MAPPING LAND USE DYNAMICS AT A REGIONAL SCALE IN SOUTHWESTERN NIGERIA

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ABSTRACT

Studying land use dynamics in Southwestern Nigeria (SWN) is essential for analysing various ecological and developmental consequences of land use change over time. This region is of great environmental and economic importance, its original land cover being the humid tropical rainforest and availability of gold in commercial quantity. In order to serve as repositories of the primary habitats of the forest ecosystems, some portions were designated as forest reserves by the government. With increasing population and heightened economic activities, especially gold mining, available land area in this region is continuously shrinking resulting in forest incursion. This makes land use mapping and change detection an essential input into decision-making for implementing appropriate policy responses relating to land use conflicts in the region. In SWN, land use change detection allows for the identification of major processes of change and, by inference, the characterization of land use dynamics. This paper describes a case of land-use mapping and change detection in the Osun state goldfield of SWN using remote sensing in addition to existing topographic maps and fieldwork. Indicators of environmental degradation were established with a view to promoting development in the region based on the principle of environmental sustainability.

1. INTRODUCTION

Studying land use dynamics is essential in order to analyse various ecological and developmental consequences of land use change over a space of time. This makes land use mapping and change detection relevant inputs into decision-making for implementing appropriate policy responses. Land use change detection allows for the identification of major processes of change and, by inference, the characterization of land use dynamics. With rapid population increase and a finite land area, available land per individual shrinks pitilessly. The result is an urgent need for proper geo-management of land and the concomitant availability of a detailed, accurate and up-to-date geo-information (see Lemmens, 2002).

Increasing population has often been cited as a major land use change agent in the Nigerian tropical rainforest zone, which has subjected the vast expanse of the unprotected landscape to intensive human colonization (see Salami *et al.*, 1999). This fact is very true of this region, but economic activities by peasant farmers, agro-forestry and gold mining (legally and illegally) are also equally important. According to Lambin *et al.* (2001), neither population nor poverty alone constitute the sole and major underlying causes of land-cover change worldwide. Rather, peoples' responses to economic opportunities, as mediated by institutional factors within an interplay of local, national and global forces, drive land cover changes. Land use/land cover data are needed as input into the econometric – based per capita consumption (expenditure) model for poverty estimation. In the small area estimation method for example, a number of geographic variables are included as regressors (geographical-level characteristics) in the consumption model (see Elbers *et al.*, 2002).

Despite the great economic importance of this region to the Nigerian economy, with gold mining dating back to 1942, there have not been systematic studies of land use dynamics neither are official land-use maps available. Adejuwon and Jeje (1973) is an earlier study that mapped vegetation/land use classes from 1:40,000 panchromatic aerial photographs of Ife. Land-use studies using satellite image in this region are recent such as Oyinloye *et al.* (2004), which had the aim of validating data from the newly operational NigeriaSAT-1 satellite of December, 2003 for land use/land cover mapping and change detection in comparison with Landsat-TM data of January 1991. The NigeriaSAT-1 data performed relatively well for land use mapping, but the radiometric qualities of the image need to be improved upon as linear features such as roads and rivers in particular can not be discriminated. Amamoo *et al.* (1998) used satellite image for the same region but their concern was to differentiate between built-up and non built-up land use for population census base map revision. This study seeks to examine the use to which land is being put and to identify driving forces of land use changes in the goldfield of SWN using satellite images covering from the period from 1986 to 2002.

2.0 STUDY AREA

The study area is the goldfield of Osun state in SWN (excluding Ile-Ife), with fieldwork extending from Ilesa town to Oke-Mesi in neighbouring Ondo state (gold is not found in this part of Ondo state, it is included because of proximity and similarity to the study area). The block lies approximately between latitude $7^0 35^1$ N - 8^0 N and longitude $4^0 45^1$ E - 5^0 E (see figure 1). Figure 1 shows the location of the study area, its major towns, the network of roads and the main river channels.

Land use generally in the study area is very much controlled by geology and terrain. Geology is the predominant factor for the location of settlements, with an historic undertone whereby settlements were located on highlands as a security measure against invasion by enemy tribes. It also determines soil type and colour which are of importance in satellite image interpretation in terms of their spectral signatures.

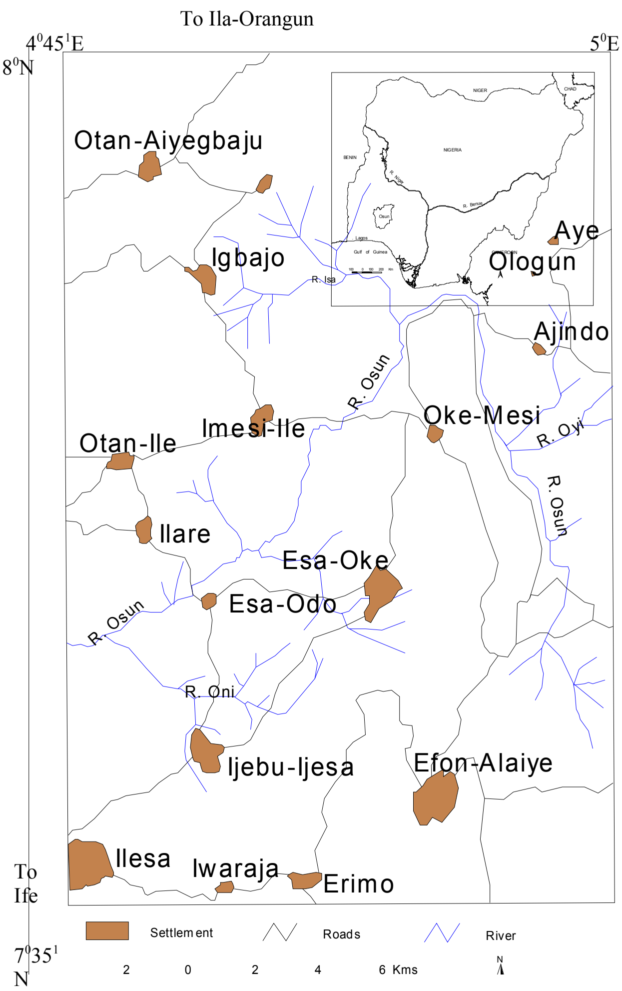

Figure 1: The study area

Rock types are quartzite/schist and undifferentiated basement complex formation and older granite. The Ife-Ilesa schist belts of SWN constitute the main source of both alluvial and primary gold field deposits (Ajayi, 1995).

It is a region with great variations in height. The digital terrain model (DTM) of Ilesa and environ in the Southsouthwest (SSW) section of the study area is shown in figure 2 (digitized with ILWIS 2.2 and made with ArcView 3.2). Figure 2 reveals that the settlements and roads follow the morphology of the terrain.

3.0 METHODOLOGY

To study land use change dynamics at a regional level with a comparable level of confidence, land-use and socio-economic data of the study area were needed. Data collection and ground truthing necessitated visits to some towns which were representative of the heterogenous nature of the region. Towns visited are Ilesa, Ijebu-Ijesa, Imesi-Ile, Otan-Ile, Igbajo, Esa-Odo, Esa-Oke and Oke-mesi (Ekiti state). According to Mertens and Lambin (1999), detailed studies of selected sample areas should lead to the identification of generic trajectories and processes of land use change, which could then be carefully generalized at broader scales. While the selected areas for intensive studies need to be representative of conditions at a broader scale, it is also important that they are chosen where sufficient knowledge on social and ecological processes leading to land use changes exists.

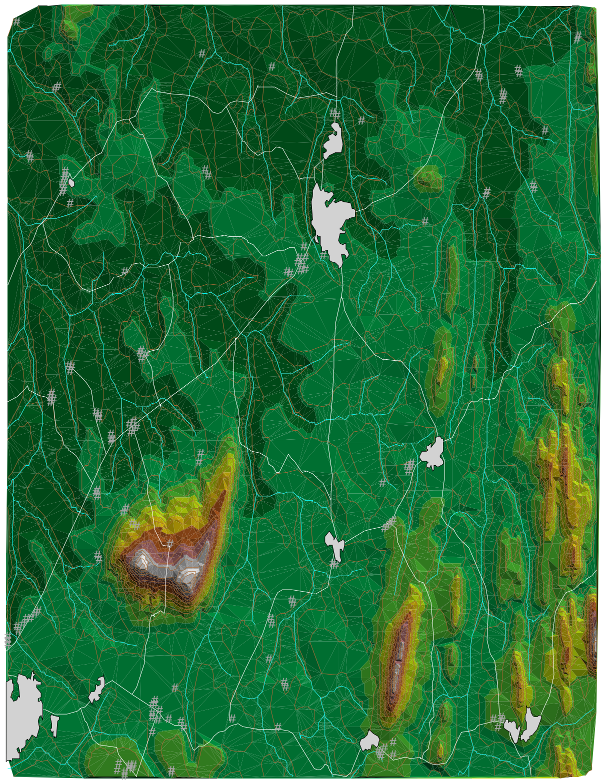

Figure 2: DTM of the SSW section of the study area

3.1 Data Acquisition and Processing

The region is covered by the Ilesha NE sheet of the Nigerian topographic map series at a scale of 1:50,000, which was scanned and digitised on-screen to produce the base data. The map being outdated (published in 1967), necessitated the use of Landsat-TM satellite image acquired on January 5th, 1991 at a scale of 1:50,000 for road network update. For mapping land use/land cover types as well as to analyse land use changes, false colour composite (FCC) images of Landsat-TM (December 17th, 1986; see Figure 3) and Landsat-ETM+ data (January 3rd, 2002; see Figure 4), were made and processed using ERDAS Imagine 8.7 software.

On the images, water appeared dark as it would absorb all the wavelengths, bare soil and bare rock surfaces appeared green, vegetation (forests and cultivated land) showed up in red and settlements and roads showed up in shades of cyan.

It was not possible to differentiate within settlements because the walls of many buildings are built with red-mud bricks. Where cement plaster is used, the corrugated iron sheets get rusted and walls turn red over time as the settlements are located on iron-rich ridges. With the roofs and walls of buildings looking reddish, coupled with the red soil as a result of oxidation, the spectral signatures of these objects will look the same on the satellite image. This was not too much of a problem as a regional scale of analysis is used in this study.

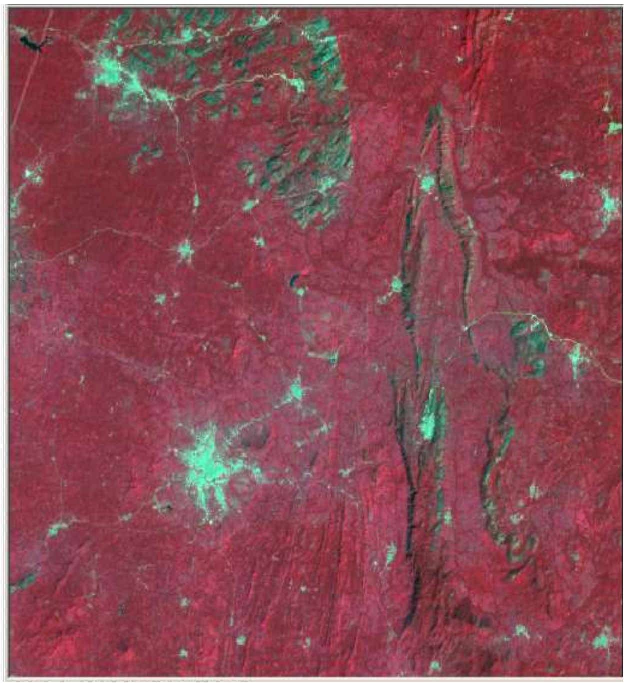

Figure 3: Landsat-TM false colour composite (Dec. 1986)

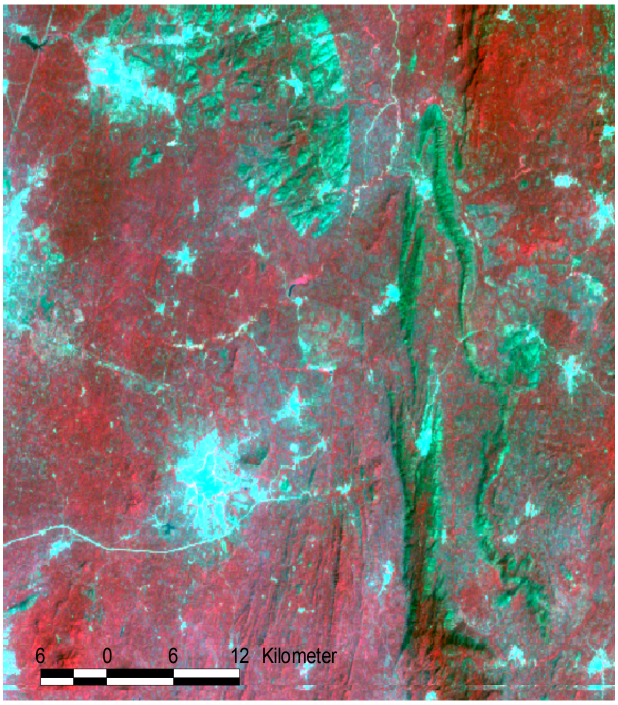

Figure 4: Landsat-ETM false colour composite (Jan. 2002)

Image Classification

On the images, supervised classification was done using the maximum likelihood classifier algorithm (see Figures 5 and 6). Five major land use/land cover classes were identified from the FCC images. Namely: (1) built-up areas/roads, (2) agro-forestry/secondary re-growth, (3) bare rocks and bare soils (4) annual crops/shrub fallows, and (5) water bodies. Figures 5 and 6 show the supervised classification of land use types for 1986 and 2002 (images filtering function was applied). Repeated visits was made to the sites for ground truthing within a five-day period.

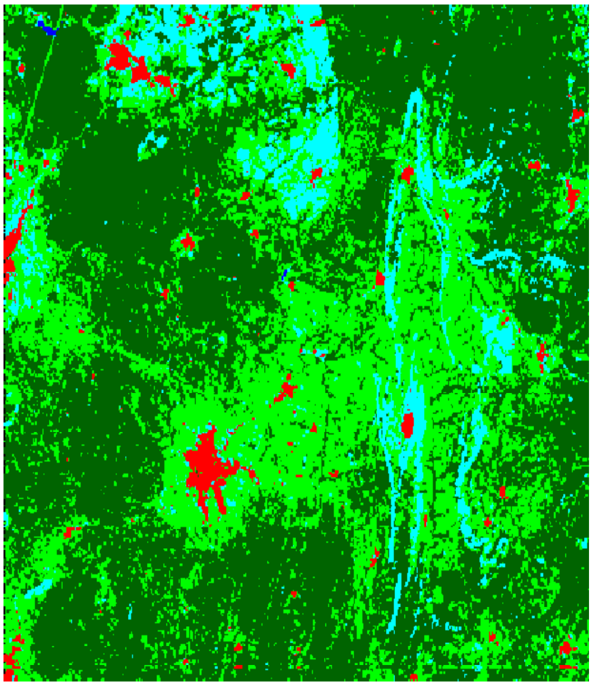

Figure 5: Supervised classification of land use types (Landsat-TM)

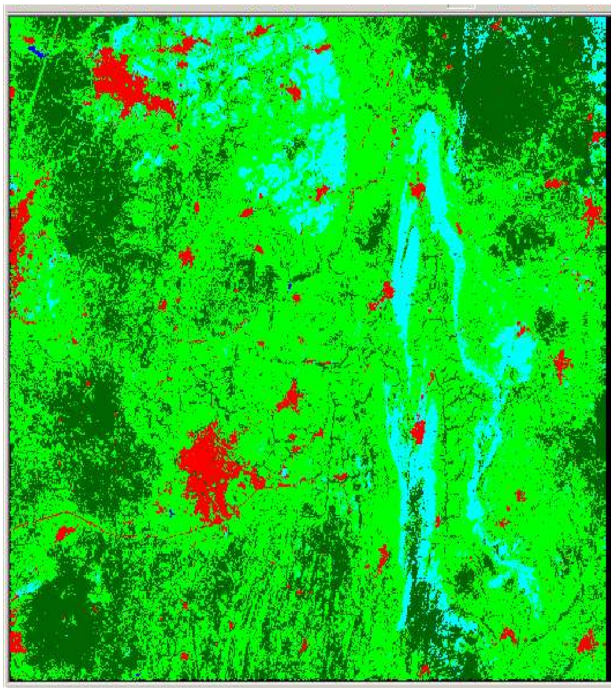

Figure 6: Supervised classification of land use types (Landsat-ETM)

3.3 Land Cover/Land use mapping

The classification scheme used is adopted from Oyinloye *et al.* (2004) in order to aid the comparison of results from the two studies. This scheme is the most recent in use for the area and is comparatively similar to a level one land use/land cover categories of the USGS classification scheme (Anderson *et al.*, 1976). A level 1 classification scheme is best suited for use for mapping land use/land cover at such a regional scale because of the images' resolution.

The classified land use images for 1986 and 2002 were vectorised to show discrete land use types as units on the land use/land cover maps that depict predominant land cover type within relatively homogeneous areas in the study area (see Figures 7 and 8).

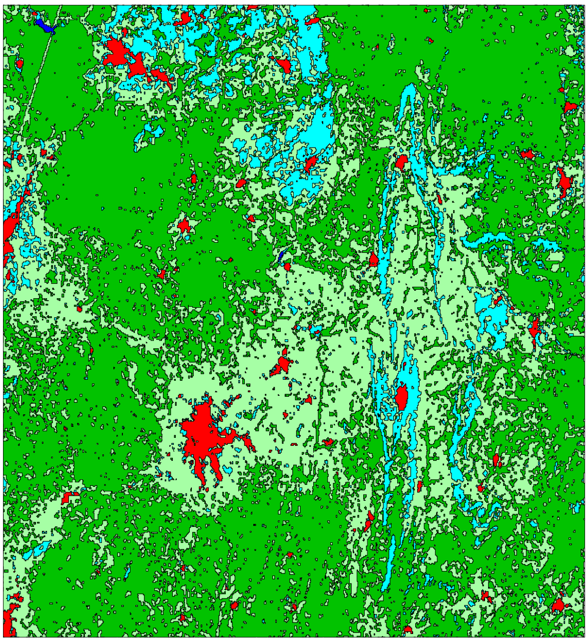

Figure 7: Land use types (1986)

Figures 7 and 8 show the land cover/land use maps.

3.4 Land Use Change Analysis

Changes in the surface area covered by each land use type were calculated between 1986 and 2002 (see table 1). The greatest percentage change for the 17-year period was recorded by the built-up areas/roads class of 88.41% at an average annual rate of 5.2%. Land area under the annual crops/shrubs and fallows increased over the time period by 71.58% (4.21% per annum). Agro-forestry/secondary re-growth class decreased by 49.06%, bare rocks and soils surfaces increased by 6.6 %, while the water bodies class increased by 0.84% (this is probably due to the higher resolution of the Landsat-ETM over the TM, whereby water bodies such as rivers were easily discriminated on the image).

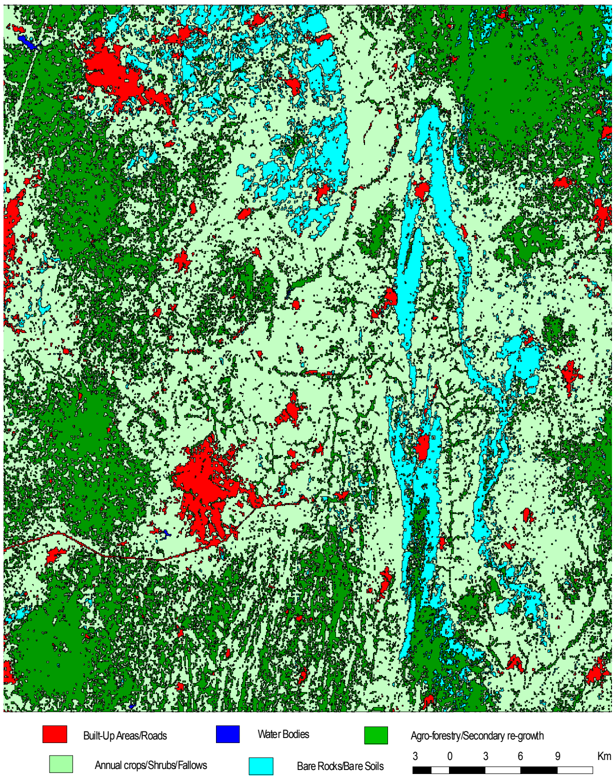

Figure 8: Land use types (2002)

Table 1: Land use surface area and change

Land use	Area (km^2)		Change km^2 (%)
	1986	2002	
bare rocks and bare soils	240530.78	256399.10	15868.32 (6.6)
built-up areas/roads	61293.20	115480.63	54187.43 (88.41)
annual crops/shrubs and fallows	994466.92	1706346.58	711879.66 (71.58)
agro-forestry / secondary re-growth	1680152.06	855888.94	-824263.13 (49.06)
water bodies	1123.34	1162.74	39.40 (0.84)

3.5 Land Use Change Impact

All of man's activities on the land have some environmental effects which may be detrimental to present and future generations. The use of land and how it changes was and is determined by historical and present decisions by individuals, governments and businesses. All these decisions are influenced by economic, social and physical factors (Gierman, 1981).
How is land use related conflict to be resolved? The solution lies in effective environmental monitoring and land management of which land use inventory and change detection mapping is an integral input.

The results, coupled with field observation, show that forest cover is decreasing at an average annual rate of 2.89%. This finding is in line with Oyinloye *et al.*, (2004) and corroborates the United Nations Millennium Development Goal (MDG) progress report (UN 2004). The report shows that forest cover is still on the decline in Sub-Saharan Africa, while forest loss in North Africa is less than 1%. The MDG has as one of its goals to ensure environmental sustainability by reversing the loss of forests in all regions of the world.

The main factor of land use change in the region are settlement expansion, agricultural expansion and gold mining activities. These factors account for the decrease in forest cover over the study period. Other activities leading to forest degradation can be attributed to fuelwood extraction, intensive biomass burning and erosion as a result of the combined effect of steep slope and deforestation. The increase in bare rock and soil surfaces can be better explained by the burning of bushes on slopes which is an annual practice for easy clearing of land for cultivation. The adverse effects of deforestation as regards rapid land degradation and erosion need to be understood by the people in order to curtail bad practices. There is the need therefore to strike an equilibrium in the uses to which the land is put in order to minimize conflict among various uses.

In order to better understand these impacts and how to better mitigate them, land use change in a sample area is treated in greater detail. In Ilesa (the largest town in the study area), demand for land is mainly for industrial, residential and agricultural uses. The pressure on land is evident from land use changes on the slopes of the *Imo* hill to the northeast of Ilesa town. The slopes of the hill which in every season is always under luxuriant forest cover, is gradually giving way to the built-up land use class which is expanding as new residential buildings are being constructed at the hill top, slope and base. In some instances, the hill slope is cut backwards and flattened for erection of buildings. Farming is also being done in the slope direction (see Plate 1).

Plate 1: Cultivation of food crops along slope direction in Ilesa

Consequently, slope stability is affected and aids runoff as loose soil are washed down the slope into the valley bottom. Further impacts observed are changes to the ecosystem of the area as both the width and depth of water channels are getting reduced.

The influence of man on the forest ecosystems has been found to be responsible for the deforestation, declining genetic diversity and massive loss of potentially useful genes being experienced in the areas originally covered by humid tropical rainforest (UNESCO/UNEP/FAO 1978 cited in Salami *et al.*, 1999). For instance, deforestation has been recognized as an important factor in climatic change via its influence on surface albedo and its disruption of regional and global balance of carbon. It has been demonstrated, for example, that increasing carbon dioxide concentrations resulting from forest destruction may lead to temperature rise (Ward and Robinson 1990 cited in Salami *et al.*, 1999).

High-tension electricity cables are also erected on the hill slope with houses built right under them. Inhabitants of such buildings are exposed to unusually high radiation which is detrimental to their health and well-being. This shows a lack of land use zoning system or if it does exist, there is a non-compliance and enforcement of existing laws.

4.0 CONCLUSION

The regional mapping of land cover/land use is necessary as a major first step to understanding and checking land use change in the study area in a bid to mitigate adverse effects. The land use dynamics of the region was studied using time series of remotely sensed data, with settlement expansion emerging as the major force driving land use change. The impact of such changes were examined, the most significant being forest degradation. Agricultural bad practices like cultivation in slope direction and bush burning were also observed during fieldwork for which corrective measures are required to enforce a change in order to minimize impact on the ecosystem.

The findings of this study corroborates the observation of Lambin *et al.*, (2001) that major forces of land use change are related to economic activity. Lo (2000) also rightly pointed out that land cover/land use change is a result of socio-economic change, which in turn affects the physical environment.

Information on land use and changes over time for this region would help the government to resolve land use conflict and curtail the negative impacts of forest cover depletion. Detailed rural and urban land use maps would also be needed for which higher resolution satellite images would be required. Higher utility from land cover/land use data as derived from this study, can be achieved by integrating data on population, such as population density, average level of educational attainment and aggregate per capita income of the various settlements in the study area.

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