Journal of Geography and Regional Planning Vol. 1(6), pp. 110-115, September, 2008
Available online at http://www.academicjournals.org/JGRP ISSN 2070-1845

Full Length Research Paper

The change detection of major dams in Osun State, Nigeria using remote sensing (RS) and GIS techniques

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Accepted 17th July, 2008

The assessment of the dynamics of major dams (Ede-Erinle and Eko-Ende reservoirs) in Osun State, Nigeria was investigated using Landsat-TM (1986) and Landsat-ETM+ (2002). The images were processed, interpreted and classified using ILWIS 3.3 software. The results of the study showed a sharp decline in the surface area of the study reservoirs as indicated by per cent of reduction from 1986 to 37.49 and 45.42% in 2002 for Ede-Erinle and Eko-Ende, respectively. In the light of the above, to prolong the lifespan of the study dams, there is need to carry to evacuate the hydrophytes which have colonized the edges of the study reservoirs / dam. Also, to ascertain the current volume of water in the dams, bathymetric survey of the impounded reservoirs should be carried out.

Key words: Assessment, dam, LANDSAT TM and ETM+, Osun State

INTRODUCTION

The increase in reservoir sedimentation resulting from accelerated erosion from farmland and bare surfaces in the interfluvial area around the dams has been identified as endemic problem all over the tropics particularly in southwestern Nigeria (e.g Ede, Ile-Ife, Ado-Ekiti, owo and Asejire) (Faniran and Jeje, 1982; Adediji, 2005). The main effect of severe reservoir sedimentation is the shortage of water supply to the communities that the dams were designed to serve. Therefore, there is urgent need to monitor the dynamics of the reservoirs with a view to ensure continuous supply of water in adequate quantity and quality to the communities they are designed for.

Several published studies exist on the rate of reservoir sedimentation in several parts of the world (e.g. Rapp et al., 1972 in Tanzania; Adam, 1996 in Poland; white et al., 1996 in Southern Pennines, UK; Adediji, 2005 in South-western Nigeria). However, in spite of many published works on the application of Remote Sensing (RS) and Geographic Information System (GIS) to Water re-sources evaluation (e.g. Alans and Thomas, 2003 in Vietnam; Dimitrios et al., 2003 in Aliakmon; Paoshan et al., 2003 in Taiwan; Muhammed et al., 2003 in Indonesia) there is little or no known studies on the application of RS and GIS to change detection of reservoir surface area in southwestern Nigeria if not in the whole of Nigeria. Therefore, information on the dynamics of dam is very important for the sustenance and management of the dam/water scheme project in Nigeria. Thus, this study is focused on the assessment of the change in the surface area of Ede - Erinle and Eko – Erinde Dams between 1986 land 2002 and also to create thematic maps for the change in the size of the study reservoirs.

Study area

Ede-Erinle and Eko-Ende Dams and its associated reservoir in Osun-State constitute the study area (Figure 1). The study area lies between Lat 7°44' 30.44" and 7°57' 00.79" N and Long 4°26'21.71" and 4°41'23.48" East of the Greenwich Meridian. The Erinle Dam (Okinni Dam), an extension of the old Ede Dam on Erinle River and Eko-Ende Dam on Otin River constitutes the study reservoirs. The dam and its impounded reservoir on Erinle River in addition to the existing Ede headwork at Ede is designated as Ede-Erinle Dam in this study. The expanded reservoir is designed to improve existing water supply system of cities such as Osogbo, Ede, Ife,

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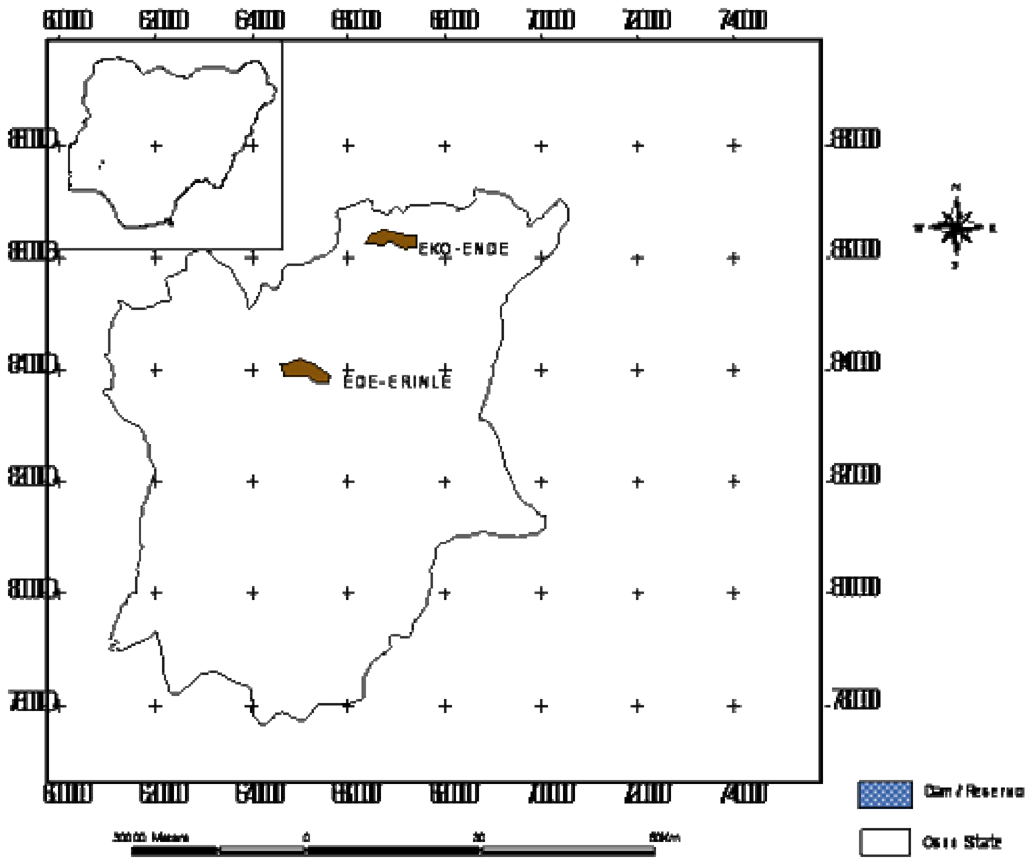

Figure 1. Map of the study area.

Gbongan, Erin-Osun, Ilobu and Ifon as well as other towns and rural communities in Osun central, Osun West and Ife area in Osun State. In fact, the dam (Ede-Erinle) was designed by the old Oyo State Water Corporation to improve and expand existing Ede headwater work.The reservoirs created behind the dam (Ede-Erinle) extend some 12 km northward along the Erinle River and its Otin River tributary with maximum width of 3.5 km. The reservoir covers about 14.0 km^2 at the normal water level, and about 15 km^2 at maximum water level (Oyo State Water Corporation Report, 1982). The gross capacity and safe annual yield of the impounding reservoir on Erinle River was estimated at 94 and 92.5 MCM, respectively (Oyo State Water Corporation Report, 1982). The Eko-Ende Dam was impounded on the Otin River (a tributary of Erinle River) in 1973, the reservoir had storage capacity of 5.5 MCM and the associated head works were designed to provide potable water supply to Ikirun, Okuku, Iragbiji, Eko-Ende, Eko-Ajala and Oba. The dam is located within a comparatively semi-urban to rural area.

The regional relief of the study area is rugged with elevations ranging from 35 m to over 400 m above sea level (Osun state Water Corporation Report, 1994). The area constitutes a part of the Basement complex of Southwestern Nigeria and characteristically is underlain by crystalline igneous and metamorphic rocks. These rocks constitute the prominent outcrops and inselbergs that define the topographic highlands in the area (Osun State Water Corporation Report, 1994). Although the rocks are essentially of migmatite-gneiss complex, they are largely monolithologic.

The study area is under Koppen's Af humid tropical rainforest climate. The mean annual rainfall is about 1400 mm with the rainy season covering eight months (April to November) and its beginning and end marked by torrential rains and thunderstorms. The rainy season in the area is normally characterized by two maxima rainfall with peaks in July and September/October. Temperatures are generally high and almost uniform (Iloeje, 1978). Tropical Rainforest characterized by emergent trees with multiple canopies and lianas. However, widespread and persistent practice of rotational bush farmings, coupled with the widespread cultivation of cash crops such as cocoa, Kolanuts, plantains around Okinni, Ifon, Erin-Osun, Ilobu, Oba-Oke and Eko-Ende has led to the destruction of the original vegetation. It was also noticed during the filed survey that the fallows vegetation were dominated by the Siam weed, *Chromolaena Odorata*, a rank growth of which protect the ground from di-

Table 1. Surface area (m^2) of the study reservoirs.

Dam	Areal Extent (m^2)		% of reduction in the surface area
	1986	2002	
Ede-Erinle	788694.80	493035.80	37.49
Eko-Ende	629493.80	343581.80	45.42

Table 2. Area extent of other land use types around the study reservoirs

Dam	Land Use Type	Areal Extent (m^2)		% of change in the land use cover
		1986	2002	
Ede-Erinle	Settlement/built-up	3729852.0	7328931.80	96.49
	farmland/vegetation	5927800.50	111278.30	98.12
Eko-Ende	Settlement/built-up	300865.50	958455.0	218.66
	Farmland/vegetation	1227798.0	63355.50	94.47

rect raindrop impact, thus reducing the rate of erosion by rain splash and detachment. Also, part of the study area specifically around the study reservoirs is increasingly being built-up and this can further contribute to sedimentation of the dams.

STUDY METHOD

The data required for this study was obtained from the Landsat TM and Landsat ETM+ for 1986 and 2002, respectively. The images used for this study were already georeferenced and geocoded. Also, the images used for this study were taken during the dry season precisely in January 1986 and 2002.

The ILWIS (international Institutes for Aerospace Survey and Earth sciences, Netherlands, 1997) 3.3 software was used for the processing of the images. But, however Arc view 3.2 software was used for visualization and production of thematic maps for the study reservoirs.

The processing of the images was done by importing the images from the file folder in the computer hard disc to ILWIS environment. In the ILWIS environment, each of the seven bands in the Landsat – TM and Landsat – ETM+ images (that is, band 1, 2, 3, 4, 5, 6 and 7) were filtered using Linear AVG 3 by 3 filter before color composite of the selected bands 4, 5 and 7 was carried out. Bands 4, 5, and 7 were selected for the classification of land uses around the study reservoirs because features such as water body (reservoir), settlement and vegetation are best displayed in infrared, near infrared and middle infrared band ranges. Thereafter, the Map list of the color composite of the selected bands was created using the filtered bands. This was subsequently followed by the creation of the submap of the study reservoirs area. The submap created for the Ede-Erinle and Eko-Ende Dams was displayed in false color composite (FCC) and image classification and analysis was done using unsupervised classification method. According to Jassen and Cote (2004), an unsupervised classification make use of a clustering algorithm which automatically finds and defines a number of clusters in the feature space. In this study, after the spectral classes (that is, dam/reservoir, settlement/built –up and farmland/vegetation) were defined, the pixels are assigned to the classes based on criteria such as color, form, pattern and association. The land uses such as settlement/built-up and vegetation/farmland are added because they are related to dam (reservoir project). Specifically, dams are created to serve communities (settlements) and also the creation of dam leads to destruction of farmland/vegetation. After the classification was completed, the surface area of study reservoirs and associated land uses was determined using ILWIS 3.3 software. In addition, the fieldwork was undertaken specifically to take the GPS reading of the study dams and settlements where they are located in order to validate their positions on the images using the Global positioning system (GPS) receivers (Germin GPS 12).

The study method is summarized in the flow chart (Figure 2).

RESULTS AND DISCUSSION

The results of the unsupervised classification of the submap of the study reservoirs/dams and other associated land uses are shown in Tables 1 and 2.Table 1 shows the change in the surface ware of the study reservoirs while Table 2 displays the change in the area extent of the other associated land uses such as settlement/built-up and farmland/vegetation around the study dams between 1986 and 2002.

Also, thematic maps that display the change in the land uses around the study dams between 1986 and 2002 are shown in Figures 3 and 4. The change in the size of the study reservoirs is mostly visible by examining the corresponding change in the surface area of the dams between 1986 and 2002 (Figures 2 and 3). As observed in the Figure 2 and 3 during the field survey, the edges of the study reservoirs surface has been colonized by hydrophytes such as *Pistia stratiotes* and *Scirpus cubensis*. The colonization of the edges by weeds is enhanced by the deposited sediments form the interfluvial area around the dams. In addition, during the field survey, footpaths used by local fishermen and farmers that cultivate arable crops such as cassava and maize were notice around the dams. This will further encouraged high rate of runoff loaded with sediment into the study reservoirs.

Furthermore, as evident from Table1, there is a sharp decline in the surface area of the study reservoir from 1986 to 37.49 and 45.42% in 2002 for Ede-Erinle and

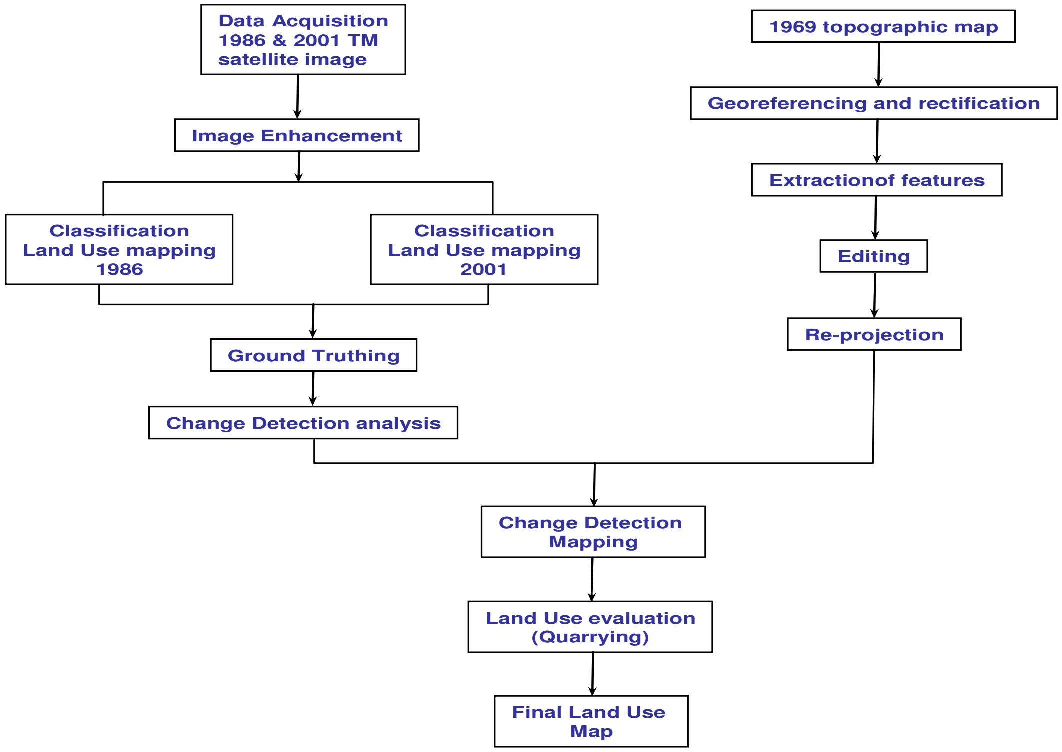

Figure 2. Flow chart showing major steps in the study method.

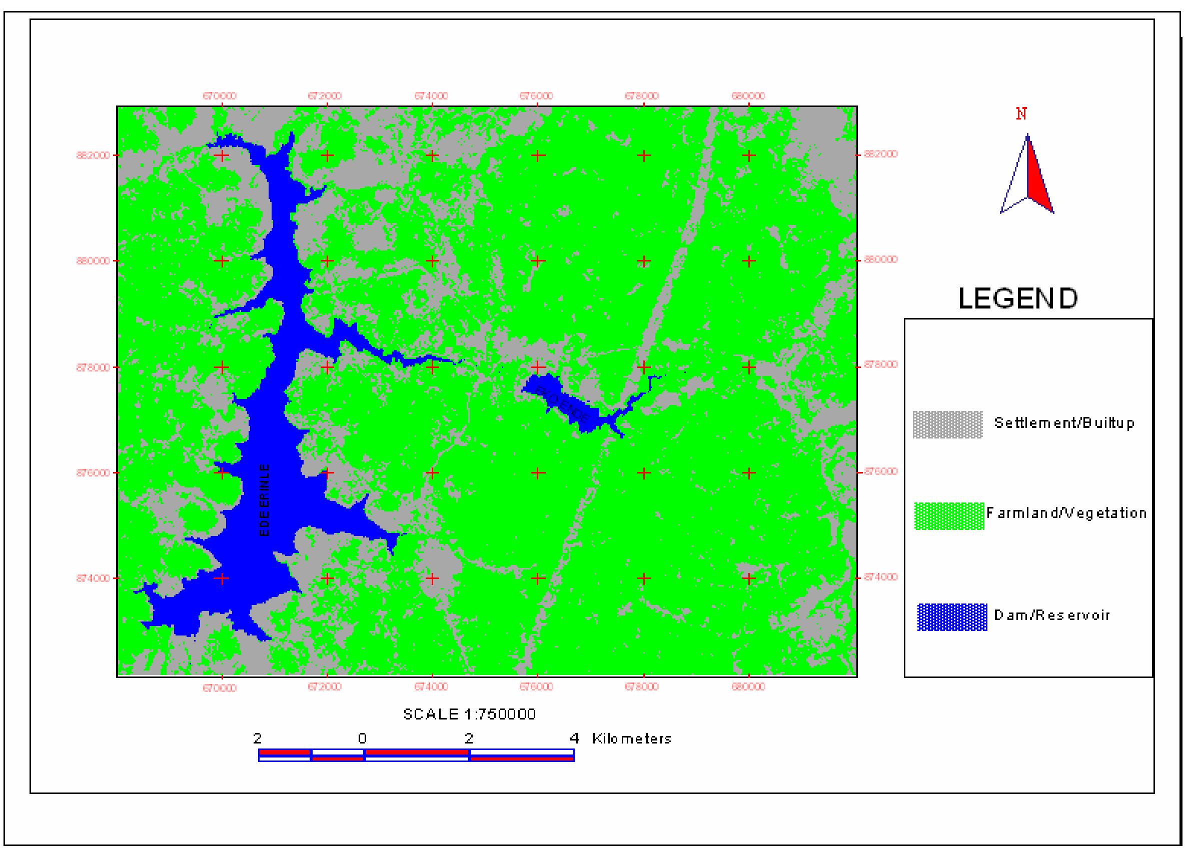

Figure 3. Unsupervised classification around Ede-Erinle and Eko-Ende Dams 1986

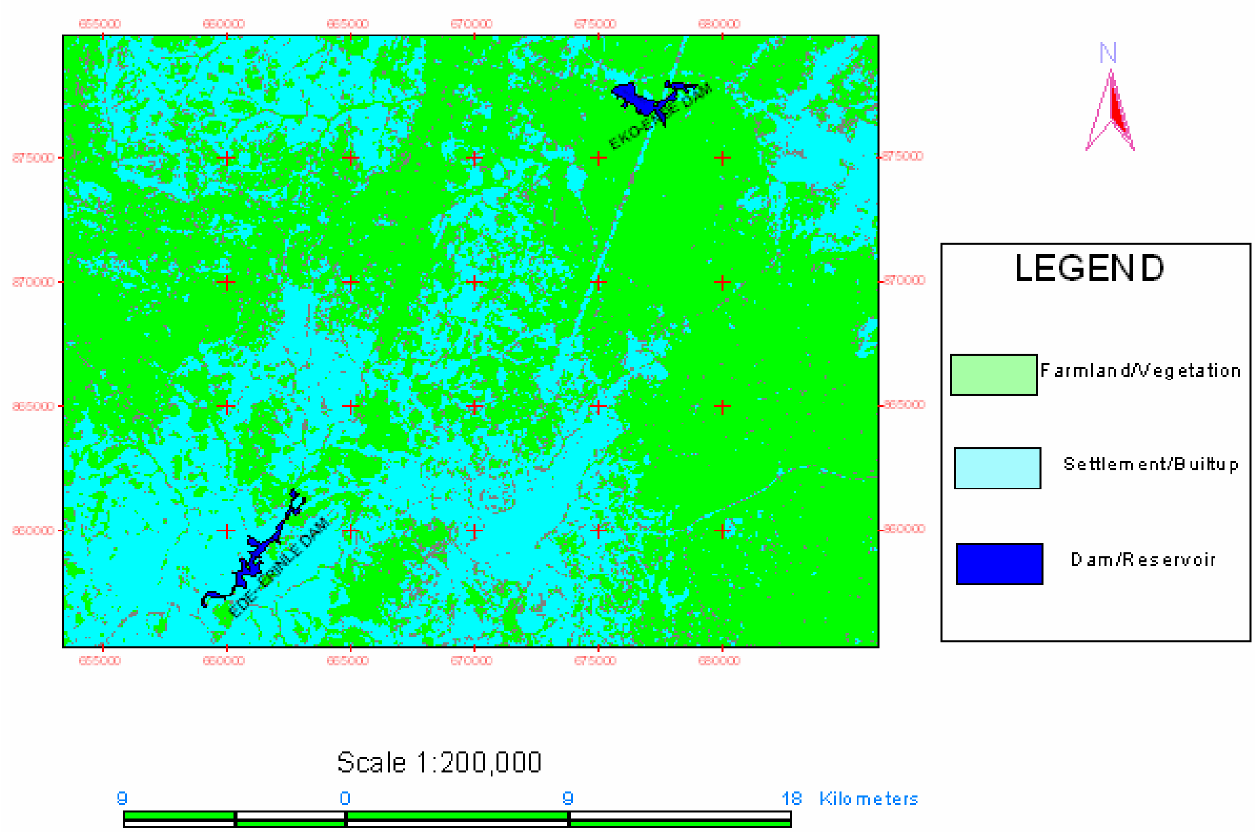

Figure 4. Unsupervised land-use classification around Ede-Erinle and Eko-Ende Dams, 2002.

Eko-Ende,respectively. As shown in the Table 1, the reduction in the surface area may not be unconnected to the increased sedimentation of the reservoirs. In addition, as evident from Table 2, the decline in the surface area of the reservoirs may possibly due to increased exposure of the land surface around the dams resulting from the sharp increase in the size of the settlement/built-up coupled with decline in the area extent covered by vegetation in the area (Table 2). This situation further exposes the area around the dams to direct rain drop impact and thus enhanced accelerated erosion into the study reservoirs. This further confirms the findings of Mironga (2004) that rapid population growth which may accompany the increase in size of settlement/built-up in the reservoir catchments in the tropics has resulted in the intensive use of land for farming, deforestation and growth of urban centres. The growth of hydrophytes around the edges of the study reservoirs as observed during the field survey was also confirmed by findings of Mironga (2004) on assessment of tropical water in the Tigray administrative region of Ethiopia

Conclusion

The assessment of the dynamics of reservoir of major dams (Ede-Erinle and Eko-Ende water schemes) in Osun state, Nigeria was investigated using Landsat-TM of 1986 and Landsat-ETM+ of 2002.

The results of this study showed that the surface area of Ede-Erinle declined form 788 694.80 m^2 in 1986 to 493035.80 m^2 in 2002. Also, the area extent of Eko-Ende Dam declined from629493.80 m^2 in 1986 to 343581.80 m^2 in 2002. In the same vein, the estimated surface area of Ede-Erinle and Eko-Ende Dams declined to 37.49 and 45.42% in 2002, respectively.

In conclusion, to prolonged the lifespan of the study dams, there is need to carry out the dredging of the area around the edges of the reservoirs so as to remove the hydrophytes which have colonized the edges and thus reduced the surface area. This will increase the surface area and subsequently increase the volume of the study reservoirs.

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