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LAND USE AND LAND COVER CHANGES IN THE CENTRE REGION OF CAMEROON.

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ABSTRACT:

Cameroon territory is experiencing significant land use and land cover (LULC) changes since its independence in 1960. But the main relevant impacts are recorded since 1990 due to intensification of agricultural activities and urbanization. LULC effects and dynamics vary from one region to another according to the type of vegetation cover and activities. Using remote sensing, GIS and subsidiary data, this paper attempted to model the land use and land cover (LULC) change in the Centre Region of Cameroon that host Yaoundé metropolis. The rapid expansion of the city of Yaoundé drives to the land conversion with farmland intensification and forest depletion accelerating the rate at which land use and land cover (LULC) transformations take place. This study aims at assessing the impacts of both agriculture and urbanization on the LULC change in the Centre Region of Cameroon. A detailed LULC map from MAPBOX high resolution images and three LULC maps were produced from Landsat TM-OLI images (1984-2015). A maximum likelihood classification techniques using ERDAS Imagine, showed forest decline with a total loss of 54% in thirty years. Also, Landsat and MAPBOX images to which we added 1951 aerial photograph and SPOT 6 (2006) were used to analyse urban growth in the city of Yaoundé. The results show a remarkable urban spatial spread of the metropolis between 1951 and 2015, with a peak in 2000. Images processing enabled us to analyse the long term dynamics of LULC change since the 1950s in this Region using ArcGIS & QGIS software's. Based on this dynamic, a LULC projection map was produced using Markov model on IDRISI Selva, demonstrating the decrease of the dense forest (45% in 2015 to 0.25% in 2050). It was estimated that by 2050, the entire dense forest can be depleted if nothing is done, while only 12.67% of the secondary forest would remain in the Region. Such a projected map is very useful to decision makers for council development and urban planning. This effective forest depletion ties with the hypothesis that urbanization of Yaoundé and its secondary surrounding satellite cities (within a radius of 30-100km) is a veritable driving force of deforestation.

KEYWORDS: *Agricultural activities, Central Region, forest cover depletion, LULC, urbanization.*

INTRODUCTION

Human activities and country level economic development have a bearing on resources and land cover since the advent of Global environmental Changes (IGPB/IHDP) in the early 1990s as observed with the global carbon cycle [1-9]. Anthropogenic activities that are transforming the face of the world have reached unprecedented magnitude leading to various policies geared towards the control of land use and land cover dynamics. Current research focuses on the drivers of Land use and Land cover transformations within countries in the world. Most of these studies are carried out in Europe, Asia, and Latin America as well as in some countries of Eastern and Southern Africa. In Central Africa, the presence of the rich forest and ecosystem of the Congo Basin, has influenced most research work in the region to focus only on land cover [10-12] in accordance with existing forest management policies and forest monitoring approaches. The present study in the Centre Region of Cameroon appears to be one of the rare occasions where investigation combines both land cover and land use changes. The main issue hinges on the major driving factors of LULC changes in this Centre Region of Cameroon. How do agriculture transformations and urban processes influence forest cover depletion in this region?

The main objective assigned to this study is to track the LULC changes and the deforestation driver in the Central Region of Cameroon since 1951. The main assumption is that if farmland activities were the most LULC and deforestation driver from 1951 to 1990. But, since 1990, urbanization and peri urbanization become the stepping motor of LULC transformation and it consequent deforestation in this Centre region of the Cameroon.

Since the caveman, antiquity and the medieval century, agriculture and urban processes have always seriously posed problems, but with less acuteness. From agriculture to extractive industries, from rural to urban processes, these problems constitute today a major concern worldwide. Land use groups all anthropogenic practices in traditional or modern economic settings such as farming, grazing, logging, mining and processes such as urbanization with it corollaries [13-14]. Agriculture with forestry and land use account for 23% of GHG emissions [15]. Land cover involves the biophysical appearance and characteristics of the land surface coverage such as forest, savanna or grassland, wetlands and bare land [13].

While multidisciplinary literature on LULC changes in the world is prolific and worthy, it is not the case in African countries. In this respect some authors [12] gave a general overview of the proximate causes and indirect factors of LULC changes and deforestation processes in developing countries [16-17]. Plentiful articles have a direct focus on land cover [18-19], land pressures [20] or Land Use and land Cover [21-22]. Deforestation being the main consequence of LULC change and the seeking for sustainability, raised up so many papers among which few proposed REDD+ solutions for mitigation and adaptation [23-28]. This original research papers help us analyze LULC changes drivers in the Centre Region of Cameroon.

Land use and Land Cover in Cameroon have underwent many transformations since independence in 1960. In Cameroon, agriculture has been tagged the main driver of these changes, which started as far back as the 1970s when the policy of five-year development plan was launched [29-30]. It stands out as the primary driver of deforestation in most sub-Saharan African countries [23, 31-33]. Agricultural activities are the main causes of land degradation, transforming initial forestlands into agrarian lands in addition to fuel wood activities [23, 33].

Thus, farmland activities combined with logging are the first known forest degradation drivers even though if deforestation deriving from farmland and other LULC types is a complex problem [34] in tropical Africa. In Cameroon, from 0.01 % between 1990 and 2000, forest degradation rate has multiplied by 9 between 2000 and 2005 [35]. Within the last three decades it has been aggravated by extractive activities and urbanization.

Urbanization is a process of political and economic power because the construction of any city is a translation and a reflection of both. For, the city appears as a crossroads of trade, enrichment center, tourism, industrialization. However, poverty can be seen as the element that tarnishes this power and particularly in the Third World [36-37]. Urbanization by threatening biodiversity and raising pressure on land tenure, is an important element in LULC modelling. Because of globalization and modernization, it becomes the main underlying factor of LULC changes in many African cities [38] even if there are just few studies available in some countries like Ethiopia, Ghana Zambia [39-41]. LULC transformations speed up urbanization which become one of the biggest challenges in Africa with 400 million Africans (40% of the population) living nowadays in urban areas, and according to UN-HABITAT [38], they will be 60% in 2050. By 2025, while 61% of the world population will live in urban areas [42], Lagos and Kinshasa will become, according to UN-Habitat, the 11th and 12th largest cities in the world. Kinshasa especially, is expected to grow by 4 million (an increase of 46%) from 8.7 to 12.7 million between 2010 and 2020 [38]. At the same time, Yaoundé could reach 4-5 millions. Thus, urban sprawl with demographic growth and migration is the main factor causing global changes and the primary deforestation driver in the studied region. For around the Yaoundé metropolis and along it continuum, massive expansion of cultivated land, settlements and infrastructure developments occurred at the expense of forests since 1990. Such a situation of urban sprawl that impacts LULC changes has been quite noticeable in the main cities of Europe [43-46], Northern America [47-49] just as in Latin America [50-51], Asia [52-55] and Africa (with specific reference to sub-Saharan Africa [41, 56-60]. Around most of the Cameroonian cities, demographic pressure transformed initials forestlands and afforested lands into agrarian lands combining to fuel wood activities, as observed in medium size cities of Cameroon like Bamenda Continuum [61], Bafoussam [62], Garoua [63] and Maroua [64].

In terms of the landscape dynamics and the methods used in the LULC, Geoinformation is widely spread because of its multidisciplinary applications like changes detection and modelling [65-71], monitoring [52, 72], quantifying impacts of LULC on climate and ecosystem [73-75]. Also, GIS and remote sensing provide the possibility to predict the trends in LULC practices and policies in order to make a better concerned projection within a territory [45, 76-77]. Thus, The data, tools and methods used for detecting changes in forest cover through farmland and urbanization were remotely sensed data from satellite images (1951 aerial photographs, Landsat images from 1984-2015, SPOT 6 of 2006, Sentinel-2A and MAPBOX images from 2015) combined with GIS technology. For decision makers, the authors succeeded in identifying the forest cover transitions trajectories, mapping the forest degradation combined with farmland and urbanization as well as projecting LULC after establishing a zoning map of the area.

BIOPHYSICAL BACKGROUND AND RESEARCH METHODOLOGY.

Characteristics of the Centre Region of Cameroon

Located at the heart of the dense rainforest, the Centre Region is part of the southern plateau of Cameroon. The mean altitude of this broad plateau is 600-700m and it is almost dominated by 900m hills separated from deep valleys. Some forested massifs such as Mt Mbam Minkom (1295 m) are featuring in the region. North of the Sanaga, the plateau is raised in contact with the Adamawa plateau up to 900m (figure 1). Its climate is cool and mild with high and constant temperatures (25°) and rainfall ranging from 1500 to 2000m. The dominant vegetation is a dense tropical forest which gradually becomes or transforms into savanna towards the North. It is a hot spot of forest depletion where one can observed severe ecosystem degradations. The soils are clayish in consistency and reddish in color. The Sanaga (918 km length) and the Nyong (750 km length) are the main rivers watering the region and the surrounding areas with their tributaries (Lom, Djérem, Mbam, Mfoumou, Mefou, So'o and Kellé.

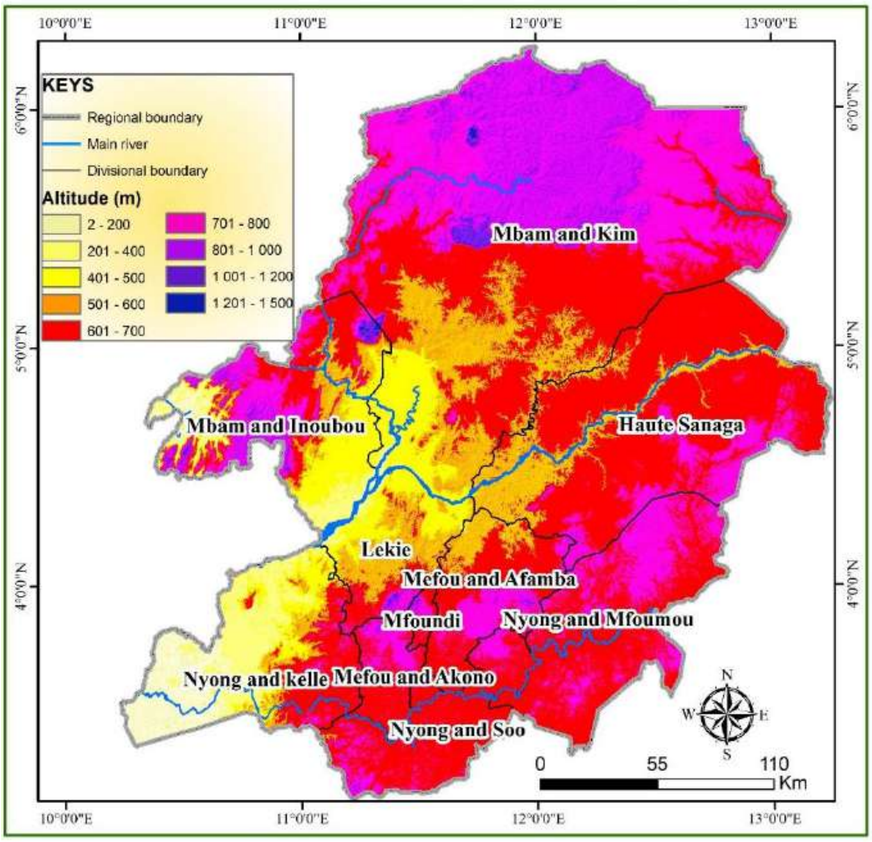

Figure 1. Altimetric map the central region done with Aster DEM images. The Northern part of this DEM constitutes a topographic contact zone between South Cameroonian Plateau (700 m) and Adamawa Plateau (1200 mm), an ecotone (forest-savanna contact) and a low population density environment. These elements are conducive the conservation of a specific biodiversity.

Demographically, the local people of the region belong to the Bantu ethnic group. The Ewondos, the Etons [78] and the Bassas (residing exclusively in the Nyong-et-Kellé division) are some important ethnic groups. Various local idioma are spoken in this region, but, the official languages are French and English. The rural population living under a matriarchal regime are the most numerous, but the urban way of life is in great progression following the pace of the rural way of life. Yaoundé is the main cosmopolitan city that gathered people of various origins and religious denominations.

Economically, the main crops are cocoa, sugar cane and oil palm, both traditionally and intensively grown. Cattle breeding is also present particularly along the Yaoundé peri urban continuum. Crafts, especially woodwork and rattan cane activities are also widely spread. In addition, modern carpentry wood industries and sand mining are important in the region. Several paved national roads connect the Central Region with the neighbouring regions. Rails also connect it to the Northern part of the country and the Littoral regions. There are some existing secondary connections from towns to the main City of Yaoundé and Highways to the Nsimalen International Airport. Figure 2 locates the Centre Administrative Region in Cameroon.

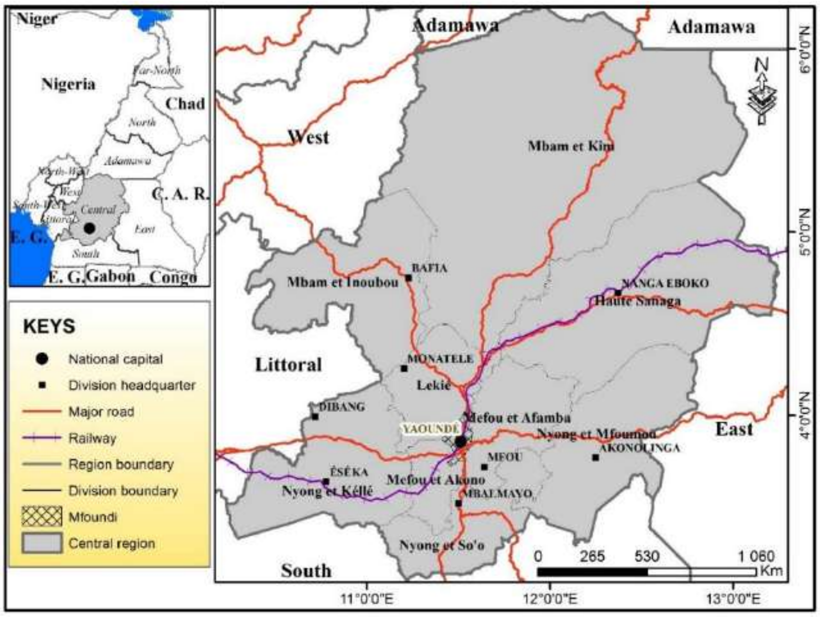

Figure 2: Administrative map of the Centre Region of Cameroon. This figure shows the 10 administrative divisions of the Centre Region split in four zones corresponding to the daily mileage of the four teams composed of 18 investigators who realized the field survey (See Table 5).

Methodological approach

Remote sensing and GIS are known to be the most relevant techniques in assessing and modelling LULC changes, trends and projections throughout the world. Satellite images, aerial photographs, topographic maps and all others existing maps are commonly used to track the LULC changes.

Main satellite images data

An old aerial photograph (1:50,000) of 1951 was collected from the Cartography archive of the department of Geography of the University of Yaoundé 1. Likewise, a variety of Satellite imageries of Landsat (TM, 1984-1990; ETM+, 2000-2010; OLI 2015) and Sentinel-2 (2015) were downloaded freely respectively from Maryland Centre and European Space Agency (ESA). The table 1 presented the characteristics of the Landsat images used for detecting LULC changes with classification techniques (Table 1).

Table 1. Landsat Images characteristics.

Year	Path	Row	sensor	Resolution (m)
Years 1984 - 1989				
1984	184	57	TM	30
1986	185	56	TM	30
1988	185	57	TM	30
1987	185	58	TM	30
1988	186	56	TM	30
1986	186	57	TM	30
1989	186	58	TM	30
Years 2000 -2002				
2002	184	57	ETM+	30/15
2000	185	56	ETM+	30/15
2000	185	57	ETM+	30/15
2001	185	58	ETM+	30/15

2001	186	56	ETM+	30/15
2001	186	57	ETM+	30/15
2001	186	58	ETM+	30/15
2002	184	57	ETM+	30/15
Year 2015				
2015	185	56	OLI	30/15
2015	186	56	OLI	30/15
2015	186	57	OLI	30/15
2015	185	57	OLI	30/15
2015	184	57	OLI	30/15
2015	186	58	OLI	30/15
2015	185	58	OLI	30/15
2015	185	56	OLI	30/15
2015			Sentinel 2	10

The differences observed on the images acquired during different dates are due to cloud cover. All effort to work with cloud-free images in forested areas has not often been possible.
Also SPOT6 image (2006) and one scene QuickBird of 0.5m resolution (2002) from Digital globe image, were consulted and at the same time with online Google Earth high resolution image of the Yaoundé City area (Table 2).

Table 2. : Images and resolutions provided.

Sensors	Resolution, zoom levels and covering percentage		
Sensors	Zoom level	Resolution (m)	coverage percentage
QuickBird	19	0,5	25
SPOT 6	18	1	75
Google Earth	17	0,5	65

MAPBOX are very high resolution images covering the entire study area. Their resolution alternates in places between 1.5m to 5m depending on the level of coverage. Finally, 60 MAPBOX satellite images (Table 3) of 0.5 to 1m resolution were purchased from Nature Attitude. These images have been digitized, with the aim of discriminating different forms of occupation and land use, with particular emphasis on classes dedicated to all forms of agriculture. This helped the team to identify a high number of classes.

Table 3: Characteristics of MAPBOX very high resolution images processed.

MAPBOX SATELLITE IMAGING			
Mapbox satellite imagery comes from a variety of sources based on zoom level and geographic coverage.			
Zoom level	**Characteristics (sensors)**		
0 to 8	Desensitized data of MODIS satellites		
9 to 12	Landsat 7		
13 to 19	Digital globe		
Features of Mapbox Satellite			
Before being added to the satellite Mapbox, all these images are color-corrected, optimized and grouped into a single dataset.			
Images and resolution provided			
Sensors	**Resolution, zoom levels, and coverage percentage**		
	Zoom level	Resolution (m)	Coverage percentage
Mapbox satellite	18	0,5 m	65%
Digital globe	17	1 m	35%

Pre-processing and interpretations

Aerial photograph scene was scanned and processed at a very high resolution (1200 dpi) with at least 4 Ground Control Points (GCPs) collected from river and road intersections in relationship with topographic Map at 1:50 000. Then, the urbanized area was digitized (Figure 3) to show the urbanized area boundary.

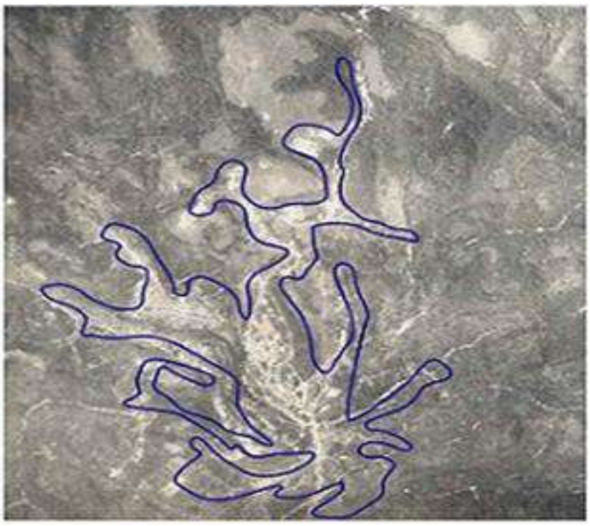

Figure 3. Aerial photograph of 1951.

SPOT 6 and MAPBOX images were also digitized via ArcGIS10.0 and QGIS 2.8 software's and processed later with object-oriented based methods with ERDAS IMAGINE 2014.

Geometric Corrections

Geometric correction in image processing is a mathematical operation or transformation ensuring the passage of a first projection system to another considered more suitable. Several factors influence the geometric quality of images: (1) characteristics of the sensor; (2) deformations during registration; (3) correction methods; (4) resampling methods [79]. As part of this work, the geometric correction was applied to the 1984-1989 image (from the Landsat TM sensor) which had a slight deviation from the image from the ETM + sensor. This geometric rectification has made it possible to see the problems of offsets between the different classes of land use, but also to make the images compatible. Landsat sensor (L1T) and Sentinel 2A images accessed were topographically corrected. The Sentinel_2A and *Landsat 2000-2015 scenes downloaded were* geometrically corrected and geo-referenced to UTM projection system (Zone 32N -33N and WGS 84) with the positions checked thanks to topographic Maps at 1:50 000 sheets of Yaoundé (Yaoundé 3B, 3D, 4A & 4C).

Radiometric corrections,

These concerned the images of 2000-2015 and consisted of spreading the dynamics of the different classes of land use. The goal was to get this image that was originally coded on 16 bits to 8 bits to make it compatible with that of 1984. This radiometric correction also led to the improvement of the contrast of the image, in order to allow better visibility of the information contained therein. Under the ERDAS Imagine® software, the operation is known as "stretching".

Analysis of the LULC dynamics and land degradation

To seize and characterize the dynamics of land use and the transitions between the different thematic classes from one year to the next, a quantitative analysis was carried out. Through a post-classification comparison, the quantitative analysis of changes over the entire study period was carried out in order to identify the different changes in occupation and land use classes. It produces a change detection matrix resulting from the comparison between the pixels of the classifications between two dates [80]. This analysis is done by calculating the rate of change (RC) commonly used in land-use change studies [81-82].

This rate of change is estimated using the following formula:

$$RC = \left[\!\left[\left(\frac{S2}{S1}\right) 1/t - 1\right]\!\right].100 \quad \text{EQ1}$$

Where: RC = rate of change (%); S1 = area of the class at the date t1; S2 = area of the class on the date t2 (t2> t1) and t = number of years between the two dates). Positive values indicate a "progression" and negative values a "regression". Values close to zero indicate that the class is relatively "stable".

The average annual rate of forest degradation [83] is estimated from the formula:

$$ARD = \left(\frac{S2}{S1}\right)/t.100 \quad \text{EQ 2}$$

Where: ARD = average annual rate of degradation (%); S2 = Total area of lost forest, S1 = Initial forest area and t = number of years between the two dates).

Thanks to field survey and image processing, five major LULC classes (Farmlands / Bare land, Forestland, Savanna/grasslands, built-up surface and Water body) were identified in this region (Table 4). This was done though Landsat classification as shown by figure 3.

Table 4. Land Cover and Land Use single typology.

LULC classes	Color	Description
Farmlands and Bare land	FBL	Areas used for cultivation, both annuals and perennials and areas used for grazing including partially wetlands Areas with little or no vegetation cover, open lands, eroded gullies and exposed rocks
Forest land	FR	These are lands identified with a tree-cover density of more than > 20% and characterized by local and native species. Also one can add agro forestlands (Cocoa, oil palm trees)
Savanna/grassland	SG	Areas dominated by grass which are either wooded savanna or shrub
built up surface	BST	Are devoted to areas recognized as residential and commercial as well as infrastructures (roads, buildings) and main cities.
Water body	WB	Areas with main rivers and natural or artificial lakes

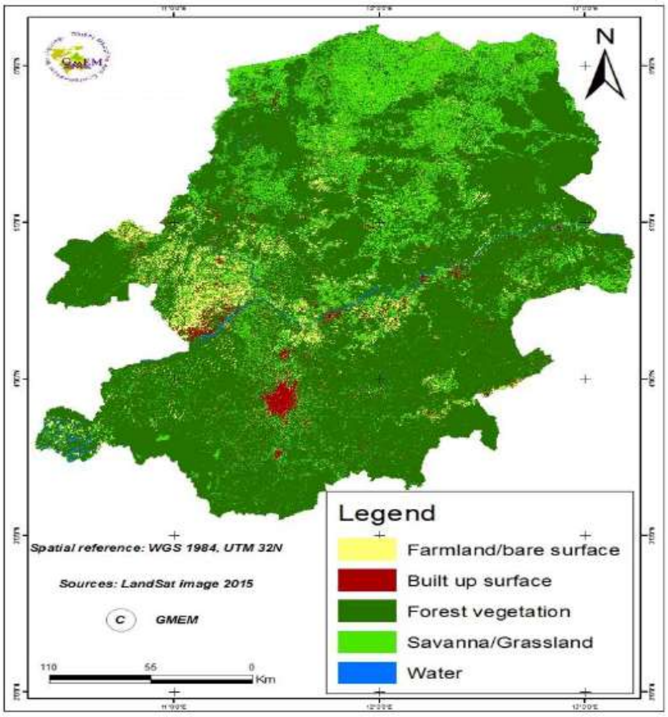

Figure 4. Main LULC Classes in the Central Region of Cameroon

For each land use class, a minimum of 100 training plots are digitized, given the size of the area. Each class has at least 5000 pixels. To illustrate this, figure 5 shows the parcels, the land use classes, and the number of pixels sampled by class.

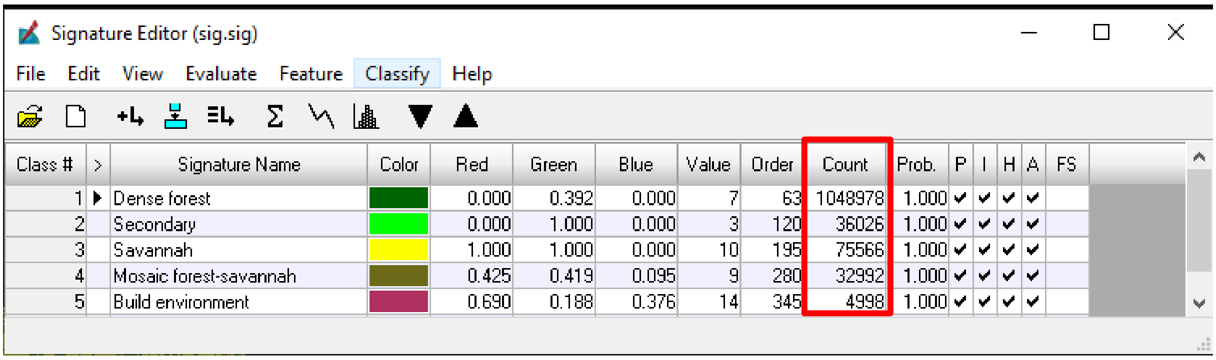

Figure 5. LULC training plots

Also it is important to notice that we explained on the methods that we make use of MAPBOX high resolution images which allow us to digitize the LULC in each division before a synthesis maps using generalization.

In order to compute soil degradation, ERDAS software was used for the Normalized Difference Soil Index (NDSI) with the following equation: $\frac{MIR-PIR}{MIR+PIR}$ corresponding to bands $B6-B4/B6+B4$. EQ 3
This equation makes it possible to launch a reclassification under ArcGIS. Based on the results of the thematic classes above (Farmland / bare surface, Built up surface, Forest vegetation, Savanna / grassland, water) resulting from a reclassification of the Landsat 2015 image, we obtained five levels of land degradation : (1) very low, (2) Slightly degraded, (3) degraded, (4) highly degraded and (5) very highly degraded.

Subsidiarydata
Additional data sets were consulted. ASTER-GDEM was downloaded from USGS website. It allows the processing team to delineate major rivers and watersheds of the region. This has been useful for zoning map as well as for LULC types and agricultural generalization. Information from topographic maps dated 1958/73/78 were also obtained at the Geography department Archives. Long term population census data (1976, 1987 and 2005/2010) were collected from Census Bureau [84].

Fieldwork and questionnaire.
The acquisition of these data made it possible to program the fieldtrip. To better plan collection operations, the Centre Region was divided into four (04) zones assigned to teams (table 5).

Table 5. : Distribution of the survey team within the division of the Central region.

Zoning	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Total**
Team Leader	**Team 1**	**Team 2**	**Team 3**	**Team 4**	**4 teams**
Administrative Divisions	Mbam & Kim, Mfoundi	Haute Sanaga, Nyong & Mfoumou,	Nyong & Kelle, Mbam & Inoubou	Mefou & Afamba, Mefou & Akono, Nyong & So'o and Lekié	10 administrative units
Team size	04	04	04	06	18 investigators
Total number of questionnaires	280	280	280	280	1120 questionnaires
Number forwarded	144	217	171	400	932

AGRISTAT data

The Cameroonian Ministry of Agriculture and Rural Development (MINADER) is in charge of the collection, processing and dissemination of statistical data on the agricultural sector in Cameroon. In this context, the agricultural statistics labelled "AGRI-STAT" are produced whereas 07, 08, 09, 11, 12, 13, 14, 15, 16 and 17 Editions [85] covering the modern and traditional sectors for the period 1999-2010 were consulted and used. As data processing are concerned, the working tools, software and techniques have been summarised in table 6.

Table 6. : Tools used for data processing.

Logiciel	Version	Characteristics	Utility
ERDAS IMAGINE	2014	Image processing and classification	✓ Colored composition ✓ Supervised classification
ArcGIS	10.0	GIS	✓ data treatment ✓ LULC changes thematic ✓ Mapping classes ✓ Digitalization
QGIS	2.8		
Mapsource			GPS ground control points extraction
Microsoft office – Excel	2013	Spreadsheet	✓ Processing and computation of statistical data ✓ Graphs generating
Microsoft office – Word		Word processing	✓ text typing ✓ Text processing

Classification processing and projection

The operational land use classification system in Central African region was taken into consideration. Following Markov model on IDRISI Selva, a projection to 2050 of LULC has been made to give an idea and to help decision makers. Figure 6 give and overview of the methodological flow chart of the present paper. Complementary to the processing techniques quoted above to detect LULC changes and forest transformations, SPOT 6 images of the city of Yaoundé (Mfoundi Division) were also digitized by object-oriented methods. The results have permitted to trace the evolution of the Yaoundé city.

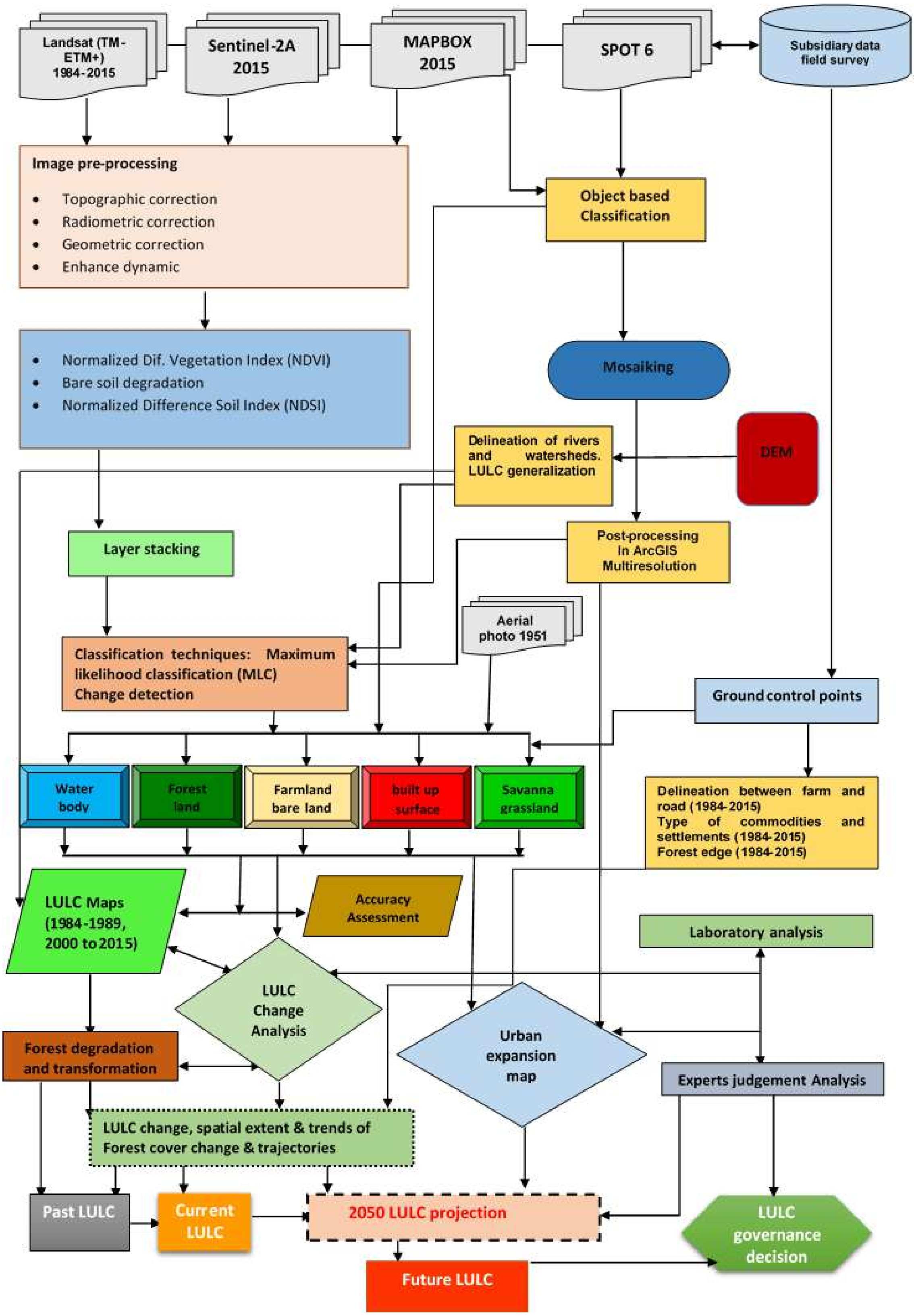

Figure 6. : Methodological sketch diagram of the study.

MAIN FINDINGS

Agricultural activities as the primary LULC changes causes in the Centre Region of Cameroon.

Existing literature indicates that agriculture in Cameroon dates back to colonial times and it is one of the German colonial heritages since independence in 1960. All the five-year plans carried out in Cameroon between 1960 and 1986, gave pride of place to agriculture and the rural world. The apogee of agriculture corresponds to the first two decades after independence

(1960-1980) where the share of agriculture in GDP stood at 30% from 1965 to 1975 before slumping to around 20% in 1982 [86].
Agricultural activities in Centre Region is the primary driver of deforestation LULC changes. On the field, a wide range of agricultural activities was observed and included crop cultivation, grazing, agroforestry, forestry, and fish farming. There are almost twenty different varieties of crops (sweet potato, cassava, cocoyam, yam, banana plantain, maize, pineapple, peanut, pepper), grown through slash and burn for subsistence purposes. Commercial or rental crops grown included cocoa, coffee, sugar cane, oil palm and income generating crops were pineapples, bananas, oil palms, and tomatoes. Subsistence shifting cultivation took the form extensive farming and was characterized by fallow periods of more than five years. Since 1990, fallow periods have reduced to between 1-3 years due to demographic pressure and urbanization. Commercial or rental agriculture is intensive but occupied large expanses of land in the region, even in the case of family farms. The cultivation of market oriented food crops was favoured by the economic crisis of the early 1980s and are cultivated extensively and intensively. Small farmers seldom cultivate more than 1ha while elites acquire farmlands of more than 10 or 200ha. There are also common initiative groups of farmers who acquire large parcels of land for the production of mainly market oriented crops. As concerns industrial farming, a few agro industries such as SOCAPALM (oil palm) and SOSUCAM (Sugar cane) exist and possess largest land holdings. In 2008, an agro pole for Banana was created in Mpagne found in the northern part of Mbam & Inoubou Division (figure 7). In addition to the development of agriculture, one can notice the clearing of the land for wood extraction for commercial, fuelwood purposes and charcoal production (mainly domestic uses) to be sold in the town (Yaoundé above all) since 1990. The region is suitable for traditional logging with carpenters (residing in the city of Yaoundé) who uses saw for cutting trees and wood for domestic and commercial uses. Industrial logging is also observed mainly in forest management units and some community forest. Wood industry and first transformations are found around the city of Yaoundé coupled with hundreds of carpenters working to produce household furniture for the city dwellers. These are factors considered as direct or proximate causes of deforestation and LULC changes in this region.

Studying these activities in the Mbam & Inoubou Division, the processing of Mapbox images show that agriculture is the main deforestation driver. This region hosts savanna and forest as well as forest savanna mosaic which conditioned the LULC changes. Due to the latitudinal location of this division, it is prone to rapid conversion of forest to savanna and as changes occurring in areas of forest management lead the appearance of the savanna as observed in the eastern border (figure 7). The residual forest is found in inaccessible areas such as mountains and hills or pieces of land closed to protected areas.

The processing of MAPBOX images of Lekié Division (Figure 8) shows that it is a forested area very closed to Yaoundé metropolis. It is worth noting that in this division which is situated some 20-90km from Yaoundé, agriculture is the main deforestation driver coupled with urbanization.

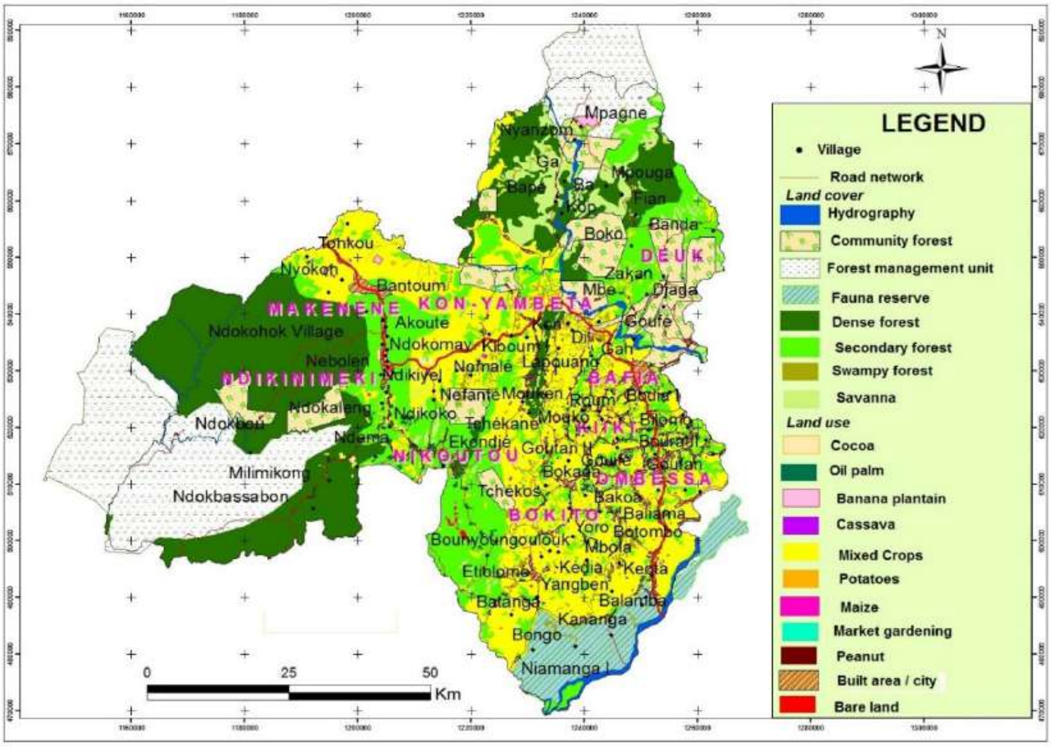

Figure 7 : the main LULC in the Mbam & Inoubou Division from Mapbox images

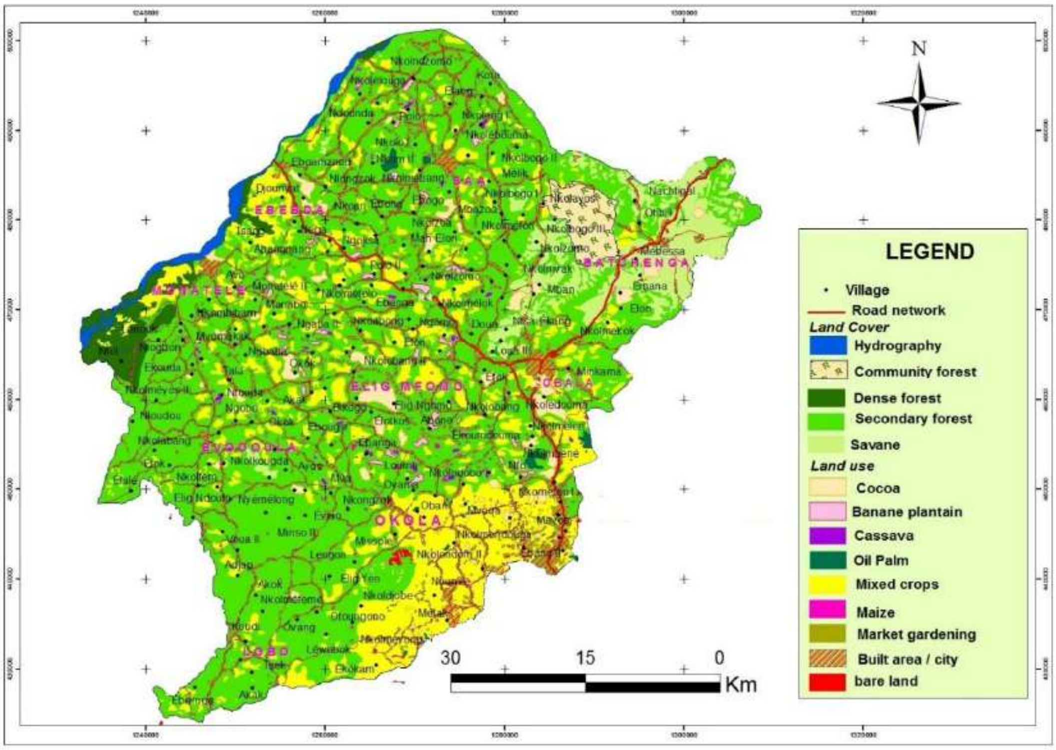

Figure 8 : the main LULC in the Lekié Division from Mapbox images

Both map (figures 7 & 8) show that the remaining dense forest accounted from 3% (Lekié) along the Sanaga River to 15% (Mbam & Inoubou). The secondary forest is scattered between multiple forms of land use.

Thus, agriculture explains LULC changes in the area. Nowadays, pieces of forestland are destroyed with fire to create food-producing farms as well as charcoal and fuel wood to be sold in the city markets. Also, the economic crisis has pushed people to turn previously subsistence agricultural crops to market oriented crops such as banana, pineapple, oil palm. Although agriculture expansion is caused by improved access to urban/peri-urban markets (almost 30) around Yaoundé is a direct factor, urbanization with increasing population demands and its corollary is the main underlying factor of LULC changes in this region.

Urbanization and LULC changes in the Centre Region of Cameroon

Urbanization is the second driver of deforestation and LULC changes in this region. Urban process incorporate so many factors as its corollaries: demographic, economic, industrial and technological, and political (institutional and cultural). All these urbanization corollaries represent the underlying causes of deforestation and consequently of LULC changes in this region.

Analysis of some underlying factors related to urbanization

Institutional, economic and cultural factors

The administrative fragmentation of this Region into 10 divisions and 70 sub-divisions led to the development of many small and medium size towns around Yaoundé (figure 9).

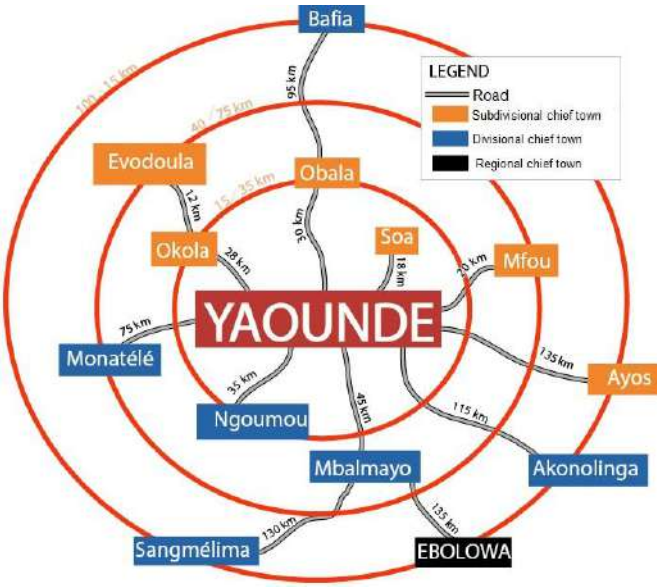

Figure 9. Circular shape and excessive concentration of cities around Yaoundé. This excessive concentration of cities and industrial clusters, networks or incomplete urban relays, are the result of an insufficient policy of housing and relocation. It can lead to an imbalance of socio-economic development factors and political choices in spatial planning.

Also, prevailing land conflicts are indicative of the inadequacy of land governance and the decisions follow-up. Thus, settlements are built on the top of hills and slums in marshes zones, both recognized as non aedificandi. In addition, there are so many industrial quarries settled on forest sites around Yaoundé. The destruction of forest on the top hill and swampy forest on humid area are proof of this land mismanagement. Institutionally, such a situation of rapid urbanization with occupation of marginal lands shows a weak mastery of urbanization. As consequence, mountainous and humid ecosystems are destroyed because of urbanization. Swamps transformations lead to the huge floods recorded since 2008.

In the economic domain, Yaoundé gathered many factories and industries (breweries, bakeries, metallurgical, first wood transformations and chemical industries) built at the expense of the forest cover (figure 10).

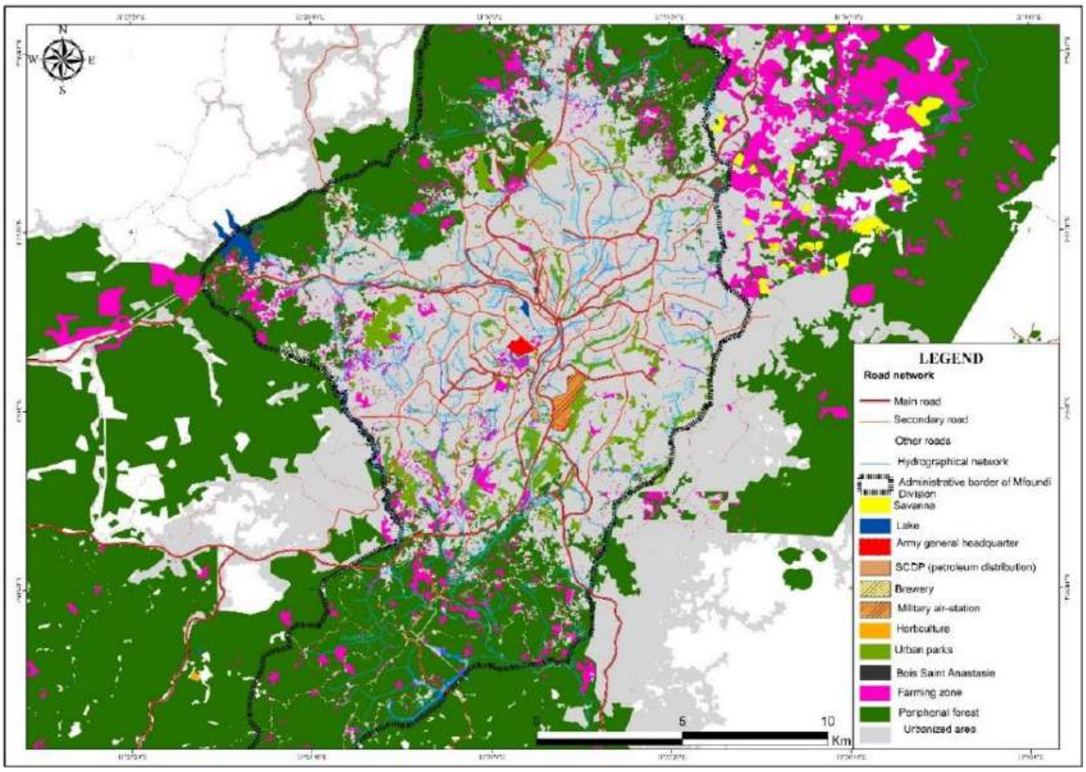

Figure 10: *The Mfoundi Division in 2006 according to SPOT 6 scenes*

As cultural domain is concerned, the original way of building settlement was based on material extraction from nature (houses with thatch roof, sticks and clays). Since 1980, increased urbanization brought acculturation with sheet-metal roof and cement blocks wall replacing clay due to comfort, aesthetic and rental reasons. Such a changes led to huge legal and illegal forest exploitation of timber and non-timber forest products which undermined initial forest resilience. Also, the initial cultural way of farming (with at least five years fallow) has changed due to urbanization and increasing demand for food from a teeming population. The fallow periods have drastically reduced or become inconsistent or inexistent due to population pressure and the uncontrolled sprawl of the main city of Yaoundé which is depicted by significant increase in settlements. The sprawl phenomenon and its rate are quite detrimental to forest cover and the city's wetlands (figure 11).

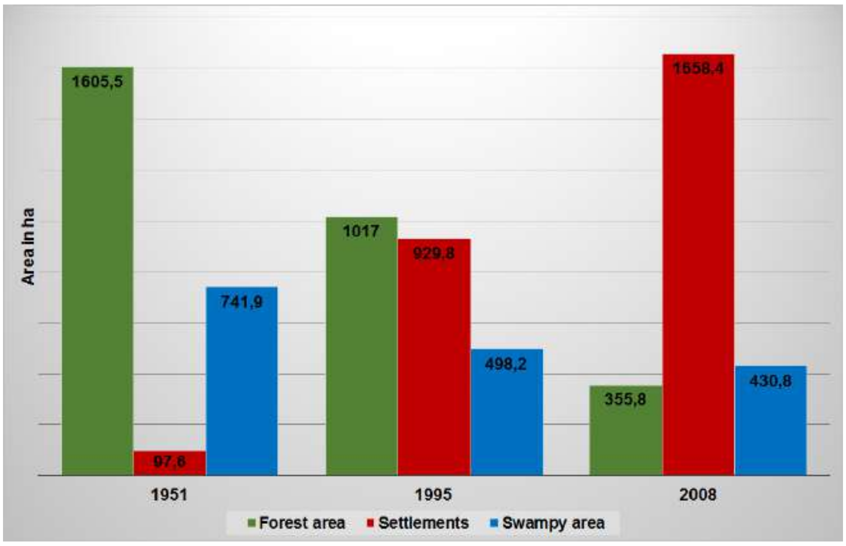

Figure 11. Dynamic of some major land occupation between 1951 and 2008 in the city of Yaoundé.

Historical and Demographic causes

Founded in 1887 by Kund Tappenbeck [87], Yaoundé, a single village of 300 inhabitants with 50 straw huts [88-92] was transformed into a great military station or fortress which became the Capital of the whole Cameroon in 1909 [88-93]. By hosting political and administrative institutions, Yaoundé attracted many people of all walks of life that led to an unlimited spatial extension of this metropolis since then. Today, Yaoundé is the second megacity of Cameroon with more than 3 000 000 inhabitants. In 2005, urbanization rate in the Centre Region was 80% [84]; far above the national rate (49%). Spatially, one can observe a predominantly westward horizontal growth of the town (figure 12), and this sprawl constitutes a fundamental driver of high LULC changes and high land degradation nowadays.

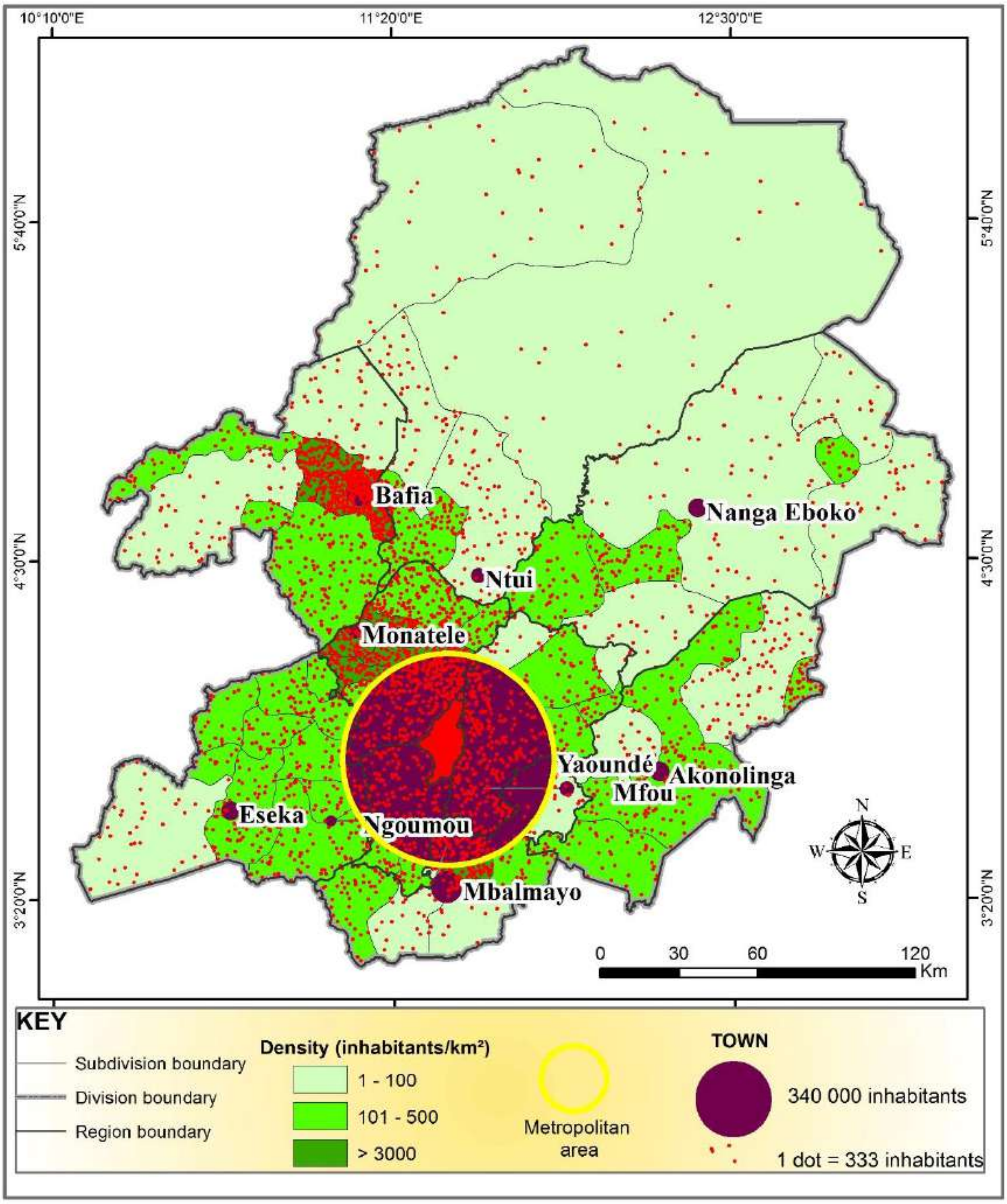

Figure 12: urbanization and population distribution in the Centre Region of Cameroon. The map shows that a huge concentration of population disseminated around Yaoundé, the main city with at least 3, 000 000 inhabitants while in small size cities, only Mbalmayo holds almost 100, 000 inhts in the city. Also, the main area densely populated (more than 100 inhts/km²) are scattered around this main city in which densities range from 3,000 to 20, 000 inhts/km² (figure 13).

Apart from it Metropolitan area (comprising Obala, Okola, Soa, Mfou and Ngoumou- see figure 9), the seven subdivisions of the City (being Yaoundé1-Yaoundé 7) show that population are spreading in all direction with Yaoundé 2 and 6 more densely populated (figure 13).

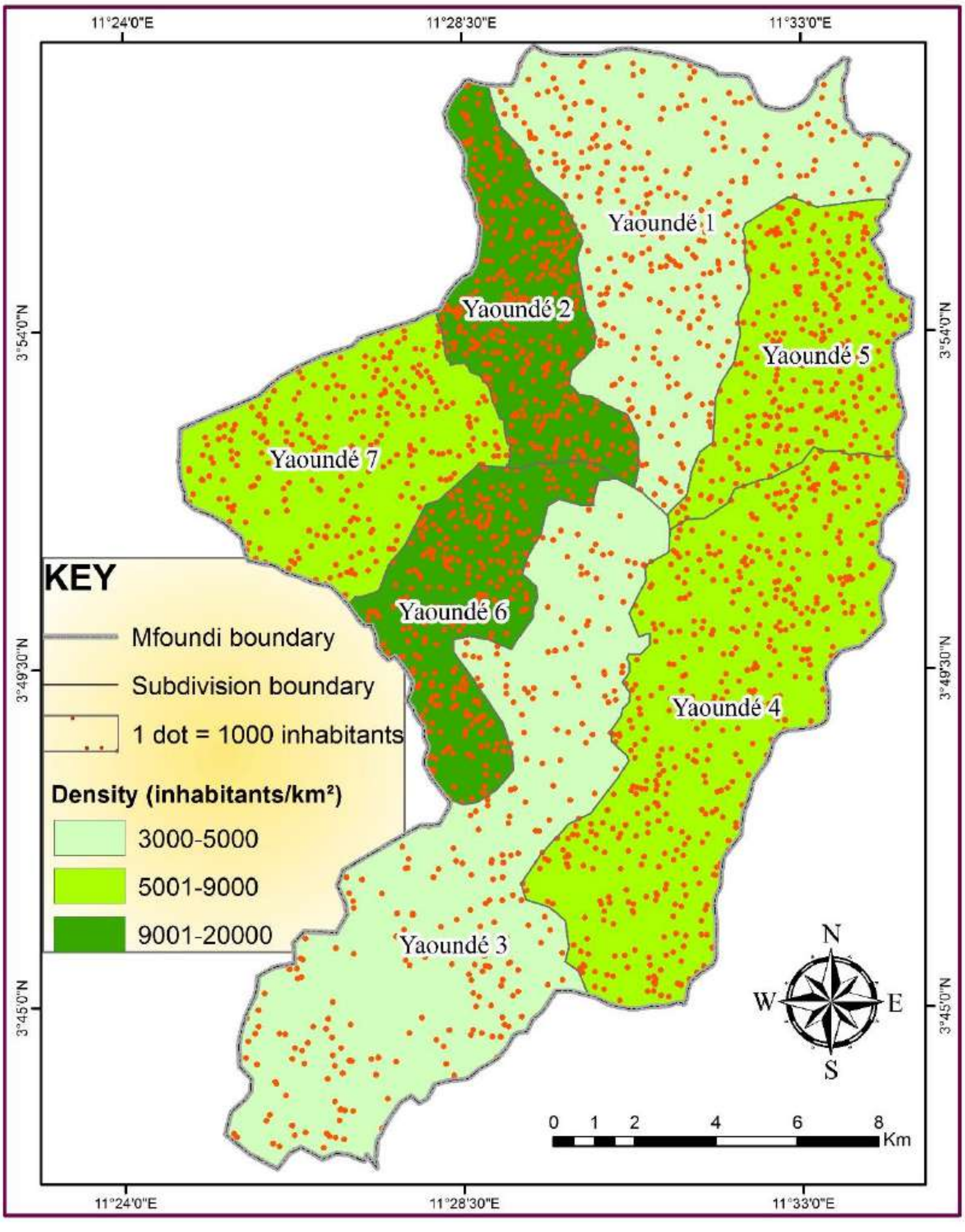

Figure 13: population distribution and densities in the seven districts of the city of Yaoundé.

The teeming population of the town (from 1.2 million inhabitants in 1976 to 3 million in 2015) keeps multiplying food needs. Also, cities are high resource consumption areas including land, urban infrastructure, buildings and roads built at the expense of the forest. With an as annual population growth rate of 3-5.7%, the high population density and distribution as the maps depict (figure 13), are also linked to internal migration associated with rural exodus, administrative, institutional and economic (unemployment or employment) reasons, showing that Yaoundé is the sole city driving deforestation processes and LULC changes most.

Spatial and demographic extensions of the city of Yaoundé between 1933 and 2019.

The city of Yaoundé is located at the heart of the South-Cameroonian Plateau and since the colonial era, its population has been growing steadily with remarkable increases as from 1987 (figures 14 & 15) which have led to many real estate works.

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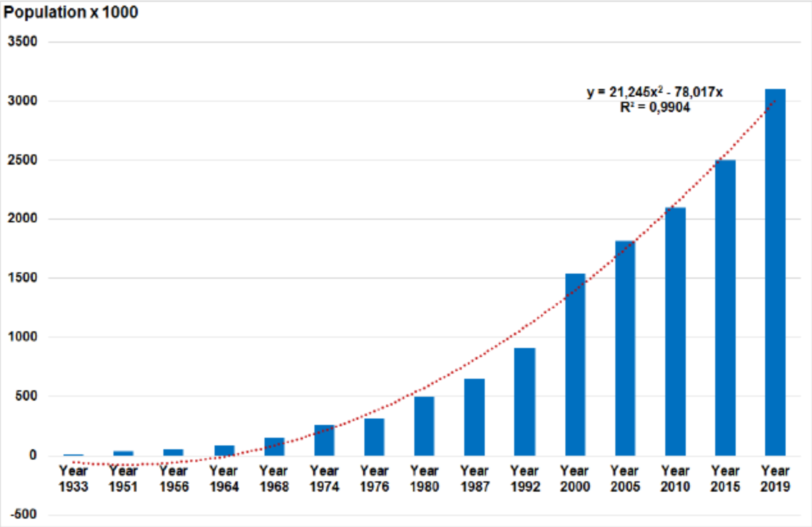

Figure 14. Population growth in Yaoundé from 1933 to 2019 as modified from [87].

The authorities have neglected the publishing and disssemination of the 1982 Urban Master Plan of Yaoundé which overwhelming depicts the fast horizontal and vertical growth [92] of Yaoundé. With an initial surface area of 9 km² in 1951, the city of Yaounde today, has a spatial extent of more than 300 km² as obtained from processed remote sensing images [57, 87, 94] (Figure 15).

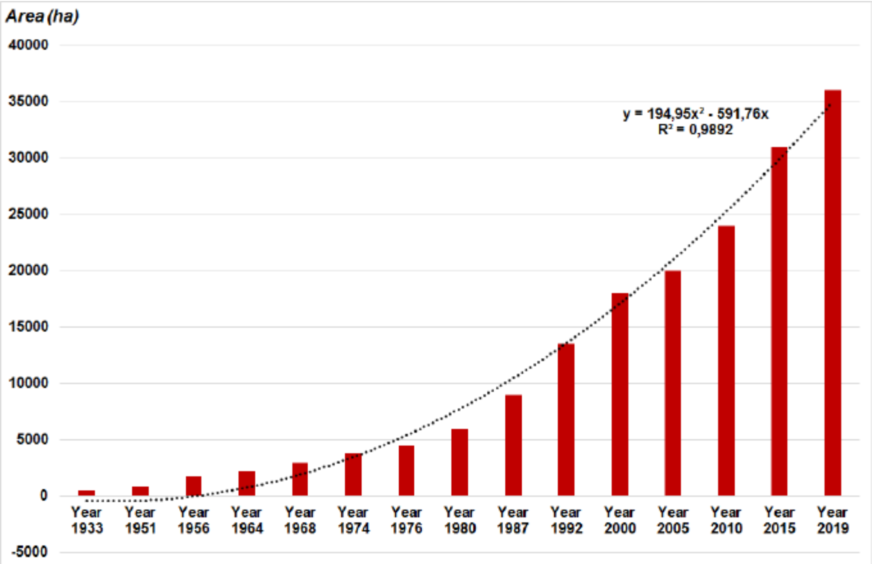

Figure 15. Spatial growth of Yaoundé as modified from [87].

Thanks to Satellite images processed and GIS, one can observed that the limits of the city are constantly being pushed back by urban sprawl and peri-urbanization. This urban sprawl has made it possible for the city to expand mode than 360 km² today (Figure 16).

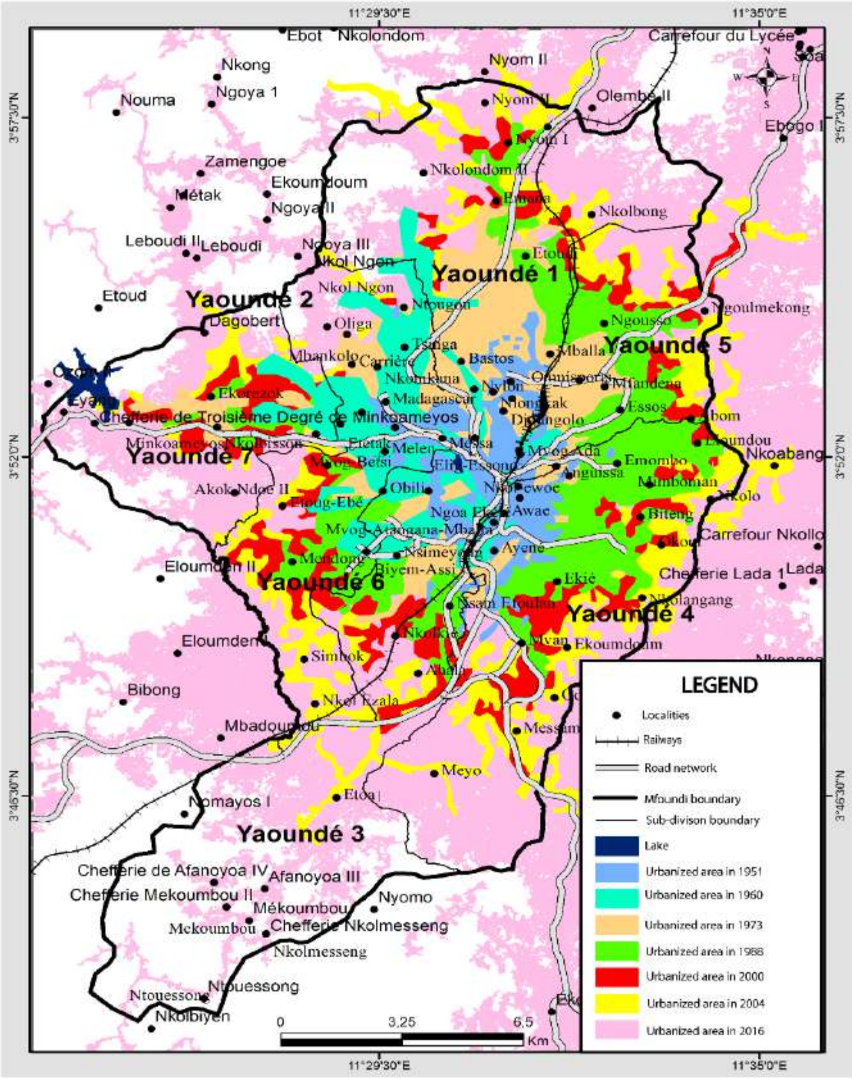

Figure 16: Spatial extension of the Yaoundé city between 1951 and 2017. (Source Aerial photograph, 1951, Landsat image 1975- 2016, SPOT6, 2006., Google earth of Yaoundé, 2017).

Consequently, urbanization becomes the main driver of both deforestation and LULC change. All the hills of the city are nearly or completely deforested (photo 1) for urban agriculture, progressive colonization by settlements and all these threatened forest cover.

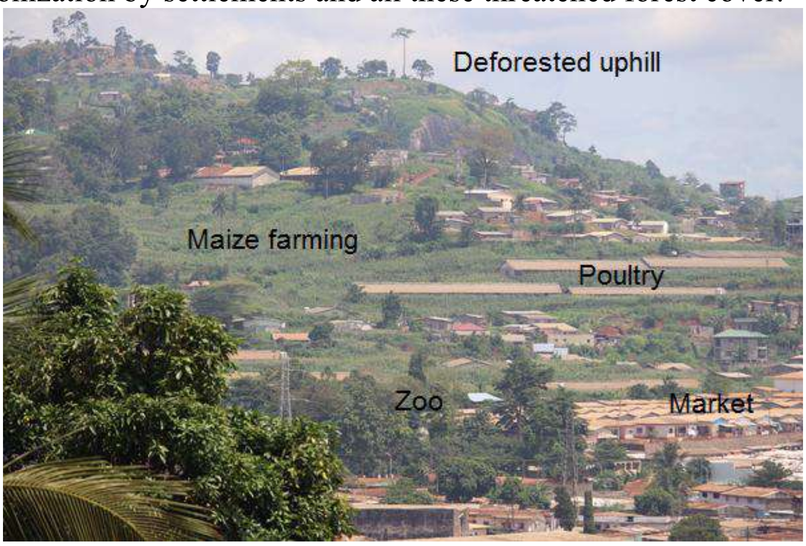

Photo 1 : A view of Vogt Betsi neighborhoods where one can distinguish : Melen Market downhill, on the left Vogt Betsi Zoo garden endangered by the city expansion, poultry at the foot of the escarpment, maize farming on the slope, habitat on steep slopes and hilltop.

In addition, charcoal has become the main source of cooking fuel for poorest households in Yaoundé with some rich households also adopting it. Increasing demand for charcoal in Yaoundé aggravates forest degradation and deforestation in the vicinity of the town and around small towns such as Soa, Obala, Ngoumou, Mbalmayo, Mfou, Ayos, and Akonolinga where it is produced.

Urbanization in Yaoundé and Africa is a continuous process with many facets, where the poorest households occupy marginal unsuitable lands such as swamps and wetlands, hills and valleys. Under such conditions, they destroyed humid zones and are exposed to environmental problems such as floods and landslides and their vulnerability to risk increases. Giving all these results, the main LULC map of this Centre Region is illustrated below (figure 17).

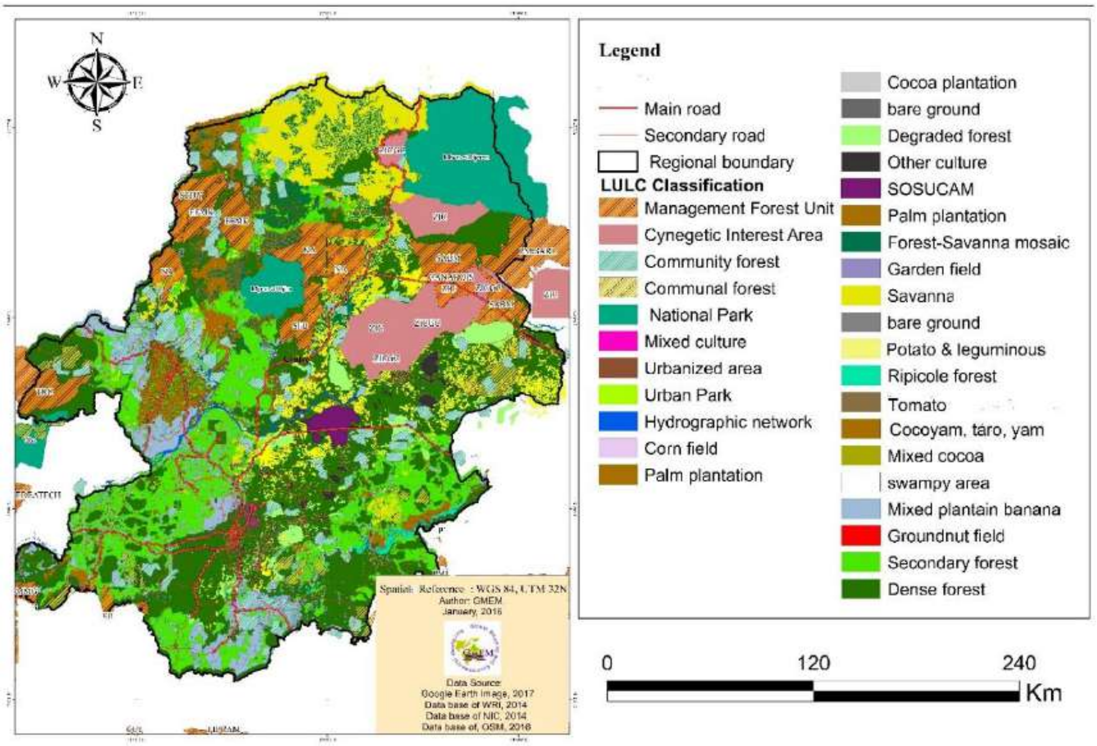

Figure 17: Main distribution of agricultural activities in the Centre region of Cameroon.

This detail map shows that land cover change is driven by agricultural activities and their forest depleting impact on the different administrative units varies from 10 to 55%. For example, in the Mbam & Kim division, where agriculture is close to 25% of the land use in 2015, forest cover represents only 13% while Nyong & Kellé, forest cover is more than 55%. Since Yaoundé is the main city of the region, urbanization explains the rush in food production to feed city dwellers and such food production activities enhance deforestation. In some divisions such as Lekié, Mbam & Kim, Mbam & Inoubou, Mefou & Afamba, farming activities associated with slash-and-burn remain the main drivers of deforestation and forest cover degradation.

LULC, deforestation and land degradation in the Centre Region of Cameroon

LULC map above shows that the Centre Region of Cameroon is undergoing intense deforestation and land degradation (figure 18). The beginning of the 2000s marked the acceleration phase.

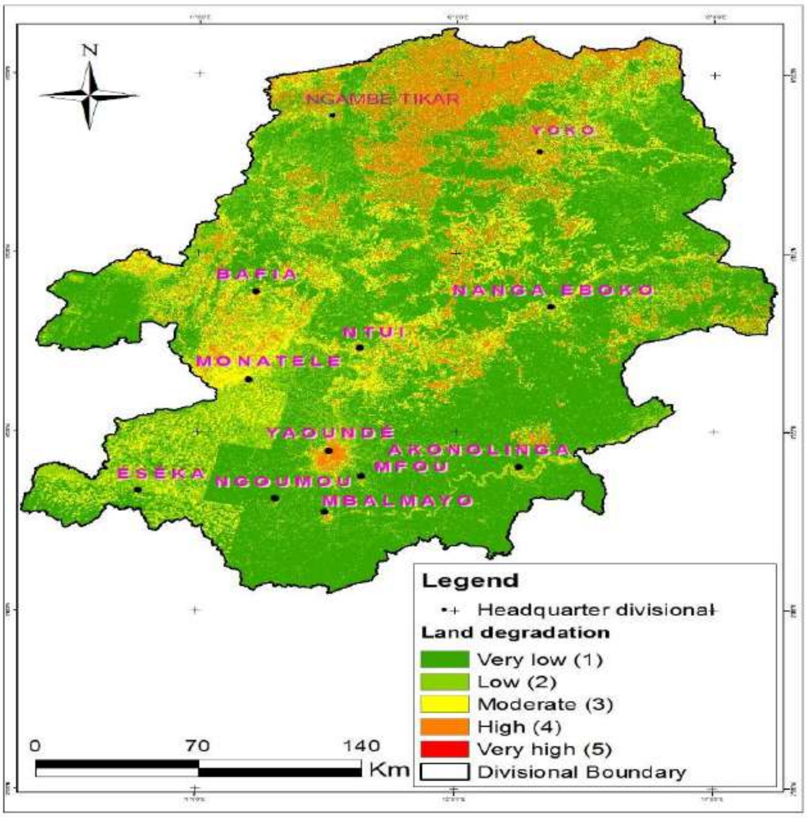

Figure 18. Land degradation index in the Central region of Cameroon.

Figure 18 illustrates a high degradation rate around Yaoundé. More than 70% of the map is closely linked to urban process. Nevertheless, the high degradation level observed in the northern part (Ngambe Tikar and Yoko) is due to a savannization processes. Various aspects of LULC as depicted by figure 18 have been examined and presented on table 8. Consequently, savanna, farmland and built area (cities & infrastructures) are the most conspicuous.

Table 7. Land degradation in the Centre Region of Cameroon.

Degradation level	LULC distribution						Color	Final %
	Forest area	Pasture savanna	farm land	Built area	Humid zone	Other		
1.Very Low	3	4	5	5	3	2		**48,77**
2.Slightly	3	4	4	5	3	2		**15,52**
3.Degraded	2	3	3	5	2	1		**21,64**
4.Highly	1	2	2	5	1	1		**14,06**
5.Very highly	1	1	1	5	1	1		**0,002**

LULC changes in this region have led to considerable decline of the dense forest from 36,157 km² in 1984 to 21,847 km² in 2000 and 16,631 km² in 2015. During this period, savanna, built up area and agricultural land have increased. Savanna land increased from 14,227 km² in 1984 to 20,261 km² in 2015. Built up area move from 109 km² in 1984 to 9589 km² in 2015 (Figure 19). The main drivers of LULC change, therefore, remain urban growth, population growth and the intensification of agricultural activities (figure 19), which are reflected in the transformation of large forest areas into other land uses. About 54% of forest cover were lost within 30 years, giving an average rate of 1.80% per year. It represented 650.86 ha of forest cover lost yearly. Consequently, there is a strong transformation of the landscape in the Centre Region.

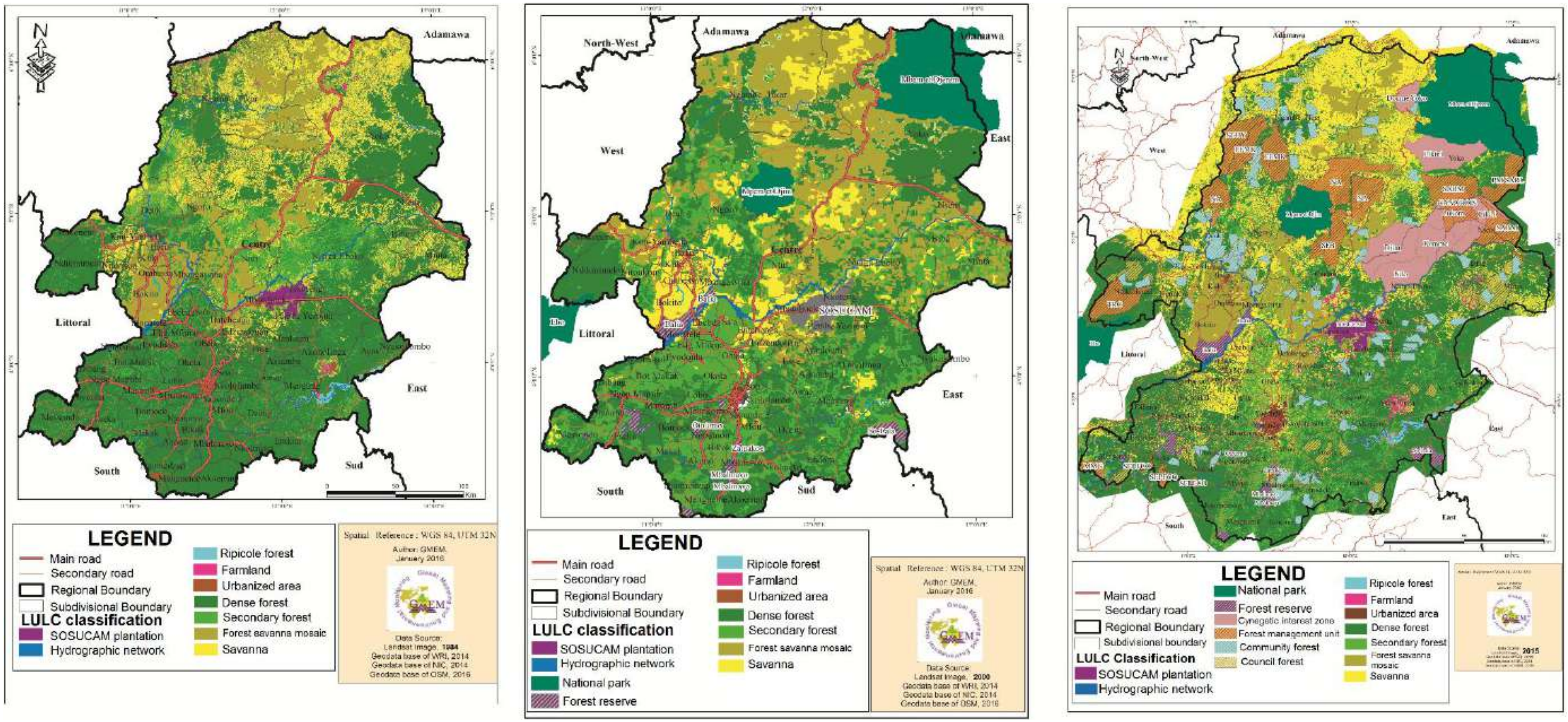

Figure 19: LULC in the Centre Region of Cameroon in 1984 (left), 2000 (middle) and 2015 (right). One can observe the depletion of the forest cover in favour of savanna and crops production despite the classifying of some parcels of land as protected areas.

The graph (figure 20) computed with EXCEL illustrates LULC dynamic between 1984 and 2015.

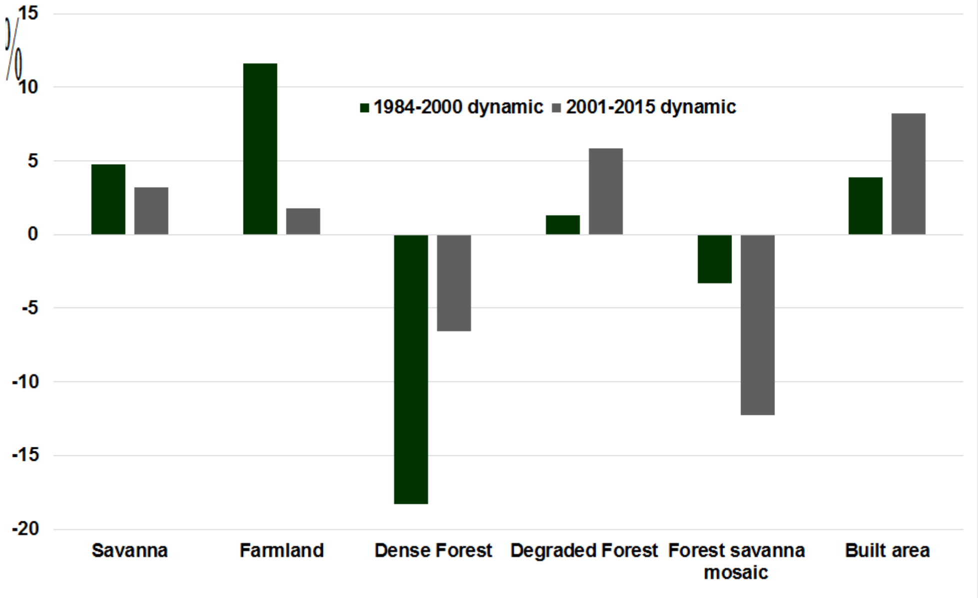

Figure 20. LULC Dynamics in the Centre Region between 1984 and 2015.

LULC zoning map and LULC projection to 2050

The splitting of Cameroon into five agro ecological zones is based essentially on the climatic and ecological factors. This allotment globally serves as a guide to climate change mitigation and adaptation policies in the agricultural sector. As far as LULC is concerned, Cameroonian authorities, since the precolonial period have created different categories of areas for conservation and sustainable management of resources. Unfortunately, due to population growth and urbanization, it is increasingly becoming difficult to reconcile land for conservation and settlement in this region. Some authors [95-96] have alluded to these land-use conflicts in Cameroon, which are fivefold.

Adjacent local population that encroaches into protected areas.

The granting of mining licenses for concessions in or around protected areas including urban neighbourhoods.

Creation of farms on wildlife migratory corridors.

Arsonist breeders in protected areas or leaving their animals to destroy farm plots.

Breeders using transhumance corridors trespass agricultural properties and destroy crops, etc.

All these are taking place due to inadequate LULC planning in the whole country and particularly, in the Centre Region. In response, therefore, we have produced a LULC zoning map (Figure 21) made up of different layers of information related to relief (Figure 1), soil, climate, population density (Figure 12), biological resources, land degradation and urbanization in all the cities of the Centre Region (Figure 16 above).

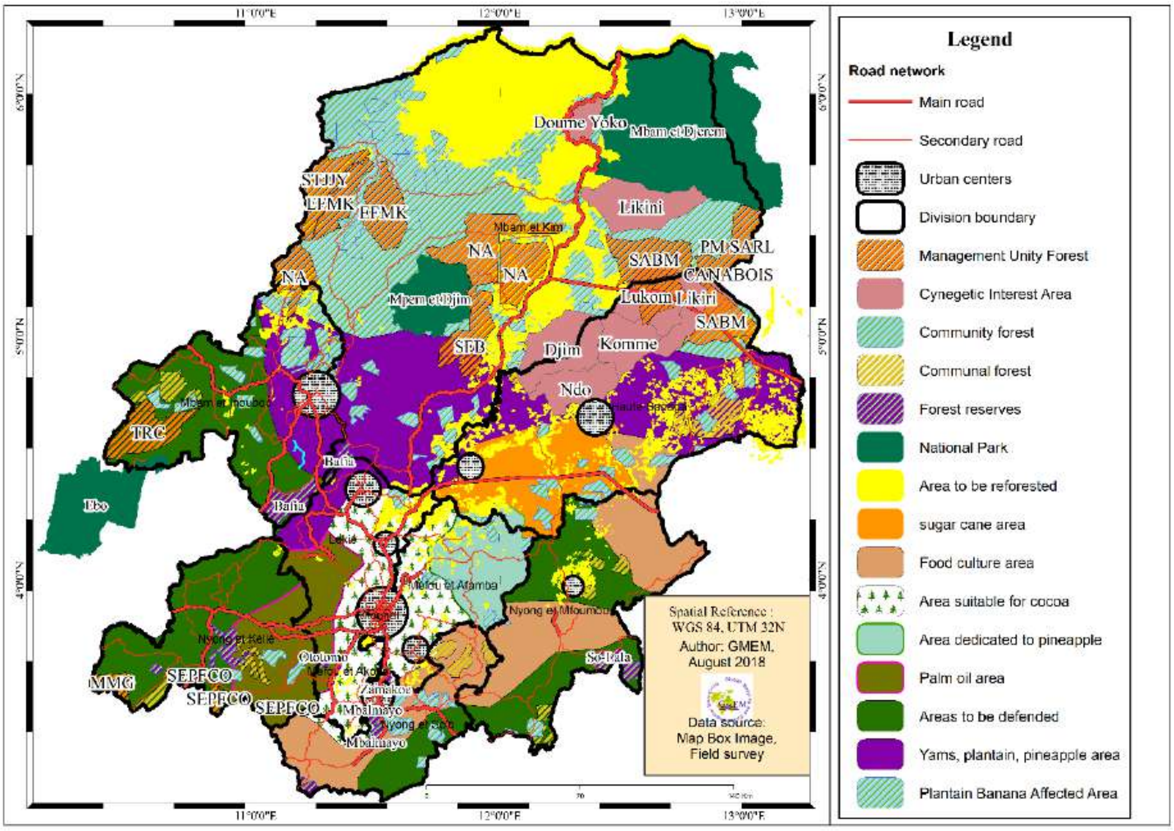

Figure 21. LULC Zoning Map of the Centre Region of Cameroon.

Furthermore, agricultural activities are highly vulnerable in the context of the modern global economy. The monetization of crops is posing enormous challenges to farmers as they become more and more vulnerable to price fluctuations, international competition and limited means of accessing markets. At the legislative level, incoherence between forest, environment and agricultural laws in Cameroonian, creates confusion and at times impact on farming activities.

Helped by the previous zoning map that was based on the actual LULC, our team succeeded in producing a LULC projected map for 2050 following the actual rhythm that will strengthen the capacity of policy makers (figure 22).

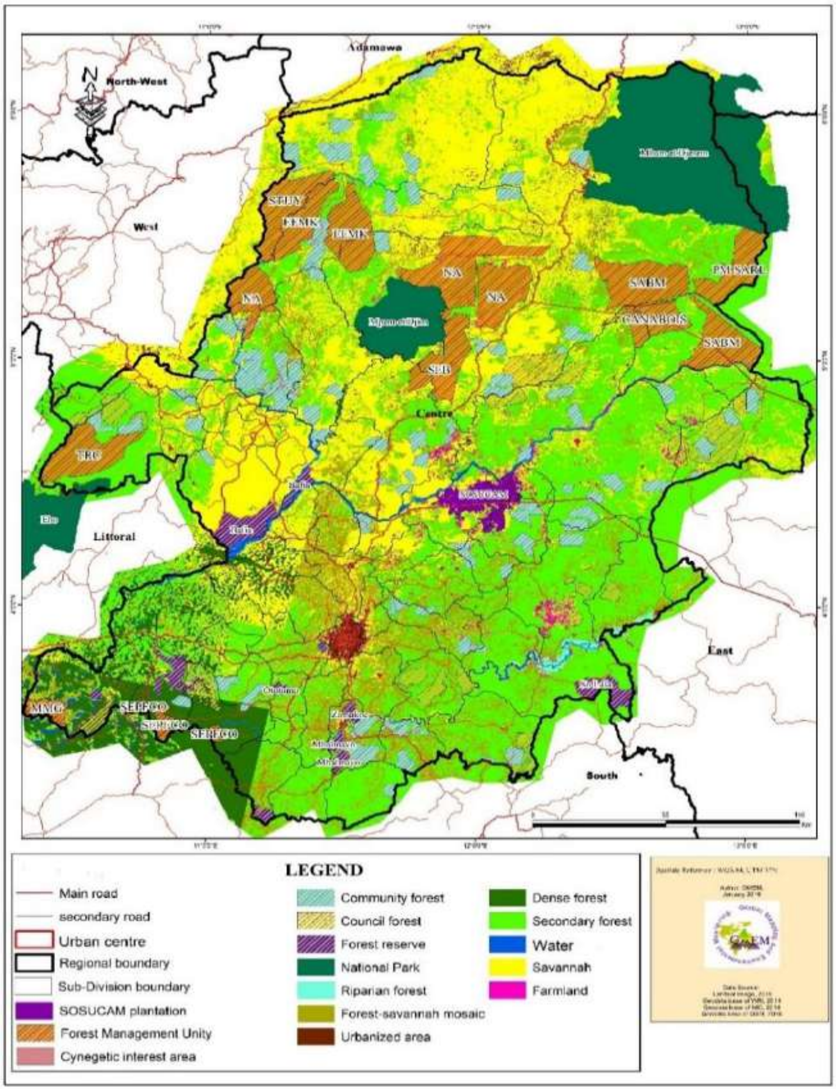

Figure 22. LULC projection to 2050 on IDRISI Selva.

Computed projection statistics of LULC indicate the following distribution: dense forest (0.25%), secondary forest (12.67%), adjacent forest (0.001%), forest-savannah mosaic (7.01%), built up area, (10.02%), Savanna (35.46%) and farmland (34.58%). The remaining forest is made up of protected areas. This will help create awareness to decision makers for better forest governance in Cameroon.

DISCUSSION

Agriculture, first factor of LULC changes and prime deforestation driver in Africa and Cameroon

Land use was the prime driver of deforestation and land cover modification across Africa between 1951 and 1990. There are many studies across Africa and the world showing that forest clearance and shifting cultivation, subsistence agriculture, traditional and modern practices are the major drivers of forest transformations and degradation. These transformations have lots of socioeconomic and environmental challenges in many Sub-Saharan African countries **[4, 10, 19, 76, 97-102]**. Growing demand for commodities such as cocoa, oil palm, sugar cane, banana plantain, tomatoes which have become major market-oriented food products due to their commercial value **[103-106]**, constitute main drivers of LULC changes and deforestation in this

region. That notwithstanding, some authors rather emphasize on the underlying causes and macroeconomic factors **[3, 4, 16, 97 & 107]**.
Globally, 80% of deforestation is due to agriculture **[33-34 & 108]**, but the figure stands at 90% in Africa **[98]**. In the Congo Basin, agriculture is also the first cause of deforestation **[17 & 109]**. Subsistence farming and the expansion of agro-industries are the two systems that contribute to this deforestation **[110]** and LULC changes. Demographic pressure on forestlands is perceived through the prism of expanding agrarian lands due to agricultural activities as well as commercial fuel wood activities.

In SSA, country level land transformation processes are generally associated with seven trends, to wit: economic opportunities and commercial production; farms transition with market specialization; ratio of added agribusiness value; economies of scale captured in production and marketing; evolving farm production technologies; movement from shifting cultivation to a more sustainable and intensive cultivation; the integration of agri-food system into the wider economy **[100 -101]**.

In Cameroon, the main drivers identified are slash and burn agriculture, commercial logging, commercial and market oriented agriculture (cocoa from 1960 to 1990 and oil palm since 1990 **[99]**, fuel woods, charcoal, mining activities since 2010 and construction of hydroelectric dams and other infrastructures (road or highways construction **[111-112]**, urbanization and ports management, etc. **[99, 112-113]**). The degradation of forest cover is one of the major concerns in tropical countries nowadays. This problem is all the more common within the context of climate change **[39, 73 & 114]**.

It was observed that the main divisions of the Centre Region that still accommodate greater rural characteristics such as Lékié, Mbam & Kim, Mbam & Inoubou, Mefou & Afamba, farm activities are the main drivers of deforestation (80-90%) forest cover degradation and LULC changes, because farming practices are essentially extensive. However, although deforestation across Cameroon and Africa is generally driven by agricultural development alone, nowadays, increased logging and mining industries from an influx of Chinese companies and urbanization are the prime drivers.

Urbanization, a modern driver of deforestation and LULC changes

The present study considers the fact since 2000, Yaoundé urban spatial and demographic spread brought a lot of pressure on forest resource. This resulted in intense deforestation in the vicinity of this metropolis. It raised up the challenge of zoning the town as well as the LULC and shows that urbanization is the main challenge nowadays in Africa. According to UN-Habitat forecasts [38 & 41], the big cities of Africa should have millions of inhabitants and be amongst the largest in the world. Due to demographic pressure and upheaval, and relative poverty of urban and rural areas of Developing Countries and SSA Africa, urbanization is booming. Managing this rapid urbanization in already congested cities is therefore becoming one of the priorities and challenges of African states. Will African cities be able to accommodate 400 million people by 2030 and create the expected wealth? What is the strategy for meeting the challenge of rapid urbanization in Africa? [38 & 41]. Will Cameroonian State be able to accommodate in Yaoundé and Douala 4 million people and create expected wealth? With what strategy?

The local context of poor land governance and the fragility of the local conservation system contribute to this degradation of the forest cover of this central region. The decline of the forest has been observed in all agro ecological zones of the country. Those that escape clearing are degraded by the irregular and unsustainable removal of resources. Focusing on the situation around the big cities, these results are consistent with the work of Bopda [90, 115-116], which emphasizes on the evolution and transformation of the city of Yaoundé. It appears that spontaneous peri-urbanization and effects on the natural environment are remarkable. The fragile nature of Yaoundé's ecological environment, which is undergoing intense degradation [117] can be evoked while also highlighting the strong degradation of the peri -urban environment [118].

Also, this article proposes a LULC zoning map because it appears to be important for African cities planners to make a zoning specifying land use and some closed forestlands for ecological processes and purposes. It would help avoiding troublesome consequences like food insecurity, youth delinquency and massive urban impoverishment. A good mastery of urban development in Africa would help Africa to feed itself with its production instead of feeding the world through foreign firms [119]. Due to inadequate urbanization, as factor of modernization and globalization, African Cities become a factor of impoverishment of the masses.
Conclusively, in, the Centre Region of Cameroon, forest loss was estimated at 18 000 km ² between 1984 and 2015. Agricultural activities contribute 55% of this loss. The particularity of the area is due to rapid urban growth that degraded forests as buildings emerge. Thus the role of urbanization should be re-evaluated amongst the direct drivers of deforestation. Several authors have paid particular attention to it in the Brazilian Amazon [50-51].

Deforestation and LULC dynamics in the Centre Region within the Context of the Congo Basin forest

This study assesses LULC dynamics of forest cover depletion through agriculture and urbanization in the Centre Region of Cameroon. Being part of the Congo Basin Forest, studies have shown that deforestation are caused by illegal and legal logging, farming, mining and infrastructural developments. Saving this remaining forest necessitates that decision-makers start tackling the poverty gap now [98]. Being a complex problem, deforestation [12, 34-35, 81 & 120] requires robust governance policies. Around this Centre Region, deforestation has reached 2.47%/year between 1984 and 2000 and 1.59% between 2001 and 2015. It is higher than in the Congo Basin forest massif in which declining rate is 0.9% per year (0.01% between 1990 and 2000 and 0.9 between 2000 and 2005 [35, 81 & 120]. The main driven factors are agriculture, extractive industries, infrastructural developments, logging and urban fabric activities [3, 92 & 113] and those transformations could affect the hydrological regime and watershed [121-122]. The net deforestation rate of the Congo Basin is 0.09 % between 1990 and 2000, against 0.17 % between 2000 and 2005 [12, 81 & 113].

Consequently, LULC dynamics and cumulative impacts spare no biome even if it is expressed at different scales and degrees. In the Congo Basin, the annual rate of gross deforestation was 0.19% between 2000 and 2010 [12]. This is an average that masks specificities for each zone. Areas with high densities generally have higher rates of deforestation [110, 112 & 123]. It is in this aggregate context that the Centre Region of Cameroon is found to have had an average of 1.7% per year between 1984 and 1990 whereas this is a hotspot of deforestation as various maps of the country indicate. Researchers who studied vegetation cover dynamics in the Congo Basin [110, 124-125] used direct factors and underlying factors to explain the rapid decline in forest. They found that other forms of land use were also involved. Based on the factors identified, the authors proposed some useful policy measures for REDD+ [23, 25-28, 126].

Towards the reduction of changes in LULC

Changes in LULC are inevitable. However, it would be relevant to think of a sustainable exploitation of resources. In the Centre Region of Cameroon, it is extensive subsistence farming that causes the rapid conversion of natural areas (forests and savannah). The roaming of plots and the use of fire are gradually leading to the loss of residual forests even in reserves and protected areas [107, 110 & 127]. The support of local populations and agro-industrial producers for the adoption of sustainable farming practices with a low impact on the LULC is recommended [128]. Zoning, improvement of agricultural practices and the sensitisation of local communities on the sustainable development goals are noteworthy (figure 23). Zoning also appears helpful in reducing impacts of LULC changes in hydrological regime and watershed.

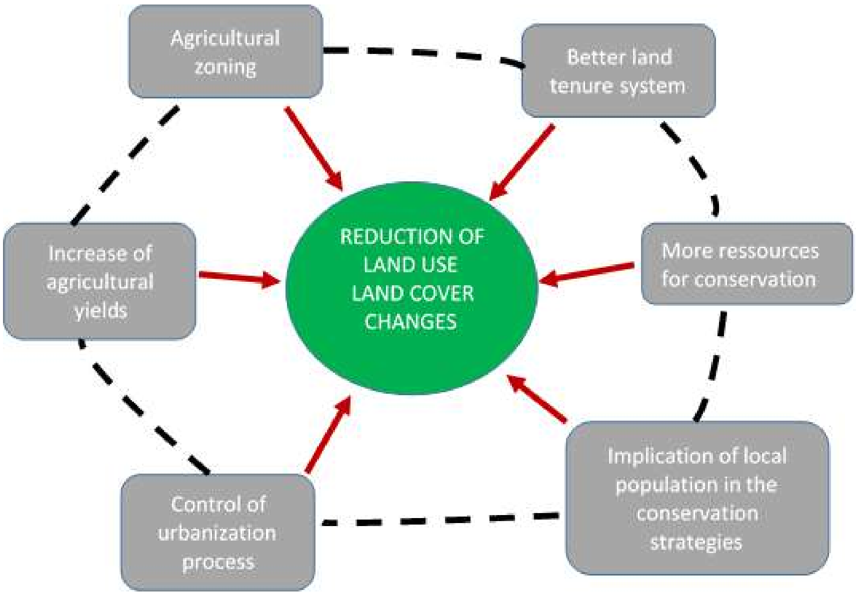

Figure 23. Proposal for LULC sustainable options.

Zoning refers to the permanent assignment of each perimeter to a particular use. The current challenge is to prevent agricultural encroachment and urban expansion that do not spare any environment. It is therefore urgent to improve land management. The prevalence of customary law for access to land is a real problem in the Centre Region of Cameroon. In addition in the field of conservation, it is necessary to reinforce the human and logistic resources to dissuade the populations to respect the protected perimeters. It is now recommended to obtain the cooperation of the populations to achieve the conservation goals. It is worth thinking over that urbanization services need to be strengthened to control and follow-up the direction of the urban fronts.

In any case, the exponential increase in demand for forest, agricultural and building plots in this Centre Region of Cameroon is leading to a shift to intensive production. In the agricultural sector, local practices recommend the creation of plantain and cassava fields, for example only on forest plots which must be cut down and burned. In addition, the exploitation of parcels for these crops does not exceed two seasons. The introduction of fertilizers (preferably organic) would feed the soil to maintain satisfactory performance over long periods. Access to fertilizer would also encourage people to exploit fallow land, giving forests the chance to maintain and rebuild.

The conservation of biodiversity through the sustainable management of forest areas is today the subject of major challenges on a global scale. Land use change (50%) and agriculture (38%) account for 88% of the greenhouse gas emissions in Cameroon [129]. Thus, Cameroon's ability to meet its commitments in the framework of the COP 21 requires the control of these two sectors. People of this Centre Region also deserve remunerations under financial mechanisms such as REDD [23, 25 & 27] to support them in low-impact production.

CONCLUSION

The objective of this study was to assess LULC changes by analysing its direct (agriculture) and indirect (urbanization) factors in the Centre Region of Cameroon. The authors tracked the transformation dynamics of forest cover in the region between 1984 and 2015 by processing more than 90 images from multiple sensors (Landsat, SPOT, Mapbox and Sentinel) with aerial photograph scenes of 1951. The finding shows that the Centre Region is characterized by overwhelming LULC dynamics due to spatial expansion of crop production. The forest thus becomes the target of farmers for fertile lands. Forest depletion rate reaches 2.47% per year between 1984 and 2000 and 1.59% between 2001 and 2015. The processing of satellite images shows a total loss of 54% of the forest cover of the Centre Region from 1984 to 2015. Between 1984 and 2000, LULC dynamic changes were essentially from local practices such as shifting cultivation which favoured forest recession. Since 1990, there has been a reduction in fallow periods (1-3 years) due to demographic pressure and urbanization. From 2000, the main driver of LULC changes and deforestation is urbanization with its corollary (spatial expansion, population growth, infrastructural development, mining, etc.). The massive conversion of forests into farm and bare lands lead to huge land degradation as well as changes on hydrological regime and watershed. Being the political capital of Cameroon, the spatial extension of Yaoundé was multiplied by 32 from 1951 to 2017. It is the same with various secondary cities such as Akonolinga, Bafia, Mfou, Mbalmayo and Ngoumou that experienced rapid expansion. From the results obtained, it has been possible to carry out effective LULC zoning and the LULC projected to 2050. This projection creates awareness as to the planning priorities in order to avoid complete loss of the forest. This case study shows that LULC dominate the transformations of the forest cover in a context where there is no longer any fallow system in the region.

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References

[1] Turner, B.L., Meyer, W.B., & Skole, D.L. Global land-use land-cover change - towards an integrated study. *Ambio*. **1994**; **23** (1):91–95. doi: 10.2307/4314168.
[2] Turner, B. L., Lambin, E. F. & Reenberg, A. “*The Emergence of Land Change Science for Global Environmental Change and Sustainability.*” *Proceedings of the National Academy of Sciences of the United States of America* 104.52 (**2007**): 20666–20671.
[3] Geist ,H. J. & Lambin, E. F. *Land-Use and Land-Cover Change (LUCC) Project IV. International Human Dimensions Programme on Global Environmental Change (IHDP) V. International Geosphere-Biosphere Programme (IGBP),* **2001,** LUCC Report Series N° 4. CIACO Louvain-La-Neuve, LUCC International Project Office University of Louvain, 116p.
[4] Lambin, E. F. & Geist, H.J. Land-Use and Land-Cover Change: Local Processes and Global Impacts, *Springer*, **2006**, Heidelberg, 222p
[5] Verheye, W. Land Cover, Land Use and the Global Change - *Land use, land cover and soil sciences* – Vol. I **2006.** Ed. Willy H Verheye. Oxford, UK: UNESCO-EOLSS Publishers, In *Encyclopedia of Life Support Systems (EOLSS)*
[6] Verburg P. H., Neumann, K. and Nol, L. . Challenges in using land use and land cover data for global change studies. *Global Change Biology* (**2011**) 17, 974–989, doi: 10.1111/j.1365-2486.2010.02307.x
[7] Bonilla-Moheno, M., Grau, H.R., Aide, M., Álvarez-Berríos, N. & Babot,J. Globalization and land use in Latin America. *Newsletter of the global land project. 2014.* 10 , 5-7.

[8] Zvoleff, A. Wandersee, S. An,L. & López-Carr, D. Land Use and Cover Change. Geography - Oxford Bibliographies. http://www.oxfordbibliographies.com/view/document/obo-9780199874002/obo-9780199874002-0105.xml?rskey=ypjB0b&result=41&print DOI: 10.1093/OBO/9780199874002-0105

[9] Tian, H., Banger, K., Bo, T. & Dadhwal, V.K. History of land use in India during 1880-2010: large-scale land transformations reconstructed from satellite data and historical archives. *Global and Planetary Change.* 2014;121(April 2016):78–88. doi: 10.1016/j.gloplacha.**2014**.07.005.

a. Mayaux, P., Bartholomé, E., Fritz, S., & Belward, A). A new land-cover map of Africa for the year 2000. *Journal of Biogeography*. (**2004**) 31(6), 861-877.

b. Brink, A. B., & Douglas, H. E. Monitoring 25 years of land cover change dynamics in Africa: A sample based remote sensing approach. *Applied Geography* 29 (**2009**) 501–512. www.elsevier.com/locate/apgeog

c. De Wasseige, C., Tadoum, M., Eba'a Atyi, R. & Doumenge, C. (eds.). *État des Forêts 2015 - Forêts et changements climatiques,* **2015**. 128p.

d. IPCC (2000). Watson et al. (Eds). *Land use, Land-use Change, and Forestry: A Special Report*. Cambridge University Press. **(2000).** Cambridge, UK. 375p

e. IPCC (2003). Penman et al (Eds). *Good Practice Guidance for Land Use, Land-Use Change and Forestry. IPCC National Greenhouse Gas Inventories Programme*. UNEP-WMO-IGES, **2003,** Japan.

f. IPCC, *Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems*. Summary for Policymakers Approved Draft. WMO, UNEP; **2019**, 41p.

g. Geist, H.J. & Lambin, E.F. Proximate causes and underlying driving forces of tropical deforestation. *Bioscience*, **2002,** 52 (2), 143-150.

h. Hosonuma, N., Herold, M., De Sy, V. De Fries, R.S., Brockhaus, M., Verchot, L., Angelsen, A. & Romijn, E. An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letter,* **2012,** (7) 044009.

i. Swart, R.E. *Monitoring 40 years of land use change in the Mau forest complex, Kenya: a land use change driver analysis*. Thesis Report GIRS-**2016**-29 Centre for Geo-Information Science and Remote Sensing Wageningen, 72p.

j. Deribew, K.T. & Dalacho, D.W. Land use and forest cover dynamics in the North-Eastern Addis Ababa, central Highlands of Ethiopia. *Environmental Systems Research,* **2019** 8: 8.

k. Jayne, T.S., Chamberlin, J. & Headey Derek, D. Land pressures, the evolution of farming systems, and development strategies in Africa: A synthesis. *Food Policy* 48 (**2014**) 1–17.

l. Oyinloye Ajide, M, Ogunlade Oluwole, S. & Owoeye Oluranti, J. Geo-Spatial Analysis of Informal Settlements on Landuse/Cover Change Areas of Osogbo, Nigeria**.** *American Journal of Environment and Sustainable Development.* Vol. 3, No. 3, **2018**, pp. 55-70 http://www.aiscience.org/journal/ajesd

m. Gadrani, L., Lominadze, G. & Tsitsagi, M. F. Assessment of landuse/landcover (LULC) change of Tbilisi and surrounding area using remote sensing (RS) and GIS. *Annals of Agrarian Science* 16 (2), **2018**, 163-169.

n. Kissinger, G. M. Herold, V. & De Sy, V. *Drivers of Deforestation and Forest Degradation: A Synthesis Report for REDD+ Policymakers*. Lexeme Consulting, **2012**, Vancouver Canada, 46p.

o. Sabogal, C. Identifying drivers of land use change In South America. *Capacity building workshop on ecosystem conservation and restoration to support achievement of the Aichi Biodiversity Targets - Linhares*, Brazil, **2014**, March 24-28.

p. De Sy, V. & Herold, M. *Monitoring drivers for REDD+: status and options*. In 2nd GLP open Science Meeting, 19{21 March **2014**, Berlin, Germany.

q. De Sy, V. Herold, M., Achard, F., Beuchle, R., Clevers, J G P W, Lindquist, E. & Verchot, L. Land use patterns and related carbon losses following deforestation in South America. *Environmental Research Letters,* IOP Publishing Ltd 10 ***2015***, 124004.

r. De Sy, V., Herold, M., Achard, F., Beuchle, R., Besnard, S., Clevers, J.,Lindquist, E., Verchot, L. & Wijaya, A,. Drivers of deforestation in REDD+ countries: Results from a pan-tropical remote sensing analysis. In *Our common Future Under Climate Change conference*, 7 (**2015**), Paris.

s. De Sy, V. Remote sensing of land use and carbon losses following tropical deforestation. PhD Thesis, **2016**,University of Wageningen.
t. Ngwa, N. E. Cameroon small farmers and agro-pastoral credit. Herder and Herder, **1989**, New York.
u. Bamou, E. & Masters, A. W. *Distortions to Agricultural Incentives in Cameroon: Agricultural Distortions.* Working Paper 42. **2007**. World Bank, Washington, DC.
v. FAO, *The State of Food and Agriculture 2016. Climate change, agriculture and food security*. **2016,** Rome 173p http://www.fao.org/3/a-i6030e.pdf Accessed on 12 March, 2019
FAO, *The future of Food and Agriculture. Trends and Challenges*. **2017,** Rome 163p www.fao.org/3/a-i6583e.pdf Accessed on 12 March, 2019
a. FAO, *The state of the world forest. Forest pathways to sustainable development*. **2018,** Rome 118p http://www.fao.org/3/I9535EN/i9535en.pdf Accessed on 12 March, 2019
b. *Agyei, Y. Deforestation in Sub-Saharan Africa. African Technology Forum*, **1998**. Vol. 8, No 1. http://web.mit.edu/africantech/www/articles/Deforestation.htm Accessed on 08 March, 2017.
c. FAO. *The State of the World's Forests.* **2011**. Rome. www.fao.org/docrep/013/i2000e/i2000e00.htm
[11] Tchindjang, M. Urbanization and Poverty; Case study of Yaoundé. Guest Speaker, LUNA Project, **2010.** Johannesburg.
[12] Tchindjang, M. L'urbanisation durable comme outil de mise en œuvre de la transformation sociale et écologique (TSE) au Cameroun : quoi faire et comment ? « *Médias et transformation sociale écologique (TSE) au Cameroun : Comment passer à l'action maintenant ?* **», 2019.** Friedrich Ebert Stiftung, Yaoundé.
[13] UN-Habitat & IHS-Erasmus University Rotterdam "*The State of African Cities 2018: The geography of African investment.*" (Wall R.S., Maseland J., Rochell K. and Spaliviero M). United Nations Human Settlements Programme, **2018**, (UN-Habitat).London 322p.
[14] Reid, Robin S., Russell L. Kruska, Nyawira Muthui, et al. "Land-Use and Land-Cover Dynamics in Response to Changes in Climatic, Biological and Socio-political Forces: The Case of Southwestern Ethiopia." *Landscape Ecology* 15.4 (**2000**): 339–355.
[15] Unruh, J., Cligget, L. & Hay, R. "Migrant Land Rights Reception and 'Clearing to Claim' in Sub-Saharan Africa: A Deforestation Example from Southern Zambia." *Natural Resources Forum* 29.3 (**2005**): 190–198.
[16] Akubia J.E. *Coastal Urbanization and Urban Land-use change in the Greater Accra Metropolitan Area, Ghana*. 2016. Water Power Working Paper, No.10. Governance and Sustainability Lab. Trier University.
[17] United Nations Population Division (**2001**). *World Urbanization Prospects: The 1999 Revision*. Key Findings. United Nations Population Division
[18] Antrop, M. Landscape change and the urbanization process in Europe. *Landscape and Urban Planning* 67 (**2004**) 9–26.
[19] Freire, S. Santos, T. & Tenedório, J. A. Recent urbanization and land use/land cover change in Portugal. The influence of coastline and coastal urban centers. *Journal of Coastal Research*, Special Issue No. 56. Proceedings of the 10th International Coastal Symposium ICS, **2009**, Vol. II, 1499-1503.
[20] Gallardo, M. & Martínez-Vega, J. *Three decades of land use changes in the region of Madrid and how they relate to territorial planning.* **2016**.
[21] Kavzoglu, T., Yilmaz E.O. & Tonbul, H. Object- based land use/land cover change detection using spatio -temporal images – a case study in metropolitan city of Istanbul, Turkey. *The 40th Asian Conference on Remote Sensing*. (ACRS). **2019**
[22] Seto, K.C., Güneralp, B., Hutyra, L.R. Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. *Proceedings of the National Academy of Sciences of the United States of America,* 109, 40 (**2012**) 16083-16088..
[23] Seto, K.C., Fragkias, M., Güneralp, B. & Reilly, M.K. A meta-analysis of global urban land expansion. *PloS One 6*, **2011**, .e23777.
[24] Wang, L., Li, W., Wang, S. & Li, J. Examining urban expansion in the Greater Toronto area using Landsat imagery from 1974–2014. *GEOMATICA*. 69, (2)**,** **2015**, 161-172. dx.doi.org/10.5623/cig2015-203

[25] Barros, J.X. Urban growth in Latin American cities: exploring urban dynamics through agent-based simulation. 2004, PhD Thesis, University College London.
[26] Eloy, L. & Le Tourneau, F-M. L'urbanisation provoque-t-elle la déforestation en Amazonie ? Innovations territoriales et agricoles dans le nord-ouest amazonien (Brésil), *Annales de géographie* **2009,** vol.3, 667, p.204-227. [52] Yin, J., Yin, Z., Zhong, H., Xu, S., Hu, X., Wang, J. & Wu, J. Monitoring urban expansion and land use/land cover changes of Shanghai metropolitan area during the transitional economy (1979–2009) in China. *Environmental Monitoring and Assessment. 177,* **2011**, (1–4), 609–621
[27] Patraa, S., Sahoo, S., Mishraa, P. Mahapatrac, S.C. Impacts of urbanization on land use /cover changes and its probable implications on local climate and groundwater level. *Journal of Urban Management* 7 (2) **2018**, 70–84 http://dx.doi.org/10.1016/j.jum.2018.04.006
[28] Pawe, C.K. & Saiki, A. Unplanned urban growth: land use/land cover change in the Guwahati Metropolitan Area, India. *Geografisk Tidsskrift-Danish Journal of Geography, 2017. 88-100.*
[29] Nath, B., Niu, Z. & Singh, R.P. Land Use and Land Cover Changes, and Environment and Risk Evaluation of Dujiangyan City (SW China) Using Remote Sensing and GIS Techniques**.** *Sustainability* **2018**, 10, 4631; doi:10.3390/su10124631
[30] Murayama, Y., Estoque, R.C. Subasinghe, S. Hou, H. & Gong, H. Land-Use/Land-Cover Changes in Major Asian and African Cities**.** *Annual report on the multi use social and economic data bank*, **2015**, vol. 92, University of Tsukuba, Japan
[31] Nkwemoh, C. A. & Tchindjang, M. Urban sprawl and agriculture : A case study of the Yaoundé metropolis (Cameroon). *Revue Scientifique et Technique Forêt et Environnement du Bassin du Congo* **2018,** *Volume 10. P. 45-58.*
[32] Yankson, P. W. K. & Bertrand, M. Challenges of Urbanization in Ghana. In Ardayfio-Schandorf, E., Yankson, P. W. K. & Bertrand, M. :*The Mobile City of Accra Urban Families, Housing and Residential Practices*. **2012**, Council for the Development of Social Science Research in Africa (CODESRIA) Dakar, pp.25-46
[33] Kasa, L., Zeleke, G., Alemu, D. Hagos, F. &, Heinimann, A. Impact of urbanization of Addis Ababa city on perurban environment and livelihood **(2011),** 28p**.**
[34] Binsangou, S., Ifo A.S., Ibocko, L., Louvouandou, L., Tchindjang, M. & Koubouana, F. Urban Growth and Deforestation by Remote Sensing in the Humid Tropical Forest of Congo Bassin: Case of Impfondo in Republic of Congo. *American Journal of Environment and Sustainable Development* Vol. 3, No. 3, **2018**, pp. 46-54. http://www.aiscience.org/journal/ajesd
[35] Kamga, A., Kouamé, C., Tchindjang, M., Chagomoka, T. & Drescher A. W. Environmental impacts from overuse of chemical fertilizers and pesticides amongst market gardening in Bamenda, Cameroon. *Revue Scientifique et Technique Forêt et Environnement du Bassin du Congo. (**2013**) Volume **1**. P. 6-19,*
[36] Tchindjang, M. *Paradoxes et Risques Dans les Hautes Terres Camerounaises: Multifonctionnalité Naturelle et Sous Valorisation Humaine*; Université de Paris: Paris, France, **2012**; p. 266.
[37] Ntsama Atangana, J., Tchindjang, M**.,** Moulende, T., Bene Bene, C. L. Evaluation environnementale de la problématique de bois de feu dans la vile de Garoua Nord Cameroun. **2010.** Colloque SIFEE http://www.sifee.org/Actes/actes_paris_2010/Communications/BLOC_4/S_4.1/3_NTSAMA_ATANGANA_TXT.pdf
[38] Tchindjang, M., Amougou, J.A., Abossolo S.A. & Bessoh Bell, S. 2012. Challenges of climate change, landscape dynamics and environmental risks in Cameroon. In *Landscape Evolution, Neotectonics and Quaternary Environmental Change in Southern Cameroon*: *Palaeoecology of Africa*, **2012** 31, Ch.5, pp. 237-286. Taylor and Francis, London.
[39] Mirkatouli, J., Hosseini, A. & Neshat, A. Analysis of land use and land cover spatial pattern based on Markov chains modelling. *City, Territory and Architecture* (2015) 2:4 DOI 10.1186/s40410-015-0023-8.
[40] Brown, D.G., Pijanowski, B.C., & Duh, J.-D. Modeling the relationships between land-use and land-cover on private lands in the Upper Midwest, USA. *Journal of Environmental Management*, **2000** 59, 247-263.

[41] Brown, D.G., walker. R., Manson, S. & Seto, K. Modeling land-use and land-cover change**.** *Land Change Science.* Chapter 20, **2004**. pp. 395-409. DOI: 10.1007/978-1-4020-2562-4_23
[42] Agarwal, C., Green, G.M., Grove, J.M., Evans, T.P. & Schweik, C.M. *A Review and Assessment of Land-Use Change Models: Dynamics of Space, Time, and Human Choice.* **2002** GTR NE-297. Newton Square, PA: U.S.D.A. Forest Service, Northeastern Research Station. 61 p.
[43] Meneses, B. M., Reis, E., Vale, M. J. & Reis, R. *Modeling land use and land cover changes in Portugal: a multi-scale and 10 multi-temporal approach*. Finisterra, LIII, **2018,** 107, pp.3-26. doi: 10.18055/Finis12258.
[44] Giri, Chandra P., (ed). *Remote Sensing of Land Use and Land Cover: Principles and Applications*. Taylor & Francis Series in Remote Sensing Applications. **2016**. Boca Raton, FL: CRC Press, 477p.
[45] Megahed, Y., Cabral, P., Silva, J. & Caetano, M. Land Cover Mapping Analysis and Urban Growth Modelling Using Remote Sensing Techniques in Greater Cairo Region—Egypt. *ISPRS Int. J. Geo-Inf.* **2015**, *4*, 1750-1769; doi:10.3390/ijgi4031750
[46] Raziq, A., Xu, A., Li, Y. & Zhao, Q. Monitoring of Land Use/Land Cover Changes and Urban Sprawl in Peshawar City in Khyber Pakhtunkhwa: An Application of Geo- Information Techniques Using of Multi-Temporal Satellite Data. *Journal of Remote Sensing & GIS* **2016**, 5:4. DOI: 10.4172/2469-4134.1000174
[47] Capucin M., Brand Sassen V., Machado Bueno C. et al. South America Land Use and Land Cover Assessment and Preliminary Analysis of Their Impacts on Regional Atmospheric Modeling Studies. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 2014(99):1-14. DOI: 10.1109/JSTARS.2014.2363368
[48] Salazar, A., Baldi, G., Hirota, M., Syktus,J. & McAlpine, C. Land use and land cover change impacts on the regional climate of non-Amazonian South America: A review. *Global and Planetary Change***. 2015,** 128, 103-119.
[49] Liu, J.; Zhang, Z.; Xu, X.; Kuang, W.; Zhou, W.; Zhang, S.; Li, R.; Yan, C.; Yu, D.; Wu, S.; et al. Spatial patterns and driving forces of land use change in China during the early 21st century. *J. Geogr. Sci*. **2010**, 20, 483–494.
[50] Lambin, E.F. & Meyfroidt, P. Global land use change, economic globalization, and the looming land scarcity. *PNAS* **(2011)** 108(9):3465–3472.
[51] Sleeter, B.M., Sohl, T.L., Wilson, T.S., Sleeter, R.R., Soulard, C.E., Bouchard, M.A., Sayler, K.L., Reker, R.R., and Griffith, G.E. Projected land-use and land-cover change in the Western United States, chap. 6 *of* Zhu, Zhiliang, and Reed, B.C., (eds.), *Baseline and projected future carbon storage and greenhouse-gas fluxes in ecosystems of the Western United States*. U.S. Geological Survey Professional Paper 1797, **2012**, 22 p. (Also available at http://pubs.usgs/gov/pp/1797.)
[52] Franqueville, A. *Yaoundé. Construire une capitale. Etudes Urbaines*, ORSTOM. **1984.** Paris, 192p.
[53] Billen, R., & Cornélis, B. Géométrie de la spatiocarte: correction et validation. *Bulletin de la Société Géographique de Liège*, **2000,** *38*(1), 25-42. https://popups.uliege.be/0770-7576/index.php?id=2505&file=1
[54] Girard M. C. & Girard C.M,. *Traitement des données de télédétection.* **1999**. Dunod, Paris, 529 p.
[55] FAO, *Forest resources assessment 1990 - Survey tropical forest cover studies of change processes*. **1996** FAO Forestry Paper 130, Rome. http://www.fao.org/docrep/007/w0015e/w0015e00.htm
[56] Achard F., Eva H. D., Stibig H. J., Mayaux P., Gallego J., Richards T. & Malingreau J. P., Determination of deforestation rates of the world's humid tropical forests. *Science*, **2002,** 297 (5583): 999-1002.
[57] Kamungandu C. M. La dégradation des forêts en République Démocratique du Congo : Études de cas sur l'évaluation de la dégradation des forêts. *Forest Resources Assessment Working Paper,* **2009**, 169.
[58] BUCREP (Bureau central des recensements et des études de population, Cameroon). *Troisième recensement général de la population et de l'habitat. Rapport de présentation des résultats définitifs.* **2010**, Yaoundé, 65p.

[59] Agri-Stat at https://countrystat.org/home.aspx?c=CMR as well https://www.worldcat.org/title/agri-stat-cameroun-annuaire-des-statistiques-du-secteur-agricole/oclc/696014592
[60] World Bank, Development Indicator **2018.** (accessed 07.05.19) at
[61] https://data.worldbank.org/indicator/NV.AGR.TOTL.KD.ZG?end=2017&locations=CM&start=1965&view=chart
[62] Tchindjang, M., Atangana, P., Bopda A., Eloundou Messi, B., Ndjawa Doutat, C., Kayo Ngouleu Mbofang, J. & Kengne Fodouop. Administrative and spatial evolution of Yaoundé town from 1898 to 1992. *International Cartographic Conference*, **2006**. www.cartesia.org/geodoc/icc2005/pdf/poster/TEMA5/MESMIN
[63] Mveng, E. *Histoire du Cameroon*. Tome II, CEPER, **1985**, Yaoundé, 316p.
[64] Kengne Fodouop, & Bopda, A. *Un demi-siècle de recherche urbaine au Cameroon.* RIEUCAM*,* **(2000)** Presses Universitaires de Yaoundé, 170p.
[65] Bopda, A. *Yaoundé et le défi Cameroonais de l'intégration : à quoi sert une capitale d'Afrique tropicale ?* Editions du CNRS, **2003**. Paris, 420p.
[66] Eno Belinga, S. & Vicat J.P. *Yaoundé, une grande métropole africaine au seuil du troisième millénaire*. Les classiques Camerounais, **2001**, Bar Le Duc, 280p.
[67] Atangana, P. *La production des objets en bois dans le panorama urbain de Yaoundé : stratégies des acteurs, impacts socio-économiques et environnementaux de la filière menuiserie-bois.* Thèse de Doctorat en géographie de développement, **2018.** Université de Yaoundé 1, 375p.
[68] Franqueville, A. Le paysage urbain de Yaoundé. *Les Cahiers d'Outre-Mer*, **1968**. 21 (82) pp. 113-154.
[69] Vaxelaire, M**.** *L'agriculture urbaine à Yaoundé : Approche cartographique en vue une meilleure*
[70] *intégration.* Mémoire de Licence Professionnelle. Université de Strasbourg Faculté de Géographie et
[71] d'Aménagement. Ecole Nationale du Génie de l'Eau et de l'Environnement de Strasbourg. **2010,** 43p.
[72] Schwartz, B. Hoyle, D. & Nguiffo, S. *Tendances émergentes dans les conflits liés à l'utilisation des terres au Cameroon. Chevauchements des permis des ressources naturelles et menaces sur les aires protégées et les investissements directs étrangers*, Yaoundé, **2012**, rapport WWF. www.rightsandresources.org/documents/files/doc_5268.pdf .
[73] Nguiffo S & Mbianda F. Une autre facette de la malédiction des ressources ? Chevauchements entre usages différents de l'espace et conflits au Cameroon « *Politique africaine* » **2013**. Editions Karthala 2013/3 N° 131, pp. 143 à 162.
[74] Lambin, E F., Turnerb, B.L., Geist H.J, Agbola, S. B., Angelsen, A., Bruce, J. W., Coomes, O.T., Dirzo, R., Fischerh, G., Folke, C., George, P.S., Homewood, K., Imbernon, J. Leemans, R., Lin, X., Moran, E.F., Mortimore, M., Ramakrishnan, P.S., Richards, J. F, Skanes, H., Steffen, W., Stone, G.D., Svedin, U., Veldkamp, T.A., Vogel, C. & Xu J. The causes of land-use and land-cover change: moving beyond the myths. *Global Environmental Change* **2001** (11) 261–269.
[75] Bhardwaj, G. How Poverty Is Causing Deforestation Across Africa. **2018.** Accessed 07/12/2018
[76] https://www.chathamhouse.org/expert/comment/how-poverty-causing-deforestation-across-africa
[77] Tchindjang, M. *Etude d'impact environnemental des palmeraies villageoises/élitistes sur la déforestation dans les paysages de la Sanaga Maritime et du bassin du Ndian : cas des arrondissements de Ngwéi et d'Ekondo Titi.* **2016**, WWF Report, OPAL Project, 126p.
[78] The Africa agriculture status report. **2016.** *Progress towards Agricultural Transformation in Africa* 288p.
[79] Jayne, T.S. & Ameyaw, D. Chapter 1 Africa's Emerging Agricultural Transformation: Evidence, Opportunities and Challenges pp. 2-23
[80] Headey, D. & Jayne, T.S. Land pressures, the evolution of farming systems, and development strategies in Africa: A synthesis. **2014** https://doi.org/10.1016/j.foodpol.2014.05.014Get rights and content
[81] Chaléard, J.-L. *Temps des villes, temps des vivres. L'essor du vivrier marchand en Côte-d'Ivoire* . Thèse de doctorat d'État **1994** Université de Paris X-Nanterre, 1041 p.

[82] Chaléard, J.L. Marchés et vivrier marchand en Afrique occidentale : le cas de la Côte d'Ivoire. In : Bart F., Bonvallot J & Pourtier R. (coord.) Regards sur l'Afrique. *Historiens et Géographes*, **2002** (379), 111-122. Regards sur l'Afrique : La Renaissance de la Géographie à l'Aube du Troisième Millénaire : Conférence Régionale de l'UGI, Durban (Afrique du Sud), 2002/08.
[83] Téné, B. *La production du vivrier marchand dans un système agraire en mutation. Le cas du haricot dans le département de la Mifi* (Ouest Cameroun). Presses académiques Francophones, **2017** ; 76p.
[84] Ebela, A.P. *Le vivrier marchand dans la lutte contre la pauvreté des ménages en milieu rural : le cas du département de la Mvila dans le sud du Cameroun*. Thèse de Doctorat de géographie. **2017.** Université Michel de Montaigne - Bordeaux III, 380P.
[85] Mertens B., Sunderlin W.D., Ndoye O. & Lambin E. F.,. Impact of macroeconomic change on deforestation in South Cameroon: integration of household survey and remotely-sensed data. *World Dev*., **2000** 28 (6), 983-999.
[86] FAO, *Global forest resources assessment 2010*. Main Report. **2010**. FAO Forestry Paper, 163, 340p.
[87] Megevand, C . Dynamiques de déforestation dans le bassin du Congo. *Réconcilier la croissance économique et la protection de la forêt. Banque Mondiale, D*irections du développement Environnement et développement durable, **2013**, 179p.
[88] Gillet, P., Vermeulen, C., Feintrenie, L., Dessard ,H. & Garcia, C. Quelles sont les causes de la déforestation dans le bassin du Congo ? Synthèse bibliographique et études de cas», *BASE*, **2016,** Vol.20, N° 2, 183-194.
[89] Laporte, N., Stabach, J., Grosch, R., Lin T.S.& Goetz, S. Expansion of Industrial Logging in Central Africa. *Science,* **2007,** 316 (5830):1451.
[90] Kleinschroth, F., Laporte, N., Laurance, W. F., Goetz, S. J., & Ghazoul, J. Road expansion and persistence in forests of the Congo Basin. *Nature Sustainability*. **2019 .**doi:10.1038/s41893-019-0310-6
[91] Tchatchou, B., Sonwa, D.J., Ifo, S. & Tiani A.M. Déforestation et dégradation des forêts dans le Bassin du Congo. État des lieux, causes actuelles et perspectives. **2015.** Papier Occasionnel 120, CIFOR, Bogor, 47p.
[92] Kalacska, M., Arroyo-Mora, J. P. , Lucanus, O. & Kishe-Machumu, M. A. Land Cover, Land Use, and Climate Change Impacts on Endemic Cichlid Habitats in Northern Tanzania. *Remote Sensing*. **2017**, 9, 623; doi:10.3390/rs9060623 www.mdpi.com/journal/remotesensing
[93] Bopda, A. *La dynamique de l'espace urbain à Yaoundé, Reconstruction et expansion post-colonial du bâti.* Thèse de Doctorat de 3ème cycle Université de Yaoundé*,* **1985,** 312p.
[94] Bopda, A. *Yaoundé dans la construction nationale au Cameroun : Territoire urbain et intégration.* Thèse de Doctorat Université de Paris panthéon Sorbonne ; **1997,** 2 tomes, 307p + 204p.
[95] Tchotsoua, M**.** *Érosion accélérée et contrainte d'aménagement dans le département du Mfoundi au Cameroun : une contribution à la gestion de l'environnement urbain en milieu tropical humide*, Thèse de Doc. De 3è cycle, Université de Yaoundé, **1994,** 296 p.
[96] Amougou, J. V. *Périurbanisation et dégradation de l'environnement : le cas des marges septentrionales de Yaoundé*, Mémoire de Maitrise Université de Yaoundé I, **1999,** 109p
[97] AfDB, OECD (Organization for Economic Co-operation and Development) and UNDP (United Nations Development Programme). *African Economic Outlook 2016: Sustainable Cities and Structural Transformation* **2016.**
[98] [FAO, *The State of World's Forests* - **2001** – Rome, 181p**. www.fao.org/3/a-y0900e.pdf Accessed on 10 May,** 2015.
[99] CSC & WUR. *Fiches d'information des pays. Scénarios des changements climatiques dans le Bassin du Congo. Fiche d'information - Hydrologie et Energie - République du Cameroun - Zone 2.* Rapport final*,* **2013,** *67p.*
[100] Meneses, B. M., Reis, R., Vale, M. J., & Saraiva, R. Land use and land cover changes in Zêzere watershed (Portugal) – Water quality implications. *Science of the Total Environment*, **2015**, *527-528*, pp. 439-447. https://doi.org/10.1016/j.scitotenv.2015.04.092
[101] Mertens B. & Lambin, E. F.. Land-Cover-Change Trajectories in Southern Cameroon. *Annals of the Association of American Geographers*, **2000**, 90, 467-494.

[102] [124] Ernst, C., Mayaux, P., Verhegghen, A., Bodart, C., Christophe, M. & Defourny, P.. National forest cover change in Congo Basin: deforestation, reforestation, degradation and regeneration for the years 1990, 2000 and 2005, *Global Change Biology*, **2013**,Vol. 19, Issue4 ; p1173-1187.
[103] CBFP & CARPE. *The forests of the Congo basin: a preliminary assessment*. **2005**, http://carpe.umd.edu/products/PDF_Files/FOCB_APrelimAssess.pdf
[104] Pacheco P., Aguilar-Støen, M., Börner, J., Etter, A., Putzel L. & Vera Diaz, M.C. Landscape Transformation in Tropical Latin America: Assessing Trends and Policy Implications for REDD+. *Forests* **2011**, 2, 1-29; doi:10.3390/f2010001
[105] Desclée B., Mayaux P., Hansen M., Lola Amani P., Sannier **C**., Mertens B., ... Vrieling A., & Mermoz S. **2014**. Évolution du couvert forestier du niveau national au régional et moteurs du changement. *In* : de Wasseige C. et al., éds. *Les forêts du Bassin du Congo : état des forêts 2013*. Neufchâteau, Belgique : Weyrich, pp. 21-46.
[106] Bahuchet, S. & Betsch, J.-M. L'agriculture itinérante sur brûlis, une menace sur la forêt tropicale humide ? *Revue d'ethnoécologie* [En ligne], 1 | 2012, mis en ligne le 30 novembre 2012, URL : http://journals.openedition.org/ethnoecologie/768
[107] UNDP. *UNDP Climate Change Country Profiles. Cameroun*. **2008.** McSweeney, M. New and G. Lizcano.http://www.helio-international.org/uploads/VARCameroun.Fr.pdf.
[1 [109]