ENVIRONMENTAL IMPACT OF WETLAND RESOURCES UTILIZATION IN SIMUYU BASIN, TANZANIA

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ABSTRACT

There is a growing appreciation of the natural functions of wetlands, and the values and different forms of uses that humans attach to them. Wise use and special conservation strategies are therefore needed in order to sustain their productivity. Wetlands are one of the most fruitful areas of archaeological research, and they are the ideal setting in which to study the interactions between physical processes and human actions that encapsulate and exemplify many of the themes of man's impact on his environment. But all these beneficial functions of wetlands seem to be in danger of being lost to draining and in-filling. This paper attempts to address how the Geographic information systems (GIS) and remote sensing techniques could be used to unveil land use patterns that have resulted in degradation of the wetlands in Simuyu basin in Tanzania. The analyses drawn upon the use of remote sensing data for assessment of wetland resources: land, forestry, agriculture settlement, grazing, and wetland management, and highlight the physical and technical characteristics of the resource. Landsat images used for vegetation mapping and land cover change study were at a temporal scale of a 10-year interval from 1973. 1973, 1985, 1995, and 2005. Landsat satellite images were used to inform landscape qualities over broad areas under the study area. The satellite sensors being used cover the visible and infra-red (VIR) spectrum up to the microwave region of the electromagnetic spectrum and are being based on a single sensor approach or sensor combination that fulfills a minimum requirement for practical land cover mapping and inventory purposes (e.g. forest and non-forest areas, wetland and dryland, varying land use density, dominant species (crop) composition, flood prone areas and impact of human activities). Both the technical capabilities and the potentials of the data are presented in correlation with the existing ground conditions.

INTRODUCTION

Wetlands are essential natural ecosystems providing social and economic benefits to human life. These benefits include among others irrigation, agriculture in flood planes, fishing, water supply, timber production, transport, recreation, tourism, papyrus production, sediment/toxicant retention, flood control, groundwater recharge and discharge, and archaeological research (de Voogt, *et al.*, 2000). According to Howard (1992) major threats to wetlands include competition for especially water resources, conversion of wetlands for agricultural and urban purposes and sectoral responsibility for management. Since wetlands are located between uplands and water resources, many intercept runoff from the land before it reaches open water.

Wetlands can benefit greatly from satellite imaging because of the presence of particular biotic assemblages that are characteristic of

Http://www.enn.com/index.asp (1999) report using satellite imagery to map water hyacinth in the Lake Victoria area. They associate the infestation with the presence of plumes of nitrogen and phosphorus rich sediments originating from the riparian areas of the lake.

Http://www.worldagroforestrycentre.org/sites/program1/specweb/SensingSoil.htm show a method of using soil spectra of red soil (Oxisols), brown gravely soil (lacustrine deposits), and black soil (Vertisols) using Landsat 5 imagery to contrast the soil types in the Nyando River basin. The plume of soils originating from the basin can be seen in the gulf of the Lake.

Asrar, *et al*. (1992); Kumar and Monheit (1981); and Myneni, *et al*. (1995) have shown that simulations with radiative transfer models support interpretation of normalized difference vegetation index (NDVI) in terms of the fraction of photosynthetically active radiation absorbed by the vegetation canopy, canopy attributes, and state of the vegetation. Seasonal variations of vegetation indices can be related to vegetation phenology and biome seasonality (Justice, *et al*., 1985). A biophysical indicator that is strongly related to land cover conditions that can be measured by remote sensing such as chlorophyl absorption in red and high reflectance by vegetation in near infrared provides unique contrasts (Anyamba, *et al*., 2002b).

Wetlands often follow a natural course that tends towards drying up as sediment fills the water depressions, or the supply of water diminishes, or vegetation becomes so abundant as to supplant the water as in the case of water hyacinth. Satellite imagery of multidate data can be used to map such changes (Anyamba, *et al*., 2001). Monitoring of the wetlands focusing mainly in the shrinkage or expansion of the wetlands water and in the health and abundance of the supported vegetation can be done from satellite imagery.

The dynamics of terrestrial ecosystems are receiving increasing attention in global-change studies (Ojima, *et al*., 1994). Changes in land cover have implications for the biosphere-atmosphere interactions, habitats (e.g. wetlands, soil conditions, water) and development process (Meyer and Turner, 1994). Quantitative estimates of rates of change in the past few decades have been collected mainly for forest ecosystems (FAO, 1995). Most of the rural populations of the tropics however, practice agriculture on land derived from shrub lands, grasslands and more recently from wetlands (Houghton, 1994).

To fully address the human aspects of land-cover change, better data need to be collected for these biomes. Suitable measurements allow evaluation of the major driving forces of changes and their potential effects and predication of future trends. For some applications, measures of land-cover change must be represented at a level of spatial aggregation that matches the spatial resolution of ecosystem models. The potential of 1 km or coarser spatial resolution of remote sensing data with a high frequency of observations for monitoring changes in the attributes of the earth's surface for example is well documented (Malingreau, 1986; Running, *et al*., 1994).

This paper addresses the application of Remote sensing technology to assess the impact of wetland resources utilization in Simuyu basin which is a sub-catchment of Lake Victoria Drainage Basin (LVDB) in Tanzania.

METHODOLOGY

Remote sensing (RS) technologies that are being applied are useful in monitoring land use/cover changes when applied in a qualified manner. The size of the farms and the crop types to be monitored, coupled with the pixel size of the chosen medium of remote sensing, together were envisaged to provide the potential for accurate RS assessment of impact of wetland resources utilization in Simuyu basin of Magu district, Mwanza region.

Landsat image data were acquired from the Regional Mapping Centre for Research and Development in Nairobi, Kenya. Then the remote sensing techniques and GIS tools provided by the Department of Geography in University of Dar es Salaam, was used to examine the impacts of land use activities. Landsat images used for vegetation mapping and land cover change study were at a temporal scale of a 10-year interval from 1973. 1973, 1985, 1995, and 2005. Landsat satellite images were used to inform landscape qualities over broad areas under the study area. The satellite sensors being used cover the visible and infra-red (VIR) spectrum up to the microwave region of the electromagnetic spectrum and are being based on a single sensor approach or sensor combination that fulfills a minimum requirement for practical land cover mapping and inventory purposes (e.g. forest and non-forest areas, wetland and dryland, varying land use density, dominant species (crop) composition, flood prone areas and impact of human activities). Both the technical capabilities and the potentials of the data are presented in correlation with the existing ground conditions.

Among the analyses made were:

- Baseline data collection based on interpretation and image classification
- Analysis and presentation of data as a basis for monitoring change
- Division of the watershed area into typical landscapes in order to illustrate past and present processes, ecological conditions, etc.

A visual interpretation was normally used for overviews. Supervised digital classification was only used in small areas and in such cases where field data is sufficient for calibration and generalization of findings often supported by collateral information. The remote sensing methods have to be cost effective and applicable in field situation. The analyses drawn upon the use of remote sensing data for assessment of wetland resources: land, forestry, agriculture settlement, grazing, and wetland management, and highlight the physical and technical characteristics of the resource

RESULTS AND DISCUSSION

The land cover classification results from Satellite Images analysis (Table 1), shows the percentage (%) of land cover and the area for each of the imaging date.

Table 1(a) Land Cover Classification Analysis for 1973, 1985 and 1995

Land use/cover Types	July 1973		March 1985		September 1995	
	Area(Km²)	%	Area(Km²)	%	Area(Km²)	%
Marsh/bog	27.66	11.43	94.678	39.138	71.116	29.398
Unidentified	0.007	0.00003	0.387	0.002	2.983	1.233
Scrub/woodland	49.013	20.261	0.387	26.921	32.239	13.327
Built up/bare or open ground	52.106	21.539	52.526	21.713	112.787	46.624
Open water	19.012	7.859	29.194	12.068	25.767	10.652
Burnt area	24.822	10.261		-		-
Riverine vegetation						

Table 1(b) Land Cover Classification Analysis for 2001 and 2005

Land use/cover Types	May 2001		June 2005	
	Area(Km²)	%	Area(Km²)	%
Marsh/bog	53.617	22.164	63.538	26.265
Unidentified	0.417	0.002	0.386	0.0026
Scrub/woodland	42.486	17.563	62.284	25.747
Built up/bare or open ground	119.212	49.280	82.244	33.998
Open water	26.176	10.820	22.086	9.131
Burnt area	-		-	
Riverine vegetation			11.368	4.699

Full Scene TM/ETM image = 241.9084 Km² (100%)

All images were geo-referenced and enhanced to facilitate interpretation. The following were interpreted/extracted from the image data/information (see also Figure 1-4).

- Progressive depletion of wetland size as seen from changes in biomass cover on the floodplain drained by Simiyu river and its tributaries (higher water table give the image darker colours tones/hues along the river valley. These were used to delineate the extent of the valley bottom).
- The normal floodplain had not been encroached onto by 1985 (in 1985, the area experienced massive flooding, impacting a large area of the floodplain.
- Weather conditions during the year 1973 reflect a peak drought period interpreted from very low vegetal cover on the land and at the floodplain. At that time the area was impacted negatively through fire that affected a large area including the wetland areas at the valley. This may have dramatically changed the ecology of the area and facilitated the communities to move in, taking advantage of the fire cleared areas
- There is progressive degradation of land resources around river Simiyu and river Duma, a major tributary.
- Beyond the valley of river Simiyu (northern side) there was initially some settlement which has disappeared.
- Density of cattle (livestock) increased; there is observed increase in erosion.
- Initially the flood plain had high water table in the valley (evidence from vegetation density and darker tones).
- The river's tributaries have reduced with time probably due to grazing which leads to high evaporation faster.
- A water dam has been developed to store water for rice paddies.
- In 1985 there was high water-level on flood plain seen from the flooded flood plain.
- There were levees naturally developed along the river bank for containment of the river water.
- The levees behaved as dykes.
- In 1995 people settled on the levees.
- In 2001 there was increased human settlement along the levees.
- 2005 cultivation takes places in the wetland and there is complete drainage of wetland.
- Settlement is extended to the levees and cultivation is extended to the flood plain.
- There is reduction of cultivation on the higher slopes of the flood plain and the people have moved to the levees of the river system.

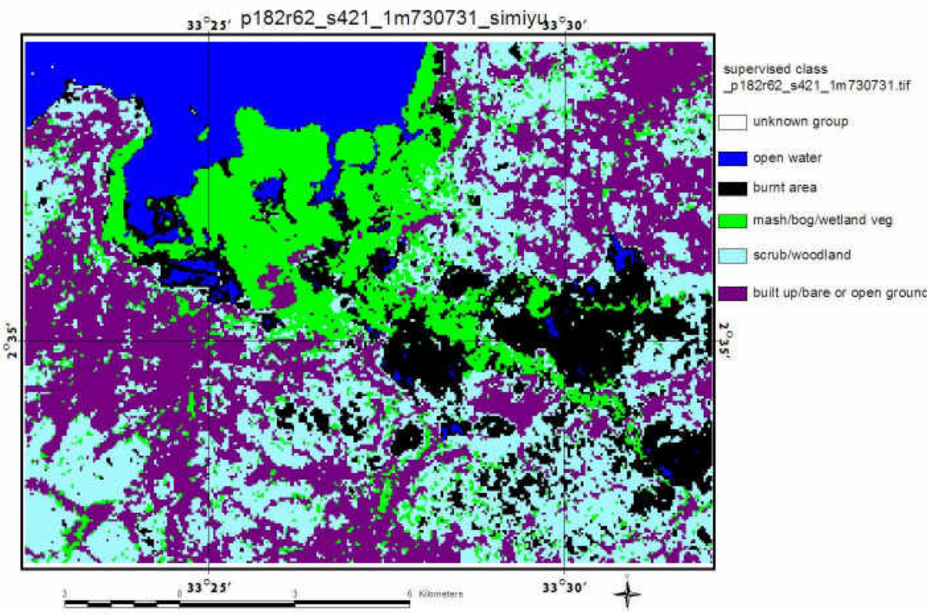

Figure 1 Land cover classification for Simuyu basin-1973.

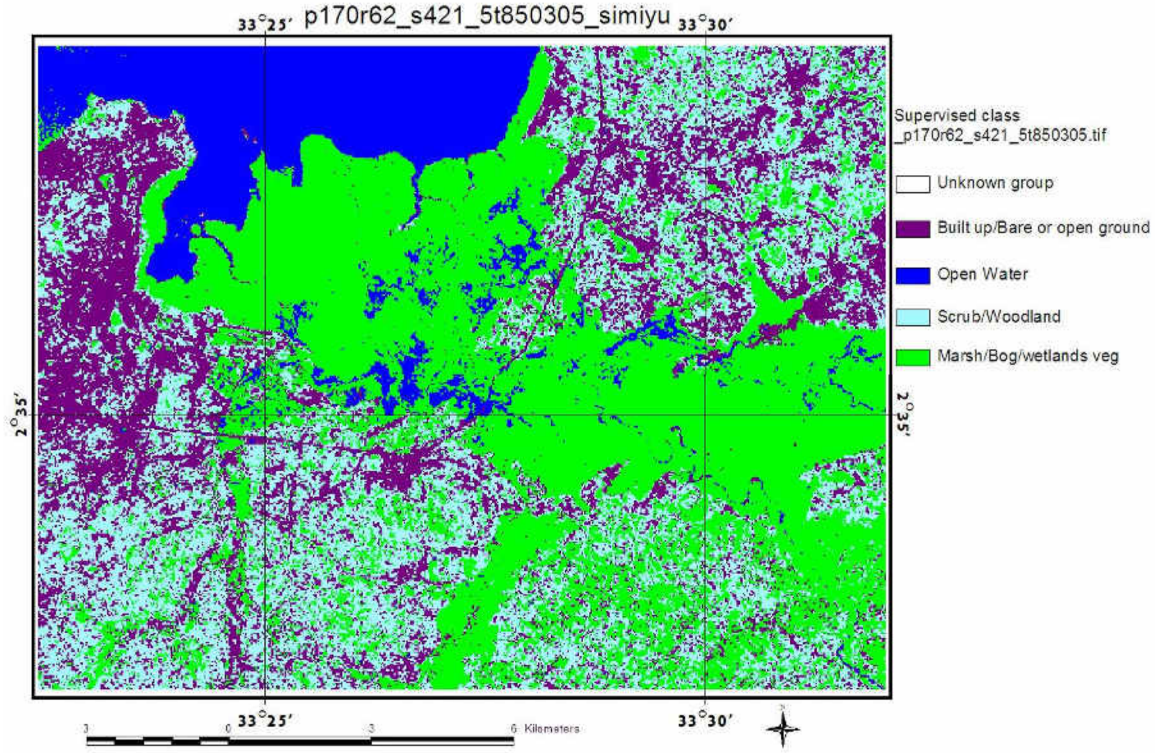

Figure 2 Land cover classification for Simuyu basin-1983.

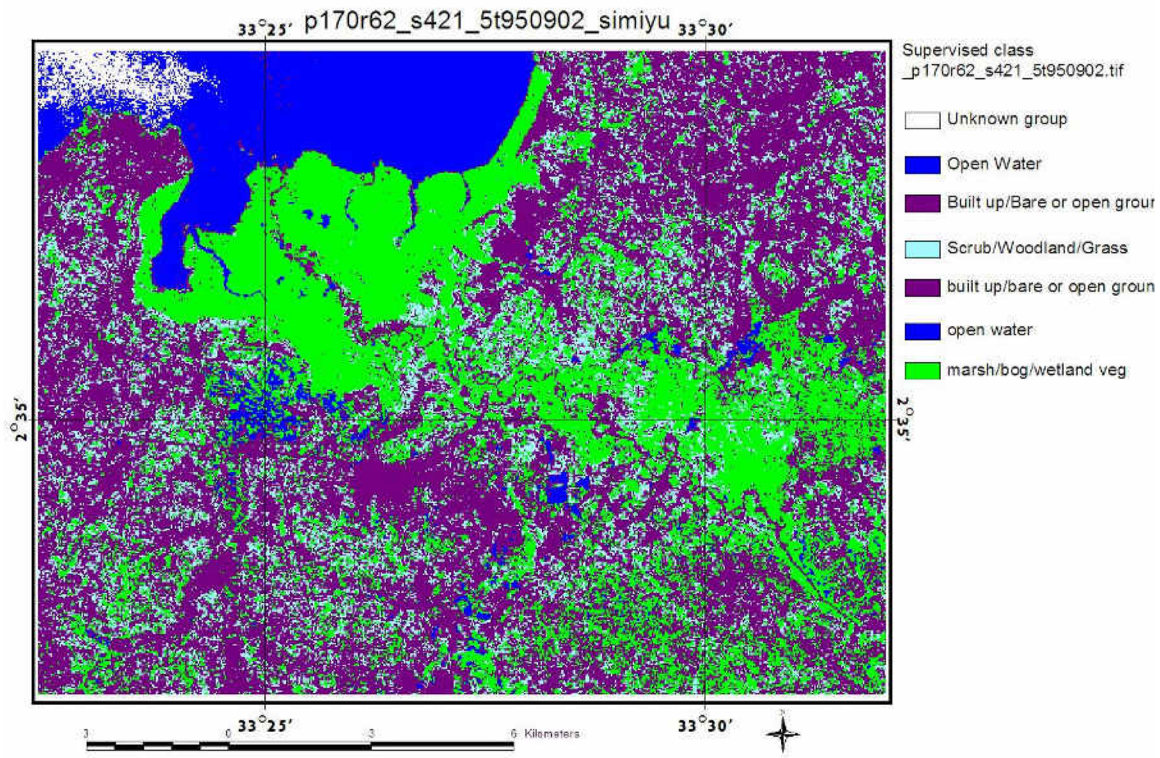

Figure 3 Land cover classification for Simuyu basin-1995

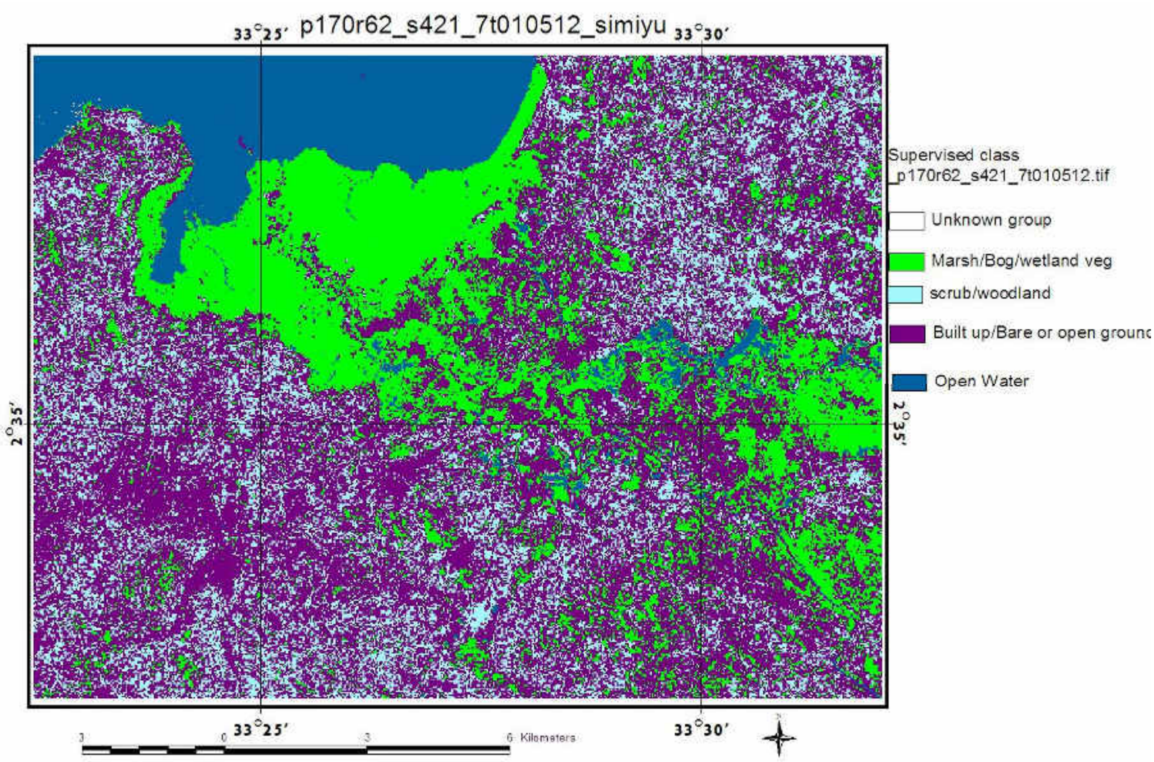

Figure 4 Land cover classification for Simuyu basin-2001.

CONCLUSION

The application of Remote Sensing Technique has shown to be instrumental to assess the impact of wetland resources utilization. Observation from the satellite images indicates progressive depletion of wetland size as seen from changes in biomass cover on the floodplain drained by Simiyu river and its tributaries. This is mainly attributed by increase in human activities involving cultivation, grazing and settlement.

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