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GEOSPATIAL ASSESSMENT OF DEFORESTATION OF SOKPONBA AND EHOR FOREST RESERVES IN EDO STATE, NIGERIA

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ABSTRACT

The study assessed the state of Sokponba and Ehor Forest Reserves in Edo State, with Landsat images of 1987, 2002 and 2018 using ENVI and ArcGIS software. One hundred copies of Questionnaire were also administered to elicit information from respondents. The study revealed that within the period of 31 years under study, Sokponba Forest Reserve has reduced from 28,913.63 hectares in 1987 to 1,578.15 hectares in 2018 while plantation and farmland increased from 15,357.96 ha in 1987 to 43,494.21 in 2018. Ehor Reserve also reduced from 11,128.86 hectares in 1987 to 3,242.28 in 2018. In the same vein, plantation and farmland increased from 1,424.97 hectares in 1987 to 9,323.28 hectares in 2018. The deliberate government policies of allocating compartment to timber contractors for logging and granting permit to farm in the Forest Reserves were identified as the major drivers responsible for the depletion of the Sokponba and Ehor Forest Reserves. Considering the consequential effects arising from deforestation the study recommends reforestation and taungya farming system for sustainable environment.

Keywords: Forest reserve; Depletion; Remote sensing; land use changes, communities, farming

INTRODUCTION

Forest Reserves are areas of forest designated by the government for the protection of trees growing or planted in order to preserve a particular type of habitat and its flora and fauna which are often considered rare or endangered (Usman and Adefalu, 2010; Farlex, 2014). Forest Reserves are thus areas of forests which are reserved and managed for conservation and to provide special opportunities for study or research. According to Oyebo (2006), Nigeria has a total of 1,160 constituted Forest Reserves, covering a total land area of 10 752,702 hectares, representing about 10% of the total land area. Forests, according to Food and Agriculture Organization (2010), provide support for one billion people that live in extreme poverty around the world and provide remunerative employment to more than one hundred million. They contain more than 80% of terrestrial biodiversity and provide essential environmental services such as soil conservation, watershed management, protection against floods and landslides, sources of industrial woods (Aweto, 1990; Ojonigu *et al.,* 2009), effective sink for carbon dioxide and release of oxygen (Oduntan *et al,* (2012).

Despite these benefits, forests are currently under severe human interference which is distorting its natural state and impacting negatively on the biodiversity composition and the environment. The continued indiscriminate cutting down of trees without replacement for constructions, fuel wood, agricultural purpose, grazing and hunting, has led to the degradation of the forest ecosystem, extinction of valuable trees, wildlife and loss of biodiversity. Cullen *et al*, (2011) are of the view that at least 18 percent of global greenhouse gas (GHG) emissions, a major cause of climate change worldwide is attributable to deforestation.

Dewan *et al (*2012) observed that since the launch of the first earth resource technology satellite (Landsat) in 1972, remote sensing has established its contribution in the monitoring of forest

resources. According to Foody, (2003) and Kumar *et al.*, (2010), the combination of the three Landsat sensors, MSS, TM and ETM+ have provided the longest time series of images suitable for monitoring changes in the earth's vegetation. Thus, Landsat data have been relied on to perform detailed assessments of changes in tropical forests worldwide. This can be seen in the works of Naemi and Tuomaala (2011) on forest degradation in Marakwet district, Kenya; Yohanna *et al* (2012) on monitoring of deforestation of south – west Nigeria; Okeke (2013) on Land Cover Change Analysis in the Afi-Mbe-Okwangwo Landscape Cross River State where he used multi-temporal remotely sensed images Landsat 5 TM, and 7 ETM+, from 1986 – 2010; Reddy *et al*, (2013) the quantification of forest cover changes and fragmentation; Ati *et al* (2010) assessment of change in Kagoro forest, in Kaduna State, Nigeria. While Akingbogun *et al* (2012) in their study, utilized 1972, 1984 and 2000 TM satellite remote sensing data to examine Eleyele Forest Reserve Plantation Degradation in North West Local Government of Ibadan in Oyo State of Nigeria, Njungbwen and Mbakwe (2013) analyzed deforestation of Uyo between 1969 – 2004, using Aerial photographs and Quick bird satellite imagery.

In like manner Mmon and Mbee (2014) in their study of Gele Gele forest reserve in Edo State observed that there is a steady growth of the population of the communities around the reserve which led to rapid decline and depletion of the rich biodiversity and biological resources in the reserve due to overdependence on the forest resources. On the other hand Aliyu *et al* (2014) in their assessment of the rate and the causes of environmental changes (land use / cover) in Fufore area of Adamawa State, through the application of Remote Sensing and GIS techniques utilized Landsat MSS 1972, TM 1987, ETM 1999 and 2007 Nigeria sat – 1 satellite images. While Saranya *et al* (2014) utilized geospatial techniques to quantify changes in forest cover and to map patterns of deforestation in Andhra Pradesh, India during 1930–2011, Adedeji *et al* (2015) in their study assessed and predicted changes in land use / land cover at Gambari forest reserve, Nigeria using Remote Sensing and GIS techniques. The study determined the magnitude, rate and dynamics of change in the spatial extent of the forest reserve between 1984 and 2014 using multi – temporal datasets (Landsat TM 1984 and 2000 and OLI/TIRS 2014).

All these works utilized geospatial techniques and results indicated decrease in forest reserves due to anthropogenic activities. None of the studies involved human dimension in the method of assessment of the state of the forest. Since man was responsible for deforestation and also at the receiving end, this study combines both Remote Sensing technique and questionnaire survey method in the research design.

FAO, (2010) observed that in Africa, Nigeria is among the five countries with the largest annual net loss of forest for 2000 - 2010, with 3.7 percent. The situation has not changed. Between the periods of 2005 to 2010, about 410,100 hectares of forest was lost per year. Batta *et al.*, (2013) confirmed that Nigeria has one of the largest rates of deforestation in the world; the country has lost 55.7% of its primary forest. Olakunle *et al.*, (2011) opined that the main drivers of deforestation in the country are agriculture, logging and mining. Considering the alarming rate of forest depletion in Nigeria and the consequential effect of global warming and flooding, it becomes paramount to monitor our forest reserve in Nigeria. This paper therefore assesses the state of Sokponba and Ehor Forest Reserves using satellite data and questionnaire survey to determine the drivers responsible for forest depletion in Nigeria.

Sokponba and Ehor Forest Reserves are tropical rainforest, rich in economic valuable trees such as Opepe, Afara, Mahogany, Albizia, Alstonia, Okwen and several others which are made up of three layers with a close canopy. These Forest Reserves serve as source of income generation to the government, communities and individuals, through lumbering, logging and farming activities taking place in the forest. The socio – economic activities of the communities in the study areas is mainly subsistence farming. Crops such as cassava, yams, plantain are cultivated.

MATERIALS AND METHODS

Study Area

Sokponba Forest Reserve located in Orhionmwon Local Government Area (LGA) (Figure 1) and Ehor

Forest Reserve in Uhunmwonde LGA (Figure 2) were selected out of 23 Forest Reserves in Edo State for detailed study (Figure 3). Sokponba Forest Reserve was constituted in 1912 while Ehor Forest Reserve was constituted in 1950. Sokponba Reserve covers an area of 49,210 hectares while Ehor covers a total area of 29,566 hectares. The total area coverage of the Forest Reserves under study is put at 78,776 hectares. The Sokponba Forest Reserve is located between latitude 6°12′10.49″N and 5°58′15.29″N and between longitude 5°49′46.42″E and 5°52′11.63″E. while the Ehor BC16/1 Forest Reserve spans between latitude 6°23′33.89″N and 6°26′10.38″N and longitude 5°57′55.42″E and 6°6′6.59″E. Sokponba Forest Reserve has 176 compartments, and Ehor 114 compartments. There are several villages in and around the forest reserves areas.

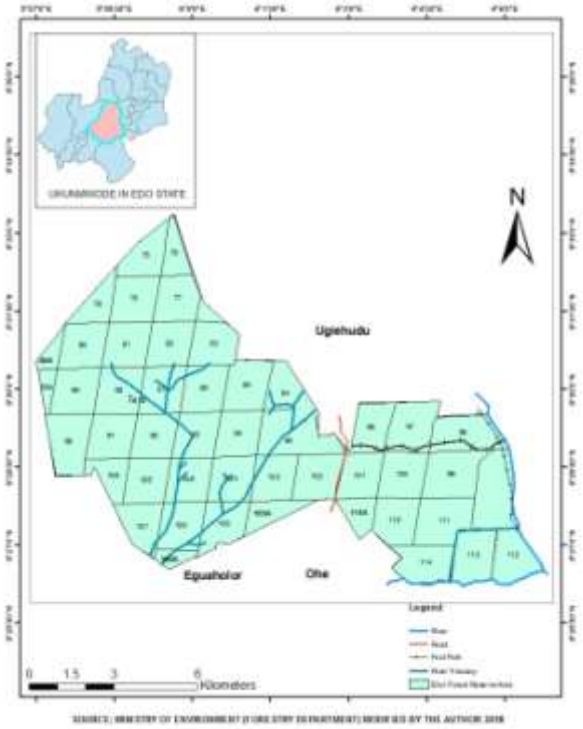

Figure 1:Ehor Forest Reserve

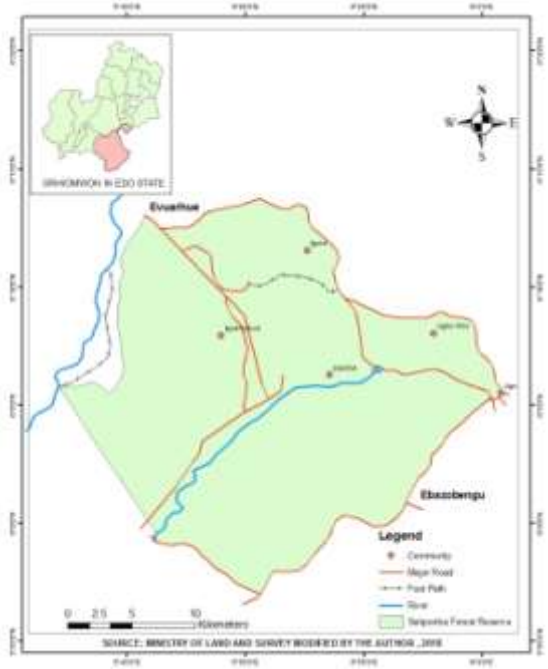

Figure 2: Sokponba Forest Reserve

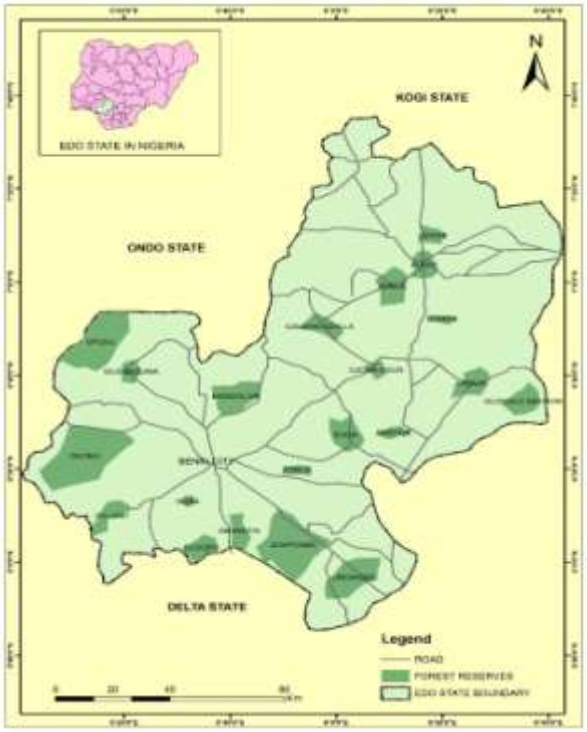

Figure : Forest Reserves in Edo State
***Source*:** Edo State Ministry of Environment, 2018

Experimental Design

Multi – temporal Landsat images of 1987, 2002 and 2018 of the study areas, with a resolution of 30 and 28.5 metres were used. What informs the choice of these images was the need for earliest and latest available images as at the time of the study that were cloud free and also the need to have an intermediate image with which to compare changes. Repeated visits to the study area were carried so as to have adequate knowledge of the prevalent and dominant land cover and land use types. This enabled accurate land use and land cover classification. Snowball sampling technique was employed in the administration of questionnaire to the target population in and around the reserves. This method involved asking an initial contact within a population to identify other potential

participants until the required number of sample size is reached. Basically, the population for this study consisted of farmers, timber contractors and forest guards. Since we do not know the potential respondents we needed an initial contact person within the population to identify other potential participants hence snowball sampling method was used. Six communities were purposefully selected from each reserve because of their proximity to the reserves. The communities chosen are Iguemokhua, Oben, Ugo, Iguere, and Evuarhue and Sokponba for Sokponba Forest Reserve and for Ehor Forest Reserve, Ugiehudu, Eguaholor, Ohe, Uhi, Egbisi and Uhie communities were selected. A total of 100 copies of questionnaire were administered for this purpose across the selected communities to elicit information from the respondents about their activities within the forest.

Images Processing and Analysis

The study employed the use of Landsat 4, 1987 TM; Landsat 7, 2002 ETM+ and Landsat 8, 2018 OLI / TIRS images. The three images corresponded with path 189, row 055 and 056 of the WRS-2. The images were cloud-free and had good radiometric quality as reported by the data provider. The entire images were already georeferenced and with a projected coordinate system of WGS_84_UTM_Zone_32N.

The clipping of the boundaries of the Forest Reserve areas was carried out using ArcGIS 10.1 and a colour composite of band 4, 3 and 2 was created because of its usefulness in vegetation analysis and forest monitoring. See Figures 4 to 9 for the colour composite images. These composites were imputed into Environment for Visualizing Images (ENVI) software via the external Landsat file format, Geostationary Earth Orbit Tagged Image File Format (GEOTIFF).

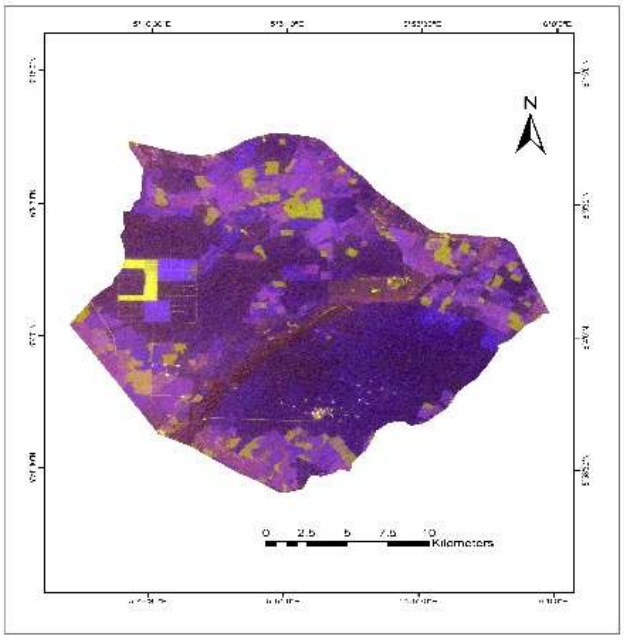

Figure 4: False Colour Composite of satelite imagery of Sokponba Forest Reserve for 1987

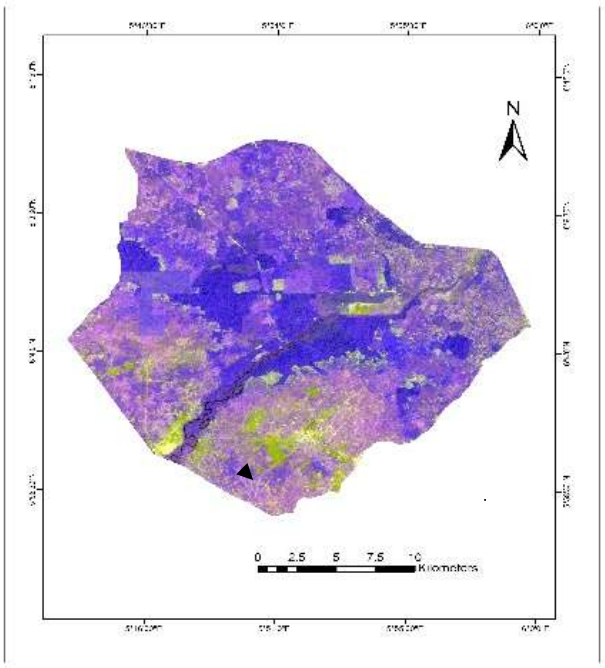

Figure 5: False Colour Composite of satelite imagery of Sokponba Forest Reserve for 2002

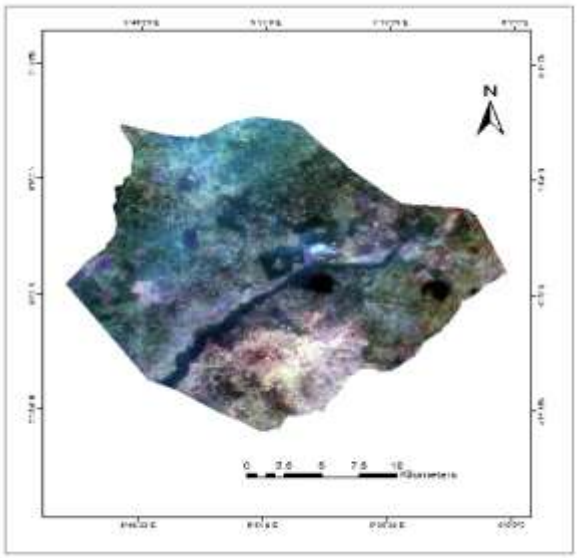

Figure 6: False Colour Composite of satelite imagery of Sokponba Forest Reserve for 2018

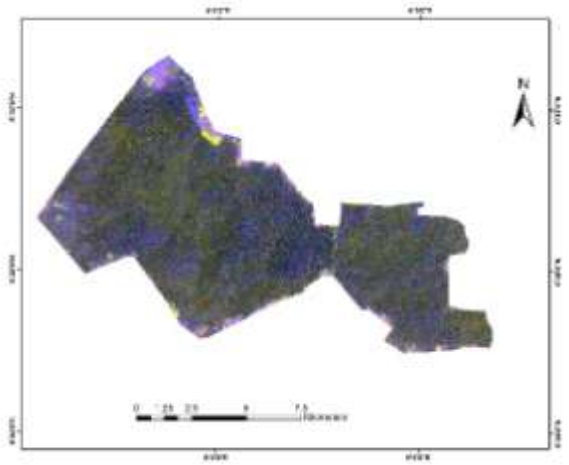

Figure 7: False Colour Composite satellite imagery of Ehor Forest Reserve for 1987.

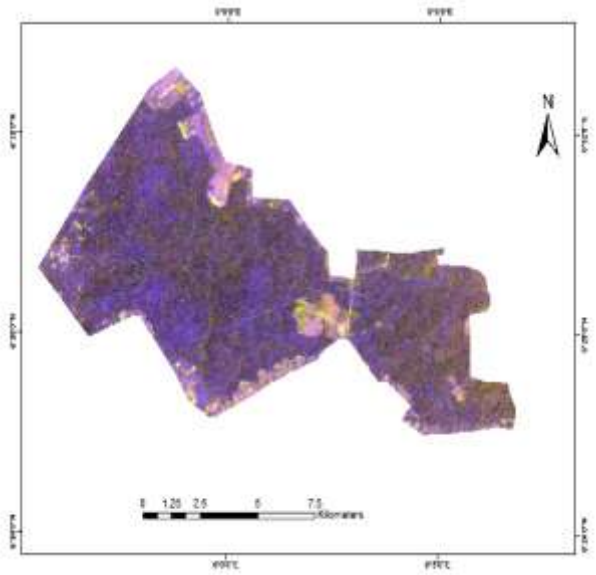

Figure 8: False Colour Composite satellite imagery of Ehor Forest Reserve for 2002.

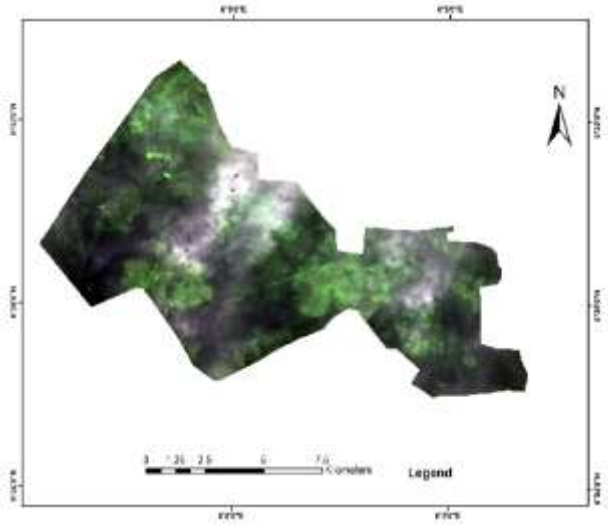

Figure 9: False Colour Composite satellite imagery of Ehor Forest Reserve for 2018.

Supervised classification method was employed by assigning pixel to classes. The knowledge obtained during reconnaissance visits to the study areas was used in the creation of Training Sites. Maximum likelihood classifier algorithm was used in transforming the spectral signature of the training sites into various land use and land cover types present in the study area (Table 1). Several other post classification algorithms such as majority analysis clump and sieve classes were used to refine the classification.

Table 1: Description of major land use land cover classification scheme

Classes	Description
Matured Forest	Forest with merchantable trees.
Light Forest	Secondary forest, shrubs and / or herbaceous vegetation association
Agricultural land	Arable land, permanent crops, pastures and heterogeneous agricultural areas
Water	Rivers and streams.
Settlements	These are villages within or around the reserves

Change Detection Analysis

Change detection statistic was used to compile a detailed tabulation of changes between two classification periods; 1987 – 2002, 2002 – 2018 and 1987 – 2018. While the statistics report included a class – for – class image difference, the analysis focused primarily on the changes which have occurred in the initial state classification. The analysis identified the classes into which pixels changed in the final state. Several methods (such as class statistics, overlay, and conversion of classification to vector) were adopted to identify, describe and quantify differences between images of the same scene at different times. This was useful in identifying the various classes which change from one class to another. The change statistic report table was divided into two, the initial state classes in the column and the final state classes in the row.

RESULTS

In Table 2, the genders composition of the respondents to the questionnaire administered to the residents of communities in and around Ehor and Sokponba forest reserves shows that 57 % were males, while females were 43 %. Among the respondents, 24. 0% do not have formal education, 39.0 % had education up to the primary school level while 21.0 % of them attended secondary school, 16. 0 % of the respondents have tertiary education. It could be said that majority of the population is literate and could understand the questions administered to them. Majority (87.0 %) of the respondents are farmers while timber contractor accounts for 13.0 %. This shows that farming and logging are the major activities going on in the various forest reserves.

Table 2: Social Economic Variables of Respondents

Demographic characteristics	Frequency	Percentage (%)
Gender		
Male	57	57.0
Female	43	43.0
Education		
No formal education	24	24.0
Primary education	39	39.0
Secondary education	21	21.0
Tertiary education	16	16.0
Occupation		
Farming	87	87.0
Timber contractor	13	13.0
Farm Location		
Forest Reserve	75	75.0
Free area	12	12.0
No response		
Source of Farmland		
Government	41	41.0
Individual	9	9.0
Community	28	28.0
Nobody	2	2.0
No response	20	20.0
Estimated cost per hectares		
>100,000	69	69.0
1000,000-200,000	1	1.0
No response	30	30.0

Demographic characteristics	Frequency	Percentage (%)
Duration of farming operation		
1-5yrs	28	28.0
6-10yrs	12	12.0
11-20yrs	5	5.0
20yrsabove	51	51.0
No response	4	4.0
Location of Logging		
Allotted comp in reserve	6	6.0
In reserve but not allotted	3	3.0
Free Areas	2	2.0
Both reserve and free areas	2	2.0
No response	87	87.0
Cost of Compartment		
200,001- 400,000	1	1.0
400,001 - 600,000	5	5.0
Above 600,000	3	3.0
No Response	91	91.0
Duration of Logging		
1- 5yrs	3	3.0
6-10yrs	6	6.0
No Response	91	91.0
Causes of change in the reserves		
Logging	40	40.0
Farming	29	29.0
Settlement Expansion	8	8.0
Bush fire	14	14.0

About 28.0% of the respondents have stayed for 1 - 5 years, those who have stayed for 6 – 10 years were 12.0 %, also 5.0% of them have stayed for 11 - 20 years and 51.0 %, have stayed for 20 years and above. More than half of the respondents have stayed long enough to give informed response to the questionnaire. About 75. 0 % of the farmers carry out their farming operations in the reserve, 12. 0% farm in free areas while 13. % of the respondent did not indicate the location of their farm lands. Among the farmers, 41.0 % indicated that they got their farm land from the government, 28. 0% from the communities, while 9.0 % of the respondents got theirs from individuals and 2. 0 % of the people decided to farm in the reserves without permission from anybody. About, 20. 0% of the farmers did not return answer to the question on source of their farmland.

Farmers who make use of the reserve pay certain amount of money for the use of the land annually. About 69.0 % of the respondents affirm that they pay below N100, 000 per hectare of land while 1.0 % says that they pay above N100, 000 per hectare of land. About 30.0% of the respondent decline answers to this question**.** Findings further reveals that about 31. 0 % of the respondents have been farming there for about 1-5 years, 33. 0 % for about 6 -10 years while 4.0 % and 6. 0 %, have spent 11 - 20 years and above 20 years respectively. This long numbers of years that farming has been taken place in the reserves account partly for the current state of the reserves.

Result of the analysis of the questionnaire shows that 3. 0 % of the timber contractors have been operating in the reserves for about 1 – 5 years, while 6. 0 % has worked there for 6 -10 years. Information from timber contractors shows that 6. 0 % of loggers carry out their logging activities in the state government allotted compartment while about 3.0 % illegally exploit the forest resources, 2.0 % of the contractor operates in free areas and 2.0%

operates both in the reserves as well as free areas. Majority (87%) of loggers decline response to the question. Finding shows that timber contractors who are allotted compartments in the reserves pay various amount of money to the government. About 1.0 % of the contractor agreed that they pay between N200,000 – 400,000 per compartment, 5.0 % pay between N400,001 – 600 -000 and 3.0 %, pay above N600, 000. Though 91% of loggers did not return answer to this question their response may not be too far from others. Respondents are aware that their activities are responsible for the changes in the forest reserves as 40% agreed that logging was responsible while 29% concur that farming was responsible. Accuracy assessments of the classified images were carried out and results (Table 3) showed high level of accuracy (above 84%).

Table 3: Confusion Matrix and Kappa Coefficient table of classified images

Forest Reserves/Year	Overall Accuracy	Kappa Coefficient
Sokponba 1987	(762/839) 90.8224%	0.8720
Sokponba 2002	(683/753) 90.7039%	0.8705
Sokponba 2018	(178/211) 84.3602%	0.7642
Ehor BC16/1, 1987	(395/423) 93.3806%	0.9003
Ehor BC16/1, 2002	(477/530) 90.0000%	0.8499
Ehor BC16/1, 2018	(459/510) 90.0000%	0.8503

Overlay operation was carried out by superimposing the shapefile of the various classes of land use / Land cover of 1987, 2002 and 2018 of a particular reserve on each other. The essence of this is to enhance effective visualization and to determine the extent to which the Sokponba and Ehor Forest Reserves have changed within the period under review. From the result obtained, it is obvious that the two Forest Reserves were severely depleted of its resources, as shown in Figures 10, 11 and 12 for Sokponba Forest Reserve and Figures 13, 14 and 15 for Ehor Forest Reserve.

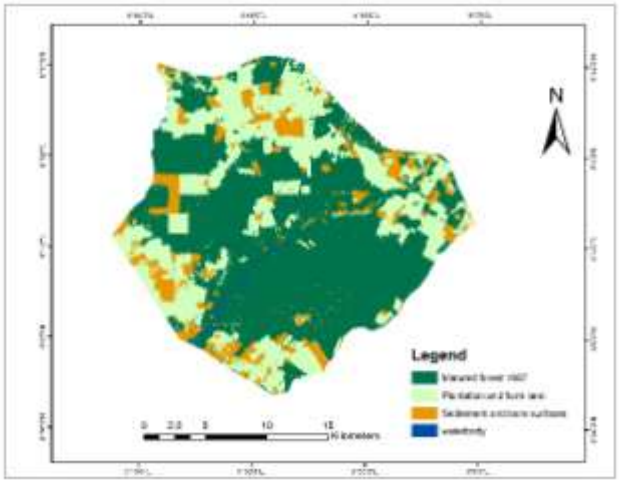

Figure 10: Classified satellite imagery of Sokponba Forest Reserve for 1987.

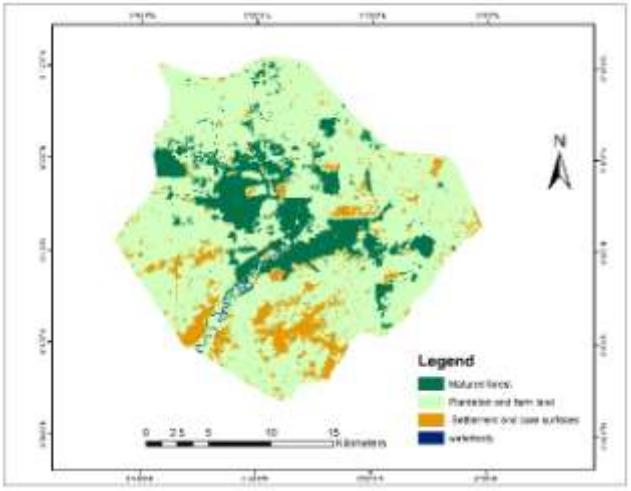

Figure 11: Classified satellite imagery of Sokponba Forest Reserve for 2002.

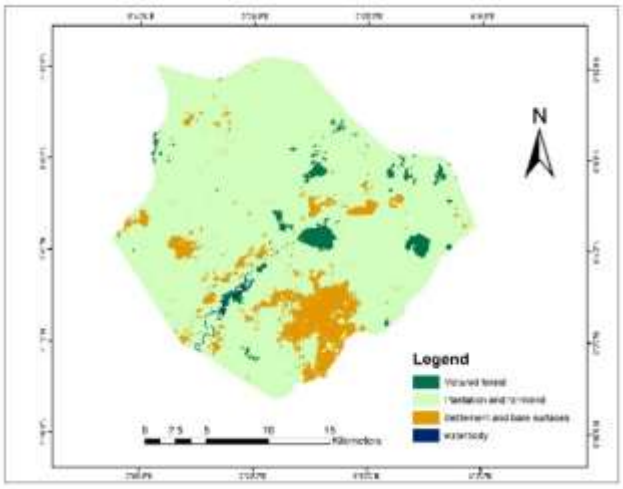

Figure 12: Classified satellite imagery of Sokponba Forest Reserve for 2018

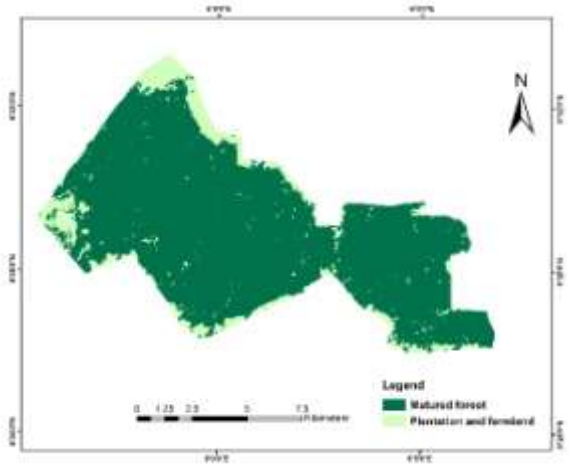

Figure 13: Classified satellite imagery of Ehor Forest Reserve for 1978

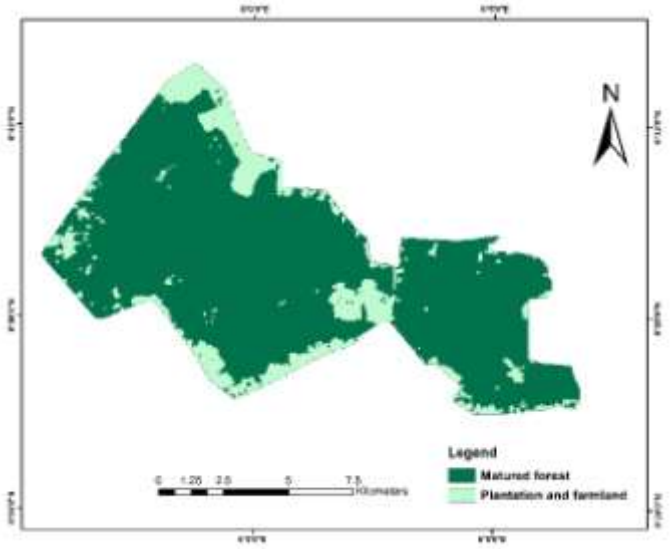

Figure 14: Classified satellite imagery of Ehor Forest Reserve for 2002

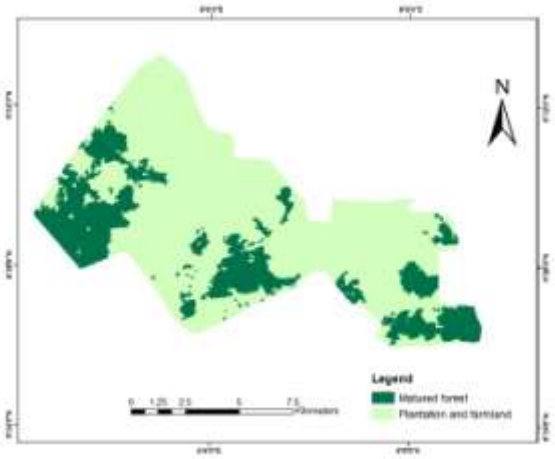

Figure 15: Classified satellite imagery of Ehor Forest Reserve for 2018

Land Use Changes in Sokponba Forest Reserve 1987 - 2018

The Sokponba Forest Reserve within the 31 years period witnessed a drastic decreased and reduction of the forest resources as only a tiny portion 4.3% of the entire forest was left (Figure 16). Sokponba Forest Reserve was divided into 175 compartments made up of different merchantable species of trees (Ihenyen *et al*., 2006). These compartments were allocated to timber contractors for exploitation by the state government for a fee, which was one of the major reasons for the forest depletion (Table 2). Also, illegal lumbering, contributed to deforestation of the forest reserve, likewise farming activities carried out by the people within and outside the forest reserve area.

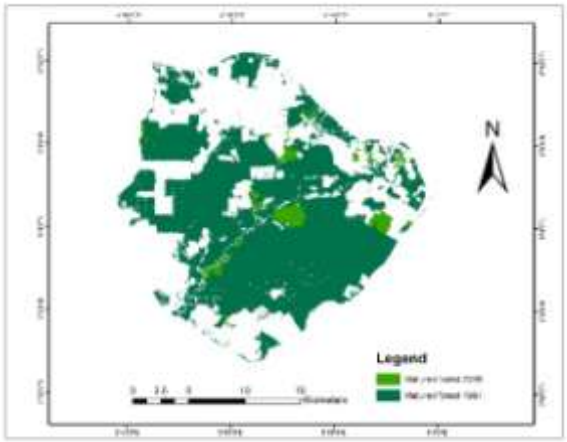

Figure 16: Overlay of classified imagery of Sokponba Forest Reserve for 1987 and 2018.

Data from Table 4 indicates that within thirty-one years, Sokponba Forest Reserve, which was 28,913.63 ha (57.9%) in 1987, decreased to 8,641.33 ha (17.3%) in 2002. It further decreased drastically to 1,578.15 ha (3.2%) in 2018. While buildings and bare surface and waterbody decreased, plantation and farmland continued to witness tremendous expansion, from 15,357.96 ha (30.8%) in 1987 to 36402.66ha (72.9%) in 2002 and further increased in size to 43,494.21 ha (87.0%) in 2018.

Table 4: Land use Changes in Sokponba Forest Reserve from 1987 – 2018

Land use	1987	Percentage (%)	2002	Percentage (%)	2018	Percentage (%)
Matured forest	28,913.63	57.9%	8,641.33	17.3%	1,578.15	3.2%
Plantation and farmland	15,357.96	30.8%	36,402.66	72.9%	43,494.21	87.0%
Buildings and bare surface	5,469.48	11.0%	4,747.50	9.5%	4,735.71	9.5%
Waterbody	195.84	0.39%	168.66	0.34%	162.54	0.33%
Total	**49936.91**	**100%**	**49960.15**	**100%**	**49970.61**	**100%**

Land Use Changes in Ehor Forest Reserve

Figure 17 indicates that Ehor Forest Reserve between 1987 and 2018, a period of 31 years, witnessed a lot of changes in the composition, content and structure of the forest. The loss of the forest can be attributed to the renting of the reserve for farming activities and giving of permit to timber contractors for exploitation by the State government for a fee (Table 2).

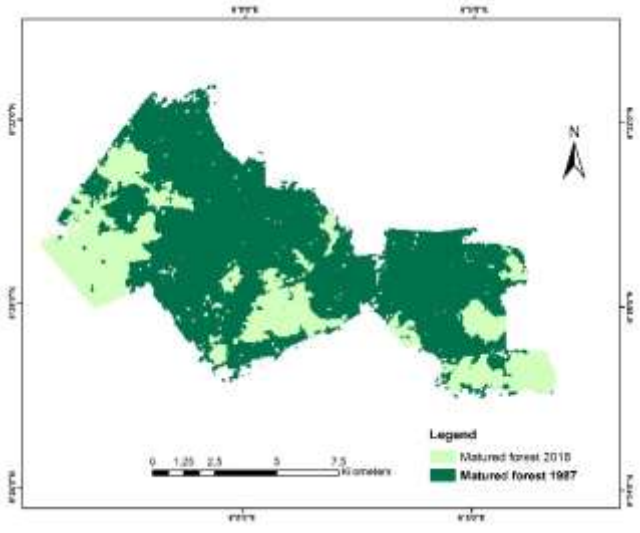

Figure 17: Overlay of classified imagery of Ehor Forest Reserve for 1987 and 2018.

The Table 5 illustrates the land use changes that occurred in Ehor Forest Reserve area from 1987 – 2018. The matured forest as at 1987 was 11,128.86 ha. It reduced in size in 2002 to 10,590.39 ha which may be considered very minimal. The Forest Reserve between 2002 to 2018 witnessed a high rate of depletion of its resource as a total of 7,348.11 ha of forest land was converted. The reserve reduced to 3242.28 ha in 2018. Plantation and farm land witness increased expansion from 1,424.97 ha (11.4%) in 1987 to 1,970.64 (15.7%) ha in 2002, and to 9,323.28 ha (74.2 %) in 2018.

Table 5: Land use Changes in Ehor Forest Reserve from 1987 – 2018

Land use	1987	Percentage (%)	2002	Percentage (%)	2018	Percentage (%)
Matured Forest	11,128.86	88.6%	10,590.39	84.3%	3,242.28	25.8%
Plantation and farmland	1,424.97	11.4%	1,970.64	15.7%	9,323.28	74.2%
Total	**12553.83**		**12561.03**	**100**	**12565.56**	**100**

Comparison of Land Use Changes of Ehor and Sokponba Reserves 1987 – 2018

Figure 18 graphically shows the changes in Ehor and Sokponba Forest Reserves from 1987 to 2018 in a combine graph. The rate of forest depletion is faster in Sokponba Forest Reserve than Ehor Forest Reserve. Consequently the rate at which farmland/ plantation is replacing forest reserve is higher at Sokponba than Ehor Forest Reserve.

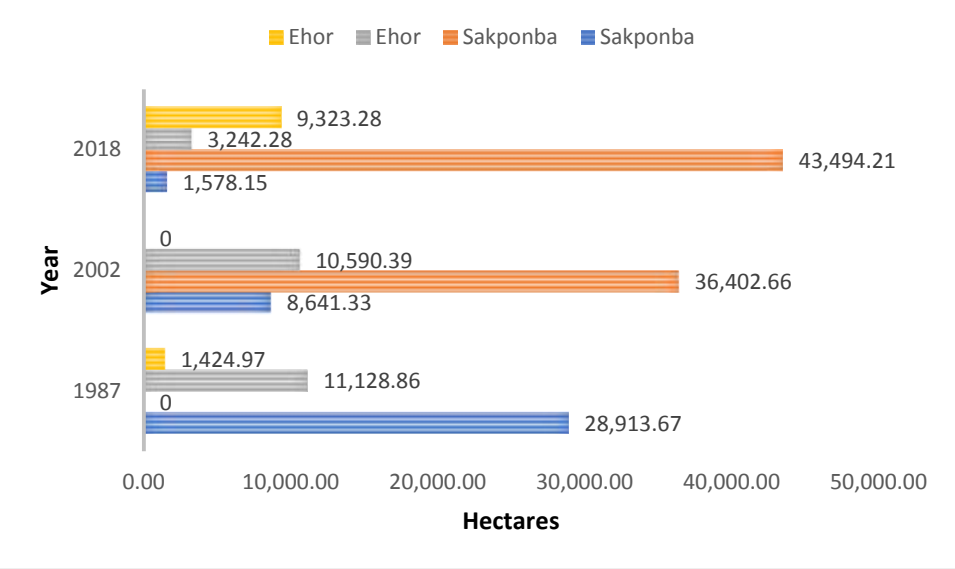

Figure 18: Comparison of Land Use Changes of Ehor and Sakponba Reserves 1987 – 2018

DISCUSSION

In comparison with other studies, the main point in this study is its combination of image processing and survey method. Most geospatial studies of deforestation stops at quantification of land use change without involving the drivers of the observe changes. The present study reveals that combination of different approaches is more revealing than a single approach. Remote sensing method enables easy identification of location of change and the quantification of the change. The result of the image processing and survey method corroborates each other. Both suggest the existence of conversion of forest reserves to other land uses.

Figures 16 and 17 along with Tables 4 and 5 show severe depletion of the forest reserves. While the forest reserves are reducing drastically, farmland is taking over the reserves. In Sokponba Forest Reserve, farmland increase to 87% while in Ehor it increased to 74.2%. About 75% of the respondents had their farm in the reserves. Majority of the farmer had permission from the government to farm in the reserves after the payment of allotted amount per annum. About 66% of these farmers have been farming in the reserves for the past 10 years. The result of this is that within the space of 31 years under study, Sokponba Forest Reserve has reduced to 3.2% and Ehor Forest Reserve to 25.8% of their original sizes. The implication of this is that if nothing is done to check mate it, in less than ten years the whole forest would have been converted.

It is clear from the finding that the farmers and the loggers are aware that their activities are responsible for the deforestation of the reserves. They may however not know the implications of their actions. Majority of loggers (87%) who decline response to questionnaire are suspected to be illegal logger. If this is correct it is evidence that there is laxity in the enforcement of regulation guiding the forest hence there are farmers, loggers and timber contractors who operate within the reserves without government permission. The government is losing revenue through this means.

Finding of study also show that renting of land generates revenue for the government. This is an indirect way of de-reserving the forest. This has implications for essential environmental services such as soil conservation, watershed management, protection against floods and sources of industrial

woods which are provided by the reserves. It is also known that forest acts as carbon sink. The depletion of Sokponba and Ehor Forest Reserves will lead to carbon trap and invariably contribute to global warming.

CONCLUSION

In this study, the potential of geospatial data was investigated for estimating the deforestation of Sokponba and Ehor Forest reserves. It is observed in the study that the reserves have been seriously deforested which carry along with it negative consequences. The importance of forest reserves in revenue generation, conservation of medicinal plant and wildlife, livelihood sustainability and environmental moderation demands that its use be regulated to avoid depletion. Hence, the need for regular monitoring of the forest using the combination of geospatial and survey methods.

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