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Remote Sensing And GIS-Assisted Approach For Land Cover Change Detection With Respect To Elevation: A Case Study In Tarkwa, Western Region Of Ghana

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---***ABSTRACT***---
The study of land use and land cover changes is vital for the management of natural resource. In this paper, land cover change detection analyses were carried out to quantify the spatial distribution of land cover types in Tarkwa with respect to elevation. Multi-Temporal Landsat images of 1991 and 2008 were analyzed and the interpretation of the Landsat images indicated five land cover/land use classes. The results show that dense vegetation, sparse vegetation and shrubs were generally confined to lower elevation between 150 m and 200 m above MSL. Built lands were found on high elevation between 200 m and 300 m whiles most bare lands were found on elevation between 150 m and 200 m. Built and bare lands appears to be increasing steadily by 25% whiles dense vegetation, sparse vegetation and shrubs where found to be decreasing by 17%, 5% and 28% respectively. The results were verified by ground-truth survey at selected points within the study area.
Keywords: *land use/land cover, elevation, remote sensing, Landsat, NDVI, Tarkwa*

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I. INTRODUCTION

The land cover type of every land parcel makes it unique. The distinction between land use and land cover are closely related to the characteristic of the earth surface. Land use deals with the way in which the land and it resources are employed. These may include urban development, agriculture, logging, grazing and mining. On the other hand, land cover depicts the land surface in it physical state. Examples of land cover include road, urban area, forest, cropland and wetland. Originally, the term land cover was used to describe vegetation in terms of forest and grass land but has now been extended to include manmade structures such as pavements and buildings (Meyer, 1995). In history, several changes in land cover / land use have occurred due to the direct and indirect impact of human activities in the environment, with the prior purpose of conserving the essential resources. However, these changes in the earth's surface occur naturally in a gradual manner, but sometimes they occur suddenly due to anthropogenic activities (Coppin et al., 2004). Most often, land cover and land use are interchangeable used. These terms have different meanings depending on the context in which it is being used. Land cover is basically the surface cover on the ground whilst land use defines the purpose the land serves. The parameters usually measured with remote sensing techniques relates to the land cover, from which land use can be incurred (Levin, 1999).

Tarkwa is one of the areas in Ghana which has undergone rapid changes in vegetation pattern as results of surface mining activities and urban settlements. These changes could also be the results of other unanticipated factors which include vegetation redistribution, population growth, climate change, changing hydrologic processes and extensive agriculture activities. Clearing of the vegetation in Tarkwa as a result of mining activities has led to continuous depletion of forest cover, erosion of top soil, destruction of virgin agricultural lands on massive scale as well as the conversion of original lush green landscape into mine spoils. These changes may adversely affect the vegetation and could lead to consequences such as famine, deterioration of the land, environmental damage, deforestation and other undesirable effects (Lunetta, 1999).

With the increasing widespread, combined implementation of remote sensing and GIS technology, more natural resource professionals have been provided with efficient and accurate tools for mapping and maintaining management information on forest and other natural resources in regional areas. GIS technology is expanding, allowing for greater integration of remote sensing with digital cartography, thus proving the means to produce more accurate land use and land cover maps (Bottomley, 1998).

Detailed investigations on LULC changes can be made by combining Remote Sensing, Geographical Information Systems (GIS) and Stochastic Modelling technologies. Remote sensing is an integral tool for land change observations. As a robust tool, it aid in observations across higher levels of Earth's surface than ground-based detections. GIS technology offers a robust environment for storing, analyzing, retrieving and displaying digital datasets relevant for change detections and database development (Demers, 2005). Reliable information on vegetation condition is essential for constant monitoring towards sustainable vegetation management. Vegetation pattern and condition required to be assessed for better management. Therefore, detailed understanding of the patterns and distribution of vegetation growth along with the affecting factors in those catchments are important and have been studied by many researches (Oliver and Webster 1986; Weiser et al. 1986; Stephenson 1990; Turner et al. 1992; Henebry 1993; Endress and Chinea 2001; Bai et al. 2004). The purpose of this research is to spatially quantify land use / land cover changes in Tarkwa with respect to elevation using satellite remote sensing data. In this paper, the spatial distribution of land cover types with respect to their elevation for the period between 1991 and 2008 is reported.

II. MATERIALS AND METHOD

2.1 Study area

Tarkwa is one of the municipal capitals in Ghana where mining activities began. It is located between Latitude 5˚ 17′ N and 5˚22′ N and Longitudes 1˚ 57′ W and 2˚ 03′ W. The area lies within forest-disserted plateau consisting of Birimian and Tarkwaian geological formations. The land surface is quite undulating with elevation ranging between 150 and 300 meters above mean sea level. Bonsa river and other stream such as Buri, Anoni, Sumin, and Ayiasu drains the area making the landscape depict dendritic pattern (Anon, 2018).

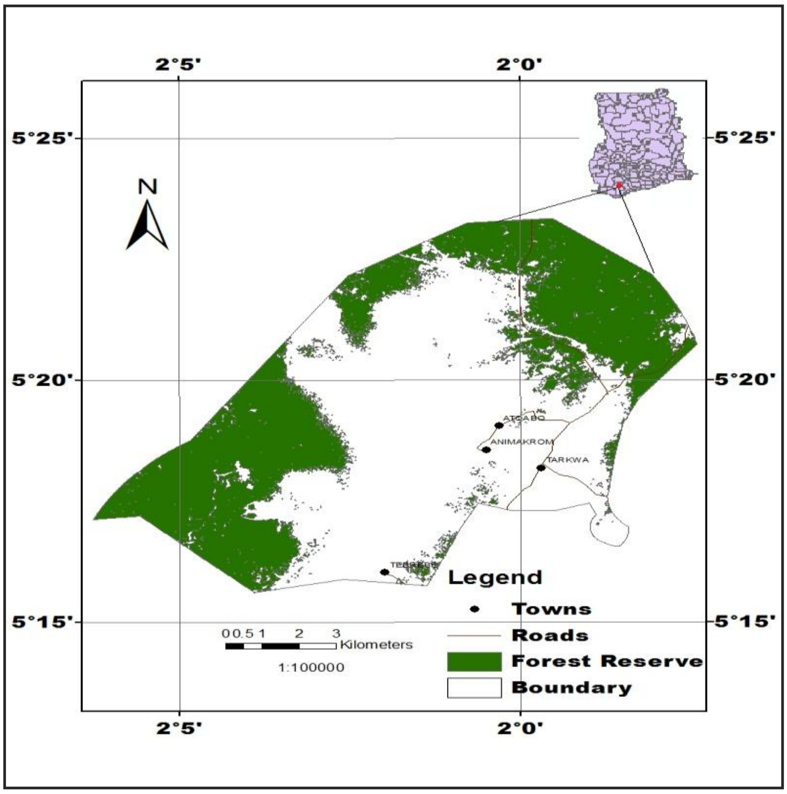

Figure 1: Map of Study Area

Tarkwa township lies generally within mountainous range area covered by thick forest. In some parts, undulating valley are found between the ranges. Most of the surrounding settlements sit on two lateral ranges of hill which is known to be the limbs of gold mountain. These mountain ranges consist of evergreen forest rich in biodiversity before mining began and with settlements in between them. These ridges are unfortunately, the main areas where gold deposits are found and they are the mineralization zones for open pit mines (Akabzaa and Darimani, 2001)

The area is dominated by tropical rainforests and shrubs trees height ranging between 14m to 40m. The trees which can be found within the rain forest belt include odum, wawa, sapele, mahogany among others.

Forest reserves such as Ekumfi reserve, Neung North reserve, Neung South reserve, Bonsa Reserve can be found within the area(Anon, 2018). Human activities such as illegal small scale mining (Galamsey), open cast mining, farming, indiscriminate lumbering are impacting negatively on these natural vegetation (Kumi-Boateng et al., 2011).

Tarkwa lies within the South – Western Equatorial Zone. Relative humidity generally ranges between 70 – 80 percent in the dry season and 75 – 80 percent in the wet season throughout the year . Annually, the mean rainfall within the area peaked at 1878.3 mm with a fairly uniform temperature ranging between 26 ˚C in August and 30˚ C in March. Torrential rainfall with bright sunshine and high humility are usually experienced throughout the year. Also, the average sunshine duration is 7 hours per day (Dickson and Benneh, 1995).

2.2 Data Acquisition

The data used for this project include: 1991 and 2008 Landsat images, Digital Elevation Model (DEM) of Tarkwa Nsuaem, shape files of Ghana and topographic map of Wassa West district. The Landsat images were downloaded via Unite State Geological Survey (USGS) Earth Resources Observation Systems data centre with Table 1 showing the characteristics of the images. The topographic map of Wassa West district was obtained from Survey and Mapping Division of Ghana Lands Commission whiles shape files of Ghana and DEM of Tarkwa Nsuaem were taken from the GIS and Remote Sensing Lab of the University of Mines and Technology (UMaT).

Table 1: Data Used

Data of Acquisition	Satellite	Spatial Resolution	Satellite Instrument	Number of Bands	Source of Data
1th February, 2008	Landsat 7	30m	ETM	7	U.S Geological Survey
1st January, 1991	Landsat 4	30m	TM	7	U.S Geological Survey

2.2 Pre-processing of satellite images

These involve the operations prerequisite to data analysis and extraction of relevant information. Co-registration and radiometric calibration was performed. Since this study deals with change detection analysis, it is imperative to normalize the multi temporal images in order to make comparison between them. These were carried out in two steps: (1) the calibrated Digital Numbers (DNs) were converted into absolute units of At-sensor spectral radiance and (2) conversion of absolute units of At-sensor spectral radiance to Top-Of Atmosphere (TOA) reflectance. With reference to Chander et al., (2009), equation 1and equation 2 were used.

$$L_\lambda = \left(\frac{LMAX_\lambda - LMIN_\lambda}{Q_{calmax} - Q_{calmin}}\right)(Q_{cal} - Q_{calmin}) + LMIN_\lambda \quad \text{(Equation 1)}$$

Where:
$L\lambda$= Spectral radiance at the sensor's aperture [W/(m2srμm)]
Qcal= Quantized calibrated pixel value [DN]
Qcalmin= Minimum quantized calibrated pixel value corresponding to $LMIN_\lambda$[DN]
Qcalmax= Maximum quantized calibrated pixel value corresponding to $LMAX_\lambda$[DN]
$LMIN_\lambda$= Spectral at-sensor radiance that is scaled to Qcalmin [W/(m^2srμm)]
$LMAX_\lambda$= Spectral at-sensor radiance that is scaled to Qcalmax [W/(m^2srμm)]

$$\rho_\lambda = \frac{\pi \,.\, L_\lambda \,.\, d^2}{ESUN_\lambda \,.\, \cos\theta_s} \qquad \text{(Equation 2)}$$

Where:
ρ_λ= Planetary TOA reflectance [unit less]
π= Mathematical constant equal to ~3.14159 [unit less]
L_λ= Spectral radiance at the sensor's aperture [W/(m^2srμm)]
d= Earth–Sun distance [astronomical units]
$ESUN_\lambda$= Mean exoatmospheric solar irradiance [W/(m^2μm)]
θs= Solar zenith angle [degrees[9]]

2.3 Visual interpretations of land cover changes

The reflectance bands for 1991 and 2008 scene were combined into layer stacks to allow easy analysis and band compositing. The true colour composites for the year 1991 and 2008 provided useful information about the land use and land cover of the study area. Green in Figure 2 indicates vegetation coverage in it true colour composite.

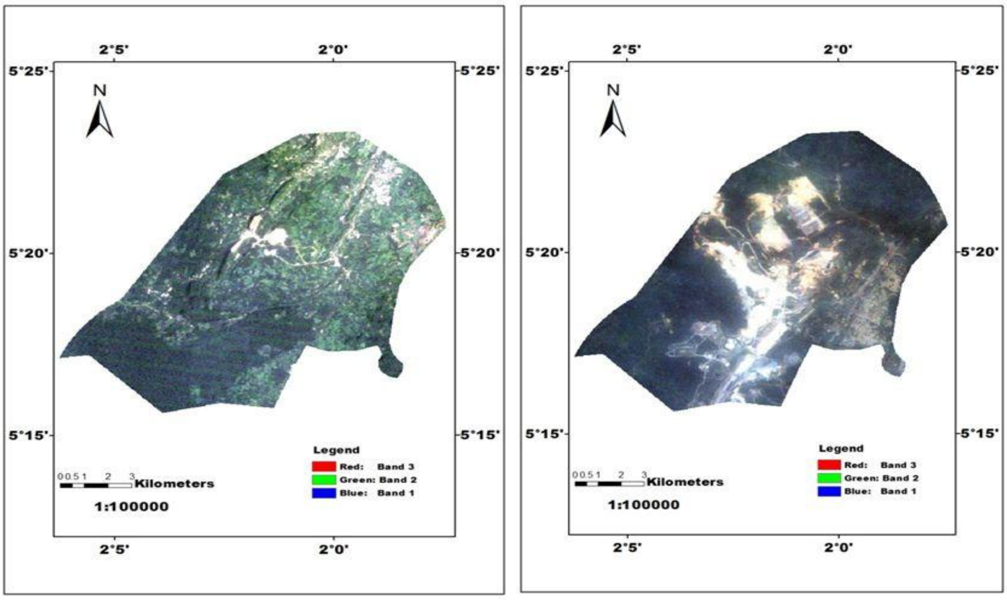

Figure 2: True Colour Composite of 1991 (Left)/ 2008 (Right) Landsat image

2.5 Normalized Difference Vegetation Index (NDVI)

NDVI is one of the indexes which are widely used in vegetative studies. It is an index obtained from reflectance measurement in the infrared and red region of electromagnetic spectrum which is use to quantify green biomass from geographical location to another (Deering, 1978). It is used to measure vegetation growth: higher NDVI values connote more vegetation abundance, Lower NDVI values connote less or non-vegetated area. In this study, equation 3 was used to calculate NDVI for both 1991 and 2008 Landsat images. The results obtained in Figure 3 shows higher NDVI value of 0.606746 in 1991 compared to 0.376882 in 2008. This means the vegetation coverage in 1991 was more as compared to 2008.

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{R})}{(\mathrm{NIR} + \mathrm{R})} \qquad \text{Equation 3}$$

Where:

NIR = spectral reflectance measurements acquired in the near-infrared region

R = spectral reflectance measurements acquired in the red region

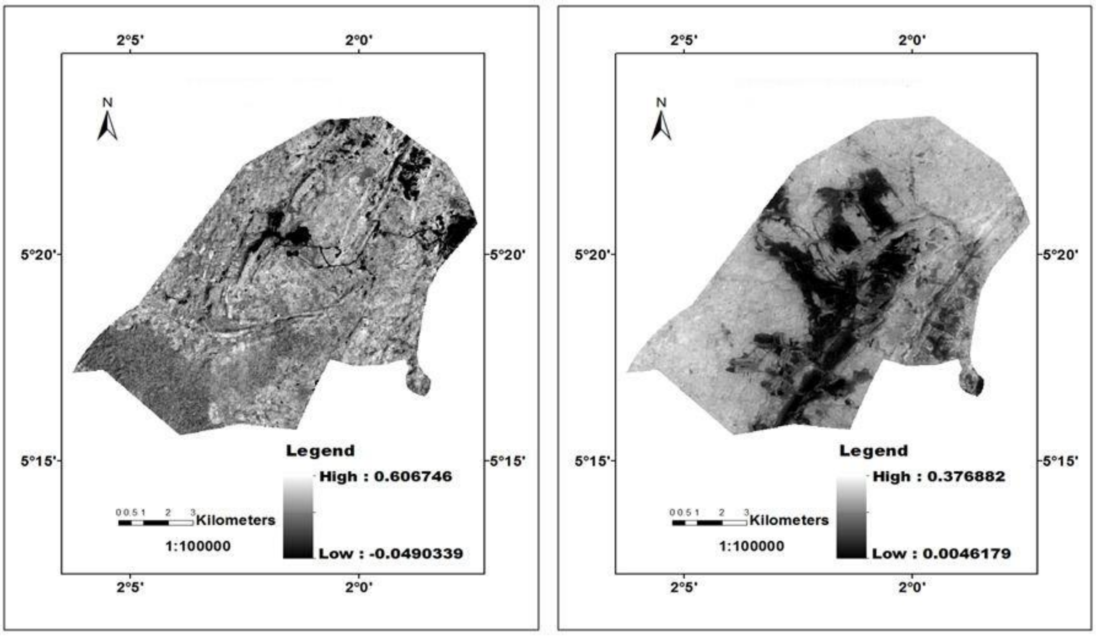

Figure 3: NDVI for 1991 (Left)/ NDVI for 2008 (Right)

2.6 Image Classification

Unsupervised and supervised classifications were carried out to obtain useful information about the study area. During unsupervised classification, pixels in the image are separated into classes by the software without the analyst direction and advance information about the required classes of interest. Data is analyzed and broken into spectral clusters. These cluster needs to be identified as land cover classes based on ground truth information (Eastman, 2001).The land cover maps shown in Figure 4 were produce from supervised classification. During the classification process, training sites depicting various land cover types were identified based on knowledge about the study area, ground truth data and other consultations made from the community people. The land cover types classified include dense vegetation, sparse vegetation, shrubs, built lands and bare lands. The classification was done using Maximum Likelihood algorithm. This algorithm utilizes variance and covariance with the assumption that the reflectance pixel forming the training data are normally distributed (Kumi-Boateng et al., 2011)

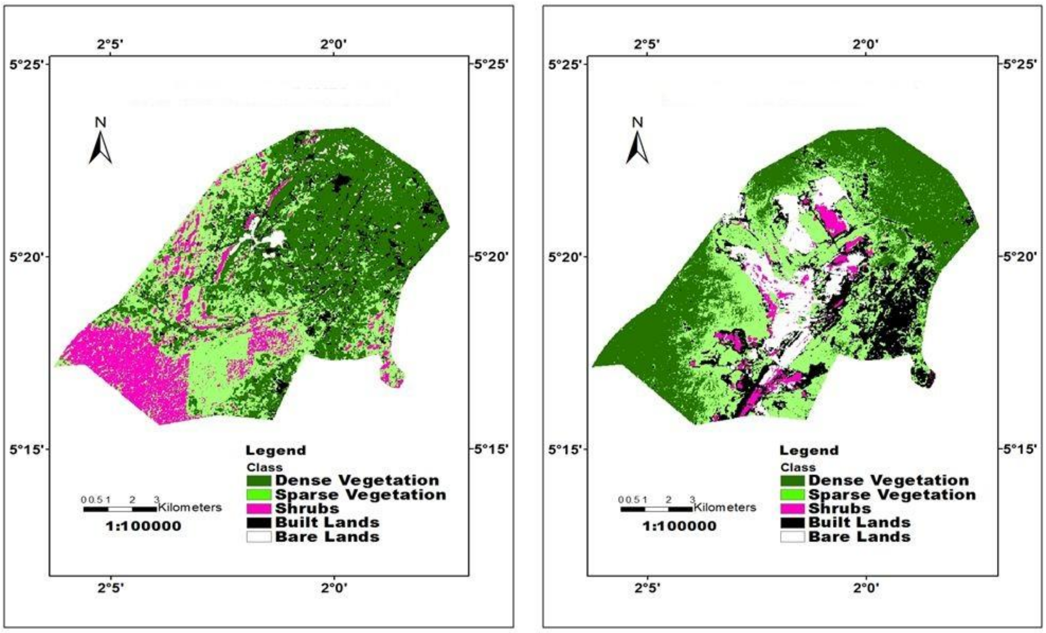

Figure 4: Supervised Classification for 1991 (Left) and 2008 (Right)

2.6 Accuracy Assessment

At the end of every classification process, whether supervised or unsupervised, the accuracy assessment of the produce images cannot be ignored (Eastman, 2001). In this research, sample locations within the study area were visited and ground truth survey conducted. The land cover types identified on the field were compared to the ones mapped in the classified images for the same location. Statistical assessment was carried out to determine the entire accuracies of the classified images. Table 2 shows the overall classification accuracy for 1991 and 2008 respectively.

Table 2: Accuracy Assessment

Data of Acquisition	Classified Image	Overall Classification Accuracy (%)	Overall Kappa Coefficient
1^{st} January, 1991	Landsat 4 TM	76.92	0.6667
1^{th} February, 2008	Landsat 7 ETM	88.89	0.8125

III. RESULTS AND DISCUSSION

3.1 Land use/cover distribution between 1991 and 2008

The classification of the Landsat images produced five land cover/use classes. These include dense vegetation, sparse vegetation, shrubs, built lands and bare Lands. In this study, descriptive statistics obtained from the land use/land cover maps were used for the change detection analysis. Table 3 shows the changes in land cover between 1991 and 2008 with respect to elevation while the pie chart shows the changes in land cover types in terms of percentages. Dense vegetation is generally observed at lower elevation between 150 m and 200 m. The area covered by dense vegetation has decreased by 17% over the period between 1991 and 2008. Sparse vegetation and shrubs were also observed at lower elevation between 150 m and 200 m with drastic vegetation change of 5% and 28% decrement. However, built lands increased tremendously by 25% and were found on high elevation between 200 m and 300 m. Bare lands were generally found on low elevation between 150 m and 200 m. It steadily increased by 25% during the study period. This may be due to surface mining activities being practiced in Tarkwa township.

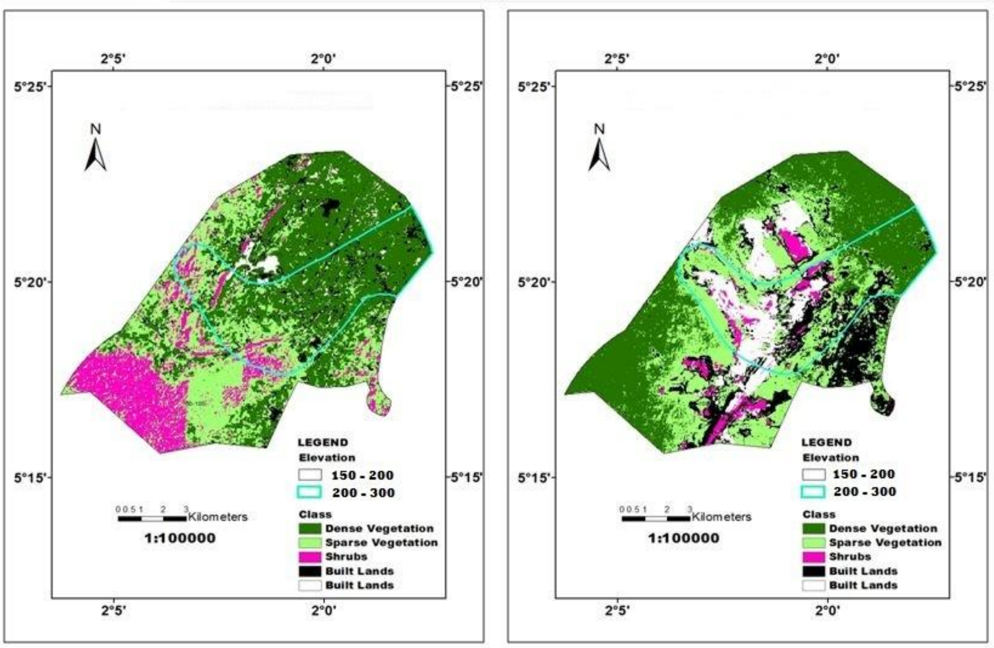

Figure 5: Land cover map for 1991 (Left) and 2008 (Right)

Table 3: Land cover types with respect to elevation for 1991 and 2008

	1991			**2008**			
CLASS	**Elevation(m)**	**Area (km^2)**	**Area (%)**	**Elevation(m)**	**Area (km^2)**	**Area (%)**	**%Change**
Dense Vegetation	150 -200	55.86	42	150 -200	46.42	35	17
Sparse Vegetation	150 -200	44.98	33	150 -200	41.94	31	5
Shrubs	150 -200	20.40	15	150 -200	5.02	4	28
Built Lands	200 -300	9.57	7	200 -300	23.56	18	25
Bare Lands	150 -200	2.38	2	150 -200	16.26	12	25
TOTAL		133.20	100		133.20	100	100.00

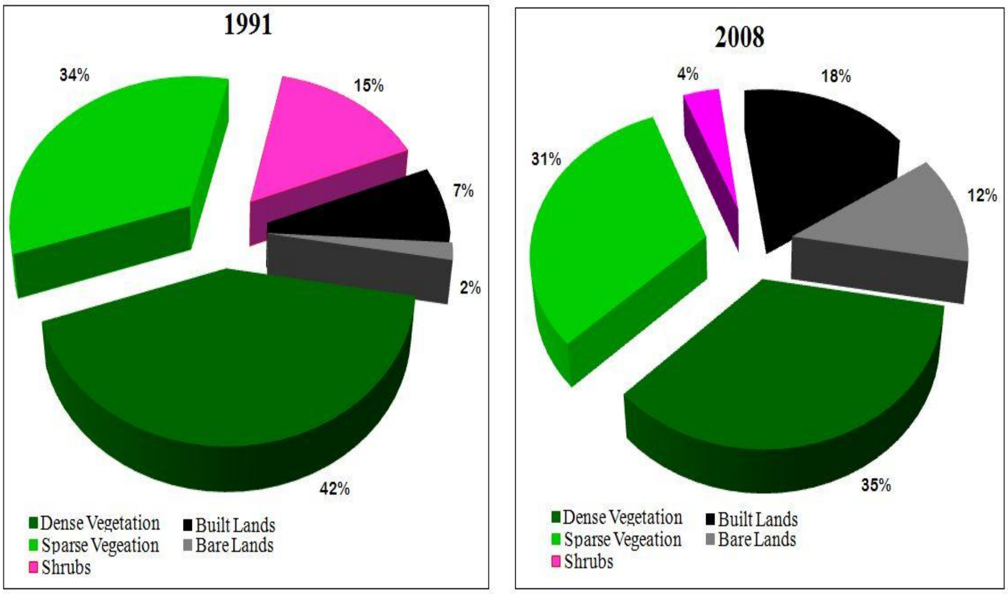

Figure 6: land use in 1991 (Left) and 2008 (Right)

IV. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were drawn from the results obtained in this study. The interpretation of satellite images resulted in five land cover/land use classes and GIS analysis indicates that the dense vegetation, sparse vegetation and shrubs were mainly confined to lower elevation i.e. 150 m and 200 m above MSL. Built lands were found to be associated with elevation between 200 m and 300 m whiles most bare lands were found on elevation between 150 m and 300 m over the period between 1991 and 2008. Built lands and bare lands appears to be increasing steadily by 25% whiles dense vegetation, sparse vegetation and shrubs where found to be decreasing by 17%, 5% and 28% respectively.

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