Technical report on ITTO Degraded phase II project [PD 30/97 Rev.6 (F)] **(activity 1.1)**

A technical report

on

Land cover change of plantation established with local communities in degraded forest reserves in three districts, Ghana

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Contents

Abstract

Farmers in six communities in three administrative districts organised to replant portions of degraded forests in Pamu Berekum Forest Reserve in the Brong Ahafo, Afrensua-Brohoma Forest Reserve in Ashanti, and Southern Scarp Forest Reserve in the Eastern Regions of Ghana. The replanting was done in two phases – 2001 and 2004 and 2012 to 2014 respectively. This report outlines the results of a study on land use and land cover change resulting from the plantations that these communities established over the years. The objectives were i) determine the extent of the forest cover in these plots as the desired land use type compared to a) grasslands and b) farmlands, which are undesired land use types. The ultimate aim of this work was to encourage the sustainable management of these plantations by the communities and the forest resource managers.

The results show that there is an appreciable increase in the amount of forest cover in most of the plantation plots that the communities established under the project. Despite this, an appreciable amount of grass and farmlands have also been observed in some of these plots of plantation, especially in Pamu-Berekum and Afrensu-Brohuma Forest Reserves, mainly due to continued farming activities and bush fire incidence.. Efforts therefore need to be made to prevent the incidence of bushfire in these established plantation as well as in the surrounding areas. Minizing the continuous farming activities in these established plantations and restocking through replanting the burnt out areas that have been turned into the grasslands will greatly help to increase and sustain the forest cover areas in these plots.

Introduction

Geospatial technology is one of the most important and emerging technology that can be used in the management and conservation of natural resources because it has the capability to provide information for managing and monitoring natural resources, such as water, land-use, soils and vegetation at both temporal and spatial scales (Lu 2006). This technology offers a rapid, affordable and important tool that has the ability to efficiently handle geospatial datasets, create maps, provide interactive user-friendly interfaces, and transform spatial data according to users need. Alireza et al (2013) and, Vashum and Jayakumar (2012) emphasized the relevance of geo-information in managing and monitoring natural resources in a timely, reliable, relational, and cost-effective way. Forest ecosystem is the natural habitat for all other forms of land resource and managing it sustainably has a direct effect on land uses. Conversion of land resources, which results in land use and land cover changes in both forest reserves and outside forest reserves, still remain a critical issue especially in developing countries and needs urgent attention (Moutinho Schwartzman 2005). These changes have become rapid and significant as population continues to increase, coupled with the impacts of climate change. This scenario of land cover change calls for frequent monitoring of the trajectory of land use and land cover change.

With financial support of International Tropical Timber Organization(ITTO), the Forestry Research Institute of Ghana organized farmers in six communities in three administrative districts to replant portions of degraded forest in Pamu Berekum reserve in the Brong Ahafo, Afrensua-Brohama reserve in Ashanti, and Southern Scarp reserve in the Eastern regions of Ghana. The replanting was done in two phases-2001 and 2004 and 2012 to 2014. This work is a report on the activity on land use and land cover change in the plots of the plantation that these communities have established over the years. The objectives are i) determine the extent of the forest cover in these plots as the desired land use type compared to a) grasslands and b)farmlands, which are undesired land use types. The ultimate aim of this work is to encourage the sustainable management of these plantations by the communities and the forest resource managers.

Materials and methods

Study area

The study covered three forest reserves and six communities in the Brong Ahafo, Eastern and Ashanti Regions of Ghana. These communities include Ntabene, Abonsrakrom and Twumkrom in Dorma Ahenkrom in the Brong Ahafo region; Olantan and Ahenkwa in Begoro in the Eastern Region and Nsugunsua in Akomadan in the Ashanti region. Farmers in these communities were engaged in the plantation established under phase I (2001-2004) and II (20012 to 2014) of the FORIG/ITTO project. The sites of these established plantations in the different areas are displayed in Figure 1.

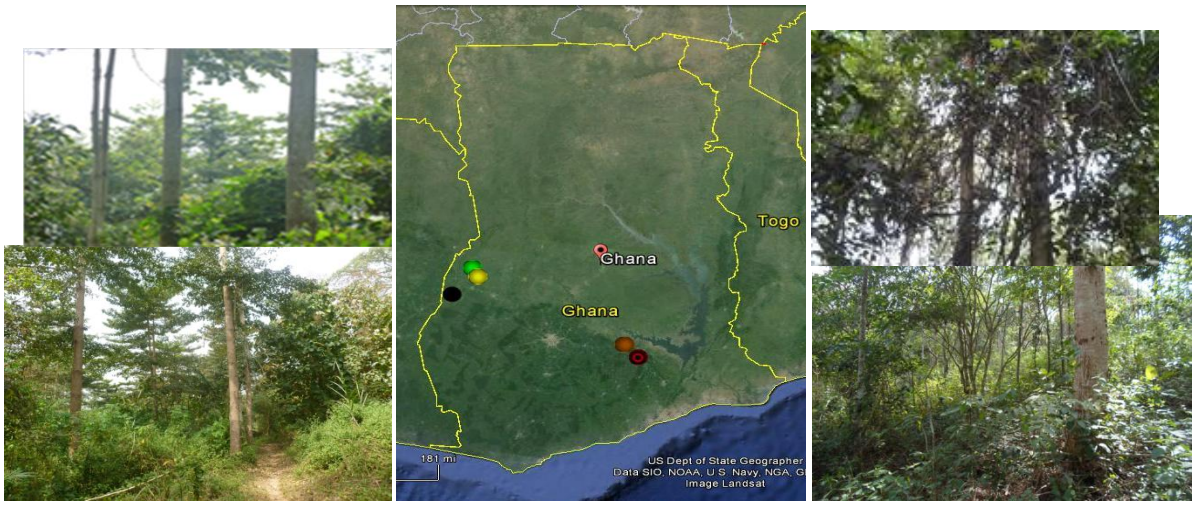

Figure 1: Map of Ghana showing the plantation sites

Development of Land use maps

The land use change for the plantation areas covered 20 year period from 1990 – 2010. To address the objectives of the GIS component, the following materials and equipment were used: i) LandSat 2014, 2010 and 2000 images; ii) 2014 MODIS NDVI products; iii) Topographic map of the study area; iv) GPS and digital camera; v) Software: ERDAS Imagine 9.2, ARCGIS9.2 and vi) MS Excel.

Desk review of existing maps

Land use maps produced under the Forest Preservation Programme (FPP) and land use maps for the year 2000 produced by Centre for Remote Sensing and Geographic information System (CERSGIS) were reviewed to adopt a common ground for the classification scheme for this study. The desk study also examined the biophysical and demographic data, which were converted to GIS-compatible format. Furthermore, all analogue maps were converted to digital maps for easy integration with other data sets.

CLASSIFICATION

The MODIS 2014 NDVI, 1990, 2000, 2010 and 2014 Landsat images were used to generate the land use maps for the four epochs. The 2014 MODIS NDVI product was used as base map to develop a sampling scheme for collecting training classes for the image classification (supervised) and development of the current land use map. The 1990 and 2000 land use maps were developed using archived forest inventory data and forestry commission progress maps of the forest reserves. The planted areas for the various communities were surveyed through the help of the community leaders. These were converted into shape files and overlaid on the land use map for the four time points to establish the changes that have occurred over the twenty four year period.

Image pre-processing

The satellite images for four time points, i.e., 1990, 2000 and 2010 and 2014 were rectified, geo-referenced and geo-coded using ground controlled points (collected from road intersections, highways, corners of identifiable points) to accurately orient the images and enhance the spectral and spatial resolution. All the images were re-projected to WGS84 Zone 30 N to make them compatible with other datasets and to ensure that linear measurements on the images are done accurately.

Enhanced Normalized Difference Vegetation Index (ENDVI) 2014 image was used to support the collection of training classes for the supervised classification. The processed ENDVI image was used to isolate vegetated and non-vegetated areas, as well as grass and trees based on the ENDVI values. ENDVI is a ratio of the spectral bands which is used extensively to differentiate vegetation classes based on the level/amount of greenness of the vegetation. For example, ENDVI value from natural old forest is different from plantation forest.

Image classification

Unsupervised and supervised classification, using maximum likelihood algorithm were used to map out the land use classes in the three reserves. The results were imported into ArcGIS to generate the land use map. The classification scheme was based on local knowledge and prevailing land use categories in the area with inputs and recommendations from the Draft MRV report commissioned by the Climate Change Unit of the Forestry Commission.

Accuracy assessment of the classification

The accuracy of the classification was assessed using the ground data and archived information from the forestry commission as well as community interaction.

Validation of the land use map

The land use map of the current year (2014) was validated through a field visit and community interaction, supported by the Google Earth software. Firstly, the map was sent to the communities for discussion on its conformity with the existing land use categorization in the study area. Secondly, Google Earth software was used to assess the accuracy since it has high resolution and very accurate representation of the land cover.

Assessment of land use change

The land use maps developed for the four time points, i.e., t_1, t_2 and t_3, were analyzed by simple comparison of the areas on the maps (see appendix A) and landuse change matrix.

Use of local knowledge

The land use maps was used as input map to investigate the local factors influencing the biodiversity, drivers of deforestation and other intervening social factors, for example, proximity of settlements to forest and economic activities (Joa˜o *et al.* 2005).

Results and Discussions

Results

The land use change (figure 1a), for ITTO/ FORIG modified taungya system plot in Afensu Brohuma forest reserve for 1990, 2000, 2010 and 2014 show significant improvement in the forest condition. In figure 1a and 1b, the Pink coloration shows grassland, the yellow shows Taungya farms (tree and food crops interplant) and the light green shows plantation/Open forest. The deep green show plantations that have matured and have closed canopy equivalent to natural forest. The green and red polygons are 2012-2014 plantation areas and 2001 - 2005 plantation areas respectively. For the 24 year period, the plots transitioned from grassland to cropland and to emergence of plantation shown in green.

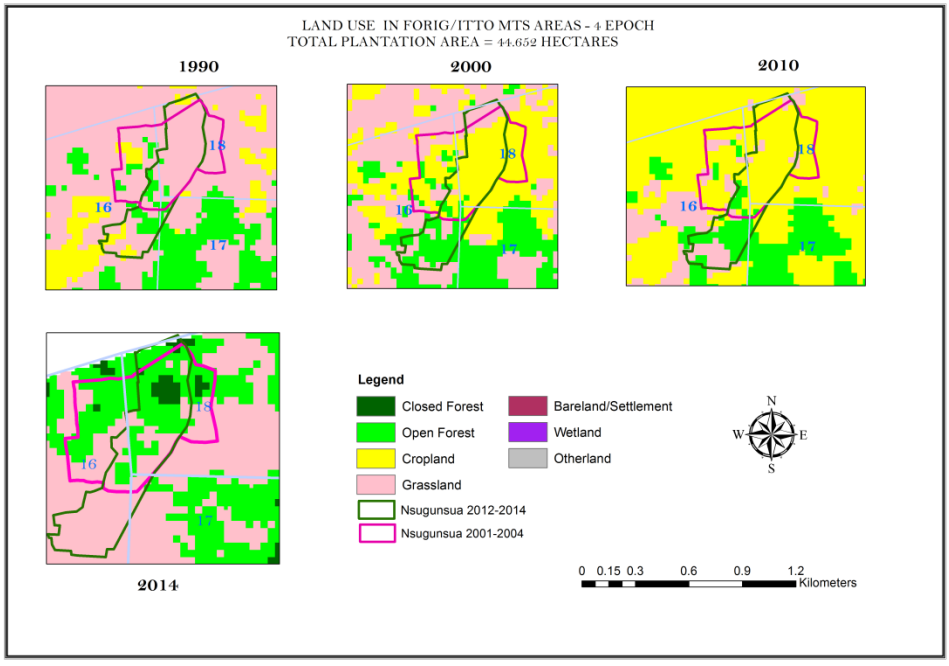

Figure 1a: Land use for 3Epochs for ITTO/FORIG plantation plots in Afrensu, Brohuma Forest Reserve

Between 1990 and2014, the portion of grassland in the plots was reduced significantly, while the open forest, suggesting increased tree cover also improved significantly in the same period (fig

1b). Although the grassland increased in 2014, significant portion of closed forest also emerged (fig 1b)

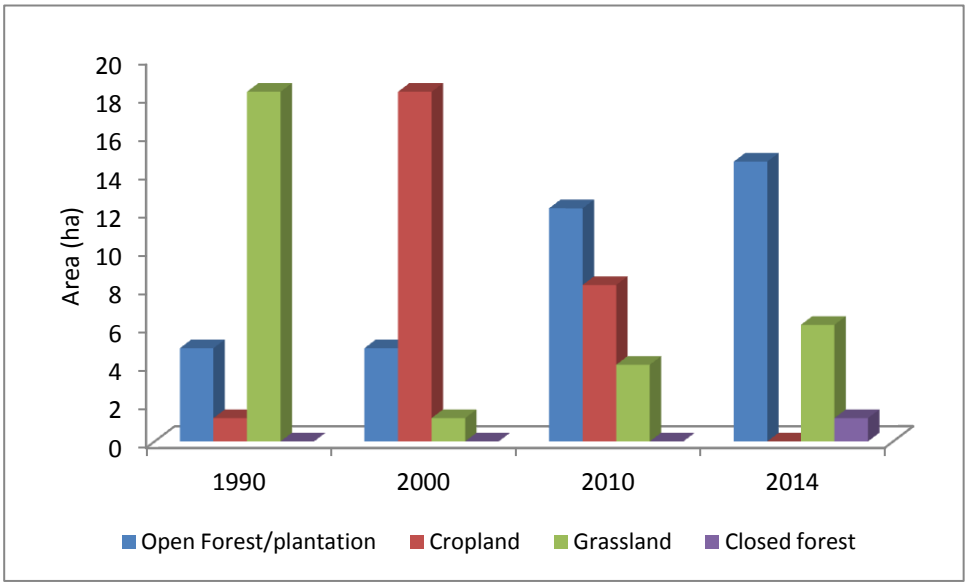

Fig 1b: Land cover change of forest plantation of Nsugunsua community in Afrensu Brohuma forest reserve, Akomadan

Figure 2a and 2b show a similar pattern for Abomsarakrom community's Plots in Pamu Berekum forest reserve. In 1990, there was significant forest cover, however in 2000 all the close forest was lost to open forest and farms, thereafter there was re-emergence of open forest. This suggests that the Taungya system had taken off and most of the trees have reach canopy level and was captured by the satellite image. This also means that the stage of the plantation qualifies as forest by the national definition of forest of Ghana as spots of deep green depicting mature of closed canopy plantation are beginning to emerge.

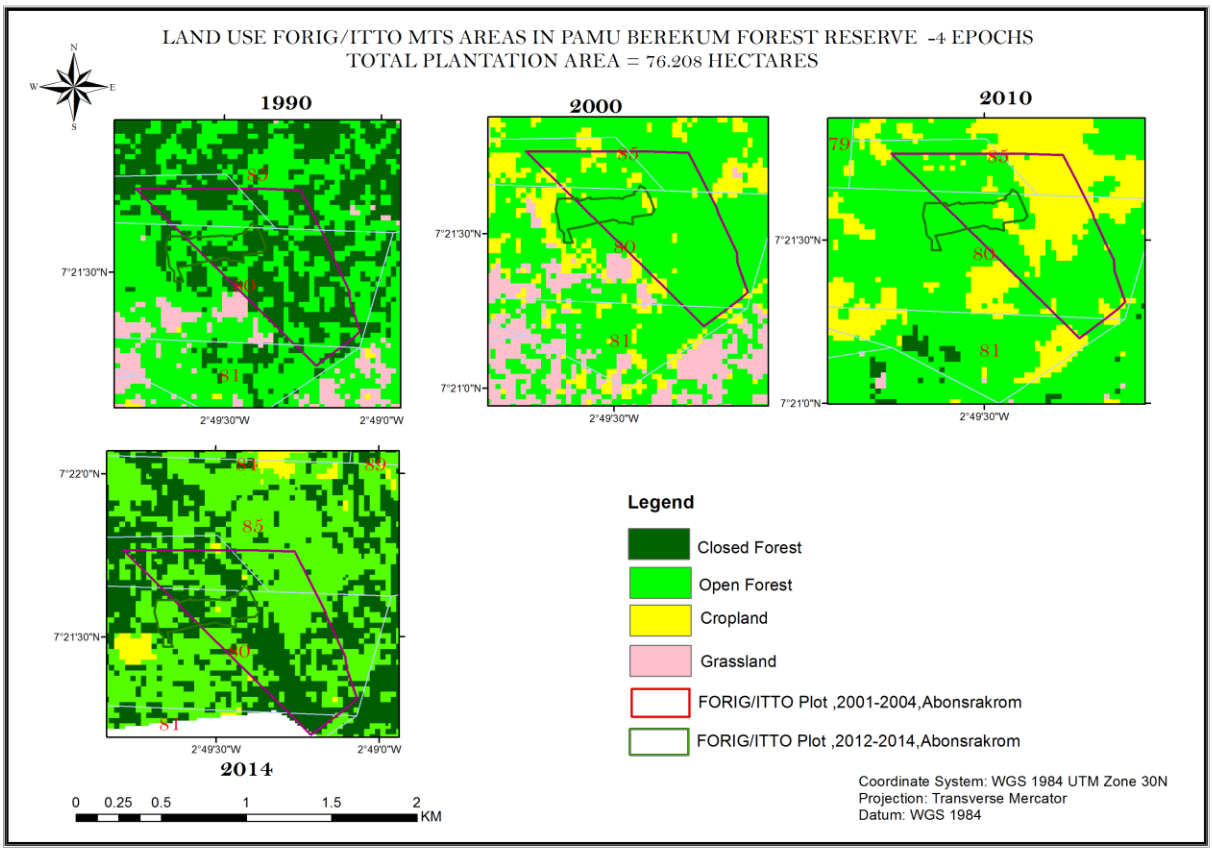

Figure 2a: Landuse for 3 epochs for ITTO/FORIG Plantation Plots (Abomsarakrom) in Pamu Berekum forest reserve

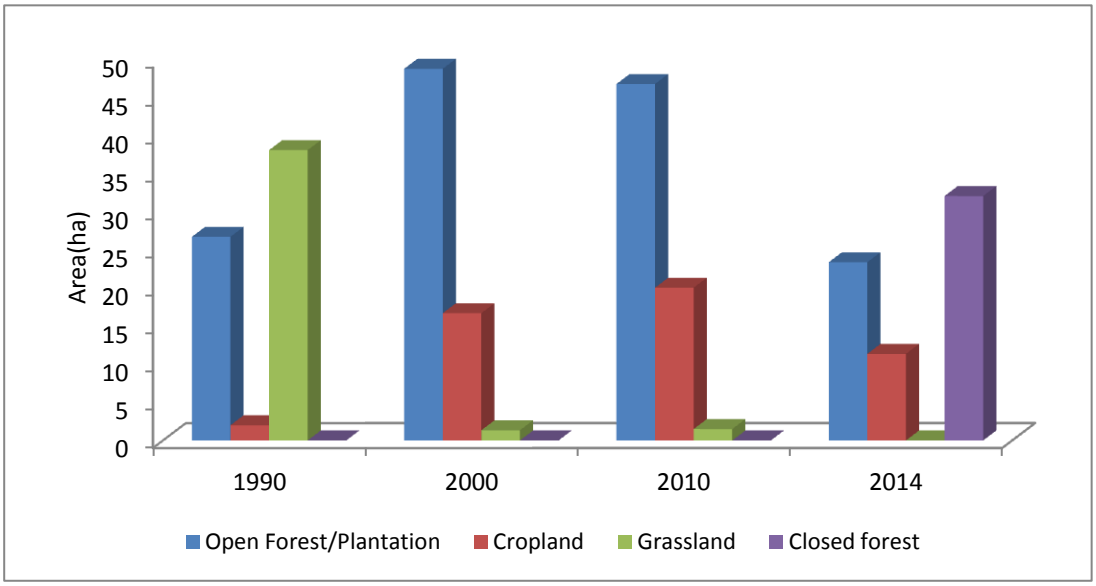

Fig 2b: Land cover change of forest plantation of Abonsrakrom community in Pamu Berekum forest reserve, Dormaa-Ahekro

A more significant improvement is observed in the Ntabene community's plots in the same reserve. Between 1990 and 2000 all the close forest was lost to grassland and farms (figure 3a, 3b and 3c). However, by 2010 the grassland and the farms were converted to light green representing plantation forest. In 2014 closed canopy or mature plantations have emerged as small polygons with deep green. Thus the plots/forest stands are transitioning to the 1990 condition

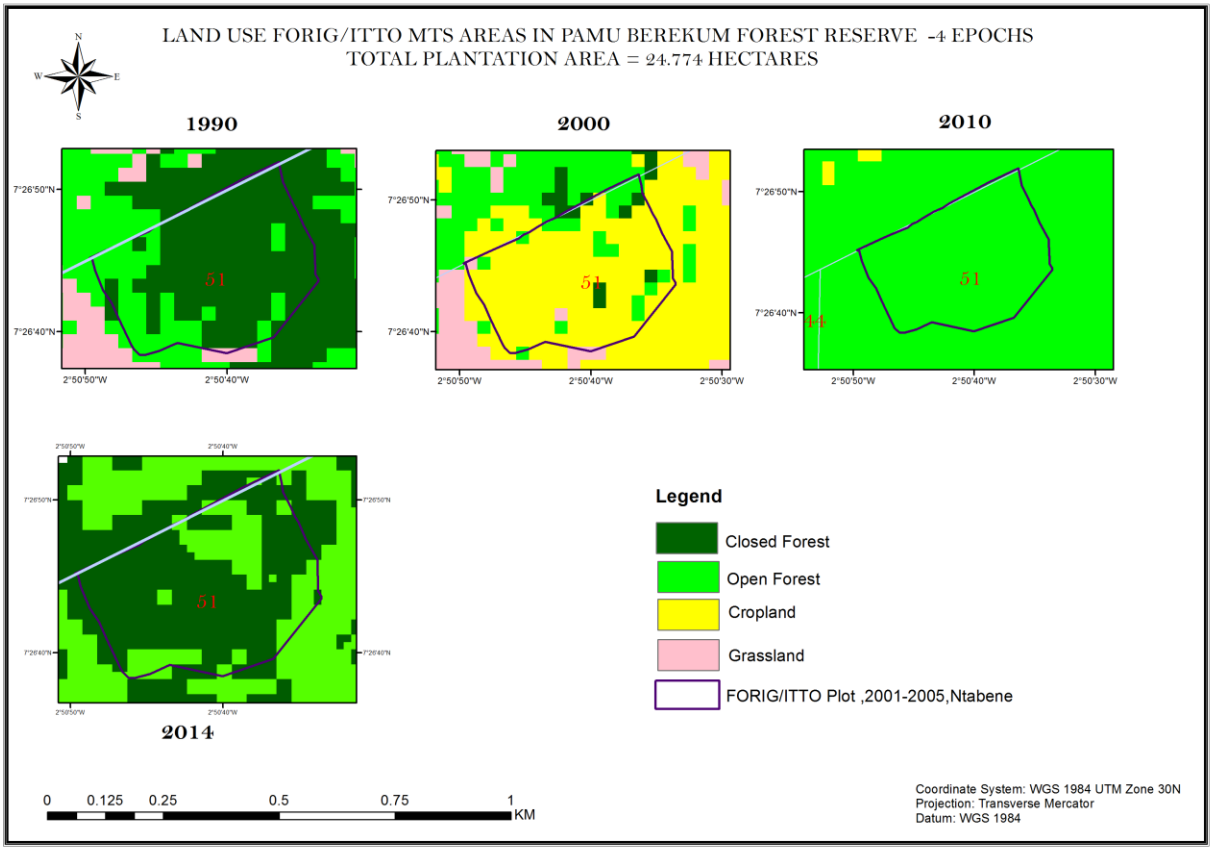

Figure 3a: Landuse for 4 epochs for ITTO/ F0RIG Plantation Plots (Ntabene) in Pamu Berekum forest reserve

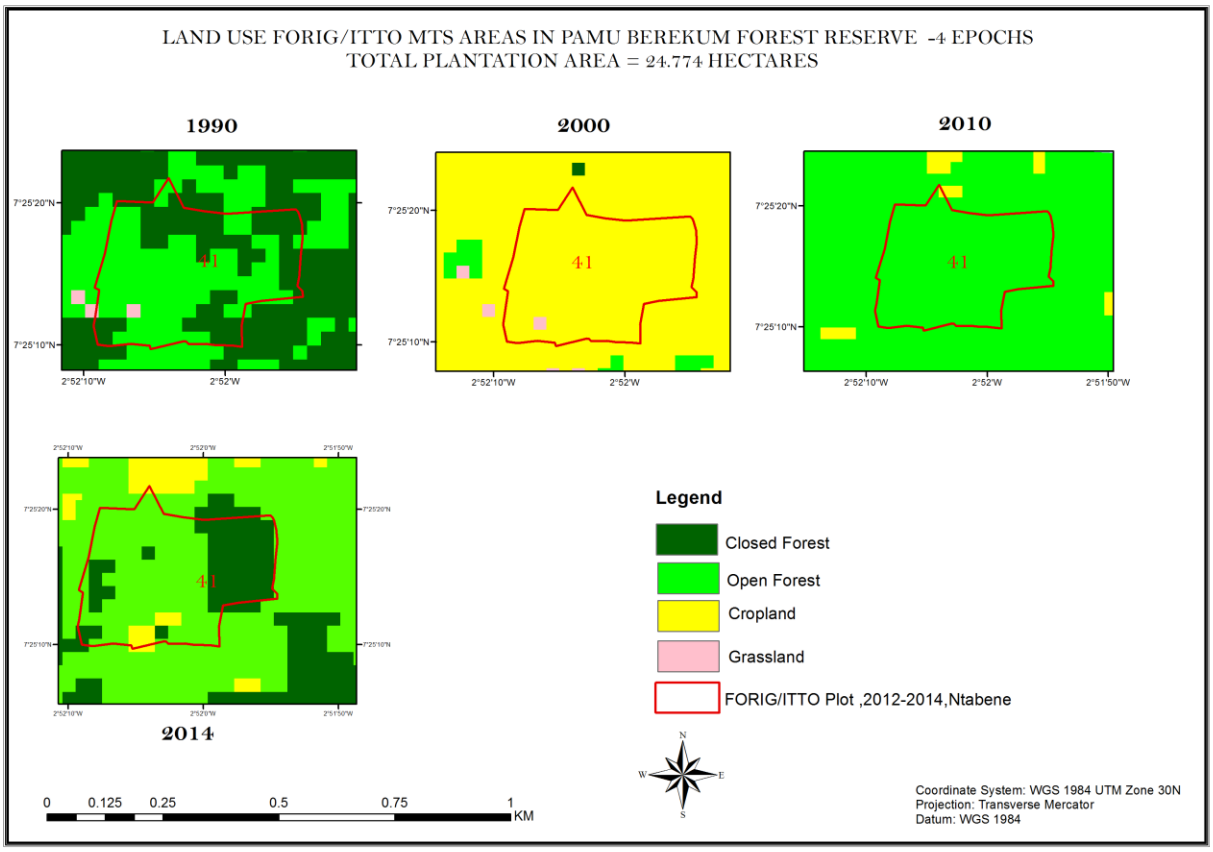

Figure 3b: Land use for 3 epochs for ITTO/ F0RIG Plantation Plots in Pamu Berekum forest reserve (Ntabene)

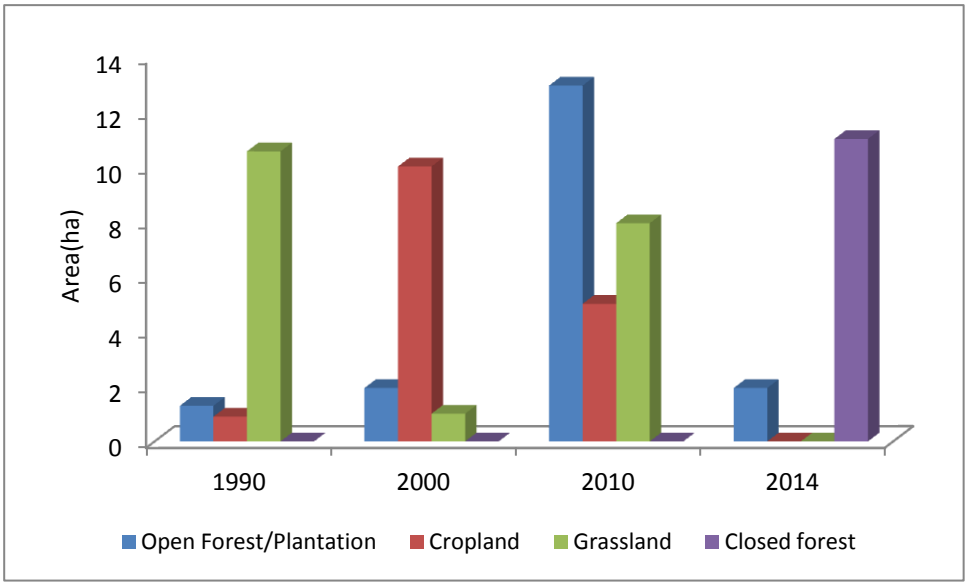

Fig 3c: Land cover change of forest plantation of Ntabene community in Pamu Berekum forest reserve, Dormaa Ahekrom

Figure 4a and b representing the Twumkrom community plots also shows a similar pattern and more importantly by 2010 and 2014 the modified Taungya plot was very successful with the area recording significant gains of forest cover.

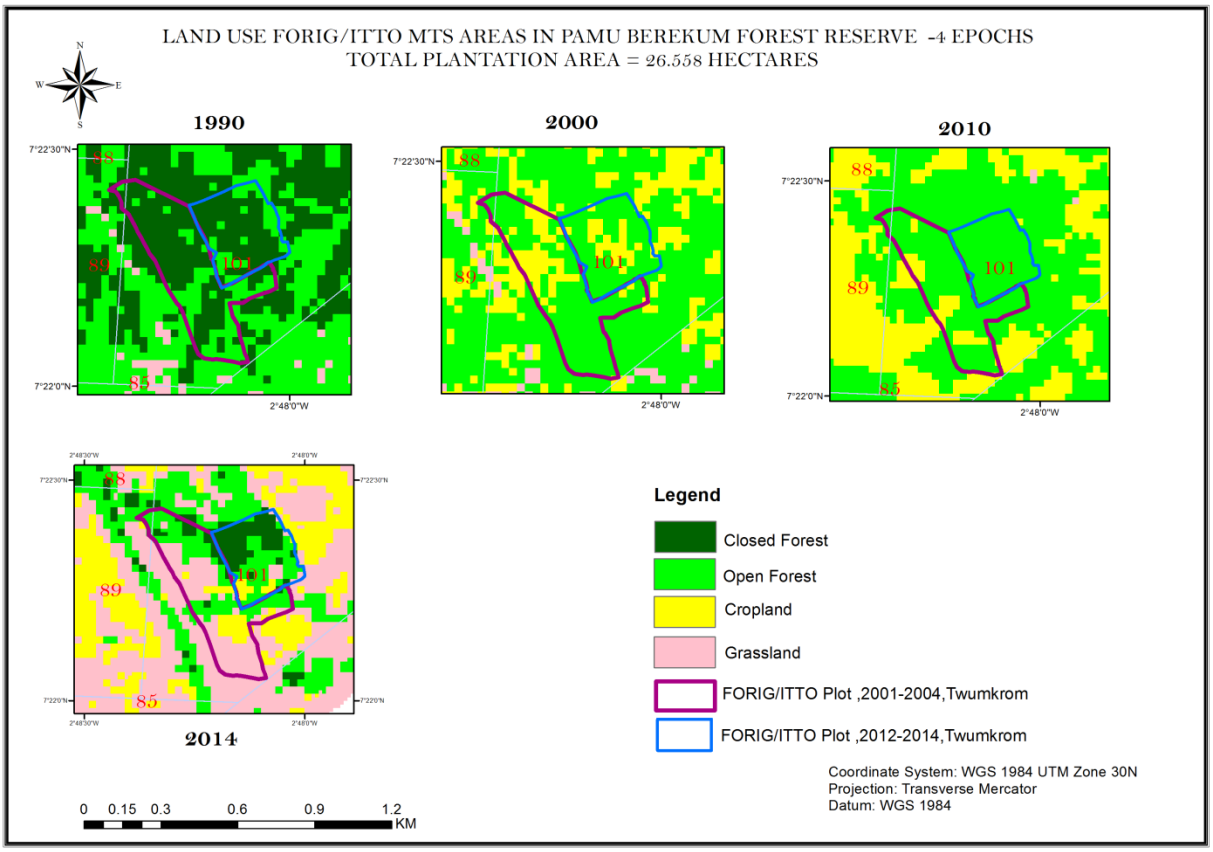

Figure 4a: Land use for 4 Epochs for ITTO/FORIG Plantation Plots Pamu Berekum forest reserve (Twumkrom)

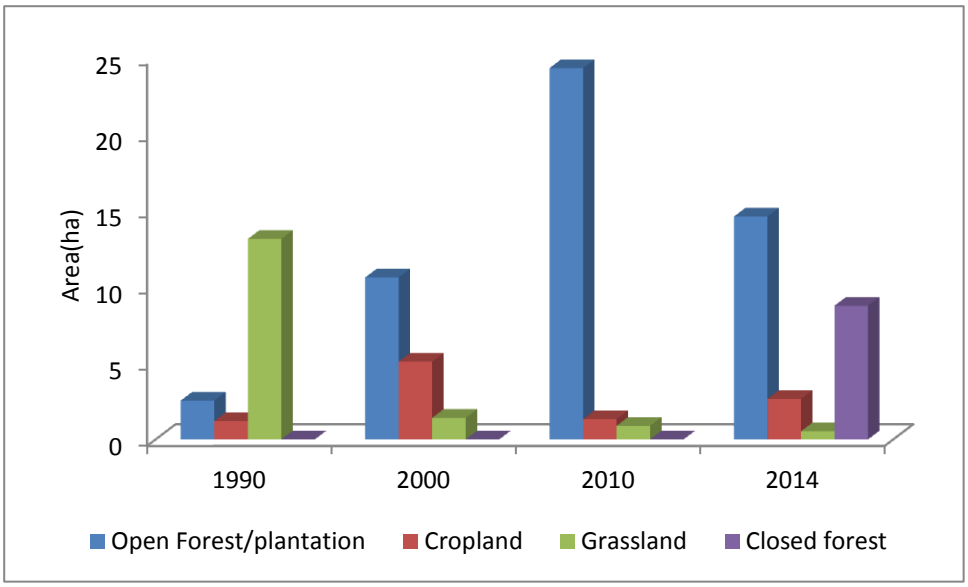

Fig4b: Land cover change of forest plantation of Twumkrom community in Pamu Berekum forest reserve, Dormaa Ahekrom

In the southern scarp forest reserve, both Ahenkwa and Olantan communities' plots show progressive gain in the forest cover from grassland and farms as indicated in fig 5a and 5b; and figure 6a and 6b respectively.

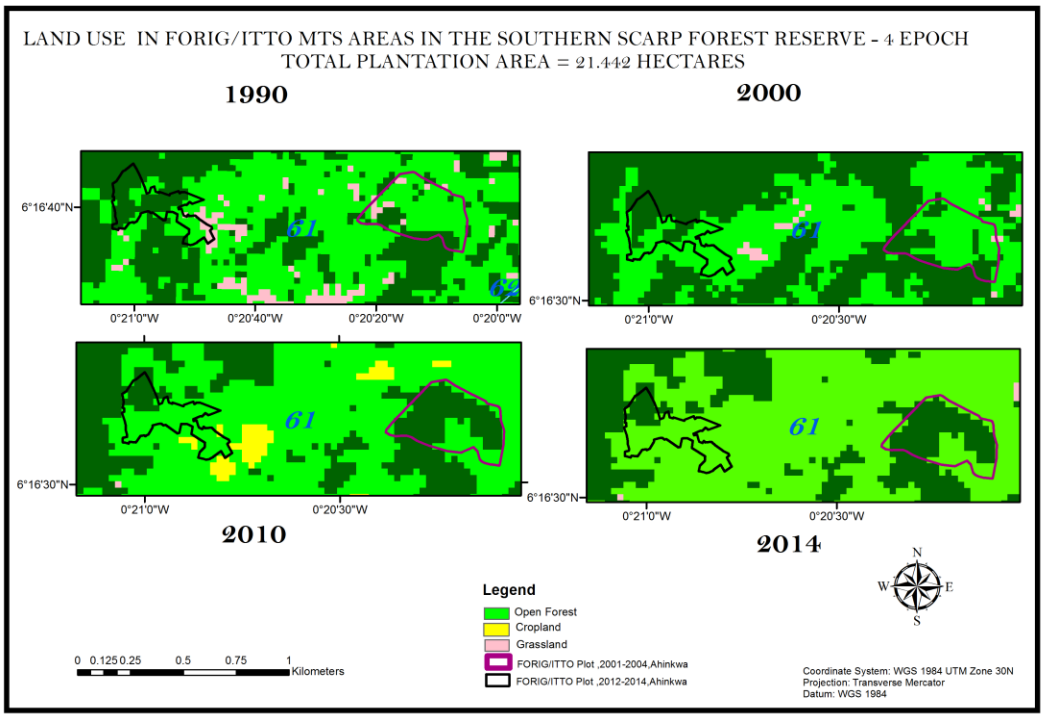

Figure 5a: Landuse 4 Epochs for ITTO/FORIG Plantation plots in southern scarp forest reserve (Ahinkwa)

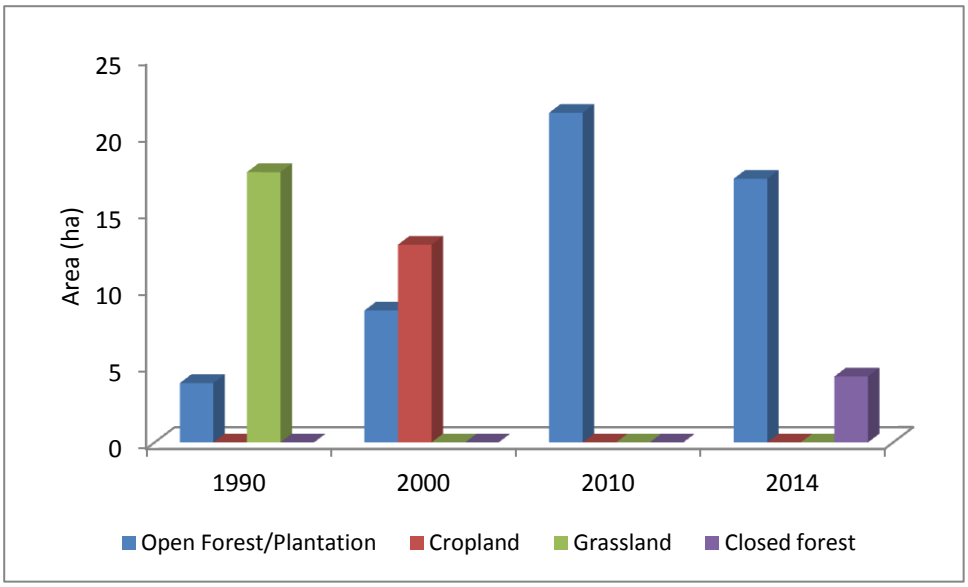

Fig 5b: Land cover change of forest plantation of Ahenkwa community in Southern scarp forest reserve, Begoro

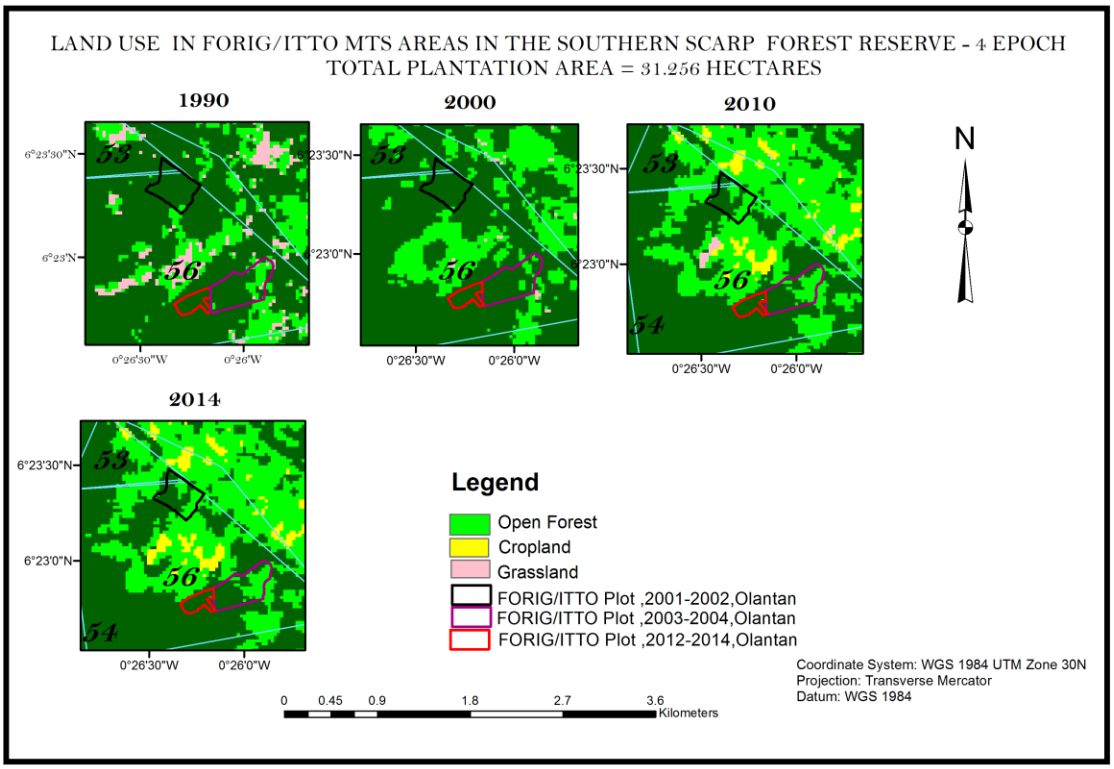

Figure 6a: Landuse for 4 Epoch for ITTO/FORIG Plots (Olantan) in Southern Scarp forest reserve

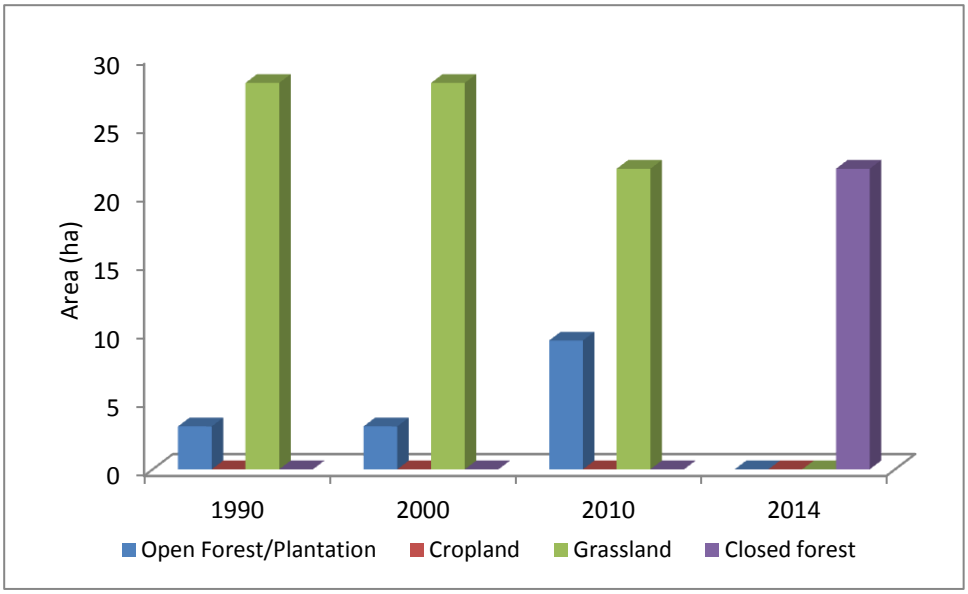

Fig6b: Land cover change of forest plantation of Olanta community in Southern scarp forest reserve, Begoro

Conclusion

The results show that there is an appreciable amount of forest cover increase in most of the plantation plots that the communities have established under the project. Despite this, an appreciable amount of grass and farmlands have also been observed in some of these plots of plantation. For instance, a significant amount of grass and farmlands have been observed in Nsugunsua community's plots owing largely to frequent bush fires and the continuous farming that is being done in the old plots (i.e.2001 to 2004 phase I plots). The cause of the visible presence of the grasslands in the remaining of the plots particularly, in the Ntabene, Twumkrom and Abonsrakrom communities' phase I (2001-2004) plots in the Brong Ahafo region is a result of the incidence of bush fires on these plots at one point in time. The difference can be observed in the Olantan community's phase I (2001-2004) plots in the Begoro forest district in the Eastern Region where there have never been incidence of bush fire and the forest is recovering very fast. As can be been seen in figures 6a and 6b, there is still close forest adjacent to these plots and that is probably one important factor that prevents the incidence of bush fires on these plantations. Owning to this, efforts need to be made to prevent incidence of bushfire in these established plantation as well as in the surrounding areas. Minizing the continuous farming activities in these established plantations and restocking through replanting the burnt out areas that have been turned into the grasslands, particularly in the phase I (2001-2004) plots, will greatly help to increase and sustain the forest cover areas in these plots.

Appendix a

Table 1: : Area change of established plantation from 2001 to 2010-2014, with 1990-2000 as base year

AFRENSU-BROHUMA(NSUGUNSUA)									PAMU BEREKUM TWUMKROM							
	1990		2000		2010		2014		1990		2000		2010		2014	
	AREA	%COVER 1990	AREA	%COVER	AREA(HA)	%COVER	AREA	%COVER		%C0VER	AREA(HA)	%C0VER	AREA(HA)	%COVER	AREA(HA)	%COVER
Open Forest/plantation	4.86	20	4.864	20	12.161	50	14.5932	60	2.546	15	11.886	70	25.23	95	14.6069	55
Cropland	1.216	5	18.241	75	12.161	50	0	0	0	0	5.094	30	1.328	5	2.6558	10
grassland	18.24	75	1.216	5	0	0	6.0805	25	14.434	85	0	0	0	0	0.53116	2
Close Forest	0	0	0	0	0		1.2161	5					0		8.76414	33
	24.316		24.321		24.322								26.558			
	PAMU BEREKUM (ABONSRAKROM)					12.962			PAMU BREKUM NTABENE							
			2000		2010		2014		1990		2000		2010		2014	
	1990	%COVER	AREA(HA)	%COVER	AREA(HA)	%COVER	AREA(HA)	%COVER	AREA	%C0VER	AREA(HA)	%COVER	AREA(HA)	%COVER	AREA(HA)	%COVER
Open Forest/Plantation	26.78	40	48.88	73	46.88	70	23.4395	35	1.296	10	1.944	15	12.962	100	1.9443	15
Cropland	0	0	16.74	25	20.09	30	11.3849	17	0	0	11.017	85	0	0	0	0
Grassland	40.183	60	1.34	2	0	0	0	0	11.665	90	0	0	0	0	0	0
Close Forest					0	0	32.1456	48		0	0	0	0	0	11.0177	85
	SOUTHERN SCARP(OLANTAN)								SOUTHERN SCARP(AHINKWA)							
	1990		2000		2010		2014		1990		2000		2010		2014	
	AREA(HA)	%COVER	AREA(HA)	%COVER	AREA(HA)	%COVER	AREA(HA)	%COVER	AREA(HA)	%COVER	AREA	%COVER	AREA(HA)	%COVER	AREA(HA)	%COVER
Open Forest/Plantation	9.21	10	11.325	10	12.377	30			3.859	28	8.577	40	21.442	100	0	0
Cropland	0.025	0		0	2.13	0			0	0	12.865	60	0	0	0	0
Grassland	4.21	90	2.125	90	1.09	70			17.582	82	0	0	0	0	0	0
Close Forest	17.78		14.68		6.281				0	0	0	0	0	0	21.442	100

AFRENSU- BROHUMA(NSUGUNSUA)									PAMU BEREKUM TWUMKROM							
	1990		2000		2010		2014		1990		2000		2010		2014	
	AREA	%COVER 1990	AREA	%COVER	AREA(HA)	%COVER	AREA	%COVER		%C0VER	AREA(HA)	%C0VER	AREA(HA)	%COVER	AREA(HA)	%COVER
Open Forest/plantation	4.86	20	4.864	20	12.161	50	14.5932	60	2.546	15	11.886	70	25.23	95	14.6069	55
Cropland	1.216	5	18.241	75	12.161	50	0	0	0	0	5.094	30	1.328	5	2.6558	10
grassland	18.24	75	1.216	5	0	0	6.0805	25	14.434	85	0	0	0	0	0.53116	2
Close Forest	0	0	0	0	0		1.2161	5					0		8.76414	33
	24.316		24.321		24.322								26.558			
	PAMU BEREKUM (ABONSRA KROM)					12.962			PAMU BREKUM NTABENE							
			2000		2010		2014		1990		2000		2010		2014	
	1990	%COVER	AREA(HA)	%COVER	AREA(HA)	%COVER	AREA(HA)	%COVER	AREA	%C0VER	AREA(HA)	%COVER	AREA(HA)	%COVER	AREA(HA)	%COVER
Open Forest/Plantation	26.78	40	48.88	73	46.88	70	23.4395	35	1.296	10	1.944	15	12.962	100	1.9443	15
Cropland	0	0	16.74	25	20.09	30	11.3849	17	0	0	11.017	85	0	0	0	0
Grassland	40.183	60	1.34	2	0	0	0	0	11.665	90	0	0	0	0	0	0
Close Forest					0	0	32.1456	48		0	0	0	0	0	11.0177	85
					66.97								12.962			
	SOUTHERN SCARP(OLANTAN)								SOUTHERN SCARP(AHINKWA)							
	1990		2000		2010		2014		1990		2000		2010		2014	
	AREA(HA)	%COVER	AREA(HA)	%COVER	AREA(HA)	%COVER	AREA(HA)	%COVER	AREA(HA)	%COVER	AREA	%COVER	AREA(HA)	%COVER	AREA(HA)	%COVER
Open Forest/Plantation	9.21	10	11.325	10	12.377	30			3.859	28	8.577	40	21.442	100	0	0
Cropland	0.025	0		0	2.13	0			0	0	12.865	60	0	0	0	0
Grassland	4.21	90	2.125	90	1.09	70			17.582	82	0	0	0	0	0	0
Close Forest	17.78		14.68		6.281				0	0	0	0	0	0	21.442	100

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