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Assessment of the forest cover change in the Forest-Savannah transitional zone, Ghana between 1990 – 2013 using remote sensing and GIS

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Abstract: Anthropogenic activities such as agriculture, mining, construction, and others have acted as alteration agents on landscapes and have over the years had an intense effect on forest cover. Since forest cover and its changes can dramatically affect soil, water quality, and water supply, Ghana faces difficult choices if it is to support rational and optimal use of its remaining forest resources. This study sought to draw attention to the major changes that have occurred in the forest cover of the forest-savannah transitional zone of Ghana over the past two decades (1990–2013). It also addresses causes and impacts and proposes approaches to address the root cause of the problems using multi-temporal remote sensing data and Geographic Information System-based techniques. The key findings include a big decline in forest of the area over the past 20 years. From the survey conducted, over 80% of respondents believe that the main driver of the declining forest cover is anthropogenic in nature. It is proposed that effective, sustainable, and environmental-friendly forest management policies be implemented through inclusive participation of key stakeholders in planning and management of forest and its resources.

Keywords: Forest cover, forest-savannah transitional zone, remote sensing, land-use and land-cover change (LULC)

1. Introduction

Large portions of forest landscapes on the Earth’s surface have been significantly altered or tampered with, in some manner by humans (Yang, 2003). The leftover forest ecosystems in West Africa including Ghana, have a lot of natural endowments (e.g. wood and non-wood forest products) and provides regulating services (e.g. climate, water and disease regulation) that are important for economic development and for sustainability of livelihood supporting systems (Locatelli et al., 2008; Seppälä, 2009; Tachie-Obeng et al., 2009; Locatelli et al., 2011). The forests’ ability to continue to provide these services and perform other functions is mostly determined by climatic conditions and human interference (Tachie-Obeng et al., 2009; 2010). Anthropogenic activities such as agriculture, mining, deforestation, construction, and shifting patterns of land use are primary components of many current environmental concerns as land-use and land-cover (LULC) change is gaining recognition as a key driver of forest cover change (Frimpong, 2011).

The condition of Ghana’s forest cover is not different. It has been deteriorating for many years, particularly since the 1970. Gyasi (1993) argues that in Ghana, there is an evidence of accelerated environmental change. The change is most noticeable in the soils, flora and fauna, which appears to be increasingly endangered in the entire agroecological zones, including the mosaic of forest-savannah (Benneh et al., 1990). Over the years, there has been a progressive decline in size, quality and number of forest reserves. They are heavily encroached and degraded and the off-reserve carbon stocks are being rapidly depleted (GFIP, 2012). Many published works, national and international policy documents, suggest that Ghana's forest zone (roughly 8.6 million ha) was intact around 1880 (Fair, 1992; Ebregt, 1995; Parren and de Graaf, 1995). The fact that there is only about 1.7 million ha of forest today, which exists only in reserves and that only about half of these are themselves in "reasonably good condition" suggests a precipitous decline. Thompson (1910) found in a survey of Ghana's forests that, "comparatively few tracts are covered with so-called primeval or virgin forest; the majority consist of secondary irregular growth that has sprung up in areas previously cleared for farms" (Thompson, 1910). Land-use practices at the local and regional levels have had dramatic effects on soil condition as well as water quality and water supply, which in turn have shown impact on vegetation cover, particularly forest cover. According to Gyasi (1993) before 1850, most of the present southern sector of the forest-savannah zone consisted of virtually uninhabited virgin high forest owned largely by the Akyem people. However, most of the forests, in the late twentieth century were not in good condition.

Verbal accounts suggest that areas now well within the moist, semi-deciduous forest zone (e.g. 30 km south of Sunyani) had extensive grasslands everywhere (Fairhead and Leach, 1998; 2010).

Ghana faces difficult choices if it is to support rational and optimal use of the remaining forest resource. The problems are familiar to most stakeholders, including government, civil society, the private sector, and the donor community. The development and implementation of sound and effective responses have proved challenging. Perhaps a good graphical presentation of the spatial extent and a convincing argument on the destruction of the forest cover, particularly the transitional zones where likely regeneration of forest, when degraded is close to zero, will serve as a clarion call for action. This age of space technology (environmental remote sensing) provides an opportunity for visualizing and quantifying the extent of forest degradation that are compelling to generate action.

The study envisages therefore carefully articulating the major changes to forest cover of the forest-savannah transitional zone of Ghana, its causes and impact and proposing approaches to address the root cause of the problems.

Questions addressed in this study are stated thus;

- What was the state of the forest 20 years ago?
- How much has the forest cover changed over the past 20 years?
- What are the primary drivers of the forest cover change within the study period?
- What is the impact of change on livelihood of the people?

It is therefore expedient that, this study tries to assess the forest cover change and trends in the forest-savannah transitional zone of Ghana from 1990- 2013.

1.1 Forest, forest cover change and implications for livelihood sustainability

The forest is known to be a valuable source of food, fibre, bio fuel, shelter and other bio-products. It provides the needs of the rapidly increasing world population, which is expected to reach 9 billion by 2050. Also, global records indicate that the total value of wood removals in 2005 was USD 64 billion whilst fuel wood brought in an additional USD 7 billion (FAO, 2005). Forest cover also plays an essential role for a country's economic growth and development but most often its importance is undermined and underutilized. Forests provide several raw materials for many industries including the paper and the construction industries. They also provide a multitude of raw materials for domestic industries and for export (FAO, 1994). In addition, forests play a critical role in regulating the world's climate and provide a variety of functions for people, including ecological, economic, social and aesthetic functions (Frumkin et al., 2017). A study found that the forestry sector provides employment for about 10 million people in the formal sector and 30 to 50 million people in the informal sector across the developing countries. Similarly, it is estimated that in Ghana, the forestry sector accounted for 2% of GDP in 2012, although it represented a decline from 8%, a decade ago.

The forest plays a crucial role in maintaining ecological balance on earth. It is among the most important repositories of terrestrial biological diversity and offers diverse habitats for various species of plants, animals and micro-organisms (FAO, 2017). Forest cover is also a major player in sustaining water sheds, carbon management, clean air and the conservation of critical species and ecosystems (United States Department of Agriculture, 2012). Hence, forests are crucial in maintaining biodiversity and the earth's ecosystem in general.

In spite of the quintessential role of forest, there is a growing concern about the rate and direction of forest cover change in recent years. The increase in population globally is presently at a rate of 1.11% estimated at 80 million per year (Worldometers, 2017) and has therefore attracted the need to clear up forest spaces and turn them to habitable and economic ventures for man. Due to population growth, there has been a drastic reduction in forest cover over the past century. Over 129 million ha of forest (an area almost equivalent in size to South Africa) have been lost since 1990, according to FAO (2015). Numerous studies used global remote sensing data to highlight the fact that during the last decade, forests in the tropics have been rapidly declining (DeFries et al., 2002). Recent estimates indicate a decline of 5.5m hectare of forests per year between 2010 and 2015 in the tropics (Romijn et al., 2015). However, Africa and South America had the highest net annual loss of forests in 2010-2015, with 2.8 and 2 million ha respectively (FAO, 2017).

The dominant causes of the changes in forest cover include: the clearing of forest lands for agriculture, especially for cash crops such as cocoa, coffee, oil palm and rubber plantations; the loss of forest lands to settlements and the exploitation of forests for timber and non- timber products (FAO, 2017). These changes in forest cover have various implications on livelihood sustainability and development. The changes in forest cover disrupt the global water cycle (Chakravarty et al., 2012). Hence the gradual depletion of the forest cover implies that the region cannot hold as much water thereby creating a drier climate. Water resources affected include drinking water, fisheries and aquatic habitats, flood/drought control, waterways and dams affected by siltation, less appealing water-related recreation, and damage to crops and irrigation systems from erosion and turbidity (Chakravarty et al., 2012). These are directly affecting agro biodiversity and aquatic life thereby affecting those that depend on it for livelihood and economic purposes. The mismanagement of our forest resources also inhibits potential future revenues and future employment that could be derived from their sustainable management for timber and non- timber products. These concerns have created a much wider global concern and the need to know attitude as a precursor to any effort at addressing forest cover change. Practitioners, researchers and politicians have all come to this realization and hence the renewed global efforts focusing on ways to know what and where of forest cover change.

Systematic field sampling and remote sensing technology have been the pillars of data collection in monitoring and assessing forest cover change. Field data collection is done continuously or periodically on permanently established sample sites to assess changes and trends of forest resources and characteristics. Remote sensing is used to map the extent and spatial distribution (fragmentation and contiguity) of the forests and land uses based on a stable classification system for change analysis and integration with field data (Tavani et al., 2009).

Traditional method of Surveying and taking inventory of trees originated in Europe in the late 18th century out of a fear that wood (the main source of fuel) would run out. The first information was organized into maps used to plan usage. In the early 19th century forest harvesters estimated the volume and dispersal of trees within smaller forests with their eyes. More diverse and larger forests were divided into smaller sections of similar type trees that were individually estimated by visual inspection. These estimates were related together to figure out the entire forest's available resources. Hence, these were not effective since such surveys could not cover a wide area due to the impenetrability of the forest. Over the years, the inventory for forested regions has been greatly influenced by political agendas. For almost 40 years after the Second World War, ample forest inventory data were collected to provide information needed for forest management at the local level, but forest information at the national level was of secondary importance (Reddy et al., 2013).

Capacities of tropical countries to monitor forests and forest cover change were limited in the past change in the sustainable wood production capacity of the world's forests, including industrial wood and fuel wood at a global level of a potential is missing, as is knowledge about actual harvests and needs, to be compared to that potential. However, through capacity building efforts capacities are strengthening at technical, political and institutional levels (Herold and Skutsch, 2011; Romijn et al., 2015). A few countries like Mexico and India had well developed national forest monitoring systems even in past times. Other countries are in the process of developing capacities and are at various stages of development, they need considerable capacity improvements before they are able to produce accurate estimates of forest area, forest area change and carbon stock change (Tulyasuwan et al., 2012). In more recent years the use of remote sensing technology which involves measuring or acquiring information about surface properties using sensors typically found onboard aircraft or satellites has gained momentum. Remote sensing provides a systematic, synoptic view of earth cover at regular time intervals and useful for changes in land cover and to reveal aspects of biological diversity directly (Turner et al., 2003; Cohen and Goward, 2004; Alqurashi and Kumar, 2013). Estimates of change in forest cover based on satellite data can help researchers to understand the likely outcomes in terms of carbon dynamics**,** climate change and threats to biodiversity. Satellite data, particularly Landsat TM (Thematic Mapper) and ETM+ (Enhanced Thematic Mapper plus) series of sensor, have been important tools in the interdisciplinary study of tropical forests that are increasingly integrated into studies that monitor changes in vegetation cover within tropical forests and tropical protected areas and also applied with other types of data to investigate the drivers of land cover changes (Trigg et al., 2006; Kumar et al., 2010; Alqurashi and Kumar, 2013). Remote sensing technologies have been effective in monitoring forest cover changes in regions such as the Amazon basin (Skole and Tucker, 1993) and the Gunung Palung National Park in West Kalimantan, Indonesian Borneo (Trigg et al., 2006).

2. Methodology

2.1 Study area

The study area consists of six political administrative districts in the Brong-Ahafo region which fall within the Forest Transitional Zone of Ghana (Figure 1). The districts include: a) Berekum Municipal, b) Tano North, c) Dormaa East, d) Dormaa Municipal, e) Sunyani West, and f) Sunyani Municipal. The total land area covered by the study area is approximately 526,400.28 ha. It lies between Latitudes 7^0 20’N and 7^0 05’N and Longitudes 2^0 30’W. It falls largely within the Moist – Semi Deciduous Forest Vegetation Zone. The area forms the transitional zone between the forest zone of the south and the savanna zone in the north. The vegetation zone covers forests with timber species, tree crops such as cocoa, citrus, and others. Because of lumbering and farming practices, most of the forest areas have been degraded. Re-afforestation is therefore being undertaken in the forest reserves to reverse the trend.

The average rainfall between 2000 and 2009 was 88.987 cm. The area experiences a double maxima rainfall pattern. The main rainy season is between March and September with the minor between October to December. This offers two farming seasons in a year which supports higher agricultural production in the area. However, the rainfall pattern of the study area is decreasing over the years because of deforestation and depletion of water bodies caused by human activities. The area falls within the Wet Semi-Equatorial Climatic Zone of Ghana, with the mean monthly temperatures varying between 23 ºC and 33 ºC with the lowest around August and the highest being observed around March and April.

2.2 Data and data analysis

The use and management of forest resources need to be based on the mapping and inventory of the forestry environment. Similarly, the changing state of the forest, as a result of natural or human-induced causes (felling, clearing, fire, reforestation decline, regeneration, etc.), also need to be monitored. Remote sensing and GIS provide for the continuous monitoring of forest developments by detecting changes and integrating results into existing databases (FAO, 1999). The aim of this paper was to determine the forest cover change from 1990 through 2000 to 2012. Landsat images were used to determine the changes that have occurred. Secondary data was collected to aid in identifying land use or cover of the location and was also used in comparison and verification and to update to what was shown on the image.

In addition, primary data was collected from the field. About 40 key informants including the youth (both male and female) were interviewed. It was backed by focus group discussions to find out the state of the forest now and years back. The respondents were purposively selected, thus from among farmers or indigenes who had worked or lived in the community for over 10 years. Figure 2 is a workflow showing steps in involved in the processing of the satellite images for the study.

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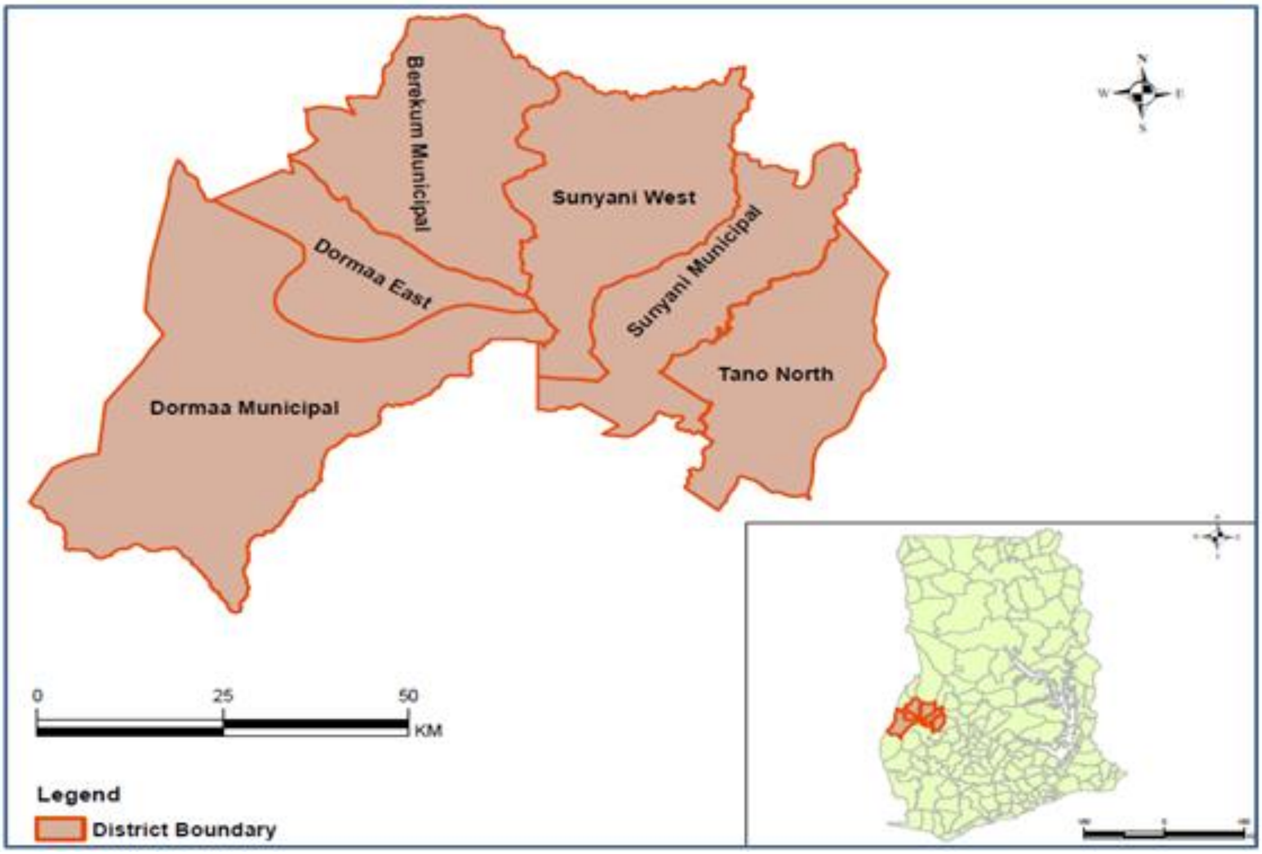

Figure 1: Map of the study area

Calibrations: Digital images collected from space borne sensors often contain systematic and unsystematic geometric errors. Geometric corrections are conversion of data to ground coordinates by removal of distortions due to the Earth's curvature and sensor motion. They are very necessary prior to any image analysis. If any measurement distortions are on an image (i.e. direction or distance) it must be rectified (Wireko, 2015). Radiometric calibration was also done. These calibrations were done in Envi 5.3 software using landsat calibration utilities. Further atmospheric calibration was done using FLAASH model in Envi 5.3. geometric calibration was performed using control points obtained from Survey and Mapping Division of Lands Commission. Ground truthing was performed to complement or validate the satellite images.

Development of a Classification Scheme: Based on prior knowledge of the study area, and a brief reconnaissance survey, with additional information from previous research in the study area, a classification scheme was developed for the study area. The classification scheme developed gives a rather broad classification where the land cover was identified by a single digit. Using Envi software, a supervised classification was employed in the classification. It is a procedure for identifying spectrally similar areas on an image by identifying 'training' sites of known targets and then extrapolating those spectral signatures to other areas of unknown targets. Small and discrete areas were used to "train" the classification algorithm to recognize land cover classes based on their spectral signatures, as found in the image. The training areas for any one land cover class need to fully represent the variability of that class within the image. There are numerous factors that can affect the training signatures of the land cover classes. Environmental factors such as differences in soil type, varying soil moisture, and health of vegetation, can affect the signature and affect the accuracy of the final thematic map. In each cover class, samples of between five (5) and eight (8) were selected.

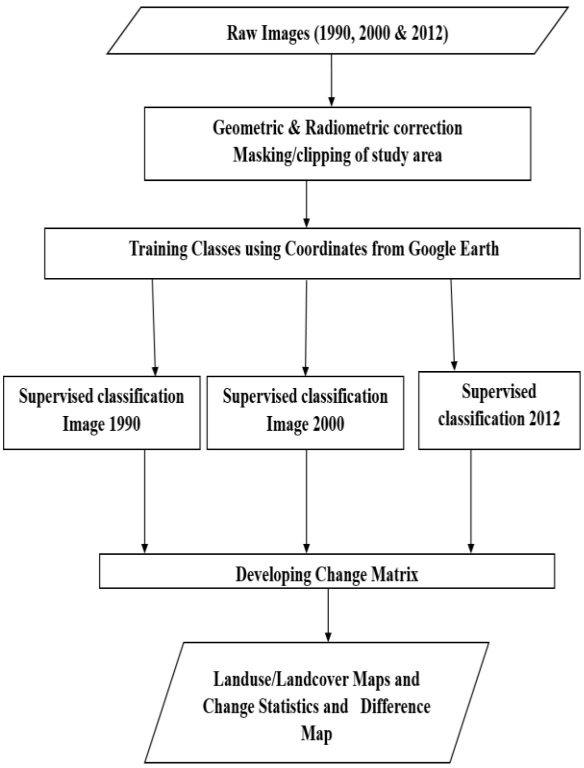

Figure 2: Image processing workflow

These factors were taken into cognisance to help give an accurate classification scheme. Numerous aspects were considered when supervised classification was being conducted. The first was developing an appropriate classification scheme. Training areas must be selected for each of the classes and statistics calculated for them. The appropriate classification algorithm must be selected, and once each pixel in the image (including the ones used as training areas) are evaluated and assigned to a land cover class, the accuracy of the classification has to be assessed. The classification algorithm used was the Gaussian Maximum Likelihood. The sampled training sites were converted into KML and opened in Google high resolution image for validation for accuracy. In all 98% of samples were accurately selected before the classification scheme was accepted and applied. A Gaussian Maximum Likelihood classifier was applied. This method evaluates the variance and co-variance of the various classes when determining in which class to place an unknown pixel. The statistical probability of a pixel belonging to a class is calculated based on the mean vector and co-variance matrix. A pixel is assigned to the class that contains the highest probability.

When the classification was conducted, an accuracy assessment was made to determine how correct the classified image is. An accuracy assessment involves the determination of the overall accuracy of the classification, errors of omission, errors of commission, producer's accuracy, and consumer's accuracy. All measures gave an indication of how well the classification of the image was conducted.

Image Classification: Classification is a process of sorting pixels into finite number of individual classes, or categories of data, based on their data file values. If a pixel satisfies a certain set of criteria, then the pixel is assigned to the class that corresponds to that criterion. Landsat TM/ETM+ image for 3 different years namely 1990, 2000 and 2012 was classified using the supervised classification scheme provided by the ENVI image processing software. This classification was guided by many observations made on the ground. Classified TM pixels were in four basic categories: Water Bodies, Settlement / Bare-grounds, Secondary Vegetation, and Primary Forest (Table 1). It is common practice to make two or more iterations of a classification process, to improve the accuracy of the result. However, with each iteration, the test sites would be edited to better reflect the representation of their class and to remove or reduce any class overlap. In this classification, we made six (6) iterations.

Change detection method was based on post-classification image differencing analysis where classified images of two intervals, are compared pixel by pixel. This method produces pixels under a particular land cover at the beginning year and compare the same pixel of the next year to determine whether the pixel has changed or not. The results are a change matrix of cover types showing from and to cover. The change statistics is a sum of pixels under the cover types at different years and this is interpreted as land cover type before and after, and which are often converted into percentage change.

Table 1: Land cover classification scheme

CODE	LAND COVER CLASS
1	Water Bodies
2	Settlement / Bare-ground
3	Secondary Vegetation
4	Primary Forest

In this study, the primary data from the key informants were analysed qualitatively, in the form of quotations, and samples were used in supporting the discussion

3. Results and discussions

3.1 Forest cover change analysis

The study focused on forest cover change using the 1990 cover as the base year. The comparison of land cover maps of 1990 and 2000 showed a considerable change in primary forest, secondary vegetation, bare ground and this is illustrated in Table 2. There is a clear decrease in primary forest coverage, but increase in land cover types like secondary vegetation, bare ground and water body. However, there are only some negligible changes in water bodies. In summary, there was a total of 169700.85 ha of primary forest in 1990 which reduced to 98574.21 ha, indicating a reduction of -71247.87 ha (-42%) from 1990 to 2000. Also, secondary vegetation changed from a total of 376172.01 ha to 325243.08 (about -13.5%) ha in 2000 to bare-ground or other settlements.

Specifically, as indicated in Table 2, 5.40 ha of water bodies turned to 'secondary vegetation' from 1990 to 2000. About 72619.29 ha of primary forest was maintained from 1990 to 2000, whilst 80130.6 ha and 16938.90 ha changed to secondary vegetation and bare ground respectively. This shows that, there is drastic change happening, mainly to forest vegetation cover. One important analysis that needs to be done is to probe whether these changes are to human and societal benefit.
Interestingly, about 25315.47 ha of secondary vegetation was noted to have turned to primary forest, from 1990 to 2000. This could be argued that, some parts of the vegetation contained young trees and scrubs, which without any disturbances for over ten years built into thick vegetative cover. It could also mean that the area was possibly mostly covered with sparse forest in 1990, which now have grown into a dense forest, being a good example of forest improvement.

Dense forest, being a good example of forest improvement. The rate of deforestation is found to be considerably higher than forest improvement as shown table 2. Table 3 compares the cover types between 2000 and 2012. It shows that 18233.67 ha of primary forest changed to secondary vegetation whiles

Table 2: Land cover differencing statistics (1990 – 2000)

Year	1990 - Area (hectares)					
	Land Cover Class / Cluster	Water body	Bare ground	Secondary Vegetation	Primary Forest	Total
2000 (Final)	Waterbody	0.00 (0.00%)	31.59 (0.09%)	108.00 (0.03%)	12.06 (0.01%)	151.65
	Secondary Vegetation	5.40 (100%)	24426.99 (72.64%)	271609.02 (83.51%)	80130.6 (47.22%)	376172.01
	Bare ground	0.00 (0%)	8529.84 (25.37%)	28210.59 (8.67%)	16938.9 (9.98 %)	53679.33
	Primary Forest	0.00 (0%)	639.45 (1.90%)	25315.47 (7.78%)	72619.29 (42.79%)	98574.21
	Total	5.4	33627.87	325243.08	169700.85	528577.2

Table 3: Land cover status by class / cluster (2000 - 2012)

Year	2000 - Area (Hectares)					
	Land Cover Class / Cluster	Water body	Bare ground	Secondary Vegetation	Primary Forest	**Total**
2012 (Final)	Water body	3.24 (2.11%)	612.43 (0.16%)	260.45 (0.48%)	663.46 (0.67%)	**1539.58**
	Secondary Vegetation	14.67 (9.54%)	177745.53 (47.14%)	7565.33 (14.09%)	18233.67 (18.46%)	**203559.20**
	Bare ground	0.00 (0.00%)	10134.57 (2.69%)	26.55 (0.05%)	38145.34 (38.63%)	**48306.46**
	Primary Forest	135.81 (88.35%)	188553.64 (50.01%)	45857.55 (85.38%)	41713.00 (42.24%)	**276260.00**
	Total	**153.72**	**377046.17**	**53709.88**	**98755.47**	**529665.24**

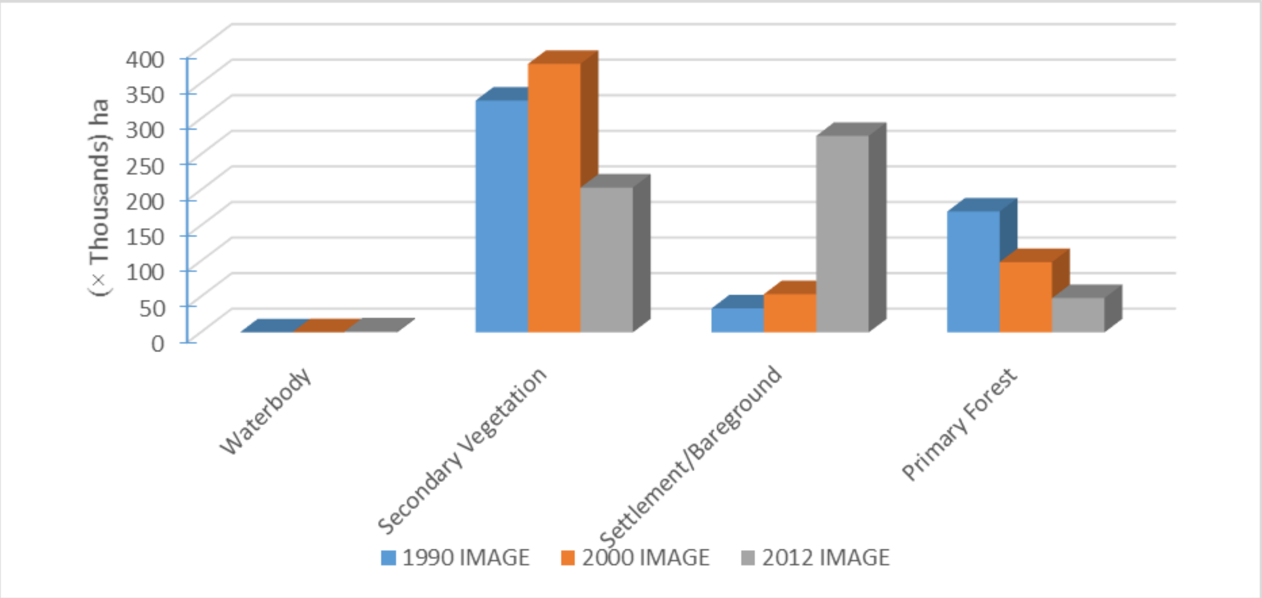

Figure 3: Bar graph comparing changes in land cover types for 1990, 2000 and 2012

The rate of deforestation is found to be considerably higher than forest improvement as shown table 2. Table 3 compares the cover types between 2000 and 2012. It shows that 18233.67 ha of primary forest changed to secondary vegetation whiles 38145.34 ha changed into bare lands. Remarkably, 14.67 ha of water bodies have turned to secondary vegetation and in some cases primary forest from 2000 to 2012. This could be due to growth of vegetation in wetlands and drying up of water bodies, galamsey (Illegal small-scale gold mining) activities destroying river sources etc.

Interestingly, as high as 41713.0 ha of primary forest remained forested for period of 12 years, extending between the year 2000 and 2012. It is remarkable to contend that, people are now appreciating the need to halt the felling of trees and growing new ones to replace already destroyed ones. Again, as high as 10134.57 ha of bare ground remained same between 2000 and 2012. Figure 3 is a bar graph showing comparison between the four land cover types over the years.

Figure 3 shows that in 2000, secondary vegetation increased. This may have been because a lot of forest had been cut down for farming activities like slash and burn', timber, or used for other purposes. It also indicates that primary forest and secondary vegetation are giving way seriously to settlements and bare-ground. Though, the changes in water body appears to be insignificant, key informant respondents were gripped with fear that the rate at which their water sources are drying up while the available few are also being seriously polluted by illegal miners, if care is not taken, may reach crises levels. These, according to the Community members, have led to them to depend on sachet water (filtered and bagged water) for drinking and cooking. The degradation is a big threat to sustainable biodiversity and food security of the country, there is therefore an urgent need for an effective land-use planning that stresses forest restoration and improvement practices. Below are the land cover classification maps of study area (1990, 2000 and 2012) showing the spatial pattern and change.

Figure 4 shows that in 2000, secondary vegetation increased. This may have been because a lot of forest had been cut down for farming activities like slash and burn', timber, or used for other purposes. It also indicates that primary forest and secondary vegetation are giving way seriously to settlements and bare-ground. Though, the changes in water body appears to be insignificant, key informant respondents were gripped with fear that the rate at which their water sources are drying up while the available few are also being seriously polluted by illegal miners, if care is not taken, may reach crises levels. These, according to the Community members, have led to them to depend on sachet water (filtered and bagged water) for drinking and cooking. The degradation is a big threat to sustainable biodiversity and food security of the country, there is therefore an urgent need for an effective land-use planning that stresses forest restoration and improvement practices. Below are the land cover classification maps of study area (1990, 2000 and 2012) figures 3, 4 and 5 respectively, showing the spatial pattern and change.

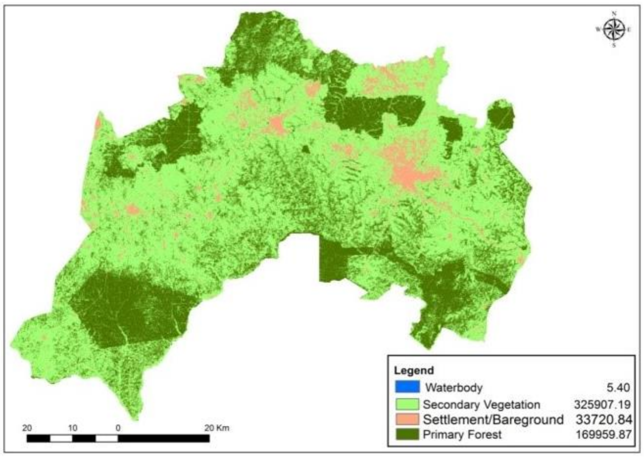

Figure 4: Land cover map of study area - 1990

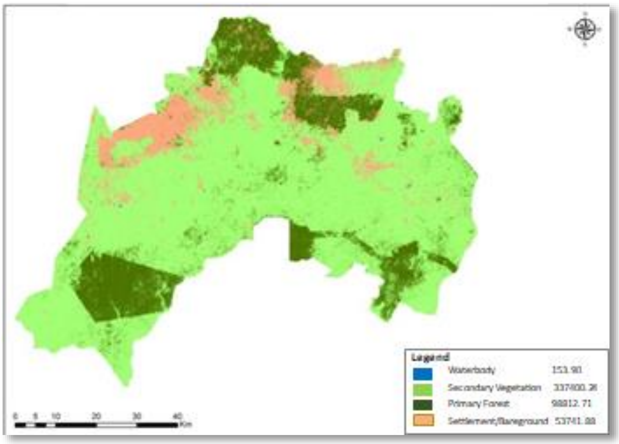

Figure 5: Land cover map for study area – 2000

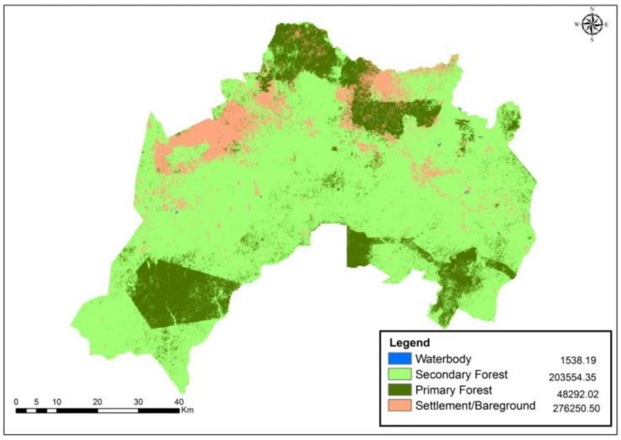

Figure 6: Land cover map of Study Area - 2012

From figure 7 above, a Change Difference Map was used to produce image difference between 1990 and 2012, initial state and final state images (that is, final - initial) and the classes were defined by change thresholds of 6. A positive change shows all areas above the threshold of 6 identifies pixels that became brighter meaning they gained vegetation (final state brightness was greater than the initial state brightness); while a negative change identifies pixels that became dimmer, meaning they lost vegetation (final state brightness was less than initial state brightness). It is clear that primary forest in the area has changed drastically (over 80%) to other forms of cover from 1990 to 2012. Some have turned into secondary vegetation and bare-ground etc. The causal factors include climatic variations, shortage in rainfall pattern/ periods, increase in built up sections of the community etcetera. These all add up to the vegetation cover changes observed in the study community.

3.2 Local perception of the forest cover change

The study also sought the views and experiences of local residents concerning forest cover change in their area over the last 20 years (1990-2012). The study selected 40 key informants from 20 towns of two (2) participants from each town. Since this section was interested in historical change, the target was two older people of above 70 years; one (1) male and one (1) Female. The selected person was on the recommendation of the District Assembly Man of the town. The person must be a knowledgeable person who can and is willing to share his or her experience. The respondents' views were analysed qualitatively. Their narratives confirmed the observations from the satellite data analysis. It was found that there was a very big decline in forest and moreover, there has been a big change in the state of forest between 20 years ago and now. This is being confirmed by GFIP (2012), that over the years, there has been a progressive decline in size and quality of many forest reserves. They are heavily encroached and degraded and the off-reserve carbon stocks are being rapidly depleted. Furthermore, the condition of Ghana's forests has been in decline for many years, particularly since the 1970s. More than 90% of respondents testified that, in about 20 years ago, the area was within a very thick, heavy forest, with all kinds of timber species and wild animals, not forgetting wild fruits of all kinds.

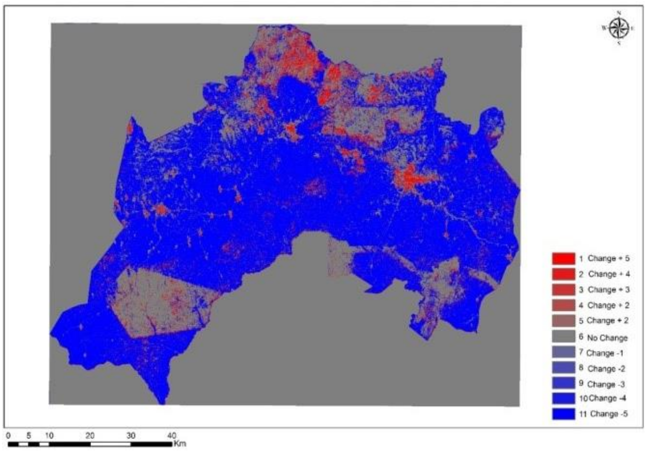

Figure 7: Land cover difference map indicating the changes and trend from 1990 to 2012

The study has been confirmed with the respondents testifying the presence of thick dark forest with many animals. The main crop was cocoa and big timber logs but now, it is said that one can't plant cocoa on large scale as before as the whole area is gradually turning into grass. Figures 8 and 9 show cocoa farms and the current forest cover outlook.

Figure 8 shows a typical cocoa farm in the area, a village about 30 km from Sunyani. It was a common scene and almost every household owned a cocoa farm. Majority (over 80%) of the people claimed they could walk throughout cocoa farms to Sunyani about 40 km and beyond. But now, as shown in Figure 9, the forest is degrading to scrubs and grassland within the last 20 to 30 years. Unfortunately, at present, over 80% of the people think, the forest is depleting and is gradually transiting to savannah and grassland. Majority believe that there is about 30% secondary forest left, which cannot be compared to the virgin forests they saw.

Figure 8: Forest with cocoa farm in study area

Figure 9: The forest is depleting to grassland

One of the respondent also testified the presence of thick forest of about 40 km and used to experience frequent heavy down-pours, that took several days before the ground could dry up while recently, after the rains, the whole place gets dried up quickly. The situation is buttressed by Gyasi (1993) who argues that in Ghana, there is evidence of accelerated environmental change. The change is most noticeable in the soils, flora and fauna, which appear to be increasingly endangered in the entire agro ecological zones, including the mosaic of forest-savannah (Benneh et al.,1990).

To them a larger part of the community forest is turning to shrubs, and some parts gradually becoming bare. They are of the view that, the root cause of the forest depleting is poverty manifesting in different ways of land use and management practices. Poverty has led to over drawing of the environment as a way of ensuring survival.

3.3 Causes of forest cover change

Over 80% of respondents who said that the forest is seriously deteriorating also believe that the causes are anthropogenic in nature. The major human activities in their view, that are causing deforestation and land degradation in the area include lumbering activities, frequent cutting down of trees for farming thus 'slash and burn', use of chemicals (insecticides and weedicides) for farming, and bush fires among others. This is in line with the UNEP (2000) claim that major direct causes of forest degradation brought on by humans include overharvesting of industrial wood, fuel wood and other forest products, and overgrazing, though forests are also susceptible to natural factors such as insect pests, diseases, fire and extreme climatic events. Lumbering, which destroys hundreds of young trees and farms are of a big concern to the community members. Though, there are bye-laws guiding the mode of their operation currently in the country and in the district, most of the youth are surprisingly engaging in illegal chain-saw operation in felling trees even at night and at times in the middle of the deep forest. It came out that; some pupils drop out of school to indulge in this 'get-rich-quick' chain-saw business to the detriment of their education, which is a major concern for parents, head-teachers and some chiefs. It was found that, the head teacher of the only JHS in Berekum, had to go through the forest to look for school going children in JHS 2 to come and register for the Basic Education Certificate Examinations. There is the need for community forest watch dogs and monitors to control the rate of bush burning.

'Slash and burn', a traditional practice of clearing the land before planting is found to be degrading the land rapidly because of population pressure and land scarcity, 'a cleared piece of land' does not get enough fallow period to rejuvenate. The serious felling of trees and weeding too close to river banks are causing a lot of small streams to dry and the temperatures are too high especially at night. The findings confirmed the argument that, land-use and land-cover changes directly impact biotic diversity worldwide (Sala et al., 2000); contribute to local and regional climate change (Chase et al., 1996) as well as to global climate warming (Houghton et al., 1999).

The study found that the Extension Officers do not visit the farms regularly as expected to sensitize them on important farming practices. About 75% of farmers were of the view that the application of chemicals (insecticides and weedicides) on farms contributes to the deteriorating nature of soil. After the application of the weedicide for a long time, they see the soil looks too dry, with deep cracks and not manageable as before. One of the youth leaders said, he has adopted a strategy of applying the weedicide only once in the crop season, that is just after sowing, but weeds manually with hoes and cutlasses for the subsequent clearings for restoration of nutrients of the soil. They are of the view that, too much chemicals dry-up the soil and could possibly destroy useful bacteria and insects that might be contributing to natural restoration of soil.

Bush burning was also said be initiated by hunters for game meat during the harmattan season, palm-wine tappers, charcoal burners, and at time 'slash and burn' farm preparation strategies, which leads to spread of fires at times beyond control. This causes a lot of destruction of food, property, and at times even human lives. The land becomes very bare, open and dry, with its attendant famine, water shortages, and disease. The root cause of these malpractices was found to be poverty related. One man said, he often depends on hunting during harmattan to pay the school fees of his children, and to him, it is lucrative. He argued that in order to stop him from doing that, he would need to be offered an alternative livelihood source, which he is familiar with. This buttresses an existing position made that 'high rates of deforestation within a country are most commonly linked to population growth and poverty, and shifting cultivation in large tracts of forests (Mather and Needle, 2000). Further, Murphree, (1993) has also stressed that poverty is identified as both the cause and the effect of forest degradation.

Most people in rural settings especially women, still use fuel wood for cooking since they don't have access to liquefied petroleum gas. Most of them cannot afford and it appears not to be reliable because it could run short in supply at any time.

3.4 Impact of forest cover change on livelihood and eco-system services

The impact of deforestation and change in forest cover is huge. Almost, all respondents of key informant interviews mentioned that, the changes have made their farming activities difficult. There has been decline in yields due to low fertility in soil. This has led to poor sales and therefore income and grass took over all the farm produce.

Years back, there were a lot of ecosystem services like easy access to game, snails, mushrooms, and wild fruits according to their seasons. These served as reliable food security/ supplement, and reliable source of income for many families. It agreed with the philosophy that economic development is a prerequisite for sustainable natural resource use (Mellor, 1998). However, with depletion of the forest, all these services and benefits are being waded-off. Further, it came out clearly that, it was becoming extremely difficult for hunters to get animals during hunting.

There are reports of excessive heat, changes in temperature and rainfall pattern forcing farmers to adapt coping strategies and these are all signs of climate change and variability. This is also affecting the forest cover. Such changes also determine, in part, the vulnerability of places and people to climatic, economic or socio-political agitations (Füssel, 2010).

3.5 Specific recommendations

The forest is seriously depreciating/depleting, from all indications from the field report and satellite data analysis and as the adage goes, when the last tree dies, then the last man dies, so the question is: what needs to be done to reverse the situation? As such the study recommends the need for all stakeholders to come together to strategize, prioritize and plan strategically for forest and environmental management for sustainable livelihoods and development. Below are some specific recommendations for sustainable forest management and development:

- There is the need for re-enforcement of the forest guard policy to protect the forest. The communities involved could also form watchdog committee to monitor, to strengthen policy efforts on illegal felling of trees, as well as show their commitment for a good cause.
- There is the need for a massive community sensitization and education on forest and environmental management. Community members should understand and appreciate the meaning and benefits of sustainable forest management, through participatory approaches to get them understand as well as to own the processes.
- Through participatory strategies, the government, NGOs, Development partners etc. should bring in feasible terms for farmers on input supply (for example, fertiliser, and weedicides), soft loans/ credit on flexible payment terms.
- Reforestation and afforestation programs with community participation on a profit sharing basis and improvement in technology and management of plantation are required.
- Agricultural Extension Officers should have regular days of visiting farmers at home or on farms to do educational programmes as well as creating access to good practices on the ground.
- There should be alternative livelihoods measures put in place, like gari processing, bread making for women, vocational skills for the youth, etc.
- It is important that policy considers 'social security scheme' for farmers, scholarships for the needy but brilliant children, especially farmers' wards.
- Putting in place laws to regulate tree cutting, bush fires - during the dry season, which destroys our forest, so that small trees/plants will grow to replace old ones in 10 years. Hunters should stop hunting for animals in bush through bush burning and they must be monitored.

4. Conclusion

In the interest of sustainable development, and forest sustainability, the study has been able to assess the change in the forest cover of the Forest-Savannah Transitional Zone of Ghana over the past two decades (1990–2013). It established that, there has been a big decline in forest cover over the study period. Larger part of the study areas was found to be in thick forest in 1990s but are now fast depleting into savannah, which should be a serious concern. About 90% of respondents testified that, about 20 years ago, dense forests covered larger parts of the study area, with all kinds of timber species and wild animals, and wild fruits. However, the forest is depleting and is gradually transiting to grassland. Majority also believe that only about 30% of virgin forests of the past exist in present days.

The main cause has been identified as anthropogenic, thus felling of trees, use of fire for land preparation and for hunting, use of agro-chemical, and infrastructural development. To them a larger part of the community's forest is turning to shrubs, and some parts are gradually becoming bare or being used for other purposes. In some few cases however, it was found that other vegetative areas got converted to forest, which may be due to good forest management practices. The best way in keeping our forest for generations to come, is through participatory forest management practices that is guided by environmentally friendly policies.

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