SPATIAL ANALYSIS TOOLS IN NATURAL RESOURCE MANAGEMENT (GIS, GPS)

TRADITIONAL APPROACH TO NATURAL RESOURCE MANAGEMENT AND ITS SHORTCOMINGS

Natural resource management involves *manipulation of the resource to preserve or supply products on a sustained basis*. It revolves around, but is not limited to the manipulation and analysis of many different types of spatial data. Spatial data is that which has physical dimensions and geographic location. Traditionally most of this data is stored in separate and unrelated databases. This makes its use in decision making complicated as spatial relationships are interpreted through visual observation of several different resources maps, unrelated in terms of scale and projection. The limiting factor in decision making is not the amount of data available to resource managers; rather it is the ability to mentally organise and compare these large quantities of information. This can be frustrating, time consuming and expensive. Many hours of manual processing are often necessary to get the data into suitable format. Consequently, managers may find themselves in a difficult position in which they cannot use all of the available information but are still required to provide solutions.

GEOGRAPHIC INFORMATION SYSTEMS

A Geographic Information System (GIS) is a computer based information system that has a capability of handling all kinds of spatially referenced land-related data at all mapping scales in support of decision making. It enables the *input, management, manipulation, analysis, modelling, output, and dissemination of spatially referenced land-related data*. Its multifunctional capability makes it a powerful tool.

GIS in Natural Resource Management

GIS is a vital tool in natural resources management. The various aspects of resource management it supports include storage and retrieval of data, interpretation and analysis of the resource data, and development of the Resource Management Plans (RMP's). Resource use alternatives are formulated, and the GIS is used to evaluate each in terms of environmental impact, economic implications, acreage, and potential use conflict. One important function of GIS is to assist in recognising underlying patterns in data. These patterns may be areas of forestland suitable for timber harvest or potential shifts in population distribution. GIS simulations can be used to understand the direct and indirect effects of human activities over long periods of time and over large areas.

By using the database integration capabilities of GIS, Planners and Resource Managers gain a better understanding of the complex interrelationship between physical, biological, cultural, economical, and demographic considerations around a specific resource. Access to this information and its understanding makes it essential in making sound resource-use decisions. This ensures balanced management and use of the resources.

GIS has increasingly replaced the traditional methods because it is faster, cost efficient and accurate. GIS analyses are hence becoming routine in a significant number of field offices.

Examples of GIS Application in Natural Resource Management

GIS applications are diverse and include *water quality monitoring, modeling narcotic crop sites, waste site assessment, analysing effects of carbon dioxide* etc.

Some analyses relative to forest are overlaying forested areas and logging areas to see what percentage of forest area is in danger of degradation. Adding data on protected areas or biodiversity hot spots allows one to see how these areas fit in the picture. Egregious problems, such as protected areas being included in logging concessions can also be detected.

One notable example is the detection of illegal oil and gas drainage from public lands by wells on private lands. GIS reduces the process of drainage detection from several days done manually to a few hours .

REMOTE SENSING

Remote Sensing is the science and art of obtaining information about an object, area, or phenomenon. This is done through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation. Remote sensing now includes photography, radar, lasers, and sonar and thus provides information with unique and valuable characteristics.

When remote sensing was first envisaged and activated in the 1960's it was viewed as the science of obtaining the image of an object in space. The image had a number of uses that were primarily concerned with identification, area estimation etc. The number of usable images was limited by technical processing limitations, resolutions problem and cloud cover.

Remote Sensing in Natural Resource Management

Remote sensing provides an opportunity to view or analyse natural resources in inaccessible areas. It can be generated in accurate unbiased form; acquired at minimal costs at a known point in real-time; geographically referenced; prepared in useful and storable format; and produced in volumes never attainable before.

Aerial photography has been used for a long time by resource managers to assess the direction and magnitude of changes in important natural resource parameters. Simple aerial photographic techniques have been used to establish baselines for comparative environmental analysis, develop an awareness of subtle long term environmental effects, identify indicators of environmental change, and provide a new source of data for environmental planning and management.

Exaples of Applications of Remote Sensing in Natural Resource Management

There are many uses of remote sensing in natural resource management; one ambitious scheme is the monitoring of food production on essentially a global basis.

From the perspective of aquaculture and inland fisheries, remote sensing is especially significant in optimising fish production. This is done in a variety of locations many of which are in areas which are remote or poorly mapped, and for which the real time digitised data emanating from remote sensing sensors will prove absolutely invaluable.

Remote sensing information, collected through RADARSAT data, contributes to the mapping and monitoring of surface water resources.

Remote sensing has many useful applications in agriculture. It is used to assess crop type classification, crop condition assessment, and crop yield estimation and to map soil characteristics and soil management practices. Radar data collected by satellite are also useful to monitor drought or flooding events that can severely impact crop productivity.

This information is valuable to decision makers and analysts within government agencies, grain marketing bodies, agricultural retailers, and insurance companies.

INTEGRATION OF GIS AND REMOTE SENSING

GIS and Remote Sensing have a degree of mutuality; GIS provides a means for increasing the utility of remote sensed data. New information can be regularly updated. GIS makes it possible

to improve the interpretation and analysis of remote sensed images. This is achieved by combining reference data from special sources. A GIS, integrated with image processing capabilities is a powerful tool for computer assisted resource mapping.

Today, it's probably more accurate to describe the remote sensor data as "ancillary" since the GIS can contain many data layers, only one or a few of which are derived from remote sensing. Remote sensing is able to capture a wide range of images through the use of more varied sensors and increase effectiveness in data extraction. This has enabled the two disciplines to complement each other, broadening their raison d'être.

CONCLUSION

Even though obstacles remain to their full deployment, Geomatics technologies now being developed and demonstrated suggest natural resource applications that were not believed possible using traditional techniques. As we progress towards the long talked about notion of integrated natural resources management, some parallel continuums along which the technology manifests are:

- The technology helps create integrated views of databases that span the levels of map scale, detail and use. This helps in understanding the earth's ecology.
- The technology meets the need for information presentation tools, as the pendulum swings towards community place based management.
- The emergence of shared data infrastructure and accelerated information delivery, e.g. Internet data ordering.
- Significant advances in data acquisition technology.
- Rapid improvement in data storage, retrieval and analysis

Use of Remote Sensing and GIS in Natural Resource Management

In natural resource management, remote sensing and GIS is mainly used in the mapping process. These technologies can be used to develop a variety of maps. Examples include:

1. Land cover maps
2. Vegetation maps
3. Soil maps
4. Geology maps

However, before these maps are developed, there are a variety of data that need to be collected and analysed. Most of this data is collected with the help of remote sensing technology. Data can be collected using either ground photographs, aerial photographs or satellite photographs of the area of study. The choice of the photograph usually depends on the topography of the area of study and the aim of the study. For instance, aerial photographs (vertical or oblique) are always useful when spatial data need to be collected in the same area of study within intervals (hours, days, seasons, years etc). This form of data collection shows the variations of the area of study within different periods of time (Elias, n.d.). Satellite photographs can also be used to collect relevant data for the study. These types of photographs are however superior to aerial photographs in the sense that they have higher spectral, spatial, radiometric and temporal resolutions. Thus, satellite images are more detailed hence a lot of data can be generated from them. However, for remote sensing data to be effective, it needs to be incorporated together with topographical maps that show the variation of climate, soils, and other factors.

The visual and digital data that has been collected is usually analysed to generate a pre-field map. Various components and elements of the data is analysed. According to Elias (n.d.), elements such as tone, texture, pattern, association, size and shape are essential in the analysis process. These elements bring about a detailed view of the area of study. The pre-field map that has been generated together with the results from the analysis of the various elements is used to determine the characteristics of different elements and themes found on the ground.

Ground verification of the collected data is a critical process. To ensure that it is carried out in the most effective and efficient manner, the study area is usually divided into quadrants or transects. This is done to ensure that the interpreted elements of the satellite data conform to the ground characteristics. The data that is collected on the ground is geo-referenced with the help of a GPS to ensure that its corresponding location can be accurately identified in the images that were collected earlier. Additionally, field points identified in the images are visited to verify information regarding the state of the vegetation, geomorphology, topography, soils, and so on. With the use of the pre-field map that was generated, information from ground verification procedure and any other secondary source that might have been used, the final

map is usually prepared. The scale of the map is also variable depending on the nature and extent of the study and the goals that it aims to achieve.

Application of GIS Data in Forest Management

Over the last century, the forest cover of the world has declined at an alarming rate. Being a renewable resource, forest cover can be regenerated through sustainable management. Hence, with the help of remote sensing and GIS data, a forest manager can generate information with regards to forest cover, types of forest present within the area of the study, human encroachment into forest land/protected areas, encroachment of desert like conditions and so on. This information is critical in the development of forest management plans and in the process of decision making to ensure that effective policies have been put in place to control and govern the manner in which forest resources is utilized.

Aboveground Woody Biomass Data by Josef Kellndorfer and Wayne Walker. Map from NASA, 2011.

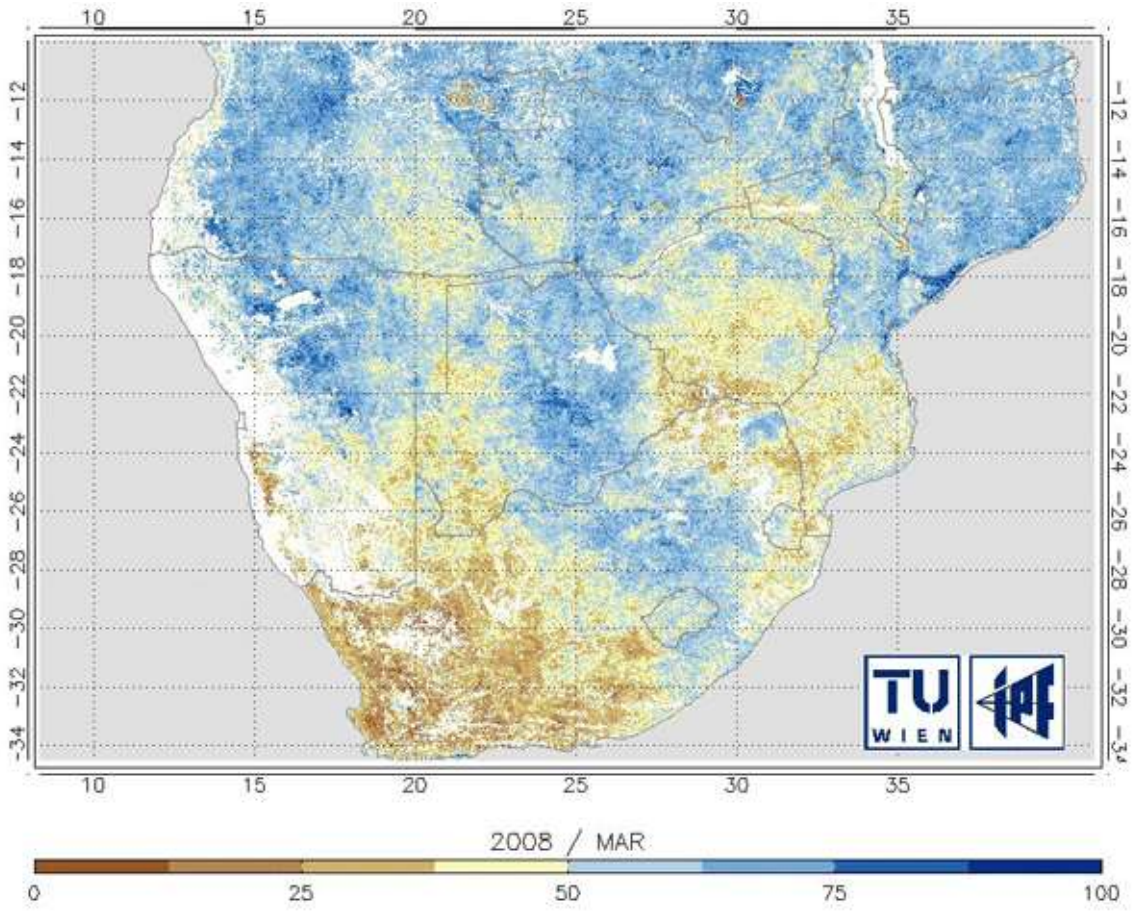
Application of GIS Data in Watershed Management

Water as a resource has been diminishing over the years. In Africa and other developing nations, the availability of clean water has been always scarce. Water management has therefore been a challenge in developing nations. However, with the use of satellite data, water bodies such as rivers, lakes, dams and reservoirs can be mapped in 3D with the help of GIS technology. This data can be used in the sustainable management of water bodies since

respective authorities can decide which regions need effective protection and management. At the same time, decisions regarding the most effective means of utilization of these regions can always be arrived at.

Application of GIS Data to Combat Desertification

Geospatial data can be used to determine the soil types present in a given area and nutrient availability. Negative change can always be identified once this data is collected over a long period of time. GIS data can also be used to determine the land use practices within a given area and vegetation constitution and the impact that they have on the environment. Consequently, slope information of a region can also be determined with the use of GIS data. With all this information, an individual can easily determine whether desert like conditions are encroaching in an area. If desert like conditions have been identified, its impacts and intensity shall be analysed in order to decide on whether artificial or natural methods shall be used to combat the situation.



Surface soil moisture at 1 km resolution retrieved from the Advanced Synthetic Aperture Radar (ASAR) instrument on ESA's Envisat satellite, operating in Global Mode, for the southern African Development Community Region (March 2008).

Application of GIS Data in Biodiversity Management

Geospatial data can also be used in the management of flora and fauna within protected areas. Ground and aerial photographs, for instance, are essential in this practice. Aerial and satellite photographs can be used to determine the presence and distribution of vegetation within a protected area. These photos can also be used to determine the presence and distribution of invasive species within an ecosystem. This information is essential as it determines the amount of cover and food that is present, particularly for herbivores during various seasons of the year. Aerial photographs can be used to ease the process of counting during animal census activities. The stop capability of photographs eases this process. It is always essential for protected area managers to determine the population and distribution of various animal species within a protected area to ensure that they have enough food and water, to eliminate the chances of overstocking that might lead to soil erosion and to ensure that a balance within the ecosystem is arrived at. Geospatial data can also be used to show human encroachment into protected areas as well as animal activities outside protected areas. This data critical especially in the process of resolving human/wildlife conflicts. Finally, the use of GPS technology can be applied to monitor the movement of endangered species as well as newly introduced species to determine their progress as well as protecting them from poachers. Finally, geospatial data can be used to carry out environmental impact assessment (EIA) of various projects carried out within protected areas. Projects such as building of roads, buildings, pipe ways, dams, and so on might have various effects on the flora and fauna of the ecosystem. Thus, geospatial data has become essential in biodiversity management.

Conclusion

With the increasing pressure on natural resources due to the rising human population, remote sensing and GIS can be used to manage these limited resources in an effective and efficient manner. Geospatial data are effective in the analysis and determination of factors that affect the utilization of these resources. Thus, with the understanding of these factors, sound decisions can be arrived at that will ensure the sustainable use of natural resources to meet the needs of the present generation as well as future generations.