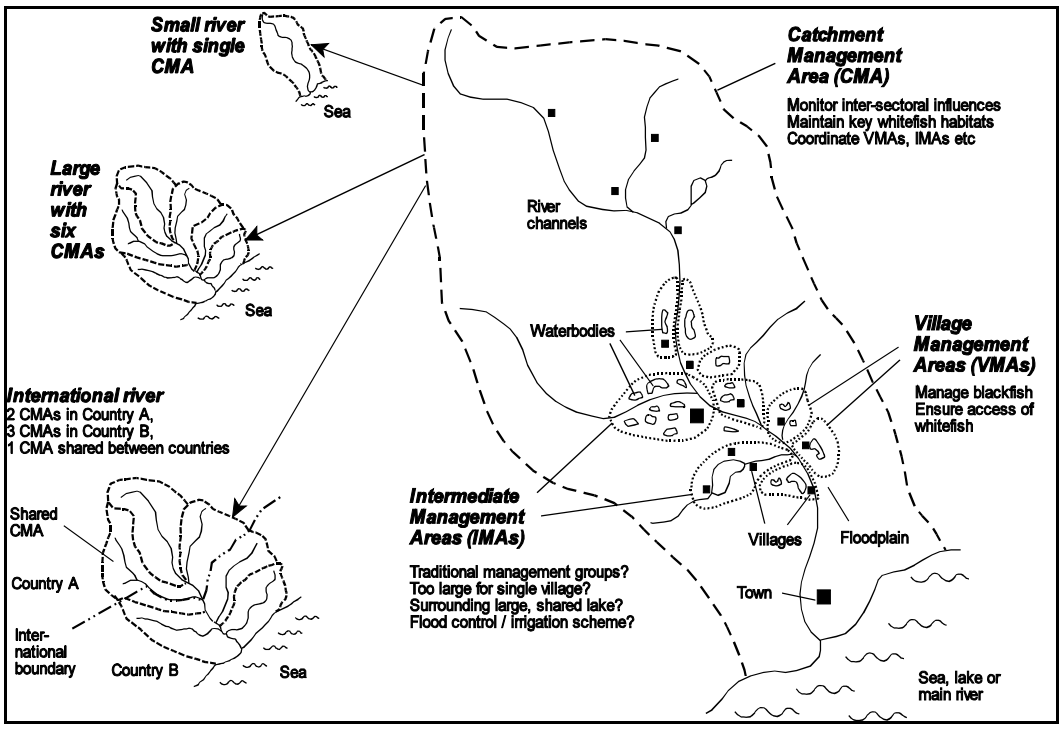

Figure 5 Floodplain-river management units (source: (Hoggarth *et al.* 1999)).

National Management Units.
Fisheries resources, particularly highly migratory species, often extend throughout a country, or a countries jurisdiction, or even between two or more countries[5]. National fisheries policy and planning decisions, including coordination of activities and conflict resolution among different sectors, must be made at this level (Section 3.2). The creation of legal frameworks for management, and the provision and sharing and information that will improve fishery management on a national scale should also be conducted at this level. National and international reporting responsibilities also exist at this level.

Catchment and Regional Management Units (CMAs and RMA's).
Catchment and regional management units represent the second tier in the nested arrangement of management units. These provide a rationale management perspective for migratory stocks confined to individual river/lake catchment areas or limited to coastal regions and an effective platform to coordinate the activities and resolve conflict among different sectors, or more local management units exploiting both sedentary and migratory stocks.

Village Management Units (VMAs)
Village management units form the lowest tear is this system of arrangements. The high spatial and temporal heterogeneity and variability within many river, lake and coastal (reef) systems and the communities that exploit them means that single overarching approaches to managing these systems are often inadequate, inappropriate or ineffective. Dividing aquatic resource systems into a number of small, local management units associated with cohesive social groups or communities such as villages, provides a potentially effective solution for the management of sedentary stocks.

[5] 'Straddling' or 'shared stocks'

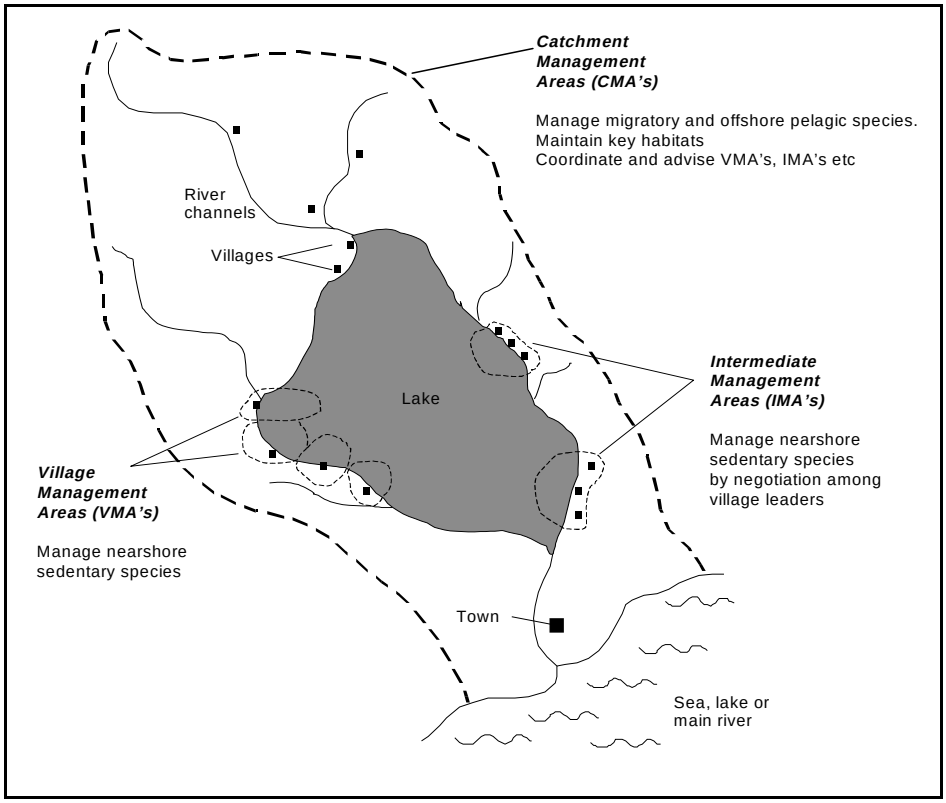

Figure 6 Lake System Management Units

VMAs should be based upon an ecosystem or some small spatial unit with well defined boundaries (Section 3.4.3) such as small floodplain waterbodies (*beels*, village ponds, small lakes...etc), small stretches of lakeshore or isolated reefs (Figure 5-7), where interactions between the environment, fishers and fish stocks can be monitored, understood and managed.

Intermediate Management Areas (IMAs)
It is not always possible or appropriate to divide aquatic systems into VMAs when the distribution of villages and resource sub units (ie waterbodies, lakeshores, reefs... etc) may mean that the catches in each village are largely dependent upon the activities of neighboring villages. This may occur when, for example, migration or transport rates of fish or progeny between isolated reefs, each under the tenure of different social groups (communities, villages...etc), is high, or when a single floodplain lake is shared between a number of villages. Under these circumstances, the management area may need to be extended to a size that is intermediate between VMAs and CMAs and RMAs in order to achieve maximum overlap between the range of authority of the social group and the distribution range of the resource.

3.6.2 Matching Stakeholders to Management Roles Hierarchically and Spatially - Who might do what?

No single group of stakeholders will have the capacity to take on all the roles necessary to manage all the levels described above. The full combination of capacities required may only be available in co-management partnerships involving representatives of different stakeholders at the appropriate levels (Hoggarth *et al*. 1999).

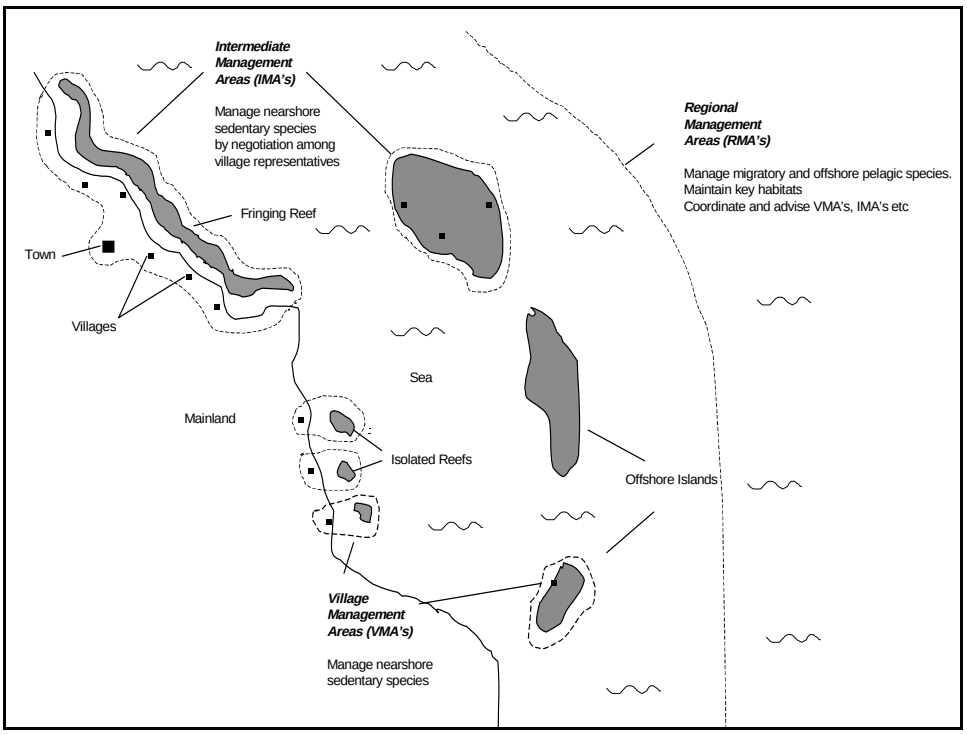

Figure 7 Coastal Management Units.

Although the stakeholders who should take on the management of the various management units will depend upon their respective capacities and other local factors, the following match is most likely to be appropriate:

Government Departments
Government involvement at all levels of management is both appropriate and necessary. Indeed, the administrative structure of ministries provides a complimentary nested structure (eg national, regional, district... etc) to support these layers of management units. At the national level, governments, as representatives of the state, will invariably be responsible for developing and evaluating national policy and planning decisions, monitoring and coordinating sectoral interactions and for ensuring compliance with (inter)national management and reporting responsibilities (Section 3.2). Governments are usually the only institution that can establish the necessary legal frameworks to support co-management arrangements.

Governments are also best positioned to take the necessary holistic perspective for the management of migratory stocks (MS) which may migrate throughout river catchments, lakes, coastal regions or even across international boundaries. They must also take responsibility for the management of sedentary resources not under the jurisdiction of local communities within VMAs and IMAs. These state owned sedentary resources (SOSRs) may correspond to extensive areas of a river and lake catchments or coastal regions, particularly during the initial stages of the creation of co-management arrangements, and may remain significant in those areas where the devolution of authority to local users is not possible because the necessary conditions or criteria for community-based management (see Section 3.4.3) simply don't exist or cannot be satisfied. At the national and CMA/RMA levels, governments would therefore be expected to have major roles in the management of these resources; establishing management objectives, and formulating and implementing overarching management plans with the support,

local knowledge and technical advice from both local users and intermediaries.

Governments would primarily hold responsibility for implementing the MPs with respect to collecting and collating their information and data, conducting ad hoc research, evaluating the performance of the management plans and enforcing the management tools or regulations employed to achieve the management objectives.

A particularly important role for governments under these arrangements would be the coordination of management plans among VMAs and IMAs to ensure that management strategies are complementary, non-antagonistic and in line with government policy. This role would require full details of each VMA and IMA management plan.

At the VMA and IMA levels, governments could help local managers formulate and implement MPs for sedentary resources on the basis of their knowledge and lessons gained through (i) *ad hoc* research; (ii) the management of migratory stocks and SOSR; and (iii) from monitoring, evaluating and comparing, on a spatial and temporal scale, the performance of individual management strategies or plans employed by local VMA and IMA managers to meet different objectives. The latter would also require full details of each management plan as well as strategy performance indicators. This provides a particularly powerful means of facilitating adaptive management at the local level (see later).

Governments may also have a role in funding or providing credit to local users or local management groups to purchase gears, fishing licences or raw materials for stock enhancement programmes such as seed fish, fertilizer...etc.

Local Communities

As described above, the spatial and temporal heterogeneity and complexity within many river, lake and coastal (reef) systems and the users that exploit them, combined with the paucity of resources and capacity faced by most fisheries departments (Sections 3.3 & 3.4) suggests that management decisions and activities should be flexible and made at a very local level with respect to sedentary resources. This is because management objectives are most likely to be achieved when management rules (decision-making arrangements) are well adapted to both the physical characteristics of local resources and to the social priorities of local users. With their intimate knowledge of their resources, and their capacity for mutual monitoring and enforcement, local communities or social groups are best placed to manage sedentary stocks at the local VMA level. The application of management strategies at this local level may result in improved local output, and give benefits to the local community. Communities thus have an *incentive* to sustainably manage their local sedentary species, particularly where they have local ownership rights'.

Where independent management by one village may be negatively affected by the actions of other villages then spatial VMAs would not be appropriate, but instead, village leaders control the fishing activities of their own local people. An umbrella committee may be formed with representatives of each village to negotiate and agree rules to be followed at an IMA level (eg Beach Village Committees (BVC) in Lake Malawi/Malombe - see Hara (1996)). Simpler management strategies are required for IMAs due to the increased difficulties of roles such as monitoring, communication, co-ordination and enforcement within larger areas and among potentially less cohesive larger social groups or communities.

VMA and IMA managers would be responsible for setting objectives and developing management plans for their local sedentary resources, but under the auspices of government representatives to ensure that they are in line with government policy and to minimise interaction among neighboring VMAs/IMAs. VMA and IMA managers may choose to draw upon the knowledge,

advice and support from intermediaries and governments departments when formulating management plans, particularly with respect to selecting, establishing and refining appropriate institutional and decision-making arrangements and management strategies.

At the same time, VMA/IMA managers may reciprocate support be providing local knowledge to help governments both formulate management plans and interpret the performance of their management strategies. They may also help governments implement their management plans for migratory stocks and SOSR by aiding data collection, and enforcement by reporting rule breaking.

Intermediary Organisations

This category covers a range of organisations, such as NGOs, international projects, aid agencies, extension and development projects. Such organisations are often active in rural areas and may help to improve linkages between government and communities. These groups often have a poverty focus which includes resource management and may extend to environmental protection. Projects are often research-based, aiming to understand the nature of the resource systems to improve management. These organisations usually have strong skills in training extension and communication which can assist both governments and communities with their responsibilities for fisheries management.

At the national and CMA/RMA levels, these intermediary organisations, have the capacity to conduct research to help governments formulate and implement their management plans, and evaluate the performance of their management strategies for migratory stocks and SOSR. At the VMA/IMA level, they can help governments evaluate the performance of local VMA/IMA management strategies by assisting with the analysis and interpretation of spatial and temporal comparisons of different VMA/IMA management plans described above.

They are also usually well equipped to help VMA/IMA managers formulate management plans for their sedentary resources during the evolution of co-management arrangements by providing technical knowledge and helping to establish effective institutional and organisational arrangements to engender collective decision-making. They are also likely to have an important role in providing credit, training and extension, developing skills, and in helping local managers evaluate the performance of, interpret, and revise, their management plans. In particular, they are critical in clarifying roles, introducing management methods and procedures, encouraging stakeholders to take on new management responsibilities, helping to identify the benefits of participation, and reinforcing the relationship between stakeholder groups (Hoggarth *et al*. 1999).

Table 2 below summaries this idealised spatial match between the main stakeholders and key management roles and activities.

Table 2 Idealised co-management arrangement summarising the spatial match between stakeholders and management roles and activities.

	Management Unit		
Stakeholder	National	CMA/RMA	IMA/VMA
Government Departments eg. Department of Fisheries	• Develop and evaluate national policy and planning. • Meet national and international management and reporting responsibilities. • Ensure compliance with International management responsibilities. • Establish necessary legal frameworks for management, including mechanisms to enable resource users to manage local resources. • Monitor and co-ordinate sectoral interactions (including conflict resolution). • Set management objectives for MS and SOSR in consultation with local resource users. • Formulate MP's for MS and SOSR with help (eg provision of technical advice) from, and by consulting with, intermediaries and local communities. • Implement MP's for MS and SOSR: collect information and data and conduct research to evaluate performance of, and review, management strategy; enforce management regulations.	• Monitor and co-ordinate sectoral interactions (including conflict resolution). • Set management objectives for MS and SOSR in consultation with local resource users. • Formulate MP's for MS and SOSR with help (eg provision of technical advice) from, and by consulting with, intermediaries and local communities. • Implement MP's for MS and SOSR: collect information and data and conduct research to evaluate performance of, and review, management strategy; enforce management regulations. • Co-ordinate management plans among IMAs,VMAs and ensure that local objectives and management strategies are complementary and non-antagonistic.	• Help VMA/IMA managers formulate and revise MP's and strategies for sedentary resources with results from: (i) ad hoc research; (ii) Management of MS and SOSR at CMA and RMA level; and (iii) Monitoring (spatial and temporal) and analysis of the performance of individual management strategies (plans) employed by local VMA and IMA managers. • On the basis of (iii) Communicate lessons and experiences of management among VMA and IMA managers regarding appropriate MP's to meet different objectives. • Fund or provide credit support for local users for stocking, buying fishing gear, licences...etc.
Intermediaries eg. NGOS's, Research Institutes, Donor Organisations	• Conduct research to help governments formulate and implement MP's for MS and SOSR. • Help governments evaluate the performance of management strategies for MS and SOSR.	• Conduct research to help governments formulate and implement MP's for MS and SOSR. • Help governments evaluate the performance of management strategies for MS and SOSR. • Help governments and local communities coordinate IMA/VMA management plans and resolve conflicts by encouraging dialogue and communication.	• Conduct research (eg stock assessments, institutional analysis...etc) to help local communities formulate and implement MP's for sedentary resources. • Help governments evaluate the performance of IMA/VMA management strategies for sedentary resources (eg stock assessments, institutional analysis or assisting with spatial analysis, including profiling IMA/VMA MP's - see above). • Help governments communicate lessons and experiences of management to VMA and IMA managers regarding appropriate MP's to meet different objectives. • Help VMA/IMA managers formulate MP's for sedentary resources by helping to build capacity and establish effective institutional and organisational arrangements to engender collective decision-making. • Help VMA/IMA managers implement MP's for sedentary resources by providing credit, training and education.
Local Communities eg Village communities, User Organisations	• Provide local perspective and technical advice (local knowledge) and any other information to help governments formulate MP's and evaluate and interpret the performance of management strategies for MS and SOSR. • Where incentives exist, help governments implement MP's for MS and SOSR by aiding data collection (monitoring) and enforcement (reporting rule breaking).	• Provide local perspective and technical advice (local knowledge) and any other information to help governments formulate MP's and evaluate and interpret the performance of management strategies for MS and SOSR. • Where incentives exist, help governments implement MP's for MS and SOSR by aiding data collection (monitoring) and enforcement (reporting rule breaking).	• Set management objectives for sedentary resources. • Formulate MP's for sedentary resources. • Implement MP's for sedentary resources. • Provide local perspective and technical advice (local knowledge) and any other information to help governments formulate MP's and evaluate and interpret the performance of management strategies for MS. • Where incentives exist, help governments implement MP's for MS by aiding data collection (monitoring) and enforcement (reporting rule breaking).