Land Use Land Cover (LULC) Change Analysis of the Akuapem-North Municipality, Eastern Region; Ghana

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Abstract: **Land-use changes are a significant determinant of land cover changes; this is on the grounds that it is human specialists; people, families, and private firms that make explicit moves that drive land-use change. An increment in family size, traveler populace, and abatement in the monetary prosperity of the indigenous area compels agricultural expansion. This paper aimed at analysing the Land-use Land-cover change pattern in the Akuapem-North Municipality and provide experimental record of land-cover changes in the municipality thereby broadening the insight of local authorities and land managers to better comprehend and address the complicated land-use system of the area and develop an improved land-use management strategies that could better balance urban expansion and environmental protection. Land cover change was observed through advanced processing and classification dependent on five multi-temporal medium resolution satellite symbolism (Landsat: 1986, 1990, 2002, 2017) into five classes. From this, precisely arranged pixel data were assigned to decide each land cover class size and the quantity of changed pixels into different classes through spatial change detection. It was discovered that land cover from 1986 to 2017 shows rapid changes in the landscape as there is high growth in built-up area. However, farmland and forest cover areas has reduced. Urban built-up area has extended outwards from the central-eastern part to the rest of the areas and has covered most of the northern, western, and southern parts. If the present growth trend continues, most of the vegetated areas will be converted into built-up areas in the near future, which may create ecological imbalance and affect the climate of the municipality.**

Keywords**: GIS, remote sensing, Landuse/landcover, Urban expansion, Change detection**

I. INTRODUCTION

Land-cover basically implies the actual elements of the earth's surface, caught in the distribution of vegetation, water, soil and other actual elements of the land, including those made exclusively by human activities, e.g., settlements (Ramachandra & Kumar, 2004). Subsequently, satisfactory information on ecological diversity and environment administrations can be considered as fundamental.

Land-use changes are a significant determinant of land cover changes; this is on the grounds that it is human specialists; people, families, and private firms that make explicit moves that drive land-use change (Lambin et al., 1999). An increment in family size, traveler populace, and abatement in the monetary prosperity of the indigenous area compels agricultural expansion.

Nonetheless, the choice for development outside of secured regions is becoming unfeasible and would soon not be supportable technique for expanding the production of food (Wood et al., 2004). Normal factors, such as, outrageous climatic conditions and geological processes like seismic tremors and volcanoes are answerable for changes in land cover.

Nonetheless, it is basically the connection of humans with the natural environment to further develop livelihoods, which have changed land use and subsequently land cover. Land cover change has for some time been seen as consistent, yet indeed it has a distinct processes with periods of rapid change. It is often triggered by an event such as, bush fire, logging and settlement expansion, which can initiate a series of changes over a period (Lambin, 2000).

Like all human-Earth cooperation, urban land-cover changes address a reaction to financial, political, demographic, and environmental conditions, to a great extent characterised by a centralization of human populaces (Masek et al. 2000; He et al. 2008). Although urban lands covers a tiny part of the Earth's surface, urban extension is seen to have significantly affected the regular landscape, creating enormous changes in the environment and related biological systems at every geological scale (Lambin and Geist 2001).

As per a United Nations report global urbanization prospects, urban population is projected to rise above 60% by 2030, with 90% of anticipated urbanization occurring in low-income earning countries (United Nations 2004). However a worldwide phenomenon, the spate of urbanization is believed to be somewhat pervasive in most African nations, including Ghana (Braimoh and Vlek 2003), but with poor financial development (World Bank 1995).

However, numerous urban areas in Ghana are confronted with huge overabundances shelter, infrastructure, and services and are confronted with progressively packed transportation networks, insufficient water supply, deteriorating sanitation, and environmental pollution (Konadu-Agyemang 1998;

Gough and Yankson 2000). As at the year 2000, almost 37% of the 18.6 million total population of the nation was assessed to live in urban regions, and this was estimated to double by 2017 (GSS 2002). As indicated by Braimoh and Vlek (2003), the greater part of Ghana's urban populace is found in just four metropolitan regions: Accra, Kumasi, Sekondi-Takoradi, and Tamale. Deforestation as a factor of land cover change has been validated by numerous researchers (Yemefack, 2005; Angelsen, 1991; Sader, 1988).

However, understanding the process of land use and land cover change is significant in foreseeing the degree of future change (Mertens et al., 2000). Change of forest resources into other cover types has been seen as spatially homogenous and a linear process of degradation (Codjoe, 2005; Mertens and Lambin, 2000).

However, different responses to biophysical environments, socioeconomic activities and cultural settings offer a more valid explanation of local land cover change. Additionally, local land cover change patterns attributable to local ecological and human induced drivers is an indispensable requirement for understanding changes at national, regional, and global levels (Pabi et al., 2005).

This paper aims to broaden our insight into urban land-cover changes in Ghana by giving an experimental record of land-cover changes in the Akuapem North municipality in the Eastern Region of Ghana. In anticipation of a rapid extension of the region sooner rather than later, the study was to help local authorities and land managers better comprehend and address the complicated land-use system of the area and develop an improved land-use management strategies that could better balance urban expansion and environmental protection.

This will assist with preventing environmental and financial difficulties regularly connected with spontaneous urban land expansion, before they become overwhelming

II. STUDY AREA

The study area for this study is the Akuapem-North Municipality in the Eastern Region of Ghana. The total population according to the 2010 population census in the municipality was 162,072.

The area is a mountainous area with high vegetation cover and their inhabitants are mostly farmers and traders.

III. MATERIALS AND METHOD

3.1 Available data and software

The research is primarily a historical pattern change analysis that use multi- temporal and multi-sensor satellite imagery. Landsat image for, 1986, 2002, and 2017 with different sensor and pixel resolutions were used. The satellite images selected and used were within the dry season and between December and February. This was because of the difficulty in obtaining cloud-free images in the rainy season in tropical regions.

Table 1: Satellite data and characteristics

satellite/sensor	Data date	Data season
Enhanced Thematic Mapper Plus (ETM1) Landsat-7	January 2017	Dry season
Thematic Mapper (TM) Landsat 4-5	January 2002	Dry season
Thematic Mapper (TM) Landsat 4-5	January 1986	Dry season

Landsat images of the study area were downloaded from the United States Geological Survey (USGS) website (http://earthexplorer.usgs.gov/). The selection had to be made from the available free download satellite images to exclude more than 10% cloud-covered or stripped which made it impossible to use much more recent image scenes. Also, for the same reasons, anniversary date synchronization that could have minimized seasonal effects on spectral properties of the multi-dated images could not be upheld. Three Landsat scenes spanning 16 years were selected for the study, but unfortunately, a period of 15years interval instead of 16years was achieved for the period between 2002 and 2017 due to the unavailability of a clear satellite image. Also, Higher spatially resolved images such as the Syste`me Pour l'Observation de la Terre (SPOT), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), QuickBird, and IKONOS have the potential to improve classification of land-cover attributes (Lillesand et al. 2004) but were not used because of their relatively higher cost.

The following software was used at various stages; ERDAS® IMAGINE 13 for image analysis, Google Earth Explorer Pro for ground-truthing, ArcGIS® 10.1 for G.I.S. analysis and map-making. Charts, graphs and statistical analysis were done using Microsoft® office 2010.

3.2 Image Processing Stages

3.2.1 Image stacking

Reflective bands 2, 3, 4, 5, 6 and 7 of each image scene were stacked and used in an image-to-image geometric projection where all the six reflective bands were combined into a single image using the Layer Stack Tool in ERDAS Imagine Software and then rectified.

3.2.2 Image Pre-processing

Pre-processing operations were carried out to correct for the radiometric distortion of the images because of curvature, earth rotation, and atmospheric and sensor effects. The Haze reduction module in ERDAS Imagine was used to correct haze on only 1986, and 2002 images since portions of these two images had some haze, which could potentially affect the classification. Haze was not corrected on the 2017 image since parts of the image with haze were few and could not affect the classification. Noise reduction module was also processed on all the three images to give a better and enhanced image for classification.

3.2.3 Image subsetting / Extraction of Subset (Study Area)

The images used for the study covered all parts of Ghana. An area of interest (AOI) tool in ERDAS Imagine was used to consider only the study area (Akuapem North Municipal) and subsets for all the three images (1986, 2002 and 2017) at different sessions. This helped extract the Area of Interest (Akuapem North Municipal) from the rest of Ghana outlined map.

3.2.4 Image classification

An unsupervised classification was first done using the Iterative Self-Organising Data Analysis Technique (ISODATA), with a maximum iteration of 10, classified into 50 different classes with a signature for detailed classification of the phenomenon in the study area. The unsupervised classified data was hence grouped into various categories with the help of Google Earth Explorer Pro for ground truthing, where the reflected images were given specific colours.

The unsupervised image was re-classified using the supervised maximum likelihood algorithm. The utility of the algorithm is that it takes the variability of the classes into account by using the covariance matrix. It allows land covers to be specified more explicitly by allocating to each image pixel, on basis of the spectral properties of the image (Mulders et al. 1992; Jensen 1996).

In our case, we considered the maximum likelihood algorithm most suitable for minimization of classification error. Training sets were defined of each land-cover class from which spectral signatures were generated for image classification. The training polygons were digitized on a screen based on terrain knowledge acquired with the help of Google Earth Explorer Pro's assistance. Google Earth Explorer Pro images were backed dated to suit the image being classified. The pixels in the polygons that were selected as representative of each class were plotted in spectral space. Places with similar spectral properties were combined to give one image class with the assistance of a suitable classification scheme. The probabilities of the individual cover classes were adjusted and used to reclassify images until the outputs reflected the expected class frequencies obtained through "ground truthing". The outputs were digital images of which each pixel was assigned to one of the below-defined classes.

Table 2 classification scheme used to assign pixels to land-cover classes.

Land cover	Explanation
Built up Area	Dense built-up areas; usually well laid out, with little or no vegetation and Built-up areas at the periphery of urban core, with or without patchy vegetation; with paved or unpaved roads
Bare land	Areas with no vegetation cover at all and exposed rocks as well as soil surfaces eg. Settlements, Roads, Exposed Rock surfaces
Grassland/Farmlands /Cultivated land	Fallow Vegetation predominantly where the potential natural vegetation is predominantly grasses, grass-like plants, forbs or shrubs and primarily for production of food and fiber and other commercial and horticulture crops.
Forestland	Forest Lands have a tree crown area with density of 10% or more and are stocked with trees capable of producing timber or other wood products

IV. RESULTS AND DISCUSSION

Although ecological ‘‘footprints’’ (Rees 1992; Turner 2001) of land-cover changes are readily appreciated, the linkage between anthropocentric land-cover change and political ecology is not that obvious. However, Bassett (Bassett 2001) has argued that the political economy of globalization and a spate of neoliberal reforms such as land privatization and decentralization filter directly into human activities, consequently exerting significant impacts on land use and so driving coupled land-cover–ecological change. Robbins (Robbins 2004) was more succinct when he noted that not only are ecological processes, including land-cover changes, political, but our very ideas about them are also delimited and directed through socio-political and economic processes. These include the interactive forces of demographic change, technology, level of affluence, human attitudes and values, political economy, and political structure (Turner et al. 1993).

4.1 Forest Vegetation

The general trend in land cover conversion among various classes shows an increased proportion of forest cover between 1986 and 2002 and a decrease in 2017.

From **table 3**, between 1986 and 2002, forest cover increased from 19514.6 hectares to 20651.9 hectares. This represents an increase of 1.9%. The rate of change was 0.08% resulting in an annual rate of change of 0.004%. Table 5 shows that between 1986 and 2002 forest vegetation increased compared to other classes. Forest vegetation between 1986 and 2002 which remained unchanged was 11656 hectares. 1944.72 hectares of forest vegetation turned to bare land. 2876.94 hectares and 3036.96 hectares of forest vegetation also changed to built-up area and Farmland respectively. The increase in forest vegetation from 32.3% to 34.2% could be attributed to the 1988’s three-year afforestation project under the Government of Ghana’s’ Forestry Commission following the rampant 1983 famine and bush fire experience. This project was mainly executed in towns including Akuapem-Mampong, Aburi, Akuapem- Larteh, Mamfe and nearby cities.

Between 2002 and 2017 forest cover decreased from 20651.9 hectares to 18537.4 hectares representing a percentage decrease of 3.5% and a rate of change of 0.10% and hence an annual rate of change of 0.006%. T**able 4** shows that between 2002 and 2017, forest vegetation was slightly lost to other classes. Forest vegetation which was maintained from 2002 to 2017 was 18999.6 hectares. 3748.69 hectares of forest vegetation turned to bare land while 11706.9 hectares and 16576.9 hectares changed to built-up area and Farmland, respectively as shown in **table 5**. The decrease in forest vegetation by 2002 in the Akuapem North Municipal can be attributed to the increase in farming and lumbering activities in the district after the afforestation program in 1988. From

table 5 it is evidence that about 16576.9 hectares of forest vegetation turned to Farmland.

4.2 Farm/Cultivated/Grasslands

Table 4 shows that the size of Farmland from 1986 experienced a tremendous decrease by 2002 with a size decrease of 6216.7, representing 10.3%. This represented a rate of change of -0.32 and an annual rate of change of -0.02. **Table 5** shows that Farmland lost 977.22, 9384.57 and 4363.65 hectares to bare land, built up and forest vegetation respectively. About 4488.93 hectares of farmland land cover went unchanged.

T**able 4** shows that from 2002 to 2017, farmlands increased from 12997.7 to 16076.3 hectares representing an increase of 5.1%. This indicated a rate of change of -0.24 and a yearly change of -0.015. From the analysis (**Table 5**), farmland lost 1848.32 to bare land, 14298.4 to built-up and 7583.45 hectares to forest vegetation respectively. There was a 'no change' of Farmland of 8387.85 hectares.

4.3 Bare Land

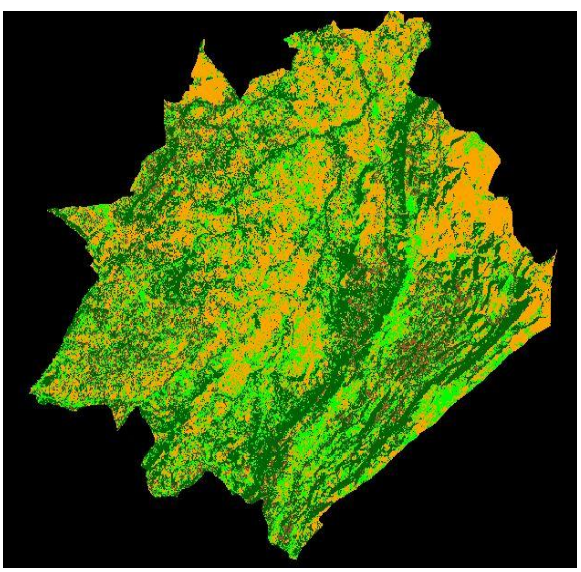
In 1986 the size of bare lands which included exposed rocks and non-vegetated lands was 2607.66 hectares representing 4.3% of the total land area. This increased in 2002 to 3983.85 hectares representing 6.6%, denoting an annual rate of change of 0.33 and a rate of change of 0.53. From **Figure 1** this change was much evidences south eastern belt of the municipality around Aburi and Akuapem-Mampong areas. In 2002 bare land changes by 743.85, 813.78 and 812.7 hectares from bare land to built-up, bare land to Farmland and bare land to forest vegetation respectively. Bare land to bare land indicating a "no change" was 237.33 hectares.

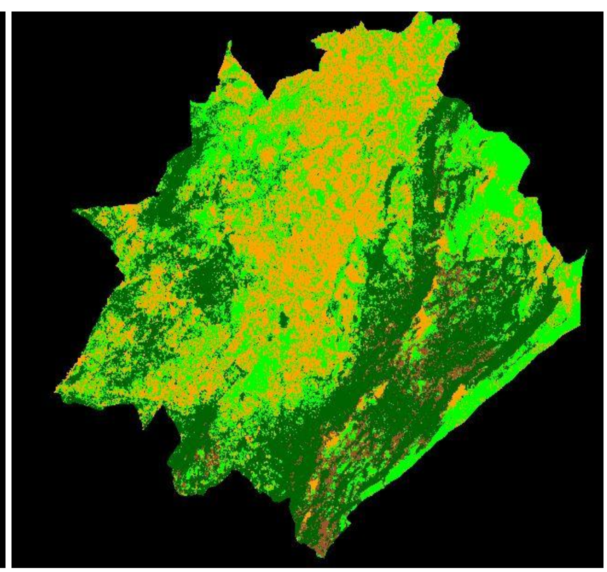
From **table 4**, in 2017 bare land decreased slightly from 6.6% to 6.1%. This represented a decrease from 3983.85 to 3651.93 hectares respectively. The rate of change was 0.08 from 1986 to 2002 and 0.005 annually. Bare land changed to other land cover by 2889.58, 3843.21 and 2452.79 hectares representing changes from bare land to built-up, bare land to Farmland and bare land to forest vegetation respectively. The "no change" pattern form 2002 to 2017 was 658.734 hectares (evidence from **figure 5**).

4.4 Built-Up Area

Table 3, indicates an increase in built up area from 1986 to 2002 by 6.1% from 31.5% to 37.6% representing 19012.2 to 22715.4 hectares respectively. The rate of change was 0.19 with an annual rate of change of 0.012. The built up area increased due to general urbanisation and rural-urban migration. Built-up to bare land, built up to built-up, built up to Farmland and built up to forest vegetation changes represents 824.58, 9710.01, 4783.32 and 3694.32 hectares respectively.

Evidence from **table 4** indicates that built up area decreased slightly from 37.6% in 2002 to 36.6% in 2017 representing an increase from22715.4 to 22083 hectares respectively. This denoted a rate of change and an annual rate of change of 0.03 and 0.002 respectively. The built up to bare land, built up to built-up, built up to Farmland and built up to forest vegetation changes representing 2768.37, 25673.9, 11722 and 15966.6 hectares respectively. This can be seen from **figure 5.**





1986 **2002**

Figure 1: Image classification for 1986

Figure 2: Image classification for 2002

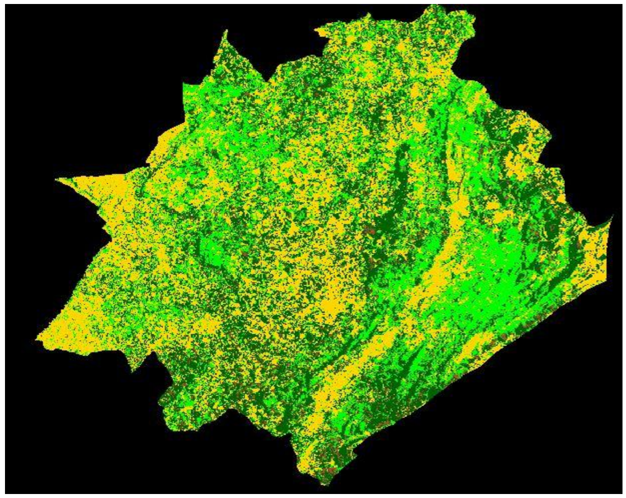


Figure 3: Image classification for 2017

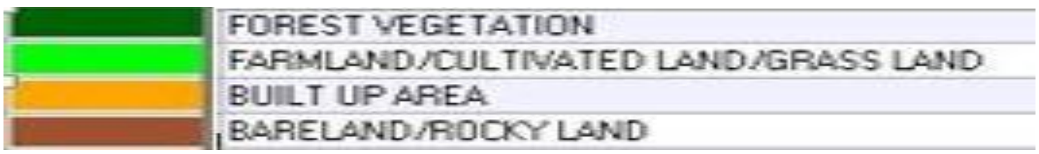


Table 3: Shows the change analysis between 1986 and 2002

CHANGE ANALYSIS							
	1986		2002		CHANGE		
VEGETATION CLASSES	size in acres	%	size in acres	%	Rate of change	size change in acres	Annual rate of change
FOREST VEGETATION	19514.6	32.33631919	20651.9	34.22086751	0.058279617	1137.3	0.003642476
FARM/CULTIVATED/GRASS LANDS	19214.4	31.83887815	12997.7	21.53761008	-0.323543688	-6216.7	-0.020221481
BARE LAND	2607.66	4.320976403	3983.85	6.601368543	0.52774927	1376.19	0.032984329
BUILTUP AREA	19012.2	31.50382625	22715.4	37.64015387	0.194780392	3703.2	0.012173774
TOTAL	60348.86	100	60348.85	100			

Table 4: Shows the change analysis between 2002 and 2017

	2002		2017		CHANGE		
VEGETATION CLASSES	size in acres	%	size in acres	%	Rate of change	size change in acres	Annual rate of change
FOREST VEGETATION	20651.9	34.22086751	18537.4	30.71708267	0.102387376	-2114.5	0.006399211
FARM/CULTIVATED/GRASS LANDS	12997.7	21.53761008	16076.3	26.63895887	-0.2368577	3078.6	-0.014803606
BARE LAND	3983.85	6.601368543	3651.93	6.051368353	0.083316086	-331.92	0.005207255
BUILTUP AREA	22715.4	37.64015387	22083.2	36.59259011	0.027831017	-632.2	0.001739439
TOTAL	60348.85	100	60348.83	100			

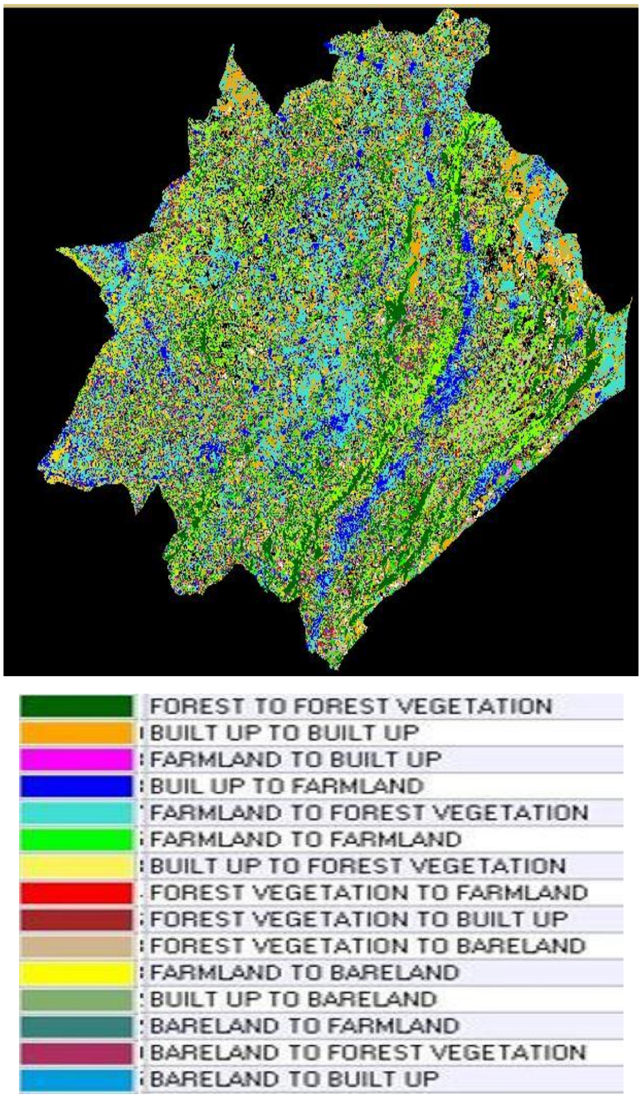


Figure 4: Change Classification for 1986 and 2002

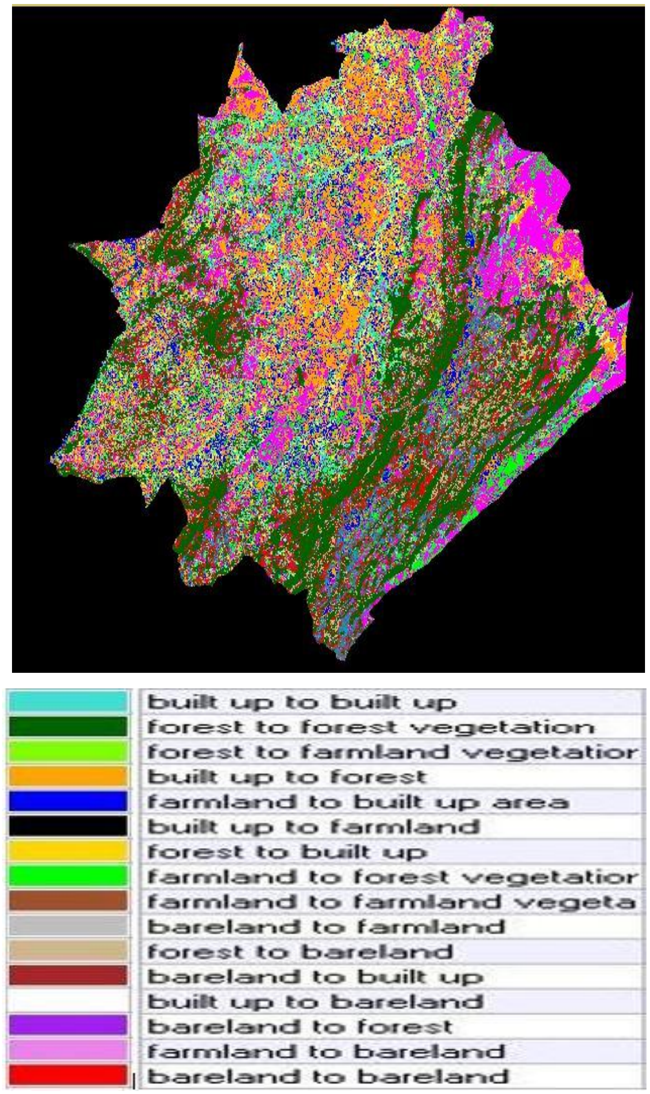


Figure 5: Change Classification for 2002 and 2017

Table 5: Shows the land cover class change between 1986-2002 and 2002-2017

LAND COVER TYPE	1986-2002	2002-2017
BARELAND TO BARELAND	237.33	658.734
BARELAND TO BUILT UP	743.85	2889.58
BARELAND TO FARMLAND	813.78	3843.21
BARELAND TO FOREST VEGETATION	812.7	2452.79
BUILT UP TO BARELAND	824.58	2768.37
BUILT UP TO BUILT UP	9710.01	25673.9
BUILT UP TO FARMLAND	4783.32	11722
BUILT UP TO FOREST VEGETATION	3694.32	15966.6
FARMLAND TO BARELAND	977.22	1848.32
FARMLAND TO BUILT UP	9384.57	14298.4
FARMLAND TO FARMLAND	4363.65	7583.45
FARMLAND TO FOREST VEGETATION	4488.93	8387.85
FOREST TO FOREST VEGETATION	11656	18999.6
FOREST VEGETATION TO BARELAND	1944.72	3748.69
FOREST VEGETATION TO BUILT UP	2876.94	11706.9
FOREST VEGETATION TO FARMLAND	3036.96	16576.9

V. CONCLUSION

Land Use/Land Cover (LULC) change detection has long been regarded as an active research topic, and different techniques have been developed and implemented in recent decades. The availability of more and various types of Remote sensing sensor data and additional ancillary data and a need for more detailed and accurate change detection information provides new challenges for developing suitable change detection techniques for specific purposes.

This study of land cover from 1986 to 2017 shows rapid changes in the landscape as there is high growth in built-up areas. Cultivated or farmland and forest cover area have reduced. Urban built-up area has extended outwards from the central-eastern part to the rest of the region and has covered most of the northern, western, and southern parts. The present growth trend continues, then most of the vegetated areas will be converted into built-up areas in the near future, which may create ecological imbalance and affect the climate of the Akuapem North Municipality.

The nature of the landscape was the difficulties faced in determining LULC using remotely sensed data in the study area. The mountainous and sloping topographic structure of the region, the complex vegetation of the area, and adverse climate conditions are the fundamental reasons for those difficulties. For this reason, it was quite hard to find usable (not cloudy) satellite images. Some other problems had stemmed from using different sensor technologies (spatial resolution and spectral resolution) in comparing Landsat MSS and ETM data and in the determination of land cover. These problems were tried to be eliminated by independently applying supervised classification change detection techniques to both images.

VI. RECOMMENDATIONS

1) A perfect balance between natural cover and built-up area should be maintained by encouraging the town planning in vertical growth instead of horizontal growth.
2) Prepare town planning by keeping in view the untouched natural cover to maintain the ratio.
3) Judicious use of land for construction purposes by planning for multiple purposes, i.e., using underground techniques and flyovers for communication on the same land and encouraging basements for housing schemes to restrict horizontal growth.

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