A DATABASE BASED INFORMATION SYSTEM FOR ARTISANAL FISHERIES MANAGEMENT

A Case Study of Moma-Angoche in Mozambique

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Disclaimer

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Abbreviations and Acronyms

AFIM	Artisanal Fisheries Information Management
AFM	Artisanal Fisheries Management
AFMA	Australia Fisheries Management Authority
ArcGIS	Architecture Geographic Information systems
BfG	*Bundesanstalt fur Gewasserkunde*
CASE	Computer-Aid Softer Engineering
CBFM	Community Based Fisheries Management
CCP	*Conselhos Comunitários de Pesca* (Community Fishing Councils)
CCTA	Central Computer and Telecommunication Agency
DAFF	Department of Agriculture, Fisheries and Forestry
DANIDA	Danish International Development Agency
DBMS	Database Management System
DDL	Data Definition Language
DML	Data Manipulation Language
DFD	Data Flow Diagram
DSS	Decision Support System
EAR	Entity-Attribute Relationship
ERD	Entity Relationship Diagram
FAO	Food and Agriculture Organisation of the United Nations
FM	Fisheries Management
FTD	Fisheries Technology Department
GBRMPA	Great Barrier Reef Marine Park Authority
GDP	Gross Domestic Product
GIS	Geographic Information Systems
ICLARM	International Centre for Living Aquatic Resource Management
ICT	Information and Communication Technology
IDPPE	*Instituto Nacional de Desenvolvimento da Pesca de Pequena Escala*

	(National Institute for Small Scale Fisheries Development)
IEM	Information Engineering Methodologies
IFM	International Fisheries Management
IS	Information System
ISAC	Information System work and Analysis of Change
ISD	Information Systems Development
ISDM	Information Systems Development Methodologies
LEK	Local Ecological Knowledge
LMS	Library Management Systems
MACs	Management Advisory Committees
MDM	Marine Data Model
MIS	Management Information System
MOD	Management Objective Driven
NAFP	Nampula Artisanal Fisheries Project
NGO	Non-Governmental Organisation
NOAA	National Oceanic and Atmospheric Administration
OOA	Object-Oriented Analysis
OOAD	Object-Oriented Analysis and Design
PARPA	*Plano de Acção Para a Redução da Pobreza Absoluta* (Action Plan for Absolute Poverty Reduction)
PEPA	*Projecto Económico para a Pesca Artesanal* (Artisanal Fisheries Economic Project)
PESPA	*Plano Estratégico do Subsector da Pesca Artesanal* (Artisanal Fishing Subsector Strategic Plan)
RAD	Rapid Application Development
REPMAR	*Regulamento da Pesca Marítima* (Maritime Fishing Regulation)
SA	System Analysis
SSADM	Structured System Analysis and Design Method
SDLC	Systems Development Life Cycle
SDM	Systems Development Methodology

SM	Structured Methodologies
TEK	Traditional Ecological Knowledge
UK	United Kingdom
US$	United States dollar (Currency)
WFC	World Fish Centre

ABSTRACT

Sound management of information and data is an essential cornerstone for efficient and effective decision making. Structured, up to date and easily retrievable data from several heterogeneous sources is often required to effectively manage, monitor and predict resource quantities particularly for depleting resources such as fish. The documentation and management of fisheries data in most developing countries however poses great challenges. The main aim of this study therefore is to design an information system (IS) for Artisanal Fisheries management. The developed IS is supported by a database. Secondary data, from the provincial offices of Moma and Angoche in Mozambique, is used to test and populate the prototype database. The manner in which the database is developed demonstrates how in practice a database can be created as part of an information system. However, due to time restrictions, a complete database for the AF system could not be developed.

To accomplish the objectives of the study, a model of the Artisanal Fisheries (AF) system was developed first. Based on standard system development approaches, the key components of the AF system that include; processes, data flows and data stores, were identified. The developed conceptual system was then used to identify critical data stores for the AF system and data models were subsequently developed. A prototype database to support the AF system was then implemented in MS Access.

The motivation for this study is as a result of two observations made on information management which are a challenge in artisanal fisheries management in Moma-Angoche. These observations are; (i) the current information system lacks a structured approach and a database to document and archive data/information on the artisanal fisheries sub-sector; and, (ii) the high proportion of the data/information collected from different sources is not well processed, analyzed and is not user-friendly as yet.

The Moma-Angoche Provincial Fisheries office was chosen because it is strategically suitable for research. This has been demonstrated by the amount of socio-economic artisanal fishing census data already collected and by the research on stock marine

resources already carried out. As a result, the study area has become a pilot zone of integrated fisheries development projects. During the life cycle of the various projects, and even after their termination, the area remained an important zone where subsequent studies (for example baseline studies) were carried out. Furthermore, the existence of subsequent data available from those studies allows a good opportunity for data comparisons to be made.

CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 Introduction and background

Fish is a very important resource that coastal communities rely on to make a living. Fish is a very valuable resource for the sustainable livelihood of humankind, for both present and future generations. It is well known that in Mozambique more than two thirds of the population live in marine and inland coastal zones. As such, therefore, fishing is very important for many communities in the coastal region as it provides important products for livelihood sustenance. Most of the population living along the coastline practice artisanal fishing, which is a good source of employment, as well as providing an income from the sale of products.

The fisheries sector contributes greatly to the growth of Mozambique's economy. For instance in 2001, shrimp catch exports earned the country about US$100 million, which represented over 40% of the country's earnings (FAO, 2004). The fisheries sector's annual total capture is around 130 000 tonnes and about 90% is from artisanal fisheries (IDPPE, 2007a). As a result, the fisheries sector has a key role to play in poverty reduction through the provision of rural employment and improved incomes to disadvantaged people. More importantly, it contributes towards providing basic food sources to many households in poor communities.

About 100 000 artisanal fishermen are directly involved in artisanal fisheries activities, which makes artisanal fisheries an important social activity that contributes to communities' social development. It also helps in improving the livelihoods and working conditions of artisanal fishing communities and also increases the level of national production of protein rich nutrition (IDPPE, 2007b). Artisanal fisheries is defined in this research as a subsistence activity characterized by the use of traditional fishing boats, fishing gear-nets and other non specialized materials (IDPPE, 2007b).

The study seeks to design an information system as one of the options that could enhance artisanal fisheries management. The information system will be supported by a database. The use of an information system in the Moma-Angoche Provincial Fisheries Office[1] will help in making better decisions on artisanal fisheries management. The concern regarding information management in artisanal fisheries and the absence of a well-designed database is a common problem in all the provinces of Mozambique and needs to be addressed. However this study focuses on Moma-Angoche coastal zone.

1.2 Problem statement

The current system of managing information on artisanal fisheries in Moma-Angoche lacks a structured approach and a database to document and archive data/information on the sub-sector. In the process of data/information collection, there are certain issues, such as data needs, that are often not well defined. Further, a high proportion of data/information collected is not well processed, analyzed and is not user-friendly. This has made it difficult for managers to make comprehensive decisions. In order to address these shortcomings there is a need for an appropriate information system to be designed. The information system approach will provide options for better management of artisanal fisheries. In addition, if such an information system is supported with a database, information management will be greatly enhanced.

1.3 Research objectives

1.3.1 Main objective

The main objective of this research is to design an information system for artisanal fisheries management that is based on a database.

[1] Fisheries Representation Head Office at Provincial Level

1.3.2 Sub-objectives

To meet the main objective of the research, the following sub-objectives were pursued;

1. To design a system model for the artisanal fisheries information system;
2. To develop a conceptual data model for the data stores of the artisanal fisheries information system,
3. To implement the developed data models (under objective 2 above) within a database environment.

1.4 Research questions

Based on the identified problem statement and in order to fulfill the research sub-objectives, the following questions were formulated to guide the research:

1. How can an artisanal fisheries information system be modeled?
2. How can a conceptual data model for the artisanal fisheries information system be developed?
3. How can the data models and field data be implemented within a database?

Based on the above research questions, both primary and secondary data collection methods were employed to address the research objectives. Observations and unstructured interviews with focus groups were mainly used to gather primary data while numerous documents were collected for use as secondary data sources. Since the research did not warrant data collection in the field, all investigations were carried out based on data collected at Moma Angoche Provincial offices and the IDPPE.

1.5 Structure of thesis

To fulfill the overall objective of this research, the thesis is systematically structured in five chapters as illustrated in the figure below (Figure 1.1). Each of the five chapters consists of different components.

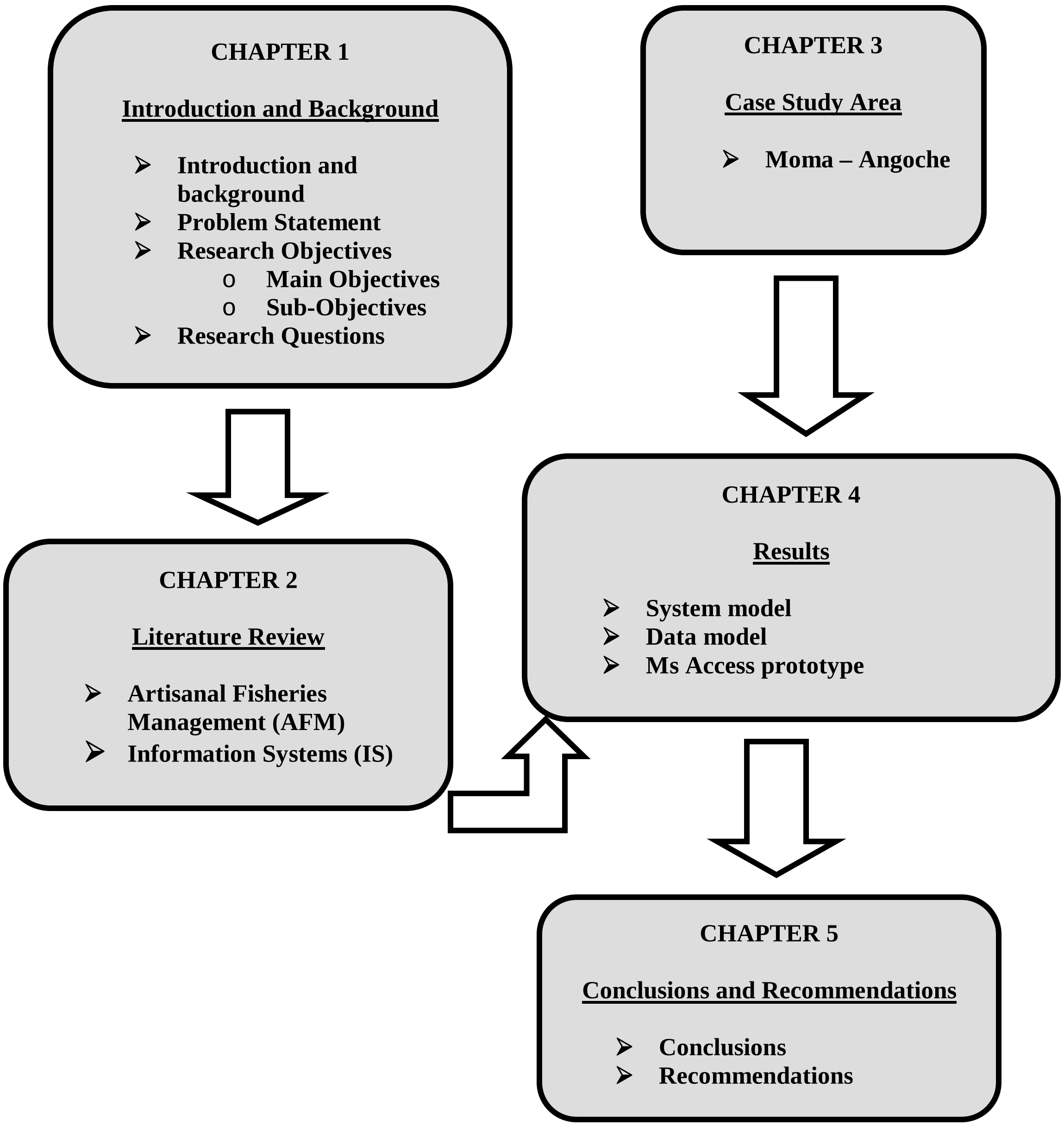

Figure 1.1: An illustration of the structure of the thesis

Chapter one provides an introduction and background information to the research topic, as well as the problem statement. The objectives of the study and research questions are also outlined. Chapter two provides an overview of Artisanal Fisheries Management and discusses some common approaches used in Artisanal Fisheries Management. The use of Information Systems approaches, in particular methodologies and techniques, are explored. Chapter three outlines the description of the Moma-Angoche study area, with the emphasis on natural geographical extent, socio-economic and demographic aspects. The justification for the choice of the research area is also provided. Chapter four discusses the results found according to the predefined sub-objectives. The research conclusions and recommendations are discussed in chapter five.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter presents a general overview of the literature that is relevant to this study. The literature reviewed specifically deals with theoretical concepts about Artisanal Fisheries Management (AFM) and Information System (IS) approaches, in particular structured system analysis and design.

2.2 Artisanal Fisheries Management (AFM)

Artisanal fishing is a traditional way of fishing that exists throughout the coastal areas and inland waters (Lopes *et al*, 1997). This subsistence activity is characterized by either the use or non-use of traditional fishing boats[2], fishing gear-nets and other non-specialized materials (IDPPE, 2007b). These fishing materials and equipment are usually operated manually and with very simple fish preservation[3] on board. The fishing ground for most artisanal fishermen is usually along the coast, while some go out to sea, but for a very limited time (IDPPE, 2007b). Therefore, fishing plays an important role in providing fish mainly for family consumption, with the surplus being sold, thus providing direct income for many fishing households (Lopes *et al* ,1997; Lopes and Kristiansen, 1997).

Different authors and organizations have defined Fisheries Management (FM) in different ways. According to (FAO & DANIDA, 1998) FM is the integrated process of information gathering, analysis, planning, and decision-making, allocation of resources and formulation and enforcement of fishery regulations by which the fishery management authority controls the present and future behaviour of interested parties in the fisheries, in order to ensure the continued productivity of the living resources. Further, FM, according to Great Barrier Reef Marine Park Authority (GBRMPA), is the effort to regulate where,

[2] The boats can be motorized or not.
[3] Ice and salt preservation.

when and how people fish, as well as how many fish they catch, to protect fish populations so that people can continue to fish (GBRMPA 2007). This research considers FM as an integrated process for sustainable exploitation of resources by applying suitable fishing techniques, boat construction, motorized boats, and fish preservation with the collaboration of fishing communities and the government. Management of fisheries consists of activities such as protection and enhancement of habitats and ecosystems, regulation in use of inputs in catching fish and regulation of output. Through such activities, conditions for sustainable production are achieved as well as sustainable use of resources (FAO, 1997).

2.3 Importance of Artisanal Fisheries Management

Artisanal fisheries often provide an economic activity and support livelihoods for the poorest strata of the rural and even sometimes urban populations. It is generally accepted that without appropriate management, benefits derived from most fisheries products are likely to diminish. In line with the concept of the “tragedy of the commons” as argued by (Hardin, 1968), it is clear that a depletion of resources may occur in the absence of management, whether that management comes from central government or communities. As emphasized by (Berkes *et a,l* 2001) the absence of management approach may lead to resources becoming commercially extinct (that is, even though some members of the species survive, they are not worth fishing for) or biologically extinct, according to (Roberts and Hawkins, 1999).

A wide range of literature shows the necessity for fisheries management to avoid the loss of economical viability or even a collapse of the fishing industry. Some authors, such as (McGoodwin, 1990), (Buckworth, 1998), (Pitcher, 1998) and (Pitcher *et al,* 1998), have referred to a crisis in fisheries and the consequent need to reinvent fisheries management. For instance the Peruvian anchoveta, northern cod, New England groundfish (lungfish), bluefin tuna and Atlantic swordfish are some of the species whose populations have diminished (Buckworth, 1998). Several small stocks have also diminished, although they have not drawn much attention, for example, the reef fish stock in many tropical countries and queen conch in the Caribbean (FAO, 1993).

As pointed by (Berkes *et al*, 2001), species in the tropics are more prone to extinction than those in the temperate zones due to the fact that the species population sizes are smaller despite being numerous. In the tropics, information on fish species facing extinction is scarce. Traditional local management has often helped maintain some small scale fisheries, for example by the use of reef and lagoon tenure systems (Berkes *et al*, 2001). Further, scientists and managers are nowadays aware of the ubiquity, effectiveness and efficiency of traditional systems and are beginning to use similar concepts in modern management (Berkes *et al*, 2001). It is worth mentioning that in the Inhassoro district of Inhambane province in Mozambique, for instance, a similar tragedy occurred recently. The tragedy has mainly been as a result of fishing activities carried out, especially during colonial times. During this period, fishing activities were often not guided by management principles that emphasised the sustainability of marine resources. In this particular case, fishermen were mainly fishing using mechanized beach seine nets. Today, the effects are visible in the Inhassoro coastal areas where marine resources are almost extinct in the on-shore zones. Since the country's independence in 1975, some efforts have been made to reverse the situation as new policies have been introduced by the Mozambican government. The challenges have been to adopt better strategies for managing the resources to ensure their sustainability. Some of the strategies being adopted are to encourage fishing towards off-shore zones (open sea) and providing loans to fishermen to get improved gear-nets and other fishing materials. Other strategies adopted include:

- avoiding catching juveniles and destroying habitat ecosystems by introducing the spawning season methods;
- use of suitable nets (with big mesh);
- imposing high taxes for any beach seine practices.

Therefore, the introduction of information systems that can assist with the management of fish resources at both national and local levels is a welcome development. Such systems would go a long way to enable the sustainability of artisanal fishing for both the present and future generations.

2.4 Information system based approaches

A system is defined as a collection of various components, organized in a particular way to accomplish specific functions. These components are interdependent and may include people, procedures, funding and equipment (Capron, 1990; Curtis and Cobham, 2002; Lucas, 1985 and Paresi, 2000).

As illustrated in the figure below (Figure 2.1), a system consists of a collection of various components that work together towards realizing some objectives. The components of the system are purpose, boundary, environment, input and output. In the context of systems environment and boundary, inputs come from the environment into the system, while outputs are transferred from the system to the environment.

In terms of the concept of boundary, (Curtis and Cobham, 2002), define the environment as whatever lies outside the boundaries of the system, but interacts with the system. The system boundaries are usually formed by the features that define the scope of the system itself. The objectives of a system, together with the area over which a person has interest and control, determines what the person perceives as a system with boundaries. In this regard, perceptions and interests of an individual or observer contribute to the idea of a system (Curtis and Cobham, 2002). This therefore means that different people could have different perceptions of the same system and its boundaries. Systems can generally be categorized into two; closed systems and open systems. Closed systems have no environment and lack inputs or outputs. In real terms, there are no strictly closed systems but the term usually refers to systems that have weak interactions with their environment (Curtis and Cobham, 2002). On the other hand, open systems are those systems that interact freely with their environment.

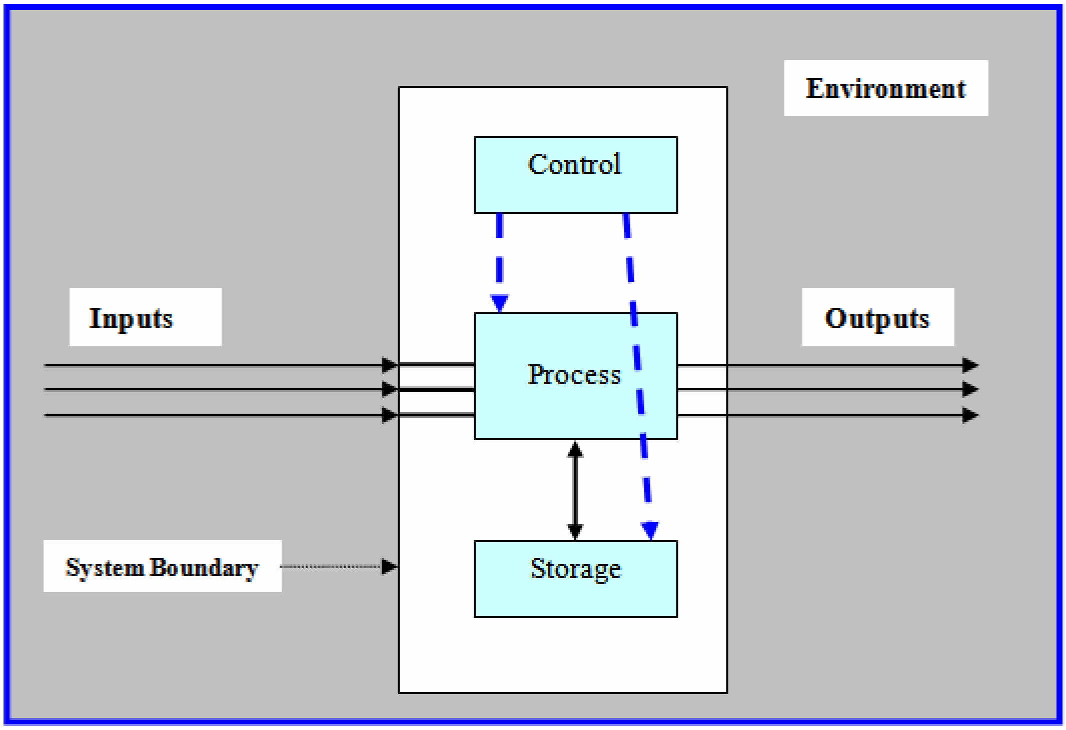

Figure 2.1: A general model of a System of Structured Methodologies

(Source: Curtis and Cobham, 2002)

Information is defined as data that is processed for a particular purpose (Curtis and Cobham, 2002) or as an answer to a specific question (Paresi, 2000). The question that the information obtained endeavours to answer generally emerges in the context of problem solving, for example in connection with managerial or decision-making activities (Paresi, 2000). Information can generally be considered as an entity that is responsible for reducing uncertainty about a particular state or event, as pointed out by (Lucas, 1985).

Information systems (IS) are meant to be systems that provide information to people in an organization and they can either be developed in structured ways or *ad hoc*. Many information systems use computer systems to manipulate information. According to (Paresi, 2000), an information system is defined as a system to transform data in information (including collection, processing, storing, retrieving, analysis, protection and communication) as such that this information can be used as input for a decision making process. On the other hand (Lucas, 1985) also defines information systems in terms of organized procedures responsible for providing information which may be useful in decision-making and adds that the information obtained could also be used in the control of the organization. Usually, people at different levels of an organization are involved in an information system. The system also involves entities such as computers, programs, procedures and personnel to operate the system (Lucas, 1985).

In the next sections, three distinct classes of information systems are discussed briefly; decision support systems, geographic information systems and management information systems. In addition, a discussion on developing information systems from scratch is presented.

2.4.1 Decision Support Systems (DSS)

A Decision Support System (DSS), in the context of fishery management, is a computer program that transfers information from research surveys and commercial fishing reports into advice for policy makers on decisions of when, where and how fishing effort should be allocated (Truong *et al,* 2005). In fishery management, DSS assists government agencies and other stakeholders in the fishing industry towards making policy decisions for fishing activities. This is made possible by providing suitable data and the use of management science techniques. The system serves many purposes, among them being analysis and learning functions (Truong *et al,* 2005). This method consists of a set of computerised secondary decision tools that have been added or modified as technology, information sources and operational needs change (DAFF, 2007).

According to (Rothschild *et al,* 1996), a Decision Support System for Fisheries Management consists of seven components, namely:

(i) Sampling design and research survey – for data collection that are independent of commercial fishing,

(ii) database and data management system,

(iii) a systems identification and statistical models – for the acknowledgement of the current situation,

(iv) simulation-optimization models - where decision analysis is applied to provide the optimal management solutions,

(v) allocation of fishing permits to vessels,

(vi) implementation of fishing activities, and

(vii) fishing trip reports - as a feedback control to evaluate and adjust management measures.

The linkages to the above mentioned components are illustrated in the figure below (Figure 2.2).

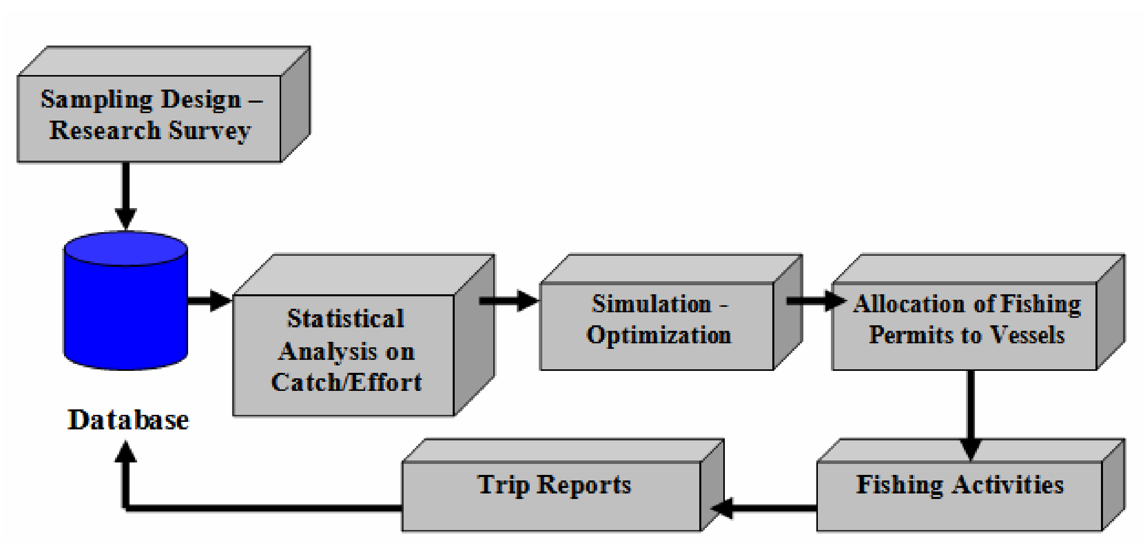

Figure 2.2: Components of the Decision Support System for Fisheries Management (Adopted from Rothschild *et al*, 1996)

One advantage of DSS is that it provides an interactive environment upon which data can be manipulated towards making specific decisions (Hoffer *et al,* 1999). At the same time, DSS is favourable because of its user friendliness due to its responsiveness and the speed of the system (BfG, 2000; Prakken, 2000). Despite DSS being user friendly, its application requires a certain level of technological knowledge, hence limiting the number of users (Answer Corporation, 2007).

2.4.2 Geographic Information Systems (GIS)

A Geographic Information System (GIS) is defined as a computer-based system that helps in capturing, storing, retrieving, manipulating, analysing and displaying spatial referenced data (Arnoff, 1989). GIS is increasingly being used as a resource management tool by fisheries and aquatic science professionals. In fisheries and aquatic science research and management, GIS has found applications in mapping and modelling of fish distributions and habitats, mapping marine protection areas and coastal zones, sighting aquaculture facilities, generating global warming scenarios, and assessing watershed land use activities on lake and stream fish habitat (Fisher and Rahel, 2006). In fisheries management, this method facilitates the evaluation of spatially-oriented fisheries problems through spatial modelling and visualization (Fisher and Rahel, 2006). Apart from being used as a tool for monitoring and management, the GIS method is also used to solve spatio - temporal problems and is finding use in fisheries applications (Valavanis, 2002).

In small scale fisheries, GIS application has been an important development especially in relation to spatially structured surplus production and modelling of fishing efforts (FAO and WFC 2005). Different models have been developed and applied in artisanal fisheries over time. For example, (Corsi, 2000) developed a model to investigate the behaviour of surplus production models in conditions of varying stock densities. On the other hand, (Caddy and Carocci, 1999) applied a model based on GIS in modelling effort where data was limited. This, they applied to artisanal fisheries in the Mediterranean, while (Payate, 2002) applied the approach to artisanal tuna fisheries in the Seychelles (FAO and WFC, 2005). Other models, such as the ArcGIS Marine Data Model, have been used, for instance in Hawaii (Wright *et al,* 2001). The ArcGIS Marine Data Model was used particularly to analyse data which was useful in trying to address the challenges of habitat destruction and risk of depletion of marine resources along the West coast of Hawaii (Aaby *et al*, 2004).

The GIS method is able to integrate geographical data with other data from other sources, hence providing the necessary information for decision-making. The use of GIS performs two functions, as a tool box and as a database. As a tool box, it allows planners to perform spatial analysis, while as a database it makes it possible for decision-makers to extract data (Hall, 1996). One disadvantage of using GIS methods is that they are usually general purpose systems which are not focused on supporting a particular type of decision. In this case, for GIS applications to make important contributions, models that are related to particular problems are needed so that decisions can be supported fully (Keenan, 1997).

2.4.3 Management Information systems (M.I.S)

In many organizations, management needs to be equipped with information that can guide it towards decision-making, among other activities. As such therefore, the concept of Management information systems (MIS) need to be developed. This concept, as pointed out by (Curtis and Cobham, 2002), is developed by putting together the ideas of information and a system. This process of developing the concept of MIS is viewed as a collection of information subsystems interacting with a corporate database. Management Information System is any system that provides information for the management activities carried out within an organization (Curtis and Cobham, 2002). The term has commonly been used for computerized systems. These systems serve the purpose of managing information by the use of hardware and software. The combination of hardware and software enables the processing and storing of data completely automatically, without human intervention (Prakken, 2000) and allows retrieval of information more efficiently. The information retrieved is basically used for planning and monitoring the organization’s activities as well as guiding it towards decision-making at managerial level. This is also in line with the definition of MIS given by (Davis and Olson, 1985), who consider MIS as an integrated user-machine system for providing information to support operations, management, and decision-making functions in an organization. The system in this case not only utilizes computer hardware and software, but also manual procedures, models for analysis, planning, control and decision making; and a database (Davis and Olson, 1985).

For situations where decision support systems, Geographic Information systems or management information systems are not in use or insufficient, information systems can be developed from scratch using conventional Information system development approaches. These are discussed below.

2.4.4 Developing Information Systems

When information systems (IS) are being changed or new ones are being developed, it is important that systems analysis be undertaken. Systems analysis (SA) is a process that investigates a system in order to determine how it operates and what possible changes would be made (Hawryszkiewycz, 1994). SA is therefore very important in the whole process of system development, as plans for the new systems are developed and necessary data gathered through the analysis (Hawryszkiewycz, 1994). As consider by (Yeates *et al,* 1994) SA is the part of the process of systems development which begins with the feasibility study and ends with the production of a target document. Investigations carried out during the analysis phase of developing a system may draw from the feasibility study conducted earlier and finally lead to production of the final document. The final or target document outlines the specifications of the new system (Yeates *et al,* 1994). On the other hand, (Osborne and Nakamura, 2000) consider SA as a means of viewing various circumstances in a realistic way and designing solutions which are practical. In their definition, (Osborne and Nakamura, 2000) mention that SA can be applied effectively in many different environments, such as the business world, the area of information studies, and the library world, among others. It is observed that though settings may be different, same basic elements of system analysis may be applied, while at the same time, people in different environments may share similar opinions as regards the meaning and purpose of SA (Osborne and Nakamura, 2000). According to (Semprevivo, 1982) SA is the process of studying the network of interactions within an organization and assisting in the development of new and improved methods for performing necessary work. In order to be certain about what must be done to carry out the functions of a system, it is necessary for system analysis be done.

This research focuses on designing an artisanal fisheries information system from scratch.

2.5 Information Systems Development Methodologies (ISDM)

According to (Paresi, 2000), five important system development methodologies have emerged from research and experience. These are:

- Soft;
- Socio-Technical;
- Structured;
- Object-Oriented and
- Formal.

To add to these five approaches, Rapid Application Methodologies have also emerged in the recent past. A combination of the above mentioned approaches can be used in system development, especially when designing a system from scratch. For instance, a combination of Structured and Object Oriented Methodologies has been considered as the most appropriate in information system development. As mentioned by (Rowley, 1998) there are different system development methodologies and that these are available in the market. Each methodology however offers different features and targets different aspects of the system development process (system analysis, design and implementation phases).

In modern information systems, different approaches are being used in carrying out assessments based on the needs of organizations. The five methodologies mentioned earlier are summarized in the table 2.1 below, based on the characteristics of each. These methodologies are used to carry out various project studies.

Table 2.1: Summary of Approaches in Information Systems Development Methodologies

Approaches	Characteristics
Soft Systems Development Methodologies	• Belong to the system paradigm; looks at the organization as a whole, not only a specific area • Take a subjectivist view of reality - reality as a social construction. SSM sees a fuzzy problem situation in the real world • See problem situation in two perspectives, as a cultural and as a system • Provide techniques (including rich pictures) to structure and define the problem • Are process oriented
Socio-Technical Development Methodologies	• Take the participative design approach • Use simultaneous design of social and technical subsystems • Have as main concern, job satisfaction (social system) and work efficiency (technical system) • Use a narrative model (not pictorial) • Consider training and education of users as an important aspect • Belong to the system paradigm • Take a subjective view of reality
Structured System Development	• Use the life cycle approach, mainly waterfall approach • Provide tools and techniques, rules and guidelines (dataflow diagrams, data dictionaries, etc.) • Take an objective view of reality – assume that there is a reality that is the same for everyone • Provide elaborate planning guidelines and case tools
Object-Oriented system Development Methodologies	• Have both structural (data) and behavioural (process) aspects • Are based on modelling of objects; the analyst thinks of the system as a collection of objects • Have as major features: abstraction, classification, generalization, aggregation, and association • Have properties including encapsulation, inheritance, polymorphism and persistence • Provide for case tools
Evolutionary System Development Methodologies	• Are using a cyclic/iterative and step-wise development approach • Are focusing on user involvement and the user of modern tools (case tools and software generators)

(Adapted from Paresi, 2000)

Although these 5 approaches cover various aspects of systems development, they have different potentials and limitations. These are summarized in the table 2.2.

Table 2.2: Potentials and Limitations of Information Systems Development Methodologies (Adapted from Paresi, 2000)

Approaches	Potentials	Limitations
Soft SDM	• Seek to structure a fussy/ill-defined problem situation in the real world that is seen as a social construction.	• Cover only the strategy and analysis phases of systems development.
Socio-technical SDM	• Emphasis simultaneous design of social and technical subsystems. • Main concern is job satisfaction and work efficiency. • Cover analysis and design in more detail.	• Feasibility and implementation in less detail.
Structured SDM	• Provide techniques and tools, procedures and elaborate planning guidelines. • Take the participative approach to analysis and are suited for automation. • Cover all the phases of system development.	• Separate data and process modelling and focus on centralized systems.
Object-Oriented SDM	• Cover all the phases of systems development and provide techniques and tools. • Take the participative approach to analysis and are suited for automation. They are especially suitable for distribution and integration. • The developed systems are more robust and easier to maintain. • Provide for horizontal integration (data and functions) and for vertical integration (between phases). • Provide for more efficiency in terms of software production.	• Still in infancy.
Evolutionary SDM	• Have the same potentials as the O.O. SDM.	• Take the cyclic/iterative and step-wise development approach.

In this research Structured Methodologies have been used so as to meet the objectives set for the study.

2.5.1 Structured Methodologies (SM)

According to various literature sources on systems development methodologies, conventional approaches often fail, especially when systems become more complex. Structured Methodologies (SM) are considered to be versatile because they seek to address these failures and, more importantly, considered to reduce the cost of rectifying changes in user requirements. However, it is possible to minimize changes in user requirements during the analysis phase of system development (Paresi, 2000).

Furthermore, the very critical issues to SM are that it takes the Top-Down approach and separates the logical from the physical design. In developing of the systems, these methodologies put much effort into developing the conceptual system during which the analyst has an opportunity of having an overall perspective of the system, and then breaking the overall picture into manageable modules (Paresi, 2000). As outlined further, it is important to emphasize that SM is also associated with different tools and techniques. In this particular case, some of the most important tools and techniques include, decision trees, decision tables, data flow diagrams (DFDs) and data dictionaries, among others. Documentation in SM includes documents describing the physical level design and the logical or the real world (Paresi, 2000). Most parts of the analysis and design can be developed, maintained and held on computer systems. An important aspect of SM is the high recognition of user participation in information requirement determination and verification (Paresi, 2000).

2.5.1.1 Phases and Scope of Structured Methodologies

All systems development methodologies have the System or Project Life Cycle that consists of a set of iterative activities. These activities are grouped in phases that have a specific beginning and end. After the end of the implementation review of each phase and between phases, some changes might be recommended to improve the system, hence repeating the cycle. Figure 2.3 below shows the major phases and life cycle of structured methodologies. There are:

- System strategy and planning;
- System analysis;
- System design and
- System realisations.

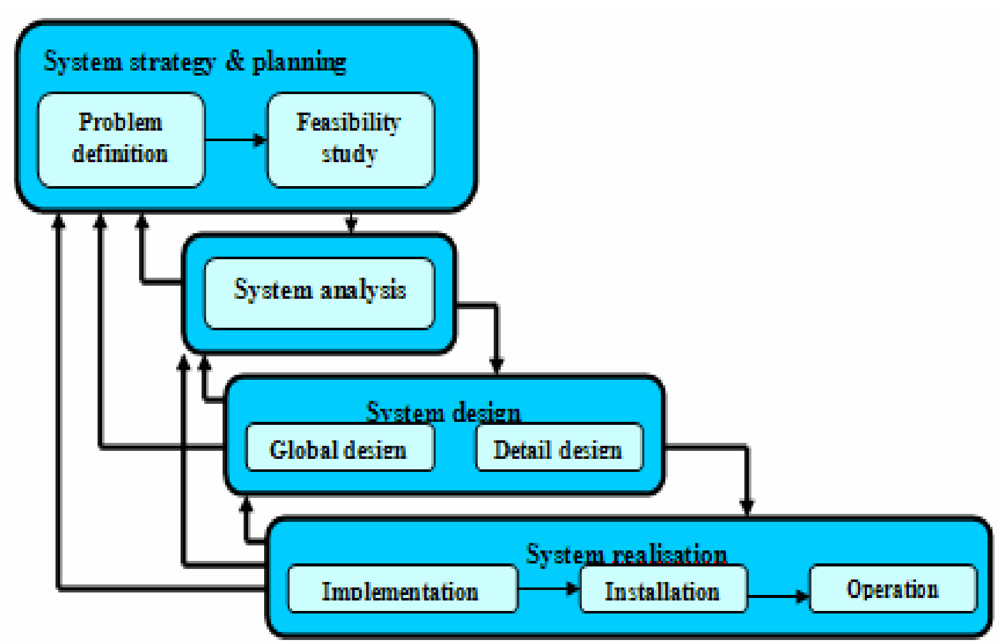

Figure 2.3: Major phases and life cycle of Structured Methodologies
(Source: Paresi, 2000)

As argued by (Garmany *et al*, 2005) the understanding of the Systems Development Life Cycle (SDLC) is a requirement in designing a database. The objectives of each of the above phases are briefly outlined in the table 2.3 below ((Paresi, 2000).

Table 2.3: Objectives of the Major Phases and Life Cycle of Structured Methodologies

Phases	Objectives
System strategy and planning	• Define the problem and its sources • Define project goals, bounds, structure, feasibility • Create a framework for the development and maintenance of the information infrastructure
System analysis	• Define why there is an information problem, where and what the problem is and what are the main demands and constraints on the information system • Perform a detailed analysis of the existing system and of the information requirements
System design - Global system design	• Design the system to a level at which sub-systems can be designed separately • Design interfaces between the sub-systems • Define a new/modified organization structure
- Detailed system design	• Refine designs and specifications to a level which permits implementation of specific system components • Detail the new/modified organization structure
System realisation (implementation)	• Build and test the system • Acquire hard/software • Integrate the separately developed system's components • Document the system and train the staff of the organization

(Adapted from Paresi, 2000)

Structured System Analysis and Design Method (SSADM) is one of the best examples to illustrate the nature of structured methodologies in more detail (Rowley, 1998). SSADM was developed in the United Kingdom (UK) and has been used widely. It was originally developed by UK's Learmouth and Burchett Management Systems and the Central Computer and Telecommunication Agency (CCTA). As mentioned by (Rowley, 1998), SSADM is a data-driven methodology which mainly focuses on data modelling as well as advises analysis and specification of process views with data flow diagrams and behaviour using entity life histories. It is structured in three main phases, namely: feasibility study, system analysis and system design. Some other examples of structured systems development methodologies, according to (Paresi, 2000), include:

- Information Engineering Methodology (IEM);
- Information Systems Work and Analysis of Change (ISAC);
- Structured Systems Analysis (STRADIS);
- Systems Development Methodology (SDM).

2.5.1.2 Systems Design Methods and Techniques

One of the purposes of system design is to choose the actual engineering design required for the implementation of the system. Designing also helps in specifying changes to existing programs and databases and provides details on procedures by outlining how the system can be used (Paresi, 2000). Techniques, on the other hand, enhance communication within the system development team and aid in clear thinking among the members (Paresi, 2000). A good technique is that which can be applied fast and easily, ensures checking, aids in the process of system change and maintenance and enables users to review the design, among other things. In application of techniques, there should be good documentation, standard interface between subsystems, and capacity to ensure good structuring of the system.

Top-to-Bottom techniques can are appropriate where there is a need to decompose a system steadily from the highest overview to the finest detail (Paresi, 2000). Database orientation is another important tool as database technology is becoming vital in most future data processing. Some of the techniques applied in system development are Data Flow Diagrams, Entity Relation Diagrams, Structure Charts, Decomposition Diagrams, Data Structure Diagrams, Matrices, Decision Trees and Tables, Control Flows Diagrams, Nassi-Shneiderman Charts, State Transition Diagrams, Michael Jackson Diagrams, Structured English and Pseudocode, Dependence Diagrams and Action Diagrams (Paresi, 2000).

The Data Flow Diagram (DFD) technique has been used in this research. This is an important tool of structured analysis and design and often ensures the top-down approaches are adopted. According to (Curtis and Cobham, 2002), DFD promotes a logical, as opposed to physical view of data stores, flow and processes. Using DFD, a logical model of the system is developed showing data flow between the various processes in the system. DFD therefore can be used in communication of the logical process model of the organization (Curtis and Cobham, 2002). DFD has been useful in situations where there has been a need to sketch alternatives using automation boundaries (Curtis and Cobham, 2002). Furthermore, (Hoffer *et al* ,1999) concludes the discussion on DFD by mentioning that the diagrams are very useful for representing the overall data flows into, through, and out of an information system.

2.5.2 Object-Oriented Analysis approach to Analysis and Design

An object-oriented approach to systems development combines data and methods into single entities called objects (Hoffer *et al,* 1999). The objects collaborate with each other through the sending of messages to request services, for example a request for a report (Rowley, 1998). Object-oriented methods, as argued by (Rowley, 1998) include, Object-Oriented Analysis (OOA) and Object-Oriented Analysis and Design (OOAD). In both methods, objects and classes are defined at the beginning, followed by a definition of relationships to put objects and class together, hence forming a system-wide view. Object detail is added into the system by giving specifications on attributes, methods and the object life history (Rowley ,1998).

According to (Garmany *et al*, 2005) the OOA begins with a traditional structured specification, before adding other information, which includes:

- A list of all objects describing the data contents of each noun, or physical entities in the data-flow diagrams (DFD);
- A list of all system behaviours: a list of all verbs within the process;

- A list of the associated primary behaviours (services) with each object: each object will have behaviours that are unique to the object. Other objects may request the behaviours of the object;
- A description of the contracts in the system between objects, such that one object will invoke the services of the other;
- A behaviour script for each object describing each initiator, action, participant, and service and
- A classification for each object and the object relationships; this generates an entity-relationship (E-R) model and generalization hierarchy for each object. This is done using traditional E-R or normalization techniques.

Based on classification for each object, an entity-attribute relationship emerges within the object.

2.6 Database design

According to (Garmany *et al,* 2005), a database can be defined as a collection of data items which are stored and can be retrieved at a later time. Alternatively defined, it is a shared collection of logically related data items needed by an enterprise and stored on a server or distributed over several computers where data can be retrieved based on user needs (Garmany *et al,* 2005). In a database, end user data and metadata are stored in an integrated computer structure (Rob and Coronel, 2007). Generally, a database can simply be defined as a collection of related data (Elmasri and Navathe , 1994). In this study a database is developed as an integral component of the information.

There are three phases of database design, namely conceptual, logical and physical design. The database design represents three components, namely: the entities, the attributes and the logical relationships between the entities (Connolly and Begg, 2005). To be able to maintain and control access to the database, a software system called Database Management Systems (DBMS) is used. A DBMS consists of five major components, which are hardware, software, data, procedures and people. Appropriate requests are issued to the DBMS, by the user's application program, which forms interactions with the database (Connolly and Begg, 2005). Access to the database is done through the DBMS which provides two sets of languages. These are:

- Data Definition Language (DDL), which allows the users to define the database;
- Data Manipulation Language (DML), which allows users to manoeuvre within the database, such that they are able to insert, update, delete and retrieve data.

The combination of the database and the software is what (Elmasri and Navathe, 1994) refers to as a database system as illustrated in the figure below (Figure 2.4).

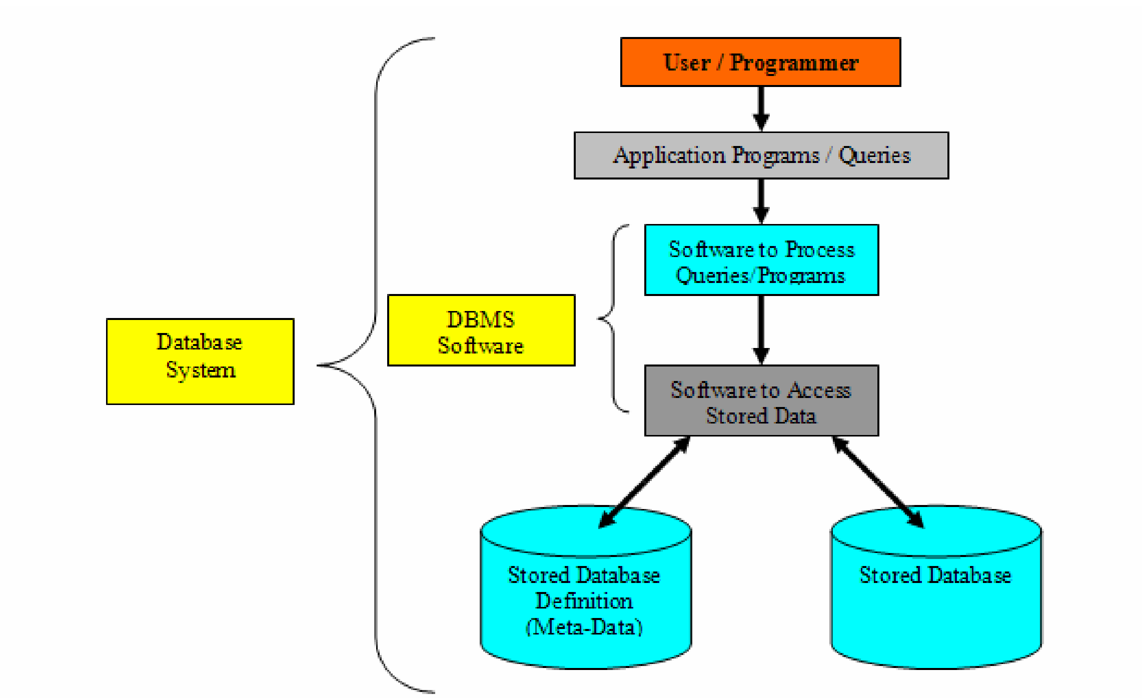

Figure 2.4: Database system environment

(Adopted from Elmasri and Navathe,1994)

One approach that is used in database design is the Entity-Relationship (ER) modelling. The process of designing a database using ER modelling begins with the identification of important data called entities and the relationships between the data that is to be represented in the model. Attributes of the entities and the relationships are then added

(Connolly and Begg, 2005). The participation of entities in a relationship could be mandatory, optional or conditional. The relationship between the entities and their attributes are summarized in the table below (Table 2.4).

Table 2.4: Entity-Attribute Relationship (EAR) (Adopted from Kavela, 2005)

Entity-Attribute Relationship (EAR)	
If the relationship is 1:1 and membership is:	• Obligatory for both entities, then attributes of both entities should be put into a single table. • Obligatory for only one entity, then two tables should be defined for each entity. The identifier of the non-obligatory entity should be posted into the obligatory entity's table. • Non-obligatory for both entities, then three tables should be defined, one for each entity and one for the relationship. The identifiers of both entities become the identifier of the relationship
If the relationship is 1:M and membership is:	• Non-obligatory both sides, three table should be defined, one for each entity and one for the relationship. The identifiers of both entities become the identifier of the relationship. • Non-obligatory on the "1" entity and obligatory on the "M" entity, two tables should be defined for each entity. The identifier of the "1" entity should then be posted into the "M" entity table. • Obligatory both sides, two tables should be defined with the identifier of the "1" entity posted into "M" entity table. • Obligatory on the "1" entity and non-obligatory on the "M" entity, then their tables should be defined one for each entity and one for the relationship. The identifiers of both entities become the identifier of the relationship.
If the relationship is M:N and membership is:	• Three tables should be defined regardless of the membership. One table for each entity and one for the relationship. The identifiers of both entities become a composite identifier of the relationship.

2.7 A Database based Information System for Artisanal Fisheries Management

The purpose of having an information system in artisanal fisheries is to transform specific data collected on fisheries to information. The data collected in artisanal fisheries may include entities such as fishing boats and gear, fishing zone, fish, fishing technology data, human activities (socio-economic data) among others. These data originate from various sources, all of which feed into the organization dealing with artisanal fisheries management. It is important to note that collection of data in artisanal fisheries sub-sector may be difficult due to several factors, among them the lack of capacity within the authorities. This leads to less documentation of the sub-sector in comparison to other sub-sectors, such as industrial fisheries.

In designing an information system model for artisanal fisheries management, this study adopts the DFD technique which falls under the structured systems analysis and design approached discussed earlier. To define the system boundary and enable a top down analysis a context diagram is designed showing the system and its environment. The context system diagram is then decomposed to a top level diagram which subsequently is decomposed to lower level diagrams. The decomposition helps in exhibiting details of the system being modelled. Each of the three levels shows how data flows in the system. Data stored within the system, on the other hand, are shown in the top and lower levels. Based on a closer examination of the data stores contained in the lower level, key data stores for the proposed system are identified. The entity relationship diagram (ERD) modelling approach is then used to create the data model of data stores. The ER data model is then implemented in a database. Data is then entered via forms and subsequently stored in tables created inside the database. The use of DFD and ERD techniques demonstrates how in practice an information system and its supporting database(s) (such as the artisanal fisheries management created in this study) can be conceptualised and created using specific information system development techniques. The database developed in this study is however only a prototype.

An artisanal fisheries information system may consist of various phases; data collection, processing, storing, retrieving, analysis, protection and communication. The information so obtained is subsequently useful in the decision-making process which could lead to better management of artisanal fisheries. Some of the information generated flows out to various stakeholders within the artisanal fisheries sub-sector.

2.8 Conclusion

This chapter has given a general overview of the relevant literature as far as this research is concerned. Artisanal Fisheries Management has been discussed, together with its role and importance. The discussion has outlined the fact that artisanal fisheries play an important role in supporting livelihoods of many people and hence the need for developing information systems within the sector. Different information systems approaches and methods such as co decision support systems, GIS, management information systems and traditional information systems development approaches have been outlined. These approaches and methods are only a few among many as it was not possible to cover all of them within the scope of this research. The approaches provide the concepts and ideas that can be applied in order to improve artisanal fisheries management. Information systems in the context of artisanal fisheries management have also been outlined briefly in the chapter.

The preceding chapter (Chapter three) gives a general overview of the case study area. The chapter also gives the justification for selecting the area for this particular research.

CHAPTER 3: CASE STUDY AREA

3.1 Introduction

This chapter describes the Moma and Angoche study area, its location and the reason why it was chosen. The importance of fisheries to this area and to the population is discussed in brief as well as the information management challenges and the types of information collected and archived in the provincial offices.

3.2 Context of the Study Area

The study area comprises the districts of Moma and Angoche, located along the coastline in the southern region of the province of Nampula in Mozambique (Figure 3.1). From the north, this is the second of the seven Mozambican provinces bordering the Indian Ocean. Nampula's coastline extends for approximately 580 km. It is divided into eight coastal districts, namely: Memba, Nacala-a-velha, Nacala-porto, Mossuril, Ilha de Moçambique, Mongincual, Angoche and Moma. Three urban centres of relevance, either for their present economic activity (Angoche and Nacala) or for their historic and cultural value (Ilha de Moçambique), are located along the coast of Nampula.

According to the (National Census of 1997), Nampula province has a population of about 2 975 747 inhabitants (National Institute of Statistics 1999), of which approximately 22 940 are fishermen (IDPPE, 2002). According to the total capture figures of fish for the province of Nampula up to the year 2001, it is estimated that the amount of annual captures for artisanal fisheries in the province´s coastal districts was 21 000 tonnes, of which 16 000 tonnes, or 76%, were from Angoche and Moma (IDPPE, 2007a). Artisanal fisheries and family subsistence farming are the main economic activities in Angoche and

Moma districts.

3.2.1 Geographical Extent of Moma and Angoche

The districts of Angoche and Moma have a geographic surface of 5 677 sq. km and 2 986 sq. km respectively (Muchave, 2000). Both are located in the southern part of the province of Nampula, between latitudes 15° 58'S and 17° 01'S and between longitudes 39° 04'E and 40° 08'E (Anon 1986). They are located to the north of one of Mozambique´s most important fishing areas, the Sofala Bank which is characterised by a relatively large continental platform (IDPPE, 2000).

The district of Moma is located along the coastline in the southwest region of the province of Nampula. It is bordered to the north by the districts of Angoche and Mogovolas, with the Meluli River acting as the border. To the south of Moma is the Indian Ocean while to the east is the district of Angoche, with the Mulele River dividing the two districts. The Ligonha River lies on the western border with the district of Marrupula, in the province of Zambezia.

The district of Angoche, on the other hand, is located along the coastal area to the south of the province of Nampula. It is bordered to the north by the Mutomote River which borders the district of Mogincual. To the south is the district of Moma and the Melule River, while to the east is the Indian Ocean. To the west, Angoche borders the district of Mogovolas by an imaginary line. The district is divided into four administrative posts, namely Angoche, Namaponda, Aúbe and Boila-Nametória, with Angoche being the main village.

Figure 3.1 shows the geographic location and area of Moma and Angoche districts.

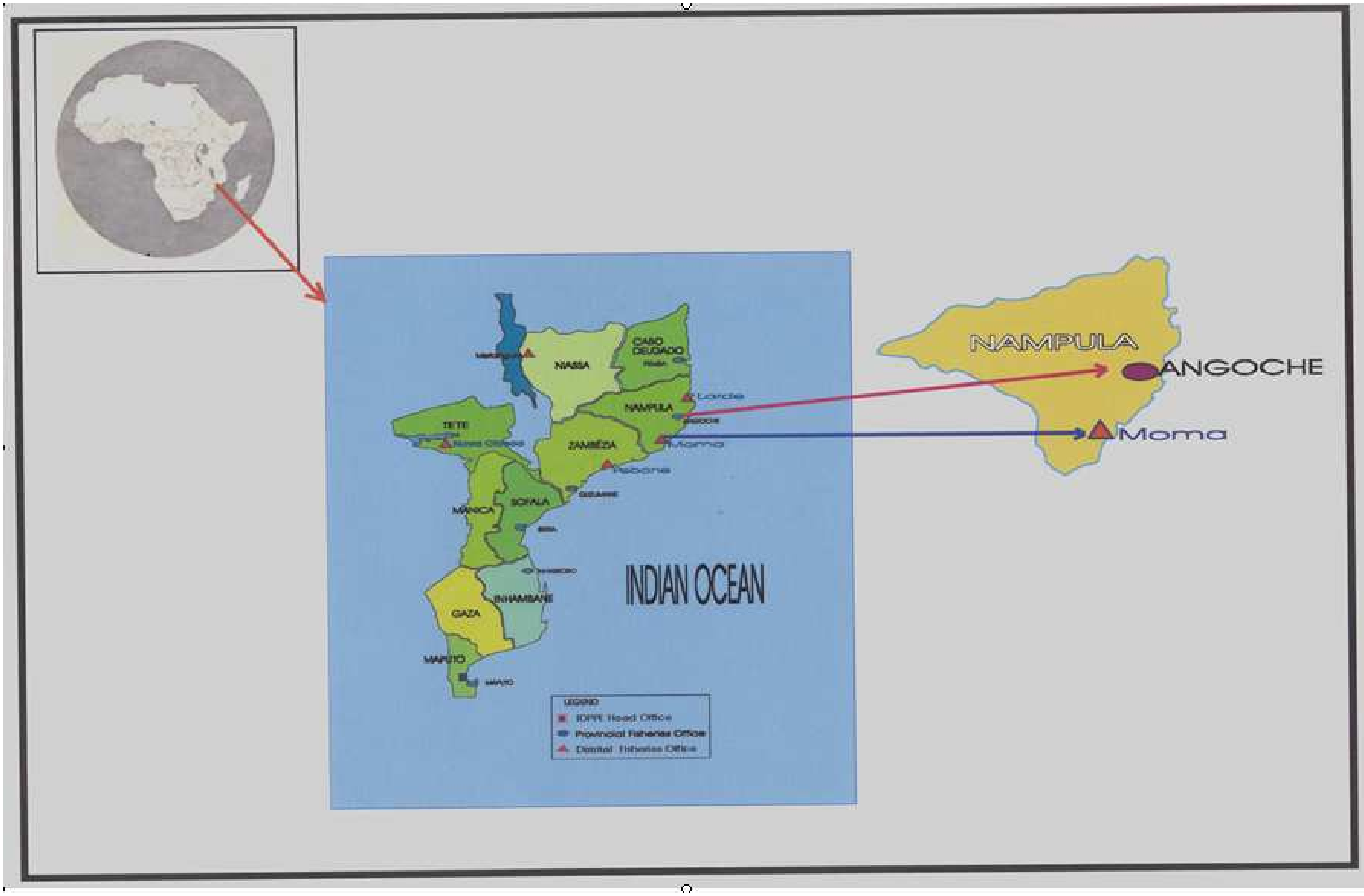

Figure 3.1: Geographic Location of the Case Study Area, Moma-Angoche, Mozambique (IDPPE , 2007c)

3.2.2 Climatic Characteristics

The region´s climate is tropical and humid, and is characterised by a large pluviometer variation throughout the year. Only two seasons exist annually, which are the hot and rainy (summer) season and the cool and dry (winter) season.

The hot and rainy season is characterised by high temperatures varying between 27° and 33°. Annual rainfall is significant, with records of around 212 mm in a month, while the relative air humidity is around 79% throughout the year. The hot and rainy season spans October to March and it is in this period that the northeast monsoon occurs. The cool and dry season is characterised by low rainfall and temperatures varying from 17° to 25°. Relative air humidity is around 78%. This season spans April to September and it is in this period that the southwest monsoon occurs (Anon, 1986).

3.2.3 Vegetation, Topography and Coastline Characteristics

The region´s vegetation has savanna-type characteristics. The topography is characterised by low (up to 200 metres) level altitudes, except in some areas such as in Paparato and Matatane which have small elevations (IDPPE, 2000). Near the sea, the plain area contains recently created sediments and alluvial sands and is usually flooded by sea water (Muchave, 2000). Except for a small portion of its northern boundaries, all the beaches in this region are sandy and slightly sloped, to a certain extent favouring beach seine in a one km wide and 90 km long stretch (IDPPE, 2000).

It is worth mentioning that the Sangage and Quinga strips located south of the districts of Angoche and Moma are composed of mangrove forests (Muchave, 2000). The important rivers that flow along the coastline of the province of Nampula provide for the occurrence of three covered estuary areas (Sangage, Moma and Larde), where fishing resources of relevance to the subsistence of the local communities exist. The average depth of the artisanal fishing area, including the open sea where fishing is carried out, is 20 metres and the average amplitude (height of the sea waves) of the sea in this region is 2 metres, with a maximum amplitude of 4 metres (Anon, 1986).

In this region, due to existing coral reefs and low lands, many islands were formed. Such islands include the Island of Moma, the Island of Caldeira, the Island of Njovo, the Island of Puga-Puga, the Island of Mafamede, the Islands of Angoche, Baixo Miguel, Baixo de Santo António and Baixo de Sangage (IDPPE, 2000).

3.2.4 Population and Artisanal Fisheries

The districts of Moma and Angoche, have a total of approximately 238 655 and 228 526 inhabitants respectively, with the population growth percentage being 7% per annum (National Institute of Statistics, 1999). Around 70% of the population in these two districts is involved in fishing activities, specifically fishing, post-harvesting technologies and/or trade of fish products.

Three main types of fishing, namely industrial, semi-industrial and artisanal, are carried out in this region. But it is artisanal fishing that is practiced by most of the population living on the coastline and provides them with employment. This activity is of importance to the communities in the region as it provides important products for livelihood sustenance. The impact of fishing is felt even inland. Fishing, being one of the Government's priority areas in the context of the Action Plan for Absolute Poverty Reduction (PARPA) and Artisanal Fishing Sub sector Strategic Plan (PESPA), has contributed towards poverty reduction and alleviating food deficiency. This has thus led to an improvement in the living conditions of artisanal fishermen communities. The two districts' fish harvesting national contribution can be measured through their share of exports and in the income generated. Existing data on artisanal fishing results show that in 1998, 14 927 tonnes of fish were obtained from the study area (Baloi *et al,* 1999).

According to the 2002 artisanal fishing census, of the 22 940 artisanal fishermen registered in the eight coastal districts of the province of Nampula, 13 468 are from the districts of Moma and Angoche, 7 282 and 6 186 respectively (IDPPE, 2002).

Given the importance of fisheries to this study area, because a high percentage of inhabitants rely on fishery activities for livelihood sustenance and the increased global dependency on fisheries, there is an imperative need for the development of an information system to support the management of artisanal fisheries. On the other hand, constant conflicts between artisanal fishermen and semi-industrial and industrial fishermen have frequently been recorded. These have been caused by the simultaneous presence of the three types of fishing due to the non-observance of the Economic Exclusive Zones as outlined in the existing laws. This needs to be looked into and probably minimised.

3.2.5 Information Organisation

Fishing data/information is manually collected on the ground every three months with the use of cards by extension workers assigned to each planning area[4] or by technicians from the Moma-Angoche Provincial Fisheries office, who do field work on a regular basis. Data/information collection periodicity (fortnightly, monthly and three-monthly) depends on its type and nature. It is worth mentioning that for various reasons, such as a lack of transportation, agenda conflicts and a lack of human resources, this periodicity does not always follow the stipulated information collection timetable. This consequently results in the discontinuity of available information.

At the Provincial Fisheries office this data/information is processed and stored in physical form (cards, reports and manuals) and electronic form (files and folders). Only part of this data/information is stored electronically for due treatment and processing for publishing at a later stage. For that purpose ACCESS and EXCEL programs have been installed.

Data/information stored at the Provincial Fisheries office in electronic files is faxed to the IDPPE main offices in Maputo. This means there is duplication in the capturing of such information because of inadequate structures to transfer the information.

[4] Geographic area along the coastline containing various fishing centres and fisherman villages in a stretch of land with an inland depth of 20 km.

3.2.6 Type of Information Collected

The information and data collected is related to the registry on: biological fish catch and effort data; post-harvest losses; fish marketing prices in fishing centres and markets and gear availability and prices in commercial centres.

3.2.7 Artisanal Fishing Management

In the context of the development of institutional technical capacity building for the control and monitoring of fishing activities, control measures and priorities are taken into consideration and administrative procedure formulated at national level for the processing of fishing information.

Some steps were taken in the coastal area of Moma and Angoche in order to ensure good fishing resource management and sustainability. These included:

- the observance of a 3 mile exclusivity area (Economic Exclusive Zone), provided for in the law for artisanal fishing;
- the observance of a spawning season, established in the Maritime Fishing Regulation (REPMAR);
- the prohibition of the use of unsuitable fishing nets, for example mosquito nets;
- the participative resource management through the creation of Community Fishing Councils (CCP) at community level and;
- fishermen awareness campaigns for the reduction of fishing efforts close to shore and the encouragment of fishing further out to sea.

3.2.8 The Justification of the Choice of the Study Area

Based on consultations made and a review of the relevant information kept on small scale and artisanal fisheries, as well as information system registers, it was realised that a problem existed in the management of the information system, particularly in the Moma-

Angoche Provincial Fisheries Office. It was therefore found appropriate to conduct a study that would lead to designing a model to manage information on artisanal fisheries, as well as to assist in decision-making. Other relevant issues that influenced the choice of the study area are:

- The Moma-Angoche Provincial Fisheries office is strategically suitable for research as demonstrated by the amount of socio-economic artisanal fishing census data already collected and by the research on stock marine resources already carried out;
- The area is already a pilot zone for an integrated fisheries development project called Nampula Artisanal Fisheries Project (NAFP), hence making it possible for studies to be carried out;
- As a result of the amount of research carried out in the area, a system to monitor fish prices in the markets has been introduced by the Artisanal Fisheries Economic Project (PEPA);
- During the life cycle of the various projects and even after their termination, the area has remained an important zone where subsequent studies (for example baseline studies) were carried out.

The case study was worth considering because of the above-mentioned aspects and of the constraints in time allocated and means available to carry out this research. Hence covering Moma-Angoche district was found to be practical and uncomplicated.

3.3 Conclusion

The chapter has given an outline of the case study area. The general characteristics of the area have been given, which include the climate, vegetation, topography and population, among others. Information organization and management of artisanal fisheries within the study area have been outlined as well. The chapter concludes with a justification for selecting the area for this particular research. The next chapter (Chapter four) discusses the results obtained.

CHAPTER 4: RESULTS

4.1 Introduction

This chapter discusses the results which have been obtained in pursuit of the research sub-objectives outlined in Chapter 1.

To meet the requirements of each of the research sub-objectives, different tools and/or techniques were used. Table 4.1 below shows the sub-objectives and the tools/techniques that have been used.

Table 4.1: The relationship between research sub-objectives and tools used

Research sub-objectives	Tools and/or techniques
1. To design an information system model for Artisanal Fisheries, using a data flow diagram (DFD) technique	1.1 Soft system approaches to structure the Artisanal Fisheries problem; 1.2 DFD tools to analyse and design the Artisanal Fisheries information flow to illustrate data stores flow and processes. The tools ensure top-down approaches regarding context level, top level and lower level.
2. To develop a conceptual data model for an Artisanal Fisheries system, using the entity relationship diagram (ERD) technique	2. ERD technique
3. To prototype the system, using Microsoft Access	3. Microsoft Access

4.2 Results

The results in this section are presented in accordance with the research sub-objectives.

4.2.1 Sub-objective 1

To design a system model for the artisanal fisheries information system.

Results obtained: DFD (context diagram (Figure 4.1), top level (Figure 4.2) and lower level (Figure 4.3)) designed for an Artisanal Fisheries system.

The identification and analysis of an existing artisanal fisheries system was done using DFD. This process started with a case description of an existing artisanal fisheries information system (Section 4.2.1.1) and an analysis of how data flows from, into, within and out of the system. Firstly, a context diagram (Figure 4.1) was designed by identifying the terminators or sources (Fishing community and stakeholders, Provincial socio-economic development, Provincial fishing technology, Provincial post harvesting, Provincial Fisheries Office, Fisheries Department Fund, Ministry of Fisheries, National Fisheries Economic Directorate and Fisheries Research Institute) that supply the IDPPE head office with artisanal fisheries information and also the data that flows into and out of the artisanal fisheries system. Secondly, a top level (Figure 4.2) was designed by decomposing the context diagram according to areas of interventions and the existing departments. The data flows were drawn based on the data needs for each department and the way data/information is stored was also shown. The departments are; fishing technology, social development, statistics, equipment and infrastructures, and planning and cooperation (Section 4.2.1.1). The study focused on the fishing technology department and decomposed it further at a lower level (Figure 4.3) and data flows were indicated as well as data stores. Since structured systems analysis and design was used and DFD the tool for each level of decomposition, data analysis was also done.

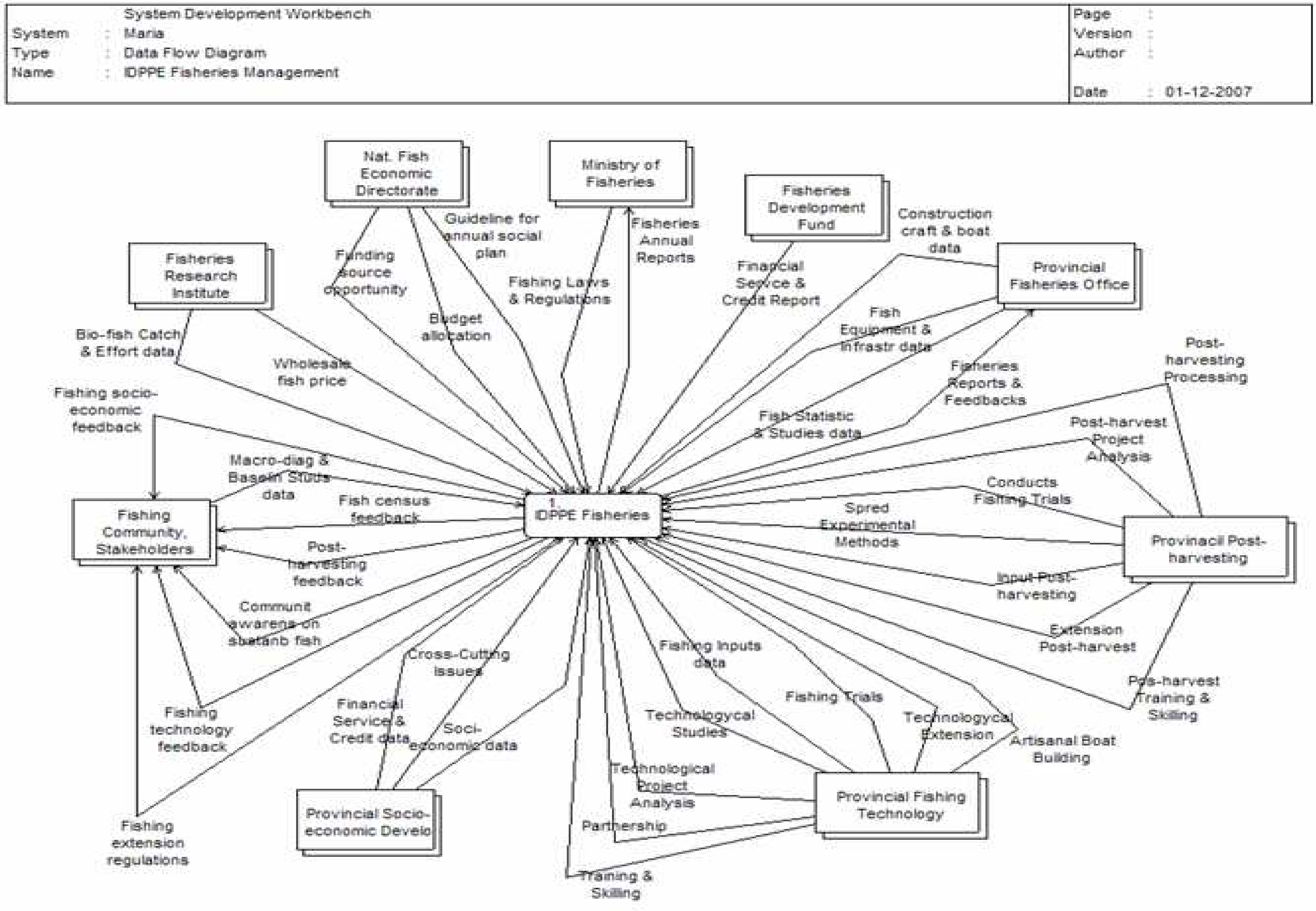

Figure 4.1: Context Diagram of Moma-Angoche

4.2.1.1 Case description of the Artisanal Fisheries Information

The IDPPE head office is composed of five departments; fishing technology, social development, statistics, equipment and infrastructure, and planning and cooperation. Tasks and responsibilities of each department are elaborated below.

i. Fishing Technology

The Fisheries Technology Department organizes relevant data related to fish technology and post-harvesting. It subsequently classifies the information into two categories, as either fish technology or post-harvesting. It also prepares the fishing technology feedback for the fishing community and stakeholders. In addition, the department conducts awareness programmes based on Fishing Laws and Regulations for the fishing community, aimed at attaining sustainable fishing.

For the department to perform its role, it obtains its mandate from the Fishing Laws and Regulations available at the Ministry of Fisheries and relies on data/information from various sources. The data/information obtained are:

- The Provincial fishing technology data (artisanal boat building, technological extension, fishing trials, fishing inputs data, technological studies, technological project analysis, partnership, training and skills development) managed by the Department of Fisheries Technology at the IDPPE Fisheries;
- The Provincial post-harvesting data (post-harvesting processing, post-harvests project analysis, conducting fishing trials, spreading best practice methods, input post-harvesting, extension post-harvest, and post-harvesting training and skills development) managed by the Department of Fisheries Technology at the IDPPE Fisheries;
- The Biologic fish catch and effort data available at the Fisheries Research Institute. The data is managed by this institution;
- The wholesale fish price data available at the Fisheries Research Institute. The data is managed by this institution;
- The Fish equipment and infrastructure information delivered by the Equipment and Infrastructures Department;
- The construction craft and boat building information delivered by the Equipment and Infrastructure Department.

ii. Social Development

The Social Development Department has to organize information related to socio-economic issues and deliver relevant data to the Statistics Department. It also prepares the fishing social-economic feedbacks for the fishing community and stakeholders, as well as conducting community awareness programmes based on fishing laws and regulations for the fishing community and stakeholders, aimed at attaining sustainable fishing.

The department also draws its mandate from the Fishing Laws and Regulations available at the Ministry of Fisheries in order to perform various roles. Data/information flowing into the department include:

- The Macro-diagnostic and Baseline Studies data available from the Fishing Community and Stakeholders;
- The Financial Service and Credit report available at the Fisheries Development Fund;
- And the Provincial Socio-economic development data (socio-economic data, financial service and credit data, and cross-cutting issues) managed by the Department of Social Development at the IDPPE Fisheries.

iii. Statistics

The Statistics Department has to prepare and update annual statistics related to the fish market and gear prices, fish catch and production, post-harvest losses and living standards of the community. It also prepares fish cartography maps, national fisheries census as well as institutional feedbacks of fisheries national census and delivers them to the fisheries sector, fishing community and stakeholders.

To perform its role, this department obtains data/information from various sources. This data/information that is used in the department include:

The Fish Statistics data (socio-economic statistics, production statistics, institutional statistics, physical progress statistics activities and cartography) and Studies data available at the Provincial Fisheries Office. This data is managed by the Department of Statistic at the IDPPE Fisheries;

- The socio-economic information delivered by the Social Development department;
- The fish technology data as prepared by the Fishing Technology Department;
- And the post-harvesting data as prepared by the Fishing Technology Department.

iv. Equipment and Infrastructure

The Equipment and Infrastructure Department has to organize data related to fish equipment and infrastructure as well as prepare relevant fish equipment and infrastructure information and deliver it to the Fishing Technology Department. It also prepares construction craft and boat building information for the Fishing Technology Department.

To perform its role, the department obtains the Fish Equipment and Infrastructure data (diagnosis and studies based on artisanal fisheries, construction craft and boat building etc.) from the Provincial Fisheries Office, managed by the Department Equipment and Infrastructure at the IDPPE Fisheries.

v. Planning and Cooperation

The Planning and Cooperation Department has to prepare annual fisheries reports and regular fisheries reports and feedbacks for the Ministry of Fisheries, Provincial Fisheries Office, District Government and Fishing Community and Stakeholders. These fisheries' feedbacks are usually delivered and spread out to stakeholders through workshops, capacity building courses and annual meetings. It also prepares annual fisheries social economic action plans and strategic fisheries plans, as well as annual fish catch and production values. The department delivers Fishing Extension Regulations and procedures to Provincial Fisheries Offices, District Governments, Fishing Communities and Stakeholders. In addition, it prepares the file with whole data related to international cooperation (this includes project analysis, partners, donors, financing needs, technical assistance needs etc).

The Fishing Laws and Regulations available at the Ministry of Fisheries provide the legal framework for performing various roles. Information/data received in the department includes:

- The Guideline for annual social economic action plans available at the National Directorate of Fisheries Economy. The information is managed by this institution;
- The Budget allocation data available at the National Directorate of Fisheries Economy.
- The Funding source opportunity available at the National Directorate of Fisheries Economy, and .
- fish statistics information delivered by the Statistics Department.

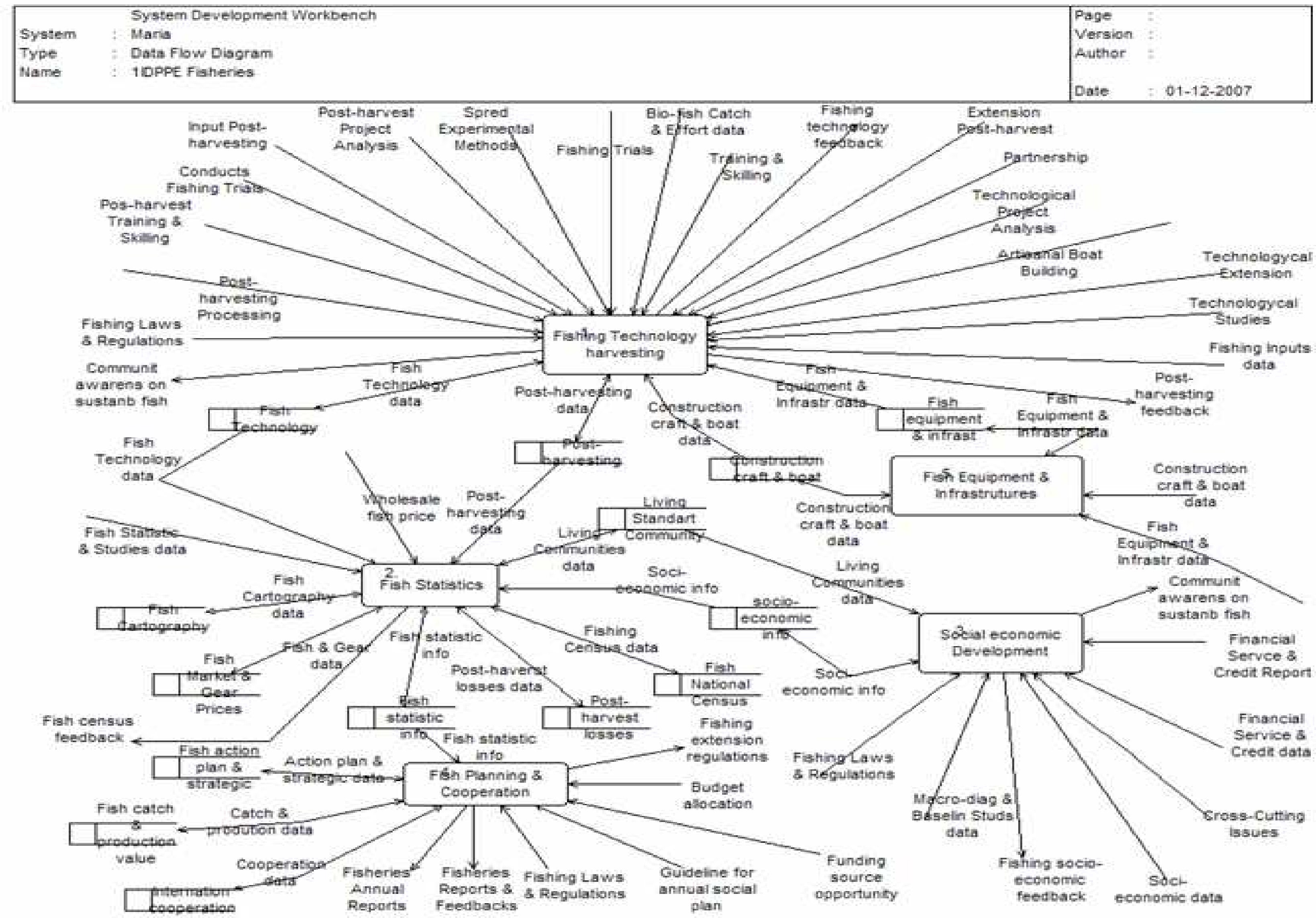

Figure 4.2: Top level of Moma-Angoche

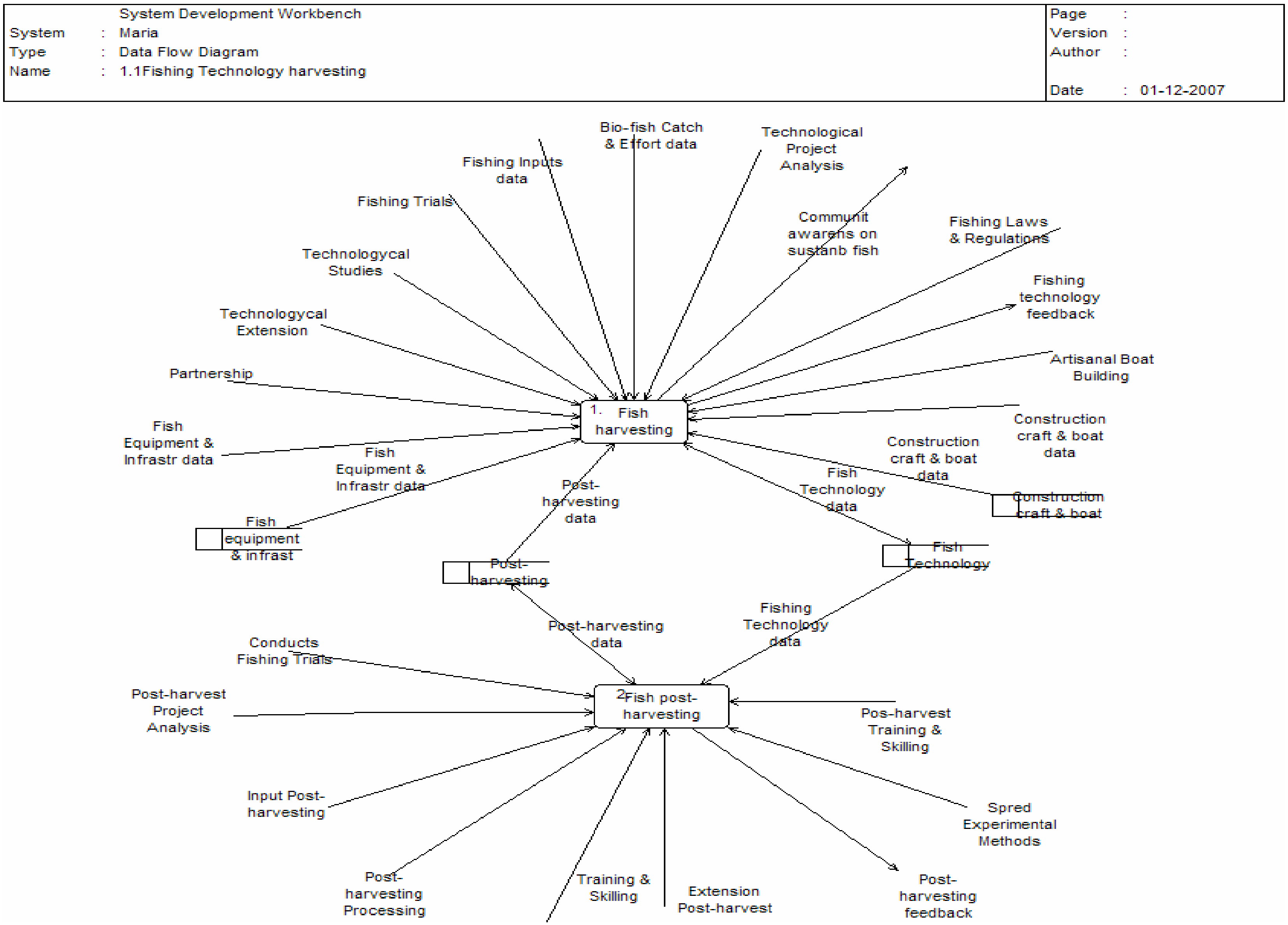

Figure 4.3: Lower level of Moma-Angoche

4.2.2 Research sub-objective 2

To develop a conceptual data model for the data stores of the artisanal fisheries information system.

Results obtained: ERD data model (Figure 4.4) developed for Artisanal Fisheries system.

The results obtained identify artisanal fisheries' key entities (Section 4.2.2.1), the attribute for each entity (Section 4.2.2.2), E-R diagram (Section 4.2.2.3), the relationships (Section 4.2.2.4), enterprise rules (Section 4.2.2.5), skeleton tables (Section 4.2.2.6) and normalized tables (Section 4.2.2.7).

Disclaimer: The system will not include fishing lines

4.2.2.1 Key Entities:

Boat, Net, Fisherman and Fish

4.2.2.2 Attributes for each entity:

- Boat (<u>Boat Registration Number</u>, Storage, Type of material, Eng-Power, Eng-Fuel, Boat-Size, Sail-Size, Sail-Type of sheet, Sail-Shape, …)
- Net (<u>Net Identification</u>, Fishing rope, Fishing twine quality, Net-Size, Type of floats & buoys, …)
- Fisherman (<u>Fisherman ID</u>, Surname, First-Name, Provincial-Location, Fishing-zone, Monthly-Production, Fishing workshop, …)
- Fish (<u>Fish Name</u>, Reproduction-Period, Spawning-Time, Seasonality, Fish-Location, …)

4.2.2.3 Entity-Relationship diagram

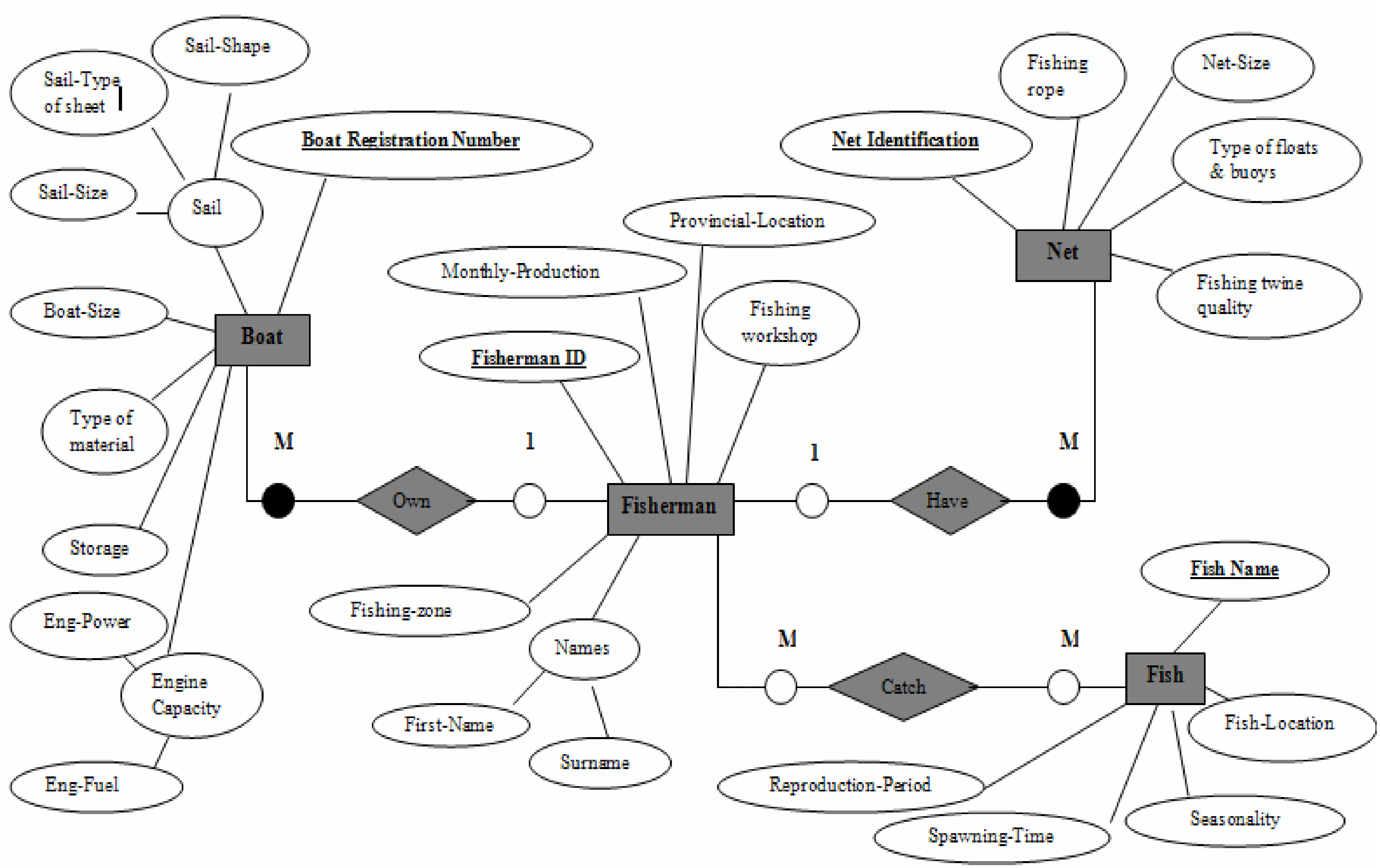

Figure 4.4: Illustration of Entity-Relationship Diagram

4.2.2.4 Relationships:

- Based on consultations made and relevant information kept on artisanal fisheries information system registers in Moma-Angoche, these relationships have been noted:

    i. **Between Boat and Fisherman: a boat must be owned by a fisherman and a fisherman may own a boat;**

    There exists a relationship between a boat and a fisherman. This implies that a relationship is "**one to many**" **(1: M)**. This relationship is **obligatory on** one side, basically **on the "M" entity**, meaning that a boat cannot exist on its own. It must belong to a fisherman. On the other hand, a fisherman may own a boat, and this relationship is **non-obligatory on the "1" entity**.

    ii. **Between Fisherman and Net: a fisherman may have a net and a net must be owned by a fisherman;**

    There exists a relationship between a fisherman and a net. This implies that a relationship is '**one to many**" **(1: M)**. This relationship is **obligatory** on one side, basically **on the "M" entity**, meaning that the net cannot exist on its own, it has to belong to a fisherman. On the other hand, a fisherman may have a net, and the relationship is **non-obligatory on the "1" entity**.

    iii. **Between Fisherman and Fish: a fisherman may catch fish and fish may be caught by a fisherman;**

    There exists a relationship between a fisherman and fish. The relationship is **non-obligatory** for both sides, and this is a "**many to many**" **(M: M)**, meaning that many fishermen may catch many fish and many fish may be caught by many fishermen.

The figure below (Figure 4.5) illustrates the relationship between the key entities (Boat, Net, Fisherman and Fish).

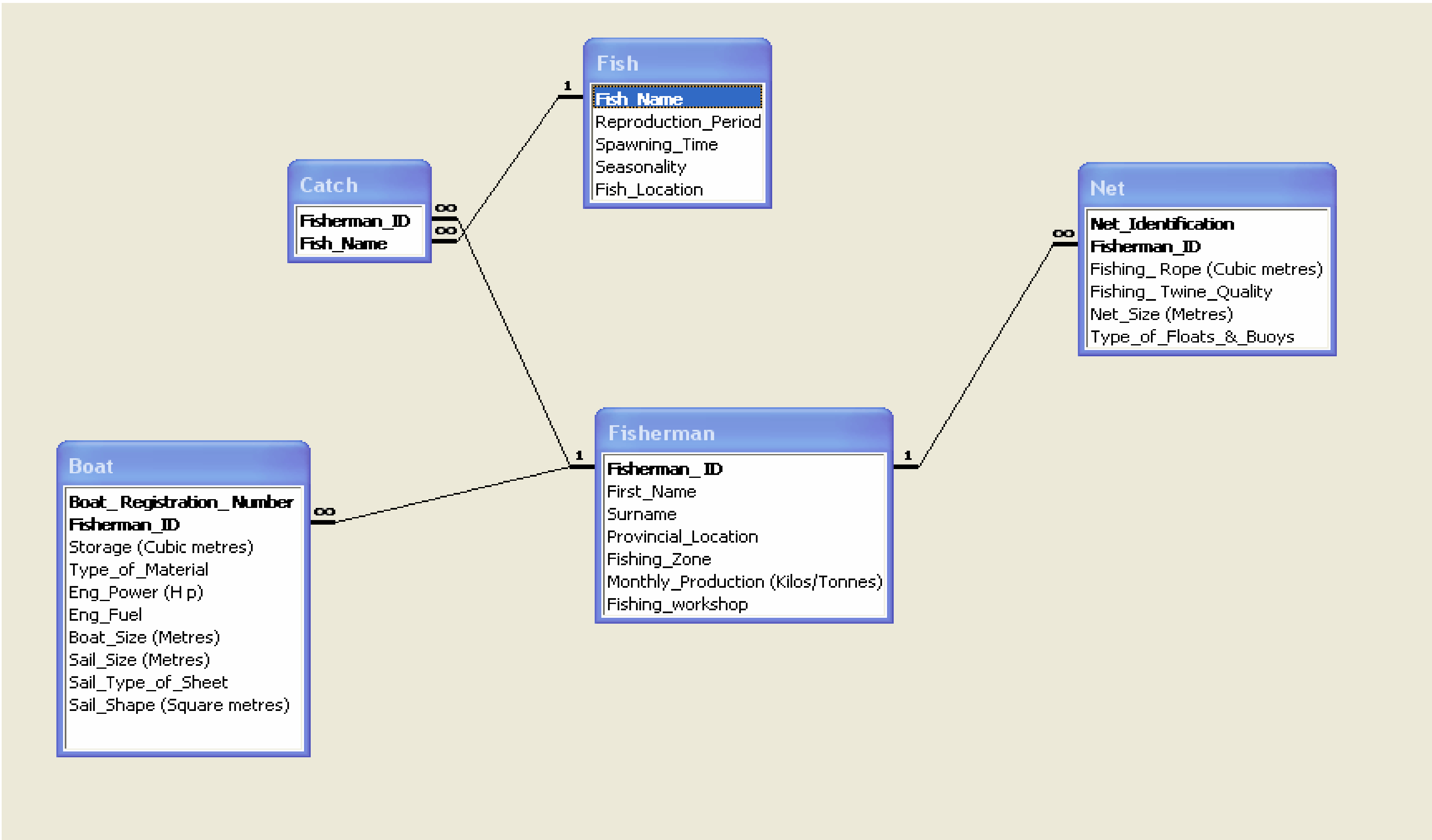

Figure 4.5: Illustration of the Relationships between the key entities (in Microsoft Access)

4.2.2.5 Enterprise Rules:

- A boat must be owned by a fisherman;
- A fisherman may own a boat.

- A fisherman may have a net;
- A net must be owned by a fisherman.

- A fisherman may catch fish;
- Fish may be caught by a fisherman.

4.2.2.6 Skeleton Tables:

Case 1: Between Boat and Fisherman: a boat must be owned by a fisherman and a fisherman may own a boat. This is a 1: M relationship and non-obligatory on the 1 entity and obligatory on the M entity.

Rules: Define 2 tables: One for each entity and identifier of the 1 entity should be posted into the M entity table, as shown below:

> Fisherman (Fisherman ID, First-Name, Surname, Provincial-Location, Fishing-Zone, Monthly-Production, Fishing workshop, …) [a]

> Boat (Boat Registration Number, Storage, Type of material, Eng-Power, Eng-Fuel, Boat-Size, Sail-Size, Sail-Type of sheet, Sail-Shape,…, Fisherman ID) [b]

Case 2: Between Fisherman and Net: a fisherman may have a net and a net must be owned by a fisherman. This is a 1: M relationship and non-obligatory on the 1 entity and obligatory on the M entity.

Rules: Define 2 tables: One for each entity and identifier of the 1 should be posted into the M entity table, as shown below:

Fisherman ((Fisherman ID, First-Name, Surname, Provincial-Location, Fishing-Zone, Monthly-Production, Fishing workshop, …) [c]

Net (Net Identification, Fishing rope, Fishing twine quality, Net-Size, Type of floats & buoys,…, Fisherman ID) [d]

Case 3: Between Fisherman and Fish: a fisherman may catch fish and fish may be caught by a fisherman. This is a: M: N relationships and non-obligatory on both sides.

Rules: Define 3 tables: One for each entity and one for the relationship and the identifiers of both entities become composite identifier of the relationship, as shown below:

Fisherman (Fisherman ID, First-Name, Surname, Provincial-Location, Fishing-Zone, Monthly-Production, Fishing workshop, …) [e]

Fish (Fish Name, Reproduction-Period, Spawning-Time, Seasonality, Fish-Location, …) [f]

Catch (Fisherman ID, Fish Name,…) [g]

It is important to note that tables a, c, and e are exactly the same as they contain similar entities, such that one can represent the others. Tables b, d, f and g, on the other hand, are different as each contain different entities. It is based on these tables that the normalization tables described below were developed.

4.2.2.7 Normalized Tables:

- Fisherman (Fisherman ID, First-Name, Surname, Provincial-Location, Fishing-Zone, Monthly-Production, Fishing workshop…)
- Boat (Boat Registration Number, Storage, Type of material, Eng-Power, Eng-Fuel, Boat-Size, Sail-Size, Sail-Type of sheet, Sail-Shape,…. Fisherman ID)
- (Net Identification, Fishing rope, Fishing twine quality, Net-Size, Type of floats & buoys, … Fisherman ID)

- Fish (Fish Name, Reproduction-Period, Spawning-Time, Seasonality, Fish-Location,…)
- Catch (Fisherman ID, Fish Name,…)

4.2.3 Research sub-objective 3

To implement the developed data models (under objective 2 above) within a database environment

Results obtained: A database prototype in Microsoft Access.

The results obtained show the creation of Artisanal Fisheries database, tables and forms using Microsoft Access. Tables were first created in Design view using Microsoft Access and thereafter the fields that make up the tables were created. The tables were created for boat, catch, fish, fishermen and net. One of the tables created is shown in the figure below (Figure 4.6).

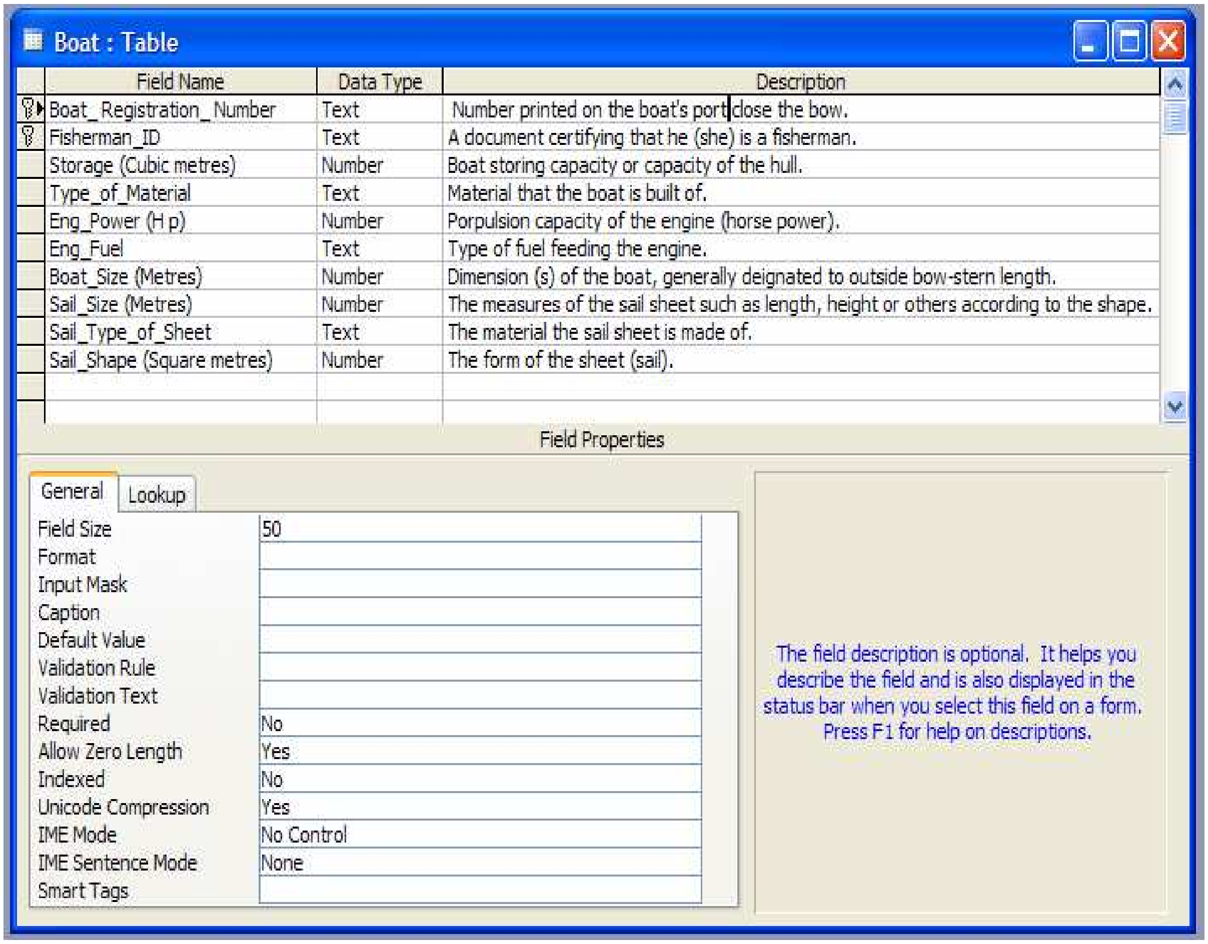

Figure 4.6: Table for boat showing various fields

From the tables, forms for boat, catch, fish, fishermen and net were created. Extra functionality buttons were added in the forms. These buttons were ‘find record’ and ‘add record’, which would give the user the opportunity to make adjustments and manoeuvre within the form. Of the forms created, two are shown below labelled ‘boat’ and ‘fisherman’ (Figure 4.6 and 4.7). Other forms created are provided in the appendices (See appendix 2).

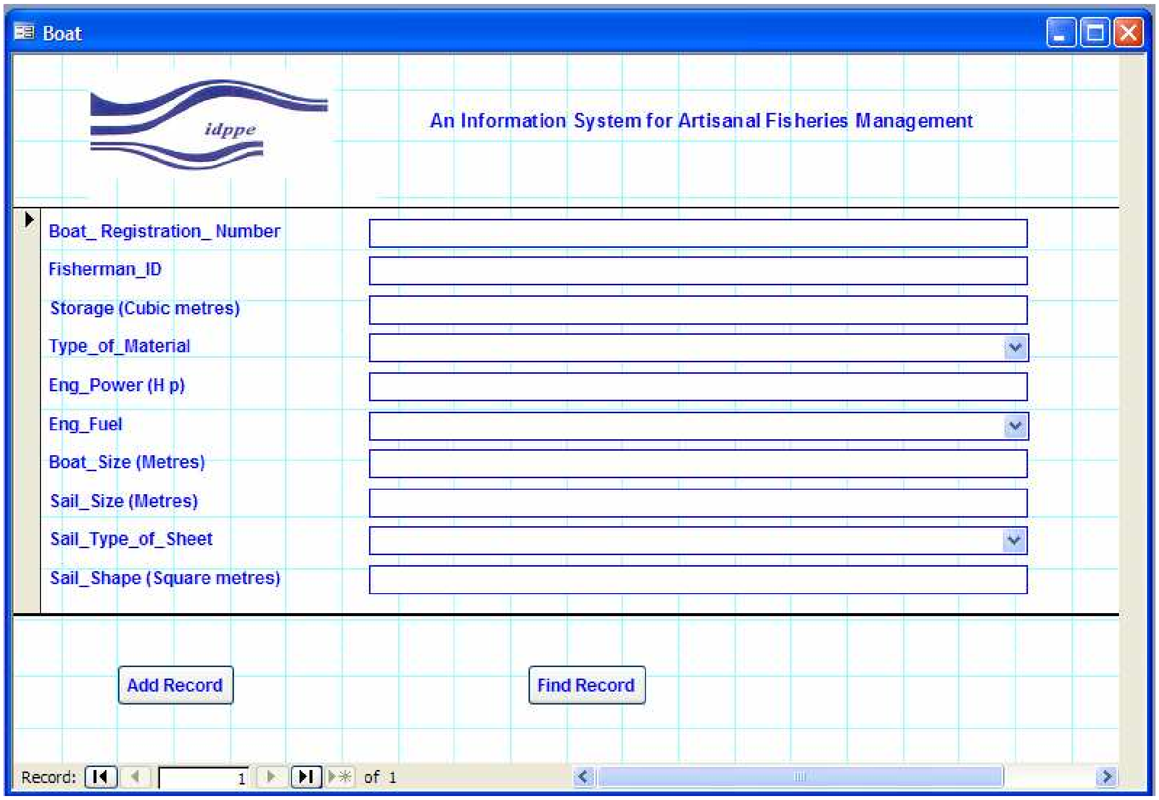

Figure 4.7: Form for obtaining boat information

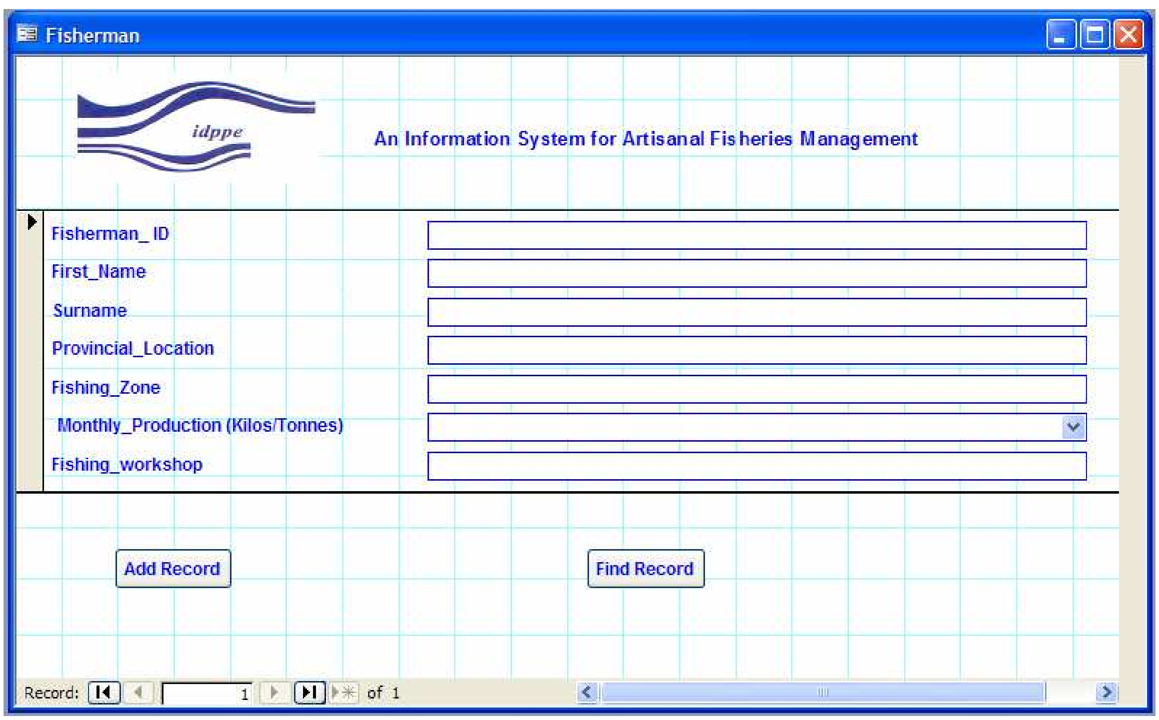

Figure 4.8: Form for obtaining fisherman information

4.2 Conclusion

The results are presented in line with the three sub-objectives. For sub-objective one the result was a DFD (context diagram, figure 4.1; top level, figure 4.2 and lower level, figure 4.3) designed for Artisanal Fisheries systems; for sub-objective two it was an ERD data model developed for the Fish Technology and harvesting component of the Artisanal Fisheries systems developed under objective 1 while for the third sub-objective, the result was a database prototyped in Microsoft Access (see accompanying CD). Diagrams, tables and forms showing the end product for respective sub-objectives are included in the chapter.

Chapter five provides the concluding remarks for the research, as well as recommendations based on the sub-objectives and the findings of the research.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter provides conclusions and recommendations for this research. These are made with regard to the three research sub-objectives.

5.2 Conclusions and Recommendations

The artisanal fisheries sub-sector in Moma-Angoche currently lacks a structured approach and database to document and archive data/information. This, coupled with other factors such as most of the data/information collected not being user friendly, has made it difficult for managers to make comprehensive decisions. The main objective of the research was to try and address this problem by designing an information system for artisanal fisheries management that would be appropriate for the study area. This was achieved by pursuing three research sub-objectives.

The first research sub-objective was to design an information system model for artisanal fisheries using the data flow diagram (DFD) technique. The results obtained are DFD designed for an artisanal fisheries system, which comprise of context diagram (Figure 4.1), top level (Figure 4.2) and lower level for fish harvesting (Figure 4.3). With the design of such a model, it is possible to see how the system works and how data/information flows through the system. This research has shown that the use of the DFD technique is ideal in designing an information system. It is therefore recommended that this technique be used to design models within the various systems in artisanal fisheries sub-sectors.

The second research sub-objective was met by using the entity relationship diagram (ERD) technique to develop a conceptual data model for part of the artisanal fisheries information system developed under objective 1. Before developing the data model, tables were created showing the relationship between the entities (Figure 4.4). The result obtained is an ERD data model for the artisanal fisheries system (Figure 4.5). The model identifies various key entities, shows the attributes of each entity and the relationships between the entities. Enterprise rules (Section 4.2.2.5), skeleton tables (Section 4.2.2.6) and normalization tables (Section 4.2.2.7) are derived from this model. The conceptual model developed in this research for the artisanal fisheries system, using the ERD technique, was based on predetermined boundaries and therefore a few key entities were selected. It is recommended that more entities, such as fishing lines and gear nets among others, should be taken into consideration in developing models that cover a wider scope. This will ensure that more relationships between the entities are identified hence providing a more comprehensive picture of how information flows within the system.

Further, the artisanal fisheries system was prototyped using Microsoft Access database, as outlined in the third research sub-objective. The results obtained show the creation of database (Attached CD), tables (Figure 4.6) and forms (Figure 4.7 and 4.8) for artisanal fisheries. These are important for capturing specific data/information obtained from various sources. Microsoft Access is known to be a good platform for prototyping, despite the fact that it has limitations in terms of the capacity of each database. It also allows for the fast creation of results and as such it is recommended that the program should be adopted for prototyping models in artisanal fisheries systems. However, due to time limitations, the prototype developed is however not a complete database. In situations where databases require larger capacities, it is further recommended that other programs, such as Oracle be used.

Based on the research boundaries, the focus in this study has been on designing an information system for artisanal fisheries for the Moma-Angoche. It is recommended, that a complete database which captures all data stores of the system be developed. A broader perspective that covers other systems within the artisanal fisheries sub-sector is further proposed.

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APPENDICES

Appendix 1: Glossary

This glossary contains most of the non-standard words used in the text. It is not intended to be as comprehensive as IS or Microsoft Access.

1. Fisherman – a person (man or woman) involved in any fishing activity.
    a. Fisherman ID – a document certifying that he (she) is a fisherman, generally a fishing license.
    b. Fishing workshop – a workshop or practical course addressing fishing activity matters.
    c. Provincial location – district/ locality (place) where the fishermen carry out their activities.
    d. Monthly-production – the total quantity of catches per month.
    e. Fishing zone – the area where fishermen carry out their activities.
    f. Names – how he/she is formally or informally called.
        i. First-name – fisherman's given name.
        ii. Surname – fisherman's family name.

2. Boat – any floating construction made of wood, iron or fibre for sailing, comprising a hull, ports, a bow and a stern. It is a watercraft designed to float or plane on, and provide transport over water.

    a. Boat registration number – a number printed on the boat's port close to the bow.
    b. Sail – the means by which the craft is propelled over the water, making use of wind. There may be one or various sheet(s) made of cotton or polyester on the boat.
        i. Sail-shape – the form of the sheet (sail).
        ii. Sail-type of sheet – the material of which the sail sheet is made.

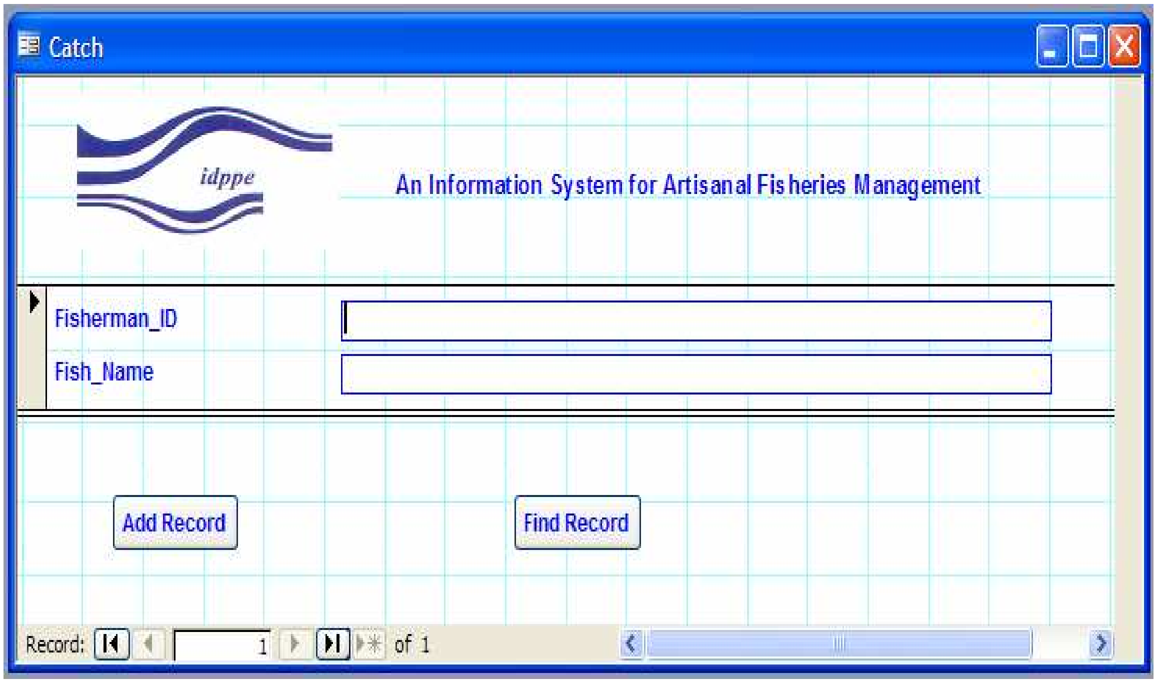
iii. Sail-size – the measures of the sail sheet such as length, height or others, according to the shape.

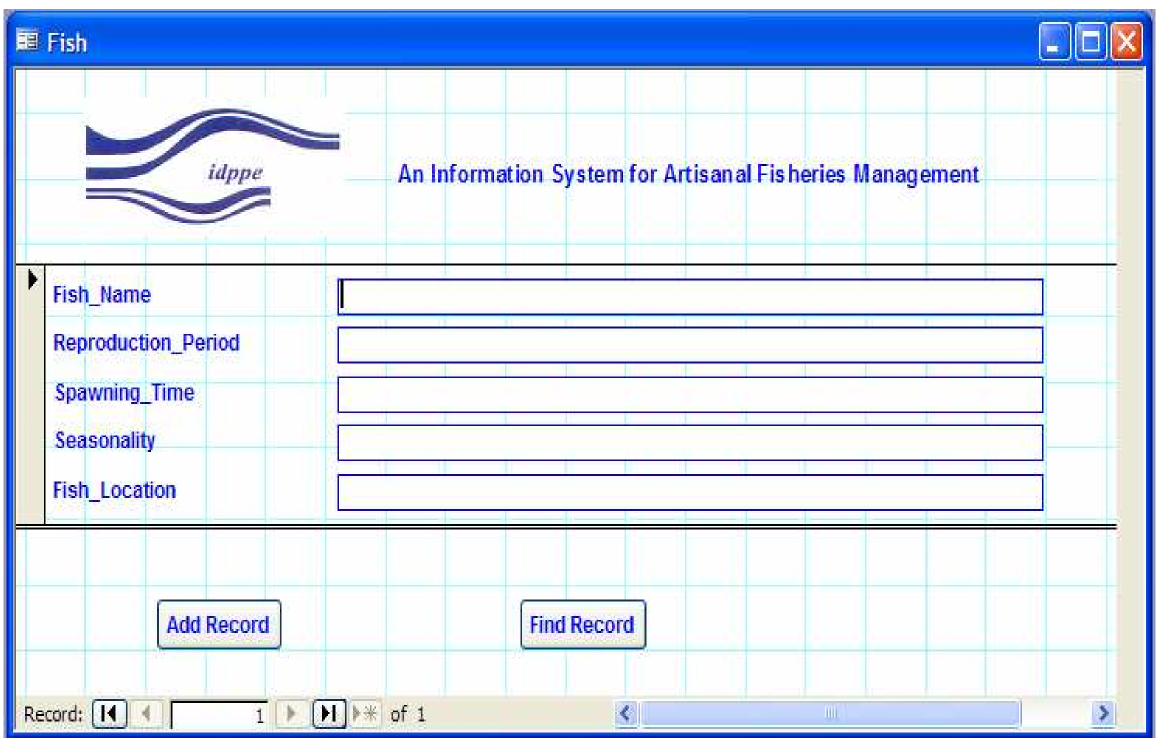
c. Boat-size – dimension(s) of the boat, generally determined by the outside length from bow to stern.
d. Type of material – the material from which the boat is built.
e. Storage – boat storing capacity or capacity of the hull.
f. Engine capacity – the ability of the engine.
   i. Eng-power – propulsion capacity of the engine (horse power)
   ii. Eng-fuel – type of fuel feeding the engine.

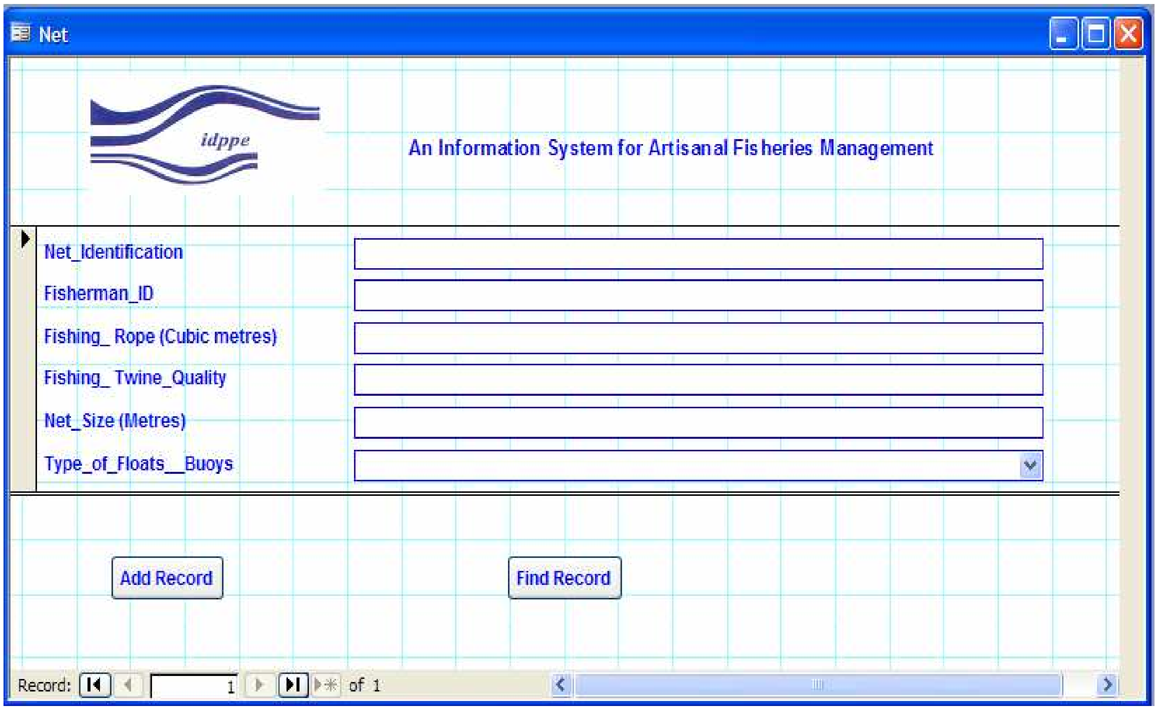
3. Net – Means used by the fishermen to catch fish, shrimp, crabs, lobsters, etc.
   a. Net identification – the type of net material, twine, mesh size, length and height.
   b. Fishing ropes – the ropes used for assembling fishing gear or hauling during fishing operations.
   c. Net-size – the dimensions of the net (length and width).
   d. Type of floats & buoys – the characteristics or dimensions (buoyancy) of the floats or buoys.
   e. Fishing twine quality – material used to make twine used for assembling or mending fishing gear or nets.

4. Fish – Aquatic invertebrates, but also designated to catches, in general.
   a. Fish name – the species of fish.
   b. Fish-location – the area where the schools are located.
   c. Seasonality – periods in the year during which species might be caught.
   d. Spawning-time – the time when fishing activity is temporarily forbidden, aimed at allowing species of fish to spawn.
   e. Reproduction-period – the period during which fish reproduce from eggs to juveniles.

Appendix 2: Results Forms






Net
idppe
An Information System for Artisanal Fisheries Management
Net_Identification
Fisherman_ID
Fishing_ Rope (Cubic metres)
Fishing_ Twine_Quality
Net_Size (Metres)
Type_of_Floats__Buoys
Add Record
Find Record
Record: 1 of 1

Appendix3: Photographs

A collection of photographs showing artisanal fishermen engaging in various activities.