American Journal of
Environment Studies
(AJES)

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American Journal of Environment Studies
ISSN 4520-4738 (Online)
Vol.7, Issue 4, pp 37 - 49, 2024

www.ajpojournals.org

Comparative Diagnosis of the Spatio-Temporal Evolution of Human Settlements Using Satellite Images in the Sprawling Bamenda, Cameroon

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Article history
Submitted 02.04.2024 Revised Version Received 08.05.2024 Accepted 12.06.2024

Abstract

Purpose: Human settlements define people's existence and play an important role in development. There is the dire need to comparatively diagnose human settlement evolution in the sprawling Bamenda city where a spatial, temporal, knowledge and evidence gaps currently exist on the subject matter. This study therefore aims to diagnoses, in a comparative manner, the spatio-temporal evolution of human settlements in Bamenda between the period 2000 to 2020.

Materials and Methods: The study used systematic field surveys via observation, structured informant interviews with relevant council authorities and 260 copies of questionnaire as primary sources of data collection. The administration of 260 copies of questionnaire was carried out using the simple random sampling techniques in the urban, peri-urban and rural peripheries of Bamendas I, II and III sub-divisions. The Bamenda City Council provided the satellite imageries showing land use patterns in Bamenda for 2000, 2010 and 2020 which were used to calculate settlement evolution over time.

Findings: Findings revealed that settlement land use, in relation to other land uses such as farmland, grassland, woodland, wetland, road and water bodies (rivers, streams and lake) increased in Bamenda from 17.37km^2 in 2000 to 54.31km^2 in 2020, given a net increase of 36.94km^2 in just over 20 years. Spatio-temporal evolution equally showed that Bamenda II Sub-division is the most urbanized with 29.78km^2 (54.77%) of all settlements, followed by Bamenda III with 15.18km^2 (28.02%) and lastly Bamenda I with 9.35km^2 (17.21%). The factors driving human settlement growth in the area are complex and many, including population growth, economic opportunities, geographical factors, social and cultural factors, relative political stability in relation to the neighbouring areas like Ndop, Kom and Oku, government incentive policy and the existence of urban planning and zoning laws.

Implications to Theory, Practice and Policy: By making a comparative diagnosis, the study proffers the need to strengthen spatial planning at the local level in organizing and managing the physical space in the urban, peri-urban and rural neighborhoods in the different sub-divisions of Bamenda. It recommends that the Bamenda City Council in collaboration with the three sub-divisional councils undertake a spatial planning assessment to help identify suitable land for other uses, create growth poles in the peripheries accompanied by socio-economic triggers (schools, financial institutions, health establishments and transport agencies) and the provision of a well-planned new layout to make the urban peripheries of Mandakwe and Mankon more attractive sites for settlement construction.

Keywords: *Human Settlement, Evolution, Satellite Imagery, Bamenda, Cameroon*

1.0 INTRODUCTION

Human settlements mean the totality of the human community-whether city, town, or village-with all the social, material, organizational, spiritual, and cultural elements that sustain it (Vancouver Declaration on Human Settlement, 1976 cited in Habitat 1996). They are places-large and small, urban and rural, formal and informal-where people live, learn, work and create. They also comprise an important component of the entire environment, namely the built environment and defines people's existence (South Africa Environment Outlook, 2012). Human settlements are ecumene areas, used to mean 'inhabited world' or dwelling place'. It refers to those parts of the earth where people have made their permanent home and to the economic activities that support that permanent occupation and use of land (Derek *et al*., 2009). The concept is both social and physical, and it can be defined as having two components; a human group, and the habitat of this group. As such, they are not just roads, houses and other infrastructure; they are also sets of social relationships. Considered in this way the issues of human settlements are wide-ranging - population, pollution, employment, social welfare, health and food as well as the more normally understood questions of shelter (Overseas Development Institute, 1977). They can be differentiated by many factors, such as topography, location, size, proximity and management structure (South Africa Environment Outlook, 2012).

Human settlements lie at the centre of global efforts to address the multiple challenges facing sustainable development (South Africa Environment Outlook, xx). In cities for instance, the United Nations sees human settlements as key influences on humanity's environmental and social well-being in the coming century (Glesson and Low, 2000). They can contribute towards economic development as long as they are able to operate efficiently, overcome inadequacies in their infrastructure and provide conditions favourable to the formation of human capital (Donald *et al*., 1998). As such, human settlement policies have an important role to play in overcoming the inequalities that now exist, as they are a means for providing the lowest income households with housing and urban services (Donald *et al*., 1998).

Achieving sustainable human settlements continue till date to be enshrined in every international development framework agenda like the Millenium and now the Sustainable Developments Goals and the Habitat Agenda. The Millennium Development Goal (MDG) 7 did set important targets relating to human settlement, in line with the principles contained in Agenda 21 and the Habitat Agenda. Whereas Target 10 of the MDG aimed to halve the proportion of people without safe drinking water by the year 2015, Target 11 committed countries collectively to improving the lives of 100 million slum dwellers by 2020. In the same vein, Goal 11 of the SDGs launched in 2015 by the United Nations General Assembly titled "sustainable cities and communities", seeks to make human settlements in general sustainable. The official mission of SDG 11 is to "Make cities inclusive, safe, resilient and sustainable".

The Habitat Agenda is an agenda for the sustainable development of human settlements. It was developed at the Second United Nations Conference on Human Settlement, Habitat II, held in Istanbul, Turkey in 1996, and it includes the goals, principles and commitments to turn the vision of sustainable human settlement into reality. There were two Habitats which were intended to cross fertilise one another. One was a formal conference of governments; the other was a forum of those nongovernmental groups with views on human settlements. The first UN conference on human settlements, Habitat I in Vancouver 1976, was a product of the Stockholm conference in 1972.

Whereas the Stockholm conference was about international environmental problems, Habitat I was convened to address local environmental problems such as housing, shelter, infrastructure, diminishing water supply, transport, etc. Astonishingly, human settlements had no place on the agenda in the preparatory meetings of the Rio Declaration (Carlson 1996 cited in Glesson and Low, 2000). However, a special chapter on human settlements was included in Agenda 21. As an overall objective the seventh chapter of Agenda 21 mentions the improvement of the social, economic and environmental quality of human settlements and of the living and working environments of all people, in particular the urban and rural poor. Human settlements, especially cities, were recognised both as a source of many global environmental problems and also as a key to their solution.

After Rio, the UN General Assembly decided that the cross-sectoral issue of human settlements was of crucial importance and decided to convene Habitat II. UNCED (United Nations Conference on Environment and Development) or Earth Summit recognised the proper management of human settlements as a prerequisite to ESD. The United Nations Conference on Human Settlements took place in Istanbul from 3–14 June 1996. The overall theme of the conference was 'adequate shelter for all' and 'ESD in an urbanising world'. It can be viewed as the culmination of decades of efforts by the UN and other agencies to deal with the vast panorama of problems and sectors affecting the sustainability of planet Earth in supporting a rapidly increasing and urbanising human population (Carlson 1996 cited in Glesson and Low, 2000).

The contemporary human settlement pattern is marked by rapid urbanisation, an increasing land area taken up by cities and the growth of mega-cities, especially in the developing world (Glesson and Low, 2000). Indeed, the term 'wild urbanisation' has been coined to describe the explosive growth of developing cities. Of the fifteen largest urban agglomerations in 1950, four were in developing countries. In 1997 eleven out of fifteen are located in developing countries (Glesson and Low, 2000). The urbanization of the world has received increasing attention over recent decades. A common refrain is that, cities have today become the major form of human settlement (Silver *et al*., 2022). Closely associated with the urbanisation process is rapid urban growth which is a recent phenomenon, as demographic evolutions of cities have consequences on their spatial growth (Pumain, 2018). Until recent times, few settlements reached the population size of more than a few thousand inhabitants. For instance, the first urban settlement to reach a population of one million was the city of London by around. A.D. 1810.

By 1982, approximately 175 cities in the world had crossed the one million population mark. By 2001, some 48% of the world's population lived in urban settlements compared to only 35% in the year 1800. Some 411 metropolitan areas each having in excess of 1 million people were registered by 2000; in 1900, there were only 12. In 2006, as many as 25 metropolises had populations of 10 million or more people, called megacities. In 1900, none was of that size (Fellman *et al*., 2008). Though with variations from continent to continent and from region to region, it follows that since the world's total population has greatly increased over the centuries, so too is its urban component-from 3% in 1880 to half (50%) in 2007. In 2001, some 48% of the world's population lived in urban settlements compared to only 3% in the year 1800. The urban share of the total has grown everywhere as urbanisation has spread to all parts of the globe. Indeed, in 2007, for the first time in history, more people were living in cities than in rural areas (Fellman *et al*., 2008). This is particularly so because cities have now become the major form of human settlement due to

urbanisation of the world, a phenomenon which has received increasing attention over recent decades (Silver *et al*., 2022).

Human settlement development is not without consequences on the spatial organisation or arrangement of particularly settlements (Pumain, 2018), which represent the different levels and opportunities of adaptation of humans and their social groups to the physical environment (Warf, 2006). It also affects economic development as economic development can be stimulated by the establishment of urban settlements in the periphery, which, through the process of agglomeration, stimulate further development across the entire region (Hanks, 2011). As settlements evolve, they also consume the environment (Gleeson and Low, 2000). Again, settlement evolution defines the underlying physical structure of an urban settlement, which is prelude to planning for urban conservation (Watson *et al*., 2003). In china for instance, Zhu *et al*., (2009) have showed that *in situ* urbanization is not an isolated, short-lived, and unique phenomenon, but is instead part of recent and profound changes in human settlement systems generated by new conditions, which did not exist in the past in developed countries when these were undergoing a process of urbanization.

In Bamenda in the Northwest Region of Cameroon, human settlements are observed as organized groupings of human habitation. Three types of such settlements exist, including, urban (densely populated), peri-urban (moderately populated) and rural (sparsely populated) settlements. Each of these settlement types reflects human relationship with the environment. Bamenda has experienced rapid urbanization over the years which has triggered the development of human settlements in all directions. As the population of the Bamenda is increasing, so too is the densification as settlement growth takes place in all directions of north, south, east and west, manifested through increase in settlements development and population numbers. Nowadays, rapid unplanned urbanisation of Bamenda has assumed an increasing trend with diverse implications such as the shortage of land in the older and more congested sites, overcrowded homes, lack of water, poor sanitation, pollution, waste management, amongst others.

Bamenda is the largest town in Mezam Division and serves as the regional headquarters of the Northwest Region of Cameroon. It is located between Latitudes 5°51’0’ and 6°3’0’ North of the Equator and Longitudes 10°3’0’’ and 10°15’0’’ East of the Greenwich Meridian covering a surface area of some 2,840km^2 (Bamenda City Council, 2023). It is bounded to the North by Tubah Sub-division, to the South by Santa Sub-division, to the West by Mbengwi Sub-division, to the South West by Bali Sub-division and to the North East by Bafut Sub-division (Figure 1). Bamenda is made up of three sub-divisions; Bamenda I, Bamenda II and Bamenda III sub-divisions.

American Journal of Environment Studies
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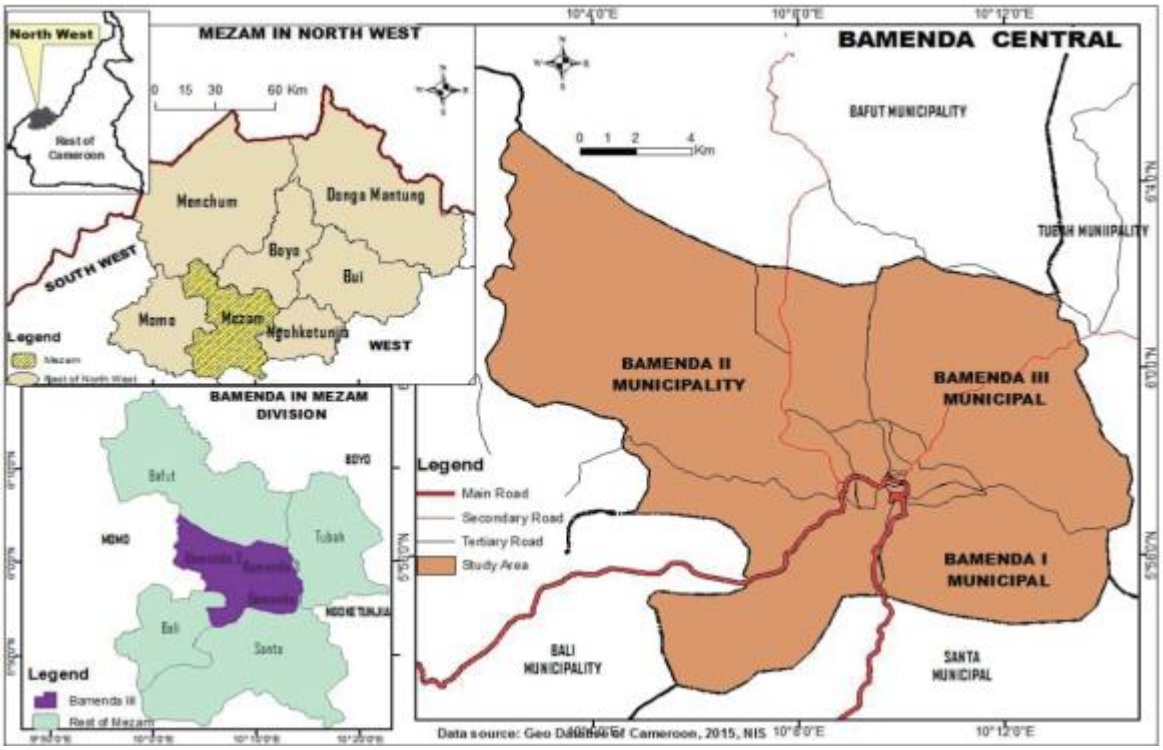

Figure 1: Location of Bamenda in Mezam Division in the Northwest Region of Cameroon

Source: Geo-Database of Cameroon (2016)

The choice and justification of the study area for this study (Bamenda) as a case study arises from the fact that Bamenda city is one of the rapidly urbanizing cities in Cameroon which happens to be the main metropolitan city in the Northwest Region of Cameroon. The city thus, remains a significant hub to the surrounding sub-divisions and satellite areas given that majority of people from the different sub-divisions happens to resides in this city for socio-economic sustenance, relative political stability and peace within the context of the on-going socio-political crisis in the Northwest and Southwest Regions of Cameroon, hence its rapidly increasing human settlements proportion in relation to other land use types.

The problem under study lies in the fact that Bamenda city has experienced rapid urbanization over the years. This has triggered the spatio-temporal evolution of Bamenda. The dynamics in the population of the Bamenda city drives rapid urban expansion evident in localities such as Nkwen and Mankon. As the population of the Bamenda city is increasing, so too is the city densifying as the urban area grows into the various directions of north, south, east and west. This is clearly marked by sprawl, with the Bamenda urban space expanding into peri-urban and rural landscapes. This is manifested in increase in buildup area and urban population numbers. Recently, the urbanization of Bamenda city has assumed an increasing trend with diverse implications. This is currently very significant as it influences human settlement evolution over time, which has both positive and negative on the environment and the population. Despite this prevailing scenario, there is the conspicuous absence from the literature of a comparative study using satellite imageries which aims to diagnose the evolution of human settlement land use in Bamenda between 2000 and 2020.

Related works on land use in Bamenda have all focused on land use dynamics and wetland management in Bamenda (Kimengsi, 2016), implications of land use/cover dynamics on resources development in Tubah Sub-Division in Bamenda (Balgah and Nformi, 2017), peri-urban land use dynamics and development implications in the Bamenda III Sub-division (Kimengsi *et al*., 2017), land use dynamics and variations in sprawl across municipalities in Bamenda (Fombe and Acha, 2020), land cover/use change and its effects on local ecosystems in the Bamenda highlands (Ndoh and Kah, 2022) and land cover dynamics and implications on water resources in Bamenda III Sub-Division (Ndikebeng *et al*., 2023).

There is consequently the dire need to comparatively diagnose human settlement land use evolution in the sprawling Bamenda where a spatial, temporal, knowledge and evidence gap currently exist as well as determining the factors responsible. The study therefore diagnoses, in a comparative manner, the human settlement land use evolution in Bamenda between the period 2000 to 2020. It comparatively diagnoses and analyse the spatio-temporal evolution of human settlements in the city during the last 20 years using satellite land use imageries and determine the contributing factors. The study therefore sets out to answers the following research questions: How has human settlements evolve in Bamenda city over the last 2 decades? What factors influence the expansion or evolution of such settlements?

Answering these questions is significant to urban and rural planners, sub-divisional and city council authorities of Bamenda, the regional council authorities, policy makers like the government of Cameroon through the Ministry of Urban Development and Housing (MINDUH) and the residents in that it will strengthen spatial planning at the local level in organizing and managing the physical space in the urban, peri-urban and rural neighborhoods in the different sub-divisions of Bamenda.

2.0 MATERIALS AND METHODS

The study employed a survey and diagnostic research designs/approach. The survey design made use of surveys via field observation, structured informant interviews and questionnaire administration in order to determine changes in settlement evolution and influential factors in Bamenda. The diagnostic design helped to ascertain the rate of change in settlement coverage during the years 2000 to 2020. The realization of this study was a combination of literature review from secondary sources and systematic field surveys for primary sources. Secondary sources constituted of published materials from the libraries of The University of Bamenda and the Department of Geography and Planning. Institutions such as the Bamenda City Council provided the satellite imageries of suitable spatial and temporal resolutions for Bamenda city between 2000 and 2020 showing the different land use patterns which were used to calculate settlement evolution over time. Various online sources also provided text and e-books and articles for review as background information.

Primary sources made use of systematic field surveys. These constituted repeatedly planned field observation of changes in urban, peri-urban and rural settlements and structured informant interview with an interview guide with quarter heads in some of the neighbourhoods. This information helped to give relevant information on settlement change during the period 2000 to 2020 and factors responsible. This was followed by the purposive administration of questionnaires to stakeholders in some 260 households in some of the rapidly expanding neighbourhoods in the

Bamenda I, II and III Sub-divisions (Table 1). The stakeholders were administered to landlords/house owners (100), indigenes (140), in-migrants who have stayed up to 10 years in the area (10) and identified government officials in charge of housing development (10). The aim was to determine from the population the factors of human settlement evolution in the town.

Table 1: Questionnaire Administration to Stakeholders in Bamenda

S/N	Municipalities	Sampled population
1	Bamenda I	50
2	Bamenda II	110
3	Bamenda III	100
Total		**260**

With the aid of ARCGIS, Landsat satellite land use maps of Bamenda were produced to show settlement change during the years 2000, 2010 and 2020 respectively. With the use of SPSS, qualitative data was also processed and presented in graphs and percentages. These showed the surface area (in km^2) under settlement occupation during the years 2000, 2010 and 2020. Cartographic analysis employed satellite images (Landsat 30m spatial resolution images) of the study area from 2000 to 2020 in order to depict land cover change. Image processing techniques via the remote sensing algorithm too ENVI was used to extract to extract build-up areas from the obtained maps, which showed changes in farmland, settlement, grassland, woodland, wetland and lake cover for a 20 years period. The bands of land use maps of the area derived from Landsat images downloaded obtained from the Bamenda City Council were imported to Environment for Visualizing Images (ENVI) image processing software. While in ENVI, the bands are stacked, and displayed using the false colours.

Thereafter, a region of interest (Roi) for the different land cover types was created with the help of the colours reflectance using the spectral signatures. This was followed by classification of the saved Roi. The classification was then generated and verified as an ARCGIS vector file with the different classes attributed to suit the land cover type. The individual pixels of the different land cover types were then dissolved to one class for each type. Thereafter, the surface area covered by each land cover class was calculated and the results copied to excel for further analysis. Finally, the real colours for the land cover types were attributed together with the legend, north point, grid and scale to produce the final maps. Changes over time was analysed by comparing the 3 images taken at different times while spatial analysis helped to understand the distribution of human settlements.

3.0 FINDINGS

Settlement Land Use Evolution in Bamenda (2000-2020)

Results show that settlement land use, in relation to other land uses such as farmland, grassland, woodland, wetland, road and water bodies (rivers, streams and lake) has significantly increased in Bamenda. This is evident through increase in the surface area under settlement cover as the years pass by from 2000 to 2020 (Figure 2A-C).

American Journal of Environment Studies
ISSN 4520-4738 (Online)
Vol.7, Issue 4, pp 37 - 49, 2024
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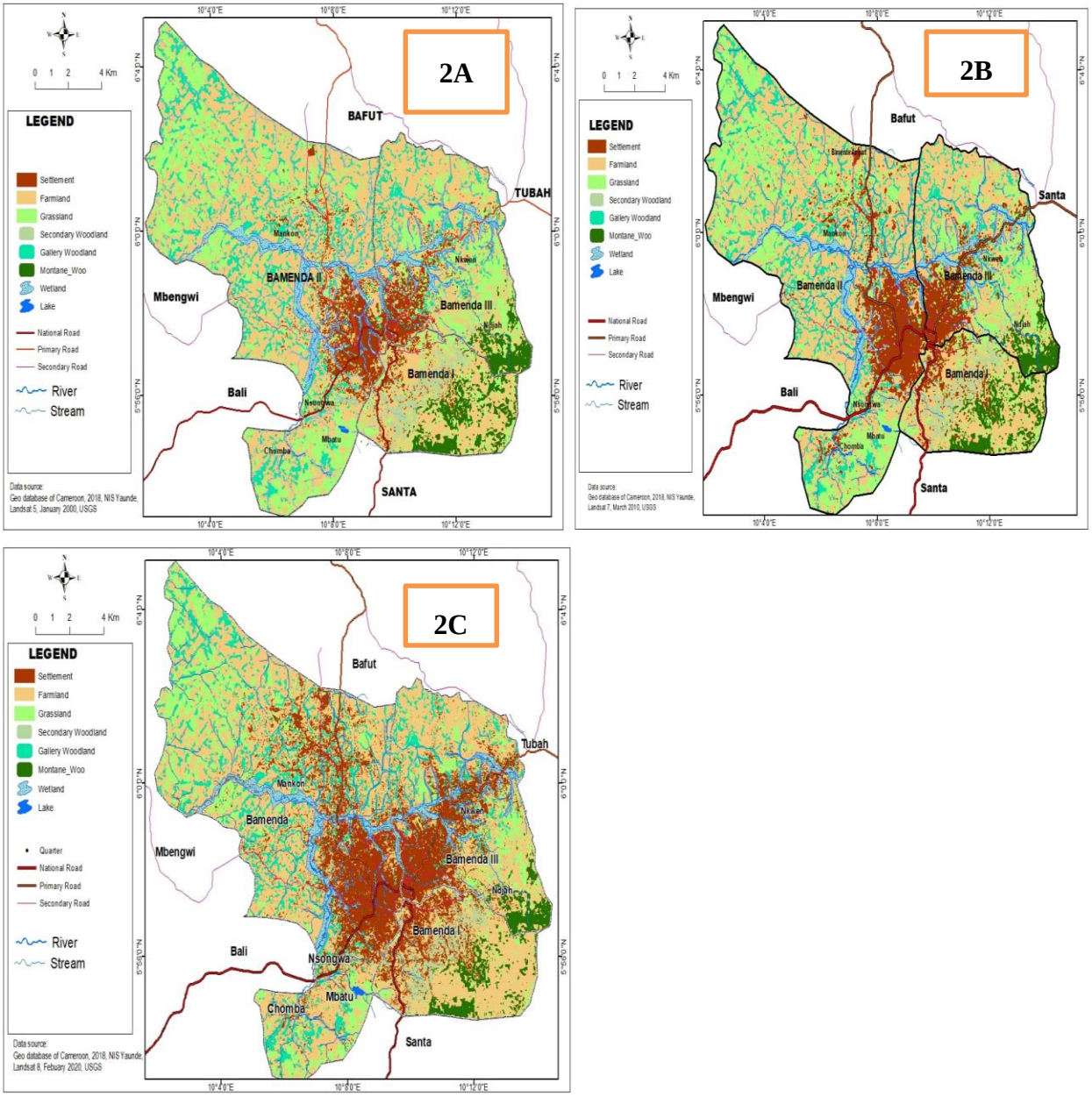

Figure 2: Land Use Pattern in Bamenda (2000-2020)

Source: USGS, 2000; NIS (Yaounde), 2018; BCC, 2023

2A-Settlement situation in 2000

2B-Settlement situation in 2010

2C-Settlement situation in 2020

Figures 2A-C vividly presents a situation of settlement land use evolution in Bamenda from 2000 to 2020 on a spatio-temporal basis. The development of settlements is shown for the different Sub-divisions (Bamenda I, II and III) that make up Bamenda as seen in Figure 3.

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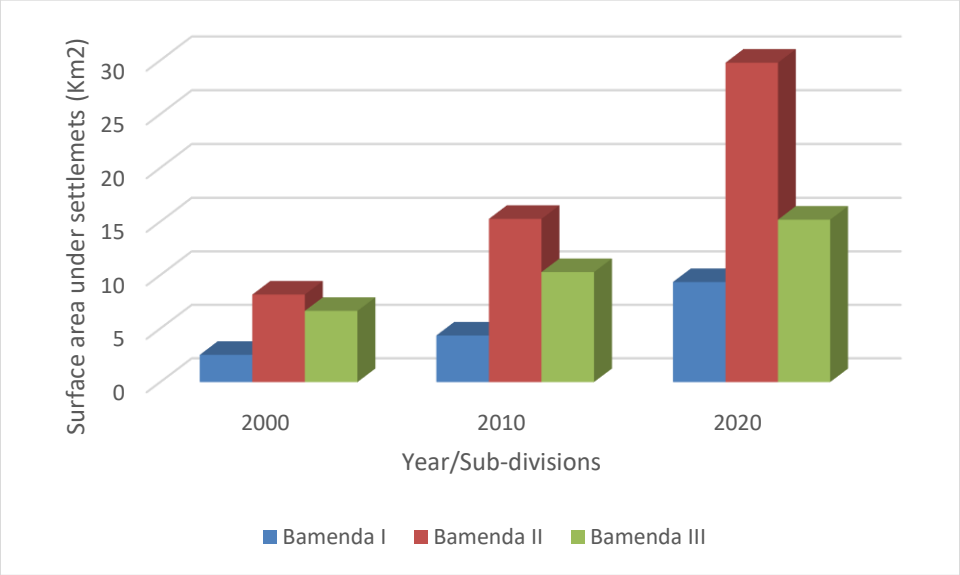

Figure 3: Spatio-Temporal Evolution of Settlements in Bamenda I, II and III (2000-2010)

Source: Computed by Author Based on Satellite Images for 2000, 2010 and 2020

Figure 3 presents the spatio-temporal evolution of settlements in terms of surface area under coverage during the periods 2000 to 2020 in Bamenda. Overall, it shows that over 54.31km^2 of the land surface of Bamenda was covered by settlements in 2020. The result also shows that throughout history till 2000, the surface area under settlement cover in Bamenda stood at only 17.37km^2. This however leapfrogged from 17.37km^2 in 2000 to 29.88km^2 in 2010 and finally to an overwhelming 54.31km^2 in 2020, clearly showing a remarkable increase over time. The net increase in terms of surface area under settlement cover between 2000 and 2020 stood at 36.94km^2 of land surface occupied. This is in contrast to farmlands which dominated many parts of Bamenda (105.68km^2 as against 17.37km^2 for settlements) in 2000. Spatial coverage in Figure 3 equally shows disparity in settlement evolution between the 3 Sub-divisions over the years. In all, Bamenda II Sub-division witnessed the highest evolution from 8.18km^2 of land surface under settlements in 2000 to 29.78km^2 in 2020. This was followed by Bamenda III Sub-division, moving from 6.65km^2 in 2000 to 15.18km^2 in 2020. The least is Bamenda III Sub-division which increased from 2.54km^2 in 2000 to 9.35km^2 in 2020. As such, Bamenda II Sub-division is the most urbanized of all the Sub-divisions, with over 54.77% of all settlements, followed by Bamenda III with 28.02% and Bamenda I hosting 17.21% of all settlements.

Factors Influencing Human Settlement Evolution in Bamenda

The observed factors influencing the rapid human settlement evolution in Bamenda are complex and many including population growth, presence of economic opportunities, geographical factors, social and cultural factors, relative political stability, government incentives and the existence of urban planning and zoning laws (Figure 4).

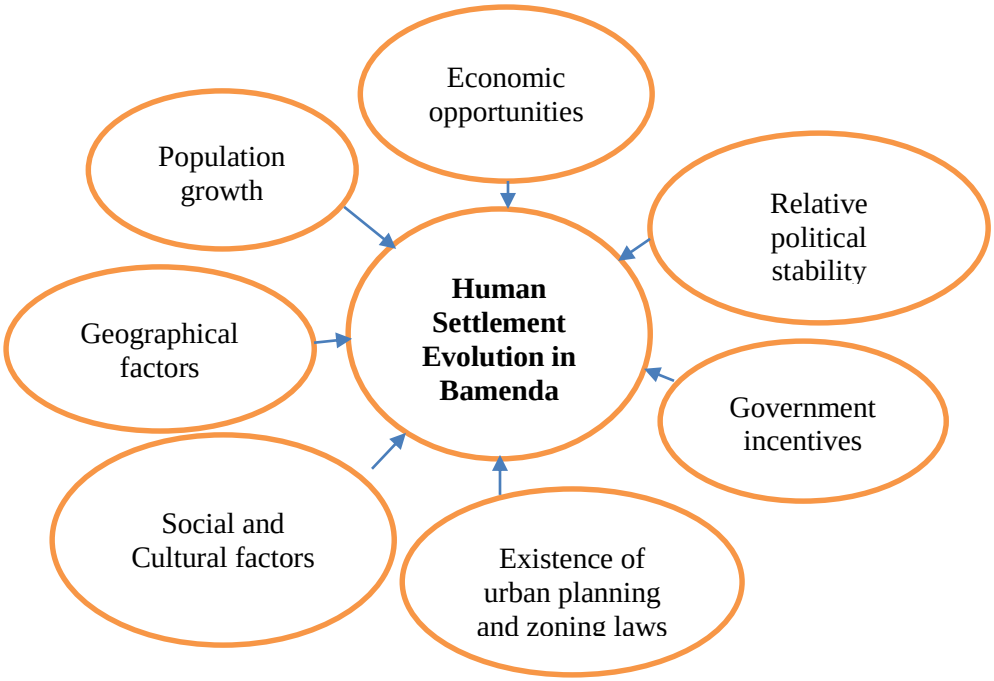

Figure 4: Factors of Human Settlement Evolution in Bamenda

Source: Conceived by Author Based on Fieldwork (2023)

From Figure 4, the factors influencing human settlement evolution in Bamenda include population growth (natural increase and rural-urban migration), economic opportunities (access to jobs and economic activities which attracts people to settle in an area), geographical factors (favourable climate for human settlement), availability of basic infrastructure (including roads, telecommunication, electricity, water which can all support economic growth), social and cultural factors (the presence of educational institutions, health care facilities, housing and other social amenities which have all attracted people especially from the neighbouring rural areas to settle in the town), political stability (Bamenda is safer and more secures compared the neighbouring rural areas in terms of crime rates and a stable political atmosphere since the advent of the socio-political crisis in the Northwest and Southwest of Cameroon in 2016, and so has drawn people from neighbouring peri-urban and rural areas such as Oku, Kom, Kumbo rural, etc into the town), government incentive policies (road construction and rehabilitation, social housing, markets creation, tax exemption, etc), and the existence of urban planning and zoning laws (which has facilitated some sort of organized sustainable settlement growth in some areas like Up-Station in Mendakwe.

4.0 CONCLUSION AND RECOMMENDATIONS

Human settlements play a vital role in development because nearly everything that happens to man takes place in settlements. There is consequently the need to comparatively diagnose human settlement growth in the sprawling Bamenda where a spatial, temporal, knowledge and evidence gap currently exist on the subject matter. Findings show that settlement land use, in relation to other land uses such as farmland, grassland, woodland, wetland, road and water bodies (rivers,

streams and lake) has significantly increased in Bamenda between 2000 to 2023 though with disparity between sub-divisions. Overall, over 54.31km^2 of the land surface of Bamenda was covered by settlements in 2020, from 17.37km^2 in the year 2000. The net increase in terms of surface area under settlement cover between 2000 and 2020 stood at 36.94km^2 of land surface, suggesting a rapid growth rate in just 20 years in contrast to farmlands which dominated many parts of Bamenda (105.68km^2 as against 17.37km^2 for settlements) in 2000. Spatial disparity in settlement growth equally showed that Bamenda II sub-division has witnessed the most rapid growth with over 54.77% of all settlements, followed by Bamenda III with 28.02% and Bamenda I hosting 17.21% of all settlements between 2000 and 2020. It was also found that the process of human settlement growth in Bamenda is driven by several complex factor, including population growth, economic opportunities, geographical factors, social and cultural factors, relative political stability in relation to the neighbouring cities like Ndop, Kom and Oku, government incentive policy and the existence of urban planning and zoning laws. Based on the findings, there of need to strengthen spatial planning at the local level in organizing and managing the physical space in the urban, peri-urban and rural neighborhoods in the different sub-divisions of the city through the following proposed recommendations.

1. The Bamenda City Council in collaboration with the Sub-Division councils of Bamendas I, II and III should undertake a spatial planning assessment in the peripheries on Nkwen, Mendakwe and Mankon. This will help identify the suitability of land for other uses.
2. The study recommends the creation of growth poles in the peripheries accompanied by socio-economic triggers. Markets, university institutes (like a faculty or school of The University of Bamenda), financial institutions, health establishments and transport agencies should be relocated in these areas in order to attract population and encourage spatial settlement growth.
3. There should also be well planned new layouts in Mendakwe and Mankon which give the urban peripheries attractive sites for settlement construction.

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