Chapter Three

METHODOLOGY AND DATA COLLECTION

3. 1 Environmental Information System (EIS) Approach

To set out and develop options for sustainable natural resource management in the WBR, as the one of UAE examples of marginal dry lands, building an environmental information system was the best choice of using Geographic information systems (GIS) as a tool. Sustainable development of the WBR biosphere can succeed, if the quality of land-use planning and decisions can be improved by incorporating a better understanding of the locations of the important elements of diversity and of human effects upon them (Davis et al., 1990).

3.1.1 Geoinformatics as a Decision Support Tool

Over the last few years, there has been a revolution in the availability of information and in the development and application of tools for managing information (Harrison, 1995). That is why Geoinformatics has been defined to be the integration of science and geospatial technologies (Knoecny, 2002). Konecny (2002) stated that surveying sciences namely; surveying, geodesy, photogrammetry, remote sensing, and cartography, are means for geospatial data acquisition and processing methods. The key element that differentiates Geoinformatics from other areas of information technology is the fact that in geoinformatics, all data is "geocoded", meaning that all things have positions on, in, or above the Earth, and their locations can be interrelated to wide range of data types for possible relationships.

Planners, emergency management personnel, policymakers, earth scientists, law enforcement personnel, environmentalists, and other land managers routinely face a number of complex problems that require intensive use of spatial data (also called "geodata") to capture, store, retrieve, analyze and present data (Zurayk, 2002; Hoeschele, 2002). Those individuals use geoinformatics to provide integrated analysis for problems such as:

- Management of natural resources,

- Planning and management of land use,
- Development of sustainable agricultural,
- Assessment of natural disasters,
- Delivering emergency supplies and their spatial aspects,
- Conservation of nature, and
- Control of environment.

The challenge is the chaotic distribution of available data sets, lack of documentation about them, and lack of easy-to-use access tools. Computer modeling and analysis codes have been major obstacles for scientists, practitioners and educators. Recent advances in fields such as computational methods, visualization, and database interoperability are now providing practical means to overcome such problems. For solving these problems GIS are increasingly used, since it is an ideal tool to support the capture, management, manipulation, analysis, modeling and display of spatially referenced data for solving management problems (Zurayk, 2002).

This development has resulted in the new discipline of geo-information science, which combines expertise from information and communication technology (ICT), cartography, geodesy, remote sensing, GIS, photogrammetry; with subject-related disciplines, such as land-use planning, geography and soil science.

Geoinformatics tools include:

- An object-relational database (ORD) or object-relational database management system (ORDBMS)
- Object-relational mapping (or O/RM)
- Geostatistics

Geospatial tools such as GIS, the global positioning system (GPS), remote sensing, and spatial modeling have proven invaluable to environmental research. Over the last decades, the increasing power of remote sensing and other geospatial technologies has led them to be widely used for monitoring and management of natural systems. Moreover, because geospatial tools help in pattern identification and prediction, they provide an effective medium for participatory appraisal where expert opinion and local knowledge are critical to natural resource management. While geospatial tools are most frequently used to facilitate participatory research on or management of natural resources, it is also possible to start from the opposite direction, using participatory methods to create geospatial tools for natural resource management (Salem, 2003a and Salem, 2003b).

3.1.2 Methodology

The spatial database, produced in the form of environmental information system, is based on automation of base maps and satellite images.

The investigation has relied principally on the combination of field methods, laboratory analysis and GIS office work. The GIS was used primarily as a tool of analysis, presentation and as a guide for field work. Laboratory analysis was mainly chemical analysis of groundwater samples collected for this study. The analyses were conducted in the Ministry of Environment and Water (MEW) Laboratory at Ras Al-Khaimah. Field work aimed at gathering data on the kind of seamless experience and knowledge of local inhabitants and authorities on their environment. This has been integrated with reports and publications related to this area, in order to broaden the common knowledge-base. The whole process involved the following:

1. Interpretation and classification satellite image,
2. Automation of spatial and aspatial data to build on the existing geodatabase,
3. Analysis of physical and chemical properties of water samples,
4. Presentation of the hydrogeochemical results,
5. Determination of groundwater quality and evaluation of its suitability for different uses,
6. Identification of vegetation types and spatially locating their major habitats,
7. Recording the indigenous knowledge pertaining to the use of resources, and
8. Conservation of rangelands and water resources.

The establishment of a master database based on the above methodology would be invaluable to be used in the evaluation of the study site, facilitate its comparative evaluation with other study sites and disseminate of information amongst the targeted beneficiaries.

3.1.3 GIS Technology

GIS is powerful tools for intergrading, manipulating and processing spatial information obtained from various sources.

The many definitions for the concept of GIS since 1972 show how GIS has developed and changed from strictly academic pursuits in research to a useful tool in handling spatial data. Tomlinson (1972) stated that the GIS are not a field by itself but rather the common ground between information processing and the many fields utilizing spatial analysis techniques. While Environmental Systems Research Institute (ESRI) (1990) defines the GIS as an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze and display of all forms of geographically referenced information; a computer system capable of holding and using data describing places on the Earth's surface.

A GIS uses a set of computer programs to derive information on the spatial distribution of features and their characteristics (Lambert and Croswell, 2000). In order to do so, each data set needs to be transformed into a computer-coded map that contains two fundamental information components: location of features such as habitats, plants, climate stations and water wells; and feature attribute such as rock type, water quality and urban planning.

The main advantages of utilizing a GIS for conducting analysis on geographic or spatial information are the ease and speed with which it allows concurrent handling of spatial and attribute data, integration of a variety of data collected from multiple sources, processing and analysis of data, and achieving higher accuracy and time efficiency.

The application of GIS methodology in this study comprised of five steps: (1) data acquisition; (2) data preprocessing; (3) data management; (4) data manipulation and analysis; and (5) data output as shown in Figure 3.1 (Gaffney et al., 1991; Al-Ghadban, 1997). The first stage, data acquisition, consists of identifying the needs required in order to understand the assigned problem; Existing data (maps, satellite images, reports, publications and filed observations) has been collected and used to serve as bases for building the information layers.

Data preprocessing comprises the second stage. It involves scanning, georeferencing and digitizing maps on-screen as well as manually entering tabular data via keyboard. This stage deals with the conversion of datasets into a suitable form for GIS storage and manipulation. All attribute data from maps, reports and field observations were entered in this way.

The data management which represents the third stage uses a relational database management system that is integrated in the GIS software; in this case it is the ArcGIS 9.1. This tool enables proper structuring and functioning of the database and then a variety of data processing, enhancement and analysis possibilities take place after the construction of the database (Crosier et al., 2005a).

The fourth stage of data manipulation and analysis deals with two main domains raster and vector domains depending on parameter characteristics of a particular data set. Land uses are examples of vector layers while precipitation is an example of a raster layer. GIS analysis functions can operate in both domains and can be categorized into the functions of retrieval, measurement, overlay, neighborhood, and connectivity (Crosier et al., 2005b).

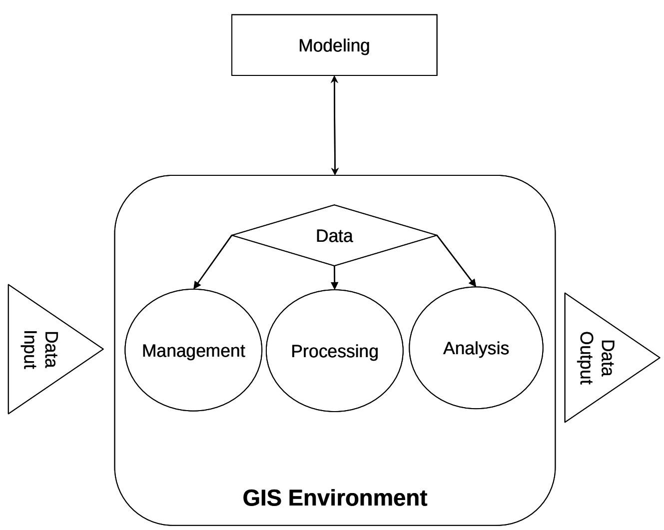

Figure 3.1 Description of how the GIS Works (ALHOGARATY).

3.2 Data Collection, Analysis and Presentation.

The data sets used in this study came from different sources, while their integration into the common GIS database required extensive data processing and management. Both tasks have been accomplished resulting in the delivery of the GIS database for the proposed Biosphere Reserve of the Eastern Coast Region through different phases of the database construction process (Figure 3.1).

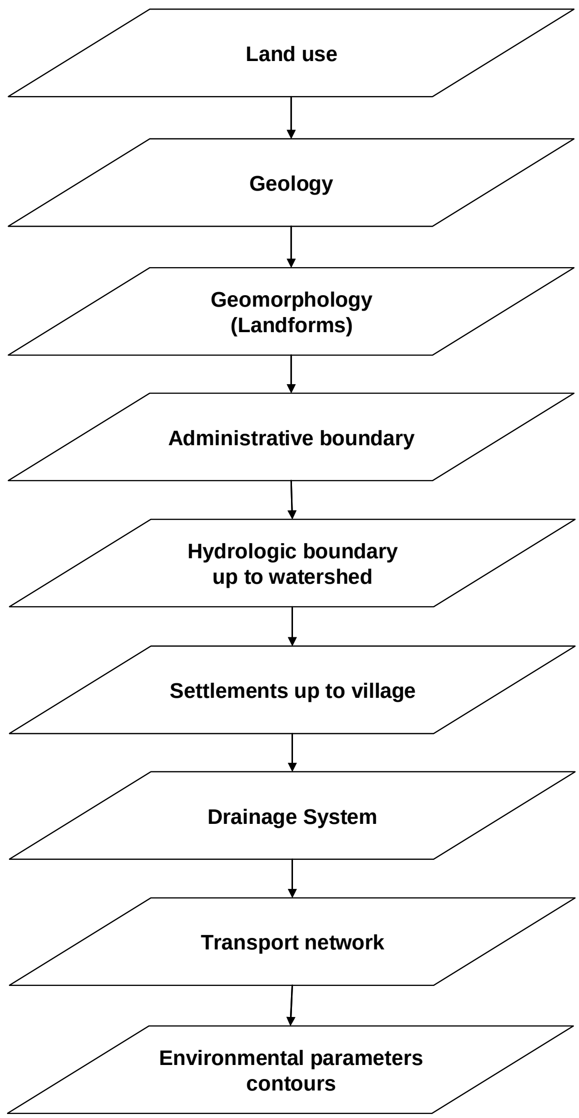

Figure 3.2 The GIS layers created for the area of Wurayah and its hinterlands (ALHOGARATY).

A thorough bibliographic search was conducted to obtain up-to-date records of the climate, geography, geology, biology, urbanization and environmental setting of the study area. This information is crucial for gaining an overall understanding of the climatic conditions prevailing in the study area, the dynamic of land use and water resources usage, groundwater availability and quality as well as the environmental system stresses (Figure 3.2). Information on the mentioned topics has been classified by data layers included in the GIS database. The GIS layers have been grouped into two categories: satellite maps and cartographic map (Figure 3.3).

3.2.1 Field Work

To study the current stress on the proposed biosphere reserve in Wadi Wurayah and its hinterlands, a field survey has been carried out in three phases between January 2007 and January 2009. The information obtained from the field survey included local landscape and their classification and distribution, local habitats, water catchments areas, local rangeland systems and indigenous agro-ecological zones. This information has then be ground-truthed and transformed into geographic data using a GPS, entered into a GIS format, and overlaid on the base maps of the study area in order to produce a georeferenced resource map. The ground-truthing phase helps to locate the boundaries of the different land use, agro-ecological zones and water catchments areas.

3.2.2 Lab Analysis

Standard analytical techniques described in Rainwater and Thatcher (1960), FAO (1970), Wood (1976), APHA (1995) and Skoog et al. (2004) were applied. Chemical analysis of major and minor constituents was performed using titration methods, ion chromatography (Weiss 1986) and atomic absorption spectrophotometry (AAS) (Ediger 1973).

For measurement of total dissolved solids (TDS), a 100 ml of well-mixed water sample was filtered through a standard glass fiber. The filtrate was evaporated to dryness in a weighed dish and dried to a constant weight at 180^{o}C. The increase in dish weight represented the total dissolved solid (APHA 1995). For determination of alkalinity, bicarbonate (HCO_3^-) anions were measured by titration of 50 ml water sample against 0.02 N HCl solution using phenolphthalein and methyl orange indicators (Skoog et al. 2004). Total hardness was measured by addition of 2 ml of the buffer solution pH-10 and 3 to 4 drops of Erichrome Black T indicator to 10 ml water sample, and titration with standard 0.01 M EDTA solution.

Ion chromatograph, model Dionex-2020i, was used for the analysis of the anions; chloride (Cl^-) and sulphate (SO_4^{2-}). The Dionex-2020i ion chromatograph is a dual-channel, high-performance chromatographic system featuring two precision analytical pumps, a dual-channel advanced chromatography module with optional column heater and two conductivity detectors. The operating conditions were 10-40^{o}C temperature range and 1,900 psi (129 atm) maximum pressure. A calibration curve was prepared for each anion using aliquots anion concentrations higher than detection limits. The detection limits in mg/L of Cl^- and SO_4^{2-} were 0.03, respectively.

Atomic absorption spectrophotometry (AAS) was used for the determination of calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{2+}) and potassium (K^+) ions by measuring their absorbance at the maximum wavelengths (Table 3.1), against reagent blank (Ediger 1973).

Table 3.1 List of wavelengths and detection limits of ions determined with the use of AAS (Vela et al. 1993).

Element	Symbol	Analytical Method Atomic Absorption Spectrophotometry (AAS) Reference Material		
		Reference Material	Wavelength (nm)	Detection Limit (mg/L)
Calcium	Ca^{++}	$CaCO_3$	239.9	0.040
Magnesium	Mg^{++}	MgO	202.6	0.010
Sodium	Na^+	NaCl	330.4	0.020
Potassium*	K^+	KCl	404.4	0.032

* Potassium detection limit is variable and highly dependent on operating conditions and plasma position (Vela et al. 1993).

3.2.3 Office Work

3.2.3.1 GIS Data Input

Various types of maps, selected according the required works related to area of study, have been used as an input data for the GIS system.

The UAE political boundaries and Eastern Coast Region boundaries has been determined based on the maps collected form the UAE Atlas.

Cities villages and towns have been recorded using maps from the Department of Land Planning at Fujairah Municipality (2005), while satellite images of high spatial resolution have been acquired for the urban and crops areas in the Eastern Coast Region were also used to format the land use layer.

To locate the protected areas, either the terrestrial or the marine one, a data collected from a walked-in visit to the MEW has been used to verify gathered information from a master thesis dealing with the role of protected areas in the environment protection at the UAE published by Bani Malik (2002).

WWF (2006) study was used to determine the areal distribution of flora and fauna at the study area. Then, they have been categorized in layers based on species classification. This study has also used to trace the boundaries of the protected area at Wadi Wurayah which was identified in this study as the core zone of the proposed biosphere reserve. The other zones buffer and transition respectively where identified by using the field survey data in the light of UNESCO’s Man and Biosphere program method.

Vegetation patterns and spectral classification maps of vegetation, bedrock and gravel plain areas where collected from Sharjah Electricity and Water Authority (SEWA) and Ghoneim (2008).

To study the hydrology and climate of the study area, several maps were digitized from the UAE Atlas. Water resources reports published by MEW (2005) and recent satellite images from SEWA in addition to the topographic maps of the area were also used.

The geologic map from UAE Atlas and the geological map produced by the Ministry of Petroleum and Energy (1972) were used to generate the GIS Geological Map of the study area. A thematic layer of the prevailing geological structure was adopted form IWACO (1986). Geographical locations of Eastern Coast Region water wells, wetlands and dams were obtained from the MEW, the Federal Electricity and Water Authority (FEWA) and SEWA.

Hard copies of maps were scanned, georeferenced, and features of interest were digitized on-screen. This was achieved by using original maps instead of photocopies; using a high resolution drum-scanner for scanning the maps; georeferencing of all scanned maps to a common reference layer; performing on-screen digitizing at a larger scale than the original map scale (this minimizes operational errors introduced during the GIS working); and finally editing and revising the finished digital maps.

3.2.3.2 GIS Output

Arc/Info and ArcGIS 9.1 was used in this research work to bring together the results obtained from satellite images and cartographic maps as well as reports and field observations. All were used to build up an Environmental Information System (EIS) which represent the required master database for the study area.

This facilitated the data archiving, analysis and query as well as combination of the scientific, administrative and social data obtained for the proposed Wurayah Biosphere Reserve in particular and Fujairah Emirate in general.

The constructed EIS would require regular updating for continually monitoring the changes occurring on or near the land surface (Figure 3.3).

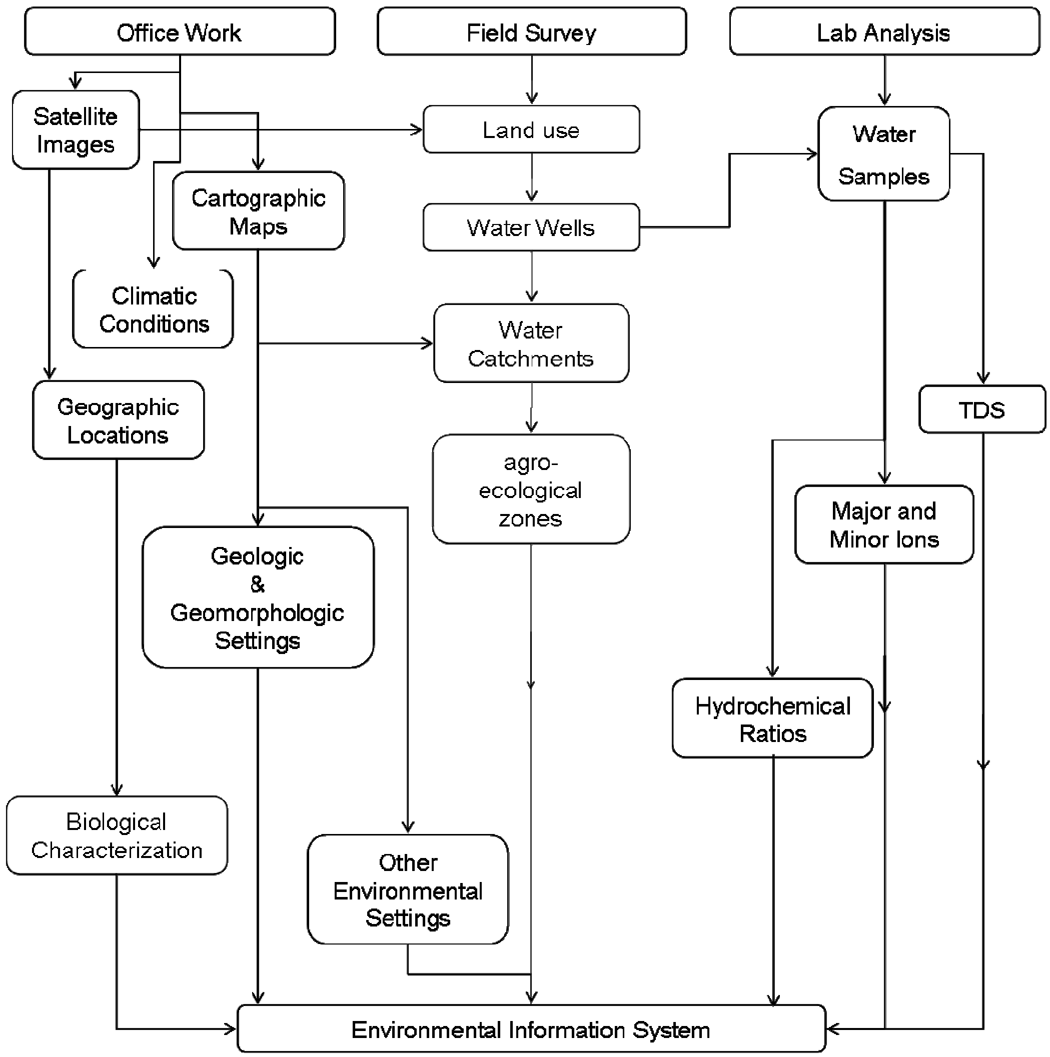

Figure 3.3 Flow chart shows the procedures of data automation and GIS process applied in this study (ALHOGARATY).