Biodiversity Management Using Remotely Sensed Data and GIS Technologies: The Case of Digya National Park, Ghana

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Abstract - Effective management of biodiversity resources in nature reserves requires accurate and up-to-date information to determine the type of land cover and land use over time. This study employed Landsat TM and ETM+ data to develop a database for Digya National Park in Ghana which will assist in the management and formulation of policies and offer decision-making tasks related to park management. The study revealed that the most significant cause of deforestation in Digya National Park is the expanding Lake Volta, which accounted for two-thirds of all deforestation factors. Other factors included human settlement and the extension of illegal farming activities. The paper concludes by outlining policy recommendations such as the need for the Wildlife Department to coordinate its protection efforts with Departments of the Government of Ghana which have authority over the Volta Dam and also to involve the community in the decision making process both at the local and national level.

KEYWORDS: Biodiversity, degradation, land use, remote sensing, GIS

1. INTRODUCTION

The loss of biodiversity has attracted the global attention for more than a decade. After the 1972 Stockholm conference on the Human Environment, the international community responded with the appointment of the Brundtland Commission, whose report in 1987 sparked heightened and increasing concerns (Grose, 1993). As human impact on the environment has intensified, more attention was directed at finding ways to preserve the existing biodiversity. One of the major obstacles to biodiversity monitoring in many places of the world is the lack of appropriate information and data. Effective management of biodiversity resources requires accurate and up-to-date information, especially time series data, to guide park managers in making appropriate decision. Much has been written about the need for information in areas needing protection. Along the southern coasts of South Africa there was an urgent need for information about land use and species habitats to prevent erosion of biodiversity (Raal and Burns, 1996). Salem (2003) recently reported that one of the major obstacles to biodiversity monitoring in many places of the world but especially in Egypt is the lack of GIS software capable of representing the distribution of species up to and including 3-D hologram images, so as to make getting a picture of the problem easy and sufficiently rapid for appropriate policy development. In discussing the problem of marine biodiversity resource management, Stanbury and Starr (1999) suggested that the development of an interdisplinary GIS for the Monterey Bay National Marine Sanctuary would be sufficient to deal with the protection problem. Taulman and Smith (2002) showed how to deal with bird habitats across mainland United States. Similar analyses are found in Zhang and Beavis (1999) for the Namoi basin in Australia.

Digya National park in Ghana, which is the focus of this study, lacks the necessary information database on land use and land cover. In the absence of such basic information on the current and historical land use and land cover in and around the Digya National Park, it would be difficult to determine future improvement interventions. and also deterioration in the integrity of the park. This suggests the need to provide an up-to-date database about land use and land cover at Digya National Park and its environs. The purpose of this paper is to add to any existing information database on forest resources using remotely sensed data, Geographic Information System (GIS) technology and global positioning systems (GPS) technologies.

2. MATERIAL AND METHODS

Study Area

The Digya National Park Reserve is situated 300 km inland from Accra, the capital of Ghana in the Brong Ahafo region. It is bounded to the east, north and south by the Volta lake (Figure 1). Its geographical coordinates are 7 degrees 05 minutes north latitude and 0 degrees 45 minutes west longitude. The park occupies an area of 347,830 hectares (WCMC, 1992, 1997; Figure 1).

As Ghana's second largest national park, it was established in 1909 during the colonial period with a relatively small game reserve of about 65,000 ha. After Ghana achieved independence its size was increased for partial restriction of expansion of Lake Volta due to the building of the Akosombo Dam, and led to legislation in 1971 creating Digya National Park (Wildlife Department, 1995; Nurah and Bakang, 2003; Twumasi, 2004).

Some 16 villages belonging to 9 chiefdoms were located within the new boundaries of the Park. As a result of the 1971 legislation, as well as the expansion of the Lake due to the need for more electrical power, people have been in motion across and outside Digya for two generations. There is a single rainfall season in the savanna zone, which extends from June to September with the heaviest rainfall in July. This is followed by a long dry season from October to May (Bates 1962; Brammer 1962; Benneh, 1990).

Digya is made up predominantly of Guinea Savannah woodland and gallery forest along the major rivers. Recent work by the World Conservation Monitoring Center has reported sightings and distributions of various species in Digya National Park. At least six primates were identified.and prominent among the primates are the patas monkey, the vervet monkey and hippopotamus. Prominent carnivores are the Cusimanse, and a range of mongoose. The report also mentions artiodactyls (quadruped) hoofed and cud-chewing mammals, the most prominent of which are various subspecies of the duiker and in much less frequency are found the antelope, bushbuck, and hog (WCMC, 1997).

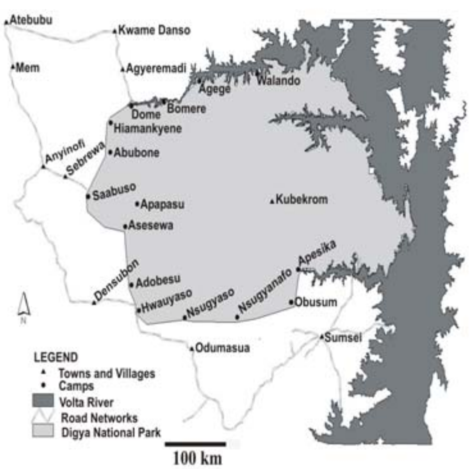

Figure 1: The Study Area

Data Acquisition and Processing

Landsat TM and ETM+ data for June 27, 1985, May 14, 1991 and June 18, 2000 was obtained from the US Geological Survey Department. The images were imported into ERDAS IMAGINE image processing software using the NLAPS importing format. After importing the data, all the images were radiometrically corrected and pre-processed to remove clouds and scan lines.The three images were geo-referenced and co-registered to the Universal Traverse Mercator (UTM) coordinates. The images were later subset from a floating scene to emphasize the Digya area, and displayed as a false color composite with a band combination of red as band 4, green as band 3, and blue as band 1. We also performed different enhancement techniques using filters to highlight common features in the image.

Categorization of the images by means of a supervised classification method was also performed. To accomplish this, different signatures were generated to determine the classes to which each pixel belongs. Once the signatures had been created, contingency and separability matrices and other techniques were used to check whether a particular signature shows the representation of the pixel in the classified image. To test the accuracy of the classification, we employed thresholding, classification overlay and accuracy Assessment. The supervised classification was compared with ground-truth information and the classification accuracy was evaluated to figures in excess of 75%. The location of villages in and outside the Park was determined by using a global positioning satellite (GPS) system.

3. RESULTS AND DISCUSSION

Figures 2, 3, and 4, and Tables 1 and 2 show the output of the supervised classification results of the Landsat Thematic Mapper and Enhanced Thematic Mapper Plus images of the Digya National Park and its environs for the years covering 1985, 1991, and 2000. An accuracy report was also performed on all of the images. The overall classification accuracy reported is 75.8 %, 81.8%, and 80%, respectively for 1985, 1991, and 2000. The presence of clouds in the 1985 and 2000 images obscured part of the land cover, thus reducing the classification accuracy. Misclassification of some pixels occurred in some of the classes. Some of the cropland areas in the 1985 image were confused with grassland and thus produced a very low accuracy percentage. This confusion can be attributed to seasonal variations and similar spectral intensities between the two land uses.

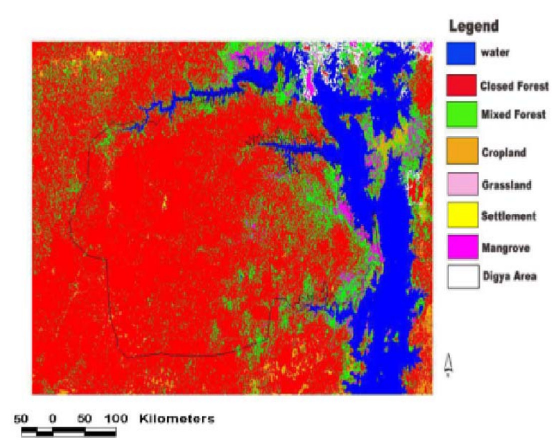

Figure 2: Classified 1985 Landsat TM Image of Digya and its environs.

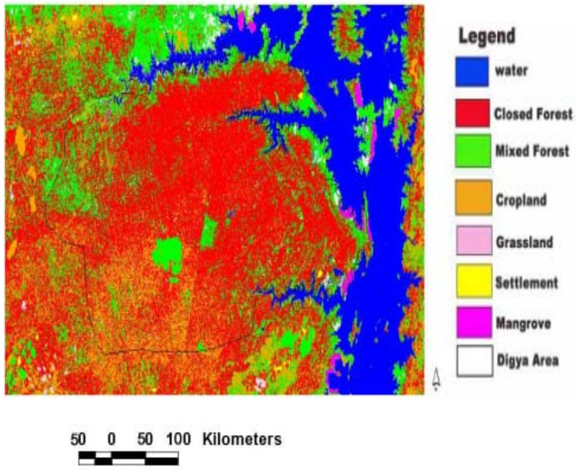

Figure 3: Classified 1991 Landsat TM Image of Digya and its environs.

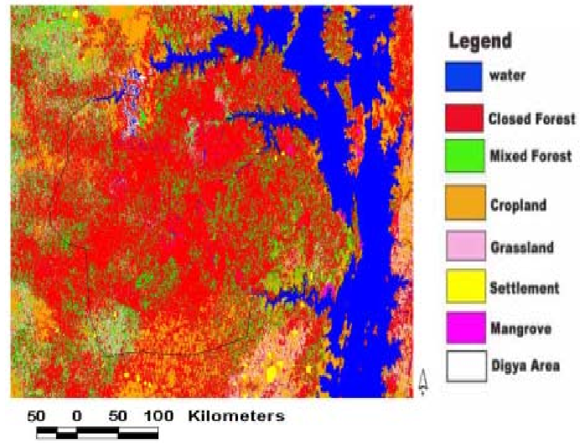

Figure 4: Classified 1991 Landsat TM Image of Digya and its environs.

Table 1. Supervised classification results for the areas outside Digya.

Classes	AREA (SQ Kilometers)		
	1985	1991	2000
Water	1,567.40	1,657.22	2,100.35
Settlement	10.00	20.00	65.00
Mangrove	600.33	520.00	100.00
Cropland	1,110.00	2,260.25	3,647.79
Closed Forest	3,670.00	1,730.00	450.00
Mixed Forest	500.00	900.00	110.00
Grassland	350.00	600.00	1,005.00
Clouds	5.00	25.00	35.44
Unclassified	100.00	300.00	400.29
Total	7,912.73	7,912.73	7,912.73

Table 2. Supervised classification result for area covering Digya National Park.

Classes	AREA (SQ Kilometers)		
	1985	1991	2000
Water	1,200.44	1,598.99	1838.16
Settlement	12.00	15.00	22.00
Mangrove	100.33	150.72	219.86
Cropland	125.72	195.00	250.00
Closed Forest	1,500.00	1,198.45	800.00
Mixed Forest	900.00	700.00	500.00
Clouds	70.00	50.00	35.44
Unclassified	0.00	0.00	153.00
Total	3,908.16	3,908.16	3,908.16

The classification results revealed that the most significant cause of deforestation in Digya National Park is the advancing size of Lake Volta, which accounted for 65% of all deforesting factors including human settlements and the extension of illegal farming. This proportion rises to 82%, if mangrove growth is included as a direct by-product of Lake expansion. In other words, most of the problem at Digya is due to decisions made by private industry and the Government of Ghana relating to the spill rate at Akosombo.

4. CONCLUSION

The general result of this study is that, while habitat control is unlikely to be successful so long as the Akosombo Dam policy is outside the decision-making loop, impacts may be mitigated by the provision and maintenance of a database covering a number of parameters which are within the Wildlife Department control. This suggests the need for the Wildlife Department to coordinate its protection efforts with other Departments of the Government of Ghana which have authority over electricity production, now that legal control over the Dam has been ceded back to the Government of Ghana by the Kaiser Aluminium Company, based in the United States (Ghanaweb, 2003; Manu, 2004). There is also the need to involve the community in the decision making process both at the local and national level. By so doing, the community would have input in the day-to-day management of the Park.

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