



Original Research Paper

Assessing forest cover change in the Bafut-Ngemba Forest Reserve (BNFR), north west region of Cameroon using remote sensing and GIS

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In order to understand and control deforestation in forest reserves, alternative tools for effective management are indispensable. Accordingly, this study employed Landsat MSS, 1978 and ASTER images for 2006 and fieldwork to assess the change in forest cover in the Bafut-Ngemba Forest Reserve (BNFR) in north western Cameroon. Images were classified using MultiSpec Version 5.01. Four cover classes were identified. Classified images were transferred to ArcGIS 9.3 and various classes were digitized on screen, statistics were registered on the attribute table and eventually used in calculating the area of each class. The results illustrated a reduction in forest cover of -37% for the 28 years period with average annual decrease rate of 1.3%. During the same period, farmland and shrub/grassland increased by 1% and 0.3% respectively. Drivers of the change were, the neighboring populations involved in farming (40%); fuel wood dealers (17.5%); charcoal burners (12.5%); the Fulani with their livestock rearing (2.5%) and equally illegal timber dealers (7.5%). This study highlighted the challenges of forest management in the BNFR and the urgency for an effective management system to be implemented if Millennium Development Goal (MDG) is to be attained at the country level. The use of remote sensing and GIS, with appropriate field work proved to be effective in this respect.

Key words: Forest cover change, Bafut Ngemba Forest Reserve, remote sensing, GIS

INTRODUCTION

Forests cover about 45.6% of Cameroon's national territory, approximately 21,245,000 hectares (FAO, 2005). Most of her forests form part of the Congo basin forest which is the second largest area of dense tropical forest in the world following the Amazon basin (CARPE, 2006). Cameroon is ranked second in terms of forest cover in Africa after Democratic Republic of Congo. These forests have been divided into permanent and non permanent forests estates. The permanent forests estates otherwise known as protected areas are considered to be areas belonging to the state and so closed from all unauthorised human activities. These protected areas which are further divided into wildlife protected areas and forest reserves proper (MINEF, 1994) are estimated to cover 11%

(approximately 5.2 million hectares) of the national territory (MINEP, 2009). A majority of these protected areas were created by the colonial administrators but after independence, the administration in place continued to designate areas as being under protection. The objective of the first administration was that protected areas should cover at least 20% of the total surface area of the country (MINAGRI, 1973) but this target was later increased to 30 % (MINEF, 1994).

Despite these efforts invested by the administration to protect the forests and its related resources, deforestation has not ceased leading to a continuous change in forest cover and land use. It is estimated that the rate of forest change in Cameroon between 2000 and 2005 was -1% to -

1.5% per year (FAO, 2007) meanwhile it was -0.9% for the period 1990-2000 (FAO, 2005). This change in forest occurs both in areas that are said to be protected and those without any legal status with obvious effects being the reduction in biodiversity.

The Bafut-Ngemba Forest Reserve (BNFR): Conservation challenges

An example of a protected area that has gradually been encroached upon is the Bafut-Ngemba Forest Reserve (BNFR) despite the fact that Cameroon signed and ratified the Convention on Biological Diversity (CBD) in 1992 and 1994, respectively. By signing the CBD, Cameroon pledged to achieve by 2010, a significant reduction of the current rate of biodiversity loss at the national level as a contribution to poverty alleviation and to the benefit of all life on Earth. This commitment referred to as the CBD 2010 biodiversity target was adopted by governments in 2002 at the 6th Conference of the Parties (COP 6) of the Convention on Biological Diversity. It was later endorsed in the World Summit on Sustainable Development (WSSD) and has been included in the Millennium Development Goal under the reducing biodiversity loss target (Bubb et al., 2008).

According to Cameroon's forestry, wildlife and fishery regulations of 1994, the BNFR is a private property of the state and so it is forbidden to: clear any part of the forest; to set fire within; exploitation of such an area is forbidden; public access to this area may be regulated or forbidden and since this area is supposed to be reserved solely for forestry and wildlife habitat, customary right may be limited if they are contrary to the purpose of such an area. In spite of these regulations, it has been noticed that with the onset of the economic crisis in the late 1980s, things took a different dimension in Cameroon in general and the areas surrounding the forest reserve in particular. Few years after the crisis begun; the 1993 unemployment rate in Cameroon rose to 24.7%, whereas the reported rates were 7.3% and 14.7% in 1983-84 and 1987 respectively. The purchasing power of all citizens was worsened with the devaluation of the Francs CFA by 50% on 12 January 1994. The percentage of poor citizens rose from 40% in 1984 to 50.5% in 1996 (PNUD, 1998).

The immediate consequence of this crisis in the study area was the closure in 1985¹ of the Santa Coffee estate which served as a major source of employment to the population of Mile 12, Santa, Awing, Akum, Piyin and Mendankwe that surround the reserve. Field observations and interviews proved that these inhabitants were forced to involve themselves in an already saturated market gardening activity in order to have an alternative source of

income and means of subsistence. Land consequently became very scarce as some villagers decided to involve themselves in rearing which requires more land couple with the fact that the Fulani (Mbororo) cattle headers and some elites of the area have already consolidated a greater part of the land for themselves. This issue of land scarcity in this area has been illustrated with the re-current conflicts between Awing and Santa-Njong, Baligham and Awing, a general uprising by the villagers of Santa, Awing, Piyin and Baligham concerning a poorly negotiated land contract with the owner of an agro-industrial plan in the region. Due to this paucity, the only option has been to turn to the once protected BNFR to seek for a means of subsistence, thereby carrying out a number of activities which according to the law are illegal. A rampant deforestation has been noticed in this area. However, the extent and rate of change to the forest landscape is not fully understood, particularly by local land users and decision makers. Documentation of land cover provides information for better understanding of historical land use practices and change as well as current land use patterns. Information is needed regarding what changes occur, where and when they occur, the rates at which they occur and the social and physical forces that drive those changes (Lambin et al., 2003). The direct field survey and traditional technique which is time consuming, financially expensive and very strenuous can no longer meet up with the challenges of encroachment and forest change. New and improved methods to analyze and evaluate the existing situation and impacts are needed. It is for this reason that the present study used Landsat and ASTER images of 1978 and 2006, respectively to assess the rate of change in forest cover and land use employing remote sensing and GIS coupled with fieldwork to identify the actors of this change.

MATERIAL AND METHODS

Spatial context of the BNFR

The Bafut-Ngemba forest reserve is one of the eight reserves found in the North West region of Cameroon. This reserve which was classified by the Bafut-Ngemba Native Authority Forest Reserve Order in 1953 and registered as the Eastern Region public notice No. 140 of 1953 as a production forest reserve is found at some 35km from Bamenda, the regional capital and approximately 3km from the Sub-divisional headquarter of Santa. Like most forests in the North West Region, it is located on a high land with heights ranging from 1800m to about 2500m as shown in Figure 1. This reserve with a surface area of 4,218 hectares is crossed by a number of rivers and is a catchment area for the water that is used by the population of Bamenda. Lake Awing which is recognised as an international touristic site and a potential Ramsar site is located in this reserve. On the biodiversity point of view, this reserve falls amongst the 34

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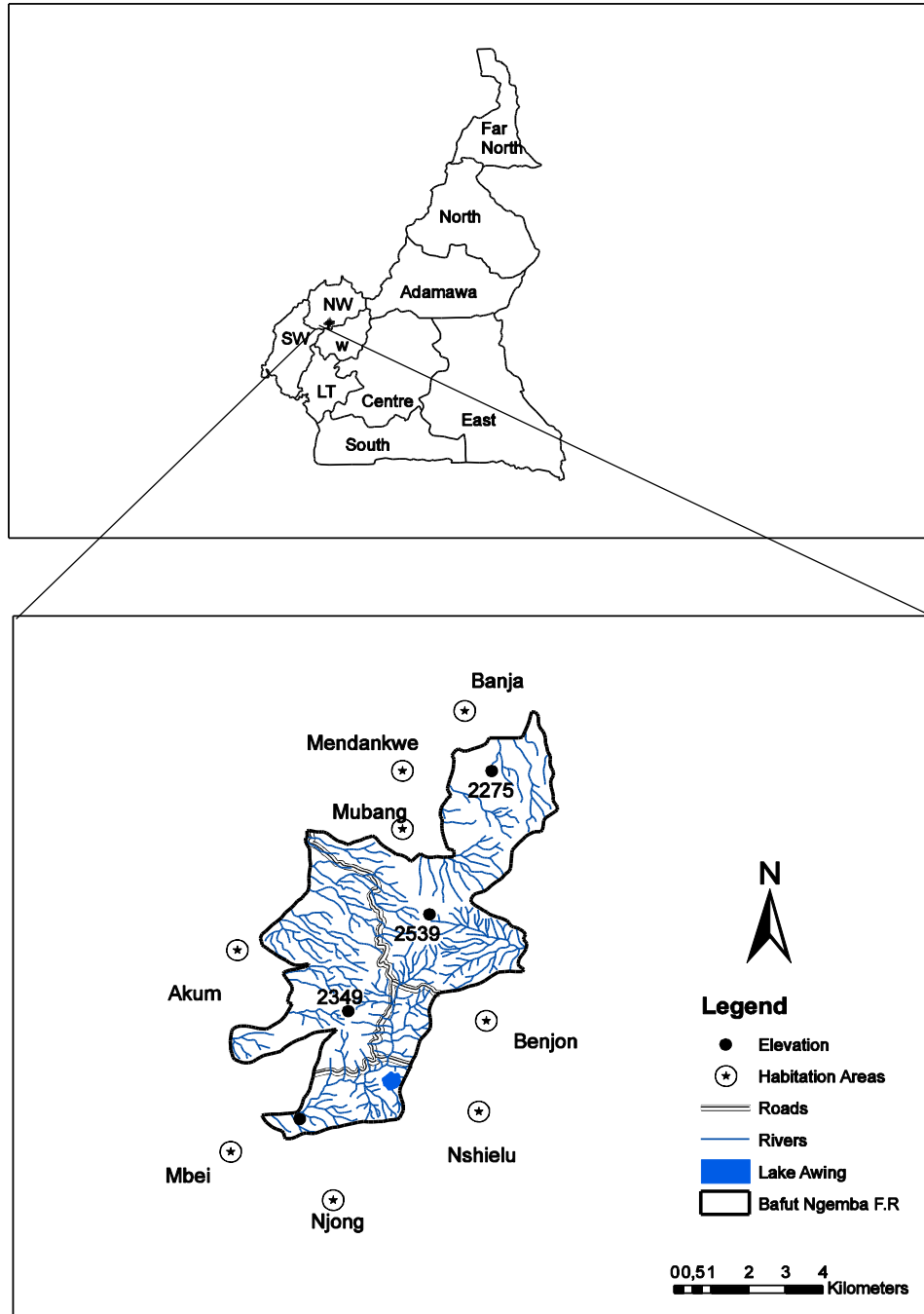


Figure 1: Location of the Bafut-Ngamba Forest Reserve in Cameroon

global hotspots (Conservation International, 2004) and the 218 Endemic Bird Areas (Bird Life International, 1998). Specifically, it is found within the Guinean forest of West African Hotspot. According to a report by Nsoh et al., (2006), this reserve harbours monkeys, chimpanzees, and antelopes amongst other species. This reserve is host to the Bannerman’s Turaco (*Tauraco bannermani*) and the Banded Wattle Eye (*Platysteira laticincta*) species of birds

which are found only in the montane highlands of the North West region of Cameroon and therefore warrants some amount of protection.

Data acquisition and preparation

The path and row for the Landsat MSS image downloaded from the Global Land Cover Facility (GLCF) website was

Table 1 . Area of cover types, general and annual changes 1978 and 2006

Land cover class	Area 1978(hectares)	%area 1978	Area 2006(hectares)	%area 2006	%Δ 2006- 1978	% annual Δ
Forest	2946	70	1373	33	-37	-1.3
Farmland	936	22	2106	50	28	1
Grass/shrub	163	4	613	14	10	0.3
Water/wetland	173	4	126	3	-1	-0.03
Total	4218	100	4218	100		

Source: Landsat satellite Image 1978 and ASTER Image 2006

P200r56_2m19781117. The ASTER image gotten from the Dresden University of Technology (Germany) had as number, AST_L1B_00310192001095522. The Landsat image which had been geo-referenced in the Universal Transverse Mercator (UTM), coordinate system, Zone 32 in datum World Geodetic System- WGS 84 was used to register the ASTER image in order to give them the same geometric properties. The images were enhanced using histogram equalization technique in Erdas Imagine 9.1 to obtain a good visualization during the extraction of the training samples for the eventual classification and to reduce atmospheric effects from haze. An overlay function was used to further verify that the images overlapped exactly across all two dates. This was done by visually swiping overlaid registered images in Arc GIS 9.3 confirming that linear features such as roads and rivers superimposed exactly on one another. This is essential to ensure that changes observed from year to year are a result of actual land-cover change and not compounded by errors in co-registration (Nagendra et al., 2006). For colour composites, bands 431 were used for the landsat image. The ASTER image was already combined. In order to extract the AOIs (area of interest), the boundary of the reserve on a geo-referenced topographical sheet of 1/50,000 gotten from the National Institute of Cartography, Cameroon covering the study area was digitized in ArcGIS 9.3 and overlaid on the satellite images to clip the reserve. An unsupervised then with the aid of field knowledge supervised classification was carried out on the two images using MultiSpec Version 5.01. Four cover classes resulted from the supervised classification. These were forest, shrub/grassland, farmland and water/wetland. The accuracy of the 2006 classified image was 93.4% with kappa statistics of 90.5%. The accuracy of the 1978 image could not be accessed due to the absence of ground truth data for that year. However, its classification accuracy was assured by picking training samples from unchanged areas.

These classified images were then transferred to ArcGIS 9.3 where the various classes were digitized on screen, statistics registered on the attribute table which eventually help in calculating the area of each cover class. In order to obtain the change in forest and land cover, the following formulae (Otukei, 2006) were used: Percentage area of

class= $AC/AT \times 100$, ΔC = Area (%) recent year – Area (%) old year; Rate of change= $\Delta C / \Delta P$. Where AC= Area of the cover class, AT=Total Area, ΔC =Cover change, and ΔP =Time difference. Two forest cover and land use maps were produced for the study area to compare and better appreciate the degree of change that has taken place in the Bafut-Ngemba Forest Reserve.

Field data collection

Field work was undertaken in the forest reserve and the surrounding villages between August and September 2012 with the use of a Garmin Etrex GPS to collect information on salient features which helped in ascertaining the validity of themes derived from the classification. During this phase, drivers of change witnessed in the reserve were identified through observations and questionnaires were also used to investigate on the reasons of encroachment upon an area considered as being under some form of protection. All the localities that immediately surround the BNFR were visited to collect data on socioeconomic conditions of the inhabitants and to identify the causes of deforestation. The localities were Banja, Mendankwe, Mubang, Akum, Santa Mbei, Santa Njong, Nshielu and Benjom. Here, guided interviews/discussions were conducted with the village chiefs and dignitaries and questionnaires were administered to the villagers on a random basis. A total of 80 questionnaires (40 men, 24 Women and 16 Youths) were administered to a corresponding number of households in the study area.

RESULTS

Change in forest and land use between 1978 and 2006

From digitizing onscreen the various classes or cover types that were obtained after the supervised classification, the following statistics presented in Table 1 were acquired.

In 1978, the Bafut-Ngemba forest reserve had more than half of its surface area covered with forest (70%) while farmland, water/wetland and grass/shrub occupied 22%, 4% and 4% of the surface area of the reserve respectively.

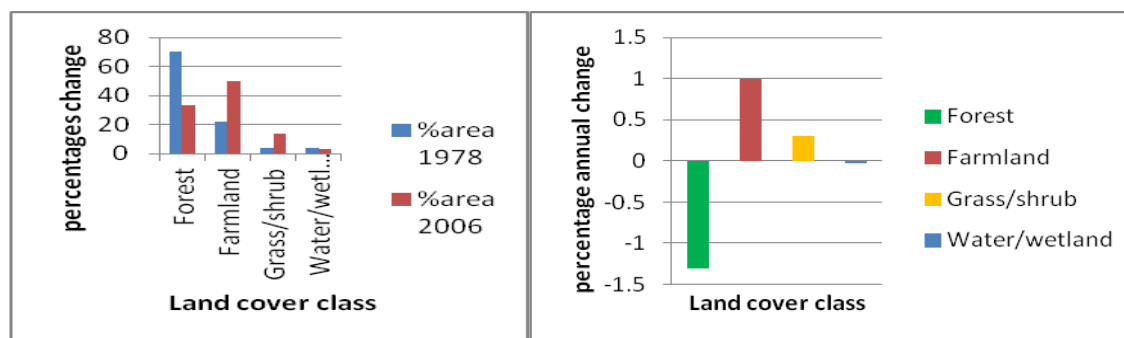


Figure 2: Percentage and annual change in forest and land cover types 1978-2006

Table 2. Socio-economic parameters of respondents

Activity	Number of Men	Number of Women	Number of Youths	Total	Percentage of Total
Farmers	18	11	3	32	40
Livestock rearers	2	0	0	2	2.5
Timber dealers	4	0	2	6	7.5
Carpenters	3	0	2	5	6.25
Fuel wood dealers	6	4	4	14	17.5
Charcoal burners	4	3	3	10	12.5
Teachers	1	3	1	5	6.25
Others	2	3	1	6	7.5
Total	40	24	16	80	100

Source: Fieldwork, 2012

However for 2006, the percentage area covered by each class was 33%; 50%; 14% and 3% in the same order as above. It is evident that some changes have occurred on the forest and land cover classes that make up the forest reserve between 1978 and 2006. Further analysis reveals that between 2006 and 1978, forest cover and water/wetland witnessed a change of -37% and -1% respectively while farmland and grass/shrub on the contrary increased by 28% and 10%. This represents negative annual rates of change of -1.3%; -0.03%; for forest and water/wetland. Conversely, grass/shrub and farmland increased annually by 0.3% and 1% respectively. These changes in forest and land cover types can be better visualised on Figure 2.

The above results show that there have been modifications on the forest and land cover types of the Bafut-Ngamba forest reserve for the 28 years period considered for the study with forest cover decreasing than any other cover types while farmland has an increased. A number of actors were identified as being responsible for these changes.

Actors of change in the Bafut-Ngamba Forest Reserve

The actors of change in the reserve as revealed through Field work in the study area were inhabitants of the

neighbouring villages, the nomadic Fulani (Mbororos) and timber dealers who encroach upon the protected area to practice several activities as shown in Table 2.

The inhabitants of Mendankwe enter into the reserve to cultivate mainly cocoa yam, cut fuelwood both for household consumption and for sale as well as burning of charcoal equally destined for the market. This village is well noted in Bamenda, the capital of the North West Region for its supply of fuelwood and charcoal to the population of the town especially on Saturdays which is considered as the principal commercial day for this town. Fuelwood and charcoal constitute the main source of income for approximately 80% of the interviewed population of Mendankwe and 60% of youths interviewed are equally involved in these activities which are concentrated in the north west section of the forest reserve.

In the eastern part of the reserve, another type of agricultural activity for commercialisation takes place. In this area are cultivated Irish potatoes, cabbages, tomatoes, onion and a variety of spices for commercial purposes. The inhabitants of Mile 12, Santa, Akum and some who come as far as Bamenda have transformed this part of the reserve for the practice of this activity. This is because these products have a short production cycle and a ready market since they are sold both internally and to far off regions as Gabon and Equatorial Guinea. In Mile 12 which serves as

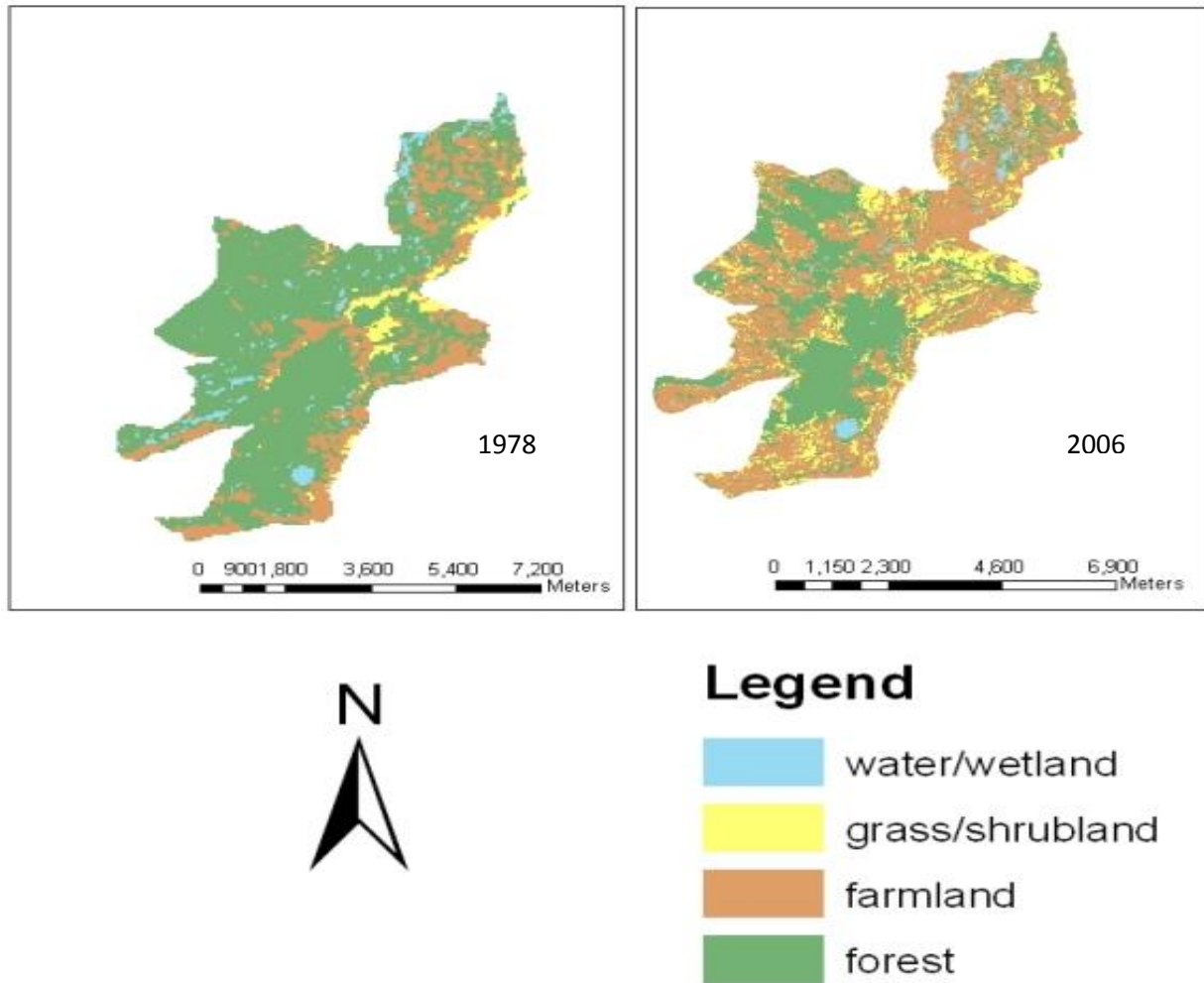


Figure 3: Change in forest and land cover 1978-2006

the collection point, these products are assembled and loaded on trucks to various destinations. This explains why farmland has increased tremendously in the reserve for the period between 1978 and 2006.

Fieldwork revealed that six cattle herd owners live in and around the reserve and are using it as a grazing ground. They usually set fire in the reserve to regenerate pasture for their animals which is against the decree enforced as most often, trees are burnt leading to a degradation of the reserve. Two of these cattle owners are from Akum, a village in the south west of the reserve while the other four are nomadic Fulani (Mbororos) who immigrated to the region.

The last activity that is used for infringing on the reserve is that of illegal wood exploitation for commercial purposes by dealers in plank. They have converted the reserve to a source of raw material for their business products. This activity has greatly been encouraged by the existence of a plank market in Mile 12 which is approximately 8 km to the reserve from the south east and the laxity in enforcing the

laws binding the reserve by the forestry administration. A combination of these activities have led to a change in forest cover and land use cover types with one gradually replacing the other in terms of surface area from 1978 to 2006 and forest decreasing more than any other cover type on one hand while farmland increases on the other hand. This spatial change is seen clearly on Figure 3.

DISCUSSION

The results of this study show a reduction in forest cover while farmland increased between 1978 and 2006. It also proved that with the use of satellite images along with appropriate fieldwork, the relationship between change in forest cover and land use could be established. Similar Studies carried out by Twumasi and Merem (2007) in the River Niger Basin demonstrated a decline in water bodies and shrubs between 1987 and 2000 while on the other hand, agricultural fields increased within the same period.

A related study carried out by Yuan et al., (2005) in Minnesota illustrated that between 1986 and 2002 the amount of urban or developed land increased from 23.7% to 32.8% of the total area, while rural cover types of forest and wetland decreased from 69.6% to 60.5%. Deforestation has greatly increased in this reserve as the inhabitants of the neighbouring villages are struggling to cultivate food crops both for consumption and for sale so as to have money to meet up with other demands especially with the onset of the economic crisis that affected Cameroon in the late 80s and is still going on. According to Sunderlin et al., (2000a), the rate of forest clearing by small farmers in the humid forest zone of Cameroon increased significantly in a period of economic crisis dating from 1986 and that macroeconomic instability can lead to unforeseen and grave consequences not only for the well-being of farmers but also for efforts to protect remaining tropical forest. The Structural adjustments programmes which led to the layoff of workers, the closing of the Santa coffee estate as well as the devaluation of the Franc CFA were identified as major sources of encroachment into the Bafut-Ngemba Forest Reserve as it has been cleared to make way for market gardening products. The result of another study by Sunderlin et al., (2000b), point out that the rate of deforestation increased significantly in the decade after the 1986 onset of the crisis, as compared to the decade prior to the crisis; the main underlying causes were macroeconomic shocks and structural adjustment policies that led to rural population growth and farming system changes. The consequences of these adjustments on forest lands were not only felt in Cameroon as Kaimowitz et al., (1998) explained in their research that for the three countries considered, forest clearing and degradation has increased since adjustment.

Fieldwork from the study area confirmed that the harvesting of fuelwood both for domestic and commercial purposes is another non negligible caused for the change witnessed on the reserve data from 1978 to 2006. Essama-Nssah and Gockowski, (2000), concluded from their study that the demand for fuelwood increased significantly as incomes plunged with the economic crisis and following the doubling in price of traded fuels after the 1994 devaluation. Consequently 83% and 96% of the total and rural population of Cameroon respectively depend on fuelwood and charcoal as principle cooking fuel. The fuelwood and charcoal market have thus been considered as the largest forest products market in terms of physical volume of timber felled.

Conclusion

With a time series analysis of satellite images, the change in forest cover and land cover types can be reliably assessed and continuously monitored. With the use of remote sensing and GIS technology, Landsat and ASTER satellite

images for the Bafut-Ngemba Forest Reserve were analysed and with the help of fieldwork, the rate of change in forest and other land cover classes were calculated. The summary of the result show a reduction in forest cover while farmland increased during the same period (1978-2006). The populations of the neighbouring villages, the Mbororos and dealers in plank were identified as the main actors of the decrease witnessed in forest cover. They encroached upon the reserve in order to seek for a means of subsistence and alternative source of income especially as the onset of the economic crisis prompted the closure of many state run structures like the Santa coffee estate in the study area. In order for this trend to be reverse and an effective management system for the reserve put in place, the use of remote sensing and geographic information system (GIS) is required since it provides a comprehensive source of accurate, up-to-date and timely information on the site of forest operation.

Addressing the issue of encroachment in the BNFR is not simply by law enforcement but by understanding the reasons behind the practice of illegal activities which pass through, the creation of buffer zones in the reserve as proposed by Jum and Oyono (2005), as these buffer zones are expected to provide additional farmland and cash income, agricultural and agro-forestry activities. Also, intensive methods of cultivation should be introduced to the locals so that more yields resulting from the cultivated parcels will consequently reduce the tendency of people searching for more agricultural land in the reserve. Alternative means of income earning like apiculture, poultry farming and the rearing of small rodents are encouraged in the area.

On the other hand, the authority in charge of managing protected areas in Cameroon should provide its external services with the necessary logistics and staff needed to carry out their duties properly. The financial remuneration of managers of protected areas should be improved so as to deter them from receiving bribes. These personnel also require constant re-training so that their role as forest managers is strengthened. The Global Forest Coalition (2008) concluded in its study that there is an increase in the numbers and extent of protected areas but little participation of local communities in their conception, creation and management. Consequently, it is recommended that the local population living around the BNFR be involved in its management. Muam (1999) refers to this as the co-management approach. That is, a better way of forest management is for the government and natives to participate in designing reserves so that every stakeholder appreciates its responsibility to sustaining forest growth.

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