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Change detection on the Volta river due to the construction of the Kpong dam using remote sensing techniques

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Abstract: Construction of dams brings about changes and this is the situation on the Volta River with the construction of the Kpong dam. The aim of this study is to detect these changes and the trend of change after some years of construction of the dam. Topographic map of the lake (1974), Landsat Thematic Mapper (TM) image (1990), Landsat Enhanced Thematic image (2000) and Landsat (UTM) image (2010) were used. The images were georeferenced and classified into six (6) classes namely, closed forest vegetation, open forest vegetation, dense shrub, grass/herbaceous cover, built up/bare surfaces and water body for the purpose of our study, using supervised classification. Maps were produced to show the changes in the land cover features. Careful observations of the produced maps showed that the most dominant change happened after the construction of the dam. wherebythe river overflew its boundary submerging some islands and communities along the river.This caused the Islands to reduce from 340.607ha in 1974 to 319.959ha in 1990 whilst the lake increased from 2266.398ha in 1974 to 4007.07ha in 1990. After that the water increase has been gradual and all other changes have been as a result of anthropogenic activities.

Keywords: Volta river, Kpong dam, Supervised classification, Land cover changes, Landsat images

1. Introduction

Construction of hydro electric dam comes as a joy to all Ghanaians since it will increase the power generation capacity and connect rural communities also to the national grid which helps in the development of a nation. Although having far reaching benefits, they also exert a number of adverse impacts as a result of potential negative impacts from the construction of infrastructures (Tortajada, 2001; Ledec and Quintero, 2003) on their immediate environment.
The Kpong dam was constructed to purposely generate electricity for the industrial and domestic uses to supplement that of Akosombo. The completion of the Kpong dam with a capacity of 160MW in 1981 has raised the power generation capacity of the hydro electric power projects on the Volta river to 1,072MW (Amankwaa, 2002).

Even though the main aim for the construction was attained, Girmay (2006) asserts that at the time of the construction Environmental Impact Assessment (EIA) was not a planning and management tool available in Ghana and in view of that, several issues of environmental impacts, have not been considered under mitigation measures as should have been done.
In most instances, changes along water bodies result in environmental, social and economic impacts of greater damage (i.e. flooding) than benefit to the area (Moshen, 1999). Also coastal zones are most vulnerable for land use changes in this rapid industrialization and urbanization epoch. It is necessary to evaluate land use – land cover changes to develop efficient management strategies (Prabaharan et al., 2010). It is therefore important to look at some of effects of the Kpong dam on the Volta river, islands on it and communities along it.

Remote sensing provides synoptic view of the terrestrial landscape and is used for inventorying, monitoring, and change detection analysis of environmental and natural resources (Narumalani et al., 1997). Although remotely sensed images seldom replace the usual sources of information concerning water resources, they can provide valuable supplements to field data by revealing broad scale patterns not recognizable at the surface, recording changes over time, and providing data for inaccessible regions (Campbell, 1996).

Change detection analysis, which is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989), is employed with multi temporal data sets to discriminate areas of land cover change between dates of imaging of the Kpong dam and its environs from 1974 to 1990 and 1990 to 2010.

The main aim of the work is to apply remote sensing techniques to detect the extent of land cover changes that have occurred as a result of the construction of the Kpong dam and the trend of change.

2. Materials and methodology

2.1 Study area

The Kpong dam is located in the Lower ManyaKrobo district in the Eastern region of Ghana. Its coordinates are 6°4'60" N and 0°12'0" E. The administrative capital of the district is Odumase. The district covers an area of

1,476 km^2, constituting about 8.1% of the total land area within the region (18,310 km^2).

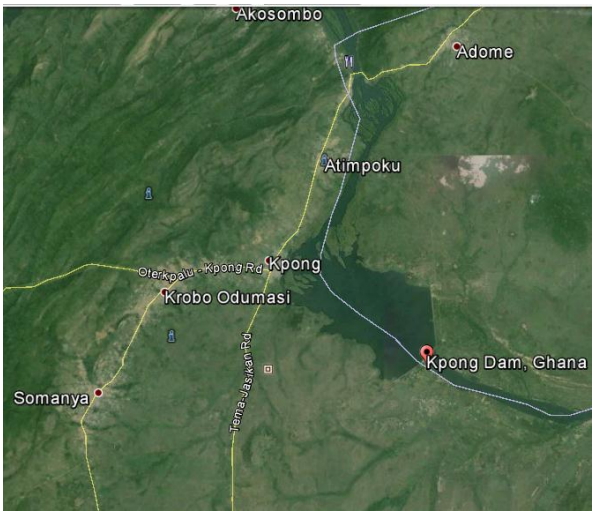

Figure 1: Google earth image showing the study area

The major towns in the district include Odumase township (which incorporates Atua, Agormanya and Nuaso), Akuse and Kpong in the Lower Manya area The district shares boundaries with Upper ManyaKrobo district to the north, to the south with DangmeWest and YiloKrobo respectively, to the west with YiloKrobo municipal and to the east with Asuogyaman district.

2.2 Methodology

Landsat Thematic Mapper (TM) image of 1990, Landsat Enhanced Thematic Mapper (ETM) 2000 and Landsat Thematic Mapper (UTM) 2010 of the study area on the Volta tiver were obtained. These images were dry season images captured in the months of March and April. The images underwent radiometric and geometric corrections.

The topographic map of 1974 and the 1990 image were used to produce another map showing the boundaries of the lake for the two different years. The Landsat images were classified into six (6) different land covers namely closed forest, Open forest, dense shrub, grass, built up/bare lands and water body using maximum likelihood method of supervised classification. Classifications for the various images were guided by observations on the ground, local residents and other techniques such as PCA and NDVI. Statistics were generated for these classes on each image to know the area covered by each land cover. Each classified image was superimposed with the data of the boundary of the river.

3. Results and analysis

A composite map of the river was produced from the map of 1974 and Landsat image of 1990 which showed the difference in size of the river before and after the construction of the dam. From figure 1, two shades of blue are used. A deep blue shows the river as at 1974 before the Kpong dam was constructed and light blue shows the size as at 1990 after the construction of the dam.

Obviously there has been an increase in the river size after the Kpong dam was constructed.

This increase occurs especially at the upstream of the river which caused the displacement of some communities. The Islands decreased from 340.61 ha to 319.96 ha whilst the lake increased from 2266.40 ha to 4007.07 ha. The change can be clearly seen in figure 2. According to the Volta river authority eight villages were fully submerged and these include Vivokope, Fremankope, Lomen, Nobotsukope, Fodzoku, Ageteklekyi, Pokyenu and Gabrunya and the villages that are partly submerged are four namely Glornu, Kasa, Alabonu, Klamadaboe. The classified maps depict the land cover/ use of the area for the three different years at an interval of ten years, i.e. in 1990, 2000 and 2010. Amount of change in area and percentages were generated to quantify the changes.

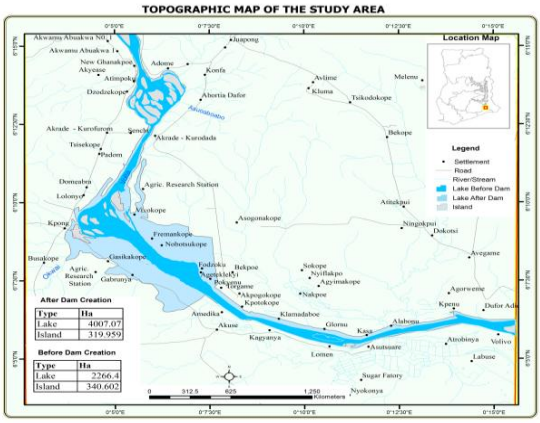

Figure 2: Map showing the boundaries of the river at 1974 and 1990 after construction of the dam

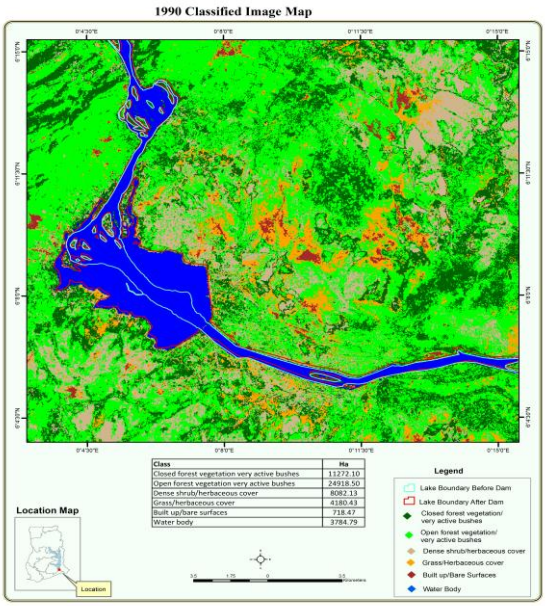

Figure 3: Land cover/use map of 1990

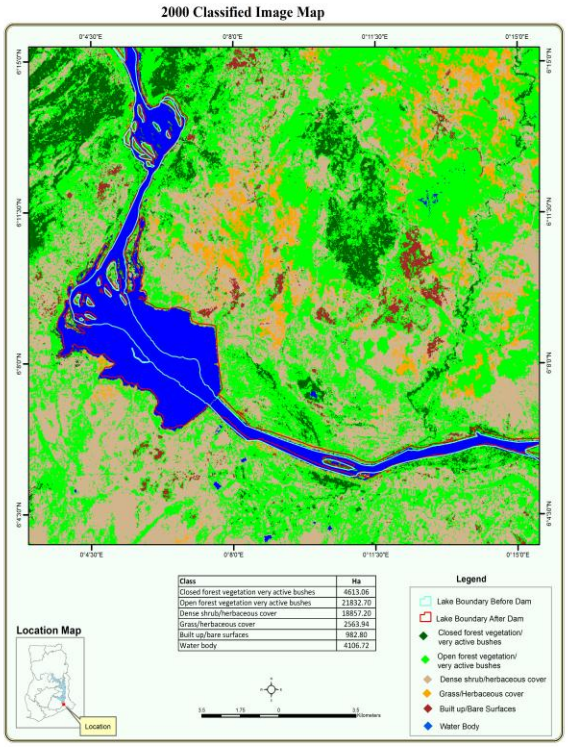

Figure 4: Land cover/use map the year 2000

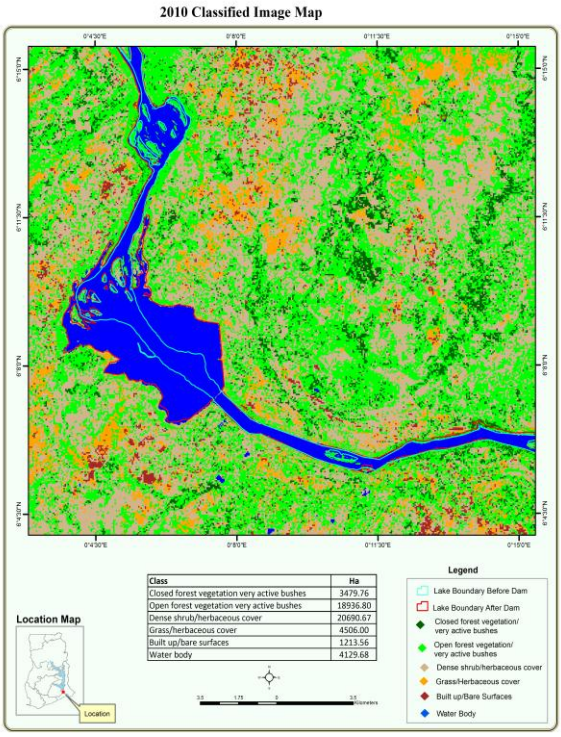

Figure 5: land cover/use for the year 2010

4. Conclusion

All the results of this study have revealed the extent of change in the Lake after the dam construction and changes in land cover from 1990 to 2010. It is obvious from the resultant thematic map that the size of the lake has almost doubled and this happened between the years 1974 and 1990. Land cover has also encountered changes due to anthropogenic activities.

Table 1: Total acreages of the individual islands and average area of the water body before and after the construction

Distribution of Land cover/use classes for the years 1990, 2000 and 2010						
Class	**1990**		**2000**		**2010**	
	Area (Ha)	%	Area (Ha)	%	Area (Ha)	**%**
Closed forest	11049.8	20.9	4613.1	8.71	3479.8	6.57
Open forest	24918.5	47.1	21833	41.2	18937	35.8
Dense shrub/herbaceous	8082.13	15.3	18857	35.6	20691	39.1
Grass/herbaceous	4180.43	7.89	2563.9	4.84	4506	8.51
Built up/bare surfaces	718.47	1.36	982.8	1.86	1213.6	2.29
Water Body	4007.07	7.57	4106.7	7.75	4129.6	7.8
Total	52956.4	100	52956	100	52956	100

Table 2 shows the rate of change of the different classes and this has been interpreted in chart 1. All the land covers that reduced in area have their bars along the negative axis whilst those that gained are on the positive axis. Closed and open forest vegetation always decreased. Changes in the built–up/bare and water body are not that significant even though they have increased along the years. Dense shrub has also increased along the years. Grass/ herbaceous however has no consistent change, from 1990-2000 there was a decrease then from 2000-2010 there was an increase in change. All these changes are due to human activities.

Table 2: Percentage and area rate change of each land cover

Land Cover	**1990-2000**		**2000-2010**	
	Area	%	Area	%
Closed forest	-6436.8	-12.2	-1133.3	-2.1
Open forest	-3.85.8	-5.82	-2895.9	-5.5
Dense Shrub/herbaceous	10775.1	20.35	1833.47	3.46
Grass/herbaceous	-1616.5	-3.05	1942.06	3.67
Built up/bare surfaces	264.33	0.5	230.76	0.43
Water Body	99.65	0.18	22.91	0.05

According to Agbenyo, (2009) hydropower-projects which include the Kpong dam on the Volta river have brought untold hardship onto the lives of the people, influencing human-induced environmental degradation in the area. Activities like farming, firewood and

charcoal burning and out-migration among a number of coping measures have been adopted by people in the area to make livelihood comfortable.

The accuracy of the 1990 and 2000 images were not verified but that of 2010, 100 points were picked with the GPS and used to validate the classification. This gave an overall accuracy of 84% and a Kappa of 80.25%.

Acknowledgement

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