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Urban Sprawl and the Implications on Land Cover Change in Bafoussam, Cameroon

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Abstract:

Spotted at the core of the Western Highlands clothed by herbaceous, shrubby and tree savanna, the Bafoussam Metropolis epitomizes urban areas with socio-economic and ecological dynamics emanating from urban expansion. Loss of Vegetation and/or ecological disturbances accounts for the most remarkable impacts on spatial Land Cover dynamics in general. As such, mapping the affected area becomes indispensable in order to evaluate the magnitude of the effects to preempt sustainable development.

Topographic maps, Aerial photographs and Satellite images have been used in this research. The use of these different methods has facilitated comparisons. Other information was canvassed through interviews; meanwhile, the Internet has equally been instrumental in this research. Findings indicate that there has been an astronomical expansion of the urban space as a result of population explosion in Bafoussam. The rising number of mouths must be fed while equally being sheltered. Meanwhile all of these have imposed increased need for farm land and building space. The resulting Land Cover shows a predominance of vegetation before 1978, a continuous drop in 1998 and a great loss of land occupied by vegetation in 2018. REDD+ has been proposed as one of the alternative measures to revamp the situation and this entails sustainable management practices. It is an approach that would guarantee an ecological/Bio city that Bafoussam is supposed to be.

Keywords: Population growth, urban expansion, remote sensing, geographic information system, vegetal degradation, land cover change

1. Introduction

Any natural habitat that is exposed to either internal or exogenous forcings/influences is bound to witness some internal dynamism as a compensation of the impacts. What might differ is the degree of change as a result of the modification emanating from the various forcings. Most if not all urban spaces are a true testimony of agglomerations where rapid population increase has imposed the need of more space for the construction of homes for the population. In addition to the increase in population number, the society is bound to push to open more land for agriculture so as to meet up with the more mouths to feed. The situation has made most of the city dwellers to occupy the nooks and crannies of the area not only for the construction of houses but also space for agriculture.

Urban expansion is a common phenomenon in most of the agglomerations in Cameroon in particular and the sub-Saharan Africa as a whole (Gleave, 1992a, 1992b and 2001; Fombe & Balgah, 2010 and Nkwemoh, 2011). The issues on man induced forces and the implication on landscape have been viewed by Harding (1968); Martin (1985); Bopda (1985); Goudie (1986); Brinkman (1990), Nkwemoh (2011) and Nkwemoh et al (2017). Other works related to our theme are more oriented towards treatment of satellite images such those of Assako (1998), Moshen (1999), Pratt (1991) Akono (1994), Tonye et al (2000), Begue et al (2010). Meanwhile other related works focus on the treatment of images and land cover change such as those of Turner et al (1995), Jukka & Aristide (1998), Neba Shu (2003) Ngouanet (2007); Nkwemoh (2011), Lambi and Kah (2012), Nkwemoh and Lambi (2016), Nkwemoh and Yungsi Nkwemoh (2019)

According to the FAO 42.1% (19,191,600 hectares) of Cameroon is forested; although 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 project (such as the construction of dams, the construction of sea ports and the setting up of plantations such as the CDC, SGSOC and many others. These are considered as major threats to the forest sector of the country because for this to go on well, large expanses of forest land must be destroyed.

The goal of this paper is to investigate on how the sprawl of the Bafoussam urban space has imposed the search for more space by Urban dweller. It also deals with the effects of rapid and uncontrolled urban expansion/sprawl on vegetation and/or land cover dynamics. The article has been structured into parts that fall under the biophysical background, materials and methods, results and discussions as well as conclusion

2. Bio-physical Background

Bafoussam town (Figure 2) is found at X= 657272,5 being Longitude 10, 4197° East of the Greenwich Meridian and Y= 604971,6 being Latitude 05, 4715° North of the Equator. This absolute location has been deduced with the GPS at the Roundabout at Hotel de Ville. Bafoussam is the headquarter of the West Region of Cameroon. The town is found on part of the High Plateau at an altitude that varies between 1000 – 1600 m above Sea level. A view of the topographic assemblage permits a classification into 3 different relief units. They are; the section with an altitudinal range from 900 - 1100m with the section that bears the Rivers Mifi and Noun. It is the part that merges with the Noun plaine and bordered by the high relief of the town. The next is the intermediate level with altitudes from 1100 – 1300m constituting the main seat or the core of the town towards the north. On this first stage water courses have incised narrow valleys. The hillslopes with slope gradients increase from the summits to the base and are equally convex. Meanwhile towards the northern part of this sector, the slopes become gentle. The last level of 1400 - 1500m and above occupies the southern half and it has a SW inclination. The relief is equally varied; with deep valleys carrying streams and their tributaries.

Concerning the hydrology, a result of the configuration of the relief, the water courses are divided into three main catchments whose watersheds are occupied by main roads. The first one occupies the right bank of the river Metchie beyond the Baleng hills. The second catchment occupies the Western and South West drained by two tributaries of the Metchie flowing from East to West from the heart of the town to North West. The third one occupies the Eastern sector. It is formed by the right bank of the River Noun that has a North/South direction of flow

The Bafoussam town belongs to the structural assemblage of the Bamileke Plateau characterized by parent materials that had been metamorphosed and granitized just as its evolution portray an evolution of the geomorphical trait that has become more complex. Since the Precambrian period, the relief that was laid down during successive orogenesis were exposed to denudational forces that wore down their surface. After this, the different tectonic phases and those of the secondary and tertiary era that followed, controlled the processes towards the basement complex. The present geomorphology is greatly controlled by two successive evolutions. The first is the process that entails activities of diastrophism that characterized the tertiary era.

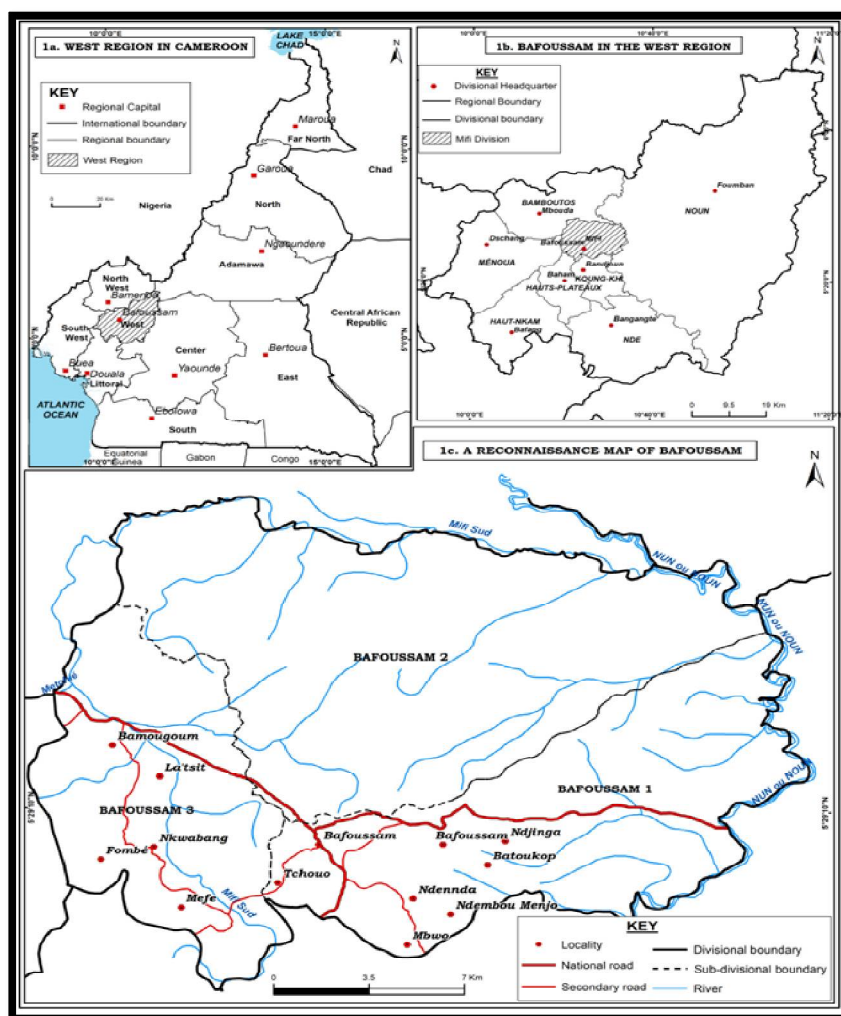


Figure 2: Location of the Study Area

The minor seimes noticed today are signs of ancient movements that have deformed the basement complex, causing the readjustment of blocks from time to time. The movements around this area are strictly linked to the tectonic activities of the Great Cameroon Line. The second evolution comprises volcanic eruption mainly composed of basaltic flows of the Mount Bamboutos System that probably took place in Miocene (16M – 5.3M years) that overwhelmed the

raised and faulted basement complex. This filling stage has contributed to the coverage of the old structural directions that are only perceptible today through some isolated horsts. Serious erosion has also greatly sculptured the relief of this site of Bafoussam town that has no doubt had a very active geological history.

The climate of Bafoussam falls within the zone that has two marked seasons, controlled by the monsoon from the Gulf of Guinea from the South West and the Harmattan or North East Trade Winds from the Saharan Region in the Northern part of Cameroon. The dry season runs from November to March meanwhile the rainy season runs from April to October. The rainfall is relatively abundant with an average of 1800mm per year and precipitated at an average of 110 – 130 days per year. July, August and September are the freshest periods of the Year. The annual average temperature is about 20°C hovering between 18°C & 23°C with absolute maxima of 21°C in March and absolute minima around 9°C in July.

Bafoussam town is part of the grassfields that is predominated by Savanna. The vegetation is basically herbaceous savanna with *Pennisetum Purpureum* & *Impérata Cylindrica*. Most of the valleys are to be found with gallery forests composed of raffia bushes. There are also planted forest that are basically composed of fruit trees such as pear trees Mango trees, Plums, Guava etc. as well as ornamental and shade trees such as Eucalyptus, Cypress and Whistling pines. Most importantly there are sacred forests in the area to be spotted mainly around three chiefdoms (Palaces) which are found in Bafoussam 1, 2 & 3.

With regards to the soil of Bafoussam, there are three sub types. The first type is the brown soil on basaltic rock. It possesses many classes that include Alfisols, Inceptisols-Lixisols Luvisols. These are richer than their counterparts-the red soils in in Baleng, Bapi, Bamoungoum, Bansoa, Baleveng and Balessing. These soils possess high organic content and their chemical properties are balanced and therefore they are very fertile soils. The second type of soil is the young soil made of Lithosols derived from basalt. These soils range generally from Intisols or Inceptisols that have been highly used and impoverished by the high population density. The third type, entails the black soil on volcanic ash/cinder. The soil is very rich except for its deficiency in oligo-elements (copper and zinc). The soil is mostly found around Bapi and baleng. Most of the humid valleys occupied by raphia carry sediments that have been eroded and deposited to produce hydromorphic soils that are dark and less aerated are equally very fertile for Market gardening.

According to his majesty Njitack Ngompe Pelé, Edition COGNITO (September 2008), Under the pressure of Peul invaders who were invading to Islamise the region towards the 17th Century; the Bafoussam natives had many migratory waves moving from the Kassap to Fankou and then to Houa in Bandjoun, Katchuet and Fancep. It was after many decades of migrations that the Chief decided to settle at the site of “Ngoungfoussam” – The Kingdom of Bafoussam at “Hiala”, its present site. Originally, Bafoussam is in bafoussam dialect - “Pefussepe” which literally signifies “those from” with time, “Pe” was transformed into “Ba” why maintaining the same meaning. Meanwhile “foussam” became foussam and together with the above, the produced ‘Pefuhssap’ or ‘Pefuhssap’ meaning Bafoussam. Pefuhssap or Pefuhssap simply means “Those who have discovered the profit or treasure are found in the retail trade. Bafoussam is a tribal group that is composed of 07 villages. (Bamendzi, Banengo, Ndiangdam, Ndiangsouh, Ndiangbou, Toukouop, Ngoueng, et Banengo ville B) with 41 quarters

3. Research Methodology

Various institutions have been consulted for data collection, including the University of Yaoundé I, the World Bank, the Ministries of Environment, Nature Protection and Sustainable Development and the Bafoussam Urban Council. In order to establish comprehensive satellite images to determine land cover and land use, information was gotten 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) as well as Google Earth, we proceeded with a workable procedure which entailed the determination of the Path and Row. Earth explorer and Google Earth we utilized for ground truthing/verification. Using the ETM+ (Enhanced Thematic Mapper +) the Scene that carries Bafoussam could be traced following Path 186 and Row 056 between the period 1978, 1998 and 2018(Figure 1).

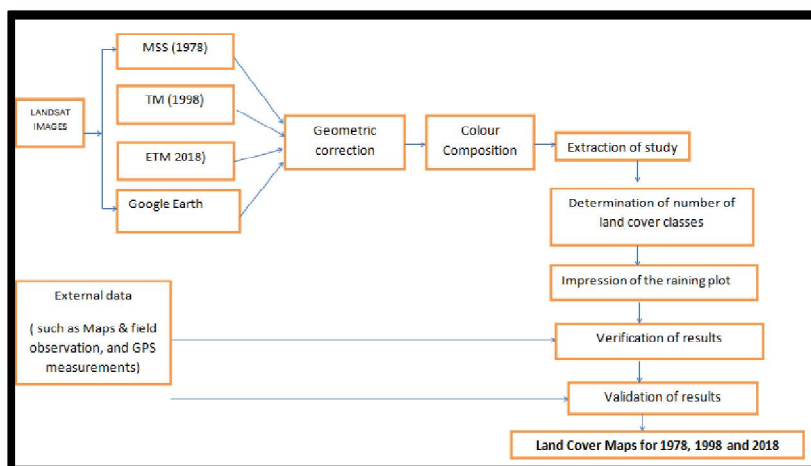


Figure 1: Methodological Approach for the Treatment of Satellite Images

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 in order 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 colour bands. Then the bands appear with the possibility of RGB colour instead of gray scales. With, the Supervised and on Signature Editor, then zooming of the image, the sample by polygons of each form of feature was taken and attributed a colour. For instance green for vegetation, brown for bare surfaces and blue (or water surfaces) constituting Land Cover Classes (LCC). The ArcGIS program in combination with the above software was subsequently used in delimiting various land cover classes. The technique has been utilized with success by Assako (1998), Bauer & als (2003); Pratt (1991), Tonye & als (2000) and Nkwemoh (2017). Global Position System (GPS) was equally utilized for collection of points.

Land Cover Classification was done by the use of the following formula

$$\frac{LCC1}{TLC} \times \frac{100}{1} = \% \text{ LCC1 of TLC}$$

LCC1b-LCC1a = Rate of change for LCC1 for 1978 – 1998 (20years)

Where LCC = Land Cover Class

TLC = Total Land Cover

LCC1a = Land Cover Class for Built –up area for the year 1978

LCC1b = Land Cover Class for Built –up area for the year 1998

LCC1c = Land Cover Class for Built –up area for the year 2018

We collected numerical Census data (1950, 1976, 1987 and 2005) and estimate projection of population of Bafoussam in that we computed using Microsoft EXCEL. The GIS programs such as Adobe Illustrator 9.0 and ArcGIS 10.2 softwares have been used for cartography. Population projection was done 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

4. Results and Discussions

4.1. Rapid population increase and Urban Expansion

Bafoussam was created in 1925 as an administrative post and grew up moderately till 1958 with the outbreak of the socio-political crisis that witnessed an influx of population from the rural areas in search of security. The population then increased from 10.000 inhabitants in 1958 to 60.000 in 1976 and then 231.000 in 2005. Applying the growth rate of the population observed in 1987 and 2005, the population of Bafoussam can be estimated in January 2010 to be 282800 (table 1 and Figure 3). With this population, the weight of the total urban population of the whole Region is 13.9%. This relatively low weight is explained by the high number of agglomerations that are found along the National Highway (N5 and N6)

The pull factors of the population centre around the fact that Bafoussam is a roundabout town that is located at the pinnacle of inter-regional exchange. Secondly, it is the Administrative Headquarter or Capital that attracts service sectors. Thirdly its position permits it to enlarge regional influence on the North West and Adamawa Regions. It has a significant might/weight that comes from its prolonged demographic trends.

Year	1976	1987	2005	2010	2018
Population	62239	112681	239287	282800	321962**
Growth Rate		5,5	4,1	4,1	

Table 1: The Evolution of Population of Bafoussam

**Projections

Source: BUCREP (2005) Bafoussam Urban Council (2017) and Projections

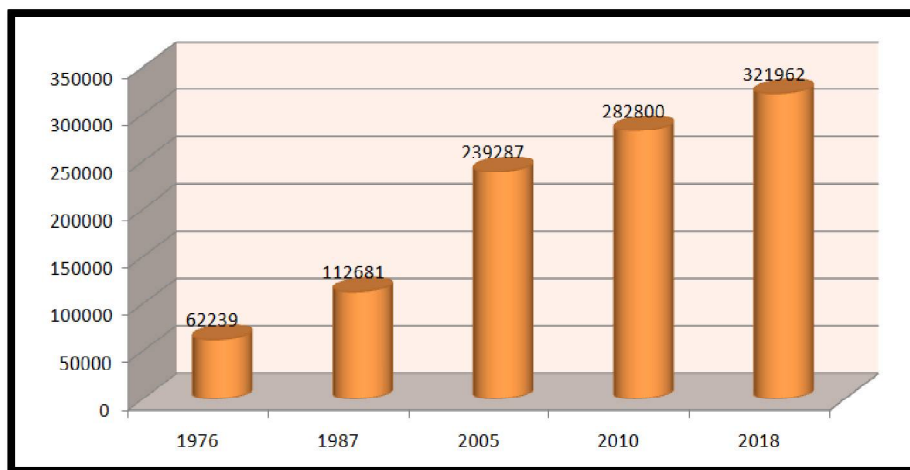


Figure 3: The Evolution of Population of Bafoussam

Source: BUCREP (2005) Bafoussam Urban Council (2017) And Projections

Considering the Mifi Division, that covers the whole of the Urban Council, the total number of population was estimated at 301,456 inhabitants in 2005. The urban population stood at 239,287 being 79% of the total while the Rural population was 62,169 persons (Table 2)

Council	Urbaine	Rurale	Total
Bafoussam	81 611	16 728	98. 339
Baleng	99 524	21 758	121 282
Bamougoum	58 152	23 683	81 835
City Council	239 287	62 169	301 456

Table 2: Population by Place of Residence

Source: Bafoussam Urban Council (2017)

The population of Bafoussam has mutated over the past years till today that it has become the primate city in the Western region followed by smaller towns like Mbouda, Dschang, Bafang and Foumban amongst others.

The term city has no unique definition since it varies with space and time but is not uncommon to be associated the meaning of the term with demographic characteristics. The United Nations holds that all places with more than 20,000 inhabitants living together are urban. However, some Nations compile their statistics on the basis of different standards. The United States for example considers an 'urban space' as an area where more than 2,500 people live. Irrespective of numerical definition, it is evident that the later course of human history after the Industrial revolution has been marked by a process of Urbanization.

Figure 4 shows the degree and evolution of spatial coverage of built-up area that constitutes that arena of townscape. The function of the urban space is a true testimony of an artificial ecosystem that is replacing a natural system.

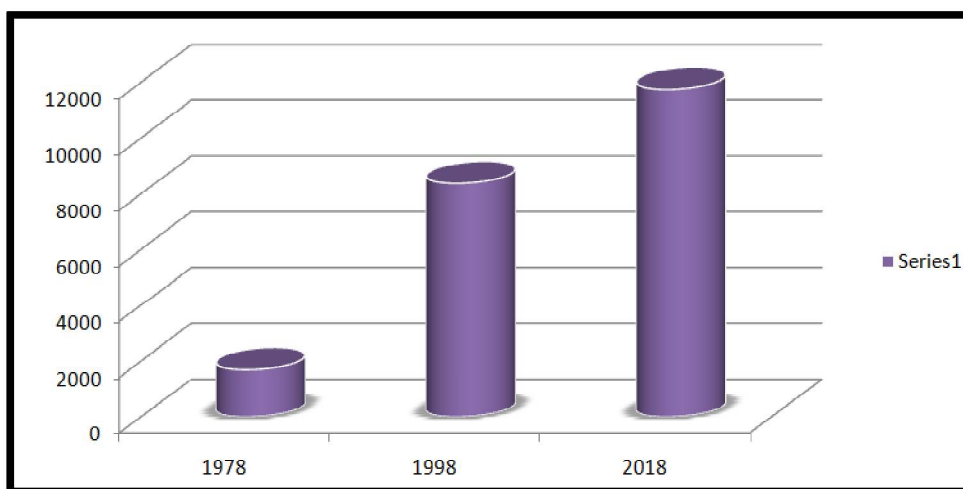


Figure 4: The Evolution of Urban Expansion in Bafoussam

Source: Satellite Images for Bafoussam 1978, 1998 & 2018

Normally in the natural ecosystem, there is an array of species that live together, playing different roles and interacting with one another as well as their natural habitat. In an urban ecosystem, man is the principal actor and even if there are other members of the ecosystem, their roles are either insignificant or non-existent. In the townscape therefore,

there comes the confrontation of Landuse imposed by Man and land cover that entails both what is laid down by Nature and by Man. Findings from the field show that about 70% of the houses in Bafoussam are owned by individuals and about 80 to 90% of those who occupy the house according to the Urbanization Master Plan (PDU) of Bafoussam (2018) are the Proprietors/Owners. The same source holds that the number of Tenants is very insignificant

4.2. Impact on Land Cover Dynamics

Results from field inquiries and analyses of satellite images give an impressive picture of the land cover dynamics of the Town (Table 3)

Landcover	Surface Area In Hectares And Percentage					
	1978		1998		2018	
	Hectares	%	Hectares	%	Hectares	%
Forest	7157	17.4	2779	7	2281	6
Savanna	24992	60.9	19725	47.5	14805	36
Built-up area	1692	4	8383	20	11748	28
Hydrography	294	0.7	138	0.3	101	0.2
Cultivated land	7101	17	10211	25	12301	29.8
Total	41236	100	41236	100	41236	100

Table 3: Land Cover Changes for Bafoussam

Table 3 and Figures 5, 6 & 7 show the spatio-temporal evolution of landcover over the past 4 decades. The primary vegetation of forest has regressed progressively. The thinning down in the surface of the areas by these land use systems are evident. Firstly, there is an increase in the built-up area from 1692 in 1978 being 4% of the total area to 8383 in 1998 being 20% of the total surface area to 11748 accounting for 28% of the total surface area.

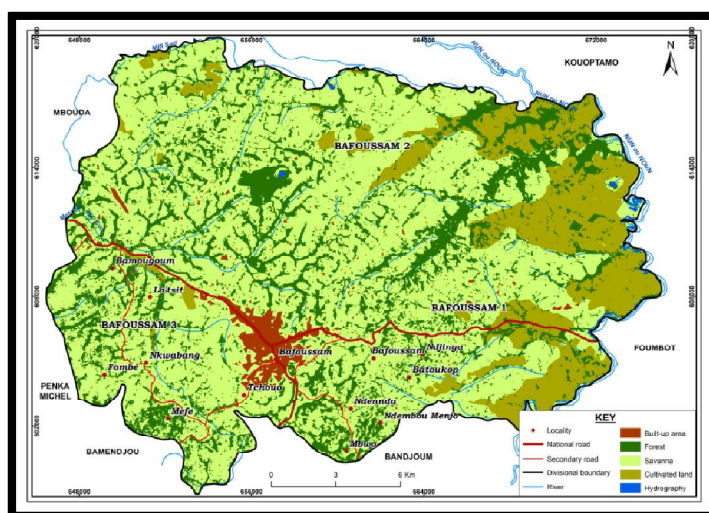


Figure 5: Land Cover in 1978

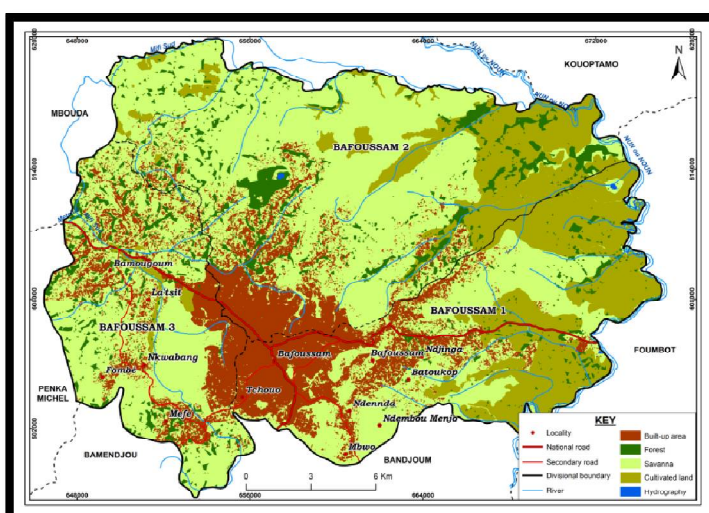


Figure 6: Land Cover in 1998

housing strategies, there should be an Expansion of roads, the use of common transport buses and the establishment of commuters' zones or residential quarters. All of this is in order to meet up with the type of Social Lodging approach and reduce the weight of horizontal expansion.

5.2. Forest Protection and Management

The Forest and Wildlife regulation Law of 1994 implemented by the Ministry of Environment laid down specific tree felling modalities to be respected by forest exploiters. This is respected in protected areas and is a good idea in protecting and managing the forest. Forests provide habitat for a variety of plants and animals and perform many other important functions that affect humans. Photosynthesis is the chemical process in the leaves that uses sunlight and carbon dioxide to produce energy-supplying sugars for the tree. In this process, the foliage gives off pure oxygen for breathing. All of this will assist in the implementation of the program of REDD+.

With regards to forest management, the first step here concerns the farmers. Since subsistence farmers in these areas still cut trees for agriculture, they should be advised on how to go about things in a sustainable way by the Forestry unit of the Delegations of Forestry. Such exchanges should either be through forums like workshops or momentary visits of forest technicians. The farmers who already own established plots should then be encouraged to practice permanent farming system as in agro forestry discussed earlier.

5.3. Forest Regeneration/Urban Forestry and Fuelwood Plantation

The mission of regeneration of forest all over the country and Bafoussam in particular has been confided to ONADEF. This institution has however regenerated forests in some areas in the 80s but today, it is no more effectively carrying out the functions. Rather, this institution is more engaged in the sales of seedlings to those who intend to plant trees. Bafoussam town is found in the ecological zone of Western and Central Africa (ICRAF 1998). This zone supports a broad variety of multipurpose tree species. These local and exotic species would also do well in urban forestry which is a measure that has been recommended here. Another method entails the planting of woody perennials along streets or roadsides. Many other methods and rewards of urban forestry, have been viewed variously by Tyrväinen et al., (2003); Ulrich et al., (1991); Daniel, (2001a) cited in Tyrväinen (2003). In the pursuit of urban forestry in Kribi, the primordial aspects in mind are ecology, sustainability and most importantly aesthetics.

The creation of MINFOF and MINEPDED in 2005 with all the Delegations had been a recognition of the fact that forest preservation is an issue. Decree No. 03-169 of April 1982 laid down forestry regulations which had a provision for forest regeneration all over the territory. Initially forestry reforms were realized by CENADEFOR and later ONAREF (Office National pour le Développement de Forêts). Institutions like this should be revamped. Urban residents in the area concerned should be invited to participate in issues related decision on management of forest. Tyrväinen and Löfström (1998), hold that active participation in forest planning may increase the participants' ecological and/or silvicultural knowledge, and thus may change their preferences towards forest management options.

5.4. Encouraging Agroforestry

It would be very appropriate if agro-sylvo- pastoralism is practiced in and around the metropolis. The practice where trees are planted sequentially or simultaneously with crops and livestock rearing would be the most sustainable system in this area just as it has proven to be in the degraded lands of the Western Highland and the Tropical Regions as a whole as viewed variously by Fogwe 1997; ICRAF 1998; Nkwemoh 1999 & 2011;). The combination of trees and crops leads to an ideal situation. This practice which is referred to as agro forestry has evolved from simple planting of trees and crops to a careful selection of plants and crops according to their mutual give and take needs. This implies that the choice of the type of agro-forestry will depend on the will of farmers and agricultural extension workers in the area. All of these would obviously re-iterate the forest coverage and hence, enhance measure advocated by REDD+

6. Conclusion

The above research has led to the establishment of some lucid facts. Since the creation of Bafoussam, the population of the town has witnessed an exponential growth and landscape mutations. These changes have been associated with the increased need for agricultural expansion to feed the population, opening the door to land use changes with more clearings within the townscape.

It was equally realized that construction of houses by both traditional and conventional methods needs forest products in the building and roofing processes. This impact on forest vegetation has been exacerbated by the need of Fuel wood/Charcoal for domestic purposes. The degradation of forest cover has even been aggravated by the need of a wide variety of wood for woodworks/furniture especially needed in the increasing number of households. This is viewed in the lay out of specific land cover classes ranging from forest land, savanna/grassland, agriculture/farm lands/ Bare surfaces, and constructed spaces and water bodies. This situation therefore calls for an urgent reaction by the powers that be to establish a sustainable city as the ultimate way ahead.

The investigation rounds with some recommendations on the urban planning and forestry policies on forest protection and management. The measures also include forest regeneration, fuel wood plantation, agroforestry and Urban Forestry that would guarantee a true eco/sustainable city that Bafoussam is supposed to be.

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