Mapping Wetlands Potential for Sustainable Environment: GIS Perspective

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Abstract

This study examined the potential of Geographic Information System (GIS) in assessing and generating inventory about wetlands in Ilesa between 1986 and 2008. This was performed with a view to developing an integrated rehabilitation and management plan for sustainable environment in the study area. Landsat TM 1986 and 1991 and ETM+ 2002 were employed for the study. The coordinates of features were tracked with Global Positioning System (GPS). The satellite images were analyzed using ILWIS version 3.4 and AutoCAD Map R2. Based on ground truth data and remotely sensed data, the study area was classified into five categories using the supervised maximum likelihood classification technique. This has been explained by Tatsuoka (1971). The accuracy assessment was carried out on the remotely sensed data. A total of 30 points each were selected for this operation and the overall accuracy of 90%, 86.7% and 85% respectively were obtained from the three image datasets. The observed changes were mapped and the results of the classification were prepared as different themes in a GIS mode using ArcView version 3.2. The result showed that the major contributor to wetlands degradation in the study area was the use of wetlands for settlement and agriculture, which had ecological and socio-economic consequences on the functioning of the wetlands. It further showed that satellite remote sensing technology is effective for monitoring these aspects of natural resource.

Keywords: Wetlands; GIS; monitoring; sustainable environment

INTRODUCTION

Wetlands are areas where water primarily controls the environment and the associated plant and animal life. Wetlands occur where the water table is at or near the surface of land, or where the land is covered by shallow water. According to Ramsar Bureau (1997), wetlands are areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt including areas of marine water, the depth of which at low tide does not exceed six metres". The importance of these wetlands has been underestimated and disregarded.

Even some wetlands were often seen as wastelands while many were drained and converted to land for other use, such as agriculture or mining. It is estimated that 50% of the original wetlands of the earth have now disappeared (Ramsar Bureau, 1997). Moreover, the pressure on the remaining wetlands is high. Population growth, hydrological changes and pollution remain a threat for wetland ecosystems. In addition, global climate change is having its impact on wetlands. In Nigeria human activities continue to adversely affect wetland ecosystems (Orimoogunje, 2008). The alarming rate at which the country's wetlands are disappearing obviously portends some dire consequences. In particular, wetlands destruction is affecting water supply and water resources management in various parts of the country (Orimoogunje, 2008). There is no gainsaying, therefore, that the degradation of wetland ecosystems in Nigeria increases the task of water resources management in the country.

To protect and conserve wetlands from further damage, wetland management is needed. This can be achieved through the use of modern technology such as remote sensing and GIS. Remote Sensing is a powerful technique for surveying, mapping and monitoring earth resources. This technology combined with GIS which involves the storage, manipulation and analysis of geographic information and socio-economic data that provide a wider application. Thus, land resource and environmental decision makers require quantitative information on the spatial distribution of land use types and their conditions as well as temporal changes. Remotely sensed satellite data in conjunction with available other data sources have been used to find such land uses. To properly assist decision-making in the usage of wetlands potential, inventory taken is very important. And this can only be properly carried out with the aid of satellite imageries.

Wetland resources in the study area was properly identified and mapped, and a proposal presented on how it can be exploited sustainably. To this end, geoinformation facilitates accurate location and definition of spatial distribution of wetland resources in the study area. It will also provide data about the richness of wetlands and allows a determination through interpretation of how best to explore wetland resources. This will permit identification of actual and potential impacts of exploring wetland resources.

METHODS AND MATERIALS

The Study Area

The study area lies within latitude 7^0 30' and 7^0 35'N and longitude 4^0 30' and 4^0 34'E (see Figure 1). Ilesa urban area is made up of two local government areas, namely Ilesa West and Ilesa East. Both council areas are bounded in the north, west and south by Obokun, Atakunmosa and Oriade Local Government areas respectively (see Figure 2). The town covers a total area of about 73.6 square kilometres. It is about 32 Kilometres Northeast of Ile-Ife and about 30 kilometres Southwest of Osogbo, the Osun State Capital. The population of Ilesa has been put at 210,141 in 2006 (NPC 2006). The climate is humid tropical type with a mean annual temperature of about 28^0C and a mean annual rainfall of over 1600 mm. The underlying geology is mainly fine-grained biotite gneiss and schists although quartzite and quartz-schist rocks are common especially on slopes and ridges. The soils are mainly the well-drained Egbeda series known as alfisols which has been classified as one of the most fertile soils in the Nigeria cocoa belt (Smyth and Montgomery, 1962). The whole area is drained by tributaries of Osun, Sasa and Oora, rivers which flow south ward and southwest ward directions. The natural vegetation is the Tropical Rain Forest which could only be found in patches all over the district but mainly on hills.

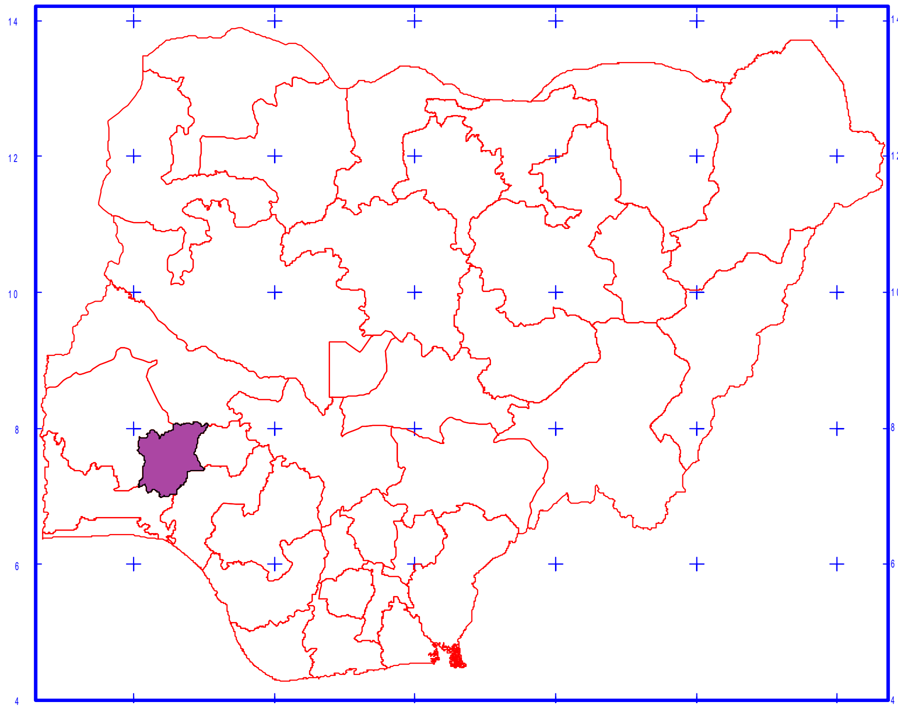

Figure 1: Map of Nigeria showing Osun State

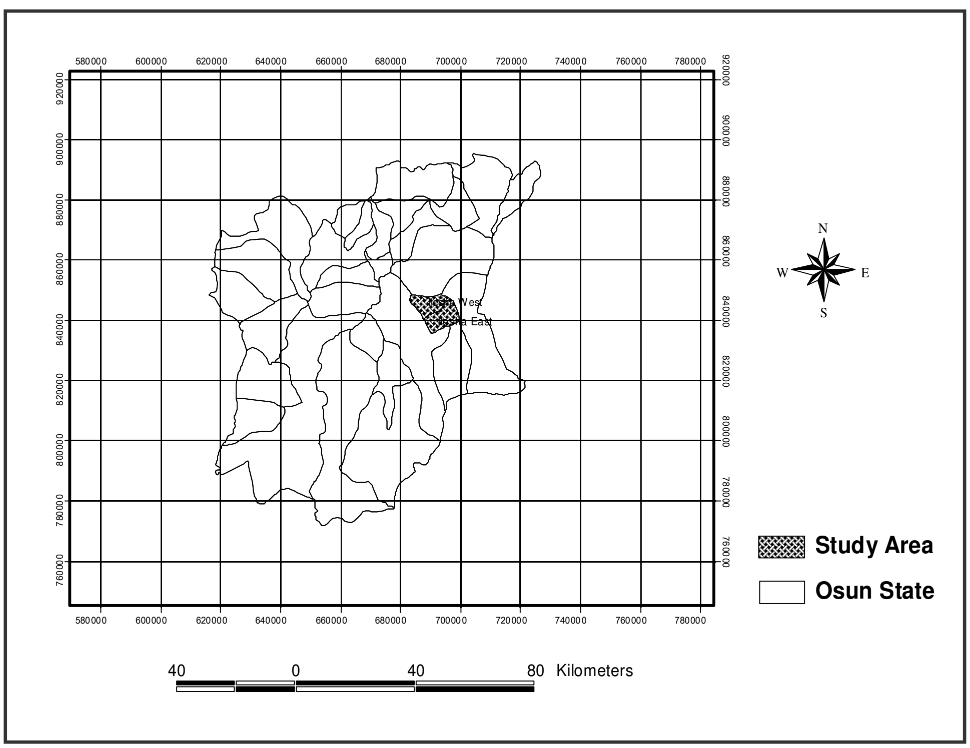

Figure 2: Map of Osun State Showing the Study Area

Methodology

Figure 3 shows the flow chart adopted for the study.

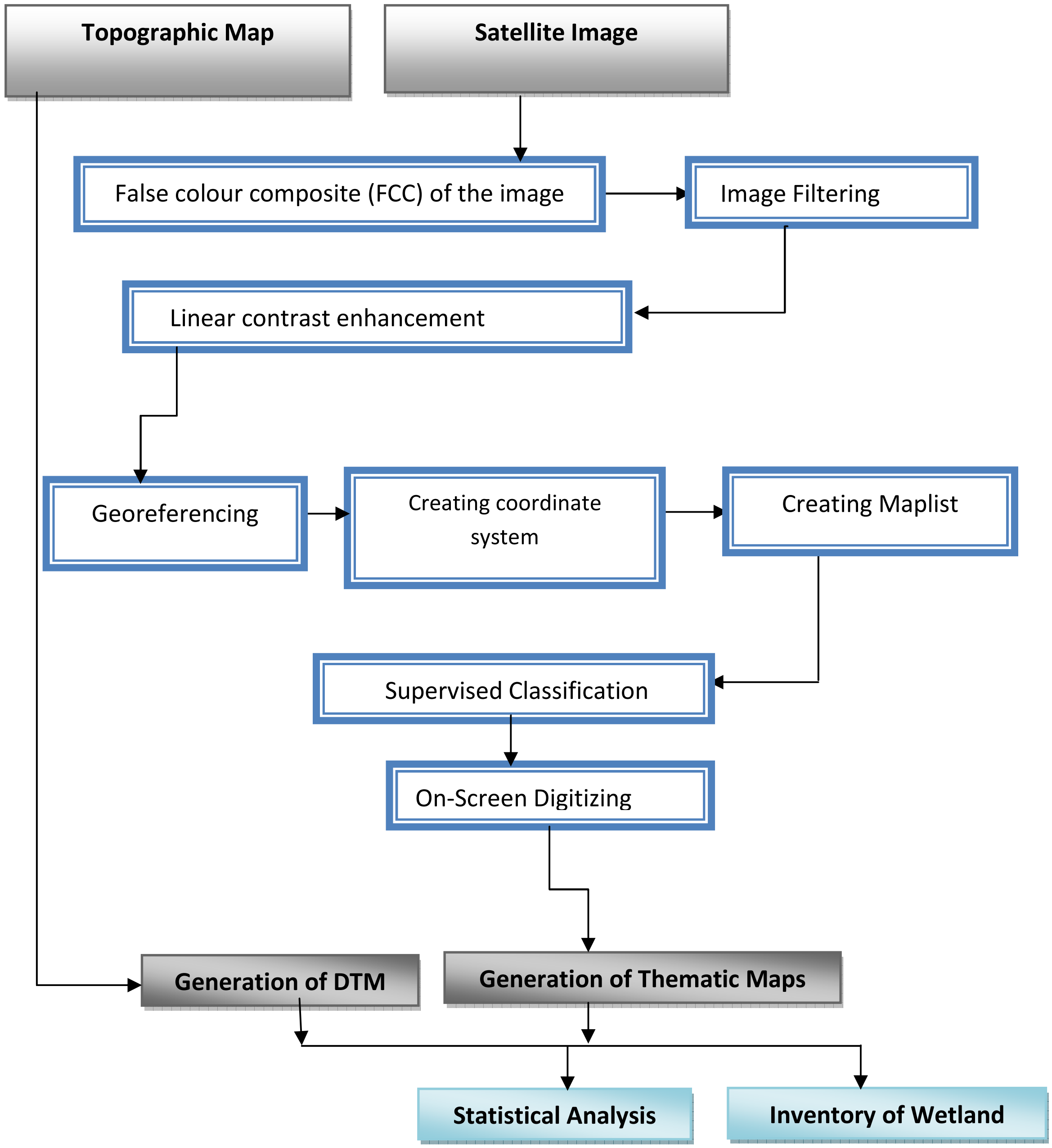

Figure 3: The Flow chart

Field and remotely sensed data were employed for this study. The field data were collected on the physical attributes of five key land use types for this study. The sampled sites were determined from the remotely sensed imageries that were used for the study. The geographical locations of the sample sites were also tracked with Global Positioning System (GPS). The remotely sensed data sources are Landsat-TM 1986 and 1991 and Landsat ETM+ 2002 covering the area. Topographical map of Ilesa SE and SW was used to generate DTM of the area. The primary dataset was summarized for eventual integration with the spatial datasets. The processing and the analysis of remotely sensed data include image enhancement, geometric correction, variable combination of spectral bands for land use mapping and a creation of a database for handling the various data types. These operations were performed using ILWIS software version 3.4, ArcView 3.2 and AutoCARD Map R2 to bring out the classes of land use types currently dominant in the area. The resulting land use characteristics were compared to assess the changes that have taken place in the wetland environment in quantitative and qualitative terms. To obtain a better result, points were identified, selected and marked. The accuracy assessment was carried out on the remotely sensed data. A total of 30 points each were selected for this operation and the overall accuracy of 90%, 86.7% and 85% respectively were obtained from the three image datasets. The geographic location of the map was determined with the adjoining points having the same coordinates. These coordinates were transformed from geographical coordinates to Universal Transverse Mercator (UTM) using GEOCALC software. The GEOCALC has the capabilities of transforming coordinates from one coordinates system to another. In the course of this project, a latlong geographic point on the map was changed to UTM.

RESULT AND DISCUSSION

The Land use / Land cover Analysis

Table 1 shows the details of land use changes in the study area. This is grouped into two types. Thus, Land use types with areal extent that had increased and Land use types with areal extent that had decreased. The first group includes those land use types with areal extent that has increased between 1986 and 1991 and between 1991 and 2002. The land use types of areal extent that has increased between 1986 and 1991 included the bare soil/ land from 1401 hectares in 1986 to 1969 hectares in 1991; agricultural activities from 7047 hectares in 1986 to 9017 hectares in 1991; and settlement from 4093 in 1986 to 4541 hectares in 1991. Similarly, the same set of features increased simultaneously between 1991 and 2002. For instance, bare soil/land increased from 1969 hectares in 1991 to 2930 hectares in 2002; agricultural land from 9017 hectares in 1991 to 10020 hectares in 2002; and settlement from 4541 hectares in 1991 to 7271 hectares in 2002. In sum, these land use types have grown tremendously in areal extent in the study area.

Table 1: Total areal extent of land use types in the study area between 1986 and 2000

Land Use Type	1986		1991		2002	
	Area/ Extent(Ha)	%	Area/ Extent(Ha)	%	Area/ Extent(Ha)	%
Bare Soil	1401	6.49	1969	9.12	2930	13.57
Dense/Riparian Vegetation	8791	40.72	5915	27.40	1300	6.02
Agricultural	7047	32.64	9017	41.76	10020	46.41
Settlement	4093	18.96	4541	21.03	7271	33.68
Wetlands	258	1.19	148	0.69	69	0.32
Total	21590	100.00	21590	100	21590	100

The second land use changes in the study area are those with extent of coverage that has decreased. By 1986 Dense / riparian which is one of the dominant features of wetland environment had decline from 8791 hectares to 5919 hectares in 1991 and to 1300 hectares in 2002. This trend is consistent with what has been described for natural resources in Nigeria (Ola-Adams, 1981; Orimoogunje, 2005: 2009). As a result of agricultural activities going on around the wetland environment in the study area, many of the valuable trees have been destroyed (see Figure 4).

Figure 4: Wetlands area that has been degraded in preparation for agricultural activities

Wetlands Inventory

Table 2 shows the list of wetlands identified in the study area and what they are used for. Land use activities such as settlement and infrastructural development, sewage and solid waste disposal and cultivation have been and continue to be undertaken in the wetlands in the study area as indicated by plate mosaic of wetlands inventory captured in the study area (see Figure 5). The larger portion of the wetlands in Ilesa and its environs were used for settlement and infrastructural development whereas in the urban periphery the larger portions of the wetlands were used for agricultural purpose. Cultivation was practised in both wetlands in urban and urban periphery of Ilesa. The settlement and infrastructural development and solid and sewage disposal in wetlands in Ilesa ended up leading to the total destruction of wetlands in the study area. It is clearly shown that there is a potential danger for the wetlands in Ilesa to become extinct in the near future as a result of high pressure. This corroborates FAO report (2000) that about 25% of the world's wetlands have already been lost, largely due to conversion to agriculture or diversion of water for agriculture and aquaculture.

Table 2: Inventory of Wetlands

SN	Name	Location		General Characteristics	Present Use/Cover
		Latitude (N)	Longitude (E)		
1.	Iloko Road	07^0 51' 10.5''	$004^0$47'42.6''	Partly fallow with arable crops	Cassava, maize and plantation
2.	River Asoro	07^0 37' 17.5''	$004^0$47'09.9''	Drained area for yam cultivation, cocoyam, sugar cane, maize	Twins Brother Aluminum products, Saw mill etc
3.	Asoro 2nd point	07^0 37' 23.7''	004^0 47'06.5''	Drained area for yam cultivation, cocoyam, sugar cane, maize	Banana, sugar cane, sedges, etc
4.	River Eruru	07^0 37' 08.8''	$004^0$42'46.6''	Dominated by banana and raffia palm	Cleared and used as car wash centre
5.	River Ayao	07^0 37' 09.9''	$004^0$44'03.4''	Not cultivated but used as dumping ground and abattoir	Car wash centre, river is far approach
6.	River Oora	07^0 37' 14.7''	$004^0$44'10.4''	No cultivation: full of grasses	In its natural status
7.	R. Ajegbadun	07^0 36' 20.1''	$004^0$44'26.4''	Fishery and farming activities	Encroachment by buildings
8.	R. Ayao 2pts	07^0 36' 03.2''	$004^0$44'15.7''	Cultivation of coconut, breadfruit; part as dumping centre	Encroachment by building e.g. churches
9.	Kappa area	07^0 37' 59.2''	$004^0$44'58.4''	Cultivation of banana, maize	Encroachment by building, churches
10.	Illo area	07^0 38' 18.5''	$004^0$45'17.0''	Cultivation of maize, banana	Ornamental garden and horticulture
11.	OSSCE Ilesa dam	$07^0$35' 57.7''	$004^0$42'44.3''	Maize plantation, cassava, yam	Dam and water supply
12.	Omi oke Aanu	07^0 35' 59.9''	$004^0$43'52.6''	Churches and cultivation of crops	Encroachment by buildings
13.	Bolorunduro	07^0 35' 59.7''	$004^0$43'59.3''	Fishery, sugar cane, maize	Encroachment by buildings
14.	Ijofi	07^0 37' 13.2''	$004^0$44'19.7''	Car wash and banana plantation	Horticultural garden
15.	Oke-ooye	07^0 37' 01.1''	$004^0$44'40.7''	Car wash and sugar cane field	Encroachment by buildings
16.	Aayo stream	07^0 36' 54.0''	$004^0$44'38.6''	Churches and tree crops	Encroachment by buildings
17.	Stadium	07^0 36' 57.6''	$004^0$44'56.3''	Swampy and waterlogged	Grasses, sedges and reeds
18.	Obokun	07^0 37' 12.1''	$004^0$45'29.1''	Churches, banana, dumping sites	Buildings are encroaching
19.	Omi asoro	$07^0$37' 17.0''	$004^0$47'08.8''	Maize field and yam farm	Car wash
20.	Oloruntedo	07^0 38' 23.1''	$004^0$44'58.6''	Banana plantation, and churches	car wash
21.	Oke-omiiru	07^0 38' 41.5''	$004^0$44' 31.4''	Banana plantation and car wash site	Car wash, Banana plantation
22.	Anglican gram sch	07^0 39' 03.8''	$004^0$43'55.8''	Fishery and car wash	Banana plantation
23.	Omi-oko	07^0 38' 18.3''	004^0 44' 24''	Banana plantation and water supply	Encroachment by building
24.	Kayanfanda	$07^0$37' 34.4''	$004^0$43'39.9''	Swampy and waterlogged	Reeds, grasses and sedges

Source: Authors fieldwork, 2008

Extra efforts are therefore needed to conserve the wetland resources including those in urban periphery of Ilesa as their existence are highly threatened by the growing demand of land for agriculture and infrastructural development. Conflicts of interest between agriculture and infrastructural development are inevitable given the analysis from the satellite imageries of the study area. Tables 1 show the agricultural activities, settlements and bar soil/land depending on the respective wetlands area in the region. The factor that exerted stress on the wetland resources in the area were shortage of lands and poverty which forced people to practise agriculture on the wetlands where they were assured of getting good returns.

Threats to Wetlands in Ilesa

The role of wetlands in a healthy environment has historically been poorly understood. Many wetlands in the study area have been considerably transformed, modified and destroyed because of human activities within and around the wetlands. In the study area, urbanization and agricultural activities put pressure on wetland resources. Urbanization, over cultivation and encroachment of the wetlands resources due to high population and the suitability of the areas for production of arable crops has increased stress to the wetland resources in the study area. For instance, the population of Ilesa has increased tremendously. As a result of the increasing population, the areas that were regarded to be wetlands (see Figures 6, 7 and 8) have been converted to agricultural purposes and settlement.

Siltation and improper handling of solid wastes were other activities causing stress to wetland resources. Over-cultivation and farming that did not take care of soil conservation in the respective hilly and mountainous areas has resulted into flooding during the rainfall. The floods brought silts from the head streams which caused siltation to the wetlands downstream threatened the existence of the wetland resources in the study area. Solid waste (see figure 5) has also been regarded as one of the factors causing stress to the wetland resources in the area. This has been associated with the blockage of water source in stream and rivers that dissected Ilesa. A typical example in the area is River *Ayao* and *Oora.*

Impacts of Wetland Uses

The uses of wetland for cultivation, settlement and infrastructural development and solid and sewage disposal have got ecological and socio-economic consequences on the functioning of the wetlands in the study area. These include the following:

Infilling in Wetlands: The use of wetlands for agricultural activities has led to the problem of infilling into the wetlands which has also led to the reduction of water in wetlands. This was mostly taking place in the wetlands in Asoro, Kappa and Iloko road. The people were originally cultivating the crops far away from the wetlands. They were increasing their cultivation each and every year in the direction of the wetlands. It should be established that, the cultivation of crops (e.g. maize, yam, cassava, etc) in the wetlands will affect the soil greatly because these crops do not bind or cover the soil like the natural wetland vegetation. As a result the wetlands will be less effective at regulating stream flow and purifying water because the drainage channels speed up the movement of water through the wetlands.

Alien Invasion in Wetlands: The use of wetlands for cultivation has also disturbed the species composition in the area. The disturbance of the area has attracted rooted plants that were non native, that is, the alien plant species such as *Psidium gujava* (Apple Guava), *Ricinus communis* (castor- oil), *Chromolaena odoratum* (Siam weed) etc. These alien plant species have now invaded the wetlands and were now out-competing the wetlands species. As a result, the ecology of the area has changed. The presence of alien species is also leading to the reduction of water in the wetlands.

Loss of Biodiversity: The conversion of wetlands to settlement and infrastructural development has led to the destruction of most of wetlands plant species such as reeds, sedges and grasses. In the absence of these plant species, the wetlands were failing to play their important functions such as trapping of sediments, removal of waste materials and purification of water. The habitat required by wetland-dependent species was frequently lost. This was also leading to the total destruction of the wetlands and this had impacts on the ecology of the area because it was making the area to change from wetlands to a settlement area.

a. Wetland encroached upon by building

b. Wetland transformed to dumping site

c. wetland transformed to abattoir

d. Wetland transformed to maize field

Figure 5: Showing Misuse and abuse of wetland potentials

Pollution of Wetlands: Solid and sewage disposal into the wetlands was taking place in the wetlands in Ilesa (see Figure 5). Sewage disposal includes used water from domestic activities such as laundries, car wash, lavatories whereas solid waste includes suspended matter especially bones from abattoir, floating matter such as tins, plastics and scraps of old motor vehicles. As a result of this, the waters natural purification process in the wetland will cease as more and more solid and sewage is disposed in to the wetlands.

CONCLUSION

The study has indicated that the land use activities that took place and were still taking place in the wetlands in Ilesa and its environs have got negative effects on the functioning of the wetlands. There is abuse of wetlands because they are used in an unsustainable manner; while settlement and agricultural activities have contributed to wetlands transformation in the study area. The areas so designated as settlement have continuously been on the increase. It also showed that the use of wetlands for cultivation has disturbed the species composition in the study area. Therefore, to protect wetlands from further damage and conserve them, wetland management is needed. And this can only be achieved or facilitated through geoinformation. Since informed decision-making will require better information about wetlands, such as, what they are, how they are changing, who exploits them, for what goods and services, and how much these goods and services are worth.

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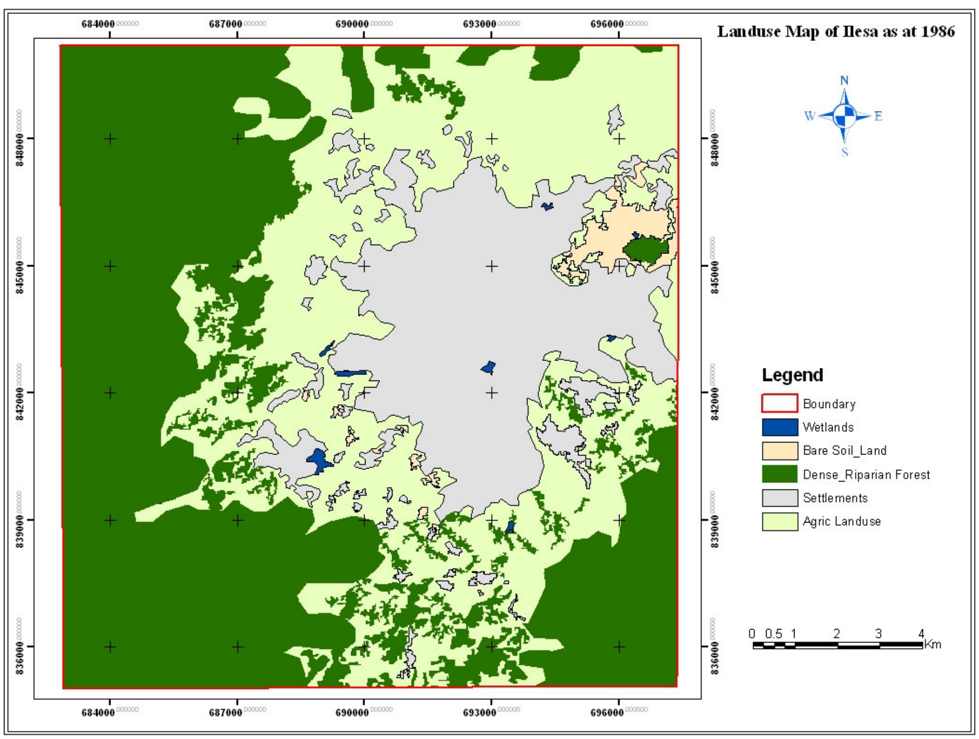

Figure 6: Land use type of Ilesa as at 1986 Landsat TM

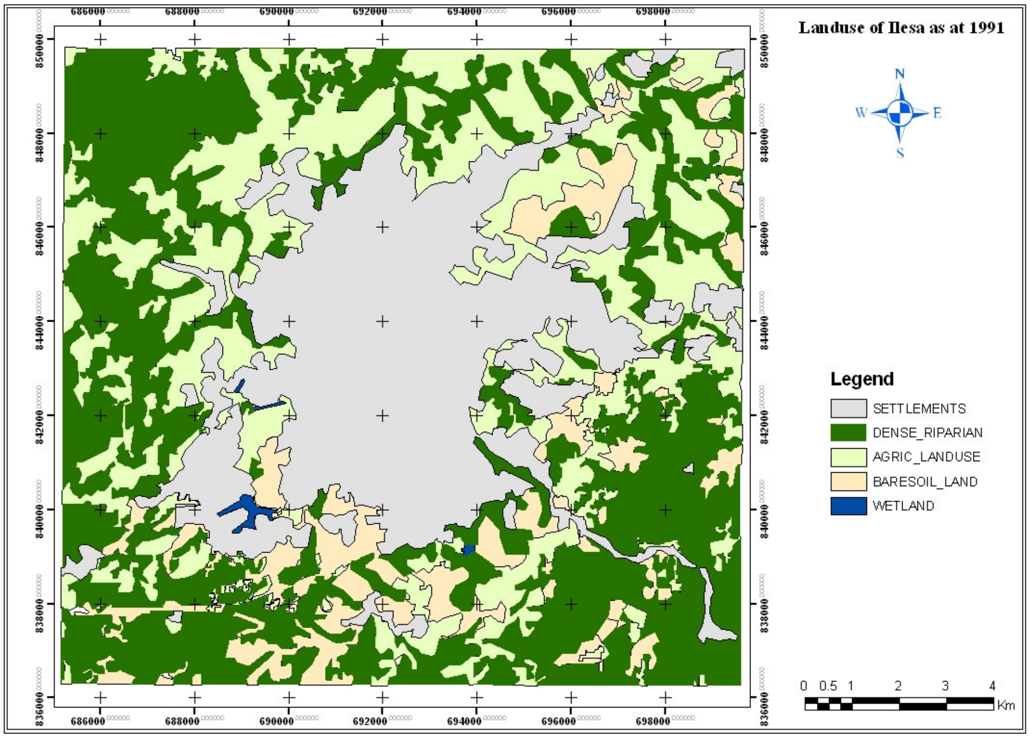

Figure 7: Land use types as at 1991 based on Landsat TM

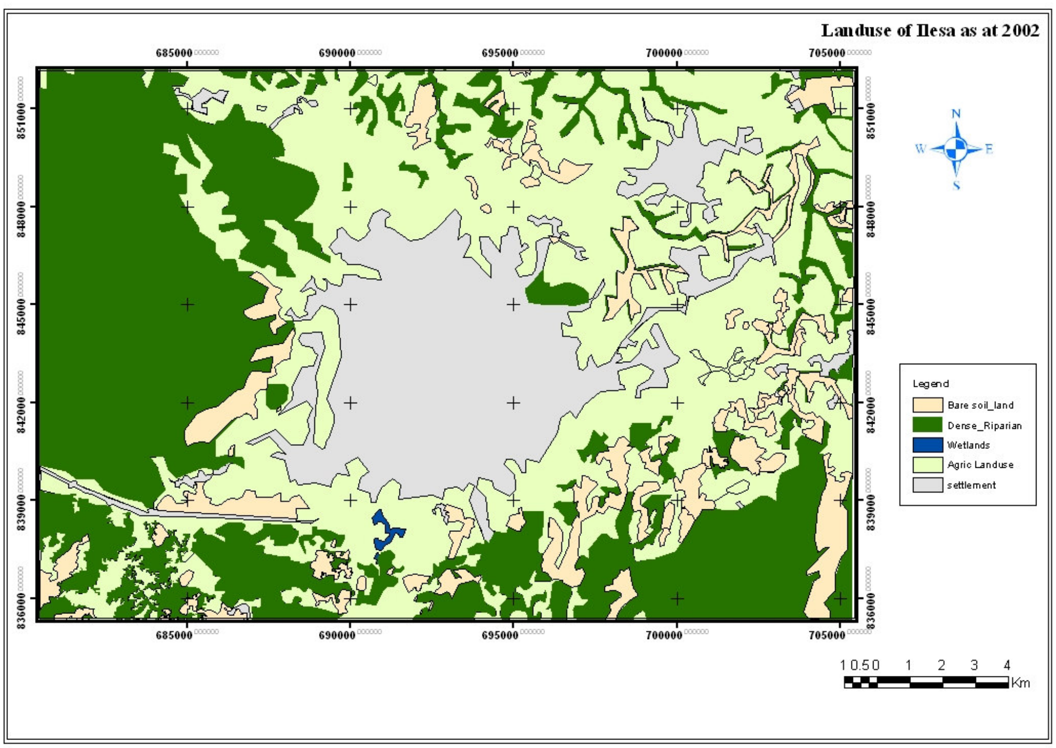

Figure 8: Land use type of Ilesa as at 2002 based on Landsat ETM+