THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

The Influence of Urban Extension on Landcover Dynamics in the City of Maroua, Cameroon

Nkwemoh Clement Anguh
Associate Professor, Department of Geography, University of Yaounde I, Cameroon
Ngwateze Mariam Mantah
Doctorate Student, Department of Geography, University of Yaounde I, Cameroon
Chia Peter Ta'-ah
Doctorate Student, Department of Geography, University of Yaounde I, Cameroon
Shegwe Quinta Tanki
Doctorate Student, Department of Geography, University of Yaoune I, Cameroon
Suh Erika Sirri
Doctorate Student, Department of Geography, University of Yaoune I, Cameroon

Abstract:
Found at the pinnacle of the Sudano-sahelian domain, the city of Maroua is an epitome of cities over the Globe where urban extension has brought wanton effects on the landscape. With a research methodology that entailed the collection of data from secondary sources such as Topographic maps, Aerial photographs, and Satellite images as well as primary sources through interviews, it was realized that there has been an untold expansion of the urban space as a result of rapid population growth in Maroua. The astronomical population increase has imposed an upward trend in the need for building, industrial and agricultural space to meet the needs of the increased number of mouths to be fed and a number of houses to shelter them. Meanwhile, the results of Land Cover Classification show a predominance of Natural landscape before 1985, an ironical slight recovery of the forest vegetation cover in 2006 and 2022. The measures that have been proposed to ameliorate the situation are those that will meet up with the needs of the present population without jeopardizing the needs of future city dwellers. These solutions are those that would lead to the establishment of a Bio-City that Maroua is supposed to be.

Keywords: *Urban extension, remote sensing, GIS, natural landscape, land cover chang, maroua*

1. Introduction

With the increase in population, society is bound to push to open more land for agriculture to meet up with more mouths to feed. The situation has made most of the city dwellers occupy the nooks and crannies of the area not only for the construction of houses but also space for agriculture.

Urban expansion is a common phenomenon in most of the agglomerations in Cameroon in particular and sub-Saharan Africa as a whole (Gleave, 1992a, 1992b and 2001; Fombe & Balgah, 2010; Nkwemoh, 2011). The issues of man-induced forces and their implication on the landscape have been viewed by Harding (1968); Martin (1985); Bopda (1985); Goudie (1986); Brinkman (1990), Nkwemoh (2011) and Nkwemoh et al. (2017). Other works related to our theme are more oriented toward the treatment of images, such as those of Assako (1998), Moshen (1999), Pratt (1991), Akono (1994), Tonye et al. (2000), Begue et al. (2010). Meanwhile, other related works focus on the treatment of images and land cover change, such as those of Turner et al. (1995), Jukka & Aristide (1998), Neba Shu (2003), Ngouanet (2007), Nkwemoh (2011), Lambi and Kah (2012), Nkwemoh and Lambi (2016), Nkwemoh and Yungsi Nkwemoh (2017) Nkwemoh et al. (2022).

Strictly following the FAO data, 42.1% (19.1916000 hectares) of Cameroon is forested. However, other estimates hold that forest cover is up to 4%. Between 1990 and 2010, Cameroon lost an average of 220,000 hectares of forest (0.9%) per year (MINFOF, 2015). In total, between 1990 and 2010, Cameroon lost 18.1% (4,400,000 hectares). This is because of a number of factors that include:

- Mass forest exploitation,
- Urbanization;
- Developmental projects (such as the construction of dams, the construction of seaports, and the setting up of plantations such as the CDC, SGSOC, and many others)

These are considered major threats to the forest sector of the country because for this to go on well, large expanses of forest land must be destroyed.

The first problem of this study concerns, Urban extension. The second deals with the effects of rapid and uncontrolled urban expansion on land cover. The article has been structured into parts that fall under the Physical and human backgrounds, materials and methods, results and discussions, and the conclusion.

2. Biophysical Setting

Maroua town is situated between latitudes 14°08'05 and 14°20' North of the Equator and Longitudes 14°00' 02'' and 10°38' 00' East of the Greenwich Meridian (Figure 1) Found within the Far North Region of Cameroon. Maroua is a town in the Diamare Division in the far North Region and is situated on a plain that runs right through towards Lake Chad. The area is interrupted by some granitic hills and characterized by some floods during the short rainy season caused by two main rivers that include the Rivers logone et chari.

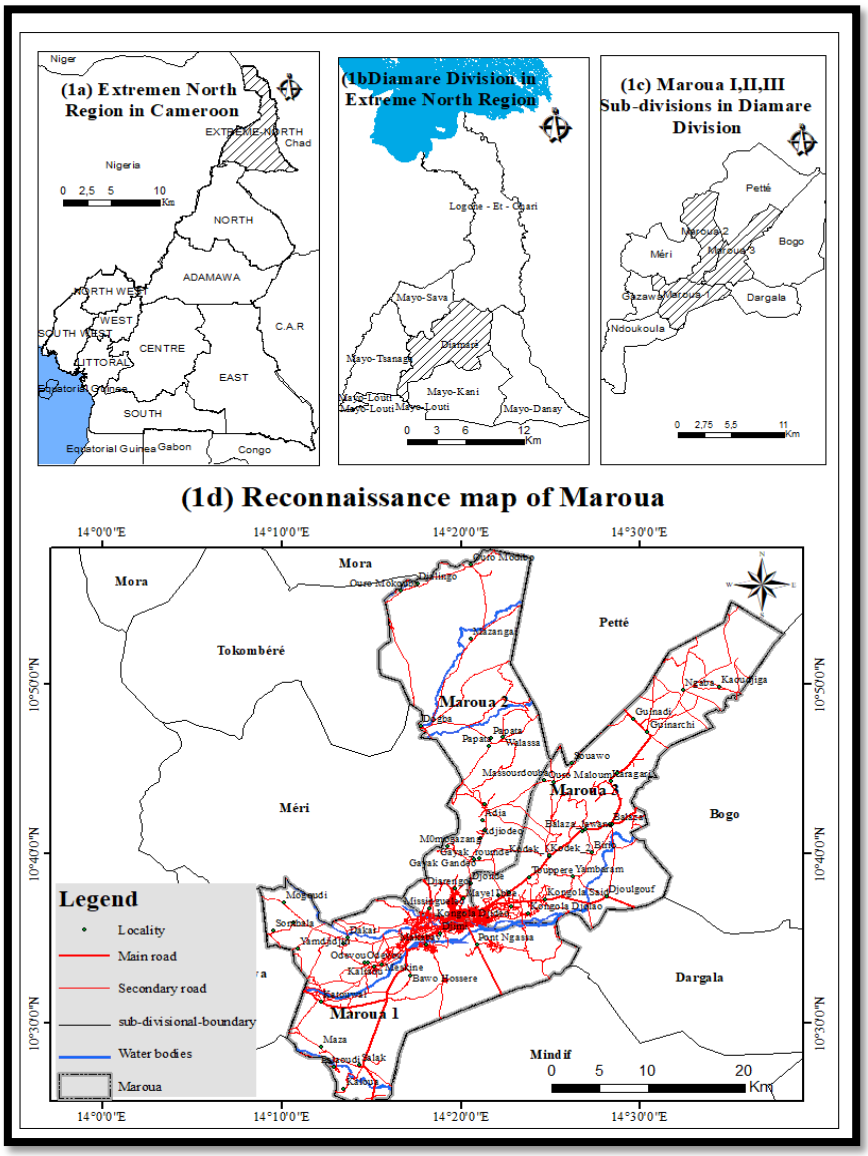

Figure 1: Location of the Study Area

To the West, the massif of Mandara mountains dominates the Diamare plain. The altitude of the lowest point is 350m. The highest altitude is 700m. Meanwhile, the average altitude is 700m. The area of Rhumsiki, which is particularly accidented, is one of the most visited places in Cameroon.

The hydrology of this area is, to a greater extent, a tributary to the Lake Chad Basin that constitutes the greatest endorheic unit of the African Continent. Joining the mayo kebbi river and then the Benue, they contribute to the load of the River Niger to the Atlantic Ocean. The main streams of Maroua are; the mayo kalioao and the mayo Tsanaga amongst others. Apart from these, there are the mayo Mizao and the logone et chari, which are principal receiving streams. It is worthwhile remarking that these streams take their rise from the Mandara mountains. The main lake in this area is the Lake Maga, which possesses a surface area of about 82km$^{2.}$

The geologic formation of Maroua is basically composed of quaternary alluvium. The subsoil of Maroua is made up of metamorphic, plutonic, and sedimentary rocks identified in the diversified landscapes characterized by broad peneplain surfaces. The average Precambrian layer is composed of volcano-sedimentary metamorphic series basically of crystalline schist and volcanic flows (Lekedji, 1991).

The climate of the area is the humid tropical type and specifically Sudano-Sahelian type. The annual rainfall is 800mm in a single rainy season that lasts for 3 to 5 months (May to September). The average maximum temperature is 40°C. The average minimum temperature is 24°C. The average temperature is 32°C. The dry season lasts 7 to 9 months. The dominant winds here include:

- The Monsoon (Southwest) humid wind, mostly blowing from May to September, and
- The Harmattan (North East Trade/dry wind), mostly blowing from October to April

The vegetal formation of the area is basically composed of savanna and steppe. The main species of vegetation entail: *Phoenix reclinata*, *Croton gratissimus*, *Albizia zygia* & Syzygium *guineense* fringing water sources, in addition to *Carissa edulis*, mostly found in thalwegs/valleys. The high level of population pressure and animal husbandry has greatly distorted the natural vegetal strata. In some areas, *Faidherbia albida* can be found in summital hollows. Other species are spotted with *Erythrina* that has been subjected to Cattle rearing (Seignobos, 2000). The dominant species are constituted of ligneous plants (trees). Some of these plants, such as Neems, Moringa, and Eucalyptus, are utilized for traditional pharmaceutical purposes. It is convenient to indicate that *Azadirachta indica* (Neem) is gaining ground in the whole area and appears to be the most recurrent vegetal formation. Its extension is favored by the phenomenon of reforestation. Within the urban space, route networks/systems are bordered by these trees.

According to Humbel (1965), about 5.7% of the soils are halomorphic. There are equally grey soils that are not very different from halomorphic soils and cover a wide expanse of the city. All these soils are developed on materials with a relatively constant granulometry, such as:

- Clay which accounts for 40%,
- Silt, which accounts for 10-15%,
- Fine sand, which accounts for 5-10% and
- Coarse sand, which accounts for 0-5%.

The soil textures vary from sand to clay. Amongst these are:

- Bare soils that are found in the 'karal',
- Durcrusts found on laterites,
- Soils with sandy clay texture, and
- Alluvial soils with sandy silt texture, basically found on the plains and notably around stream banks

Soils that are closer to settlement are clayey sand soils. Meanwhile, those that are in depressions are vertisols mostly utilized for the cultivation of 'Muskuwari' (Yellow Millet).

2.1. Human Background

The name Maroua is derived from a Guiziga word called 'Marva' which means 'Stone'. It is said that the people of Guiziga constitute the first settlers of the town. They had settled long before the Peuhl hegemony. Thereafter, it was Islamization and the Holy wars that the 'Guiziga' was pushed by the Peuhls on the Mountains with the excuse that they refused to practice Islam. Before the town of Maroua was separated into three District Councils, there was only one Urban Council that stayed until the Presidential Decree N° 2007/117 of 24/04/2007 that established District Councils (Microsoft ® Encarta ® 2009). Maroua is a cosmopolitan town and a blend of many ethnic groups, cultures, and religions. A greater majority of the city dwellers are Peuhls, Guiziga, Mofou, Bornouans, and Haussas. The main religions practiced are Islam, Christianism, and Animism. The social organization is built around traditional chiefdoms where the leaders are well-feared and respected. They are the ones who assure security and peace in their area of jurisdiction. There are also 3rd class chiefdoms under the jurisdiction of Lamidos.

3. Materials and Methods

Various institutions (secondary sources) have been consulted for data collection, including University of Maroua, the World Bank, the Ministries of Environment, Nature Protection, and Sustainable Development, and the Maroua Urban Council. Satellite Images (LANDSAT 1986, -TM & ETM+, and Google Earth 2022) have been utilized for the location and mapping of specific sites. We collected numerical population data from State Departments in Maroua for 1919 and 1930 and Census data for 1976, 1987, and 2005 as well as an estimate projection of the population of Maroua between 2006 and 2035 that we computed and presented using Microsoft EXCEL. The GIS programs such as Adobe Illustrator 9.0 and ArcGIS 10.2 software have been used for cartography. Meanwhile, Population projection was made by the use of the formula:

$P_x = P_2 + N/n(P_2 - P_1)$

Where:

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

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

Given that each Scene has a surface area of 185 km^2 and that the scene is composed of many pixels, with each pixel having a surface area of 30m, various bands were determined to exploit and show the various aspects that constitute the land cover classes. ASTER Images also assisted in the elaboration of Digital Elevation Model (DEM) and the Hydrology. The ERDAS software program was then utilized in the location and combination of the various color bands. Then the bands appear with the possibility of RGB color instead of gray scales.

With the Supervised and on Signature Editor, then zooming of the image, the sample by polygons of each form of the feature was taken and attributed a color. For instance, green for vegetation, brown for bare surfaces, and blue (or water surfaces).

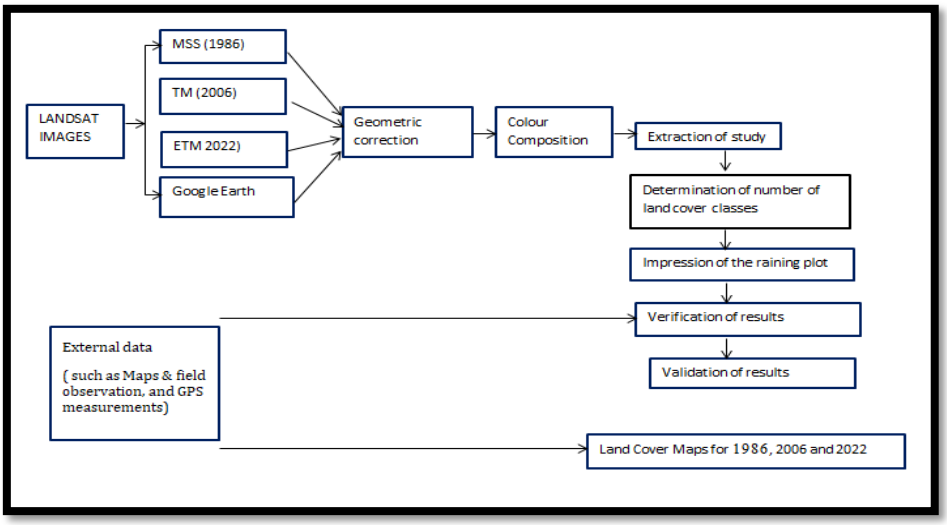

Figure 2: Methodological Approach for the Treatment of Satellite Images

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

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

4. Results and Discussions

4.1. An Untold Population Increase and Resulting Spatial Extension

The population numbers since pre-colonial, colonial period, right through to independence, show a constant and steady rise in the population of city dwellers in Maroua (figure 3).

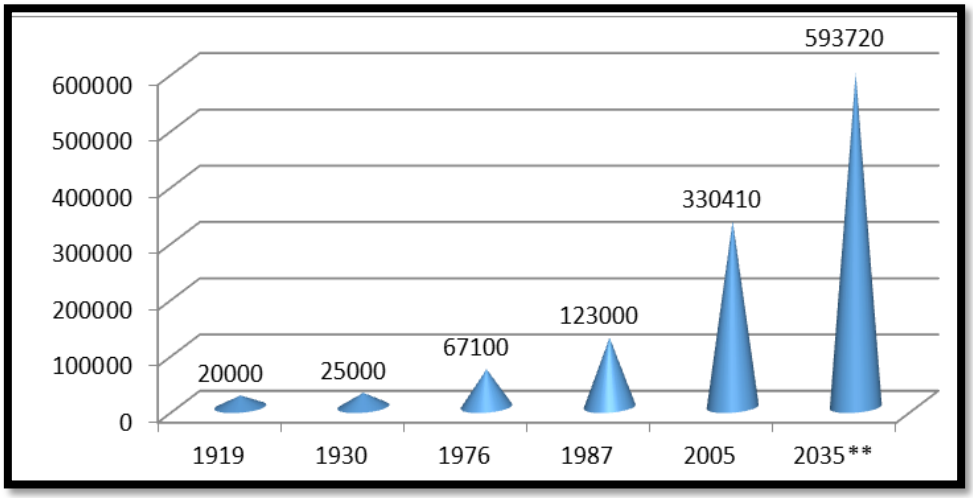

Figure 3: Population Evolution for Maroua
*Source: Atlas De La Province De l'Extrême – Nord – Cameroun, Avril, 2000, BUCREP, 3er RGPH, Volume III, Tome III, ** Projections*

As can be seen in the above figure, the population moved from 20000 inhabitants in 1919 through 1976 to 330410 inhabitants in 2005. A population projection based on the National Population Census of 1987 and 2005 permits the establishment of the population of City dwellers would attain 593720 persons by the year 2035. Following these figures, some diachronic analyses of data from Satellite images for the years 1986, 2006, and 2022 (figure 6) have permitted us to realize a consistent increase in the built-up areas to accommodate the astronomic increase in population numbers.

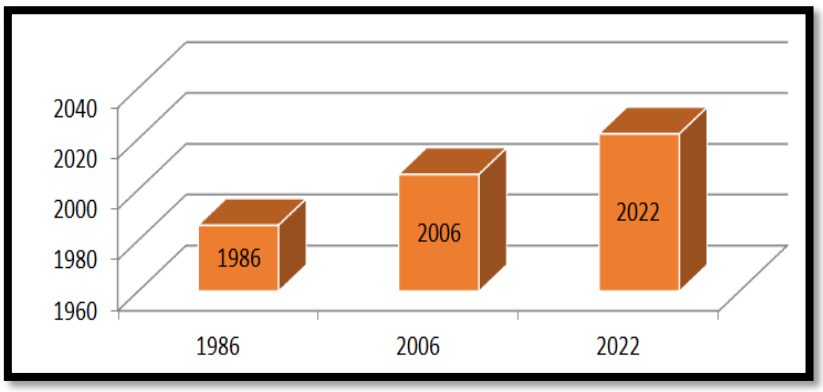

Figure 4: Evolution of Constructed Space in Maroua
Source: Diachronic Analysis Derived From LANDSAT and Googleearth (1986-2022)

Casual extrapolation and projection of the extension of the built-up area of the Maroua clearly indicate that the upward trend of spatial extension and/or coverage is bound to persist amidst an uninterrupted population explosion.

4.2. Effects on Land Cover Change

Utilizing the ERDAS IMAGINE (2014) program, we could attribute color combinations to Land Cover Classes (LCC). The ArcGIS program, in combination with the above software, was subsequently used in delimiting various land cover classes. The technique has been utilized with success by Assako (1998), Bauer & als (2003), Pratt (1991), Tonye & als (2000), and Nkwemoh (2017). Global Position System (GPS) was equally utilized for the collection of points.

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

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

LCC1b-LCC1a = Rate of change for LCC1 for 1986 – 2006 (20 years)

Where

- LCC = Land Cover Class
- TLC = Total Land Cover
- LCC1a = Land Cover Class for Built–up area for the year 1986
- LCC1b = Land Cover Class for Built–up area for the year 2006
- LCC1d = Land Cover Class for Built–up area for the year 2022

Figures 5, 6, & 7 and Table 1 show the spatio-temporal evolution of land cover over the past 5 decades.

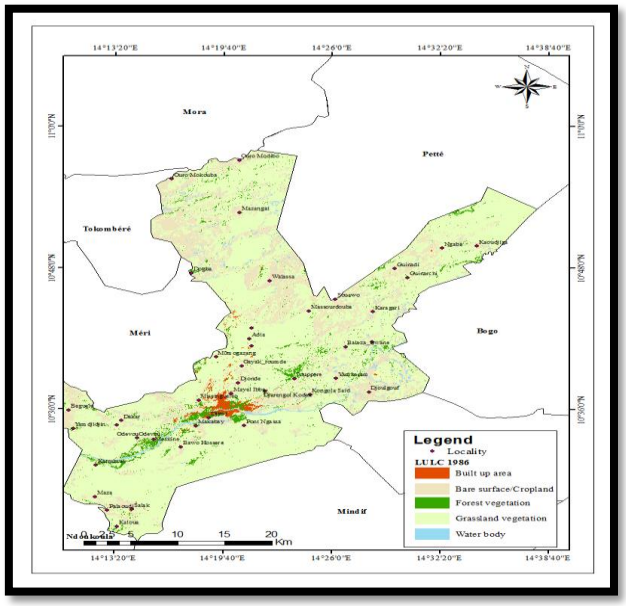

Figure 5: Land Cover Map for 1986

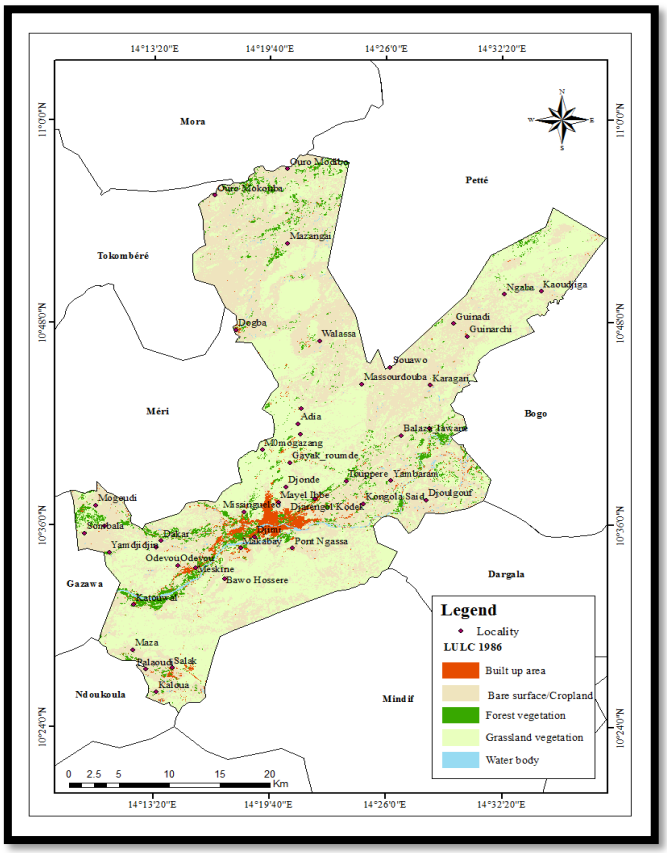

Figure 6: Land Cover Map for 2006

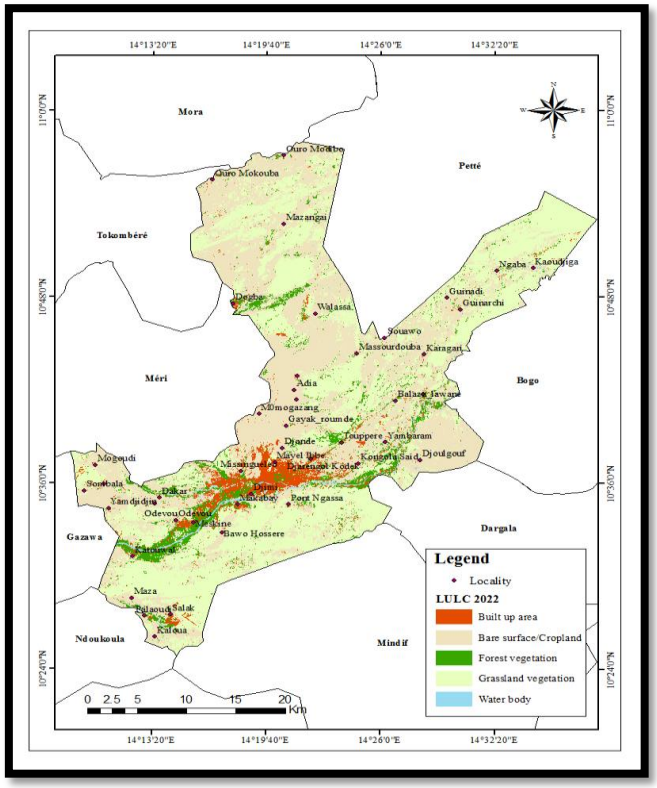

Figure 7: Land Cover Map For 2022

Here is the recapitulation table for land cover and land use for three periods: 1986, 2006, 2022.

Land Cover	1986		2006		2022	
	Absolute	Percentage	Absolute	Percentage	Absolute	Percentage
Bare surface/Cropland	24832	21.3	55198	45.8	55834	47.9
Built up area	1257	1.1	2691	2.2	4901	4.2
Forest vegetation	4113	3.5	5151	4.3	6838	5.9
Grassland	84579	72.5	56561	46.9	48210	41.3
Waterbody	1822	1.6	1000	0.8	820	0.7
Total	116602	100	116602	100	116602	100

Table 1: Land Cover Absolute Figures Per Hectare and Percentages for 1986, 2006 and 2022

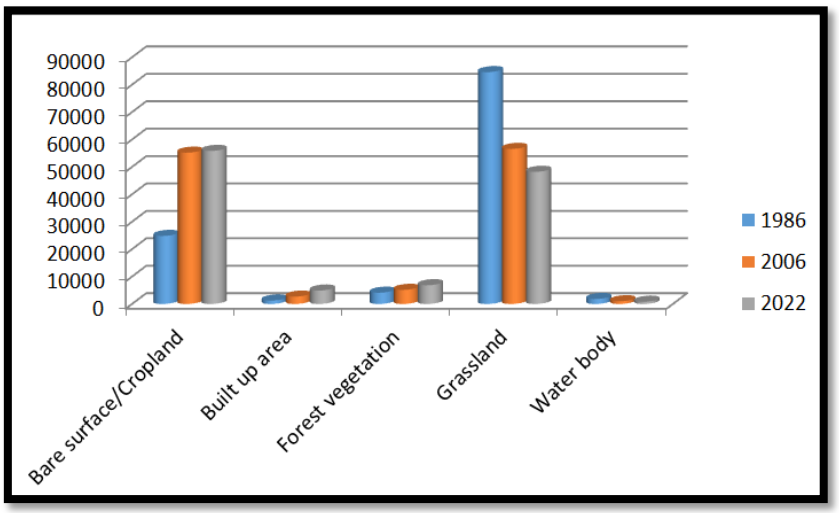

Figure 8: Land Cover Absolute Figures Per Ectare for 1986, 2006 and 2022

An analysis has been carried out and can be seen in a number of syntheses below:

- In the first place, there is a striking increase in the croplands from 24832 ha in 1986, being 21.3% of the total area to 55198 ha in 2006, being 45.8% of the total surface area to 55834 ha representing 47.9% of the total surface area in 2022.
- Secondly, there has been an increase in the built-up area from 1257 ha in 1986, being 1.1% of the total area to 2691 ha in 2006, being 2.2% of the total surface area to 4901 ha accounting for 4.2% of the total surface area in 2022.
- Thirdly, there has been a surprisingly consistent slight increase of dense forest from 4113 ha being 3.5% of the total surface area in 1986, through 515 ha being 4.3% of the total area in 2006, to 6838 ha being 5.9% in 2022. This growth is surely due to the Operation Green Sahel program; the permitted the extensive planting of trees and specifically Neems, Acasia Spp, and Fruit trees.
- Fourthly, there has been a sensible decrease in Grassland from 84579 ha, being 72.4% of the total surface area in 1986, to 56561 ha being 46.9% of the total area in 2006, to 48210 ha, being 41.3% in 2022
- In the fifth position, there has been a consistent drop in the surface area occupied by water bodies from 1822 ha, being 1.6% of the total surface area in 1986, to 1000 ha being 0.8% of the total area in 2006, to 820 ha being 0.7% in 2022.

5. Recommendation

However, the Maroua Urban Council has been working in collaboration with the Divisional Delegation of Housing and town planning and the Ministry of Forest and Fauna to create and maintain just a few lawns and green areas within the city of Maroua. These are measures that are taken to safeguard the environment. It is worthwhile noting that more needs to be done to make Maroua a sustainable/BioCity that it is supposed to be.

5.1. Town Planning and Housing Strategy

The main way that the government can solve the problem of anarchical growth concerns what is partially being practiced. This is by funding and ensuring the construction of multiple housing structures. The type of housing structure recommended here includes single and double-room complexes. This is because city dwellers are composed of basically; the youthful and middle age population. The buildings should be in blocks of approximately 3-6 storied structures. This option is more efficient and practical with vertical constructions. In addition to these housing strategies, the expansion of roads, the use of common transport buses, and the establishment of commuters' zones or residential quarters should be enhanced.

5.2. Forest Regeneration, Fuel wood Plantation, and Urban/Agro-Forestry

The mission of regeneration of forests all over the country and Maroua, in particular, has been confided to ONADEF. However, this institution has regenerated forests in some areas in the 80s. However, today, it is no longer effectively carrying out its functions. Rather, this institution is more engaged in the sales of seedlings to those who intend to plant trees. This, however, notwithstanding, the Maroua Urban Council is effectively carrying out some measures, but they are insufficient. More trees should be planted.

The creation of MINFOF and MINEPDED in 2005 with all the Delegations had been a recognition of the fact that forest preservation is an issue. Decree No. 03-169 of April 1982 laid down forestry regulations that provided forest regeneration all over the territory. Initially, forestry reforms were realized by CENADEFOR and later ONAREF (Office National pour le Développement de Forêts). Institutions like this should be revamped with all vigor. Urban residents in the area concerned should be invited to participate in issues related to decisions on the management of the forest.

Farmers should be encouraged by the Ministries of Agriculture and Rural Development to intensify or practice Home gardening, Intercropping, and Avenue farming in and around the town. The practice where trees are planted sequentially or simultaneously with crops is a practice that has proved to be the most sustainable system in degraded lands. The combination of trees and crops leads to an ideal situation. This practice, which is referred to as agroforestry, has evolved from the simple planting of trees and crops to a careful selection of plants and crops according to their mutual give-and-take needs. This implies that the choice of the type of agroforestry will depend on the will of farmers and agricultural extension workers in the area.

5.3. Forest Protection and Management

The Forest and Wildlife regulation Law of 1994 implemented by the Ministry of Environment laid down specific tree felling modalities to be respected by those concerned with tree cutting. This is usually more respected in protected areas and is a good idea for protecting and managing the forest. This law should obviously equally apply to city dwellers.

Concerning forest management, the first step here concerns the farmers. Since subsistence farmers in these areas still cut trees for agriculture, they should be advised on how to go about things sustainably by the Forestry unit of the Delegations of Forestry. Such exchanges should either be through forums like workshops or momentary visits of forest technicians. Some farmers who already own established plots are already planting trees. They should then be encouraged by forestry agents to practice permanent farming systems as in agro/urban forestry.

6. Conclusion

The above investigation has permitted us to draw some conclusions.

- Firstly, there has been a rapid increase in the population of the Maroua Metropolis.
- Secondly, the increase in population implies the increased need for space to accommodate the growing number of inhabitants.

This also means the increased need for agricultural land to cultivate in order to feed more mouths. The implication of all the above is the clearing of vegetation in areas that had not been occupied by either construction or expansion towards the Urban fringes.

It was equally realized that unlike in other cities where natural forests continue to diminish, in the city of Maroua, forest cover is instead increasing even though the rate of this increase is not satisfactory. This situation, therefore, calls for a prompt reaction by the Authorities to establish a sustainable city as the ultimate way forward.

The investigation rounds up with some recommendations, such as the incessant need for forest regeneration and fuel wood plantations, agroforestry, and, most importantly, Urban Forestry.

7. References

i. Assako A. J. (1998). Apport de la Télédétection et du SIG dans la Recherche des zones constructibles d'un site urbain de collines du Cameroun: Le cas du Yaoundé (Cameroun). *L'espace Géographique*, Tome 27, n° 2, pp. 122-128.

ii. Atemfack, F.B. (2016). *L'apport de la Géomatique dans l'évaluation de l'empreinte des projets structurants sur le couvert Forestier du Cameroun dans la perspective de la REDD+: Cas du Projet du Port en Eau Profonde et du Complexe Industrialo-Portuaire.* Masters Thesis University of Yaounde 1.

iii. Baker, W.L., (1989). A Review of Models of Landscape Change, *Landscape Ecology*, 2:111-133.

iv. Bauer M.E. Yuan F. and Sawaya K. E. (2003). Multi-Temporal Landsat Image Classification and Change Analysis of Land Cover in the twin cities (Minnesota) Metropolitan area. *Second International Workshop on the Analysis of Multi-temporal Remote Sensing Images*. Ispra, Italy. pp 1-8.

v. Bell, E.J., (1974). Markov analysis of land use change-Application of stochastic processes to remotely sensed data, *Socio-Economic Planning Sciences*, 8(6): 311-316.

vi. Bopda, A. (1985). *La dynamique de l'espace urbain à Yaoundé, Reconstruction et expansion post-colonial du bâti,* Thèse de Doctorat de 3ème cycle Université de Yaoundé, 312p.

vii. Bopda, A., Brummett, R., Dury, S., Elong, P., Foto, Menbohan, S., Gockoski, J., Kana, C., Kengue, J., Ngonthe, R., Nolte, C., Soua, N., Tanawa, E., Tchoundjeu, Z. and Temple, L. (2010). Urban farming systems in Yaounde; Building a mosaic. In Prain G., Karanja N & Lee Smith D. 2010. African Urban Harvest. *Agriculture in the cities of Cameroon.Kenya and Uganda*.Chap. 3 PP. 39-60.

viii. Brinkman (1990). How Hungry Mouths are devouring the Planet. *The Independent*, Sunday, October p.58.

ix. Brown D. G, Goovaerts P., Bumlckl A., and Meng-Ylng U (2002). Stochastic Simulation of Land-Cover Change Using Geostatistics and Generalized Additive Models *Photogrammetric Engineering & Remote Sensing* Vol. 68, No. 10, October 2002, pp. 1051-1061.

x. Bamenda Urban Council (BUK)(2012): Master Plan of Bamenda City Council 2011-27.

xi. Ekong, E.E. (1983). *Sociology of the Ibibio: A study of Sociology of Organization and Change*. Calabar: Scholars Press.

xii. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation. All rights reserved.

xiii. Fogwe Z.N. (1997): *Landscape Degradation on the Kom HighLands, North West Province, Cameroon.* Doctorat de 3ème Cycle Thesis, Univ. of Yaoundé 1, 341p.

xiv. Fombe, L.F & Balgah, S.N. (2010). *The Urbanization Process in Cameroon: Patterns, Implications and Prospects.* Series: African Political, Economic, and Security Issues. 194p.
https://www.ecologyandsociety.org/vol9/iss2/art1. Accessed in September 2017
https://www.kribicomplex.com/ Accessed in October 2017

xv. GFW (2004). L'Imagerie Satellitaire au service de L'Exploitation Forestière au Cameroun. Etat des lieux et recommandation quant à la disponibilité et l'acquisition des images. Note de synthèse. 8p.

xvi. Gleave, M.B. (1992a). Urbanisation, in M. B. Gleave (ed.) *Tropical African development. Geographical Perspectives*, Harlow, Longman Scientific and Technical.

xvii. Gleave, M.B. (1992b). Urban bias and agricultural development in West Africa in West Africa in K. HOGGART (ed.) *Agricultural change, environment, and economy Essays in honour of WB. Morgan*, London, Mansell.

xviii. Gleave, M. B. (2001). Some issues in the urbanization of West Africa. In: C.M Lambi and E, B Eze (eds) *Readings in Geography*, Unique Printers, Bamenda.

xix. Gobster, P.H., (1999). An ecological aesthetic in forest landscape management. *Landscape Journal* 18(1):54 – 64.

xx. Goudie, A. (1986). *Human Impact on Natural Environment*. The MIT Press Cambridge Massachusetts, 2nd ed.

xxi. Harding, G. (1968): 'The Tragedy of the Commons' *Science.* Volume 62, 1243-1248.

xxii. Hastie, T., and R. Tibshirani, (1990). *Generalized Additive Models*, Chapman and Hall, London, United Kingdom, 335 p.

xxiii. Hauser, P. (1965). Urbanization: an overview. In: P. Hauser and L. Schnore (ed) *The study of urbanization*, Wiley Press, New York.

xxiv. Hawkins, P. H, and Brunt, M. (1965). The soil and Ecology of West Cameroon, Report to FAO Rome, Vol 1 and 2 285p.

xxv. Human and Technology Resources (HTR) Cameroon Consultants (2012): Master Plan of Bamenda City Council 2011-27.

xxvi. Humbel, F. X. (1965). *ETUDE DE SOLS HALOMORPHES DU NORD - CAMEROUN (MAROUA).* ORSTON Yaoundé: Centre de ORSTOM de Yaoundé.

xxvii. ICRAF (International Centre for Research in Agroforestry) (1998). *Annual Report* for 1997.

xxviii. Joseph Abena Abena (2015). Inauguration du Port de Kribi: Les Autorités simulant l'arrivée de Biya. *La Nouvelle Expression.*

xxix. Jukka, H. and Aristide V. (1998). Land Cover/Land use classification of Urban Area; a Remote Sensing approach. *International Journal on Pattern Recognition and Artificial intelligence*. Vol. 12, n° 4 pp. 475-489.

xxx. Lambi C.M. and Kah E. F. (2012). The Application of Remote Sensing in the Evaluation of Land Use Dynamics in the Mount Cameroon Region. In *African Journal of Social Sciences*. Volume 3 Number 4. Pp 4-27.

xxxi. Lekedji, P. T. (1991). les grands traits géomorphologiques, géologiques et hydrogéologiques. *in Elevage et potentialité pastorales sahéliennes*, 13.

xxxii. Letouzey, R. (1968). *Etude phytogéographique du Cameroun*. Ed Paul le Chevalier, 511p.

xxxiii. Mandjek, C. S. (2005). *Atlas de la province extrême - nord Cameroun.* Marseille: IRD Edition.

xxxiv. Martin, B. (1985): Impact de l'homme sur la foret. Ecologie ou Economie? Paris pp 4-16; 111 Bibliographie extraite de *Revue Forestière Française*, Vol xxxvii.

xxxv. Meyer, W.B., & Turner, B. L., (1994). *Changes in Land Use and Land Cover: A Global Perspective,* Cambridge University Press, New York, N.Y., 537 p.

xxxvi. Microsoft ® Encarta ® 2009. © 1993-2008 Microsoft Corporation.

xxxvii. Minimal Urban Local Development Scheme (SMAUL) (2007): Urban Diagnosis Phase II.

xxxviii. Financement: Fonds Européen de Développement. *Projet n° 8 ACP CM 17/ 8 ACP TPS 052 Corperation Cameroun – Union Europeenne.*

xxxix. MINPAT, (2008). Répertoire des projets d'infrastructure Stratégique.

xl. MINPAT, (2012). Le projet de construction du Port en Eau Profonde de Kribi en Quelque Points.

xli. Mfoumban, N. G. C. (2016). Contribution de la modélisation a l'évaluation de la dynamique du trait de côte: le cas de la côte Méridional du Cameroun (1973 – 2015).

xlii. Neba Shu G. (2003). *Detection Analysis of Land Cover Dynamics in Moist Tropical Rain Forest of South Cameroon. Master's Thesis*. International institute of Geo-Information Science and Earth Observation, Enscheda, The Netherlands 61p.

xliii. Ngouanet, (2007). *Contribution des technologies spatiales à l'étude des risques et catastrophes naturels.* Communication à l'atelier de lancement official des activités de la Fondation AZOMARC et pour le compt de la commémoration du 21eme anniversaire de la catastrophe du Lac Nyos, Yaoundé Chambre d' Agriculture.

xliv. Nkwemoh, C. A. (1999). *The Impact of Agro-Pastoral Activities on the Physical Environment of the Mezam - Ngoketunjia Area*. Doctorat de 3ème Cycle Thesis, Univ. of Yaoundé 1, 282p.

xlv. Nkwemoh, C. A. (2011). *The Environmental Stresses of Urbanization in the Yaoundé Metropolis.* Unpublished Ph.D. Thesis, University of Buea. 301p.

xlvi. Nkwemoh, C. A. & Lambi, C.M. (2016). The Impact of Urbanization on Land Cover Dynamics in the Yaounde Metropolis (Cameroon). *The Annals of Faculty of Arts Letters and Social Sciences,* Vol 1. No.18 pp.199-220 University of Yaounde 1. ISSN: 0379-1793 (Online).

xlvii. Nkwemoh, C.A & Yungsi D, W. (2017). Application of Remote Sensing and GIS in the Evaluation of the Impact of the Lom Panga Hydro-Electric Power Dam Project on Vegetation Cover (Land Cover Dynamics), Cameroon. International *Journal of Humanities and Social Sciences* ISSN 2250-3226 Volume 7, Number 2 (2017), pp. 117-134.

xlviii. Nkwemoh, C.A, Tchindjang, M. & Afungang, R. N. (2017). The Impact of Urbanization on the Vegetation of Yaounde, (Cameroon). *International Journal of Innovative Research and Development*. Vol 6 No 5 pp. 5-18 . ISSN 2278-0211 (Online).

xlix. Nkwemoh, C. A. (2019). The Adverse Impact of the Kribi Sea Port and Urban expansion on the Land cover dynamics of Kribi. In eds Tchindjang M, Steck B et Bopda A.: *Contruire la ville portuire de demain en Afrique Atlantique. Eds EMS Menagement et Societé* pp. 527–549.

l. Nkwemoh, C. A. (2019). Urban Sprawl and the Implications on Land Cover Change in Bafoussam, Cameroon. *In International Journal of Innovative Research and Development*, Vol 12, Issue 8 December. Pp 120 – 130 DOI No.10.24940/ijird/2019/v8/i12/DEC19059.

li. Nkwemoh, C. A., Ngwateze M. M., & Chia P. T. (2022): Urban Expansion and Land.

lii. Cover Dynamics in Bamenda, Cameroon. *In The International Journal of Science and Technoledge*. Vol. 10 No. 8 pp. 1-14. ISSN: 2321- 919X (Online) – DOI No.: 10.24940/theijst/2022/v10/i8/ST2208-003

liii. Pagiola, S., Von Ritter, K. and Bishop, J (2004). Assessing the economic value of ecosystem conservation; *The World Bank, in collaboration with Nature Conservancy and IUCN*, *Environment* Dept., number 101.

liv. Pratt W. K. (1991*). Digital Image Processing*. Second Edition, Wiley, New York. Schneider, L.C., and R.G. Pontius, (2001). Modeling land-use change in the Ipswitch watershed, Massachusetts, USA, *Agriculture Ecosystems and Environment*, 85:83-94.

lv. Seignobos, C. (2000). Parcs et végétations anthropiques. *Atlas de la province de l'extrême – Nord*, 1 – 22.

lvi. Silvennoinen, H., Alho, J., Kolehmainen O. & Pukkala, T. (2001). Prediction models of landscape preference at the forest stand level. *Landscape and Urban Planning* 56: 11 – 20.

lvii. Silvennoinen, H., Pukkala, T. and Tahvanainen, L.(2002). Effect of Cutting on Scenic the Beauty of a Tree Stand. *Scandinavian Journal of Forest Research* 17: 263 – 273.

lviii. Stren, R.E. and R.R White, (eds.) *African cities in crisis: managing rapid urban growth*, Boulder, Col., Westview Press.

lix. Sterns, F, and Montag, T (1974). *The urban ecosystem: a holistic approach*. Dowden, Hutchinson and Ross, Stroudsburg.

lx. Suchel, J. (1972). *Répartition des pluies et régimes pluviométrique au Cameroun.* Travaux et Documents de Géographie Tropicale, 287p.

lxi. Susan, B. et al. (1992). Conserving Biological Diversity: A Strategy for Protected Areas in Asia-Pacific Region, *World Bank Technical Paper* No. 93.

lxii. Tarr, J. A. (1996). The search for the ultimate sink; Urban Pollution in Historical Perspectives, Akro. OH.

lxiii. Tahvanainen, L., Tyrväinen, L., Ihalainen, M., Vuorela, N & Kolehmanainen, O. (2001). Forest Management & Public Perceptions-Visual versus Verbal Information. *Landscape and Urban Planning*, 53:53-70.

lxiv. Tchatat, M. (1996). *Les Jardins de case agro-forestiers des basse terre humides du Cameroun: Etude de cas des zone forestières des province du Centre et du Sud*. Thèses de Doctorat ; UniversitéParis, VI. 146p.

lxv. Tonye E., Akono A. & Ndi Nyoungui A. (2000). *Le Traitement des images de Télédétection par exemple*. Gordon and Beach Science Publishers, Paris 179p.