



LAND USE AND LAND COVER CHANGES AND ENVIRONMENTAL IMPLICATIONS IN THE BUEA MUNICIPALITY

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ABSTRACT

The recent urbanization trends and changes in land use and land cover have had profound effects on the natural environment. This research seeks to examine the trends and patterns of LULC changes over a period of 32 years and their implications on the environment. The study made use of primary and secondary sources of data. The stratified random sampling technique was used in the selection of sample sites and the administration of 250 questionnaires. Landsat image files for the three-time interval were downloaded from the Global Land Cover Facility website and the various bands were modulated and corrected to reveal land use features using ENVI version 4.3. Change detection and analysis were identified through image differencing in the same geographical area for the three intervals. The findings revealed that agricultural land use decreased from 83.8km² to 60.4km², forest cover dropped from 339.24km² to 330.27km², whereas settlement land use increased from 4.90km² to 37.36km² between 1987 and 2019. The study further revealed that changes in LULC situations in the Buea Municipality have resulted in a host of environmental problems, namely, pollution, loss of biodiversity, soil erosion, water scarcity and floods. The study recommends an up-to-date master plan for Buea and its effective implementation. It also suggests that urbanisation and population growth should be matched with local planning objectives and the involvement of the local population of Buea in developmental issues.

Keywords: Land Use, Land Cover, Change Detection, Environment, Implications.

1. INTRODUCTION

Every place has to evolve, and at a certain pace, based on a couple of elements influencing the population. This evolution takes place on land, and land is a scarce resource that is gradually affected by competition for mutually exclusive uses. Thus, land has about standing characteristic of being the central factor in human sustenance (Adarkwa & Johan, 2001). Land cover reflects the natural processes and human endeavours on the earth's surface such as groundwater, savanna, forest cover and paved surfaces, whereas land use is the term employed to embrace those anthropogenic activities such as built-up, recreation and agriculture carried out on the land cover to satisfy human needs (Balgah and Nformi, 2017). Land use changes refer to the conversion of land from one form to another. These changes involve modifications, which exert either a direct or an indirect impact on the society and the environment. The development of every community depends largely on the careful use and management of the available land resources (Asamoah,

2010). The recent world's population increase, rapid urbanisation and modernisation has unleashed a series of developmental problems.

Urbanisation is now a common feature in developing countries with the growth of primate cities and megacities (Aleenjeet et al., 2013; Brockerhoff, 2000). In Asia, Africa and Latin America, the unprecedented population growth that described much of the 20th Century has advanced into unparalleled urban growth. The United Nations (2010) estimated that, between 2007 and 2025, the annual urban population increase in developing nations is expected to be over 53 million (2.27%) compared to 3 million (0.49%) in developed nations. The rapid population growth rate has triggered a lot of unplanned patterns of land use and land cover in most urban areas. The implications of these changes would be spread around the globe either directly or indirectly on man and the environment (Addis, 2009).

The land surface has always been an area of interest to geographers and other scholars interested in spatial analysis. Throughout geological times, the earth's surface has been changing. But the recent changes have been occurring at a much faster rate coupled with rapid urban expansion. Land use and land cover change detection, mapping and measurements at frequent intervals provide real time information for planning and management. Land is a vital natural resource whose quantity is fixed over space, time and usage. It is a scarce resource, but attracts diverse uses. The inevitable consequences are pressure and upsurge of conflicts between the competing land uses.

According to Balgah (2007), human activities on the earth's surface have significantly transformed the natural environment. Hence, leaving few landscapes in their natural state. The division of the world into More Economically Developed and Less Economically Developed Recent researches have shown that socioeconomic activities are the main causes of land use and land cover dynamics. These activities determine the structure and function of landscapes. The evaluations of the impacts of socio-demographic changes on land use and land cover have recently been comprehended with the use of geospatial technologies (Mubea & Menz, 2012).

Cameroon like other West African nations has experienced a rapid and unplanned urban growth, however, the rate of urbanization in Cameroon has been very rapid (Kimengsi et al., 2016). Geographic Information System (GIS) technology in Cameroon is commonly used for conservation projects and by international Non-Governmental Organisation (NGO's) working on natural resource management. Observing the earth from space is now vital in determining the effect of human activities on the earth's surface over time. Areas of rapid and unrecorded changes in land use, spatio-temporal observations of the earth surface provide the necessary information for planning. In recent times, data from satellites images are becoming very important in mapping land use and land cover on the earth's surface for planning and management purposes (Zubair, 2006).

The Buea Municipality represents one of the fastest growing towns in Cameroon. Its population increased from 90,088 inhabitants in 2005 census to 213,911 inhabitants in 2014, with the rate of urbanisation estimated at 5% (BUCREP, 2014). This has had tremendous implications on land use with the passing time. This change is problematic in that, land remains fixed despite the growing rate of urbanisation and population. The failure by town planning authorities to institute

town planning decisions and to budget with rapid urbanisation in mind has further deteriorated the problems associated with urbanization in Buea. So many localities within the Buea Municipality do not follow the land use plans due to poor implementation by town planning authorities and the non-respect of these decisions by the inhabitants.

The Buea Municipality has witnessed an intensive process of land use and land cover change within the last decades. Unfortunately, much of these changes have not been tracked and properly recorded. This is evident in the many conflicts over land resources and environmental problems. Looking at these issues, there is need therefore for a spatio-temporal LULC change analysis in the Buea Municipality and their implications on the environment.

2. STUDY AREA

The Buea Municipality occupies a surface area of 870km² and lies between latitudes 4°12' and 4°31' North of the Equator and longitudes 9°9' and 9°12' East of the Greenwich meridian. The Buea Municipality is bordered to the West by Mount Cameroon, to the East by Tiko Sub-Division, to the North by Muyuka Sub-Division and to the South by Limbe Sub-Division (Figure 1). Buea is the Regional Headquarter of the South West Region of Cameroon. It is a highly complex community made up of urban and rural settings. The situation of Buea at the foot of Mount Cameroon and its proximity to the Atlantic coast influenced the humid climate. The higher elevations of the town are cool and cloudy, while the lower elevations are warm and less humid. The rainfall in Buea is usually high with an annual total of over 3500mm, distributed evenly almost throughout the year (Balgah, 2007). The average temperature is mild, between 23°C and 25°C. It is a host of Mount Cameroon, with the highest peak in West Africa (4095m). Buea has a radial drainage pattern with streams flowing from the highland to low-lying areas. Buea has a tropical evergreen forest, with fewer trees in areas of high housing density. In addition, anthropogenic activities such as subsistence agriculture and urbanization have reduced the natural forest cover. The settlement pattern in this region forms a closed ring around the foot of the mountain with no permanent settlements on altitudes above 1500m. The rate of urbanisation in Buea has risen to 57% with an annual urban population growth rate of 5% (CVUC, 2016). The population of Buea has been distributed into densely populated areas (Molyko, Great Soppo and Government Residential Areas (GRA), moderately populated areas (Buea town, Muea, Bokwango and Bomaka) and sparsely populated areas (Tole, Bonjongo and Dibanda). Before the 1990s, the predominant land use pattern was agriculture, especially with the creation of Cameroon Development Corporation (CDC) banana plantation. However, by 1993, with the creation of the University of Buea, land uses have dramatically changed. These land uses acted as a strong gravitational pull force for people from all over the country and beyond. With the rapid population growth, agricultural land use has given way to residential and commercial uses. Molyko for instance, has been transformed into an academic and economic land use area.

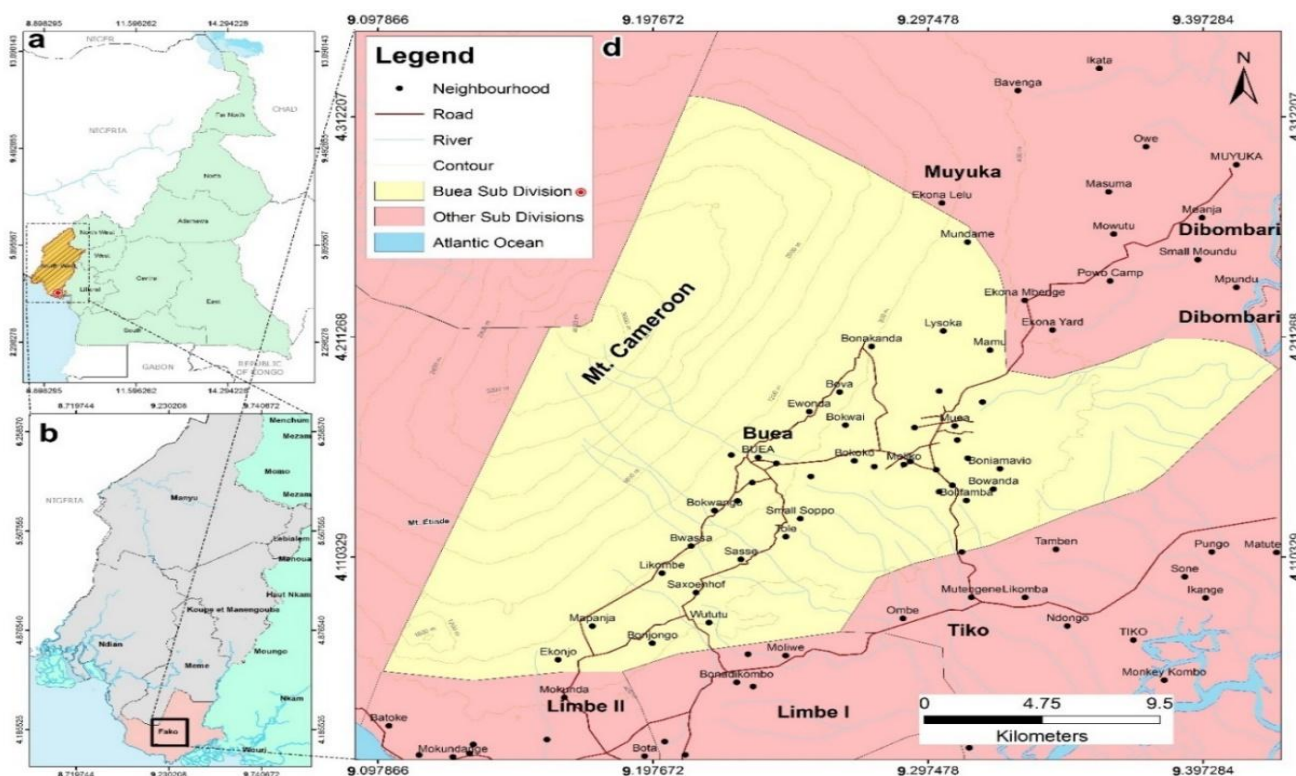


Figure 1: Location of the Buea Municipality in the Fako Division, South West Region of Cameroon

3. MATERIALS AND METHODS

The study made use of the descriptive research design and employed qualitative and quantitative methods of data collection. Data from primary and secondary sources were used. Primary data were obtained from field observation, questionnaires and interviews. The stratified sample technique was used to select the 16 sampling sites. The Buea Municipality was stratified into two strata; the urban space and the suburban space. 8 neighbourhoods were selected from the urban space (Muea, Mile 17, Molyko, Boduma, Soppo, Clerks quarters, Federal quarters and Buea station), and 8 neighbourhoods from the suburban space were also selected for the survey (Bomaka, Bolifamba, Bitwingi, Bokwai, Bokova, Bova, Lykokomembea and Tole). 250 questionnaires were administered randomly in the sample sites. A Global Positioning System (GPS) was used to mark out waypoints for specific land uses for the production and interpretation of land use maps. Satellite imageries were downloaded for the three intervals; 1987, 2002 and 2019, a span of 32 years long enough to show the changes on land. This study classified farmland and plantation as agricultural land use, the Mount Cameroon forest and areas with natural tree cover as forest cover, and areas with high and low housing density were considered as settlement land use. Google Earth, Global Mapper version 15 and ArcGIS version 10.2 were used to upload waypoints which helped in the generation of information for the realisation of land use maps. Landsat imageries for all the years were downloaded from Global Land Cover Facility website and the various bands for each were modulated and corrected to show land use features using ENVI version 4.3 and digitized using MapInfo Professional version 6.0. Secondary data was obtained from the Buea National archives, relevant official documents,

published and unpublished works related to this research work. To find out changes in LULC, the magnitude of change (LULC situation of New year minus the LULC situation of the previous year), the percentage of change (magnitude of change divided by base year multiplied by 100) and the annual rate of change was calculated by dividing the magnitude of change by the difference in the study years.

4. RESULTS

4.1 Land Use and Land Cover Situation in the Buea Municipality for 1987, 2002, 2019

4.1.1 Land use and Land Cover Situation in 1987

Before the 1980s, the forest cover and agricultural land use were predominant in the Buea Municipality. Areas such as Molyko, Muea, Bomaka, Bolifamba, Lysoka and Mamu were occupied by the CDC plantations, while Bonakanda, Bwassa and WonyaMavio were largely occupied by the forest cover (Figure 2). Bova, Bojongo and Wotutu were occupied mostly by small scale subsistence farming while residential settlements were concentrated in the Government Station, Buea Town and Great Soppo neighbourhoods. Small scale commercial activities were equally located in these localities to serve the needs of the administrators. Given that Buea began as an administrative capital and an agricultural town, population growth was very slow. This equally retarded the growth of the entire subdivision causing Buea to develop mixed characteristics of rural and urban features.

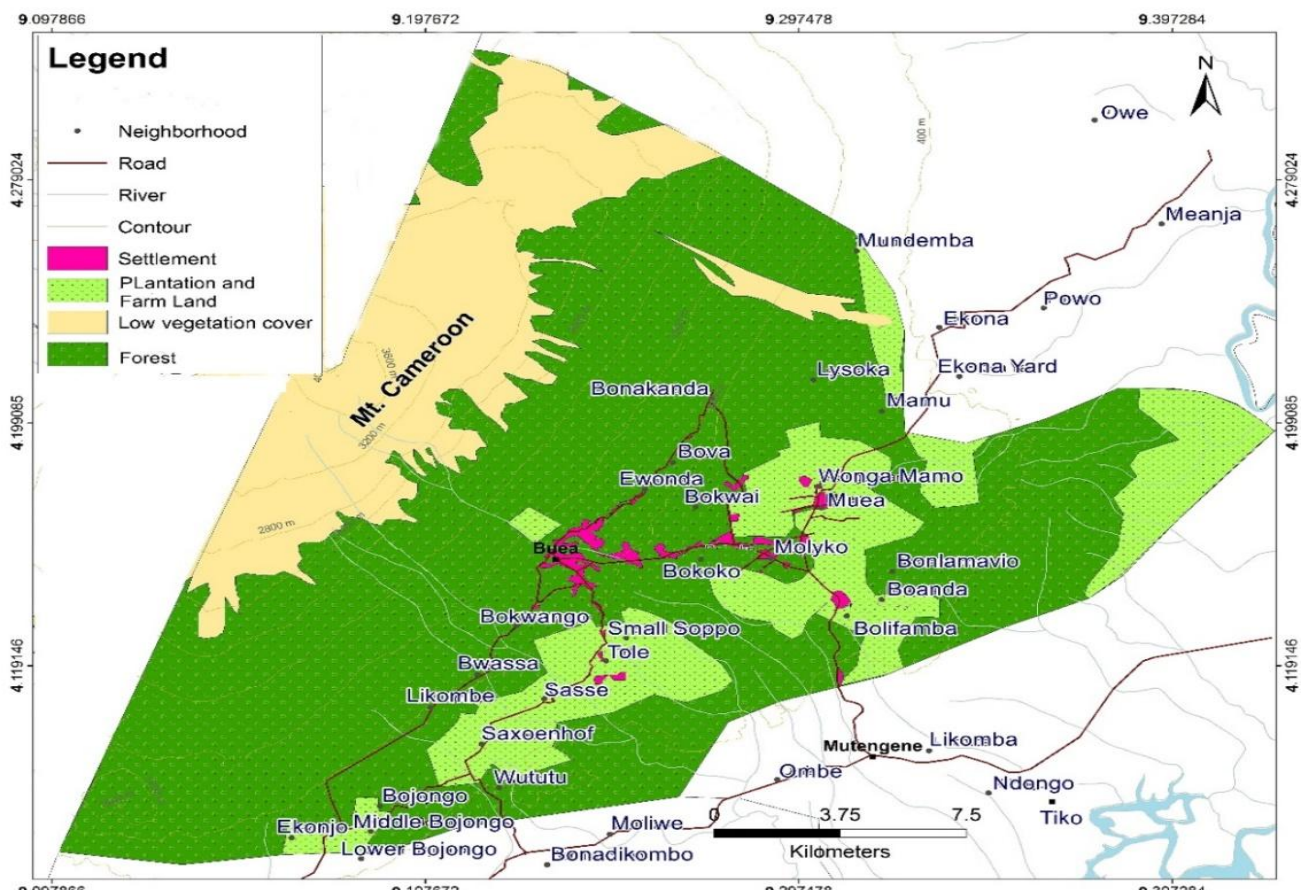


Figure 2: Land use/land cover situation for the Buea Municipality in 1987

4.1.2 Land Use and Land Cover Situation in 2002

By 2002, the Buea Municipality experienced an increase in population from 65,853 in 1987 to 96,323 in 2002 (Tosam 2009). This increase was attributed to the creation of the University of Buea, the Catholic University Institute of Buea (CUIB) among other higher institutions which resulted in an influx of immigrants into the study area. This led to drastic changes in land uses, not only in the Buea urban space but in the suburban space. With the rapid population growth, agricultural and forest cover begun giving way to settlement land use due to the increase in demand for shelter. The Molyko neighbourhood was formally dominated by agricultural land use, but the academic and economic activities have transformed the neighbourhood. Areas like Bova, Ewonda, Saxoehof, Wututu and Bokwango which were formally forested, were transformed into settlement land use as shown in Figure 3.

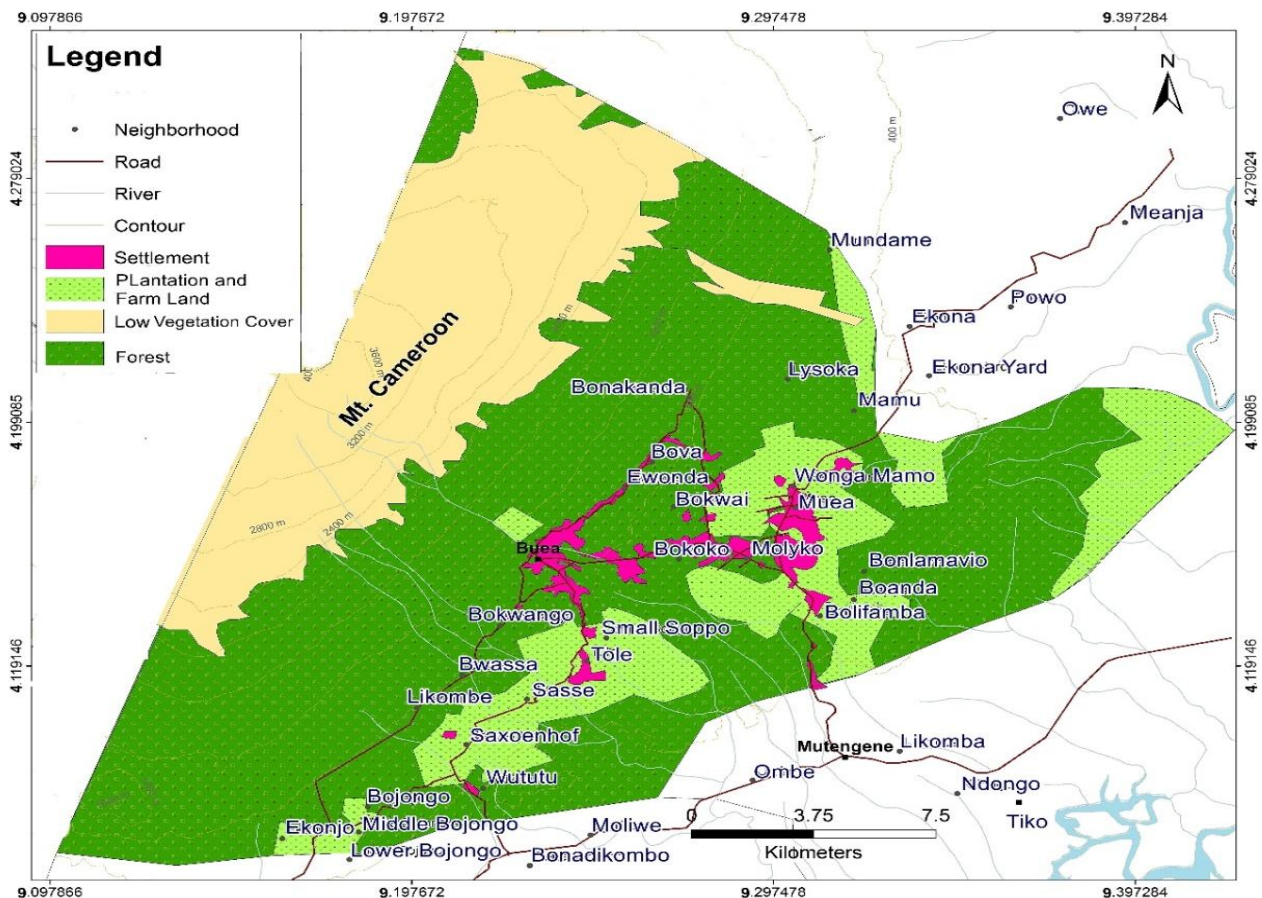


Figure 3: Land Use- Land Cover Situation of the Buea Municipality (2002)

4.1.3 Land Use and Land Cover Situation in 2019

There was a further increase in population from 96,323 persons in 2002 to 213,911 persons in 2016 (BUCREP, 2017). The increase in population has had a direct relationship with land use changes. Settlement land use has increased to meet up with the needs of the rising population. Buea witnessed a massive increase in urban functions like schools, hospitals, banks, commerce, amongst others. The rapid urbanisation and development in the study area, have resulted in an increase in land value, especially within the urban space leading to spatial expansion into

suburban areas and the encroachment in to marginal areas (river banks and marshy areas) like the case in Ndongo stream, Bomaka and Bolifamba areas causing some environmental and social implications. The presence of the market at the Bitwingi area which was formerly a CDC banana plantation attracting more settlements. The continuous decrease in forest cover and agricultural land use, is accounted for by the different opportunities offered in Buea ranging from social amenities, education and commercial services. This attracts people from different regions of the country into the Molyko neighbourhood (Figure 4). Hence, the ever-increasing human demand can only be achieved by taking up more land for cultivation in order to meet their food and settlement needs.

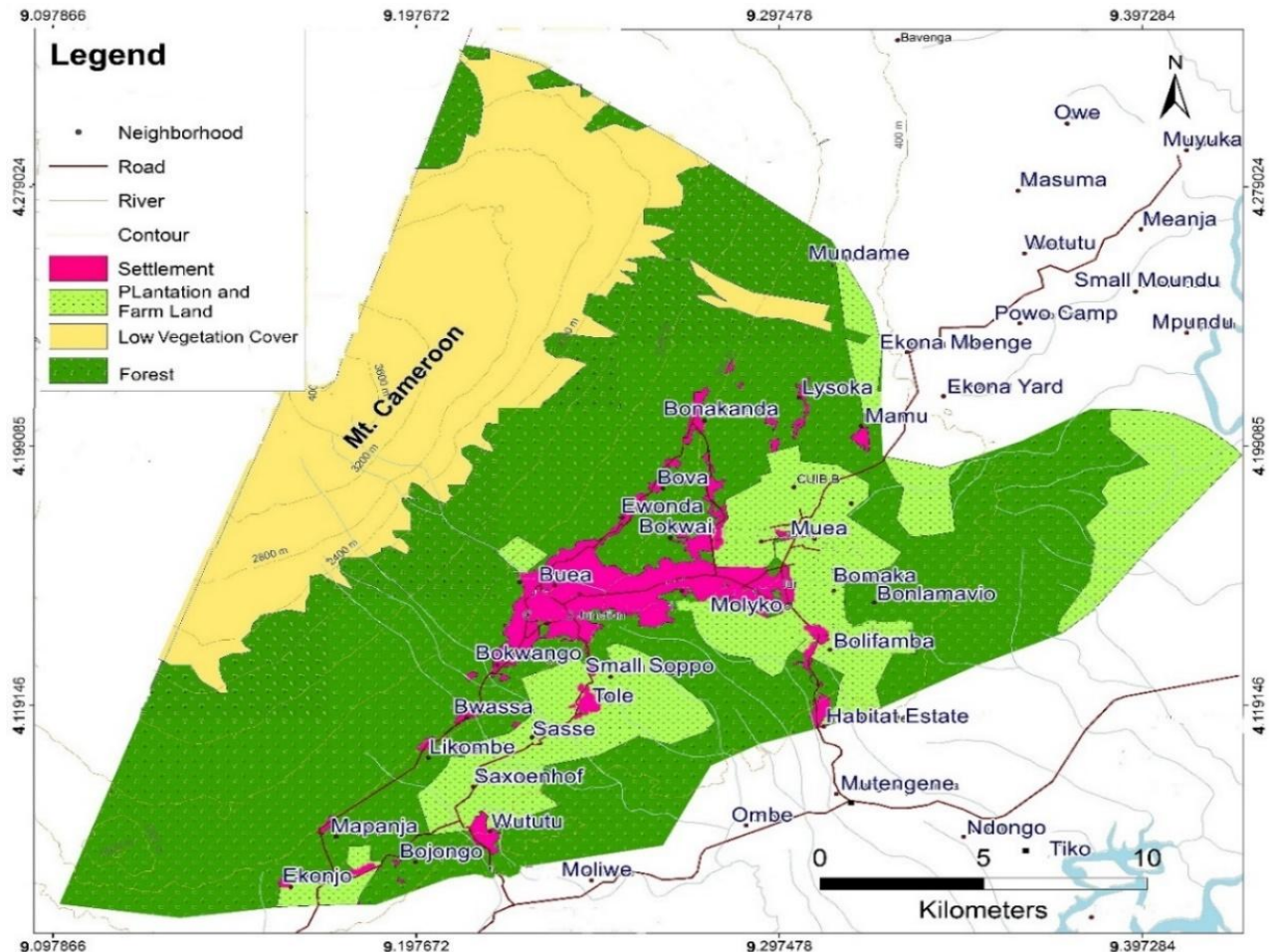


Figure 4: Land Use- Land Cover Situation of the Buea Municipality (2019)

The land use and land cover situations for 1987, 2002 and 2019 was examined to determine the rate of change. The results revealed positive and negative changes in their area coverage. From Table 1, forest cover decreased from 339.22km² (79.2%) in 1987 to 338.02km² (79%) in 2002 and further dropped to 332.27km² (77.1%) in 2019. Plantation and farmland also witnessed a decrease in land use from 83.88km² (19.5%) in 1987 to 78.25km² (18%) in 2002 and further dropped to 60.49km² (14.1%) in 2019. While settlements experienced an increase from 4.90km² (1.3%) in 1987 to 12.26km² (3%) in 2002 and 36.39km² (8.8%) in 2019.

Table 1: LULC Evolution in the Buea Municipality for 1987, 2002, 2019

Land Use Categories	1987		2002		2019	
	Area in km ²	% Coverage	Area in km ²	Percentage of change	Area in km ²	Percentage Coverage
Forest	339.24	79.2	338.02	-0.45	330.27	77.1
Plantation/Farmland	83.88	19.5	78.25	-1.18	60.4	14.1
Settlement	4.90	1.3	12.26	+1.63	37.36	8.8
Total	428.02	100	428.02	1987-2019	428.02	100

Source: Derived from the Land Use Situations for 1987, 2002 and 2019

4.1.4 Land Use and Land Cover Dynamics (1987-2019)

The period between 1987 and 2019 experienced changes in the land use and land cover in the Buea Municipality. Forest cover decreased with a magnitude of -8.97km², a mean annual rate of change of -0.29% and a total percentage of change of -0.45% in favour of farmland and settlements. Plantation and farmland decreased with a magnitude of -8.97km², an annual rate of change of -0.78% and a percentage change of -1.18% in favour of settlement land use. Whereas settlement land use increased with a magnitude of 32.46 km², an annual rate of change of 1.08% and a percentage change of 1.63% at the expense of forest, plantation and farmland in the Buea Municipality as shown in Table 2 and Figure 5.

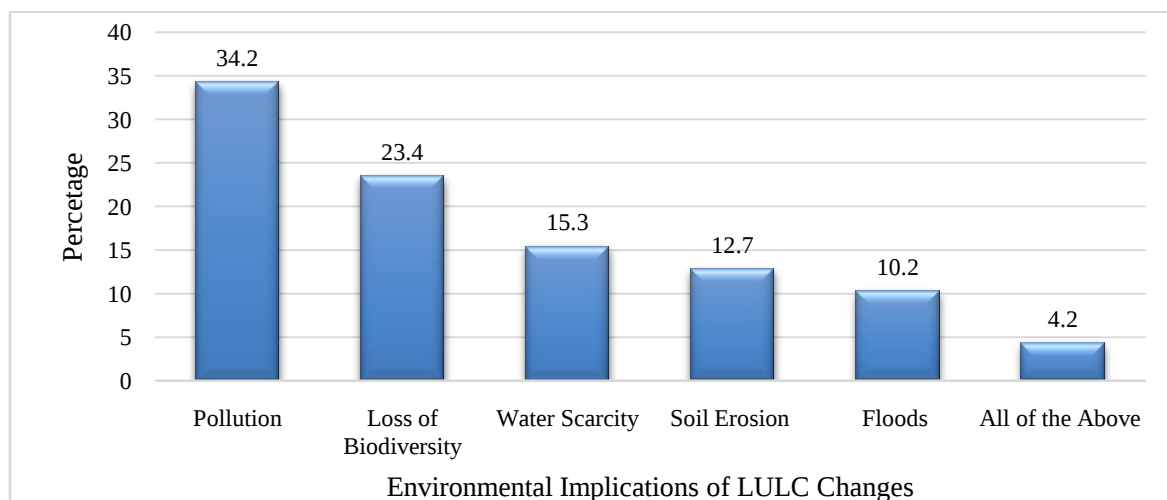
Table 2: Magnitude of Change among LULC Categories from 1987-2019

Land use/ land cover	1987-2019	1987-2019	1987-2019
	Magnitude of Change in Km ²	Mean Annual Rate of change (%)	Percentage of change
Forest	-8.97	-0.29	-0.45
Plantation and farmland	-23.48	-0.78	-1.18
Settlement	32.46	1.08	1.63

Source: Derived from Land Use and Land Use of 1987-2019

Source: Derived from LULC Situation from 1987to 2019

The implications of LULC dynamics in the Buea Municipality on the natural environment was seen through their effects on biodiversity, soils and water among others. The changes in land use and land cover changes of Buea has resulted in a number of environmental implications as presented in Figure 6.



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Figure 1 revealed that, the most disturbing environmental impacts of LULC changes in the Buea Municipality include pollution (34.2%), loss of biodiversity (23.4%), water scarcity (15.3%), soil erosion (12.7%) and floods (10.2%), while 5.4 % of the sampled population attested to the fact that they encounter all of the environmental problems in their neighbourhoods.

The increase in population and changes in human activities such as the use of modern agricultural practices and chemical substances like herbicides and pesticides are the main sources of pollution in the Buea Municipality. Farmlands situated very close to water catchments leached out some of these chemical substances from the soil into the underground water sources which are harmful to the inhabitants. The increase in the population of Buea has also increased the quantity of waste generated by households. But the indiscriminate dumping of waste on vacant land, streets, gutters and running streams block drainage systems, stream channels, increase flood intensity and pollutes the environment resulting in health problems. The findings revealed that forest cover in neighbourhoods like Molyko, Bokwai, Bolifambe and Muea has undergone pressure over time from deforestation and degradation. The respondents revealed that the increase population (39.9%), settlement (37.5%), agriculture (13.5%) and logging (10%) were the main reasons responsible for the change in the forest cover. The adverse effects of forest and forest resource exploitation in the Buea Municipality include habitat loss and deterioration, habitat fragmentation, species loss and canopy damage, hence reducing the amount of carbon dioxide that could be absorbed in the atmosphere leading to increase temperatures in the sub division especially in the Molyko neighbourhood with high population density. The decrease in forest cover and agricultural lands loosens the top soil and exposes it to soil erosion causing soil infertility. In addition, the replacement of forest cover with impermeable surfaces such as housing, roads and gutters has reduced the degree of infiltration and percolation resulting in a drop in the water table especially around water catchments. This has increased the pressure on the available water sources, hence over exploitation and water scarcity in the Buea Municipality, especially in high-density neighbourhoods like Great Soppo and Molyko. The respondents attributed the reduction in water supply, quantity and quality to population increase, deforestation, poor management, limited investment and inadequate government intervention. The increase in tarmac surfaces, sewers and the reclamation of dry valleys in neighbourhoods like Bomaka and Muea reduces lag-time. Hence, floods are eminent during the rainy season.

5. DISCUSSION

The results from the LULC analysis indicate a negative change in forest cover and agricultural land use, where as settlement land use increased significantly from 1987 to 2019. These changes were attributed to population increase, infrastructural development, the presence of academic institutions, socio-economic activities and the improvement in technology. This corroborates the finding of Balgah and Nformi (2017) in Tubah Subdivision and Fombe and Acha (2018) in the Bamenda urban space, they revealed that settlement land use has been on a steady increase at the expense of forest cover and agricultural land use. They attribute these changes to population increase and increase in social facilities. The destruction of the natural forest cover into farmland and settlement land use has resulted in the reduction and extinction of some plants and animal species. This corresponds to the work of Ndenecho (2003), who observed that most of the forest cover in Tuban Subdivision was intact in the 1920s. But the rapid urbanisation and market orientation of livelihood activities have accelerated biodiversity degradation. The growing population of Buea has led to the conversion of the natural forest cover for crop production,

settlement, road construction and recreation. This exposes the soil to erosion and flooding especially in Muea, Bomaka and Ndonga areas. Summerfield (1991) opined that the natural environment produces biophysical boundaries that cause problems to human activities. To adjust and overcome these problems, man has constructed on river courses, occupied wetlands and altered forest cover, resulting in water pollution, floods, accelerated runoff as well as other environmental hazards. In addition, the exploitation in the forest cover for fuel wood and slash and burn method of farming especially in the Muea, Mile 17, Molyko, Buduma, Buea town, Great Soppo, Tole, Bokwai, Bokova and Bolifamba neighbourhoods are the main causes of increase in temperature. The destruction of the forest vegetation over the years has resulted to global warming and water shortage. The reduction in water quality and quantity in the Buea Municipality is attributed to deforestation, poor management, pollution inadequate investment and government intervention. Fonjong and Abongwa (2014) also pointed out that water crisis in Buea is human-induced and greatly affect women and child who have to trek over long distances to fetch water for their socioeconomic activities.

6. CONCLUSION AND RECOMMENDATIONS

Looking at the spacio-temporal LULC analysis of the Buea Municipality, it indicates significant changes in forest cover, agricultural and settlement land uses. Agricultural land use witnessed a steady decline in favour of settlement, followed by forest cover which decline slightly in favour of agricultural land use. While settlement land use increased at the expense of forest and agricultural land use. The LULC changes have resulted in diverse environmental problems ranging from pollution, loss of biodiversity, water scarcity, floods and soil erosion. Therefore, it is evident that, dynamism in land use and land cover is inevitable hence the need for effective planning and land management. Sustainable farming practices such as agroforestry practices (forest farming, wind breaks), integrating livestock and crops, integrating pest management, cover cropping and crop rotations should be encouraged in the Buea Municipality to reduce soil erosion, improve soil fertility and improve on water quality. The different Regional Delegations should carve out boundaries of forest reserves, prime agricultural and settlement land uses and ensure restrict implementation of such zoning so as to avoid the growth of incompatible and conflicting land uses. Alternative livelihoods options that do not depend on extensive land use should be promoted in Buea. The Ministry of Housing and Urban Development should effectively enforce the building and construction regulations in Buea so as to reduce the unplanned and unauthorised conversion of wetlands and river valleys for housing development. The Hygiene and Sanitation Department of the Council should sensitize the population against the illegal dumping of waste in stream channels and impose punishment on defaulters. The inhabitants of the Buea Municipality should diversify their sources of water such as rain water harvesting and boreholes with proper treatment for basic uses. The water rationing system that has been operational in the Buea Municipality should be properly implemented for effective distribution of water to the general population. There should be a proactive planning process wherein inhabitants get the opportunity to suggest, discuss and participate in the preparation and implementation of planning schemes of the area. This requires the effective implementation of the master plan and the land use plan of Buea which will take into consideration housing development, urban renewal, monitoring and controlling land use and eliminating incompatible land uses, minimise environmental problems and aid in the attainment of goal 11 of the Sustainable Development Goals.

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