KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

COLLEGE OF SCIENCE

DEPARTMENT OF THEORETICAL AND APPLIED BIOLOGY

LAND USE AND COVER CHANGES IN THE MAMPONG MUNICIPALITY OF THE ASHANTI REGION

BY:

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BSc. (Hons) Forest Resource Technology

November 2015

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A Thesis submitted to the Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology In partial fulfilment of the requirements for the degree

of

MSc. ENVIRONMENTAL SCIENCE

BY:

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DECLARATION

I hereby declare that this submission is my own work towards the MSc. and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

The land use and cover pattern of a region is an outcome of natural and anthropogenic processes. Land use and land cover change have become a central component of current strategies in managing natural resources and monitoring environmental changes. The present study was carried out with an integrated approach using Remote Sensing and Geographic Information Systems (GIS) techniques together with socio-economic data for land cover change detection. Landsat images of 1991, 2001 and 2009 imagery were used to evaluate land cover to quantify land use changes of the Mampong Municipality by using GIS and remote sensing techniques. The aims of the study were to create a land use land cover classification scheme, determine the trend, rate and magnitude of land use land cover change and to show the extent of forest cover and settlement using image overlays by the process known as image mosaicing, and finally, evaluate the socio-economic factors that drive land use changes. Supervised classification was used to prepare land use maps. Image classification was carried out by emphasizing four main categories. Ground verification was done in January, 2014 followed with questionnaire survey in April. The study revealed that there is a net decrease in forest cover from 1991 to 2009. In between 1991 and 2001, the forest cover rapidly decreased from 44% of the total land mass of the Municipality to 26.7%, and a steady decrease to 24.18% in 2009. Settlement jumped exponentially from 3.1% in 1991 to 23.2% in 2001 and further increased sharply to 37.96%. Farmlands appreciated by 1.5% from the initial 24.4% in 2001 and a drastic decrease to 13.68% in 2009.Grassland was reduced by 4.3% from the initial 28.5% in 2001 and marginally decreased by 0.02% in 2009.The overall accuracy of the map was 80%.Suggestions were made at the end of the work on ways in which land can be used optimally, and going forward there is the need for more precise and spatially congruent data, so that there could be harmony between resources and the local users.

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LIST OF ABBREVIATIONS AND ACRONYMS

ºC	Degree Celsius
DN	Digital Number
et. al	etalii
FAO	Food and Agriculture Organization
FSD	Forest Services Division
GIS	Geographic Information System
GPS	Geographic Positioning System
ha	Hectare
ISCCP	International Satellite Cloud Climatology Project
Km	Kilometre
NDVI	Normalized Difference Vegetation Index
RMSC	Resource and Management Support Centre
RS	Remote Sensing
Km^2	Square Kilometre
UNESCO	United Nations Education Scientific Cultural Organization
U.S.EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
WCRP	World Climate Research Programme

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Lastly, to the entirety of my family and friends for their support and prayers throughout my study. I say *Ayekoo*.

DEDICATION

I gladly dedicate this piece of work to my sweet mother, Mrs Agnes Agyenim – Boateng Fosu. This is the reward for your hard work over the years.

CHAPTER 1

INTRODUCTION

1.1 Background of the study

There are few landscapes remaining on the Earth's surface that have not been significantly altered or are not being altered by humans in some manner (Yang, 2001). Mankind's presence on the Earth and his modification of the landscape has had a profound effect on the natural environment. The influence of anthropogenic activities such as agriculture, mining, deforestation and construction influence on shifting patterns of land use are a primary component of many current environmental concerns as land use and cover change is gaining recognition as a key driver of environmental change. Changes in land use and cover are pervasive, increasingly rapid, and can have adverse impacts and implications at local, regional and global scales (Yang, 2001). Global, continental and regional land cover data are essential to global change research (Loveland *et al.,* 2000). Only satellite sensor data can provide us with a truly synoptic view of the earth that may potentially increase the quality, internal consistency, and reproducibility of global land cover information (Townshend *et al.,* 1991)**.**

1.2 Land use/Land cover

Land use refers to human's activities on land which are directly related to the land (Clawson and Stewart, 1965). Land cover, on the other hand, describes the vegetation and artificial constructions covering the land surface (Burley, 1961). The pace, magnitude and spatial reach of human alteration of the earth's land surface are unprecedented. The Land use and cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by humans in time and space.

Changes in land cover (biophysical attributes of the earth's surface) and land use (human purpose or intent applied to these attributes) are among the most important (Turner *et al.,* 1990). Land use and cover changes are so pervasive that, when aggregated globally, they significantly affect the key aspect of Earth system functioning. They directly impact biotic diversity world-wide (Sala *et al.,* 2000) and contribute to local and regional climate change. Thus, land cover corresponds to the physical condition of the ground surface, e.g. forest, grassland, agricultural land, etc. while land use reflects human activities such as the use of land for different purposes as industrial zones, residential zones and agricultural fields. This definition establishes a direct link between land cover and the action of people in their environment, i.e. land use may lead to land cover change (Phong, 2004). FAO (2001) estimated that the world's forests were converted to other land use/cover rate of 0.38 % (i.e. deforested) annually in the 1990s and more rapidly and diverse in developing tropical countries.

The land use and cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by humans in time and space. Land is becoming scarce resource due to immense agricultural and demographic pressures. Hence information on land use and cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands or basic human needs and welfare. Land cover changes take two forms: conversion from a category of land cover to another and modification of condition within a category (Meyer and Turner, 1992). It is regarded as the single most important variable of global change affecting ecological systems (Vitousek, 1994) with an impact on the environment that is at least as large as that associated with climate change.

According to the Ghana National Land Policy (1999), Ghana's territory of land and inland water areas cover a total of 238,539 km². The nature, scope, and totality of the natural resources inherent in Ghana's territorial domain constitute the nation's socio-economic backbone, the basis of its wealth, the realm of its physical and political strength and the source of its sustainable livelihood and very survival. Ghana like many other countries whose economies depend largely on the utilization of natural resources is not an exception to land use and cover problems. Ghana’s landscape has been categorized into land use classes such as small and large scale farming, forestry, wood fuel, cattle grazing, urbanization, tree plantations of exotic and indigenous species (cocoa, rubber, timber), and game/park reserves in order to provide the mentioned goods and services (Agyarko, 2001). However deforestation stands out as the most prominent change factor within the Ghanaian landscape.

The Structural Adjustment Programme which was prescribed for the country by the World Bank in the 1980’s also encouraged the expansion of timber companies and increased timber exploitation to raise foreign exchange earnings to service Ghana’s debt (Kufuor, 2000) as redeployed civil servants turned themselves into self made loggers with a reduced number of forest guards (Mensah *et al.*, 2002). Hawthorne and Abu-Juam (1995) observed that most forest conversion activities that took place in the past were legal, intentional, and necessary for national development.

In order to match up the challenge, there is the need for information on land use activities and their resulting land cover alterations for effective management. The role of land use and cover change in the future of natural resource distribution can be better appreciated by measuring where and when changes took place, understanding the driving forces and the mechanisms of the changes from fine spatial scales (Lambin and Ehrlich, 1997).

1.3 Statement of the Problem and Justification

According to the National Land Policy (1999), in order to enhance the conservation of environmental quality and preserve options for the present and future generations, there is the urgent need to ensure wise use of land.

The Municipal area is endowed with a beautiful landscape and numerous tourist sites with the most popular sites being the Mampong Scarp, the Kogyae Nature Forest Reserve, the Kyirimfa and Offin Head Water Reserve, and the Ogun and Adom Forest Reserves. Inimical human activities such as bush burning, illegal lumbering, charcoal burning, shifting cultivation and sand winning are gradually depleting these forest resources as well as changing the beautiful landscape of the municipality. The situation seems to be exacerbating due to the fact that there has not been any stringent measures and conscious efforts by both the government and the assembly to curb the situation. (Draft Strategic Environmental Assessment Report, 2010).

However, classification of land cover in the Mampong Municipality is unclear. To-date-changes in land cover in the study area have not been quantified and there is lack of empirical data about the changes in land use patterns. There is the need to generate land use and cover changes in the Mampong Municipality using modern remote sensing and GIS techniques.

1.4 Main Objective

The aim of this study was to produce a land use and cover map of the Mampong Municipality at different epochs in order to detect the changes that have taken place over time.

1.4.1 Specific Objectives

The specific objectives pursued in order to achieve the aim were:

- To create a land use and cover classification scheme.
- To quantify land use changes of the Mampong Municipality by using GIS and remote sensing.
- To show the location of forest cover and settlement using image overlays by the process known as image mosaicing.
- To evaluate the socioeconomic factors that drive land use changes.

1.5 Directional Hypothesis

1.5.1 Null Hypothesis

There is massive change in land use in the Mampong Municipality as changes are very imminent under the study period.

1.5.2 Alternate Hypothesis

The changes in land use are not that massive as changes are not that imminent under the study period.

1.6 Scope of the Study

The study was carried out in the Mampong Municipality using satellite images for the Municipality for the years 1991, 2001 and 2009 to determine the changes that have occurred with respect to land in the Municipality. Transects were followed to verify the situation on the ground concerning land use and cover changes.

1.7 Limitations of the Study

The following limitations were encountered during the study:

- Acquisition of landsat images of equal interval with respect to time (years) was not possible.
- Accessibility to some parts of the Municipality was not possible most especially the north-eastern parts of the Municipality.

1.8 Organization of the chapters

1.8.1 Chapter 1: Introduction

This chapter gives a general overview of the thesis structure along with the background information, statement of the problem, significance of the study, research questions. It also provides the hypothesis used in the study, scope and limitations of the study and the general overview of contents or the thesis structure.

1.8.2 Chapter 2: Literature Review

This chapter consists of a summary of previous studies related to the causes of land use and cover by using GIS and remote sensing, which were reviewed during the entire thesis work.

1.8.3 Chapter 3: Study Area and Methodology

This chapter discusses how the research data was collected. It provides the research design and data used and methodology derived and used for the whole analysis along with the interpretation of the collected data. Thus, detail about the data and methodology used for the corresponding chapters are described in subsequent sections of Chapter 3.

1.8.4 Chapter 4: Result

Results first show the presentation of the map works and subsequently the socio economic survey taken in the study site. The results are presented and interpreted with various maps, tables and graphs in this Chapter.

1.8.5 Chapter 5: Discussion

This explains the trends of the findings of the study. The chapter ends with the discussion of the results that have been obtained from the study with the comparisons with previous studies.

1.8.6 Chapter 6: Conclusions and Recommendations

This Chapter provides conclusion of the thesis work and the recommendations of the work.

CHAPTER TWO

LITERATURE REVIEW

2.1 Definitions and Rationale for Land Use and Cover Change Study

Land cover is defined by the attributes of the earth's land surface captured in the distribution of vegetation, water, desert, ice and the immediate subsurface, including biota, soil, topography, surface and groundwater, and it also includes those structures created solely by human activities such as mine exposures and settlements (Lambin *et al.,* 2003). On the other hand, land use is the intended employment of land management strategy placed on the land cover by human agents, or land managers to exploit the land cover and reflects human activities such as industrial zones, residential zones, agricultural fields, grazing, logging, mining and many others (Zubair, 2006). It is estimated that undisturbed (or wilderness) areas represent 46% of the earth's land surface. Forests covered about 50% of the earth's land area 8000 years ago, as opposed to 30% in recent times. Agriculture has expanded into forests, savannas, and steppes in all parts of the world to meet the demand for food and fibre (Lambin *et al.,* 2003). Based on data from diverse sources, the Global Forest Resources Assessment 2000 estimated that the world's natural forests decreased by 16.1 million hectares per year on average during the 1990s, which is a loss of 4.2% of the natural forest that existed in 1990 (Lambin *et al.,* 2003). Accordingly, land cover classification has recently been a hot research topic for a variety of applications (Liang *et al.,* 2002). A great deal of research has been conducted throughout the world in an attempt to understand major shifts in land use and cover and to relate them to changing environmental conditions. According to Baulies and Szejwach (1998), during the next decades, land-use dynamics will play a major role in driving the changes of the global environment. Hence, global mapping of irrigated and dry land agriculture, semi-natural areas and forest cover, reflecting their dynamics, can contribute to the assessment of the biophysical implications of land use and cover change within the Earth's system. Generally, agriculture is found to be the major driver of land cover change in tropical regions (Lambin, *et al.*, 2001). Understanding the mechanisms leading to land use and cover changes in the past is crucial to understanding the current changes and predicts future ones. These changes occurred at different time periods, paces, and degrees of magnitude and with diverse biophysical implications (Baulies and Szejwach, 1998). Therefore, land use and cover change research needs to deal with the identification, qualitative description and parameterization of factors which drive changes in land use and cover, as well as the integration of their consequences and feedbacks (Baulies and Szejwach, 1998). However, one of the major challenges in land use and cover change analysis is to link behaviour of people to biophysical information in the appropriate spatial and temporal scales (Codjoe, 2007). But, it is argued that land use and cover change trends can be easily assessed and linked to population data, if the unit of analysis is the national, regional, district or municipal level. Land use and cover changes result from various natural and human factors within social, economic and political contexts. Hence, the local human activities expressing the drivers can be determined by measuring the rates and types of changes and analyzing other relevant sources of data like demographic profiles, household characteristics and policies related to land resources administration. To achieve this, it is crucially important to consider multiple sources of information and to acquire temporal, spatial and other non-spatial forms of data. This is due to the fact that land use attributes are complex and the boundaries between different types of data are quite diffuse (Baulies and Szejwach, 1998). Land use and cover change studies have been designed to improve understanding of the human and biophysical forces that shape land use and land cover change. Thus, linking human behaviour and social structures to biophysical attributes of the land is a fundamental aspect of land use and cover change research (Baulies and Szejwach, 1998). Land use and cover plays an important role in global environmental change and sustainability, including response to climate change, effects on ecosystem structure and function, species and genetic diversity, water and energy balance, and agro-ecological potential (Codjoe, 2007).

2.2 Land Cover Change

From FAO (2000), land cover change can be of two types:

• Conversion from one land cover category to another, e.g. from forest to grassland;

• Modifying within one category, for example from dense forest to open forest.

2.3 Causes of Land Cover Change

Land cover change is a natural and/or anthropogenic phenomenon. However, it results more often from human activities than naturally occurring. Studies by Turner (1989) showed that landscapes influenced by natural rather than anthropogenic disturbances may respond differently, with natural disturbances increasing landscape complexity. The natural causes include storms, landslides, and diseases and pests of existing vegetation as well as fire which are the most prominent one in most areas. Land cover change is the response of the increased use of nature to meet the numerous diverse human survival and development needs. Meyer and Turner II (1992) categorized the main cause of land cover change into technology capacity, socioeconomic organization, level of development and culture. In addition, Heilig (1994) mentioned unprecedented increase of population; the growing affluence in Europe, North America, and parts of Asia and Latin America; the worldwide changes in lifestyles, which are partly explained by rising per capita income; and the growing influence of geopolitical, economic, and military structures and strategies as important causes most of which are usually ignored in discussions. The negative contribution of the rapid human population growth to the large pressure on land resources has been noted by most literature on land cover change (Lambin and Ehrlich, 1997).

2.4 Application of Remote Sensing for Land Use and Cover Change

There is significant variation between various sensor instruments' capability and wealth of information captured and also the applicability depends on the objective of the intended study. There is also clear variation in the spatial and spectral properties of satellite images acquired by different versions of a particular sensor instrument. Landsat instruments can be taken as a good example of showing continuous improvement in radiometric and spectral property of images enabling better understanding of land resources.

Since 1972, the Landsat satellites have provided repetitive, synoptic, global coverage of high-resolution multispectral imagery. Their long history and reliability have made them a popular source for documenting changes in land use and cover over time (Turner *et al.*, 2003) and their evolution is further marked by the launch of Landsat 7 by the US government in 1999.

2.4.1 Basics of remote sensing

Spectral resolution is the size and number of wavelengths, intervals, or divisions of the spectrum that a system is able to detect. Fine spectral resolution generally means that it is possible to resolve a large number of similarly sized wavelengths, as well as to detect radiation from a variety of regions of the spectrum (Engineering Manual, 2003). Similar to gray scale, bright regions of colour composite images have high reflectance, and dark areas have low reflectance. However, interpretation may get difficult when we combine different bands of data to produce what is known as false-colour composites (Engineering manual, 2003). But this can be addressed by using field knowledge of the areas and historical information.

The majority of image processing exercises are done based on raw DN values in which actual spectral radiances are not of interest (e.g. when classifying a single satellite image). However, there are problems with this approach as the spectral signature of a habitat is not transferable, if measured in digital numbers. These values are image specific as they are dependent on the viewing geometry of the satellite at the moment the image was taken, like the location of the sun, specific weather conditions, and so on. Accordingly, it is generally far more useful to convert the DN values to a spectral signature with meaningful units as they can be compared from one image to another. This process is called image calibration and is required where the area of study is larger than a single scene or if scenes taken over a period of years are being compared. The relative calibration of satellite imagery will correct for differences in atmospheric path radiance, detector calibration, sun angle, earth-Sun distance, atmospheric attenuation, and phase angle conditions. (U.S. EPA, 1999).

Radiometric control sets representing temporally invariant features are used to derive gains and offsets for a linear transformation (U.S. EPA, 1999). Calibration is band specific and is undertaken on each band of all images with reference to a common radiometric reference, which involves the transformation of digital numbers to physical values of radiance or reflectance. There are numerous approaches to characterizing land cover change. Each one has a set of strengths and weaknesses and as a result no single approach is optimal for all types of landscapes and land cover features (U.S. EPA, 1999). There are two major approaches of classification of remotely sensed images for various applications. In a supervised classification, the software is “trained" to recognize that certain types of pixels represent specific land cover types. Knowledge of the area and information collected during field work are important inputs, which are used by the software to classify the pixels into similar groups based on sample signatures specified.

According to the Modified UNESCO Classifications scheme, there are only about 157 different land cover types and no study site will have all of those different land cover types (GLOBE toolkit, 2003). Hence, it will be necessary to group pixels together into a smaller number of closely related "classes", based on spectral similarity. This is done in a process known as "Classification”. In an unsupervised classification, or "clustering", the desired number of groups, or "clusters", will be inputs to the software (GLOBE toolkit, 2003). The software then groups the pixels according to similar spectral characteristics in order of decreasing brightness. These groupings are not made on the basis of land cover, but on the similarity in spectral characteristics of the pixels. It is also common to come across a third approach known to be hybrid classification that combines both supervised and unsupervised classification techniques.

2.4.2 Approaches in image classification

Remote sensing change detection techniques can be broadly classified as either pre- or post-classification change methods. A pre-classification process refers to operations carried out to bring satellite images to the desirable geometric and spectral standard by correcting errors, and it is performed prior to image classification. Whereas, post-classification methods refers to activities done after classification of images like computation of class statistics, accuracy assessment and map preparation. Pre-classification methods can further be characterized as being spectral or phenology based. Originally, the post-classification approach was considered to be the most reliable approach and was used to evaluate emerging methods (Weismiller, *et al.*, 1977 as cited in U.S. EPA, 1999). Factors that limit the application of post-classification change detection techniques include cost, consistency and error propagation (Singh, 1989 as cited in U.S. EPA, 1999). Numerous pre-classification change detection approaches have been developed and refined to provide optimal performance over the greatest possible range of ecosystem conditions (Lunetta *et al.*, 2006).

The satellite instruments employed some decades ago provided images with coarse resolution. With advancement in remote sensing science, various sensor instruments with improved radiometric, temporal and spatial resolution are being developed. Hence, this allowed the integration of satellite images acquired by various sensor types in order to better understand land resources dynamics. The use of data from different sensors poses a serious challenge to many change analyses, which can be addressed through use of post classification comparisons (U.S. EPA, 1999).

2.4.3 Pre-processing of remote sensing data

The principle in using remote sensing data to monitor change is that changes in land cover must be represented in radiance values and these changes should be large enough with respect to radiance changes caused by other factors (Singh, 1989).

2.4.4 Geometric correction

Raw digital images usually contain both systematic and unsystematic geometric distortions so significant that they cannot be used directly as base map without processing. The sources of these distortions range from variations in the altitude and velocity of the sensor platform to factors such as panoramic distortion, earth curvature, atmospheric refraction, relief displacement, and non-linearity in sweep of a sensor's Instantaneous Field of View (IFOV) (Lillesand and Keifer, 1994). The intent of geometric correction is to compensate for the distortions introduced by these factors so that corrected image will have the highest practical geometric integrity.

Accurate geometric fidelity is particularly important for change detection analysis. The geometric correction is normally implemented as a two-step procedure. First, those distortions that is systematic, or predictable, is corrected using data from platform ephemeris and knowledge of internal sensor distortion. Second, those distortions introduced that are essentially random, or unpredictable, are corrected with acceptable accuracy with a sufficient numbers of well-distributed ground control points (GCPs). Earth scientists follow two common procedures to correct random geometric distortions of the remotely sensed data:

i. Image to map rectification and
ii. Image to image rectification.

2.4.5 Image mosaicing

Image mosaicing overlays of two or more images that have overlapping areas (typically geo-referenced) or to put together a variety of non-overlapping images and/or plots for presentation output (typically pixel-based). Individual bands, entire files, and multi resolution geo-referenced images can be mosaiced. We can use mouse or pixel-pixel or map-based coordinates to place images in mosaics and we can apply a feathering technique to blend image boundaries.

2.5 Elements of aerial photo interpretation

Interpretation of aerial photographs is a difficult task in creating land use map. The interpretation of air photos departs from conventional daily photo interpretation in three important aspects, viz:

(1) The portrayal of features from an overhead, often unfamiliar perspective,

(2) The frequent use of wavelengths outside the visible range of the spectrum, and

(3) The depiction of the earth's surface at unfamiliar scales and resolutions.

A systematic study of aerial photo usually involves several basic characteristics of features shown on the photograph. Though the exact characteristic useful for any specific task depends on the field of application, most applications consider that the basic characteristics are: shape, size, pattern, tone/colour, texture, shadows, site, and association (Lillesand and Kiefer, 1994).

2.6 Change Detection Techniques

Change is usually detected by comparison between two images, or sometimes between an old map and an updated remote sensing image. Change detection mapping and analysis can be facilitated through the interpretation of remotely sensed data. It is necessary for updating land cover maps and the management of natural resources. Many change detection methods have been developed and used for many applications. Some of the change detection methods and their applications are discussed as follows:

2.6.1 Image Differencing

Image differencing is probably the most widely applied change detection algorithm (Singh, 1989). It involves subtracting one date of imagery from a second date that has been precisely registered to the first. According to Coppin and Bauer (1996), image differencing appears to perform generally better than other methods of change detection. In image differencing change detection Zero value pixels represent no change areas in the difference image. If there was a change between the two dates, the pixels had either negative or positive values. However, there are also difficulties to detect changes in brightness values (BV) between two dates due to atmospheric conditions at different dates, sensor differences, etc., even after radiometric normalization and corrections were performed as a pre-processing procedure.

2.6.2 Image Ratioing

Another technique for creating an image where certain land cover classes are more readily discernible is band ratioing. Two co-registered image dates are ratioed pixel by pixel in each band. Depending on the nature of changes between two dates, changed areas will have higher or lower values (Singh, 1989). This method is easy to implement, but also has disadvantages. Jensen (1996) discussed the unavailability of ‘from-to’ change classes, and the requirement to select the place of threshold boundary for change/no-change. Since the same change values (difference between pixels) may belong to different classes or phenomena (e.g., 120-50 =70 and 80-10=70), image differencing may generate misleading data (Singh, 1989). This method is also sensitive to image mis-registration and mixed pixels. Stow (1999) developed a compensation method for mis-registration effects on change detection approaches. The model was tested on multi-temporal Thematic Mapper (TM) images for rapidly urbanizing landscape using the image differencing method. Stow (1999) concluded that the mis-registration compensation model enhances land use and cover changes features at or near pixel scale, and reduces noise caused by mis-registered multi-temporal data. This method has been frequently used in land-use change detection using different satellite data. The following are some examples of them: Quarmby and Cushnie (1989) used image differencing on SPOT (HRV) data to detect changes at the urban fringe in South east England. The study indicated the successful detection of changes from rural to urban development. Howarth and Wickware (1981) reported on the identification of ecological changes by band ratioing of MSS bands 5 and 7.

2.6.3 Change Vector Analysis

This technique is used if one wants to undertake comparisons on multi-dimensional images. With change vector analysis, difference images are created for each of the corresponding bands. These difference images are then squared and added. The magnitude of the change vector is calculated by finding the square root of the sum of the squares. The magnitude of the image has the same unit as the input bands and is the distance between the date 1 and date 2 positions (Eastman, 2003).

2.6.4 Vegetation Index Differencing

In vegetation studies, the ratio between near infrared and red reflectance (known as vegetation indices) is used to enhance the spectral differences between strong reflectance of vegetation in the near-infrared part of spectrum and chlorophyll absorption band (red part) of the spectrum (Singh, 1989). Typical vegetation indices include: Ratio Vegetation Index, Normalized Difference Vegetation Index and Transformed Vegetation Index. Normalised Difference Vegetation Index is an index calculated from the reflectance obtained from Red and near Infrared bands. It is related to the fraction of photo synthetically active radiation. Reflectance in Landsat TM channel 4, the near infrared, is most strongly influenced by biomass, or amount of available chlorophyll-containing plant structures. The NDVI, the normalized difference of the brightness values from the near infrared and visible red bands, has been found to be highly correlated with crown closure, leaf area index, and other vegetation parameters. Based on the reflectance difference that green vegetation displays between the visible region (20%) and the near infrared region (60%) of the electromagnetic spectrum, in channels 2 and 4 of the images of the Landsat satellites, the Normalized Difference Vegetation Index (NDVI) can be obtained. The size of NDVI links to the level of photosynthesis that is going on the vegetation. The Normalized Difference Vegetation Index (NDVI) is obtained from the formulae:

NVDI = Infrared – Red / Infrared + Red (Singh, 1989)

2.7 Digital Image Classification

Digital image classification is the process of assigning pixels to classes (Jensen 1996). Usually, each pixel is treated as an individual unit composed of values in several spectral bands. By comparing pixels to one another and to pixels of known identity, it is possible to group similar pixels into classes that match the information categories of interest to the users. In the conventional procedure of the unsupervised classification, spectral classes of pixels are first identified by cluster analysis. ISODATA (Interactive Self Organizing Data Analysis) is a non-hierarchical clustering algorithm commonly used in remote sensing (Richards, 1993). Once the clusters are obtained, 'rules of correspondence between the spectral and the land use and cover categories are established; these rules are normally known through fieldwork or ancillary information (ground data). The standard procedure of unsupervised classification is based on the assumption that each spectral class corresponds to one and only one land use and cover category and vice versa, but this does not always work because there are different possible patterns of correspondence (Lark, 1995)

2.8 Surface Albedo

Albedo is the fraction of Sun's radiation reflected from a surface. The term has its origin from the Latin word albus, meaning "white". It is quantified as the proportion, or percentage of solar radiation of all wavelengths reflected by a body or surface to the amount incident upon it. An ideal white body has an albedo of 100% and an ideal black body, 0%. Visually we can estimate the albedo of an object's surface from its tone or colour. This method suggests that albedo becomes higher as an object gets lighter in shade. Light toned surfaces like snow do have high albedos. Low albedos are associated with surfaces that appear dark coloured to our eyes. Some dark coloured surfaces include black-top roads, coniferous forest, and dark soil. When Sun angles are high, water tends to absorb more than 95% of the insulation falling on it. At low Sun angles, the surface of water becomes much more reflective. On average the Earth and its atmosphere typically reflect about 4% and 26%, respectively, of the Sun's incoming radiation back to space over the course of one year. As a result, the earth-atmosphere system has a combined albedo of about 30%, a value that is dependent on a number of factors including soil type, vegetation cover, and cloud distribution. The reflectance of locations on the Earth's surface exhibit large geographic variation. Mean annual albedo values differ considerably between the equator and the poles, largely due to the presence of snow and ice-covered surfaces. As the characteristics of a surface change from one season to another, so do its reflectance properties. Global measurements of the Earth's surface albedo can be determined with the aid of sensors aboard orbiting space satellites. NASA's Earth

Radiation Budget Experiment (ERBE) was one of the first attempts of making such measurements. This experiment used a variety of satellite sensors aboard Nimbus-7 and the Earth Radiation Budget Satellite (ERBS) to monitor the Earth's albedo for a period of about four years. The patterns seen here are probably representative for most other years. For both January and July, the lowest surface albedos occur over oceans in a zone that covers more than 100 degrees of latitude. Albedo values of this zone are between 8 and 13%, and the centre of this zone shifts seasonally. In July, the low albedo zone is located approximately at the Tropic of Cancer (23.5°N), while in January it migrates to the Tropic of Capricorn (23.5°S). At the higher latitudes, the albedo of the ocean surface increases significantly because of low Sun angles or the presence of sea ice. In the July image, the region occupied by the Arctic Ocean has an albedo between 45 to 60%. On the Earth's terrestrial surface, vegetated areas have an albedo from 15 to 25%. Non-vegetated regions like the Sahara Desert reflect about 30 to 40% of the Sun's incoming light. Other land surfaces with high albedos are glaciers and seasonal snowfields. The large glaciers covering Greenland and Antarctica reflect as much as 75% of the insulation falling on their surfaces. Comparing the January and July images, we can see that the albedos of areas with latitude greater than 45°N vary annually because of seasonal snowfall. In these areas, summer albedos typically are around 20%, while winter values jump to as high as 70%. (Budikova, 2013)

2.8.1 Terrestrial factors affecting albedo

A variety of factors affect terrestrial albedo including:

(a) soil type;

(b) soil moisture or icing;

(c) vegetation types;

(d) soil and vegetative colour;

(e) micro-topography and

(f) macro-topography. (Budikova, 2013)

2.8.2 Measurement of albedo

Surface reflectance has been derived through the use of satellites and remote sensing technology. The International Satellite Cloud Climatology Project (ISCCP) established as part of the World Climate Research Programme (WCRP) has been collecting surface and atmospheric reflectance data since 1983. A traditional technique for estimating the Earth's albedo is observation of the moon's ash grey light-earthlight reflected from its dark hemisphere (Budikova, 2013).

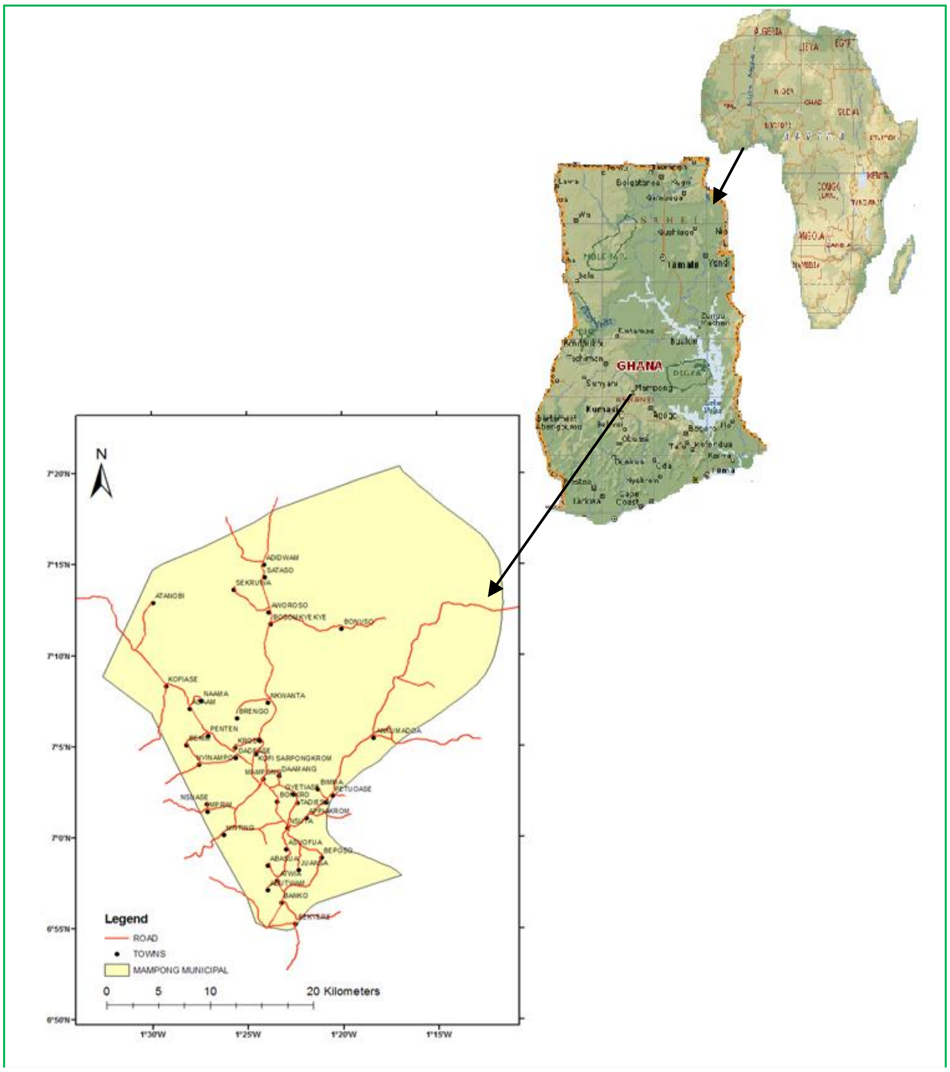
In some instances, land use and cover change may result in environmental, social, and economic impacts of greater damage than benefit to the area (Moshen, 1999). Therefore data on land use change are of great importance to planners in monitoring the consequences of land use change on the area. Such data are of value to resources management and agencies that plan and assess land use patterns and in modelling and predicting future changes as Pandit (2011) studied the forest cover and land use changes in the Laljhadi Forest (Corridor), Far Western Development Region, Nepal which concluded that neither population nor poverty alone constitute the sole and major underlying causes of land cover change worldwide. Rather, people’s responses to economic opportunities, as mediated by institutional factors, drive land-cover changes.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Municipal Profile

Mampong Municipality is one of the six municipal areas in the Ashanti Region. The municipal capital, Mampong is about 57 km from the regional capital Kumasi. The municipal area forms about 2.2% of the total land area of the Ashanti Region. The Mampong Municipality is situated in the transitional zone; between the forest and the savanna region of Ghana (Draft Strategic Environmental Assessment Report, 2010).



Source: RMSC, Kumasi (2013)

Figure 3.1: Vector map of the Asante Mampong Municipality showing roads and towns

3.2 Bio-physical Conditions

The Municipality has an average annual rainfall of 1270 mm and two rainy seasons. The major rainy season starts in March and peaks in May. The Municipality also has an average temperature of about 27^{o}C with variations in mean monthly temperature ranging between 22-30^{o}C throughout the year. The Mampong Municipality lies within the wet semi-equatorial forest zone. A survey and panoramic view of the municipal area shows that the land is fairly low at the south and undulates at the north. The highest point is about 2,400 m whilst the lowest point is about 135 m above mean sea level. The Municipality exhibits five major soil types. They are the Budewa-Sutawa Association, Ejura-Denteso Association, Nyankpala-Kpelesawgu-Volta Association, Denteso-Sene Association and Dukusen-Bramba Association. It is underlain by Pre-Cambrian rocks of the Birimian formation. It rises from about 135 m to the highest point of 2,400 m above sea level and has serious implications for development, as it is known to contain most of the mineral deposits, especially sand and stone deposits (Draft Strategic Environmental Assessment Report, 2010).

3.3 Primary Data Collection

Social data that were directly related to land use, settlement and forest in the Municipality were collected and represented in descriptive form.

3.3.1 Key - informant interview

To decipher more information on land use and cover, informal key - informant interview was conducted using open ended questions. The interview was carried out with the Forest Services Division Office and Land use planning unit of Mampong. The information obtained was very useful in the final discussion of this work.

3.3.2 Other Socio – economic data

Various literatures collected from different sources were used as secondary sources and were analyzed. Secondary data of population and other necessary bio-physical and socio-economic data were used.

3.3.3 Sampling techniques/ Household Questionnaire Survey

The sampling technique used in this research was purposive random sampling in which households were randomly selected. The sample size was three hundred and eighty three (Creative Research Systems, 2012).

Both close and open ended questions were used for this purpose. The purpose of conducting household survey was to collect information on their dependency on land and resources thereof on their day to day lives.

3.4 Secondary Data Acquisition and Source

For the study, Landsat satellite images of Mampong Municipality were acquired for three Epochs, i.e. 1991, 2001 and 2009 (Table 3.2). All the images were obtained from the GIS and Remote Sensing Department of the Resource Management Support Centre of the Forestry Commission in Kumasi.

3.5 Software Used

Basically, three professional software were used for this project viz:

(a) ArcGIS 9.3 – this was used for displaying and subsequent processing and enhancement of the image. It was also used for the display and processing of the data.

(b) Erdas Imagine 2010 - for the processing of the images and the classification of the images.

(c) SPSS version 16 – This was mainly used for the data analysis collected from the questionnaire survey.

3.6 Image Processing

Landsat images of the Mampong Municipality for the years 1991, 2001 and 2009 and a vector map showing the roads and towns were used for the study. Remote sensing software: Erdas Imagine 2010 and ArcGIS versions 9.3 were used for the processing of the images. The raw data satellite image was converted from Tag image file format (Tiff) to img format using Erdas in order to be compactible with other Erdas Imagine files. The layers were stacked and sub-set to delineate the study area for classification. The UTM Zone 30N coordinate on the WGS 84 was used to geocode the imported image. This was followed by geo-referencing using the Traverse Mercator projection with reference units in metres to allow compatible positioning of other themes such as roads and towns which were digitized in that format.

Band combination of red, blue and green was used to display the raw images in standard colour composites. The spectral band combination for displaying images often varies with different applications (Trotter, 1998). This was necessary for the visual interpretation of the images. A band combination of red, blue and green (RGB) is often used to display images in standard colour composites for land use and vegetation mapping (Trotter, 1998).

Finally, maps were composed, using ArcGIS (Version 9.1) programme.

3.7 Accuracy Assessment

After completing the image classification, accuracy of the supervised classification was assessed. For this Confusion matrix was used which is one of the most common means of expressing classification accuracy. Fifty Ground Control Points within the Municipality were selected for the ground truthing.

3.8 Development of a Classification Scheme

Based on a brief reconnaissance survey with additional information from previous research in the study area, a classification scheme was developed for the study area after Anderson *et al.,* (1976). The classification scheme developed gives a rather broad classification where each land use and cover was identified by a single digit.

3.8.1 Description of the main Land Use and Cover classes in the study area

The land cover was categorised into four classes namely; settlement/bare ground, forest, farmland and grassland with the criteria for the groupings elaborated in Table 3.1.

Table 3.1: land use and cover classification scheme

Code	land use and cover	**Description**
1	Settlement/Bare ground	Areas with high intensity of infrastructure and land areas of exposed soil surface resulting from human activities or natural causes. Usually contains sparse vegetation cover and relicts of secondary forest.
2	Forest	Made up of grouped trees, cocoa farms, raffia and palm trees
3	Farm land	Consist of land put under cultivational use such as annual cropping
4	Grassland	Includes all forms of grasses, ranging from creeping species up to tall elephant grass.

3.9 Methods of Data Analysis

Two main methods of data analysis were adopted in this study:

(i) Calculation of the area in hectares of the resulting land use and cover types for each study year.

(ii) Overlay Operations.

Both methods were used for identifying change in the land use types. Therefore, they have been combined in this study. The comparison of the land use and cover statistics assisted in identifying the percentage change and rate of change between 1991 and 2009. In achieving this, the first task was to develop a table showing the area in hectares and the percentage change for each year (1991, 2001 and 2009) measured against each land use and cover type. Percentage change was used to determine the trend of change for each land cover type. In obtaining annual rate of change, the percentage change is divided by 100 and multiplied by the number of study years 1991 – 2001 (10 years), 2001 – 2009 (8 years). In evaluating the socio – economic factors that drive land use changes, the collection of the household data was used as the major tool.

CHAPTER FOUR

RESULTS

4.1 Land Use and Cover Distribution

The static land use and cover distributions for each study year as derived from the maps are presented in Table 4.1. Forest recorded the highest percentage of 44 whilst settlement/bare ground recorded the least in 1991. All classes recorded percentages that are close to each other in percentage in 2001. Settlement recorded the highest and farmlands recorded the least in 2009 as shown in Table 4.1.

Table 4.1 Land use and cover Distribution for 1991, 2001 and 2009

LANDUSE/LAND COVER CATEGORIES	**1991**		**2001**		**2009**	
	AREA (ha)	**AREA (%)**	**AREA (ha)**	**AREA (%)**	**AREA (ha)**	**AREA (%)**
SETTLEMENT/ BARE GROUND	3158.64	3.1	23806.1	23.2	38930.9	37.96
FOREST	45109.6	44	27374	26.7	24798	24.18
FARMLAND	25062.7	24.4	26532	25.9	14040.1	13.68
GRASSLAND	29238.76	28.5	24857.6	24.2	24800.7	24.18
TOTAL	**102569.7**	**100**	**102569.7**	**100**	**102569.7**	**100**

4.2. Land use and cover Change

4.2.1 Land use and cover Change from 1991-2001

The comparison of land cover between 1991 and 2001 showed a drastic increase in the settlement/bare ground with a change of 20.1%. The forest cover, however, decreased by 17.3%. Farmlands appreciated by 1.5% whilst grassland decreased by 4.3% as shown in Table 4.2.

4.2.2 Land use and cover Change from 2001-2009

In Table 4.2, the results show that settlement/bare ground still increased by a percentage of 14.76%, farm land also increased marginally by 0.15%. However, forest and grassland decreased by 1.73% and 0.43% respectively.

4.2.3 Rate of change of land use type from 1991-2001

The settlement/bare ground throughout that decade increased exponentially. There was also an increase in farmlands; however, grasslands and forests recorded decreases in quantity over that decade recording 0.43% and 1.73% in the reverse respectively as shown in Table 4.2.

4.2.4 Rate of change of land use type from 2001-2009

Once again, settlement/bare ground shot up with a rate of 1.476% per annum. However, the other land classes recorded decreases in quantities as shown in Table 4.2

Table 4.2: Land Use and Cover Change: Trend, Rate and Magnitude

LANDUSE/LAND COVER CATEGORIES	1991 – 2001		2001 – 2009		ANNUAL RATE OF CHANGE (%)	
	AREA (ha)	PERCENTAGE CHANGE	AREA (ha)	PERCENTAGE CHANGE	1991 - 2001	2001 – 2009
SETTLEMENT/ BARE GROUND	20647.46	20.1	15124.8	14.76	2.01	1.845
FOREST	- 17735.6	-17.3	- 2576	- 2.52	- 1.73	- 0.315
FARM LAND	1469.3	1.5	- 12491.9	- 12.22	0.15	- 1.528
GRASS LAND	- 4381.16	- 4.3	- 56.9	- 0.02	- 0.43	- 0.003

**Negative sign represents a decrement.*

4.3 Description of Landsat Images

4.3.1 Landsat Image of 1991

Settlement/bare ground in 1991 occupied the least class. Also, farming seems to be practised moderately, occupying 24.4% of the total classes. The south-western part of the municipality was mostly covered with forest. However, the north-eastern part was made up basically of farmlands and grassland. The forest recorded the highest composition occupying 44% of the total land size of the municipality as seen in figure 4.1.

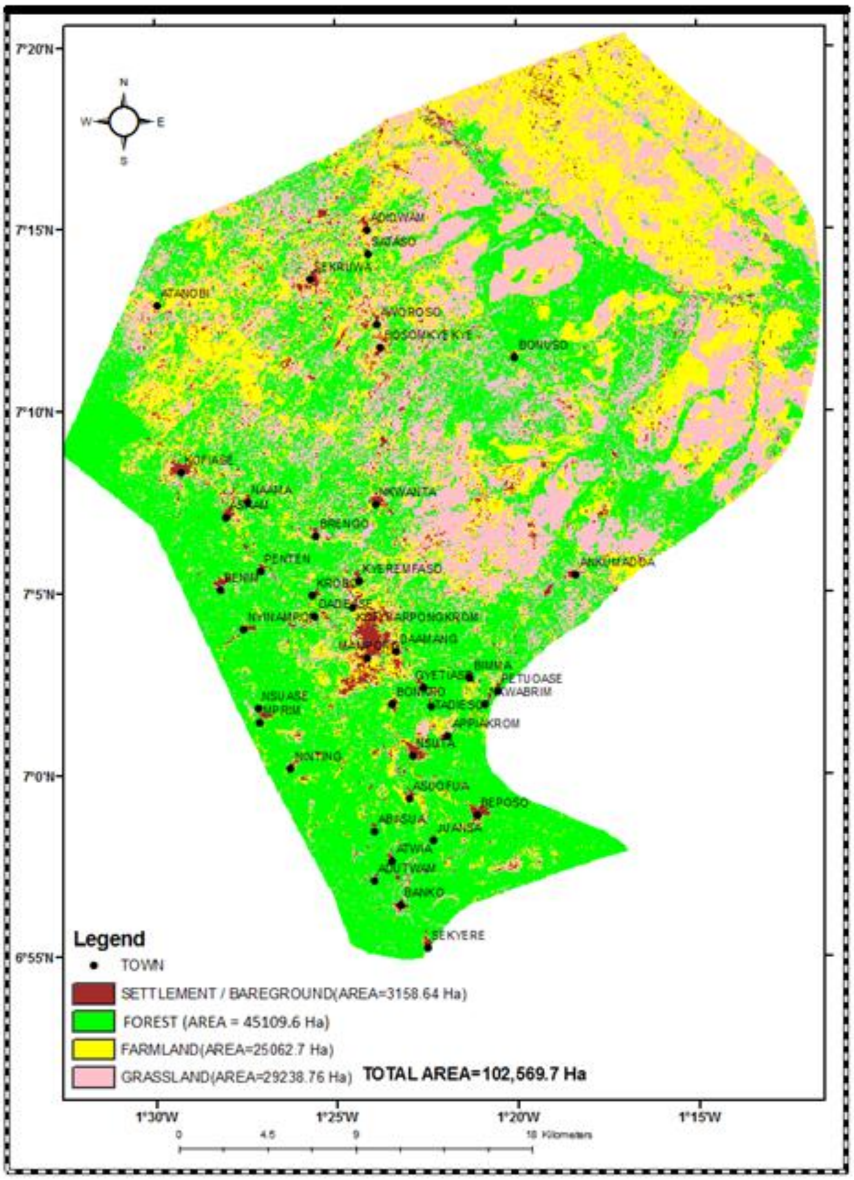


Figure 4.1: Landsat image of Mampong in 1991

4.3.2 Landsat Image of 2001

All the classes recorded above 20% in quantity in 2001. The settlements shot up to 23.2% with a massive reduction in the forest cover to 26.7%. The north-eastern part was covered mostly with grass. The southern part was still made up of forest cover. The central portions were no longer having any forest cover as seen in figure 4.2.

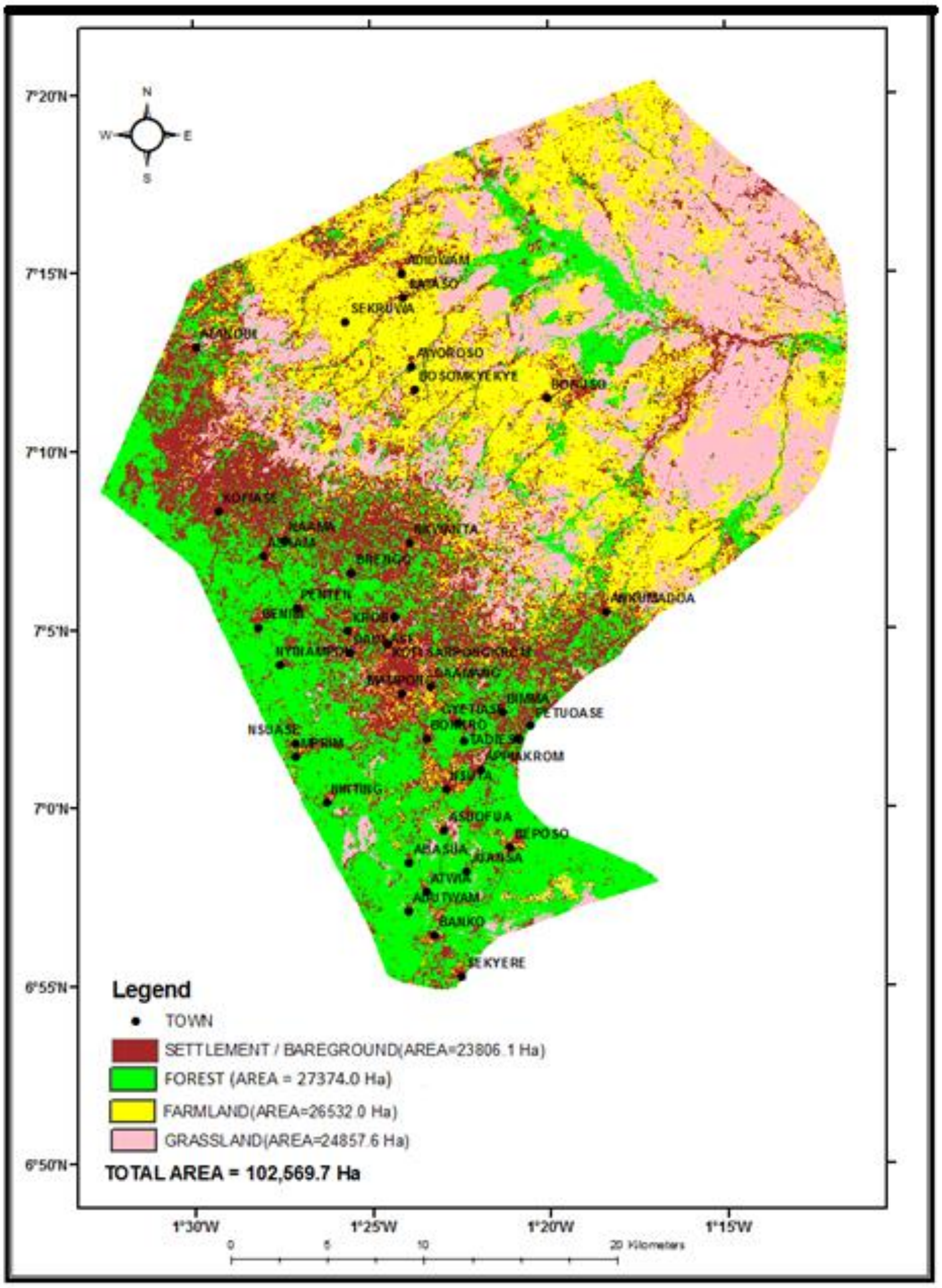


Figure 4.2: Landsat image of Mampong in 2001

4.3.3 Landsat Image of 2009

The farmlands recorded the least value of 13.68%. The southern part constituted the highest portion of the forest cover. Settlement rapidly continued to increase with time reaching 37.96% in 2009 as seen in figure 4.3.

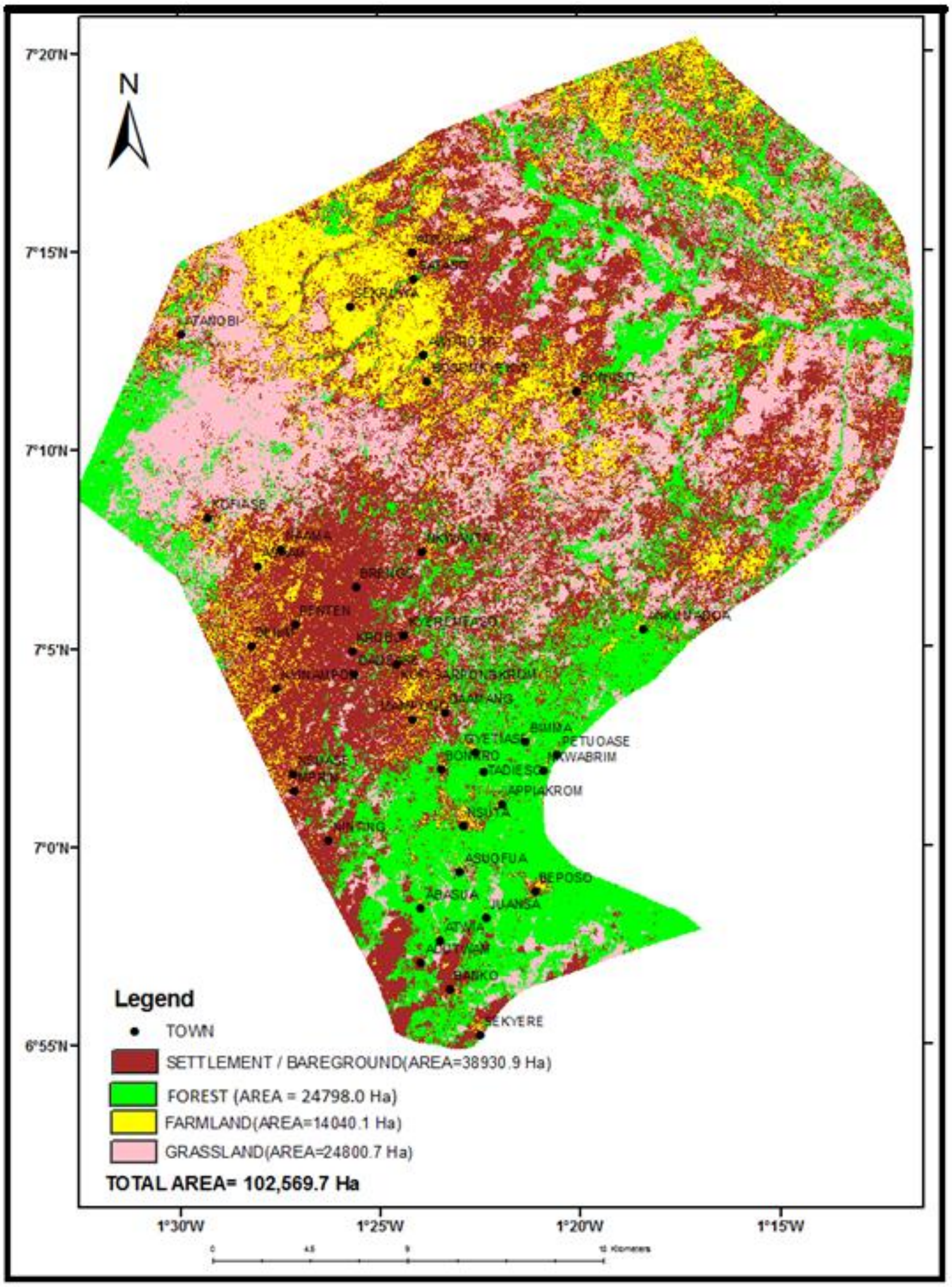


Figure 4.3: Landsat image of Mampong in 2009

4.4 Location of Change in land use and cover

The process of comparison of the study year images is done through image overlay. In terms of location of change, the emphasis is on settlement and open forest. Figure 4.4 shows the change in settlement between 1991 and 2001. The observation here is that there seems to be overwhelming growth in terms of human settlements and other development projects. Human settlement increased throughout the centre of the capital of the Municipality and towards the western part of the Municipality. The appreciation in settlement also spread almost throughout the entire Municipality. Between 2001 and 2009 as shown in figure 4.5, there still exists drastic increase in the spatial expansion of the city with regards to settlement. The settlement has also spread to the North Eastern and the South Western parts of the Municipality.

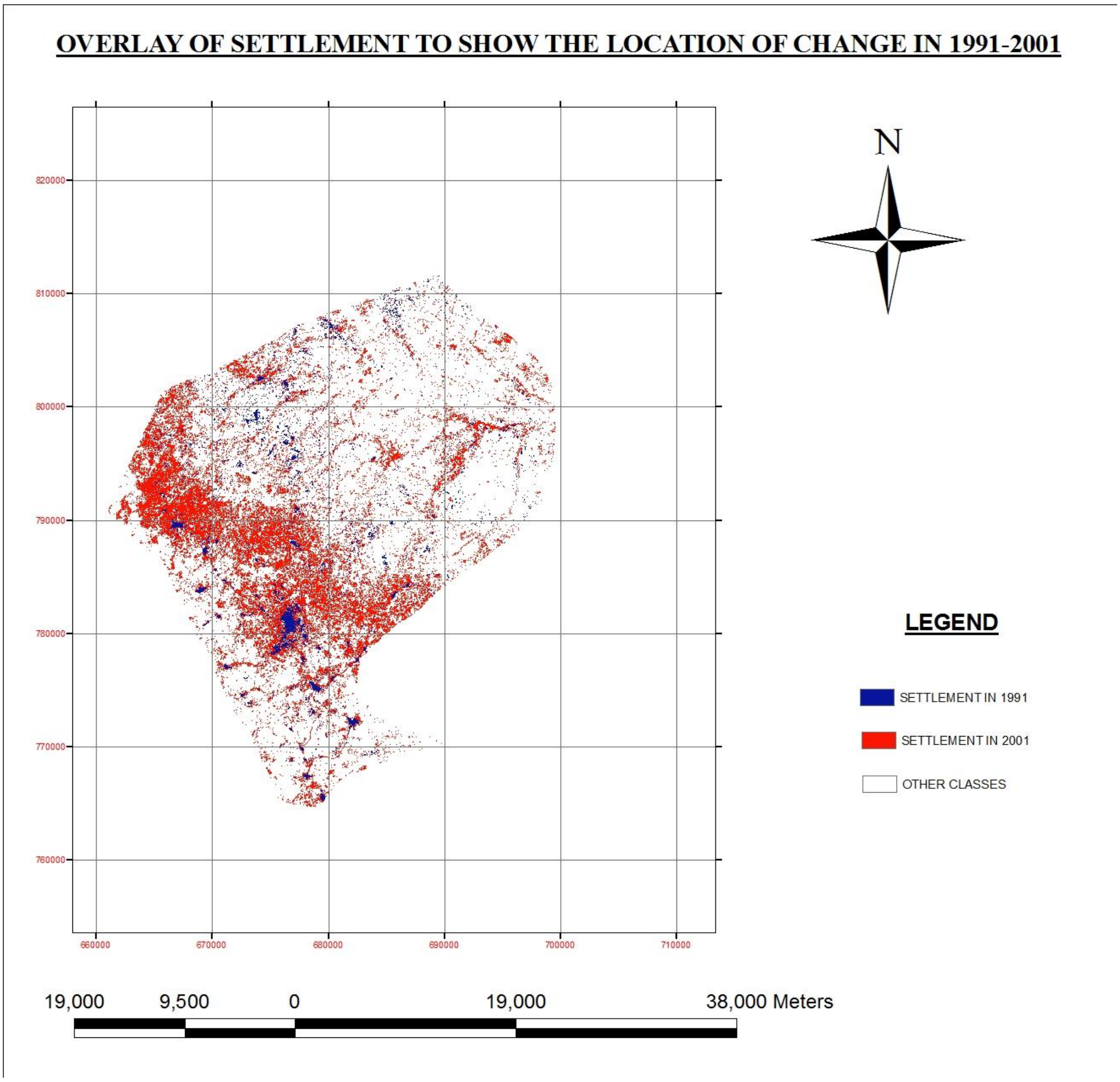


Figure 4.4: Derivative from the overlay of 1991 and 2001 land use and cover map

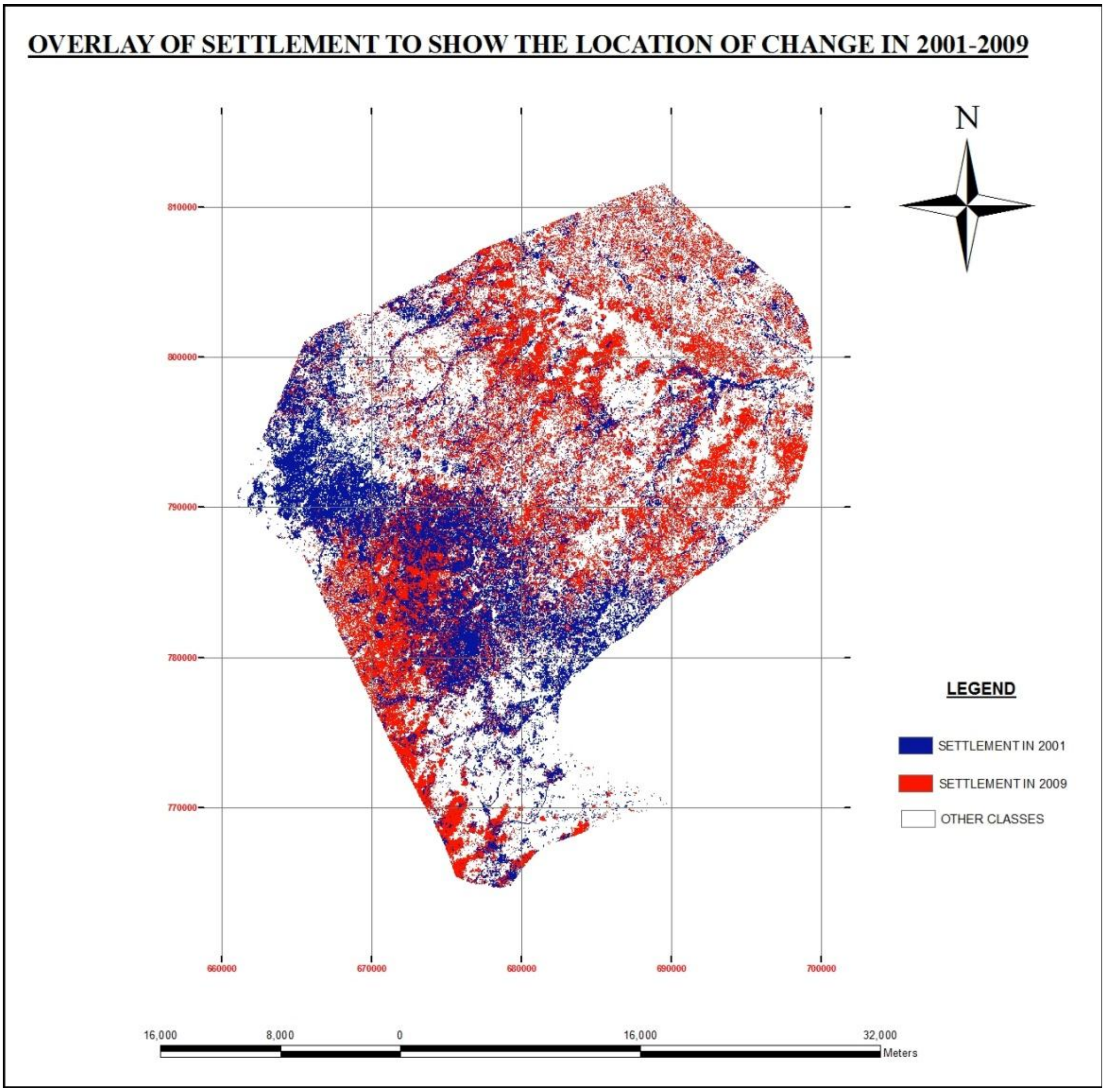


Figure 4.5: Derivative from the overlay of 2001 and 2009 land use and cover map

Figure 4.6 shows the change in forest between 1991 and 2001. There was rapid decrease in the portion of the forest. Its conversion rate to other classes was very huge. Most of the areas that initially used to be forest around the Municipality's capital and other towns within the Municipality were no more available because of the conversion to other classes. Change in forest between 2001 and 2009 is shown in figure 4.7. Although some of the forest was lost, some of the other classes were also converted to the forest class.

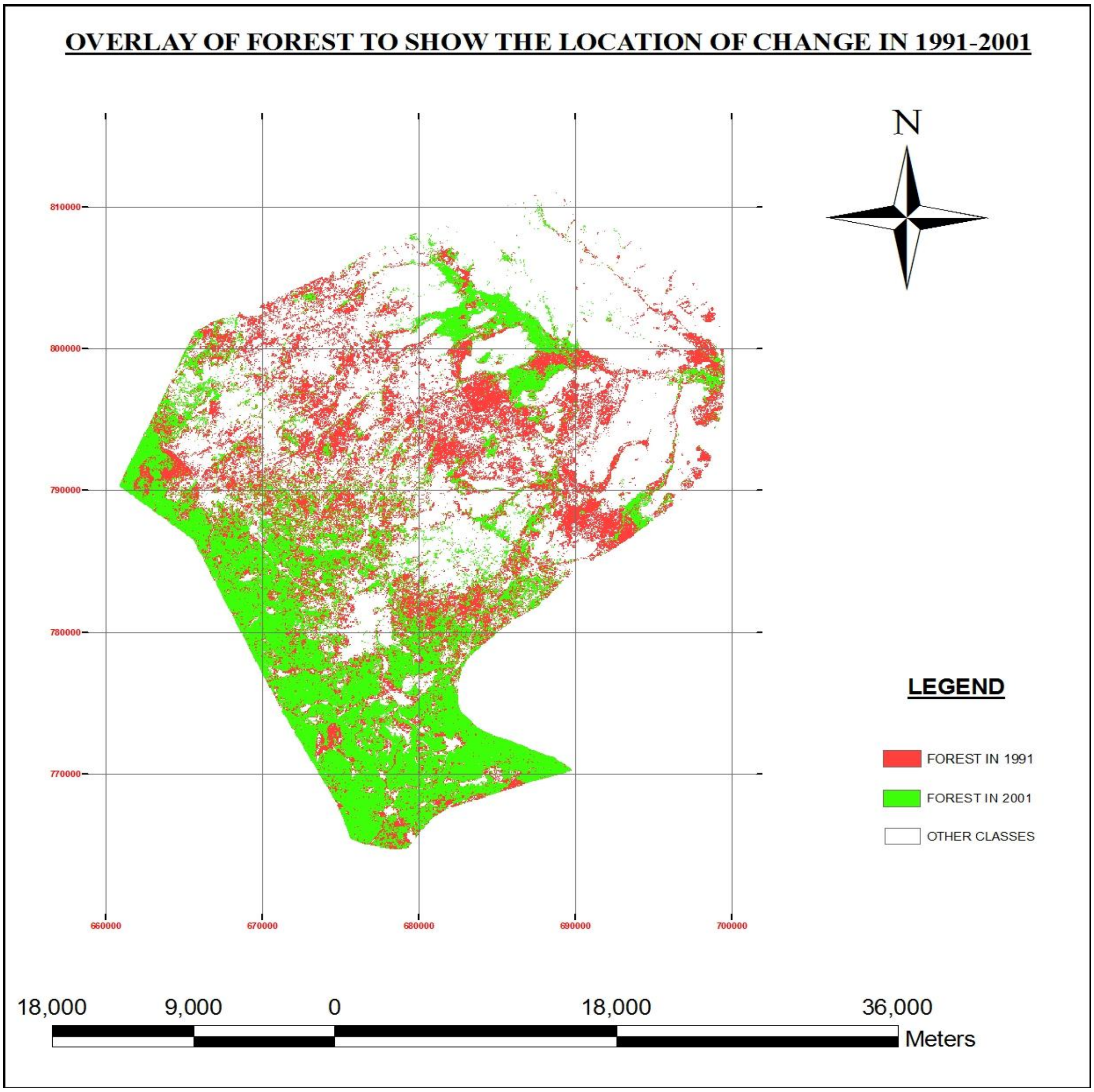


Figure 4.6: Derivative from the overlay of 1991 and 2001 land use and cover map

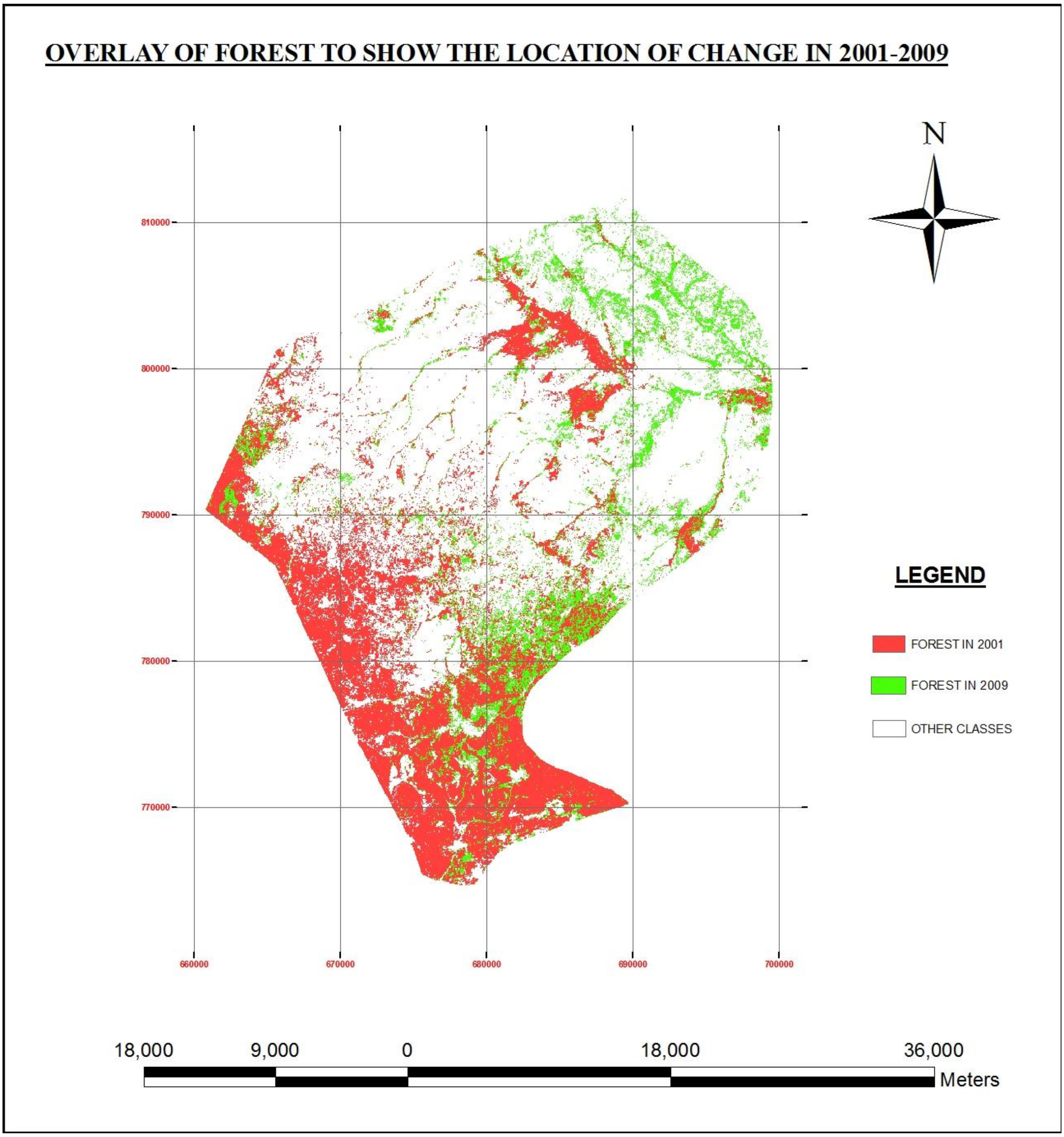


Figure 4.7: Derivative from the overlay of 2001 and 2009 land use and cover map

4.4.1 Nature of change

On the other hand, looking at the nature of change under stability i.e. areas with no change and instability- loss or gain by each class between 1991 and 2001 particularly in the change in hectares, stability seems to be a relative term as no class was actually stable during this period except when observed from the percentage change. Thus, between 1991 and 2001, settlement has a gain of 20.1% and still gained 14.76% between 2001 and 2009. Forest on the other hand lost 17.3% between 1991 and 2001 and again lost 2.52% between 2001 and 2009. Farmland increased i.e. gained by 1.5% between 1991 and 2001 and a massive decrease of 12.22% between 2001 and 2009. Grassland was reduced by 4.3% between 1991 and 2001 but lost marginally by 0.02% between 2001 and 2009.

4.5 Accuracy Assessment

The user accuracy, producer accuracy and overall accuracy were computed from confusion matrix produced using Microsoft Excel. The overall accuracy gives probability of correctly mapped points in the map with field and user accuracy which compares map with field data. Producer accuracy, however, compares field data with maps. In this case, the field data was collected using GPS and noting the attribute of the associated point. The overall accuracy of the map was 80%. The producer and user accuracy for each classification is tabulated in the Appendices.

4.6 Socio – economic factors

4.6.1 General Information

Table 4.3: Population of the selected communities within the Municipality

No	SETTLEMENT	POPULATION	QUESTIONNAIRES ADMINISTERED	PERCENTAGE (%)
1	Mampong	46026	244	63.71
2	Kofiase	6448	34	8.88
3	Benim	2815	15	3.92
4	Adidwan	2854	15	3.92
5	Ninting	2170	12	3.13
6	Asaam	3386	18	4.69
7	Bosofour	1568	8	2.09
8	Daaho	2779	15	3.92
9	Apaah	2359	13	3.39
10	Mprim	1627	9	2.35
	TOTAL	**72032**	**383**	**100**

Source: (Draft Strategic Environmental Assessment Report, 2010)

4.6.2 Socio – Economic Aspects

The sample from the population had 318 (83%) natives and 65 (17%) migrants with most of the natives living in the Municipality for more than twenty years. Most of the migrants have come to stay within the Municipality because of their occupation. The most prevalent form of farming within the Municipality is subsistence farming and as such annuals such as maize, cassava, plantain, etc. are grown in the Municipality. Few of the respondents were into the cultivation of cash crops. On livestock rearing, 309 (80.7%) were rearing animals whilst 74 (19.3%) were not into livestock rearing. The keeping of poultry and the rearing of goats were the dominant with 134 (43.23%) and

127 (40.97%) respectively. Sheep and cattle had 46 (12%) and 3 (0.8%) respectively. Very large scale of the production of livestock was rare during the research.

4.6.3 Environmental Aspects

4.6.3.1 Indiscriminate felling of trees

All respondents said that they really knew of indiscriminate felling of trees and it had started over twenty years ago and still continues to gain momentum. Figure 4.8 shows the socio economic factors of indiscriminate felling of trees. The major cause of indiscriminate felling was unemployment followed by population pressure, agricultural expansion and lastly inappropriate forest management systems.

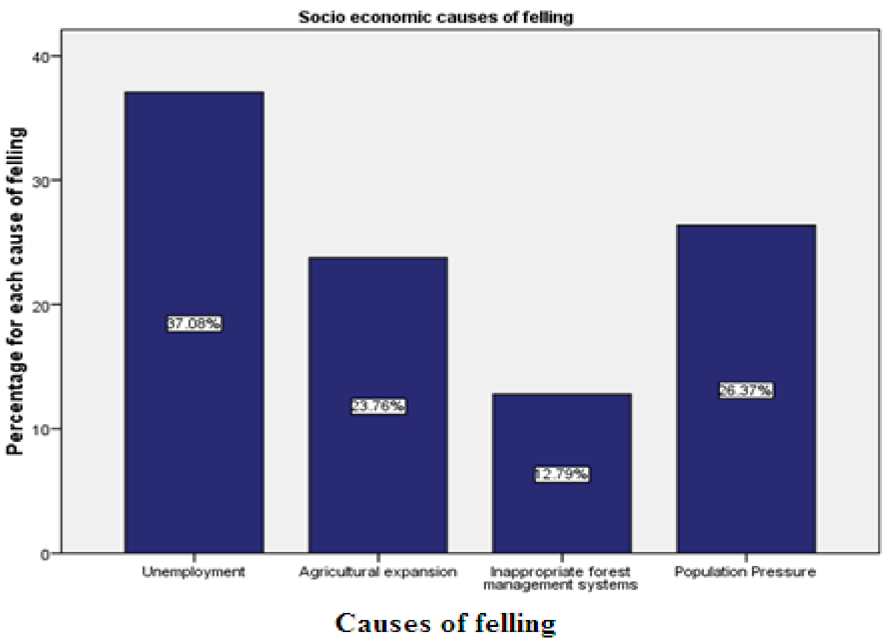


Figure 4.8: Causes of felling of trees

The impacts of indiscriminate felling of trees were also evaluated as most of the respondents said that this rampant activity would lead to biodiversity loss, deforestation and climate change. Single impact of climate change, deforestation and biodiversity loss followed in descending order of their percentages as shown in Figure 4.9.

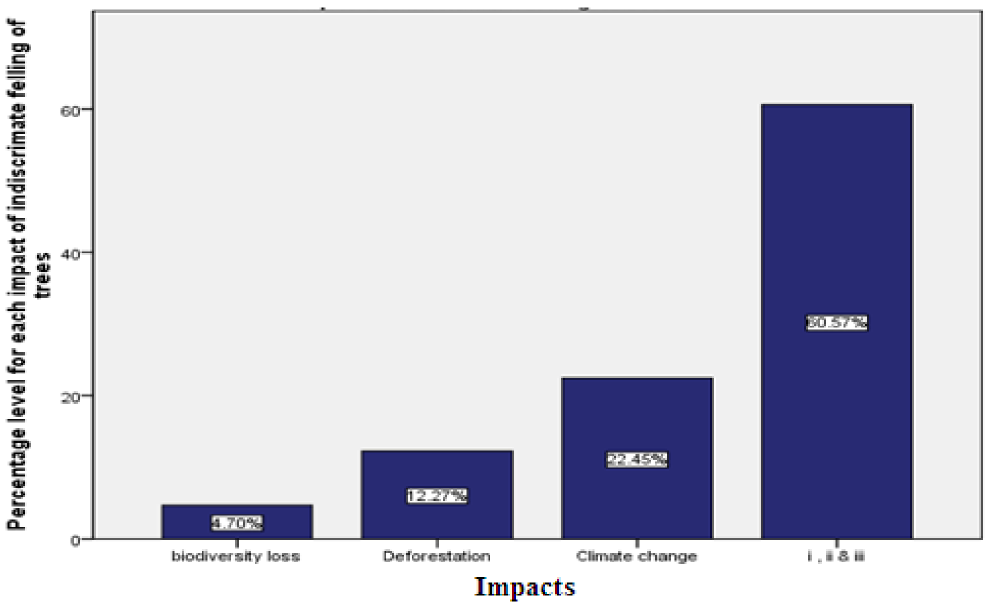


Figure 4.9: Impacts of indiscriminate felling

4.6.3.2 Sand Winning

Majority of the respondents said that they are aware of sand winning activities within the Mampong Municipality which started above twenty years ago. Figure 4.10 shows the socio economic factors that drive sand winning within the Municipality.

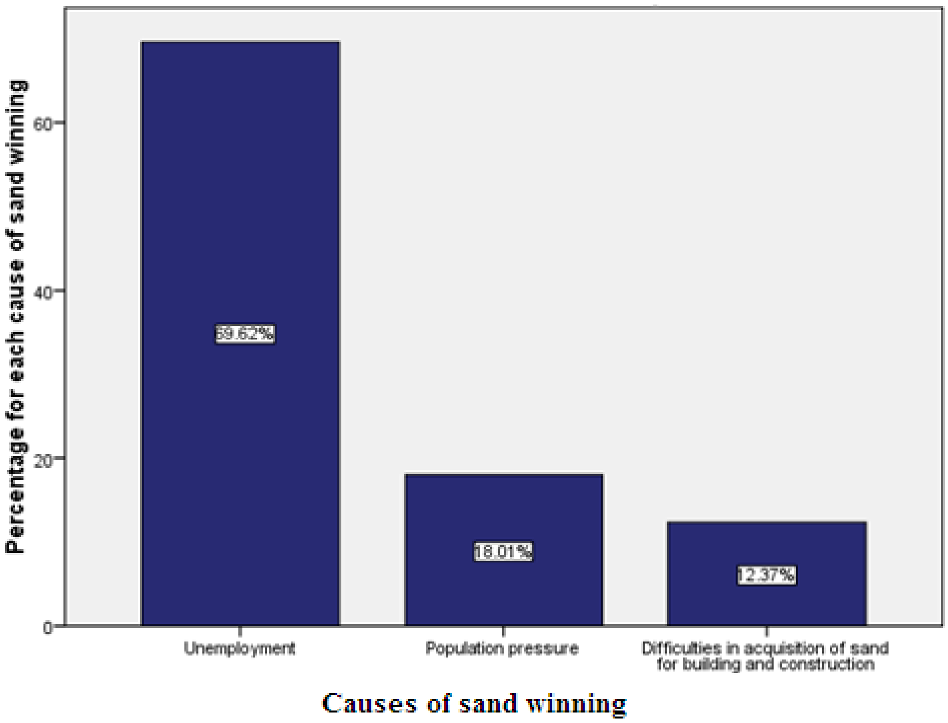


Figure 4.10: The causes of sand winning

With the impacts of sand winning, most of the respondents chose biodiversity loss as the major effect of sand winning on the land and climate change was the least as shown in Figure 4.11.

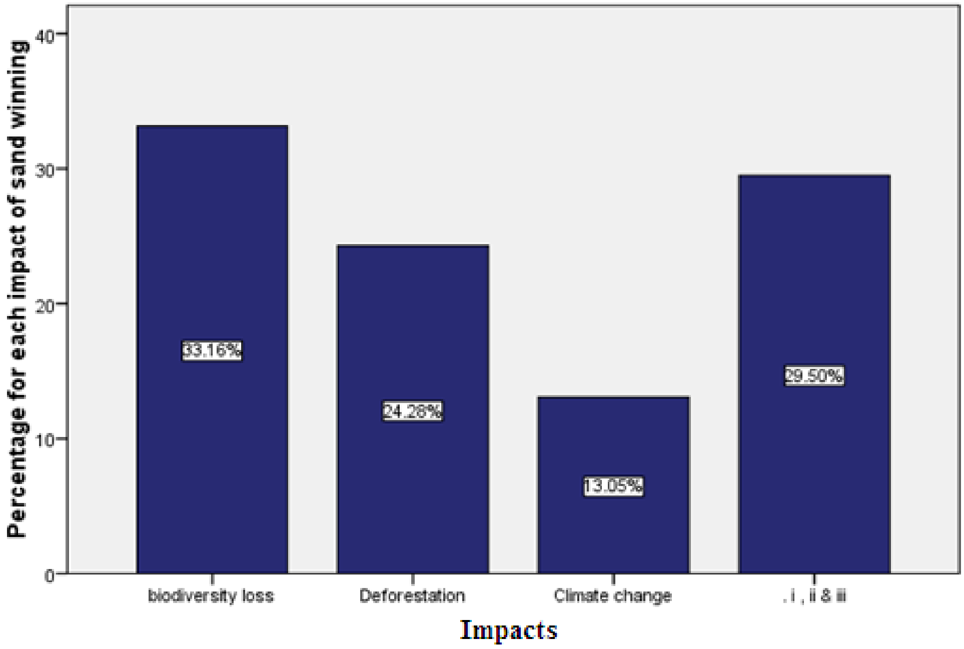


Figure 4.11: The impacts of sand winning

4.6.3.3 Charcoal Burning

Charcoal burning is also on the ascendency in the Municipality. It is also a major environmental problem. Figure 4.12 shows the socio economic causes of charcoal burning in the Municipality. The major cause of the engagement in the burning of charcoal is the lack of other livelihood activities in the Municipality. Thus unemployment is the major cause of charcoal burning, followed by high demand of fuel wood and lastly the cheapness of charcoal for cooking.

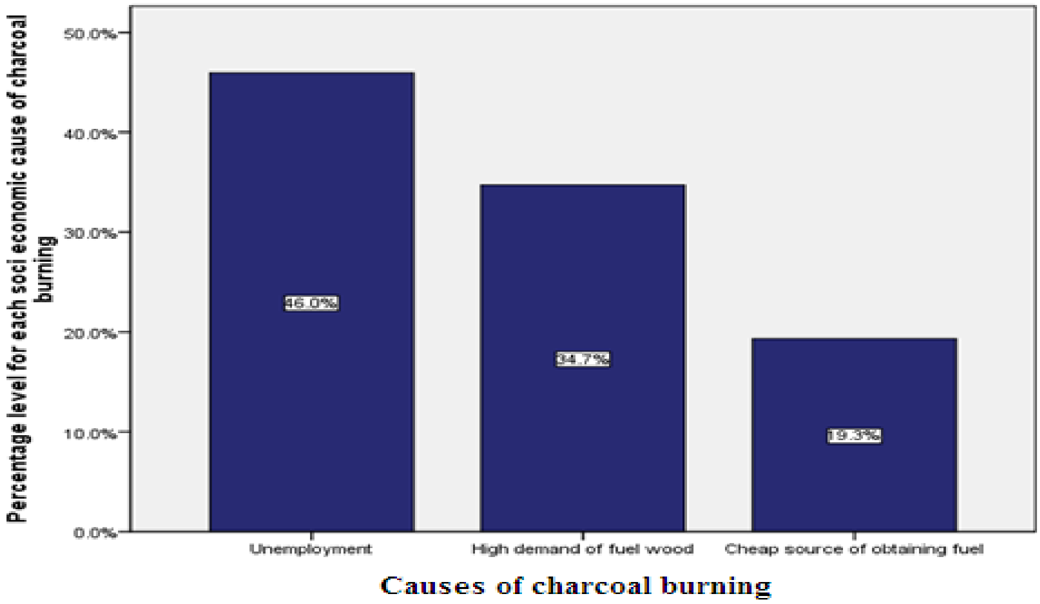


Figure 4.12: The causes of charcoal burning

The impacts of charcoal burning are also illustrated with climate change dominating the answers given by the respondents as shown in Figure 4.13.

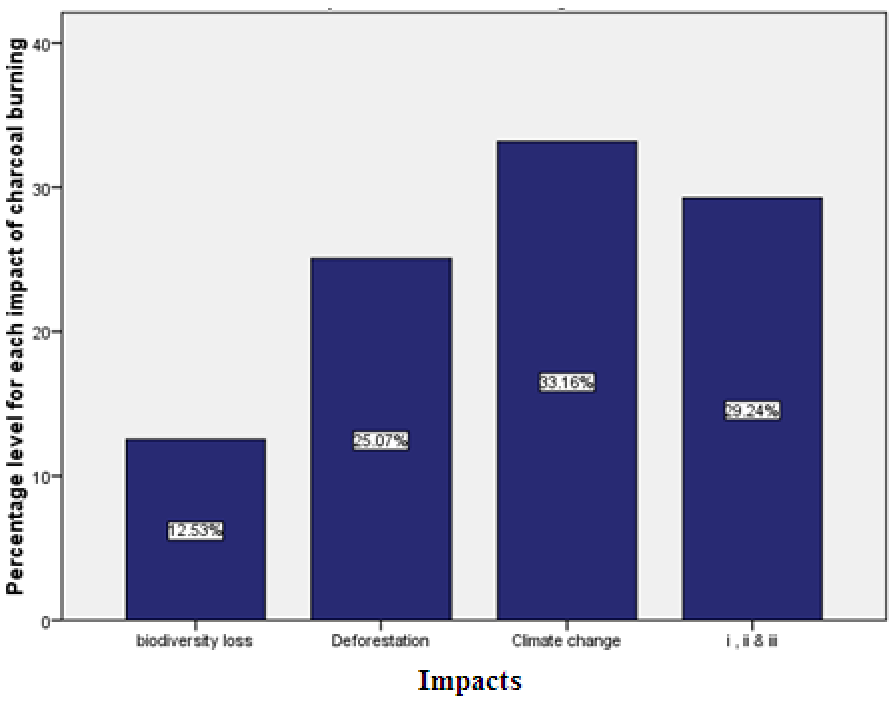


Figure 4.13: Impacts of charcoal burning

4.6.3.4 Bush Burning

Bush burning is also a major problem for the indigenes in the Municipality. It was started well over twenty years ago. Its occurrence is very prevalent during the dry season. Figure 4.14 shows the frequency at which bush burning occurs.

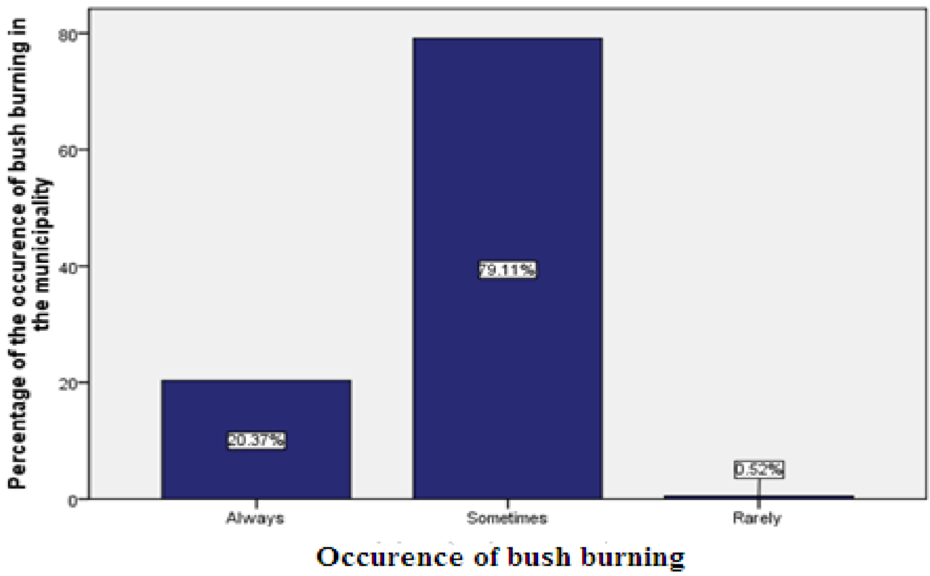


Figure 4.14: Occurrence of bush fires in the Municipality

The socio economic causes of bush burning were also evaluated with game hunting seen by the respondents as the main cause of bush burning within the Municipality as shown in Figure 4.15.

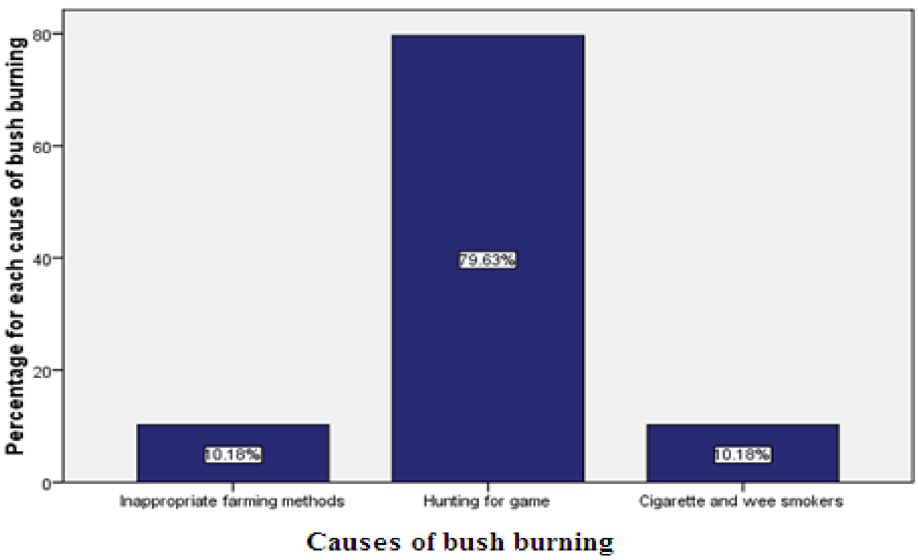


Figure 4.15: The causes of bush burning in the Municipality

On the impacts of bush burning, most of the respondents said the combination of all the first four factors was the most selected impact of bush burning as shown in Figure 4.16.

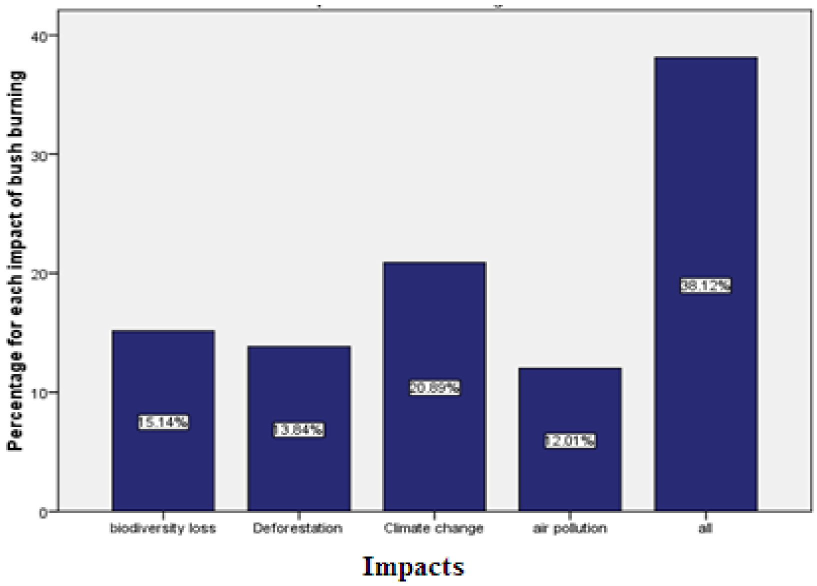


Figure 4.16: Impacts of bush burning

4.6.3.5 Shifting Cultivation

This practice according to the respondents started very long time ago as it is a very common practice by farmers. Figure 4.17 shows the socio economic causes of shifting cultivation.

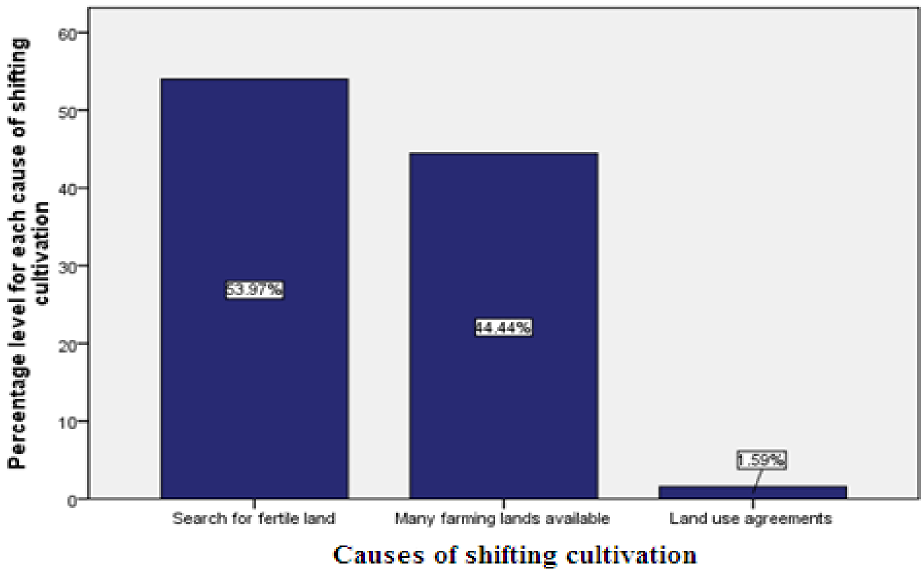


Figure 4.17: Socio economic causes of shifting cultivation

The impacts of shifting cultivation as surveyed from the respondents are shown in Figure 4.18 which had sizeable percentages for each impact of shifting cultivation.

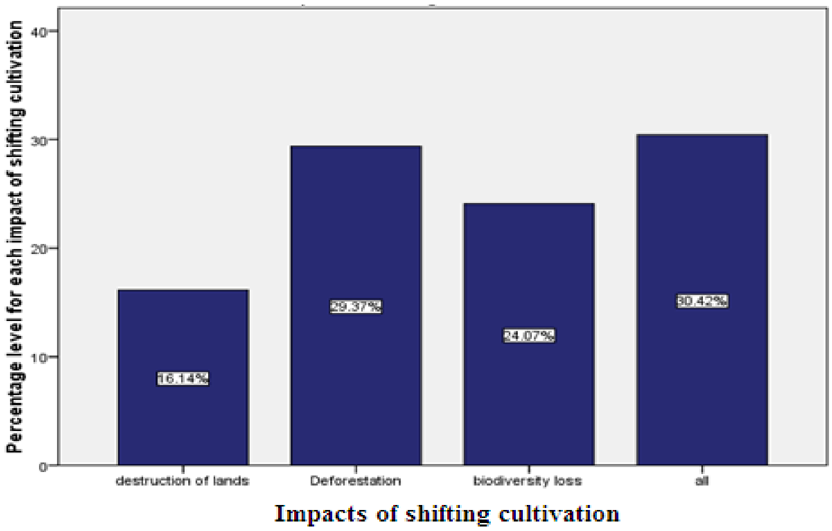


Figure 4.18: Impacts of shifting cultivation

CHAPTER FIVE

DISCUSSION

5.1 Classified Maps of 1991, 2001 and 2009

The total area of the landscape remained constant for 1991, 2001 and 2009 at a value of 102569.7 (see Table 4.1) as used throughout the study. The classified map of 1991, 2001 and 2009 shows that the forest is highly depleted over the years studied. The major causes were identified to be the population growth, sand winning and indiscriminate felling of trees (the leading economic activity in the community). The increase in population has significant implications for the conversion of forest covers to other land cover classes.

5.2 LULC change analysis of 1991, 2001 and 2009

In between 1991 and 2001, the rate of deforestation which was at an annual rate of decrease of 1.73% was much higher than the estimation made by FAO (2001) that the world's forests were converted to other uses/cover at a rate of 0.38 % (i.e. deforested) annually in the 1990s and more rapidly and diverse in developing tropical countries.. The rate of forest conversion to other land use types for 1991 – 2001 shows that the forest area shrank at a faster pace. The 2001 – 2009 period showed a lower rate as the rate of decrease of 0.315%. This can be attributed to the fact that there were afforestation programmes within 2001 – 2009 which yielded 491.1 ha of forest established by the Mampong Forest District which helped reduce the annual rate of decrease of the forest (see appendices). Settlement/bare ground saw an annual rate of conversion of 2.01% for 1991 – 2001 and 1.845% for 2001 – 2009. Farmlands increased slightly in 2001 but decreased drastically to 13.68% in 2009. The reduction in farmlands is a threat to food security to the Municipality and other dependent communities. They can be attributed to the fact that settlements are taking over the farmlands as observed during field visits. Grassland showed the greatest stability during the study period. Its stability is related to the fact that most of the grassland cover are in the north-eastern parts of the municipality as there is less pressure on them. The grasslands are not exploited and those areas consist mostly of rural areas and are far from the capital of the Municipality where pressure on the land is high.

5.3 Causes behind the changes from the Socio-Economic Study

This study also tried to attempt to identify the driving forces behind the change that has resulted at faster pace over the time. Several factors propelled by the activities of man are responsible for this massive land use and cover changes within the Municipality. The questionnaire survey highlighted some of the hot issues that were observed in the field during the research period about the environment. The forces behind the land cover change problem are partly population pressure as well as the dependence on forest based products like fuel wood and charcoal. To buttress this, the survey data showed that 72.06% of the sample from the population studied use firewood and 26.11% use charcoal meaning that there is much pressure on the forest for its products. The increase in demand of forest products has led to the depletion of the forest cover. Decrease in farmlands might be due to the degradation of the environment through activities such as the conversion of farmlands to settlements, bush burning, shifting cultivation, and charcoal burning which is in conformity with the assertion that Agyarko (2001) made that Ghana like many other countries whose economies depend largely on the utilization of natural resources is not an exception to land use and cover problems.

5.4 Consequences of Land Use and Cover changes on the Environment in the Mampong Municipality.

5.4.1 Effect of deforestation on Global Warming

Trees absorb CO_2 that humans release into the atmosphere through respiration. They use it to prepare their own food through photosynthesis and release O_2 into the atmosphere. When there is an increase in deforestation (either burning or cutting down of forest), CO_2 is released and its content in the atmosphere increases, which in turn increases the average global temperature of the earth's surface and causes global warming.

5.4.2 Consequences for biodiversity

Vegetation loss within the Mampong Municipality poses a lot of threat to natural habitats, there by affecting the local biodiversity of the landscape. The influence of human activities is altering the natural landscapes by changing the abundance and spatial pattern of these habitats (Harris and Miller, 1984). The increasing problem of the deforestation for timber and other forest products has eroded most of the original biodiversity over the past decades.

5.4.3 Soil Degradation

When soils are exposed due to the destruction of vegetation through sand winning, bush fires, lumbering and fuel-wood harvesting, leaching of soil nutrient take place and the sulphides in the original soils are converted into sulphuric acid leading to acidification. The soil may shrink upon drying and can no longer support good agriculture or plant life. (Ministry of Lands and Forestry, 1999)

5.5 Image Classification and Accuracy Assessment of Classified Images

Supervised image classification method were employed to extract thematic information on the land covers from 1991, 2001 and 2009 satellite images which resulted in the production of the four (4) land use and cover classes. Accuracy assessment of the classified image is an important step in image classification. The quality of a thematic map from a satellite image is determined by its accuracy. An accuracy assessment was performed on the 2009 Landsat image and an overall accuracy of 80% was obtained. This study suggests that the experience of this Municipality may constitute a broader idea of how GIS and RS programme can aid to determine the cover situation of an area.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Land use and cover classification scheme consisting of settlement/bare ground, forest, farmland and grassland was created after a reconnaissance survey of the study area. Quantification of the land use classes was done using GIS and remote sensing techniques. The trend showed that forest continues to decrease which is in sharp contrast with settlement which continues to increase at a faster pace. From 2001, farmlands have been decreasing. Grasslands despite a sizeable reduction from 1991 to 2001, there have been minimal decrease since 2009. Image Mosaicing also illustrated that if care is not taken, most of the forest cover will be taken away whereas settlement/ bare ground will continue to rise as a result of population increase and will really exacerbate the dependency on the environmental resources. Finally, evaluation of the socioeconomic factors that drive land use changes showed that over dependence on forest products seem to exacerbate the situation. The underlying causes for the forest cover change are multifarious including rapidly increasing population with the dependency on the forest for firewood, timber, fodder and other products.

The present study was an integrated approach of remote sensing, GIS and analysis of socio- economic data used for land use and land cover change detection. The result of change detection using Landsat imagery, suggest that most of the forest cover has been under human pressure degrading its originality over the years.

The study site is a typical example of how rapidly resources, especially forest cover is disappearing in the Ashanti Region. The broad pattern of major land use and cover changes are known with some confidence and the literature is rich in contending explanation for them. The aforementioned forces behind these changes require most attention. Cases reviewed and the research done support the conclusion that neither population nor poverty alone constitutes the sole and major underlying causes of land cover change but responses to economic opportunities by inhabitants, as mediated by institutional factors, drive land-cover changes.

6.2 Recommendations

The following suggestions are made based on the findings and the conclusions drawn:

- People should be encouraged to put up storey buildings instead of scattering small housing units just to occupy space.
- Further studies should be made to assess the effects of land use and cover on ecosystem services in the Mampong Municipality.
- Livelihood strategies need to be diversified to include other income sources outside farming that can provide incentives for non-forest based livelihoods.
- Areas where there is complete absence of trees need to be replanted with fast growing trees.
- There is a need for proper designing policies and strategies to protect the environment from being destroyed by government and the local authorities.
- Reducing direct dependency on forest for firewood and use of energy efficient devices and alternative energy especially natural gas.
- Better extension services should be given to farmers on good farming practice.

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APPENDICES

Appendix 1: PLANTATIONS UNDERTAKEN IN THE DISTRICT FROM 2002 - 2007

Mampong Forest District – Modified *Taungya* System – Teak

POLITICAL DISTRICT	FOREST RESERVE	COMPARTMENT/ SERIES	COMMUNITY	YEAR ESTABLISHED	AREA (ha)
Mampong Municipal	Aboma	25	Konkoma	2005	13.80
		25	Timber Nkwanta	2004	17.70
		25	Timber Nkwanta-Dagarti	2005	31.00
		26	Timber Nkwanta-Asaam	2006	45.25
		27,28	Sekruwa	2007	15.89
	Ongwam II	Ninting	Ninting	2003 – 2006	86.18
	Offin Headwaters	Hwidiem	Hwidiem	2002 – 2006	29.81
	Abrimasu	11.12,16	Dome	2002 – 2009	112.43
		12,13	Atonsuagya	2003 – 2009	74.91
		18	Aframso	2003 – 2007	53.41
		19	Dome - Oseikrom	2007	11.52
TOTAL					**491.1**

Appendix 2

Appendix 2: **Ground Control Points taken during Ground truthing**

POINT	**Name**	**Land cover on map**	**East (x)**	**North (y)**	**Picked** East (x)	**Picked** North (y)	**FIELD DESCRIPTION**
1	MAMPONG	Settlement1	676411	779950	676405	779957	Settlement
2	MAMPONG	Settlement 2	676492	779892	676495	779887	Bareground
3	MAMPONG	Farmland 1	676388	779959	676388	779958	Settlement
4	MAMPONG	Farmland 2	676415	779897	676415	779896	Settlement
5	MAMPONG	Forest 1	676530	779944	676525	779944	Farmland
6	MAMPONG	Forest 2	676459	779809	676458	779809	Forest
7	PENTEN	Settlement 1	670987	784361	670986	784361	Settlement
8	PENTEN	Settlement 2	671110	784320	671111	784322	Settlement
9	PENTEN	Farmland 1	671255	784592	671251	784589	Settlement
10	PENTEN	Farmland 2	671343	784566	671343	784566	Farmland
11	BOSOMKYEKYE	Settlement 1	677059	795672	677.058	795672	Bareground
12	BOSOMKYEKYE	Settlement 2	677080	795798	677079	795797	Settlement
13	BOSOMKYEKYE	Farmland 1	677124	795610	677123	795610	Bareground
14	BOSOMKYEKYE	Farmland 2	677243	795617	677242	795616	Farmland
15	BOSOMKYEKYE	Grassland 1	677135	795743	677134	795743	Grassland
16	BOSOMKYEKYE	Grassland 2	677215	795764	677214	795762	Grassland
17	ADIDWAN	Settlement 1	676432	801663	676435	801660	Settlement
18	ADIDWAN	Settlement 2	676460	801662	676460	801662	Settlement
19	ADIDWAN	Farmland 1	676417	801632	676415	801606	Farmland
20	ADIDWAN	Farmland 2	676369	801666	676371	801665	Farmland
21	BANKO	Settlement 1	678149	767448	678148	767446	Settlement
22	BANKO	Settlement 2	678151	767530	678153	767530	Settlement
23	BANKO	Grassland 1	677928	766967	677930	766965	Grassland
24	BANKO	Grassland 2	677875	766874	677876	766874	Grassland
25	BANKO	Forest 1	677999	766965	677996	766960	Farmland
26	BANKO	Forest 2	677937	766792	677938	766791	Forest
27	KOFIASE	Settlement 1	666950	789402	666949	789411	Settlement
28	KOFIASE	Settlement 2	666922	789571	666921	789571	Bareground
29	KOFIASE	Farmland 1	666727	789515	666726	789516	Farmland
30	KOFIASE	Farmland 2	667438	788763	667436	788765	Farmland
31	KOFIASE	Forest 1	667117	788911	667117	788912	Forest
32	KOFIASE	Forest 2	667073	789131	667070	789129	Farmland
33	KOFIASE	Grassland 1	666084	789862	666081	789862	Grassland
34	KOFIASE	Grassland 2	666353	789538	666351	789535	Grassland

35	AWOROSO-SEKRUWA	Forest	676969	796839	676967	796838	Forest
36	AWOROSO-SEKRUWA	Farmland	676852	797260	676850	797259	Farmland
37	AWOROSO-SEKRUWA	Settlement	677012	796941	677010	796941	Settlement
38	AWOROSO-SEKRUWA	Grassland	675546	797613	675545	797613	Settlement
39	NSUTA	Settlement 1	678732	775005	677626	775000	Settlement
40	NSUTA	Settlement 2	678680	775028	678679	775028	Settlement
41	NSUTA	Forest 1	678811	774961	678811	774961	Farmland
42	NSUTA	Forest 2	678645	774935	678644	774934	Forest
43	NSUTA	Farmland	678793	775016	678792	775015	Settlement
44	NSUTA	Grassland	678957	775009	678956	775008	Settlement
45	BUNSO	Farmland 1	683749	795483	683748	795483	Farmland
46	BUNSO	Farmland 2	683690	795400	683689	795400	Farmland
47	BUNSO	Settlement	683895	795513	683894	795513	Settlement
48	BUNSO	Grassland	683957	795245	683957	795244	Grassland
49	BUNSO	Grassland 2	684023	795276	684022	795275	Grassland
50	BUNSO	Forest	683836	795200	683835	795200	Forest

Appendix 3: **ACCURACY ASSESSMENT OF THE CLASSIFICATION**

CONFUSION MATRIX OF THE CLASSIFICATION

	REFERENCES				
CLASSIFICATION	**Settlement**	**Farmland**	**Forest**	**Grassland**	**TOTAL**
Settlement/ Bareground	**16**	0	0	0	16
Farmland	4	**10**	0	0	14
Forest	0	4	**6**	0	10
Grassland	2	0	0	**8**	10
TOTAL	**22**	**14**	**6**	**8**	**50**

CLASS	REFERENCE TOTAL	CLASSIFICATION TOTAL	CORRECT TOTAL	PRODUCER ACCURACY (%)	USER ACCURACY (%)
Settlement/ Bare ground	16	22	16	**100**	**72.73**
Farmland	14	14	10	**71.43**	**71.43**
Forest	10	6	6	**60**	**100**
Grassland	10	8	8	**80**	**100**

- **Producer Accuracy =** $\frac{\text{Correct total}}{\text{Reference total}} \times 100\%$

- **User Accuracy =** $\frac{\text{Correct total}}{\text{Classification total}} \times 100\%$

Appendix 4: **Data Sources**

S/N	**DATA TYPE**	**DATE OF PRODUCTION**	**SOURCE**
1.	Landsat image	03-01-1991	Global Land Cover Facility (GLCF) *via* **RMSC-FC**
2.	Landsat image	04-04-2001	Global Land Cover Facility (GLCF) *via* **RMSC-FC**
3.	Landsat image	01-02-2009	Global Land Cover Facility (GLCF) *via* **RMSC-FC**
4.	Vector map showing towns and roads of Mampong	13-11-2013	**RMSC-FC**

Appendix 5: **HOUSEHOLD QUESTIONNAIRE TO SURVEY THE PEOPLE OF THE MAMPONG MUNICIPALITY TO EVALUATE THE SOCIO-ECONOMIC FACTORS THAT DRIVE LAND USE CHANGES**

A. GENERAL INFORMATION

NAME OF COMMUNITY	
NAME OF RESPONDENT	

1. Family Size

i. 0 – 5 ii. 6 – 10 iii. 11 – 15 iv. 16 – 20 v. > 20

2. Age

i. 21 – 30 ii. 31 – 40 iii. 41 – 50 iv. > 50

3. Literacy

No schooling☐ Primary ☐ MSLC/JSS/JHS ☐ O level/A level/SHS ☐

Tertiary ☐ Other (state)..........

4. What is your occupation? ....

B. SOCIO ECONOMIC ASPECT

5. Did you migrate from elsewhere?

If yes, from where? .... and Why? ....

6. How long have you been living here? (years)

i. 0- 5 ii. 6 – 10 iii 11- 15 iv. 16 – 20 v. > 20

7. Do you own a land? Yes or No

8. If Yes state/tick the size of land owned

Total Land owned (acres)	Major Activities/Major crops
0 – 20	
21- 40	
41- 60	
61- 80	
> 80	

9. Does the production from your land meet your food demands? i. Yes ii. No

10. If yes, is the food sufficient for:

i. One month ii. Up to six months iii. Up to 1 year

11. Does your income match your expenditure? Yes or No

12. If not how do you manage the extra expenditure?

i. Extra job ii. Remittances iii. Others (please specify)....

C. LIVESTOCK

13. Do you rear any livestock? Yes or No

14. What livestock do you keep?

i. Cattle ii. Sheep iii. Goat iv. Poultry v. pigs

15. If yes, what is the total number of livestock kept?

i <50 ii. 51 – 100 iii. 101 – 150 iv. > 150

16. How do you feed your livestock?

i. Grazed ii. Hay iii. Grazing + Hay iv. Poultry feed

D. ENERGY SOURCES

17. What do you use for cooking?

i. Firewood ii. charcoal iii.Kerosene

18. If firewood, what is the source of firewood?

i. Forest ii. Farm iii. Others (specify)............

E. ENVIRONMENT

19. What major benefits are you getting from the forest?

i. Firewood ii. Fodder iii. I and II iv. Farm

20. Have you heard about indiscriminate felling of trees? i. Yes ii. No

21. What do you think are the socio-economic causes of indiscriminate felling of trees?

i. Unemployment ii.Population pressure iii. . Agricultural expansion

ivDifficulties in acquisition of land v. Inappropriate forest management systems

22. When do you think indiscriminate felling of trees started in the area? (In years)

i. 0- 5 ii. 6 – 10 iii 11- 15 iv. 16 – 20 v. > 20

23. What measures do you think should be implemented by the government to combat indiscriminate felling of trees?

i. Strong enforcement of laws ii. Proper policies iii.coordination between stakeholders

24. What is (are) the impact(s) of illegal felling of trees?

i. biodiversity loss ii. Deforestation iii. Climate change iv. i , ii and iii

25. Have you heard about sand winning? i. Yes ii. No

26. What do you think are the socio-economic causes of sand winning?

i. Unemployment ii. Population pressure

iii.. Difficulties in acquisition of sand for building and construction

27. When do you think sand winning started in the area? (In years)

i. 0- 5 ii. 6 – 10 iii 11- 15 iv. 16 – 20 v. > 20

28. What measures do you think should be implemented by the government to combat sand winning?

i. Strong enforcement of laws   ii. Proper policies   iii. Coordination between stakeholders

29. What is(are) the impact(s) of sand winning?

i. biodiversity loss   ii. Deforestation   iii. Climate change   iv. i , ii and iii

30. Have you heard about charcoal burning? i. Yes   ii. No

31. What do you think are the socio-economic causes of charcoal burning?

i. Unemployment   ii. High demand of fuel wood

iii. Cheap source of obtaining fuel   iv. Others (specify).............

32. When do you think charcoal burning started in the area? (In years)

i. 0- 5   ii. 6 – 10   iii 11- 15   iv. 16 – 20   v. > 20

33. What measures do you think should be implemented by the government to regulate charcoal burning?

i. Strong enforcement of laws   ii. Proper policies   iii. coordination between stakeholders

34. What is(are) the impact(s) of charcoal burning?

i. biodiversity loss   ii. Deforestation   iii. Climate change   iv. i , ii and iii

35. Have you heard about bush burning? i. Yes   ii. No

36. How often do you hear about bush burning in the municipality?

A. Always   B. Sometimes   C. Rarely   D. Never.

37. What do you think are the socio-economic causes of bush burning?

i. Inappropriate farming methods   ii. Hunting for game   iii. Cigarette and wee smokers

iv. Others (specify).............

38. When do you think bush burning started in the area? (In years)

i. 0- 5 ii. 6 – 10 iii 11- 15 iv. 16 – 20 v. > 20

39. What measures do you think should be implemented by the government to combat bush burning?

i. Strong enforcement of laws ii. Proper policies

iii. coordination between stakeholders

40. What is(are) the impact(s) of bush burning?

i. biodiversity loss ii. Deforestation iii. Climate change iv. i, ii and iii

41. Have you heard about shifting cultivation? i. Yes ii. No

42. What do you think are the socio-economic causes of shifting cultivation?

i. Search for fertile land ii. Many farming lands available iii. Others (specify)..........

43. When do you think shifting cultivation started in the area? (In years)

i. 0- 5 ii. 6 – 10 iii 11- 15 iv. 16 – 20 v. > 20

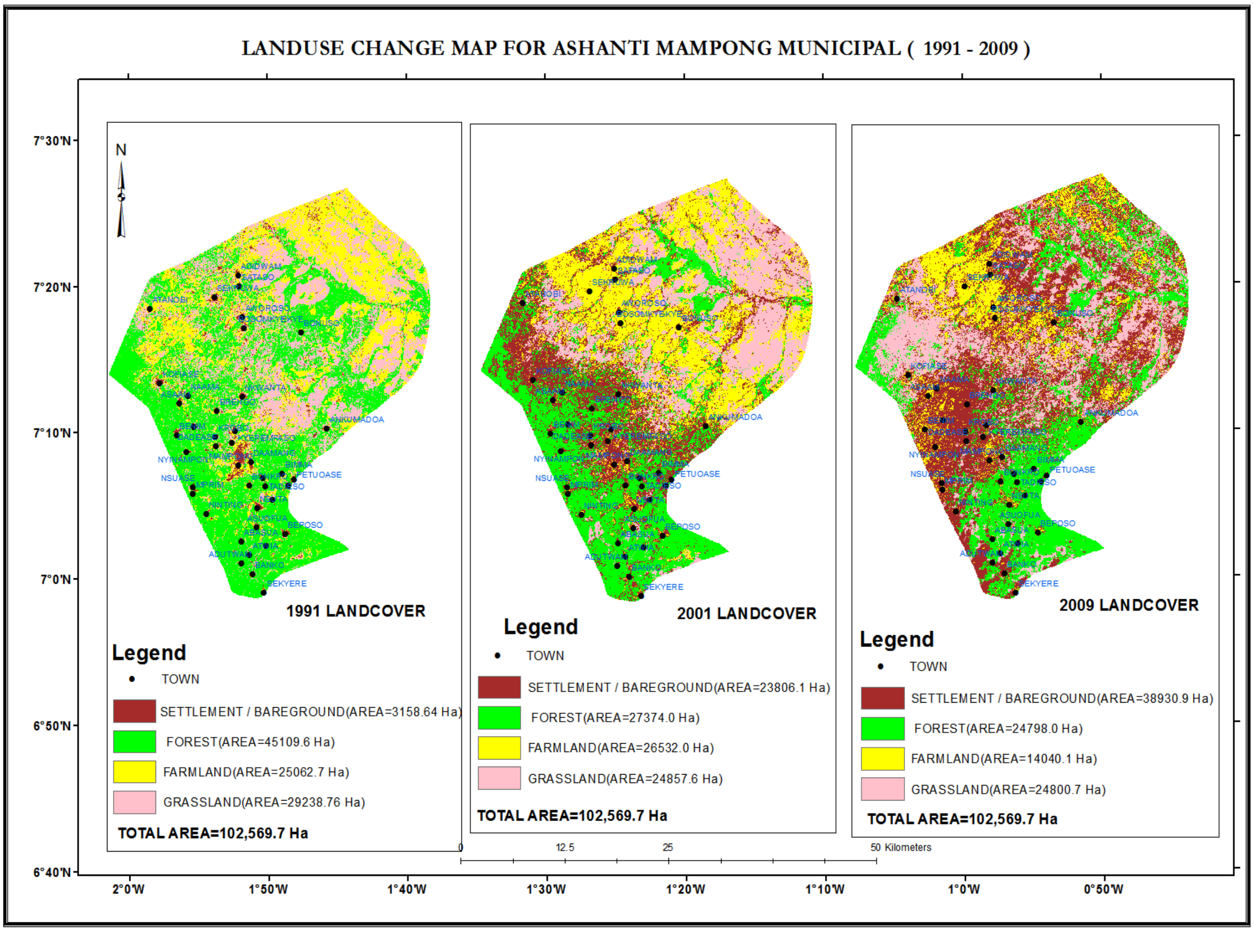
44. What measures do you think should be implemented by the government to combat bush burning?

i. Strong enforcement of laws ii. Proper policies iii. Coordination between stakeholders

45. What is(are) the impact(s) of shifting cultivation?

i. Destruction of lands ii. Deforestation iii. Biodiversity loss iv. All

Appendix 6: Combined land use map for Mampong Municipal



Appendix 7: Photographs of the field

Plate 1: GPS Point location at Kofiase

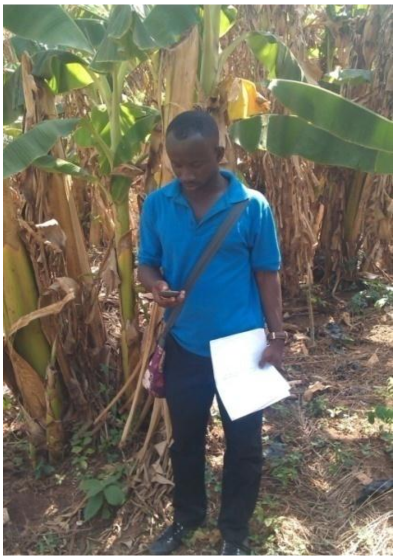


Plate 2: GPS Point location at Mampong

Plate 3: Questionnaire Survey with locals at Daaho

Plate 4: Questionnaire Survey with locals at Benem

Plate 5: A visit to the FSD office, Mampong