

Land USE / Land Cover Dynamics in the Western Highlands of Camerroun: The Case of The Bamoun Plateau (1975/2022)

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ABSTRACT: Man has greatly modified his environment at various scale be its through science, technology or dynamism. These changes constitute land use/land cover changes. This research describes the impacts or effects of human activities on vegetal degradation of the Bamoun plateau between 1975 to 2022. The research made use of remote sensing techniques and geographic information system in describing land use/cover changes in the Bamoun area. Primary data was obtained through field observation and ground truthing in order to affirm observation on satellite imageries. land use maps were produced using GIS soft wares packages of Google Earth, Envi 4.3, global mapper 15 and ArcGIS. Maps were generated to show changes in land use/ land cover which were transposed into tables and bar graphs to show the magnitude of changes, percentages of change and the rate of changes. These changes are good for economic and social development but often come with huge consequences on the environment. The analysis of static land use maps of 1975, 1995,2015 and 2022 all pointed to the fact that, there have been significant changes observed on forest cover, farmland, grazing land and settlement land uses. The findings revealed that the study area has experienced a drastic change in land use/land cover during the last forty years. The study area is characterized with decrease in grassland areas, forest and increase in settlement and farmland due to the increasing population which are the main triggering force of land use/land cover changes that has led to the reduction in vegetal cover. Forest decreased from 136,735 hectares (29.2%) in 1975 to 90323 hectares (19.6%) in 2022 indicating a magnitude change of -46412 (9.6%) and grass land decreased from 248777 hectares (53.2%) in 1975 to 265378 hectares in 2022 (57.7%) in 2022 that is a magnitude change of -16601 (-14%). These decreases gave way to settlements and farmland. Therefore, a reduction in the excessive consumption of fuel wood, the practice of eco-forestry, raising of awareness and a dialogue plate-form are amongst the measures recommended to reduce land use/land cover change in the study area.

KEY WORD: land use, land cover changes, Plateau, Bamoun, Natural landscape and dynamics

I. INTRODUCTION

Man influence on land cover dates back to ancient civilization with early agricultural practices, urbanization and trade. However, the pace and scale of land cover changes have accelerated dramatically since the industrial revolution. Land is very important to mankind's existence and development. Man has used land and its resources to meet needs. Land cover refers to the biophysical characteristics of the earth's surface, including the distribution of vegetation, water, soil, and other physical features of the land. According to tuner et al (1995), land cover dynamics refer to the changes in spatial distribution of land cover types over time. Lambi et al (2001) describe land cover dynamics as the process of change in land cover which include deforestation, urbanization and other human induced changes meanwhile land use While land use refers to the way in which land has been used by humans and their habitat, usually with an emphasis on the functional role of land for economic activities (McConnell, W. J2015, Lambi E. 2006, Arsanjani J. J. 2011). For instance, in terms of urbanization, a large amount of forest and grassland has been transformed to urban land and other modification are seen in the aspect of archaic agricultural activities, cattle rearing, and deforestation. Land cover (LC)

describes the physical state of the land surface; cropland, mountains or forests (Meyer W. B 1995, Moser, S. C., 1996)

According to (Molombe J. M, 2011)), since creation mankind has relied on land to sustain his ever-changing needs. Furthermore (Nguh, B. S., & Maluh, N. B., 2017) intimates that change is inevitable and this too applies to land. The earth surface has been significantly transformed through human activities (Millennium Ecosystem Assessment, 2005). In developing countries like Cameroon, the population solely depends on natural resource exploitation for livelihood, and with increasingly competing demands for the utilization, development and sustainable management of land resources (Toh, F. A., Angwafo, T., Ndam, L. M. and Antoine, M. Z., 2018). This process, they have modified and are modifying land in various ways and intensities (Fogwe, Z. N., 1997) identified “population pressure, demands for fuel wood and construction material, agricultural expansion, policy and tenure insecurity as the major driving forces behind land use/land cover changes”. Some studies suggest that demographic dynamics contribute more than any other process to land cover changes (Mather and Needle, 2000). Others suggested that the superiority of economic factors is the major contributing factor (Lambin and Geist, 2001).

The issues of man induced forces and their implication on the landscape have been viewed by Harding (1968); Brinkman (1990), Nkwemoh (2011) and Nkwemoh et al. (2017). Other works related to our theme are more oriented toward the treatment of images, such as those of Bamou E, (2007), Kamusoko, M. Aniya (2006) and Elvidge (2007). Meanwhile, other related works focus on the treatment of images and land cover change, such as those of Arsanjani J. J. (2011) Turner et al. (1995), Nkwemoh (2011), Lambi and Kah (2012), According to the FAO data, 42.1% (19,191,600 hectares) of Cameroon is forested. However, other estimates hold that forest cover is up to 4%. Between 1990 and 2010, Cameroon lost an average of 220,000 hectares of forest (0.9%) per year (MINFOR, 2015). In total, between 1990 and 2010, Cameroon lost 18.1% (4,400,000 hectares). This is because of a number of factors that include: Mass forest exploitation, Urbanization, developmental projects (such as the construction of dams, the construction of seaports, and the setting up of plantations such as the CDC, SGSOC, and many others) These are considered major threats to the forest sector of the country because for this to go on well, large expanses of forest land must be destroyed.

This study seeks to show the impacts of man on vegetal degradation of the Bamoun plateau with the use of satellite images and GIS tools. the article has been structured into parts that fall under the Physical and human backgrounds, materials and methods, results and discussions, and conclusion.

II. BIOPHYSICAL SETTING

The study area is situated between longitude 10° 30' to 11° 19' East of the Greenwich Meridian and latitude 5° 20' to 6° 00' North of the equator. It is located in the Western Region of Cameroon. The Bamoun area lies within its shrunken limits, enclosed by the rivers Mbam and its confluence (Mvi and al Mape) to the east and the Noun to the South. The area occupies a total surface area of approximately 7,300 km and inhabitants of 455,083 people (National demographic census 2005). It is made up with a density of 31 habitants/km² in relation to the average regional density, which is (102km²). It is bounded to the North by Mayo-Banyo, to the West by Mifi Division, to the South by Nde and to the East by Mbam and kim. The Bamoun relief is a plateau, made up of hills with gentle slopes dominated by three volcanic cones at Nka'nyam, Nkoumelap and Bangourain. This plateau belongs to the Cameroon volcanic line, and it is situated on the western flank of the North-East of Mt Cameroon. It is presented as a vast plateau of 1000 to 1600m dominated by a massif of about 2000 and it is surrounded by valleys, rivers and lakes that greatly favored agriculture. It is subdivided into six (6) subdivisions which are Foubot, Fouban, Koutaba, Kouoptamo Njimom and Bangourain.

The hydrology of the Bamoun plateau is a fast moving rivers of picturesque falls and isolated craters lakes. The Bamoun Plateau belongs to the Noun sub-basin and the large basin of the Sanaga. The principal river course is the Mbam and Noun the flow Northwest to Southwest on the study zone. Secondary watercourses are the river Nkoup in the South, that flow directly in the Noun, river Mou and Nchi that flow in the Mbam. There are many rivers network sources, and the rivers flows throughout the year with the highest debit during the rainy season. It has formed a sub-parallel and dendritic pattern. These Rivers follow a Cameroon regime, experiencing a period of high waters during the wet season and a period of low waters in the dry period.



Figure 1: Map of the study area

Source: Extract of the Administrative Map of Cameroon by 2010.

The geology of the Bamoun plateau is made up of the great Massifs such as the Kogham, the Mbam and the Mbetpit. From the geochemical point of view, the volcanism of the region constitutes an alkaline series ranging from basalts to rhyolites. Basalts being the most abundant facies. All these formations rest on an orthogenesis bedrock. The Bamoun Plateau has successively known three types of volcanism, which are:

- **The fissure dynamism which gave rise to the plateau basalts:**
- **Central dynamism**
- **Strombolian volcanism**

The climate of the Bamoun plateau is situated in the Tropical Sudano-Guinea climatic Zone, thus it belongs to the Cameroonien type of the tropical climate. It is under the influence of the tropical monsoon climate. This climate is influenced by the Harmattan or the Northeastern trade winds, which are hot, dry air masses, which blow annually from mid-November to mid-March. From mid-March to mid-November, the region is under the influence of the monsoon, which is an unstable air mass that is hot and very humid. The monsoon by colliding with relatively high relief of the region caused important precipitations. While moving toward the equatorial low-pressure belt, the Harmattan coming from the North and monsoon from the south meet there by forming the Inter-tropical convergence front, which is at the origin of season's succession.

The Bamoun plateau is characterized by diversified soils and relief (PCD 2009) with the majority from volcanic origin with black color that favored numerous agricultural practices. There three major types of soils in area

- Volcanic soil occupied 30%
- Ferrallitic soil occupied 45%
- Hydromorphic soils occupied 25%

2.1 Human Background

The Kingdom of Bamoun was founded in the 14th century by a dynasty of Tikar origin (1394-1916) also spelled as Bamum, is a pre- colonial Central African states in what is now Northwest Cameroon. The Bamoun Kingdom was founded in 1390 by Nchare, a prince from Rifum (present-day Bankim), Greary and Njoya (1985), Dugast (1949), Fanzo (1989) in the Tikar plain. The Bamoun are therefore of Tikar origin (before migrating to Kimi, the Tikar are believed by some scholars to have come from Bornu, a Sudanese kingdom around the Lake Chad Basin). Nchare the founder of the Bamoun kingdom was the son of a Tikar chief. The Bamoun share the same ancestry with other ethnic groups such as the Nso, Bafut, Kom, Bum Fungom, Ndop and Ntem, Niba (1999). The genesis of the Bamum Kingdom is attributed to the migration of three members of the Tikar royal house, namely Nchare, Nguonso and Morunta, who broke off from the main group at Rifim (Kimi) (Mohammadou 303) after the death of their chief.

III. MATERIAL AND METHOD

Various institutions (secondary sources) have been consulted for data collection, including University of Yaounde 1, the World Bank, the Ministries of Environment, Nature Protection, and Sustainable Development, and the Noun Urban Council. Satellite Images (LANDSAT MSS 1975, -TM & ETM+, and Google Earth 2022) have been utilized for the location and mapping of specific sites. We collected numerical population data FROM Census data of 1976, 1987, and 2005 as well as an estimate projection of the population of the Bamoun plateau between 2006 and 2035 that we computed and presented using Microsoft EXCEL. The GIS programs such as Adobe Illustrator 9.0 and ArcGIS 10.2 software have been used for cartography. Meanwhile, Population projection was made by the use of the formula: $P_x = P_2 + N/n(P_2 - P_1)$ Where:

- P_x = Projected Population
- P_1 = Initial Population
- P_2 = Last known Population
- N = Period between P_1 & P_x
- n = Period between P_1 & P_2

In order to establish comprehensive satellite images to determine land cover and land use, information was obtained from LANDSAT. We proceeded with access to the GLCF (Global Land Cover Facility) and then the ESDI (Earth Science Data Interface). With the study of images from MSS (Multi-Spectral Scanner or Generation 1 satellite) and TM (Thematic Mapper or Generation 5 satellite), and ETM+ (Generation 7 Satellite) (figure 2), we proceeded with a workable procedure that entailed the determination of the Path and Row. Using the ETM+ (Enhanced Thematic Mapper +), the Scene that carries the Bamoun plateau could be traced following the Path 184 and Row 053.

Given that each Scene has a surface area of 185 km² and that the scene is composed of many pixels, with each pixel having a surface area of 30m, various bands were determined to exploit and show the various aspects that constitute the land cover classes. ASTER Images also assisted in the elaboration of Digital Elevation Model (DEM) and the Hydrology. The ERDAS software program was then utilized in the location and combination of the various color bands. Then the bands appear with the possibility of RGB color instead of gray scales. With the Supervised and on Signature Editor, then zooming of the image, the sample by polygons of each form of the feature was taken and attributed a color. For instance, green for vegetation, brown for bare surfaces, and blue (or water surfaces)

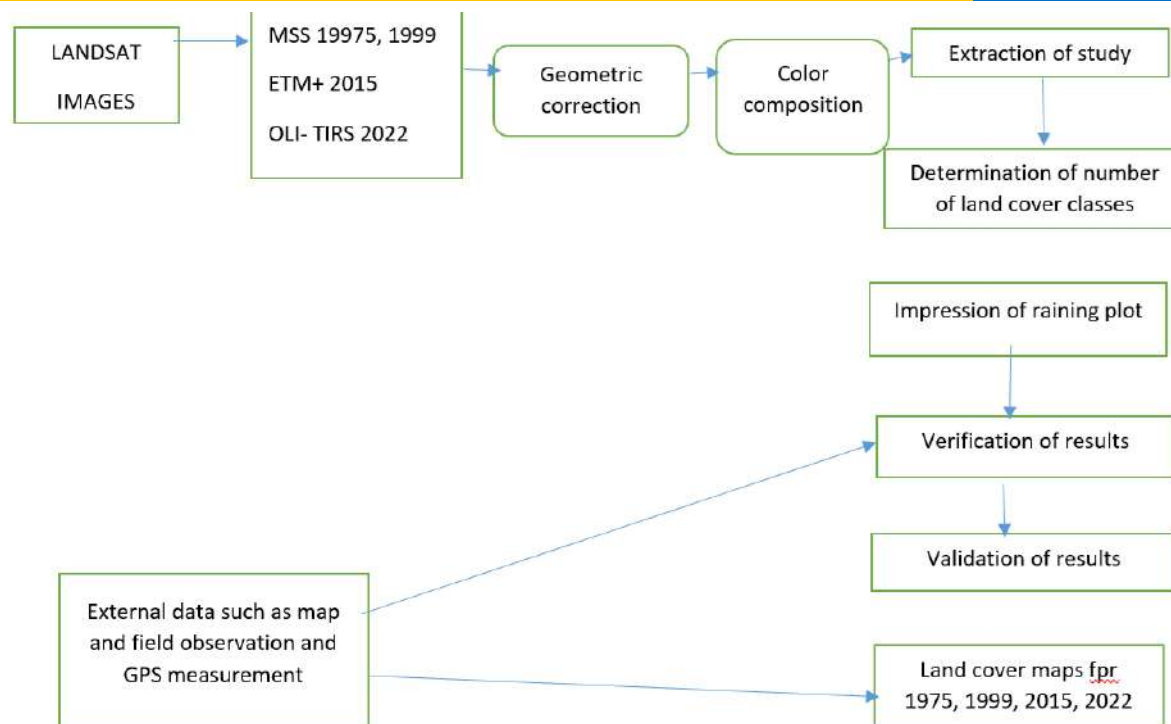


Figure 2: Methodological Approach for the Treatment of Satellite Images

The ENVI program was used to attribute color combinations to Land Cover Classes (LCC). The MapInfo program was subsequently used in delimiting various land cover classes. The technique has been utilized with success by Assako Assako J. R. (1998), Bauer, Yuan. and Sawaya K.E, (2003), Pratt (1991), Tonye, Akono & Ndi Nyoungui (2000). Five cover classes were identified as follows:

- Forest,
- Grassland vegetation,
- Built-up area,
- Cropland/Cultivated area, and
- Water bodies

IV. RESULTS AND DISCUSSIONS

4.1 Land cover/ land change

The study made use of Landsat MSS 1975, 1995, Landsat ETM+ 2015 and OLI-TIRS (Operational Land Imager, Thermal Infrared Sensor) 2022 to assess the change in land cover classes. The supervised classification of the four (4) images yielded land cover maps of the study area and from these, 5 land cover classes were identified. The land cover distributions for each study year as derived from the maps are presented in Table 1.

Table 1: Land use/ cover Distribution (1975, 1995, 2015, 2020)

Land cover classes	1975		1995		2015		2022	
	Area in hectares	%	Area in hectares	%	Area in hectares	%	Area in hectares	%
Forest vegetation	136,735	29.2	119,629	25.9	93,391	20.5	90,323	19.6
Grassland vegetation	248,777	53.2	253,974	55	264,135	58.1	265,378	57.7
Built-up area	20,723	4.4	27,576	5.9	33,764	7.4	38,424	8.3
Bare surfaces/ cultivable land	52,144	11.1	53,006	11.4	56,308	12.3	58,439	12.7
Water bodies	8,878	2	7,217	1.56	6,915	1.52	6,615	1.44
Total	467,257	100	461,402	100	454,513	100	459,179	100

Source: calculated from Landsat MSS, ETM 1975, 1995, 2015 and 2022

Table 20 presents the land cover distribution for four years. It shows the area occupied by each land cover classes for a particular year in hectares and this is equally expressed as a percentage (%) of the total class value for that year. Generally, land cover classes occupied a total surface area 73,000 hectares. The forest vegetation land cover class occupies 136,735 hectares, which accounts for 29.2% of the total surface in 1988, 119,629 hectares in 1995 that is 25.9%, 93,391 hectares in 2015 that is 20.5% and 90,323 hectares, which accounts for 19.6% for the year 2022. From these statistics, we observed a successive reduction in forest vegetation due to man role on vegetal degradation thus leading to landscape dynamics. In the same light, we equally noticed that there is an increase in habitation as built up area increases from 20,723 hectares being 4.4 % of the land cover class for 1975, to 5.9% in 1995 that is 27,576 hectares, to 7.4% in 2015 that is 33,764 and 8.3% in 2022 that stands for 38,424 hectares of land cover classes. There is equally a slight change in the hydrography class from 8,878 hectares in 1975 to 7,217 hectares that is 2%, in 1995 it was 6,915 hectares that is 1.56% and in 2015, 6,915 hectares representing 1.52% of the total surface area.

4.6.1 Analysis of the situation of the Bamoun plateau in 1975

Findings from field survey demonstrated that the area was initially covered by different aspects that illustrated the role of man and his land use and nature. Utilizing base satellite images, we were able to establish a land cover classification for the study area in 1975 as seen in Figure2

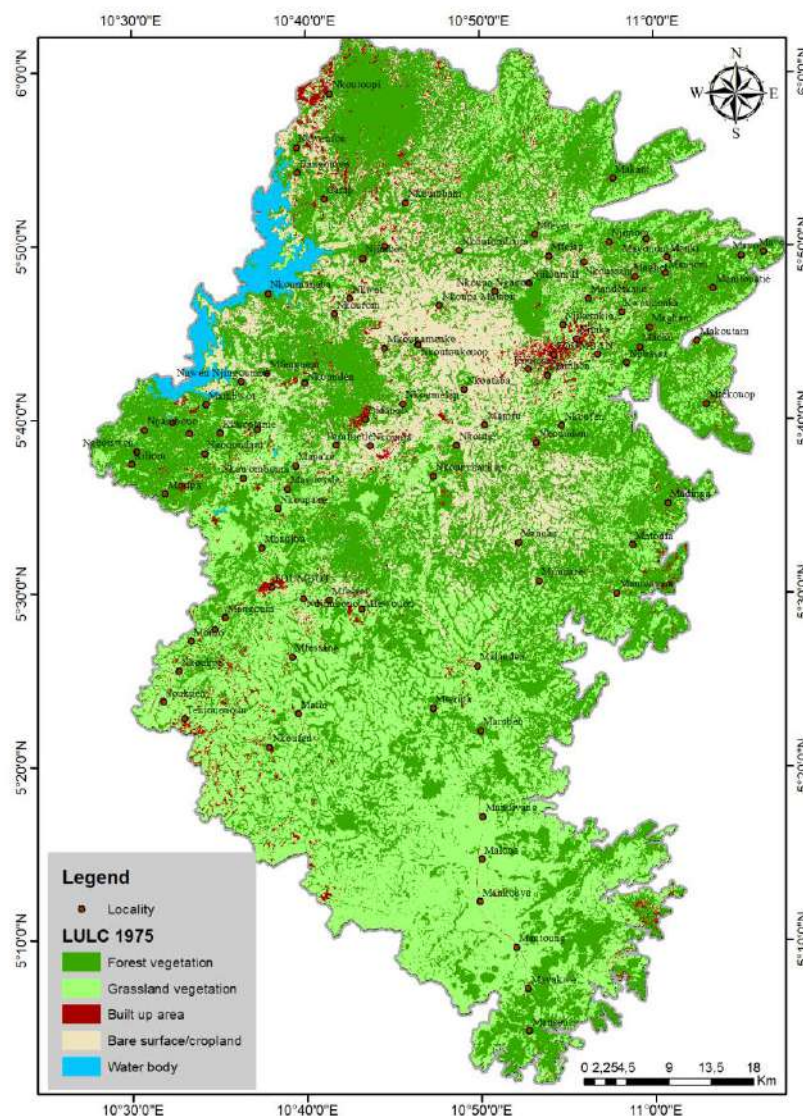


Figure 2: The LULC of the Bamoun plateau 1975

Source: Global Land Cover Facilities/ Landsat MSS, February 1975/ National Institute of Cartography

Figure 3 shows the land cover of the Bamoun plateau 1975. The map shows the state of the area when most of the natural milieu had not been greatly altered. Here, forest vegetation still occupied a significant area of the land cover classes because most of the agricultural tools were crude and could not permit mass destruction. Again, the population was not that significant and there was less pressure on land for farming. Built up area which consisted of human activities in terms of building and road infrastructure occupies the lowest percentage of the total land cover class. The low percentage is basically due to the low population. Bare surfaces, which are either farmlands or degraded areas and grassland, occupies the largest surface area of the total land cover classes 53.3% and 11.1% respectively. Grassland has been seen to occupy the large portion mainly because the Bamoun plateau is found within the grassland vegetation in Cameroon.

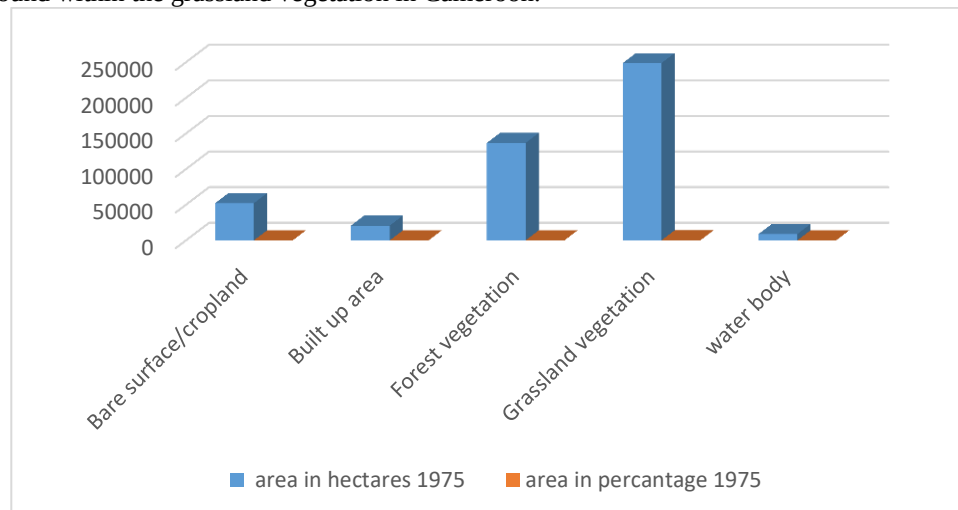


Figure 3 shows the surface area in hectares express as a percentage for the year 1975

Source: Landsat MSS 1975

4.6.2. Analysis of the Situation of the Bamoun Plateau 1995

The spatial extent of the 1995 land cover map after a supervised classification yielded land cover classes with forest vegetation occupying 29.9% of the total value as seen in Figure 4.

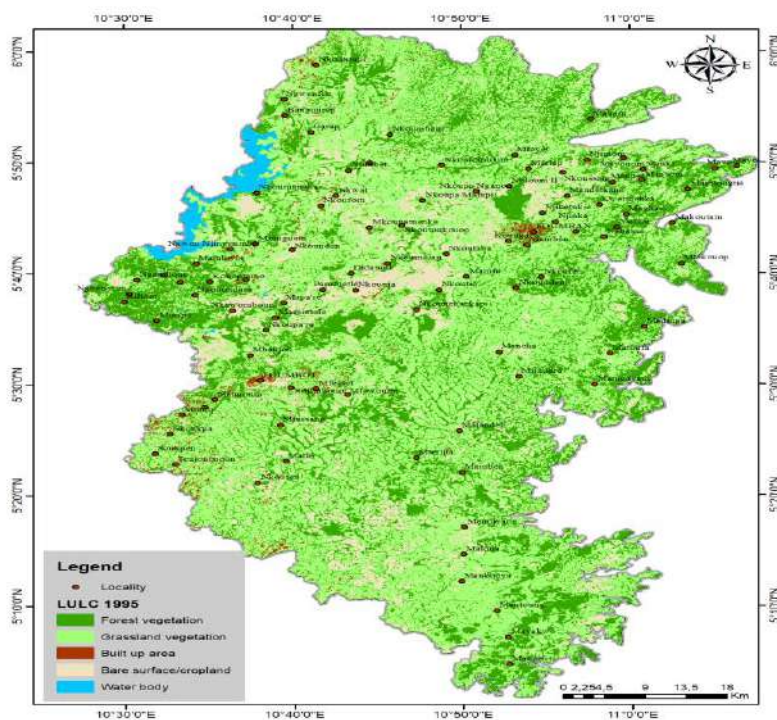


Figure 4: The LULC of the Bamoun plateau 1995

Source: Global Land Cover Facilities/ Landsat MSS/ National Institute of Cartography

The land cover maps for the years 1995 are quite significant as can be seen from the map (Figure 3). Statistics derived from the map show an insight of the change.

Comparatively, the forest vegetation has reduced from 29.2% in 1975 to 25.9% in 1995 because of man-induced actions on the environment. The reduction in forest vegetation juxtaposed an increase in the grassland vegetation and built-up areas for 1995 land cover classes. The buildup area increased from 4.4% to 5.9% in 1995 and savannah increased from 53.2% in 1975 to 55% in 1995. This is seen in Figure 5.

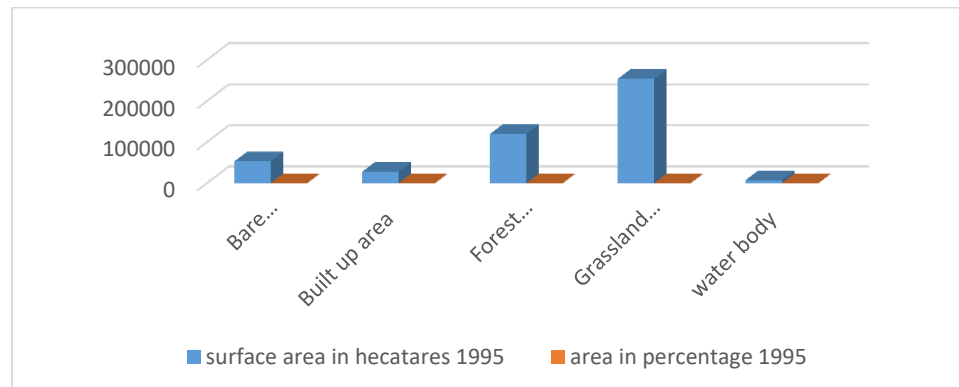


Figure 5: Shows the surface area in hectares express as a percentage for the year 1995

Source: Landsat MSS 1975

Figure 6 shows the surface area occupied by the different land cover classes for the year 1995. Here we can see clearly that there is a slight change in built up area as compared to 1988 and a more significant change in the grassland land cover class.

4.6.3. The Analysis of the Situation of the Bamoun Plateau in 2015

The 2015 satellite image processing was carried out to evaluate the changes that have taken place in the natural milieu from 1988 to 2015. Figure 6 shows the situation of the Bamoun plateau in 2015.

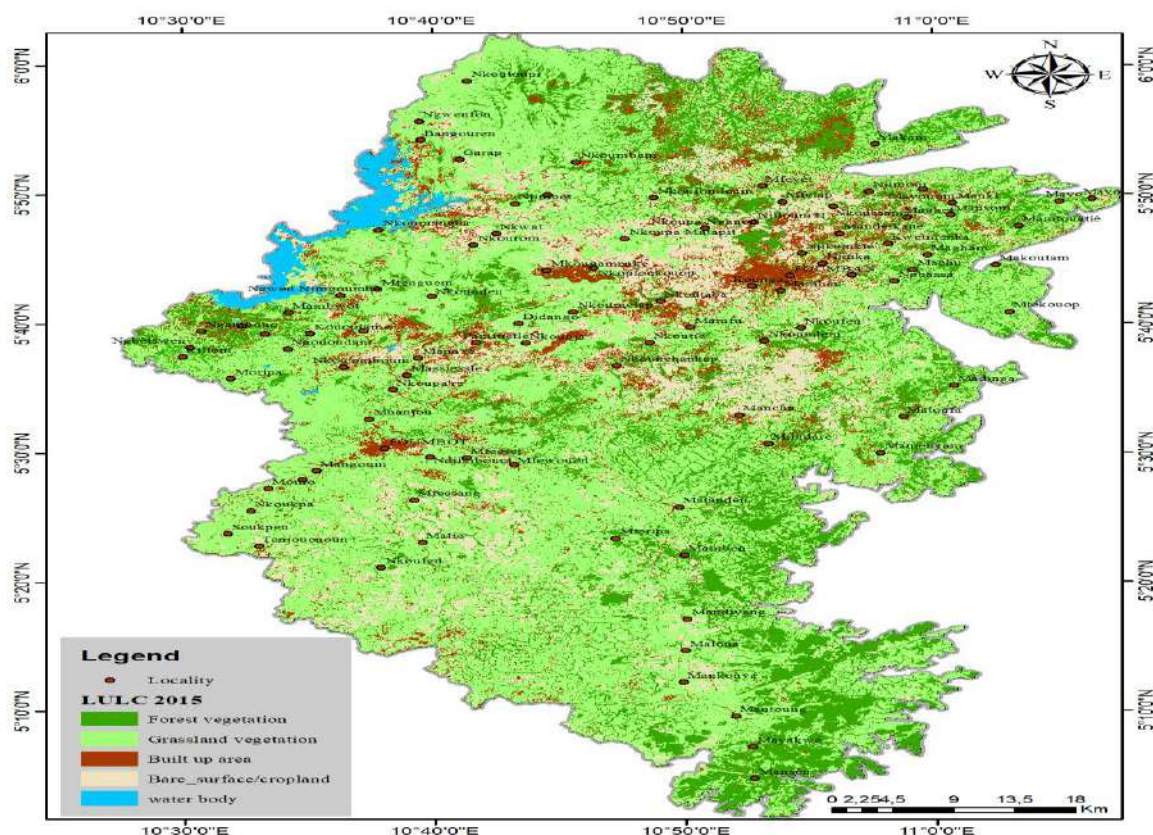


Figure 6: The LULC of the Bamoun plateau 2015

Source: Global Land Cover Facilities/ Landsat MSS, / National Institute of Cartography

Figure 6 shows a drastic change in land cover classes due to man's intervention through his different activities. Here, forest vegetation occupies a smaller class that is from 136735 hectares in 1975 to 93391 hectares in 2015 with a 10% reduction in the land covered by forest vegetation. Again, built up area further increases from 5.9% in 2001 to 7.4% in 2015 with a 3% change in built area. The largest classes observed here, are bare surfaces and grassland. This is because after forest has been exploited, the area is transformed to either farming land or grazing land (Figure7).

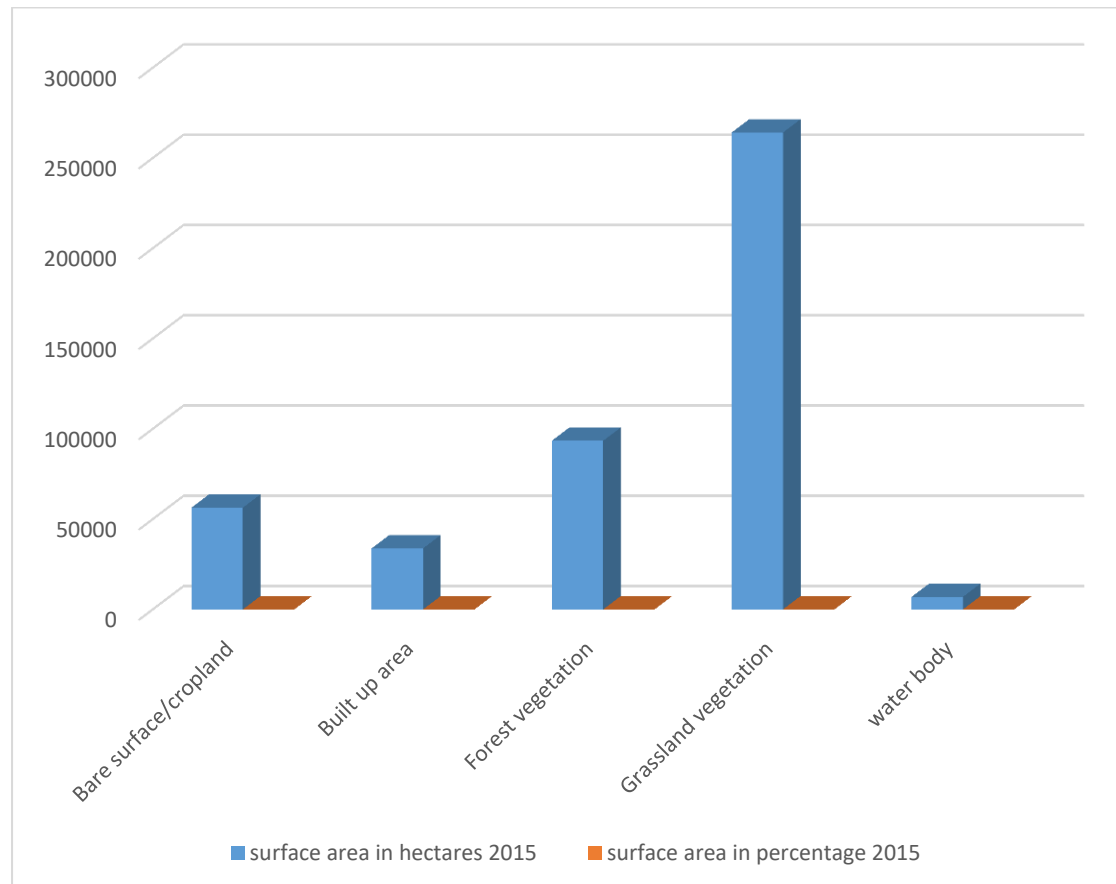


Figure 7: surface area per class in hectares for 2015

Source: Landsat ETM+2015

Figure 7 shows the surface area occupied by the different land cover classes for the year 2015. Here we can see clearly that there is a change in built up area as compared to 1975 and a more significant change in the grassland and bare surface.

4.6.4. The Analysis of the Situation of the Bamoun plateau in 2022

The 2022 satellite image processing was carried out to evaluate the changes that have taken place in the natural milieu since 1975 to 2022 Figure 8

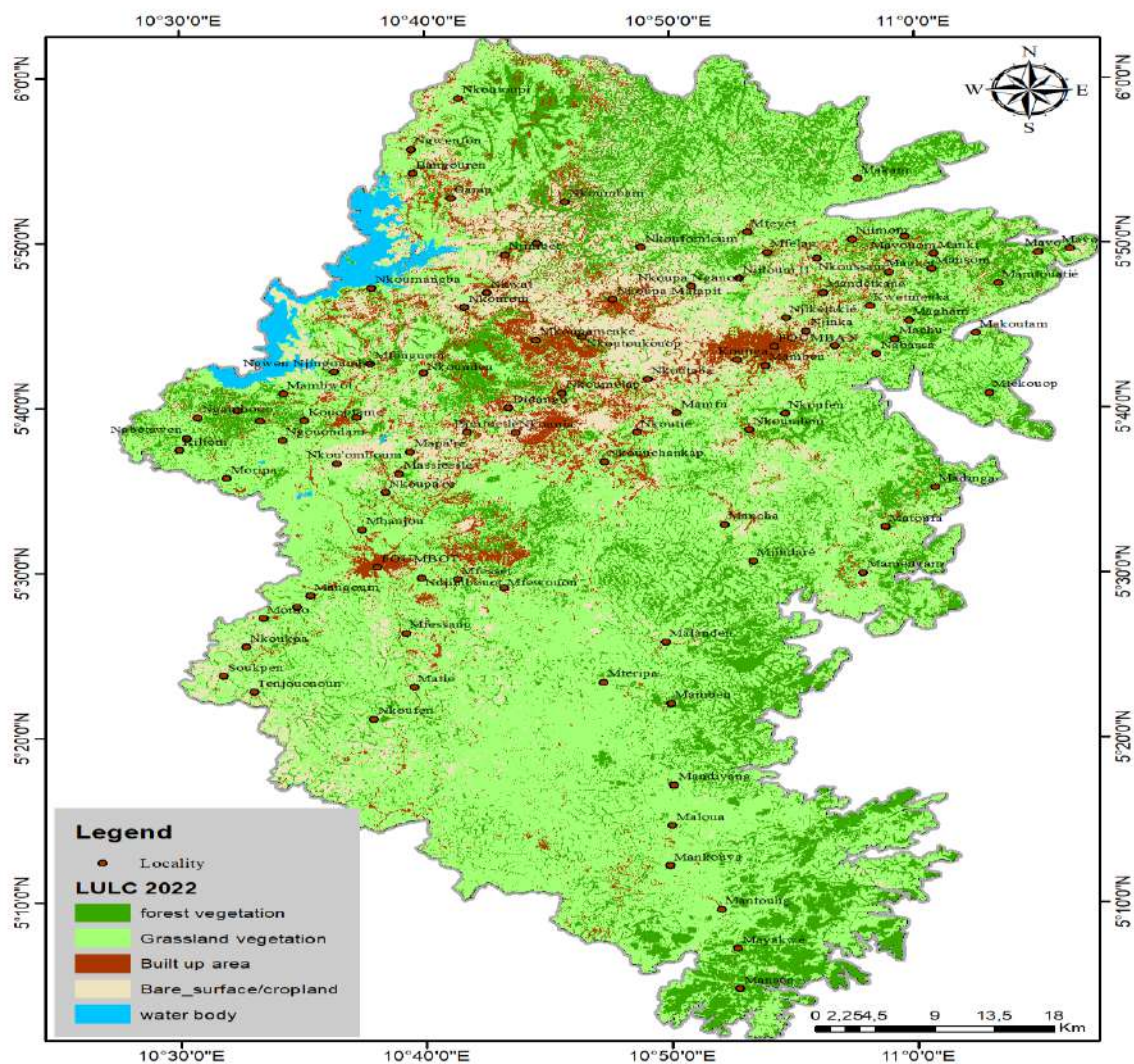


Figure 8: The LULC of the Bamoun plateau 2022

Source: Global Land Cover Facilities/ Landsat ETM 2022/ National Institute of Cartography

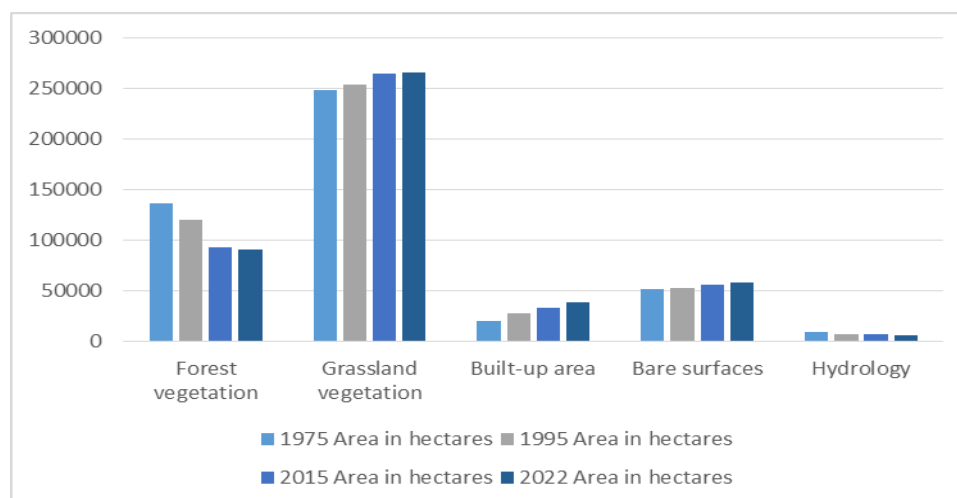


Figure 8: Surface Area per class in hectares for 2022

Source: Landsat ETM+2022

The figures above demonstrate that there have been modifications on the vegetation and land cover types of the Bamoun plateau for the 47 years' period considered for the study. Forest, hydrology, and grasslands cover is decreasing than any other cover types while bare surface and built-up area have witnessed an increase. Several actors were identified as being responsible for these changes. In 1975, the area covered by bare surface was 11%. But in 1995 the surface under bare surface increased to 11.4 % in 1995, to 12.3% in 2015 and 12.7% in 2022. The reason for this increase in bare surface is because of the economic crises of the 1980s and led to unemployment and reduction in salary. As a result, people had no choice but to look for more land to cultivate. The quest for more cultivable land gradually led to the extension of cropland into forest area and thus reduction of vegetal area.

Furthermore, in 1975 forest occupied 29.2% but as years goes by, forest reduced drastically to 25.9% in 1995, to 20.5% in 2015 and 19.6% in 2022. Water has reduced from 2% in 1975 to 1.5% in 2015 and to 1.4 % in 2022. The reason for this reduction was identified during the field study undertaken in the study area. It was realized that the actors responsible for this reduction are the inhabitants of the villages, the nomadic Fulani (Mbororos) and traders of plank, who encroaches into forest and riverbanks area to practice several activities. The inhabitants of the Bamoun plateau area entered into forest and riverbank to cultivate, cut fuel wood both for household consumption and for sale as well as burning of charcoal destined for the market. Fuel wood and charcoal constitute the main source of income for approximately 80% of the population and 60% of youth interview are involved in these activities.

Wood exploitations by traders in plank for commercial purpose have led to the conversion of the forest as their source of raw material for their business products. This activity has greatly been encouraged by the existence of a plank market in Foubot, Fouban and Koutaba and the laxity in enforcing the laws binding forestry administration. A combination of these activities has led to the changes in forest cover and land use cover types with one gradually replacing the other in terms of surface area from 1975 to 2022 and forest decreasing more than any other cover type on one hand while farmland increases on the other hand. These spatial changes are clearly seen on figures and tables above.

Furthermore, with the case of settlement, in 1975 settlement stood at 4.4% but in 1995 it increased to 5.9%, in 2015 it was 7.4% and in 2022 it was 8.3%. This shows that settlements have doubled as year passes. The reason for this double increase is because population is growing at a very high rate in the area. For instance, in 1987, the total population of the area was 293,725 inhabitants and in 2005, it was 455083 people. This population growth in the study has enabled the occupation of marginal site for either agriculture or habitation. The method of agriculture (crops cultivation or animals rearing) is predominantly traditional and has led to the disruption of vegetal cover. The population also need land for settlement, and this is the reason there has been an increase in built-up area from 1995 to 2022. The above parameters are all elements that have caused vegetation land dynamics and have resulted to a reduction in of vegetal cover.

V. Conclusion

The objective of the study was to examine land use/land cover changes and the authors realized Land use dynamics is inevitable and occur on permanent basis. These changes are essential for economic development and social progress, but often come at a substantial cost has been carried out in the Bamoun plateau area from 1980 to 2022. The analysis of the land use maps and field observations, all point to the fact that there has been a significant change in land use/cover in this area with forest and grazing land witnessing a steady decline in favor of settlement, bare soil and farmland. This situation has as consequences the destruction of vegetal cover which culminated to soil erosion. These changes in land use/cover have led to environmental and resource issues ranging from loss of biodiversity and impacts such as land use conflicts and haphazard development were also witnessed. This paper can provide substantial source of information to the population of the area and Cameroon at large.st on the environment and resources. A spatial-temporal analysis of land use/land cover.

As seen from above, the various ways through which man induced action leads to vegetation degradation cannot be undermined because of the environmental impact they have on the ecosystem. This man induced activities has led to landscape degradation, this validate and affirm the hypothesis that "man role on vegetal cover has led to vegetal destruction as well as landscape degradation of the Bamoun plateau

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