1 Introduction

Fisheries management and planning has many spatial components (e.g. movements and migrations of resources, definition of fishing grounds, transportation networks, markets), and many serious issues like habitat loss and environmental degradation have spatial dimensions, so fisheries biologists, aquatic resource managers and decision makers in developing countries have to address issues of great complexity. In this regard, GIS is a technology that can help to clarify the issues and lead to solutions by treating many spatial components simultaneously. However, many people are still unaware or afraid of the technology and its potential for fisheries management.

This manual is written to overcome this knowledge-gap. It is not a GIS course, but more a "do-it-yourself"-course giving a short introduction to GIS software and its applications. Different examples and exercises will introduce you to several possibilities of application of GIS in fisheries (inland or marine) management. You are encouraged to apply this knowledge and your creativity to explore additional possibilities within the software. The overall objective of this manual is to encourage the use of GIS to foster the sustainable use of natural resources. Users of this manual will be able to apply learned principles and GIS to their own professional situation and will become aware of the vast possibilities that GIS can provide, so that communication with GIS expert counterparts will be easier.

During the last decade, the application of GIS in fisheries has increased as presented (as recent developments of spatial analysis) at the first and second International Symposium on the use of GIS in fisheries and aquatic sciences (Nishida, Kailola and Holingworth, 2001; Nishida, Kailola and Holingworth, in press); the FAO COPEMED Project [http://www.faocopemed.org/en/index.htm], and two excellent handbooks (FAO, 1991a and Valavanis, 2002). However, most of the publications are scientific and deal with marine fisheries in the western hemisphere.

Practical manuals, explaining the basic of GIS and its use in fisheries, aquaculture and management for developing countries, are difficult to find. Except for the manual developed by de Graaf *et al.* (2000) for Bangladesh, the only other manual similar to the present one was developed with software called 'Idrisi' and it only includes one exercise on aquaculture suitability. The workbook was developed and is distributed by Clark Labs (http://www.clarklabs.org/home.asp) through a memorandum of understanding with the United Nations Institute for Training and Research (UNITAR). The workbook explores the use of GIS analytical techniques in the defined field of study, complete with extensive bibliography and includes a set of exercises that allows the user to apply these techniques to geographically diverse case study problems using real digital data sets and GIS software. Volume 3 of the workbook series explores the role that GIS may play in coastal zone research and management and includes an exercise on aquaculture suitability analysis, Gulf of Nicoya, Costa Rica that is based on the study by FAO (1987a).

This manual is useful for a broad range of fishery applications. However, this manual by no means covers all possibilities of GIS, it merely touches upon some of the most important features for fisheries management. Interested readers are highly encouraged to become aware of past and current activities at FIRI to enrich their training.

1.1 GIS AND REMOTE SENSING ACTIVITIES AT THE INLAND WATER RESOURCES AND AQUACULTURE SERVICE (FIRI)

1.1.1 Past activities at FIRI from 1985 to 1999

The activities of FIRI in respect to GIS, most relevant to this manual, can be divided in two main categories, namely training courses and projects. The aim of the training courses was to instil an appreciation of benefits and constraints of GIS and remote sensing. Both aquaculture and inland fisheries were covered. Courses were held in Rome (Travaglia and Appelkamp, 1985), Asia (FAO, 1989b), Anglophone Africa (FAO, 1991b), Francophone Africa (FAO, 1992), and in Latin America. A manual for self-training on GIS and remote sensing applications was produced (FAO, 1991a) and it is still being widely disseminated to date as much of the main text remains relevant (see http://www.fao.org/DOCREP/003/T0446E/T0446E00.HTM).

The objective of the projects was to demonstrate the capabilities of GIS and remote sensing to address aquaculture and inland fisheries issues, mainly for strategic planning. Projects included assessments of coastal aquaculture potential in Costa Rica in cooperation with UNEP (FAO, 1987a), Malaysia (FAO, 1989a), and Sri Lanka (FAO, 1999b), and remote sensing was used to inventory shrimp farms, also in Sri Lanka (FAO, 1999a). Inland fish farming potential was assessed in Ghana in (FAO, 1991c and FAO, 1990).

A continent-level assessment of inland fish farming potential was carried out for Africa (Kapetsky, 1994b) along with an appraisal of the potential of aquaculture to contribute to food security (Kapetsky, 1995), and Africa was subsequently reassessed on the basis of improved data (FAO, 1998b). Latin America constituted another continental assessment (FAO, 1997a), and the Caribbean Island States (FAO, 1998a) and Southern Africa (Kapetsky, 1994a) were assessed as regions.

Not all of the outputs dealt with aquaculture. The use of remote sensing to inventory small water bodies for community fishery development was assessed in Zimbabwe (FAO, 1987b). At global level an assessment was carried out to estimate the potential for inland fishery enhancements (FAO, 1998c), and GIS applications in inland fisheries were reviewed worldwide (Kapetsky, 2001).

1.1.2 Current activities

Two current activities at FIRI are most relevant to this manual and are highly recommended to the readers to complement the contents found in the present manual: (1) the Global Gateway to GIS, Remote Sensing and Mapping for Aquaculture and Inland Fisheries and (2) the African Water Resource Database.

The Global Gateway to GIS, Remote Sensing and Mapping for Aquaculture and Inland Fisheries

There are many opportunities to use GIS and remote sensing to improve the sustainability of aquaculture and inland fisheries and fundamental issues in aquaculture and inland fisheries can be resolved with the help of GIS and remote sensing. However, overall, our research has concluded that the aquaculture and inland fisheries GIS user base is low. Therefore, the objectives of this Gateway are to: (1) improve the sustainability of aquaculture and inland fisheries by promoting the use of GIS, remote sensing and mapping; (2) facilitate the use of GIS, remote sensing, and mapping through easy access to comprehensive information on applications and training opportunities; and (3) provide a "one stop" site from which to obtain the depth and breadth of the global experience on GIS, remote sensing and mapping in aquaculture and inland fisheries.

The Gateway is being designed for a very broad range of users. The beneficiaries will mainly consist of people working with global and regional analysis on aquaculture and inland fisheries management and planning, including researchers and project

managers in national and international organizations and scientific institutes. Other beneficiaries are the commercial sector and planners and managers in fields apart from aquaculture and inland fisheries, specifically those involved with coastal area management and river and lake basin management.

The Gateway is a work in progress at FIRI and will be located in FIGIS (http://www.fao.org/figis/index.jsp) in early 2004.

African Water Resource Database (AWRD)

The African Water Resource Database (AWRD) is a Geographic Information System (GIS) analytical framework supporting natural resource planning with a specific focus on inland fisheries and integrated water resource management. The present AWRD is an expansion and enhancement of the work by ALCOM's Water Resource Database (http://www.fao.org/fi/alcom/wrd.htm) for subequatorial Africa which has been extended to cover the entire African continent. Development of the AWRD is a work in progress being carried out under the guidance of FIRI.

The core datasets which populate the AWRD include: various depictions of surface water bodies, multiple watershed models; aquatic species; rivers; administrative boundaries; population density; soils; satellite imagery; and many other physiographic and climatological data types. To display and analyse the data, the AWRD contains an assortment of new custom-designed applications and tools. These tools are designed to facilitate integrated water resource management and planning, as a means of promoting the responsible management of living aquatic resources and increasing food security.

The beneficiaries of the AWRD will mainly consist of people working with global and regional analysis on water and inland aquatic resource management and planning, including researchers and project managers in national and international institutions.

The tools developed for the AWRD are for use with ESRI's ArcView 3.x and Spatial Analyst software, so we recommend the readers to explore the AWRD once they have become acquainted with GIS-basics using the GIS manual in front of you.

The first version of the AWRD will be made available in early 2004 as an FAO technical publication and a set of CD-ROM data disks.