

Analyses and Determinants of Land Use-Land Cover Dynamics in Dimako Sub-Division, East Region of Cameroon

Original Research Article

ABSTRACT

The transformation of forested lands by human actions represents one of the great forces in global environmental change and one of the great drivers of biodiversity loss. Forests are cleared, degraded and fragmented through timber harvest, conversion to agricultural lands, and road construction amongst others. In this vein, this study aims at analysing land use-land cover changes as well as their determinants in Dimako. A mixed research design was used in this study with primary data obtained through the use of questionnaire, group discussions, key informant interviews and field observations in order to identify the various ways of forest exploitation. Satellites maps were downloaded and analysed with the aid of geographic information techniques to assess the extent of forest cover and land use changes in Dimako. The findings revealed a decreasing trend in forest cover change from 1986-2016 by 0.285% per year. Forest was found to be exploited by local populations and by industrial logging companies for NTFPs and timber respectively. Also, the major factors contributing to the fast disappearance of the natural forest were attributed to industrial logging, agricultural land expansion, the rising demand for tree products, and poverty which have severe negative repercussions on the human population and environment. The study recommended providing environmental education, afforestation or agro-forestry, increasing income of rural households, providing alternative form of fuel (energy), strengthening participatory forest management and community based organization initiatives, and strong law enforcement on the part of the government on those who illegally and indiscriminately exploit the forests.

Key Words: Deforestation, Determinants, Forest Degradation, Forest Management Land Cover, Land Use

1. INTRODUCTION

The transformation of forested lands by human actions represents one of the great forces in global environmental change and one of the great drivers of biodiversity loss [1, 2]. Forests are cleared, degraded and fragmented through timber harvest, conversion to agricultural lands, road construction, and a myriad of other ways. The effort to use and subdue the forest has been a constant theme in the transformation of the earth in different societies especially within the international, national, states and local government or communities' circles [1, 2, 3, 4].

The global forest estate is estimated at over 40 billion hectares covering 31% of the earth's total land area and more than 1.6 billion people in the world depend to varying degrees on forest for their livelihoods and the forest plays a key role in economic development of many developing countries [5, 6]. Approximately 60 million indigenous people are almost wholly dependent on forest alongside some 350 million people who live within or adjacent to dense forests depend on them for subsistence and income [7]. Despite immense socio-economic and ecological functions, the loss of forest through degradation and deforestation from anthropogenic and natural causes has steadily increased over the years. In this regard, the Forest Resource Assessment [FRA] [8] reveals that while in 1990 forests made up 31.6% of the word's land areas, or some 4,128 million hectares, this has changed to 30.6% in 2015, or some 3,999 million hectares. Meanwhile, the net annual rate of forest loss has slowed from 0.18% in the early 1990s to 0.08% during the period 2010-2015 [7]. Africa and South America had the highest net annual loss of forests in 2010-2015, with 2.8 and 2 million hectares respectively. These figures of forest lost are mainly explained by extensive forest exploitation (timber extraction) of African forest which is not generally accompanied by sustainable measures but rather the focus is only on the economic gain. For many developing countries, Cameroon not being an exception, forests represent an important resource base for economic development. If managed wisely, the forest has the capacity to provide a perpetual stream of income and subsistence products, while supporting other economic activities (such as fisheries and agricultural activities) through its ecological services and functions [9, 10].

The need for a healthy environment has given rise to the global fight against deforestation identified as the main problem affecting climate, biodiversity, ecosystems and the usefulness of the forest as a resource [11, 12]. To reduce deforestation, forests mapping and the monitoring of their evolution are very important. Mapping areas of forest cover change is essential for developing locally adapted strategies to better control these dynamics [13, 17]. Land use change detection is often conducted to critically discern trends, drivers

and their impacts on the landscape to enhance decision making for of conservation biodiversity and ecological functions [15]. In a bid to redress threats and impacts of forest cover lost, to promote community participation and alleviate poverty, the Cameroonian forestry wildlife and fisheries law enacted in 1994 enshrined the concept of community forest corresponding to a maximum area of 5000 hectares, granting local community's access, to use and manage substantial portion of the non-permanent forest estate [16]. In this line therefore, to attain the goal of effective and sustainable management of forest resources in Dimako, the council created two community forest managed in synergy with the local communities concerned and a council forest of 18.052 hectares (classified under the permanent Forestry Domain in Cameroon) solely managed by the council following an operating plan [17].

The diverse uses of forest resources are vital for the livelihood of the population in and around Dimako [18]. However, this over-dependence and over-reliance on forest resources has greatly contributed to the over-exploitation, thereby threatening the sustainability of these forest resources. There exist greater chances that in the long run the forest will be unable to play its function of providing the population with the basic needs such as food, shelter, and clothing and substantially contribute to the sustainable development of the council area if it is not sustainably managed. This study therefore initiated a remote sensing-based land use-land cover baseline assessment, that is non-existent in Dimako, as a strategy for informing policy makers involved in the sustainable governance and management of this forest. The objective of this study was to make an appraisal of forest resource exploitation and analyze the spatial and temporal dynamics of land use-land cover changes in Dimako for the period 1986-2016.

2. THE STUDY AREA AND RESEARCH METHODS

2.1. Location of the Study Area

Dimako is located in the East Region of Cameroon and lies between latitudes $4^{\circ} 23''$ and $4^{\circ} 38''$ north of the equator and longitudes $13^{\circ} 34''$ and $13^{\circ} 56''$ east of the Greenwich Meridian (Fig. 1). The sub-division covers a total surface area of 750km^2 . It is bordered to the east by Mbang and Ndemnam in Kadey Division, to the north by Bertoua I and Bertoua II sub-divisions, to the west by Ndiang sub-division in the Lom and Djerem Division and to the south by Doume in Upper Nyong Division. Dimako is crossed from north to south by the Number 10 national road linking Yaounde, the nation's capital, to Bertoua. Dimako is located some 26km from Bertoua and by a secondary road linking Abong-Mbang Lambou Batouri in its eastern part at a distance of 18km. The district is about 75kms away from Abong Mbang the headquarters of the Upper Nyong Division and about 310kms from Yaounde, the nation's capital [19]. Dimako comprises of 30 villages and neighbourhoods sub-divided into five sectors.

2.2 Research Methods

The target population (2471 inhabitants) constitutes all the men and women of Dimako aged 40 and above and are permanent residents the area and are directly involved in forest related activities and the population used to estimate the sample size is 494 households. A total of 262 questionnaires were effectively administered. Questions targeted the exploitation and utilisation of the forest resources such as timber and non-timber products, their marketing, the drivers of forest degradation and deforestation in Dimako, the methods of forest resource exploitation, importance of forest resource exploitation to livelihood, and the environmental impacts of deforestation and mitigation strategies. This source of information was corroborated with interviews with various authorities and stakeholders involved in the exploitation of forest and non-timber forest products in Dimako. This sample size was stratified to the various targeted sectors or clusters after been weighted by the population size. The household heads were sampled purposively and conveniently.

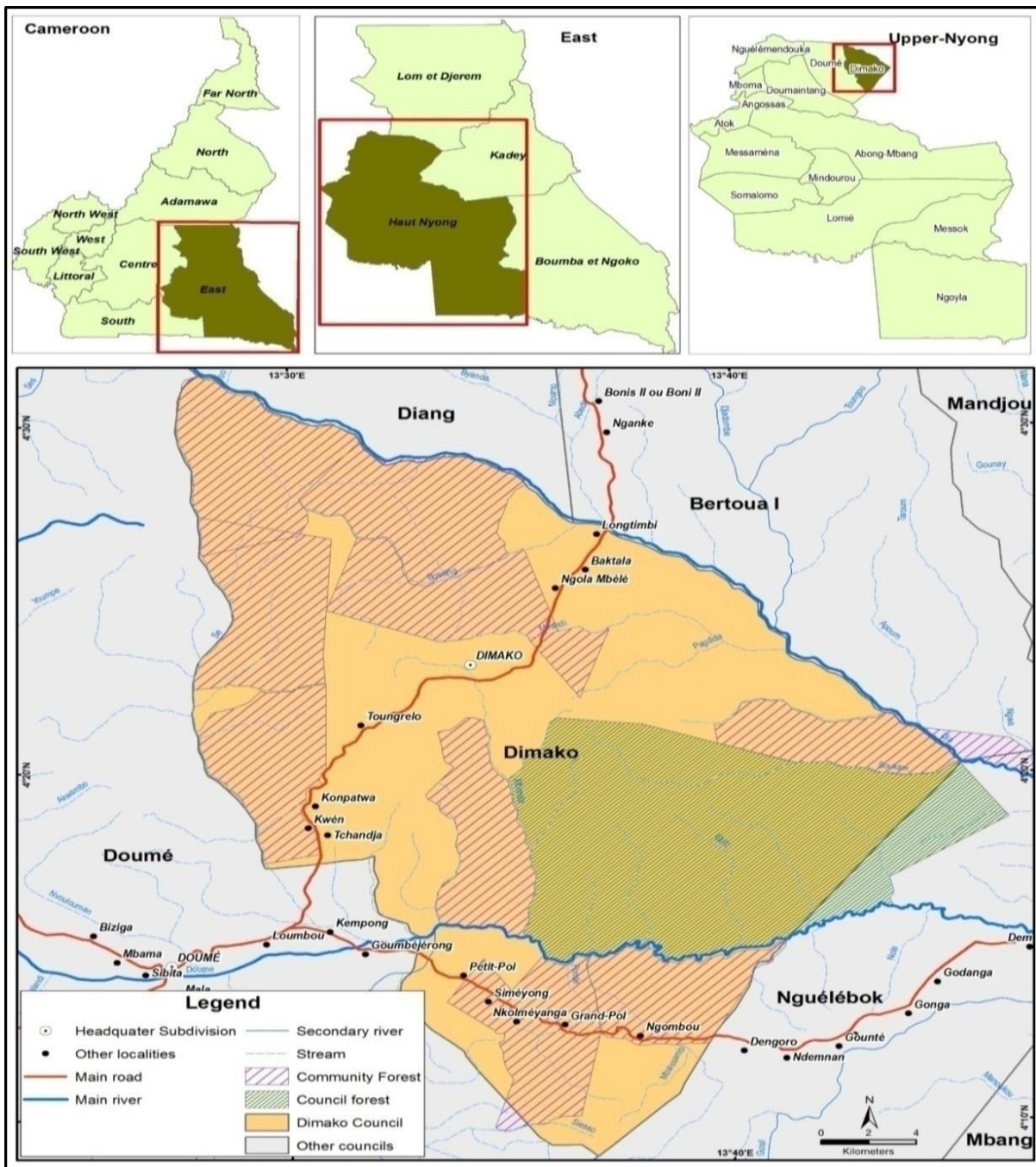


Fig. 1: The location Map of Dimako Sub-division in Cameroon

Source: USGS Data Base extracted by Authors (2016)

The secondary sources of data entailed the use of textbooks, journals, magazines, websites, radio and televisions, as well as conferences. Materials and information from existing published and unpublished works such as dissertations in public and private libraries (such as the University of Buea Library), related to the topic were also consulted. Maps showing the location and forest sites of Dimako were equally obtained from the Dimako Council.

Data generated from the semi-structured questionnaires were subjected to statistical analysis to produce descriptive and inferential statistics. Frequency tables were used to represent data in tabular form starting with percentages. Tables were equally used to describe the variables and attributes of the nature of forest exploitation in Dimako, and the environmental impacts to the inhabitants. The analysed data were presented in the form of descriptive writing, tables, photographs and graphical representations for easy understanding and to answer the study objectives.

Assessments of land use-land cover changes were conducted using Landsat MSS (Landsat Multispectral Scanner) and Landsat ETM+ (Enhanced Thematic Mapper Plus path 185, row 31). The Landsat ETM+ images were downloaded from USGS Earth Resources Observation Systems data Centre and Landsat MSS images were provided by a commercial data provider. GIS 2013 and Base camp were also used to download

satellite images of high resolution for Dimako subdivision and environs for the four different years that is, 1986, 1996, 2006, and 2016. These time periods were deemed preferable because there are massive land use-land cover changes at the decadal level from 1986-2016, due to extended forest exploitation, agricultural expansion, settlement development and industrial logging, amongst others.

These different images were processed using ENVI 4.5 software to extract desired information. Landsat images were subjected to image enhancements activities such as pan sharpening, normalized difference vegetation index calculations, layer stacking and colour composition activities were carried out to ameliorate the brightness, contrast and visibility of objects, to reduce omission and confusion errors to increase accuracy in spectral differencing of objects during classification. Extraction of the study zone was made using a geo-rectified vector map (UTM 32 WGS 84).

3. RESULTS AND DISCUSSION

3.1 Land use-land cover Analysis

3.1.1 Spatial extent of land use-land occupation in Dimako (1986-2016)

From the classification of images obtained from Landsat scenes for the period between 1986- 2016, six main land cover classes were identified (Table 1).

Table 1: Areal extent of land use-land occupation (1986-2016) in hectares (Ha)

Class Name	1986 (Ha)	1996 (Ha)	2006 (Ha)	2016 (Ha)
Dense forest	62,204	59,530	61,486	54,715
Farmland/ shrub	8,389	9,330	6,940	11,649
Forest exploitation	1,228	2,452	1,934	2,210
Bare soils	1	519	1,321	2,749
Built up area	206	225	365	723
Water surface	2	11	3	2
Total	72,030	72,049	72,049	72,048

Source: Satellite images (1986-2016)

From the maps presented, there are differences in land use-land cover in the Dimako. The area is characterised by dense forest cover which as per 1986 covered a total surface area of 62,204ha. This corresponds to the main land cover in the area (Fig. 2a). Farmlands cover a surface area of 8,389ha of the total land area, forest exploitation area covered 1,228ha as per the base year 1986. The built-up area made up just 206 hectares by then while water surfaces occupied a surface area of approximately 2 hectares.

The period between 1986 to 1996 dense forests covered a total surface area of 62,204ha and 59,530 respectively (Fig. 2b) and this implies that there has been a reduction in area coverage of dense forest of 2,674ha representing a percentage change of 4.3 between this period principally accentuated by industrial forest exploitation which was at its peak. Despite this reduction in area coverage during this time, dense forest still covers a greater portion of Dimako sub-division. In 2006, dense forest covered a total surface area of 61,486ha as compared to 59,530ha in 1996 and this shows that there has been a substantial increase in area coverage of +1956ha representing a percentage increase of 3.286% (Fig. 2c).

This increase was attributed to the successes of various reforestation programmes in the council specifically in the south eastern section of the council reinforced by the presence of a council forest and some community forest all geared toward forest conservation and regeneration.

In the year 2016, the destructive effects of unsustainable forest exploitation have become more visible on the environment and as such as revealed by satellite image corresponding to this year, the total land surface covered by dense forest in this year was 54,715ha implying that there has been a decrease of over 6,771ha over a period of only 10years (2006-2016) indicating a 11.012% decrease per annum (Fig. 2d). This decrease is attributed to an increase in industrial forest exploitation. These findings are in line with those of Akodewou et al [20] in Southeastern Togo, West Africa and Baig et al [21] in Selangor, Malaysia, who both established severe land use-land cover changes over time as a result of human-induced activities.

3.1.2 Forest cover loss to land occupation from 1986-2016 in Dimako

Analysis on the different land use-land occupation reveals a lot of changes as proven by the various statistics on satellite images captured for the period covered by this study and from this perspective therefore an in depth analysis will reveal a more complex scenario. Changes on the different land use-land cover in Dimako subdivision over the period covered by this study shows a variation in trends from the overall trends as shown by the different satellite images and statistics corresponding to the different years covered (Table 2).

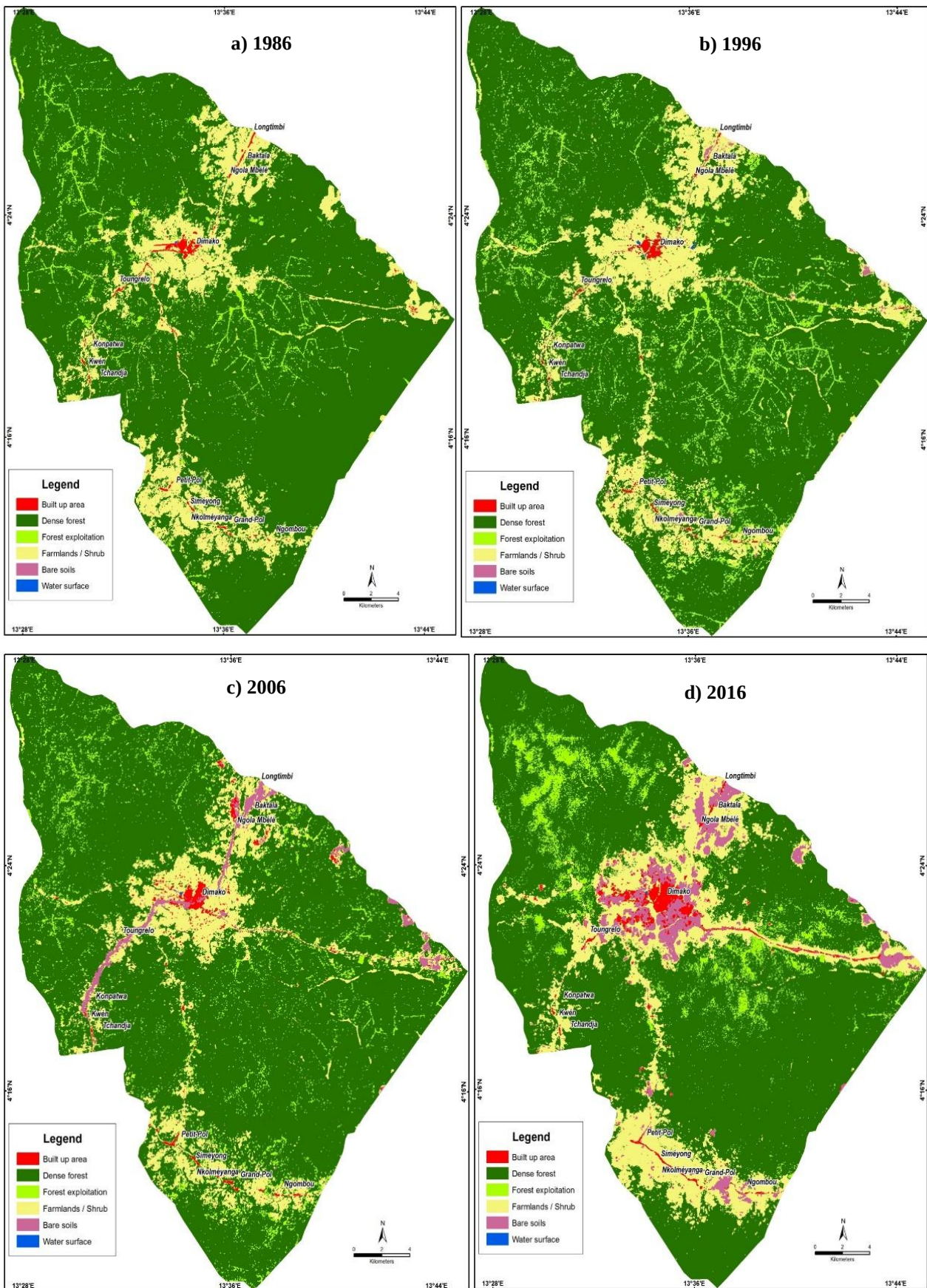


Fig. 2: Spatial extent of land use-land occupation from 1986-2016 in Dimako
 Source: Compiled from satellite images (1986-2016)

Table 2: Dynamics in Land use-land occupation for the period 1986 - 2016

No	Class names	Area covered in hectares		Change in area coverag e	% change	Area covered in hectares	Change in area coverage	% Change
		1986- 1996	1996- 2006			2006-2016		
1	Farmlands/ Shrub to Dense Forest	1704	2555	+851	49.941	389	-2166	-84.774
2	Dense forest to farmland /shrub	3162	1050	-2112	66.793	6435	+5,385	+512.857
3	Dense forest to forest exploitation	1863	1135	-728	39.076	2033	+898	+79.118
4	Forest exploitation to farm land /shrub	149						
5	Forest exploitation to dense forest	586	1785	+1199	204.607	1457	-328	+18.37
6	Farmlands/shrubs to build up	94	229	+135	143.617,	355	+126	+55.021
7	Dense forest to Bare soils	78	247	+169	216.666			
8	Farmlands/shrubs to Bare soils	394	729	+335	85.025	1903	1,174	161.042
9	Bare soils to Farmlands/shrubs		185	+185	100	522	+337	182.162
10	Bare soils to Dense forest					89	-	-
11	Bare soils to Build up					148	-	-

Source: Satellite Images (1986-2016)

Fig. 3 presents a summary of land use-land cover dynamics in terms of changes in area coverage in Dimako. Land use-land occupation for the period 1986-1996 (Fig. 4a) reveals a lot of variation with dense forest conversion to farmland/shrubs (3,162ha) being the highest change that occurred during this period followed by the conversion of forest to forest exploitation zone (1,863ha). Thirdly, by the conversion of farmlands / shrubs to forest (1,704ha) whereas the least change involved the conversion of dense forest to bare soils (78ha) (Table 2). The different changes simply illustrate a scenario whereby there was an increase in industrial forest exploitation activities propelled by the installation of the sawmill by the French company SFID and the corresponding high demand of timber in the world market (Personal Communication, 2021). As such, this vast exploitation contributed in opening of the forest which was converted to agricultural land without any of forest conservation and regeneration efforts.

The period 1996-2006 was marked by considerable dynamism on the different land use-land cover categories in Dimako, as such the conversion of farmlands / shrub to dense forest skyrocketed from 1,704 ha in the period 1986-1996 to 2,555ha in period 1996-2006 (Fig. 4b). This happened predominantly in the south around Simeyong, Ngombou and Grand Pole. This variation shows a drastic increase in area covered by dense forest of 851ha and this shows with vigour that an acceptable effort was made towards forest regeneration by the different stakeholders involved in forest exploitation and management though much still remains to be done in this domain so as to equate the ever-increasing rate of forest degradation. The increase in population witnessed in and around Dimako has led to an increase in demand for foodstuff and this situation was a call for the rural dwellers to put in more efforts in farming to meet up this ever increasing demand coming especially from Bertoua which is just 28km away from Dimako.

This could be attributed to forest regeneration campaigns and the low yield of agricultural production generally caused by poor agricultural methods and low prices especially for cash crops whose prices are on the declined in the world market thus forcing many to abandon their cultivation to concentrate more only on farming for sustenance which do not necessitate large farm size as compared to cash crop production. This has made farmland sizes to be small and dense forest to be on the increase.

During this same period, the conversion of dense forest to forest exploitation zone witnessed a considerable change passing from 1,863ha to 1,135ha representing a reduction in area coverage of 728ha equivalent to 39.076% (Table 2). This figures simply depicts a clear picture of the fact that there has been a form of awareness about the negative externalities of deforestation and as such the stakeholders insisted on the preservation and regeneration of forest ecosystem and this made the exploiters to an extent to adhere to this although much still need to be done to meet up with forest degradation rate witnessed in this municipality.

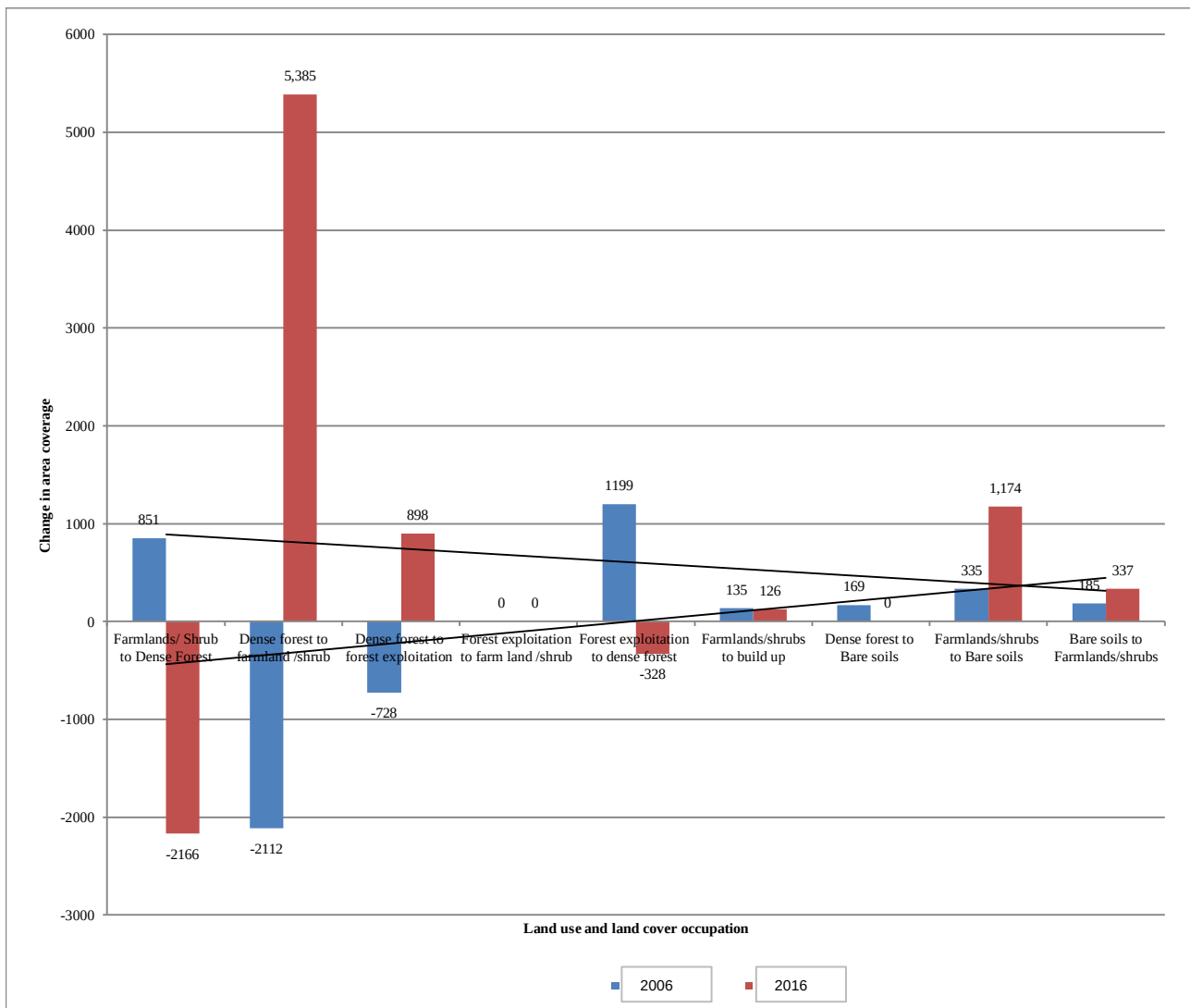


Figure 3: Summary of changes in land use-land cover in Dimako

Source: Field work (2017)

Also, the desire to increase farm size so as to meet up with increasing demand for food supply implies that there was need to convert forested areas to farm land /shrub which were estimated at 149ha during the period 1986-1996. This land use change is particular in the fact that it only existed during this period of time and this can be attributed to the fact that timber exploitation generally takes place deep and far in the forest and as such very far from homes and as a result people generally finds it difficult to cultivate in such remote places but rather prefer nearby lands for their agricultural activities.

Also, during this same period, the conversion of forest exploitation zone to dense forest witnessed a positive change depicted by the fact that while in 1986-1996 it was estimated at 586ha and increased to 1,785ha in 1996-2006 which is equivalent to an increase of +1199ha. This is due to forest regeneration programs undertaken by the various stakeholders with the participation of the local population and the sensitization campaign about the vital role of forest ecosystem.

The ever increasing population of Dimako led to a consistent increase in the demand for more land for residential purpose and to this effect the conversion of farmlands/shrubs to built-up areas witnessed a positive change from 94ha during the period 1986-1996 to 229ha in 2006, representing a change of 135ha (Fig. 4b), predominantly around the Dimako Centre stretching toward Ngolambe with small portion around Toungrelo. These figures therefore depict the fact that there has been an increase in demand for residential land and as such nearby farms have been continuously converted into built-up lands as a response to an increase in demand for housing.

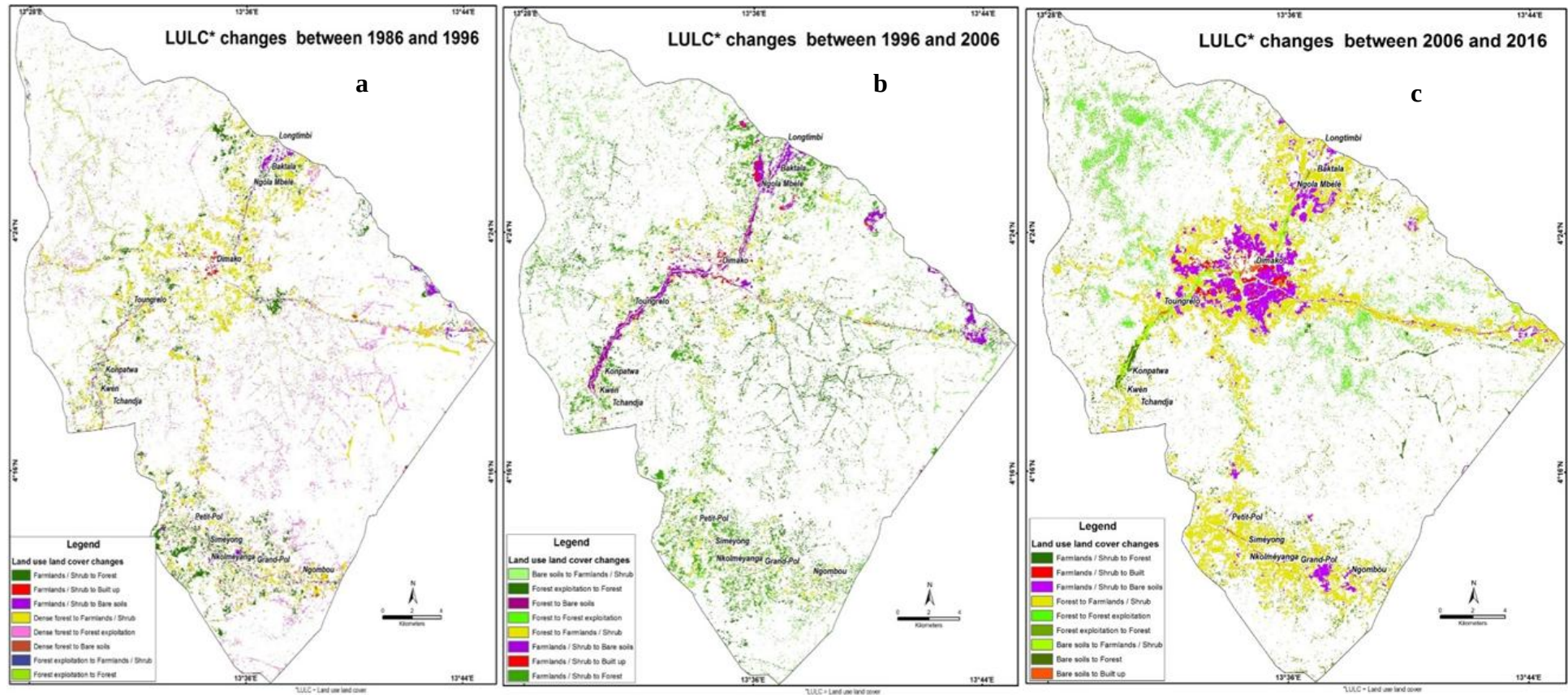


Fig. 4: Land use-land occupation changes for the period 1986 to 2016

Source: Satellite images (1986-2016)

During this period, the conversion of dense forest to bare soils has been on the increase from 78ha to 247ha representing a significant change in area coverage of 169ha equivalent to 216.67% change (Fig. 4b), principally occurring around Longtimbi and Toungrelo areas. This figure depicts with vigour that the forest ecosystem and the environment as a whole have greatly suffered during this period.

The conversion of farmlands/shrubs to bare soils during this period witnessed a significant increase from 394 ha to 729ha representing a substantial increase of 335ha. This figure shows that there has been an increase of bare soils in Dimako as a result of extensive unsustainable forest exploitation. The fall in prices of agricultural produce especially cash crops has greatly discouraged the poor farmers of Dimako and as such many decided to abandon their cultivation thereby contributing to the accentuation of bare soils in Dimako.

By the year 2016, Dimako witnessed a drastic reduction in agricultural activities as depicted by the different changes in land use-land cover whereby the conversion of farmlands / shrub to dense forest faced an appreciable reduction of 2,166ha in total land cover by farmlands as compared to the period between 1986-2006 where this land use-land cover change was on the increase (+851). Later on due to increase in demand for food stuff and the tarring of main road linking Dimako to the rest of the country that helped in the easy evacuation of agricultural products, the recent increase in prices of certain cash crops and the vulgarization of agricultural projects in the area pushed many to go back into agriculture to meet up with the high demand for agricultural products and as such the municipality witnessed a significant increase in the conversion of dense forest to farmland /shrub passing from 1,050ha in 2006 to 6,435ha in 2016 which is equivalent to an increase in area covered of 5,385ha in almost all the municipality especially around the centre which has high concentration of farmlands stretching toward the south. Despite this increase in farmlands, production still remain low and as such much still remains to be done in this domain in order to lift Cameroonian agriculture to the next level through mechanization (Fig. 4c).

The ever increasing demand for timber products both locally and internationally has urged many to indescribably exploit the forest. As such, there has been a substantial increase in the conversion of dense forest to forest exploitation zone from 1,135ha to 2,033ha which represents an increase in area coverage of +898ha in 2016. This illustrates that as demand for timber continues to increase so too the forest will continue to be exploited. Moreover, to further substantiate on the ever increasing demand for timber products, the forest ecosystem in Dimako has witnessed severe deterioration as illustrated the by the fact that there is a decrease in the conversion of forest exploitation zone to dense forest passing from 1,785ha in 2006 to 1,457ha in 2016 representing a lost in area coverage of -328ha equivalent to 18.37% change and so long as the demand continues to increase without the implementation of sustainability in the forestry domain the forest in Dimako will continue to declined significantly.

Forest exploitation in the municipality has serve as a pull to attract population from near and far attracted by the substantial job opportunities offered by the forestry sector and as a result of this massive movement of people there is need for additional space for lodging purpose. Farmlands near the Dimako Centre stretching towards Toungrelo, Baktala and Longtimbi were rapidly converted into built-up areas to respond to the increase in demand for additional space for housing purpose and as such the conversion of farmlands/shrubs to built-up increased from 229ha to 355ha portraying a change in area coverage of +126ha. These figures therefore show that the increase in population led to increase in demand for land for settlement in Dimako.

Furthermore the different activities carried out led to a change of the different land use-land cover in Dimako and as such, the conversion of farmlands/shrubs to bare soils during this period of time witnessed a significant increase from 729ha in 2006 to 1,903ha in 2016 representing a substantial increase of 1,174ha. This figure shows that there has been an increase of bare soils in Dimako which shows with assurance that there is high level of environmental degradation emanating principally by extensive unsustainable exploitation of forest resources and the fall in prices of agricultural prices especially cash crops. This has greatly discouraged the poor farmers of Dimako and as such many decided to abandon their cultivation which may be to a smaller extent responsible to the accentuation of bare soils. Furthermore, the presence of vast land area covered by bare soils showed the high level of forest degradation there by hindering the forest to play its main function of climate moderator, pertinent role in the hydrological cycle and providing food to the local population and this situation negatively affects their livelihoods due to their high dependence on forest. As a response to increase in land area covered by bare soils, the population resorted in their conversion into built-up area estimated at 149ha in 2016, agricultural land moving from 185ha in 2006 to 522ha in 2016 depicting an increase in farmlands +337 ha to meet up with the ever increasing demand for food stuff in and around the municipality Another important use of these bare soils is seen in the promotion environmental sustainability through the introduction of forest regeneration schemes aimed at revitalizing the forest ecosystem and in 2016 these efforts paid up with an estimated 89ha of bare soils converted into dense forest.

These findings are in line with those of Takem-Mbi [13] in the North West Region of Cameroon, Njilla and Djou [18] in Dimako, East Region of Cameroon, Akodewou et al [20] in Southeastern Togo, West Africa and

Baig et al [21] in Selangor, Malaysia, who established severe land use-land cover changes over time as a result of anthropogenic activities.

3.2. Determinants of land use-land cover changes in Dimako (1986-2016)

The major determinants of land cover changes in Dimako from 1986 to 2016 are industrial logging, agricultural land expansion, fuel wood production and harvesting, increase in poverty and population pressure (Fig. 5).

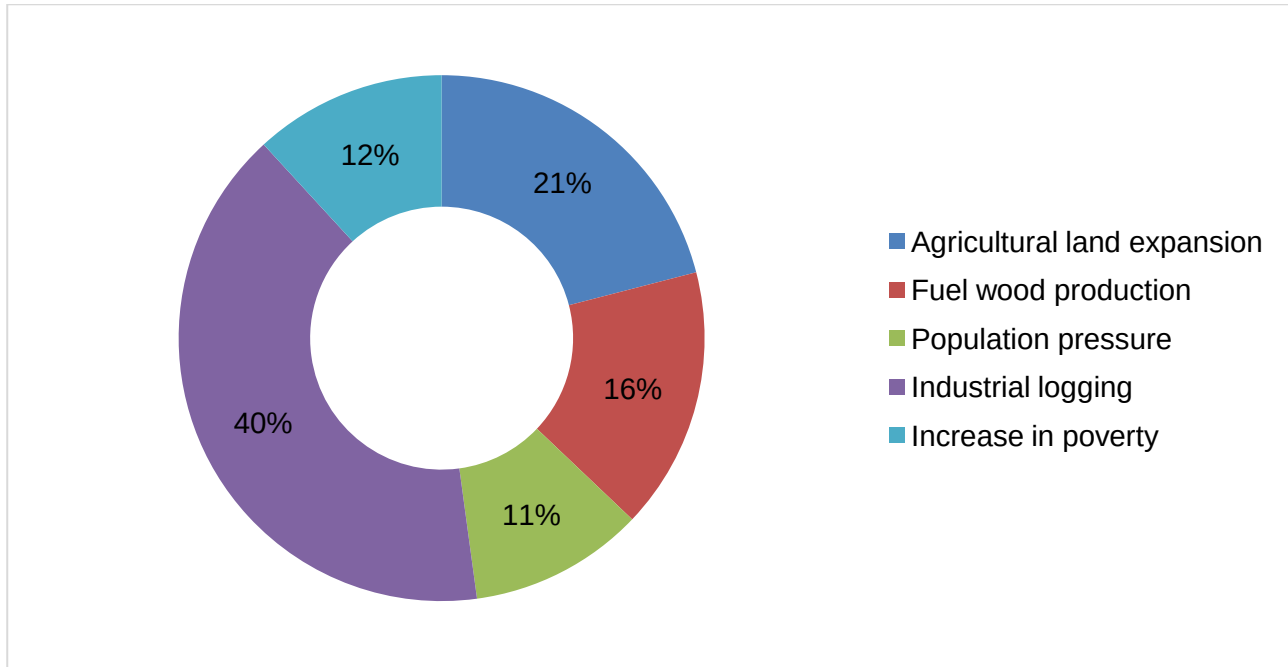


Fig. 5: Perceived Factors for Changes in Forest Cover (1986-2016)

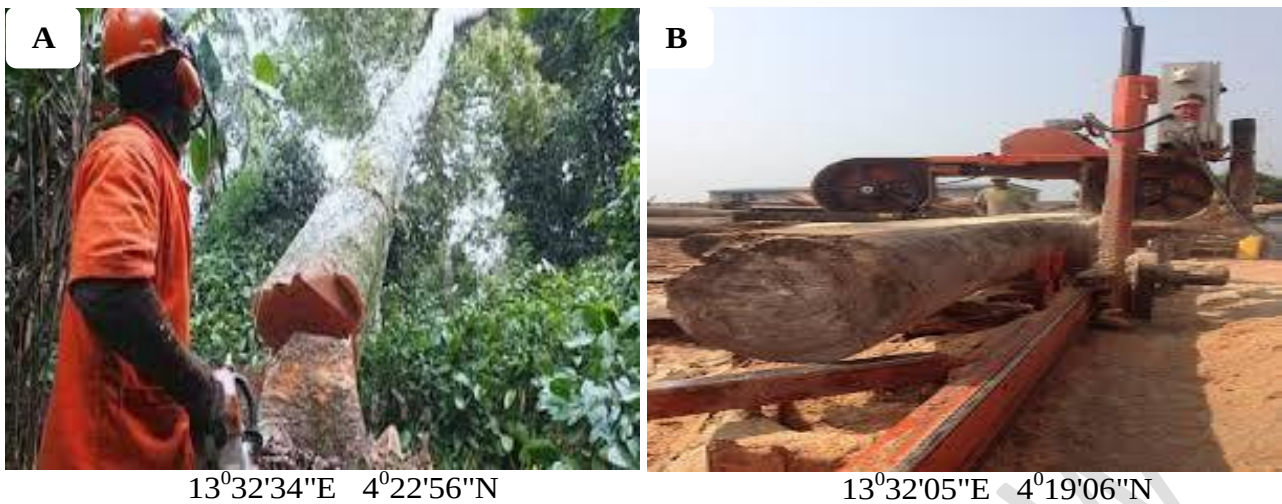
Source: Field work (2016)

3.2.1 Industrial logging

Industrial logging (Fig. 6) is the major factor of the degradation of the tropical forest in Dimako. Since the establishment of the saw mills in the early 1965, there has been an increase and intensive forest exploitation. Logging activities are intense in the subdivision and it's carried out in two ways; legal and illegal exploitation. Legal exploitation is done in the council forest by the council and in the two community forests by the population organized in Common Initiative Groups (CIGs).

Industrial logging which represents 40% is the major cause of forest change and this activity causes a lot of damages to the forest ecosystem and the environment at large in Dimako sub-division. This implies that logging when carried out intensively and in an unsustainable manner greatly contributes to the degradation of the forest and consequently to deforestation. For many years, the timber trade has claimed that it plays a negligible role in forest loss and that most deforestation is caused by agricultural clearance or fuel wood collection. Population growth rather than industrial exploitation has been blamed as the underlying problem. However, research conducted by the WWF led to the opposite conclusion. Taking the survival of biodiversity as a major criterion WWF concludes that the timber trade is currently the most significant cause of loss of biodiversity and forest degradation in the world. These findings are in consonance with the situation of Dimako, where biodiversity loss has increased during the period of industrial logging. Another dimension of the problem is when roads are constructed by the logging companies for the evacuation of timber. Huge expanses of land are destroyed in order for a road to pass, sometimes to evacuate only a few trees (Fig. 7).

From the above-mentioned point, it is but clear that logging companies contribute enormously to the destruction of our forests and this. In any place where logging companies are present, it implies the use of heavy equipment like caterpillars and bulldozers. This means that when a logging company is in an area in a matter of a short period of time, the entire forested area is cleared. This reflects the situation of Dimako and the East Region of Cameroon where trucks are seen every day transporting timber (both processes and unprocessed) to Douala for onward transportation to the world markets. This has been a major cause of deforestation in this area of study.



13°32'34"E 4°22'56"N

13°32'05"E 4°19'06"N

Fig. 6: Industrial Wood Exploitation in Dimako (A) timber being fell in the forest, (B) modern saw mill for sawing plank

Source: Field work, Council Forest Technical Unit and Getty View (2017)



13°33'12"E 4°21'39"N

13°34'06"E 4°19'32"N

Fig. 7: Road Construction within the Forest for Evacuation of Timber

Source: Field work, Council Forest Technical Unit and Getty View (2017)

3.2.2 Agricultural land expansion

The population of the study area estimated at about 14,621 inhabitants are highly dependent on agriculture as their main means of livelihood. Generally, people in Dimako practice mixed cropping, i.e., a combination of cultures, on the same piece of farmland of about one to two hectares of land and agricultural land expansion is seen as a major cause of change on the forest cover over time in Dimako. The increase in population entails more demand for food and so more land for crop farming and animal husbandry. Deforestation is inextricably linked to the expansion of agricultural lands. The poor farming methods practiced by the population of Dimako such as the use of bush fires, shifting cultivation and subsistence farming in general has greatly contributed to the rapid destruction of vast forest in rural communities of Dimako as confirmed by 21% of the respondents stating that the conversion of forest land into farmland was the major cause of forest destruction in their locality.

In the late 1960s and early 1970s, farm sizes ranged from about 0.25ha – 3ha compared to those of today where farm sizes range from 0.25ha to more than 100ha. This portrays that the areas under cultivation have greatly increased leading to a fast and rapid encroachment into the forest. Also, the fallow period today ranges from only a few years compared to about 5 to 6 years some 20 to 25 years ago. This has greatly intensified agriculture leading to deforestation and forest degradation in Dimako. It is really difficult to estimate the agricultural production in the municipality because producers do not keep accounts and there is no statistical data at the delegation of agriculture.

Concerning the use of fire, it often goes beyond the expected boundaries, burning more forest surface. In Dimako, the poor implementation of highly productive agricultural practices results to poor yields per surface area cultivated. Therefore, more land is needed to produce more food. From this perspective, it can be concluded that the poor agricultural practices and farming methods used by the farmers in Dimako have greatly contributed to rapid forest degradation in Dimako.

3.2.3 Forest exploitation for Fuel Wood

Field data indicated that, 16% of the population confirmed that forest exploitation for fuel wood was a major cause of forest change next to agricultural land expansion in Dimako. Fuel wood production was the third highest cause of change in forest cover in Dimako sub-division and the wood is required for fuel in rural areas and for sale in neighbouring town of Bertoua where it is in high demand. The excessive cutting of trees for firewood greatly contributes to the destruction of the forest cover in Dimako and a great majority of the population clearly put out the fact that local collection of firewood by the indigenes for home consumption is not really a serious threat to forest cover in this locality but the problem emerges when they start engaging in the massive sale of fire wood to the neighbouring town (Bertoua). The increase in demand for fuel wood in nearby agglomerations has been a motivational factor toward forest destruction so as to meet up with the demand and from this regard therefore it is clear that as long as the demand for fuel wood is going to increase in neighbouring towns so too will the forest disappear in Dimako. In relation to this, key informants noted that they were collecting a lot of firewood for cooking and heating as there were few or no sources of alternative energy in their locality and as such the only way to have energy for the household is by cutting down trees thereby causing a significant change in forest in the locality.

3.2.4 Increase Poverty

Poverty is one of the causes of forest exploitation in Dimako sub division and 12% of the population perceives poverty as one of major causes of forest disappearance and consequently deforestation in Dimako. Rural poverty continues to increase because producer prices for cash and food crops declined, resulting to 60% in rural incomes. This situation caused many inhabitants in the predominantly cash crop producing areas like Dimako sub-division to abandon their farms and resolved to subsistence agriculture through slash and burn or forest encroachment and also the over-reliance of the population on wood for settlement construction. These have greatly affected the surface area of the forest in Dimako leading to forest degradation and deforestation.

3.2.5 Population pressure

Population growth is a significant driver of forest change and degradation, as well as one of the underlying causes of deforestation in Dimako. This is manifested through changes in the number of rural families seeking land to cultivate, harvest fuel wood or exploit timber; populations indirect effects on labour markets; demand for agricultural and forest products, particularly the harvesting of non-timber forest products and their commercialization; and induced technological or institutional changes, particularly in the industrial logging sector.

Likewise, population growth is the cause of forest degradation in Dimako which has been accentuated by the implantation of the sawmill by SFID specialized in veneer and plywood manufacturing. This and other wood processing factories has all attracted immigration to the sparsely populated area making the population to significantly increase and this entails the need for more land for agriculture and settlement to feed and accommodate this influx and to attain this therefor there is need to clear down more forest. The household questionnaire revealed that about 11 % of the respondents reported population pressure on land was one of the major (underlying) causes of deforestation in the study area. According to the national census statistics of 2005, the Dimako subdivision is inhabited by 14,621 people, with more than half of the population living in the Dimako Centre. The average density is 4.5 inhabitants per km² and growth rate is 3.2%. Findings indicate that the highest household size of the study area is found to be 7-10 people per a household. Besides, during the field survey, the investigator observed that the household had a large family size and due to this fact, he observed that more people required more food and space which in turn necessitated extra land for agriculture and habitation. This in turn resulted in additional clearing of forests.

These findings are in line with those of Takem-Mbi [13] in the North West Region of Cameroon, Njilla and Djou [18] in Dimako, East Region of Cameroon, Akodewou et al [20] in Southeastern Togo, West Africa and Baig et al [21] in Selangor, Malaysia, who established various aspects of the determinants of land use-land cover changes over time. However, the present study went further to examine in a holistic manner the determinants of land use-land cover changes in Dimako which is a rapidly urbanizing area in Cameroon.

From the foregoing, an assessment of the relationship between forest cover and forest exploitation in Dimako (Fig. 8), illustrates that there is an inverse relationship between rate of forest exploitation and extent of forest cover in Dimako. This is indicated by a correlation coefficient of -0.599.

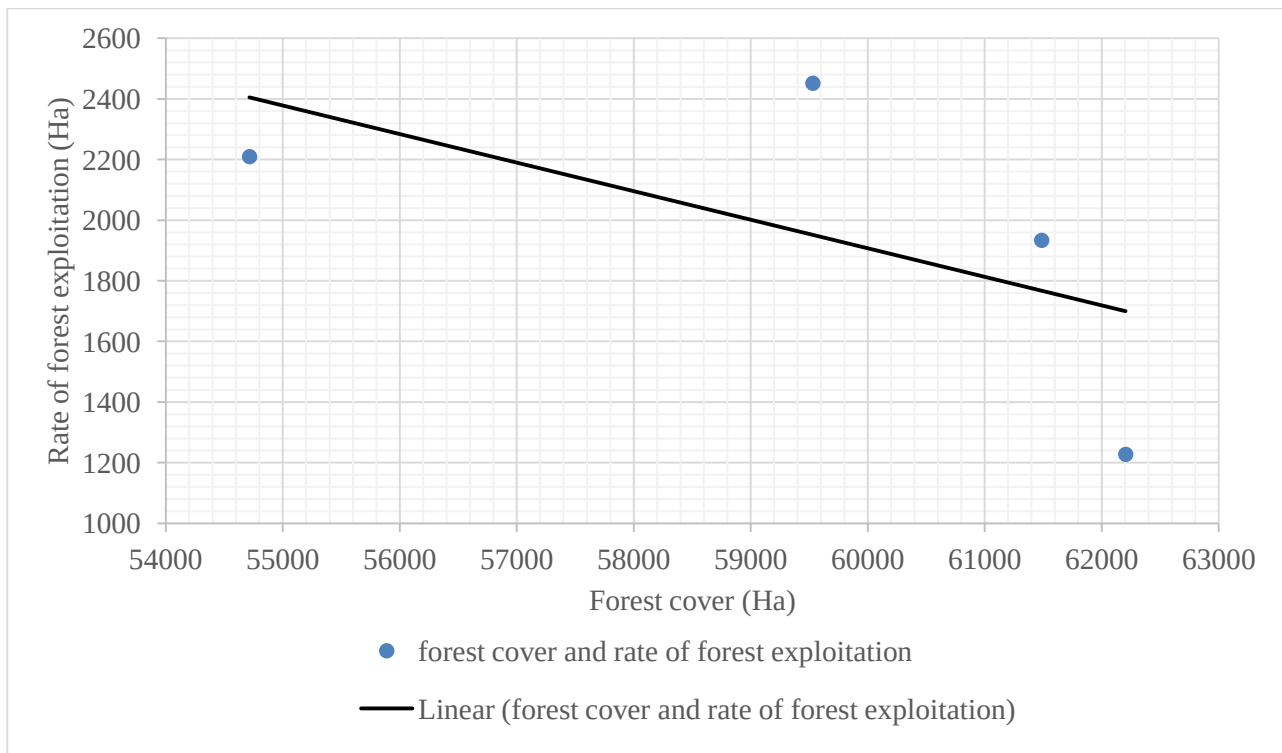


Fig. 8: Scatter plot of forest cover and rate of forest exploitation in Dimako

4. CONCLUSION AND RECOMMENDATIONS

The trend of the change observed in land use-land cover in Dimako reveals a gradual reduction of the dense forest which gave way to other land uses as a result various activities that have developed in this locality. The above lost in forest cover is a result of actions led by farmers, cattle grazers and wood extractors who through farming, grazing and lumbering activities in the forest convert the dense forest cover. Of all pressures, agricultural and infrastructural expansion notably wood exploitation, opening of roads, agriculture are at the centre of forest cover lost. Economic motives notably the need to increase household incomes facilitated by frequent demand for agricultural and wood products in markets represent the main driver of forest change in the Dimako council. It is therefore important to control forest exploitation activities through the effective implementation of sustainability in the forest management process to ensure a continues availability of forest products and there is also a need to bring alternative activities that can generate income for the local population thereby permitting them to reduce the pressure on the forest, to sensitization campaign on the importance of proper management of forest resources alongside reforestation activities either through natural regeneration or tree planting campaigns.

The study recommends providing environmental education, afforestation or agro-forestry, increasing income of rural households, providing alternative form of fuel (energy), strengthening PFM & CBO and strong law enforcement on the part of the government on those who illegally and indiscriminately exploit the forests, as to curb the impacts of deforestation on the environment and strengthening the livelihood conditions of the local people and the state at large in the prospect of sustainable development.

From this regard therefore though, significant efforts are made towards forest regeneration, more efforts need to be applied to attained a respectable level of forest regeneration and environmental sustainability and as such there is a clarion call on every member of the society, stakeholders, nongovernmental organization and the local population to fully participate in forest regeneration schemes, conservation and sustainable exploitation so as to make our forest great again.

REFERENCES

- [1]. FAO (2008a). *Contribution of the forest sector to national economies 1990-2006*. Available at <http://ftp.fao.org/docrep/fao/011/K4588e/K458e00.pdf> {access on 04/02/2017}.
- [2]. FAO (2008b). *Working with countries to reduce deforestation and forest degradation: Taking Climate change Action through Sustainable Forest management*. Rome: FAO.
- [3]. Food and Agricultural Organization (2016). *Global Forest Resource Assessment 2015: How are the world forest changing?* (Second edition). Rome: Food and Agricultural Organisation.

- [4]. Pinedo-Vasquez, M, D. and Zarin, P. J. P. (1992). Economic Returns from Forest Conservation in the Peruvian Amazon. *Ecological economics*, 6:163-173
- [5]. FAO (2010). *Global Forest Resource Assessment Forestry paper No 163*. Rome: Food and Agricultural Organization of the United Nation.
- [6]. Food and Agriculture Organization of the United Nations and the Centre for International Forestry Research (CIFOR) (2015). *State of the timber sector in Cameroon (2015) Report*, by Cerutti P.O, Mbongo M and Vandenhoute M.49
- [7]. World Bank (2009). *Forest people program 1c*. Fosseyway Business Centre, Strasford Road Morenton –in –Marsh GL569NQ United Kingdom.
- [8]. Forest Resource Assessment (2015). *How are the world forest changing*, second edition Rome: Food and Agricultural Organization of the United Nations.
- [9]. CIFOR (2001). *Annual Report: Forest for the future*. Retrieved from <http://www.cifor.org/library/1084/cifor-annual-report-2001-forest-for-future>.
- [10]. ITTO (2017). *Annual report 2016*, International Tropical Timber Organization, Yokohama, Japan ISBN 978-4-86507-038-5
- [11]. Cerruti, P. O., Lescuyer, G., Assembe–Mvondo, S. and Tacconi, L. (2010). The challenges of Redistribution of forest –related monetary benefits to local governments a decade of logging area fee in Cameroon. *International Forestry Review*, 12(2), 130-138.
- [12]. Charkravarty, S., Ghosh, S. K., Suresh, C. P., Dey, A. N. and Shukla, G. (2012). Deforestation: Causes, Effects and Control Strategies, Global Perspectives on Sustainable Forest Management. Okia, C. A. (Ed.), ISBN: 978-953-51-0569-5, In Tech, Available from: <http://www.intechopen.com/books/global-perspectives-on-sustainable-forest-management/deforestation-causes-effects-and-control-strategies>.
- [13]. De Wasseige, C. and Defourny, P. (2004). Remote sensing of selective logging impact for tropical forest management. *Forest Ecology and Management*, 188, pg 161-173.
- [14]. De Wasseige, C., et. al. (2009). *Les forêts du Bassin du Congo: état des forêts 2008*. EU Publications Office.
- [15]. Takem-Mbi, B. M. (2013). Assessing forest cover change in the Bafut-Ngamba Forest Reserve (BNFR), North West region of Cameroon using remote sensing and GIS. *Int. J. Agric. Policy Res.*, 1(7):180-187.
- [16]. MINFOR (2009). Manual of the procedure for the attribution and norms for the management of community forest in Cameroon (Revised version) Ministry Forest and Fauna Yaoundé Cameroon.
- [17]. CANADEI (2010). Plan de developement de Dimako 2010 – 2014. 90 pages.
- [18]. Njilla, R. M. N. and Djou, E. (2016). The Socio-Economic Importance of Forest Exploitation and the Environmental Impact of the Consequent Deforestation in Dimako, East Region of Cameroon. *International Journal of Research in Environmental Science (IJRES)*, 2, (4), 17-34 ISSN 2454-9444.
- [19]. Plan Communal De Developpement De Dimako. Réalisé avec l'appui de L'Association Pour Le Developpement Des Initiatives De L'environnement (ADIE) Bp 10084 Yaoundé-Cameroon Financement PNDP/IDA Mai 2011.
- [20]. Akowewou, A., Oszwald, J., Saidi, S., Gazul, L., Akpagana, K. and Gond, V. (2020). Land Use and Land Cover Dynamics Analysis of the Togodo Protected Area and Its Surroundings in Southeastern Togo, West Africa. *Sustainability*, 12, 5439; Doi: 10.3390/su12135439.
- [21]. Baig, M. F., Mustafa, M. R. U., Baig, I., Takaijudin, H. B. and Zeshan, M. T. (2022). Assessment of Land Use Land Cover Changes and Future Predictions Using CA-ANN Simulation for Selangor, Malaysia. *Water*, 14, 402. <https://doi.org/10.3390/w14030402>.