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Accomplishing Sustainable Development in Southern Kurdistan Using Geoinformatics: An Overview.

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Abstract: Southern Kurdistan is experiencing a rapid rate of development, which is often associated with increased industrialization, population growth, economic development and urbanization. These events generally lead to continuous degradation of the environment and natural resources i.e. water, soil, air, natural habitats and biological diversity. These in turn, if not managed, could eventually slow down and threaten the pace of economic development. Consequently, there is a real need to understand and attempt to manage these events. This paper argues that the specific conditions in southern Kurdistan, the nature and unavailability of reliable information for decision making necessitates the use of Geoinformatics as an effective tool to sensibly utilise and conserve the environment and natural resources whilst furthering the development process. An overview of the likely environmental problems in Southern Kurdistan and the possible usage of Geoinformatics for achieving sustainable development has been discussed.

Keywords: Geoinformatics, Kurdistan,

1. Introduction

Since the early 1990's, southern Kurdistan has been experiencing rapid economic development due to the relative stability and prosperity as a result of the 'no-fly- zone policy in northern Iraq. Based on experience elsewhere [1], rapid development is often associated with a rapid rate of industrialization, urbanization, agriculture and population growth. Consequently there will be a substantial increase in demand for water, building material, cleared land and in the amount of industrial and domestic waste produced. These developments, as is the case in other parts of the world, will disturb the ecological balance, degrade natural resources and lead to environmental problems on land including the destruction of forests, a reduction in biological diversity, high rates of erosion and water quality degradation. The sediments and the pollutants will ultimately be transported to, and deposited in local rivers, lakes and reservoirs [2].

It should be mentioned that the literature shows the absence of comprehensive scientific studies that can provide information for decision making on sustainable development in Southern Kurdistan. Accordingly, there is a severe shortage of reliable information about the environment,

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natural resources and potential vulnerable environmental zones particularly in terms of location, type, levels and impact of pollutants. Therefore there is a need to determine the sources of pollutants, locality of the degraded environment and natural resources, volume of the wastes and concentration of potential pollutants due to the development process.

Possible factors causing environmental degradation independently and jointly in Southern Kurdistan, based on experience elsewhere, can include;

i. Population growth

Economic development and prosperity are often followed by population growth, which inevitably will increase the demand for water as well as other natural resources will increase the amounts of human waste. As the main disposal practices consist of discharging mostly untreated wastewater into the environment, more poorly treated or untreated sewage wastewaters will be discharged into the environment. These in turn could lead to increasing health problems through consumption of contaminated fish [3, 4]. It may also precipitate seasonal episodes of fish kills caused by the depletion of dissolved oxygen in the water. Population growth will also impose further changes on the land use; deforestation of river basin watersheds, in particular, will increase the sediment loads carried by the rivers causing sedimentation problems in lakes and reservoirs [2]. This is a common problem in developing countries, for example a study by the Food and Agriculture Organisation of the United Nations (FAO) estimated a reduction of 221 x 106 hectares of forested lands and predicted a reduction of 175 x 106 hectares in the Caribbean region by the year 2000 due to deforestation practices [5].

ii. Agriculture

Continued economic growth and development will result in an increase in use of marginal agricultural land at the expense of forestlands. These in turn will lead to increased turbidity of lakes and reservoirs, as a result of riverine transport of eroded soils. Pesticides (insecticide, herbicides, fungicides, etc.) are often used extensively to increase agricultural production. Significant quantities of pesticides will reach the lakes and reservoirs environment through runoff, erosion and misapplication, where they may affect habitats and contaminate the food chain [6]. Another possible source of pollution is the discharge of nitrogen and phosphorous compounds in enclosed lakes and reservoirs, leading to eutrophication, the ecological effects of which include algal blooms, changes in aquatic community structure, decreased biological diversity, fish kills and oxygen depletion events.

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iii. Solid waste

Economic prosperity and population growth will inevitably lead to an increase in the amount of solid wastes being generated within the region. The impact of this problem is often compounded due to the deficient collection systems and inadequate disposal practices such as using rivers and dumpsites as evident in many countries of the region.

iv. Toxic substances

Toxic substances are often released from manufacturing operations, effluent discharges and accidental spills are associated with several relevant industries, including petroleum (oil refineries and petrochemical plants), chemical (organic and inorganic), wood/pulp plants, pesticide and metal and electroplating industries. The wastes generated may contain heavy metals, carcinogenic hydrocarbons, dioxins, pesticides and noxious organic and inorganic substances. Other sources may include mining, organic pollutants originating from domestic and industrial discharges and industrial wastes.

2. Living with Information Poverty and achieving Sustainable Development.

The survival and development of human societies have always depended on their interaction with the environment and humans endeavour to understand this interaction with the view to manage the environment [7]. Information is one of the most important strategic factors influencing development. Modern political and economic systems cannot function without a continuous interchange of reliable information. In fact, one of the barriers to sustainable development in developing countries is lack of information requisite for effective planning [8].

Southern Kurdistan suffers from a scarcity of information and the unreliability of available data sets in terms of land use/cover, soils and topographic maps in terms of detail and scale to deal effectively with the issues raised previously. Obviously, this information poverty makes decision making for development planning and control, and managing the environment a difficult task. However, these obstacles may be mitigated through determining a strategy to cope with information poverty.

This strategy will require the following;

i. Collecting and evaluating all existing relevant data sets.
ii. Identifying areas of Information poverty and possible information gaps.

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iii. Identifying the necessary tools for collecting, managing and analysing the necessary data sets. Additionally examining the capacity of local expertise to use these tools to develop and manage the essential data sets.

iv. Establishing a clear understanding of the processes involved on a local/regional scale in order to identify the impacts of development on the region. Furthermore to explore various management strategies and to examine their possible environmental and societal consequences on the region

v. Developing plausible scenarios to account for the effects of development on the region. This step is necessary to cope with the inevitable information gap, which will appear as a result of i-iv above.

vi. Developing a Kurdish agenda to manage these issues by all stakeholders in southern Kurdistan.

3. Geoinformatics and Bridging the Information Gap

The shortage in reliable and accurate data sets can be best handled by using Geoinformatics, which encompass Environmental Remote Sensing, Geographical Information Science (GIS) and Global Positioning Systems (GPS). Geoinformatics contains the necessary tools to generate, collect, handle and analyse the necessary data sets as well as expanding our knowledge of the processes involved at the appropriate scales. These tools include;

3.1. Environmental Remote Sensing

The foundation of most remote sensing applications is based on the wavelength-distribution of electromagnetic energy transmitted or reflected by land use/cover types, which provides signatures of the materials involved (Fig 1). These signatures are detected by satellite systems such as the Satellite Pour I' Observation de la Terre (SPOT), the Landsat Thematic Mapper (TM) and so on which were designed to detect various land cover/use types and features at specific bands (Fig 1). It follows that the consequences of changes in land use/cover will be associated by an alteration in the optical properties of the study area [9]. The analysis of remotely sensed data is primarily concerned with mapping and quantifying such characteristic spectral signatures of all the relevant features to environmental management. However, at first the raw image will need to be adjusted and numerically processed through a number of stages (e.g. correcting the image for any distortions and degradations, increasing the apparent distinction between the features to optimise visual interpretation, and to maximise the contrast between features of interest) producing an optimised image for use. Finally, the image will need to be calibrated with a number of measured relevant parameters on the ground (ground

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referenced samples)(Fig 1) [10]. In addition the researcher will need to be familiar with limitations in terms of the available and suitable spatial, spectral, radiometric and temporal resolutions.

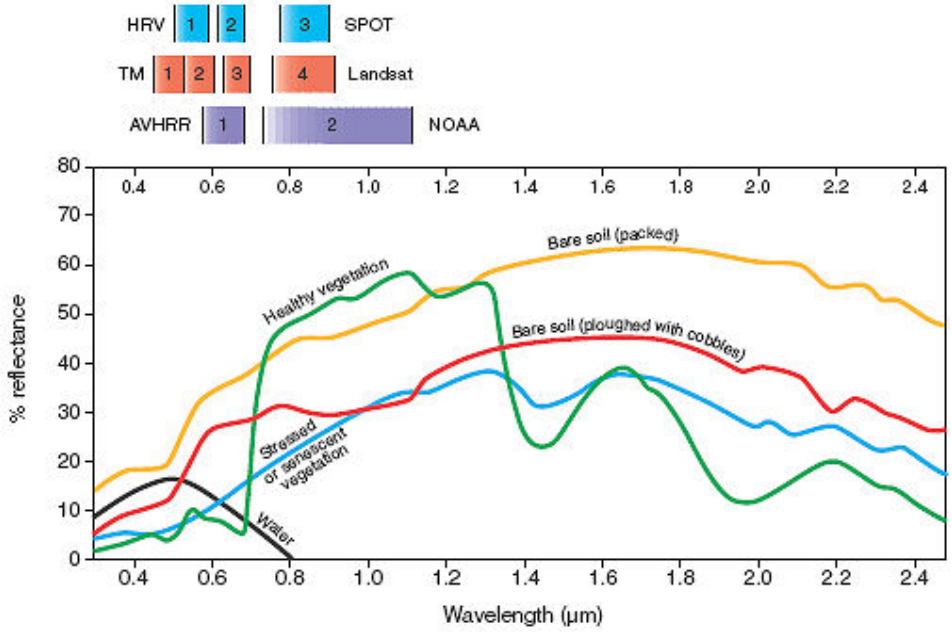

Figure 1: Simplified spectral reflectance curves for landcover in an arid, and a semi-arid, environment. Example spectral bands of SPOT, Landsat TM and NOAA satellite sensors are shown. (Adapted from Abrams et al, 1984, Barrett and Curtis, 1992 and Harris, 1991)

Remotely sensed data have been used successfully to provide relevant information on catchment characteristics, e.g. mapping and monitoring the spatial extent of various types of land use and land cover including; changes in agricultural land [11], mapping parent material type, soils, vegetation type and canopy densities [12, 13] as well as water quality parameters in, and bathymetric charting for lakes and reserviours [10, 14] (Fig 2, 3). Remotely sensed data can also be utilised to provide the necessary area based land use/cover parameters to run conventional mathematical models used to simulate environmental response to different conditions/management scenarios [15].

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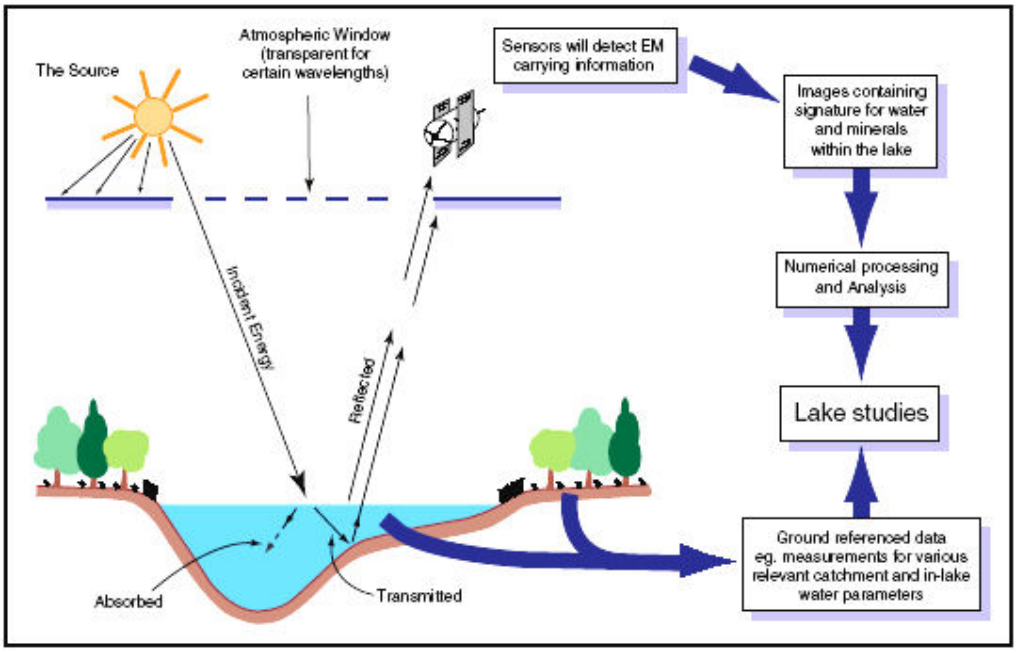

Figure 2: Schematic Representation of Gathering and Using Remotely Sensed Information in Lake Studies

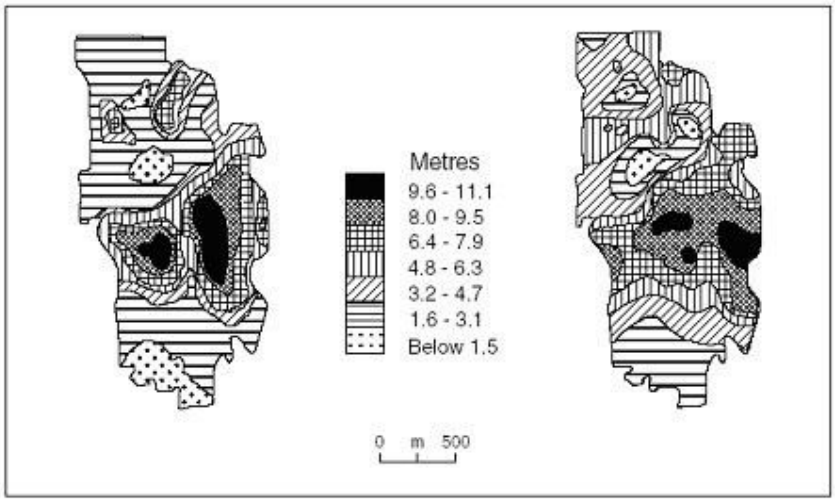

Figure 3:

Remotely sensed data can provide vital information for managing the environment and natural resources in southern Kurdistan. This is mainly due to

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i. Providing an understanding of the physical phenomena associated with the interaction between radiation and matter based on the information contained in the various wavelengths. Using Remote sensing, it is possible to map natural resources as well as the factors influencing and contributing to environmental degradation such as vegetation cover, soil characteristics, and human activities.

ii. Providing information for monitoring change and conducting time-series studies. One of the problems involved in studying the environment is the extreme variability of many phenomena over time. Geostationary satellites such as the National Oceanographic and Atmospheric Administration (NOAA) or Meteosat, or the combination of geosynchronous satellites in the Landsat series or SPOT series, can provide the necessary information.

iii. Supplying a synoptic coverage, which provides information for vast areas. As certain phenomena are transient it is very important to obtain information at regional basis at specific points in time (Fig 4).

iv. Conducting detailed analyses based on combinations of high and low resolution data. Images with various resolutions are essential for examining regional and site-specific problems. Remotely sensed images of such description are available for Southern Kurdistan (Fig 4, 5).

v. Providing information on the topography and relief. SPOT images can be used to compile a topographical map with an elevation accuracy of 5 to 10 m.

vi. Providing data for areas that have no ground measurements based on the interpolation of area-based information from sampled sites with similar attributes; subject only to the size of the area and the spatial resolution of the imagery.

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Figure 4:

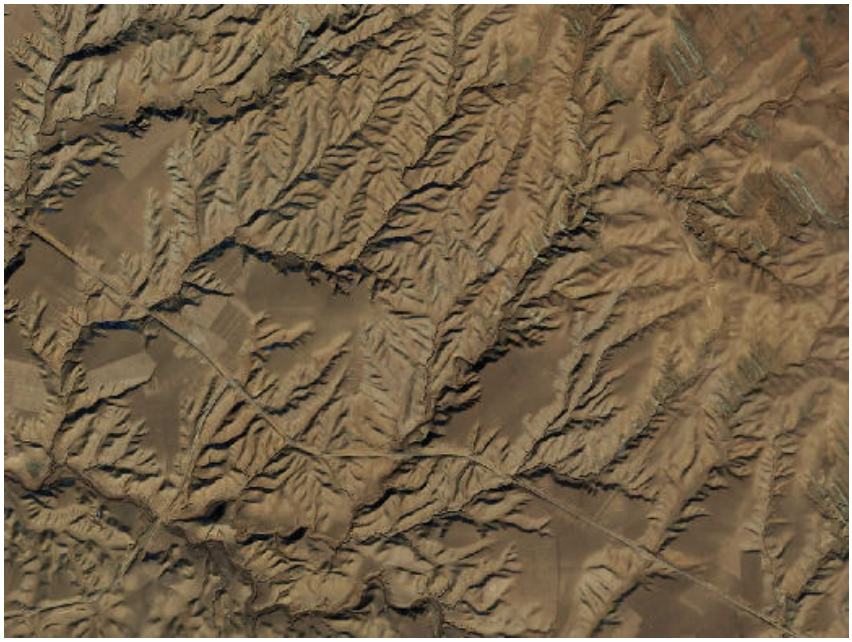

Figure 5:

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3.2. Geographical Information Science (GIS)

GIS uses in environmental management can, in general, be classified into inventory, modelling and suitability mapping. Inventory is the collection of base-line data and its subsequent storage in a GIS, for monitoring and management purposes [16]. Modeling; can be used to simulate environmental processes and to predict the outcome of development actions, natural hazards or environmental change.

GIS has evolved for handling diverse data sets for specific geographic areas by using co-ordinates as the basis for an information system. Therefore, based on the spatial nature of the acquired data, GIS can be used effectively to: firstly, input, store, organise and analyse the ground referenced data, then to integrate these data with data from satellite imagery and other sources. Secondly, to employ the spatial analysis, visualisation and query capabilities of GIS to identify and map natural resources as well as environmental degradation/ pollution problems and their geographical locations [2]. Furthermore, GIS can be used to construct and simulate various management scenarios responding to various conditions of the identified problem. Then, to establish which is the most suited scenario for a location under a given set of constraints [17]. Finally, GIS are designed for assembling, integrating and analysing spatial data in a decision-making context. Information provided by GIS can be used at operational, management and strategic planning levels by a variety of users in Southern Kurdistan including the scientific community, universities (which must be capable of to playing its leading role in the process) and decision makers and legislative bodies (Fig 6) [18, 19].

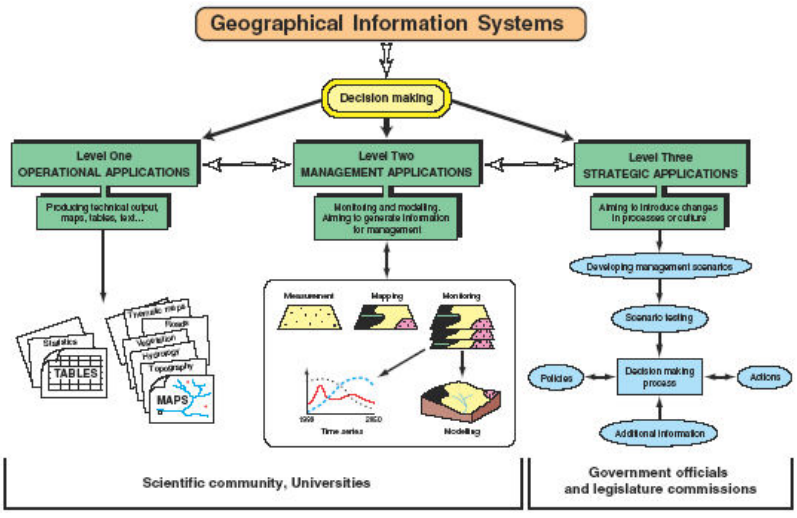

Figure 6: GIS protocols, uses at various levels in the decision making process, and the main interest groups in the Badia region. (Adapted from Morain et al., 1996; Baban, 1997; Heywood et al., 1998).

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3.3. Global Positioning Systems (GPS).

Global Positioning Systems (GPS) are space-based radio positioning systems that provide 24 hour three-dimensional position, velocity and time information. The satellites transmit timing information, satellite location information and satellite health information. The user requires a special radio receiver - a GPS receiver - to receive the transmissions from the satellite. The GPS receiver contains a specialized computer that calculates the location based on the satellite signals. The satellites are controlled and monitored from ground stations, which monitor the satellites for health and accuracy [7]. Maintenance commands, orbital parameters and timing corrections are uploaded from the ground on a periodic basis. The Navigation System with Timing and Ranging (NAVSTAR) GPS system, operated by the U.S. Department of Defense, is the first GPS system widely available to civilian users. The Russian GPS system, Global Orbiting Navigation Satellite System (GLONASS), is similar in operation to the NAVSTAR GPS system. Both NAVSTAR and GLONASS provide two sets of positioning signals. The higher accuracy system is reserved for each country's military use. The lower accuracy system is freely available to civilian users. Some GPS receivers have the ability to store attribute information in addition to position information. Position and attribute information can be stored in a GIS to help users manage their assets more efficiently..

4. The Holistic Approach to Sustainable Development in Southern Kurdistan.

In any management, the most important aspect is understanding the characteristics and territory of the environment to be developed. For example, in attempting to manage the impact of development it is essential that the type, possible levels of pollutants as well as the biogeochemical processes that operate within that environment be identified. Therefore achieving sustainable development in Southern Kurdistan requires the decision-makers to adopt a holistic approach and use every aid available to them as they attempt to anticipate the consequences of their decisions. Reasonable decision-making is often based upon all available information and uses an objective approach in arriving at appropriate decisions [2, 20].

In southern Kurdistan obtaining accurate information on the geographical distribution as well as the condition of natural resources and the environment is a problem. However, Remote sensing can assist with the identification and the mapping of these two critical aspects (Fig 4, 5). The GPS can then be used to assist with deriving the geographical coordinates for specific targets of interest in the field as well as mapping and verifying the outcomes from the remotely sensed data. The GIS can after that be

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utilised to examine and spatially analyse the data and to suggest a range of possible management scenarios to sensibly utilise a particular natural resource under a given set of development conditions.

Furthermore, establishing a management strategy often involves the use of models to simulate the response of the environment to different development scenarios. Many of the models used require parameters based on catchment characteristics. Even when conventional data is available, the assembly and management of these parameters are particularly difficult for large areas. However remotely sensed data can be used in parameter determination. Furthermore it could be integrated with regular ground referenced measurements to create a comprehensive information database. Digital Landsat imagery, aerial photographs and digital image processing can provide up to date, digital, reliable, regular and relatively cheap information about both the land and coastal marine parameters, providing that the spatial resolution and the satellite sampling periods are sufficient to detect the studied phenomena. It will also provide data for areas, which have no ground measurements based on the interpolation of area-based information from a number of sampled locations, subject to their size and the spatial resolution of the imagery [2]. This approach will contribute to a better understanding of natural resources, the environment and will make the knowledge digestible and useable by managers in deciding on the optimal course for development. Moreover it will provide an opportunity to adopt a holistic approach, enabling the region to be studied as an integrated system rather than individual entities of land parcels tied to possible development projects.

Additionally, increased environmental awareness will require subsequent changes in national and international laws and policies have increased the pressures and requirements placed on decision makers by government and society. They now have to make decisions taking into consideration public satisfaction, environmental safety and economic practicality [7]. The decision-making in Kurdistan will be required to fulfill the same requirements in the foreseeable future. This situation will create a need for more consistent and objective methods for making decisions as well as improved access to, and better management of, environmental information with the view to achieve sustainable development. GIS have the capability to store volumes of necessary multidisciplinary information, structuring and integrating a variety of economic and environmental constrains. Thus GIS can play an important role as a decision support tool and as a means for achieving sustainable development [2].

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5. Conclusions

The economic growth in southern Kurdistan is most likely to be associated with a rapid rate of urbanisation and population growth leading to a substantial expansion in industrial and agricultural development. These actions are expected to lead to environmental degradation of natural resources and habitats and could eventually threaten the pace of economic development. Consequently, there is a real need to map, monitor and assess the impact of development, predict future conditions and arrive at a better understanding of the processes supporting and harming the environment.

The lack of reliable and compatible data sets as well as the deficiency in the scientific knowledge regarding some of the processes involved represents a problem. However, this problem can be managed by adopting a holistic approach and using Geoinformatics, which contains the necessary tools (Remote sensing, GPS, GIS) to collect, handle and analyse the necessary data sets as well as expanding our knowledge of the processes involved at the appropriate scales. More specifically, the objective can be achieved by implementing a holistic approach and using remotely sensed data and GPS to establish a geographically referenced inventory for various environmental resources and the potential impacts of development. Having established the status and the spatial distribution then the abundance can be monitored efficiently over time. The GIS can be used to understand, evaluate, simulate and manage the impact of various development projects. This information will allow effective sustainable development strategies to be developed, simulated and tested, within a GIS framework, for vulnerable regions.

In summary, Geoinformatics can assist with managing the natural resources and environment in the southern Kurdistan region without slowing down the pace of development.

References

1. Morse S. and Stocking M. (1995). People and Environment. USL Press UK, 215p
2. Baban S.M.J. (2001). Managing the Environment in the Caribbean Region Using Remotely Sensed Data and GIS. Proceedings of the Urban and Regional Information Systems Association (URISA) 2001 Caribbean GIS Conference, September 9-12, Montego Bay, Jamaica. 202-213.
3. Ward, R.E., and N.C. Singh. (1987). Bacterial Pollution Monitoring in Castries Harbour, St. Lucia, West Indies. J. Shoreline Management Vol. 3, 225-234.
4. Broutman, M.A., and D. L. Leonard. (1988). National Estuarine Inventory. The Quality of Shellfish Growing Waters in the Gulf of Mexico, NOAA, Strategic Assessment Branch, Rockville, Md.
5. Short, F.T. (1991). Effects of Excessive Nutrient Loading of the Eelgrass Community. The National Estuarine Eutrophication Project: Workshop Proceedings. (Eds) K.R. Hinga, D.W. Stanley, C.J. Klein, D.T Lucid and M.J.

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Katz, pp. 25-27. Strategic Environmental Assessment Division, National Ocean Service, NOAA, Rockville, MD.

6. FAO. (1979). Overview on Natural Resources for Food and Agriculture in the Caribbean Region (E/CEPAL/PROY./3 L. Inf. 10).
7. Baban S.M.J. (2004). Attaining a Balance between Environmental Protection and Sustainable Development in the Caribbean Using Geoinformatics. West Indian J. Engineering. 2, 22-34.
8. Bernhardsen, T. (1992). Geographic Information Systems. Norwegian Mapping Authority, Norway, 318p.
9. Lillesand T M. and Kiefer R. W. (1994). Remote Sensing and Image Processing Interpretation. 3rd Edition. John Wiley & Sons. USA.
10. Baban S. M. J. (1999). Use of Remote Sensing and GIS in Developing Lake Management Strategies. Hydrobiologia. 395/396, 211-226.
11. Pattie N., (1993). Farmwatch UK. GIS Europe. November 22-24.
12. Lo C. P. (1986). Applied Remote Sensing. Longman. London.
13. Barrett E. C. and Curtis L F. (1992). Introduction to Environmental Remote Sensing. 3rd Edition. Chapman & Hall. London.
14. Baban S.M.J. (1993). The evaluation of different algorithms for bathymetric mapping of lakes using Landsat imagery. Int. Journal Remote sensing, Vol. 14, 2263 2273.
15. Baban S.M.J. and Wan-Yusof K. (2001). Mapping Land Use/Cover Distribution in Mountainous Tropical Environments Using Remote Sensing and GIS. Int. J. Remote Sensing. Vol. 22, 1909-1918.
16. Armand, K. (1991). Guarding the water environment with GIS. The Association for Geographical information Yearbook 1991. London, Taylor and Francis.
17. Jones C. (1997). Geographical Information Systems and Computer Cartography. Longman, England 319p.
18. Morain S., Estes J., Foresman T., and Joseph S. (1996). Image Formation and Raster Characteristics. In: Morian S. and Baros S. L. (editors). Raster imagery in Geographic Information Systems. Onward Press. USA. 1-27.
19. Heywood I., Cornelius S. and Carver S. (1998). An Introduction to Geographical Information Systems. Longman. 279p.
20. Baban S. M. J. (2000). Developing a Holistic Plan to Manage Desertification and Water Shortages in the Badia Region in Jordan Using Remote Sensing and GIS. Desertification Control Bulletin. United Nations Environmental Programme. 36, 34-41.