Macrothink Institute™

International Journal of Global Sustainability
ISSN 1937-7924
2023, Vol. 7, No. 1

Land Cover Dynamics and Implications on Water Resources in Bamenda III Sub-Division, North West Region, Cameroon

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Received: May 4, 2023 Accepted: May 23, 2023 Published: June 1, 2023

doi:10.5296/ijgs.v7i1.21031 URL: https://doi.org/10.5296/ijgs.v7i1.21031

Abstract

There exists a complex relationship between land use change and hydrology as exemplified by the quantification of its spatio-temporal impacts. Water resources are stressed by significant land use alterations linked to rapid population growth and urbanization in Bamenda III. This paper analyzes the trend of land use activities in Bamenda III Sub-Division, using LANDSAT images of 1986, 2003 and 2022, to portray land use dynamism over space, their impacts on water resources, and the planning implications thereof. To achieve this, a random survey of 70 households in Bamenda III was conducted, complemented by key informant interviews. The results indicate that significant changes have been recorded in land uses brought about by population growth and urbanization. Seventy percent (70%) of water resources including wetlands and water catchments have been lost to infrastructural development and agriculture. The expansion, and replacement of land uses has stressed water resources, resulting in watershed degradation, deforestation and floods. Water sources like streams and rivers have witnessed a decline in their flow characteristics. The study recommends the strict implementation of town planning laws, to assure the sustainability of water resources.

Keywords: land cover change, water resources, population growth, watershed degradation

1. Introduction

Land use change affects water resources; this is mirrored through changes in both runoff behavior and the balance between evaporation, groundwater recharge and stream discharge in specific areas and in entire wetlands and catchments (Sahin and Hall, 1996; DeFries and Eshleman, 2004, Shrivastava, 2019). The global land cover has witnessed modifications from a mosaic of native woodlands, forests, and grasslands to an increasingly impacted mixture of degraded and fragmented native habitats, exotic croplands, and impervious urban surfaces (Goldewijk, 2001). Land use relates to the processes by which human activities shape land cover. It includes agriculture, residential, commercial, and recreational land uses, among others. The change in land use entails a shift or an intensification of existing use (Gurnell *et al.,* 2008). These processes are unequivocally linked to water resources and the environment (Kometa and Kimengsi, 2018), with further impact on global change processes. For instance, river discharge worldwide has increased noticeably since 1900, altering the hydrologic system with potentially large impacts on the environment (Shrivastava, 2019).

Changes in land cover and land management practices have been regarded as the key influencing factors behind the alteration of hydrological systems. Land use modification and/or transformation globally is greatly perceived as the primary catalyst of water resources degradation. Urbanization, increasing population and economic competition induce land use changes in developing countries like Cameroon. This alters runoff behavior, groundwater recharge, atmospheric stability and impacts on the population of Bamenda III Sub-Division (Kimengsi and Balgah, 2016).

The physical environment of Bamenda III Sub-Division and its environs that knew little or no stress prior to the 1980s has witnessed progressive change of the land cover and land use patterns over the past three to four decades. The quality and quantity of water in a watershed may determine the different human activities which are carried out including cattle rearing and gardening (Kometa and Ashu, 2012). Several catchments, rivers, wetlands have undergone marked reduction in flow rates and surface area, with huge repercussions on livelihoods, agriculture and biodiversity. This paper bridges a knowledge gap in previous studies like (Mbanga 2018; Tume, 2021; Tume and Kongnso, 2022) on context specific hydrological implications of land use change. These authors assessed water accessibility through the impacts of climate change and human settlement dynamics respectively, but failed to show their links to hydrology in Bamenda III subdivision Water resources are threatened by inappropriate land use planning and inadequate implementation measures. This article sought to analyse the pattern of land use modification and replacement over time and consequences thereof on water resources in Bamenda III Sub-Division.

2. Study Area and Methods

Bamenda III (Figure 1) is one of the seven Sub-Divisions of Bamenda council area, Mezam division. It is located in the Northwest region of Cameroon and lies between latitudes 6’15 and 6’25N of the equator and longitude 10’02 and 10’15 of the Greenwich meridian. Bamenda III council is the gate way to and from the division of Boyo, Ngoketunjia, Bui and Donga Mantung. This Sub-Division is an important transit for passengers and goods to and from the

Northwest region. It is linked to the Northwest region by the Bamenda-Kumbo highway, Bamenda-Fundong highway, Bamenda-Wum and Bamenda-Mamfe highways. To the West is the Bamenda-Bafoussam Highway. It is bounded by Tubah council to the west, Bamenda I Sub-Divisional council to the north, Bamenda II Sub-Divisional council to the east and Bafut Council to the south. It has a total surface area of 22.9km^2 and population estimated at above 186000 inhabitants (Bamenda III Council, 2012). The population is largely cosmopolitan, made up of indigenous - Nkwen and Ndzah people together with migrants from all over the Northwest and West regions, and other regions of Cameroon and Nigeria (Bamenda III Council, 2012).

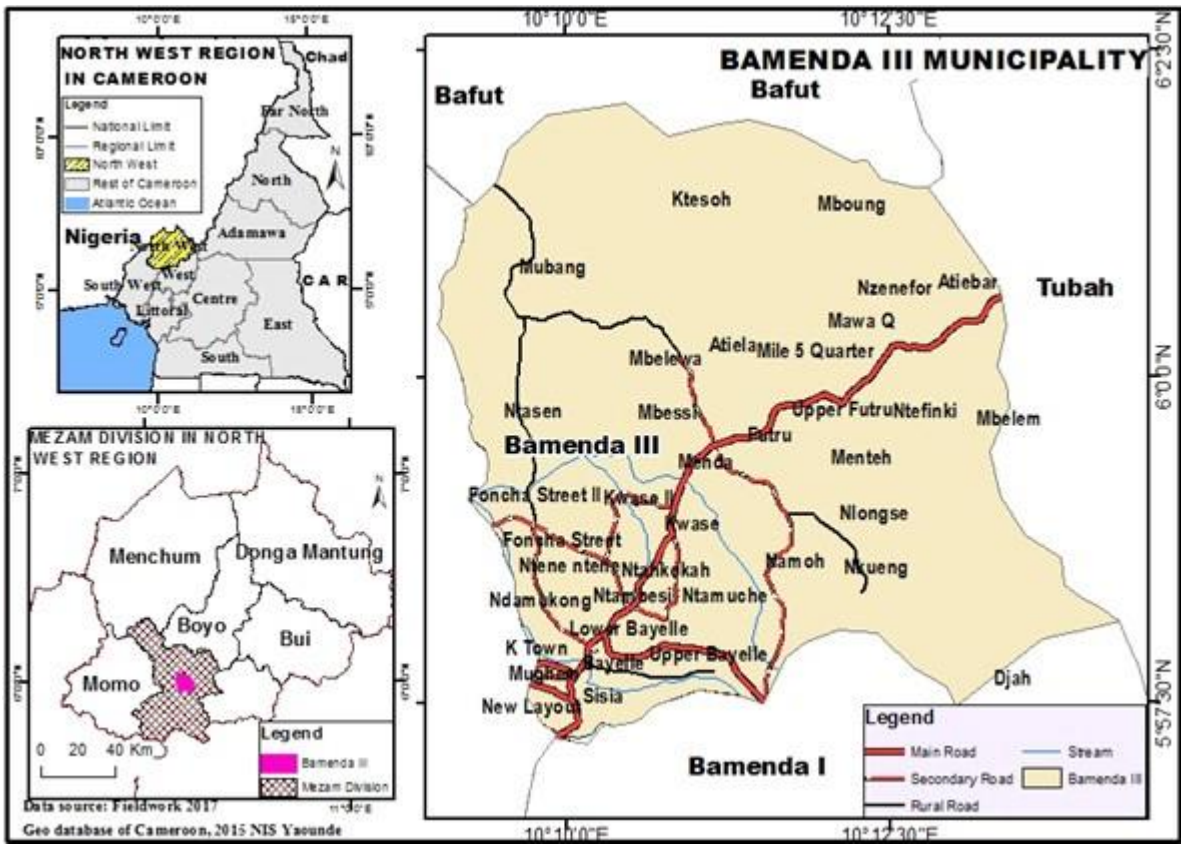

Figure 1: Location of Bamenda III Sub-Division in Mezam Division

Methods

Data for the study was collected for one month (August 2018) through primary sources (Field observation, interviews and questionnaires). The key instrument used was a semi-structured questionnaire (75). This took into consideration socio-economic characteristics of the population, the trends and patterns of land use change, impacts of land use on water resources, and future planning implications thereof. Socio-demographic information such as age, gender, education, occupation, duration/duration of stay in community were obtained. The sampling frame for the study was heads of households and quarter heads from selected villages. A simple random sampling technique was used to select households for questionnaire administration and

interview based on the "draw method". This was to provide equal chances for household head to be selected in the sample and provide essential information. By this method, the total population of the selected quarters of the two villages constituting Bamenda III Sub-Division (Nkwen and Ndzah) was obtained alongside the total population of the entire Sub-Division. Based on the number of questionnaire (N=75), the percentage of questionnaires administered per quarter were obtained. This constituted the sampling unit. The same procedure applied for interviews (N=15). A significant proportion of Nkwen constitute Bamenda urban area while the whole of Ndzah is rural.

Table 1. Distribution of questionnaires

Villages	Neighbourhoods	Population (2017)	Number of questionnaires	Number returned
Nkwen Urban	Ntabru	2888	03	03
	Mugheb	8300	06	04
	Bayelle	36885	27	25
	Ntaghem	8054	06	06
	Ntakikah	5926	04	04
	Nkwasi	3237	02	02
	Sisia	11912	08	08
	Ntenefor	8600	06	05
	Futru	1232	01	01
	Atiela	476	01	01
Nkwen Rural	Mbelem	1348	01	01
	Ntasen	1893	02	02
	Njenefor	1262	01	01
	Alahlie	630	01	01
Ndzah	Mokop, Mobakuh, Terrekoh	796	01	01
Total	24 neighborhoods	93439	75	70

Data was collected from 70 household heads out of the 75 households targeted, using a systematic sampling design with emphasis on residents of the area that have lived in Bamenda III for more than one decade and consisted. This consisted of both men and women. Ninety-three percent (93%) of the questionnaire were retrieved for Bamenda III Sub-Division. Data were analyzed both quantitatively and qualitatively. The Pearson's Product Moment Correlation with the aid of SPSS version 21.0 was used to show the relationship between land use patterns and water resources in Bamenda III Sub-Division. The analyzed data were presented qualitatively through charts, graphs, tables, maps and photographs. The presented data shows the association between land use dynamics and impacts on water resources in Bamenda III Sub-Division.

3. Results

3.1 Trends and pattern of land uses in Bamenda III Sub-Division

Prior to the 1990s, agriculture was the principal land use that predominated the Bamenda III municipality. This was the main sector of concentration in the municipality. Nearly all inhabitants during this period were involved in agriculture in one way or the other because the area was still in a stage of terra incognita. This was immediately followed by settlement land use. Next in line was the commercial land use alongside recreational land use. The availability of water resources during this period witnessed little stress in quality and quantity. The pattern of land uses during this period had limited negative impacts on water availability and accessibility because the rate of settlements and commercial activities was still not alarming. Settlement and commercial land uses emerged especially around the Central Business District. In spite of this, agricultural land use still dominated.

The period between 1990 and 2000 witnessed an increase in the migratory pattern of people from the rural areas. Rural flight and natural increase led to an upsurge in the population. This period witnessed intense pressure on land uses and infrastructures. However, agricultural land use was still dominant. This period witnessed an increase in refuse disposal in streams brooks and brooklets. Coupled with poor waste management systems during this period, water sources were contaminated. Moreover, this period also witnessed recreation and communication activities alongside settlement and agriculture. Commercial activities skyrocketed especially in areas that constitute part of the CBD. The availability of water resources here witnessed a remarkable change due to rapid multiplication, expansion and replacement of land uses.

Between the period 2000 and 2018, commercial land use emerged as the dominant land use in the area. More attention was tilted towards commercial activities due to population increase. Studies show that between this period, the surface area for farmlands in Bamenda III reduced from 2943 ha to 1389 ha with a corresponding increase in the surface area for settlements from 1389 ha to 2943 ha (Gwan and Kimengsi, 2020). Costs of living during this period increased resulting to illegal constructions and the development of squatters and slums within the municipality. Many businesses came to existence (28.3%) while 25% of the population were still involved in both agriculture, settlement and commercial activities. This change greatly stressed the hydrological system with actual and potential impacts on water resources. For instance, several catchments during this period were degraded and wetlands reclaimed. Settlement activities increased and altered water flow. Significant land use changes have been registered over the past 25 years. Settlement and commercial land uses for example increased due to widespread construction and extension into wetlands and catchments (Figure 2).

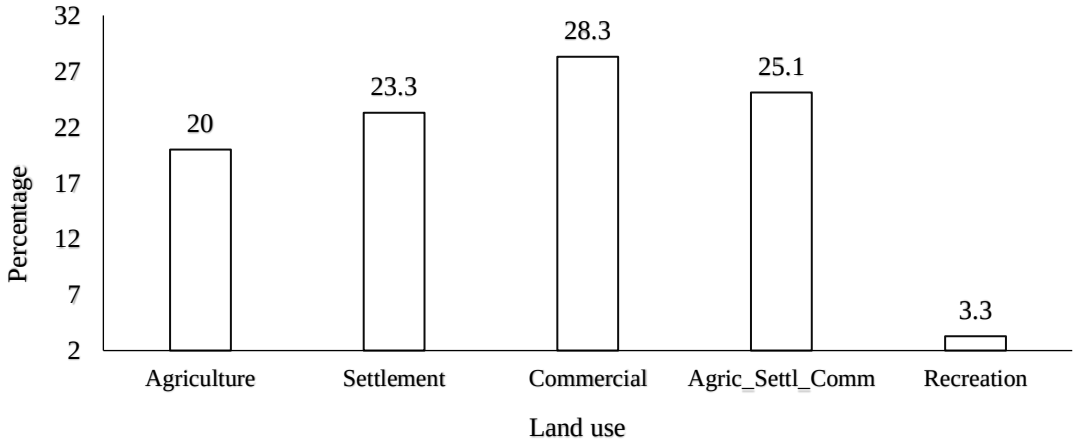

Figure 2. Dominant land uses in 2018

Though commerce and settlement land uses emerged dominant, communication and recreational land uses also evolved during this period. Agricultural land use also intensified because of the increasing population and the need for food to support and sustain the growing population. This has led to agricultural intensification, expansion and encroachment of wetland and a reduction in stream volume and deforestation. This sector needs to be improved so as to make modern urban agriculture an integral part of urban land use plan

There is an increasing urbanization pattern in Bamenda III urban space. This rapid socio-economic development drives land use change through increasing population, development pressures in-proper land use planning and competition for water resources, thus contributing to the degradation of water resources on spatial and temporal scale, affecting water yields, evaporation, groundwater recharge and runoff. However, there has been growing knowledge of the land use implications on water resources in Bamenda Sub-Division (Table 2).

Table 2. Land cover/use change statistics from 1986-2022

Land cover/use	Area (Ha)			
	1986	2003	2022	Land use/cover change
Grassland	651	506.51	424.54	-226.46
Settlement	892.71	1238.1	1351.2	458.51
Degraded forest	2014.4	1964.9	2836	821.64
Farmland	3729.7	3578.3	2676	-1053.69
Total	7287.8	7287.8	7287.8	

There is a continuous tendency and change in the trends and patterns of land uses. This is evident through a marked reduction in area for grasslands (-226.46Ha) and farmlands (-1053.69Ha) from 1986 to 2022. There have been remarkable changes in the patterns of land uses brought about by colorization, expansion and densification of settlements, with accompanying degradation of forests. For instance, Settlement increased by 458.51Ha from 1986 and 2022, while degraded area amounted to 821.64Ha, within the same time frame. Population increase and demands precipitate the dynamics on land use, as man quest for development within the urban landscape (Figure 3).

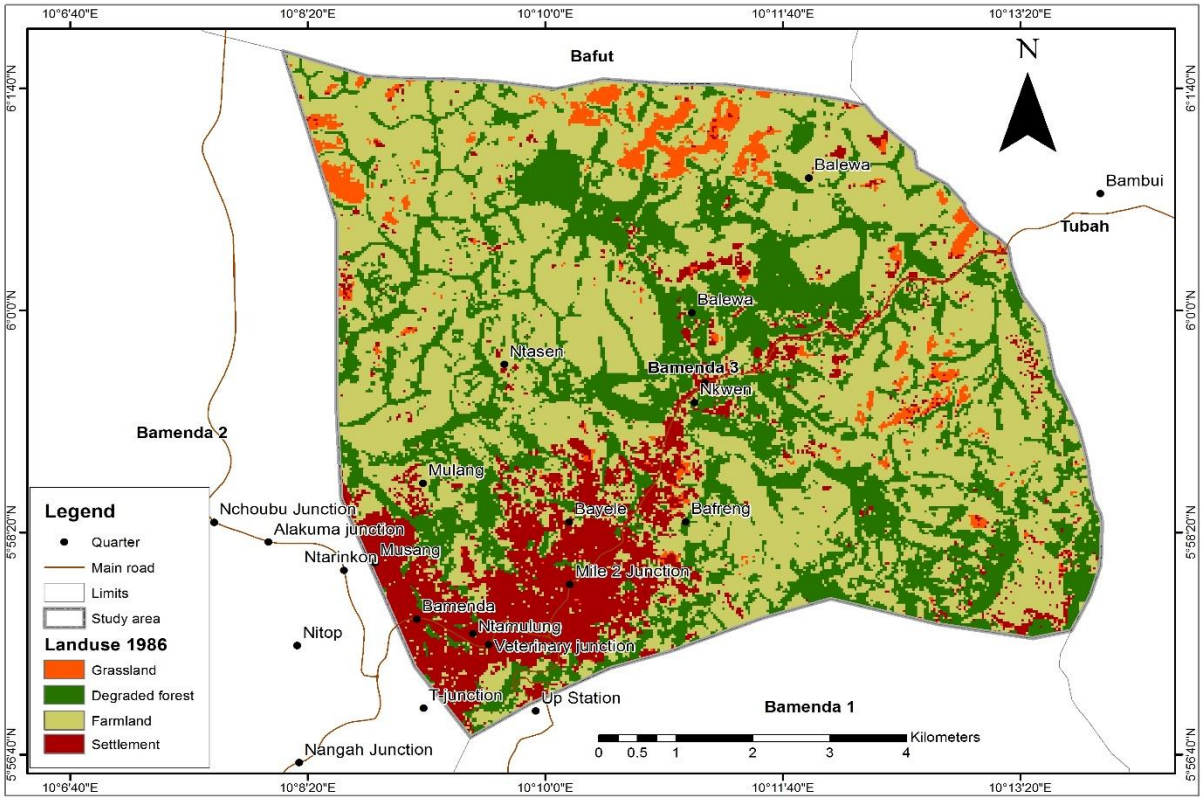

Figure 3. Land cover/use in Bamenda III Sub-Division
Source: Landsat 5 (NASA, 1986)

The land cover/use in Bamenda III in 1986 shows more of land manipulation rather than land modification compared to future trends (Table 2). For instance, the quantity of grassland available in the area was 651 hectares. degraded forests in hectares stood at 2014.4. agriculture especially farming was 3729.7Ha. The area for Settlement amounted to 892.71Ha. Water resources during this period witnessed little or no stress as farmland predominated the area. The trajectory however, witnessed dynamism in less than two decades onward in its land cover (Figure 4).

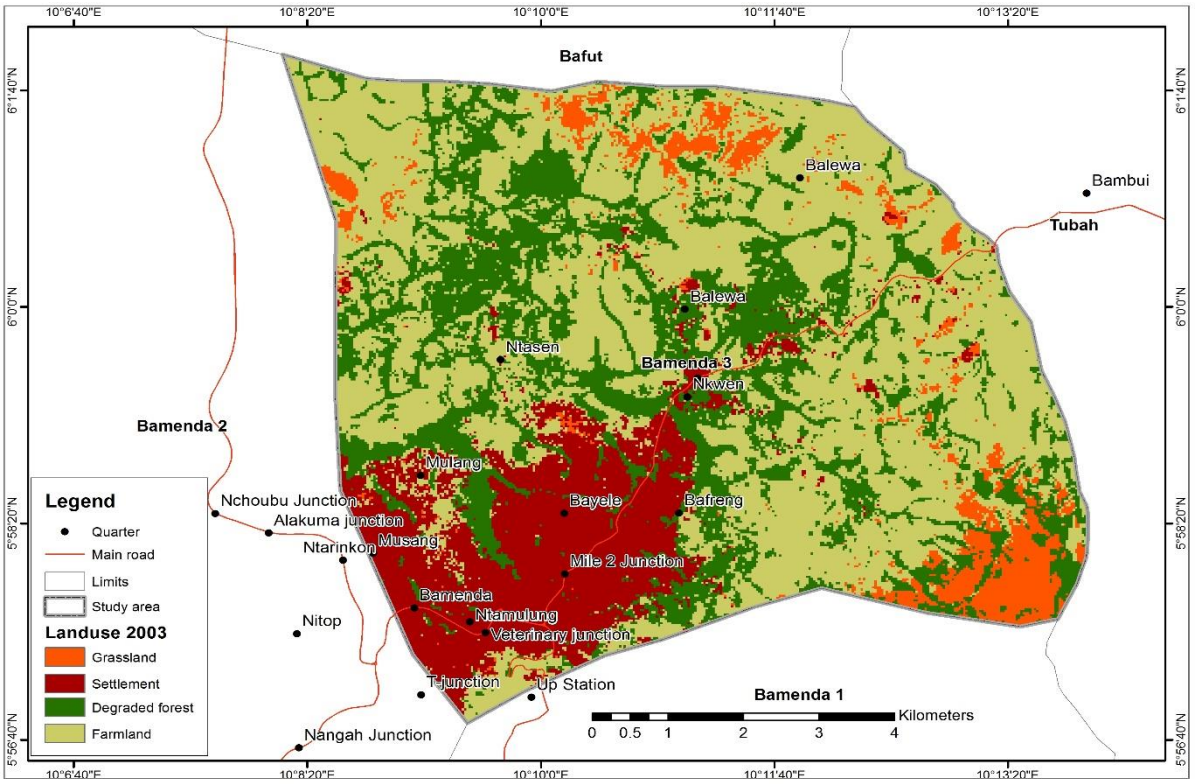

Figure 4. Land cover/use in Bamenda III Sub-Division
Source: Landsat 7 (NASA, 2003)

Human induced factors like deforestation activities, unsustainable farming especially along water courses for settlement expansion, the planting of environmental hazard trees like eucalyptus along water courses, settlement construction at river banks, the effects of climate change on discharge, together with the seasonal reversal of the monsoon winds, the extreme temperatures in the dry season greatly degraded water resources in the area. This affected flow characteristics with huge implications on livelihoods, as water resources diminished in quantity and quality. Discharge reduced by more than 40% from 1986 to 2003. moreover, the preceding period witnessed a more severe challenge to water resources than the previous (Figure 5).

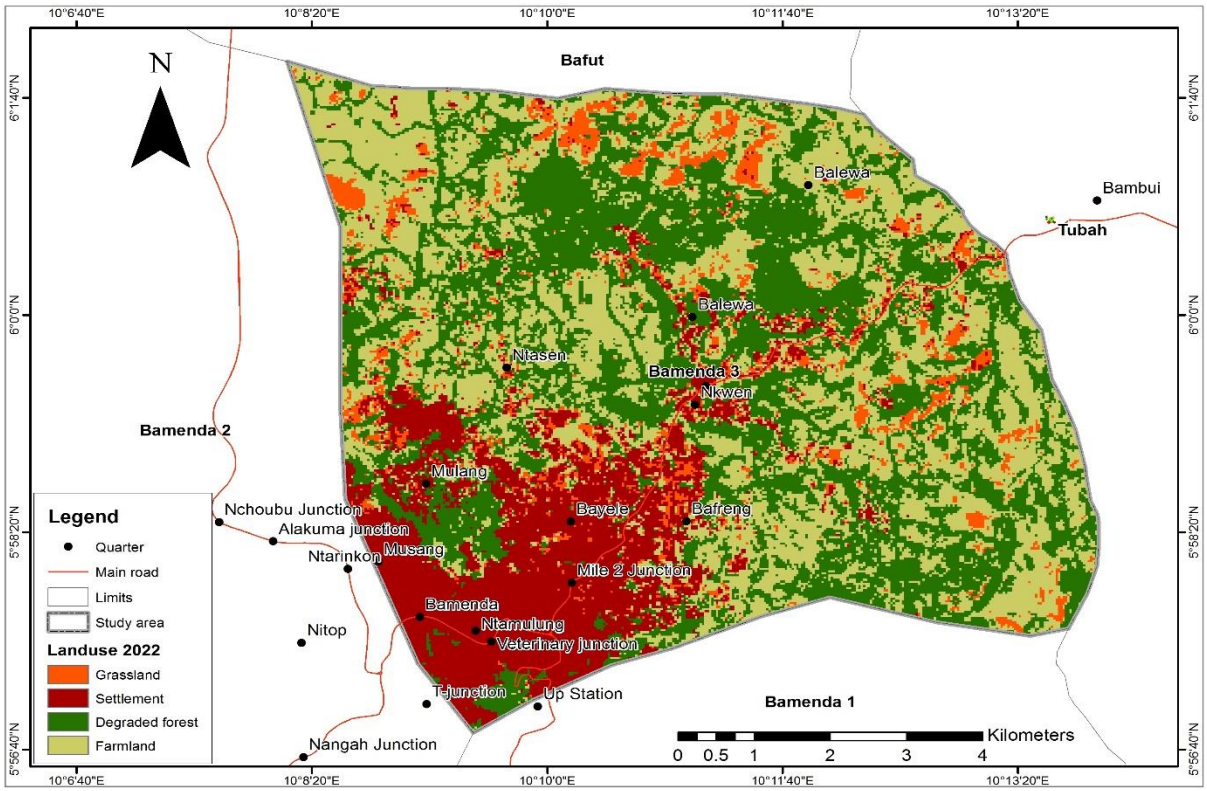

Figure 5. Land cover/use in Bamenda III Sub-Division
Source: Landsat 8 (NASA, 2022)

In 2022, there was a higher degree of land use multiplication and replacement over more than four decades. This inevitably can be attributed to rapid economic development, population growth and urbanization. The pervasive lifestyle of most inhabitants in Bamenda III subdivision has continuously been shaped by intricate land use considerations, compelling unalterable repercussions through continuous pressure on the land for food, shelter and accommodation. This rigorous process stresses water resources especially around water sources like catchments, streams, rivers and brooks (Figure 6). This triggers generic and acute implications on livelihoods, agriculture and biodiversity in the municipality.

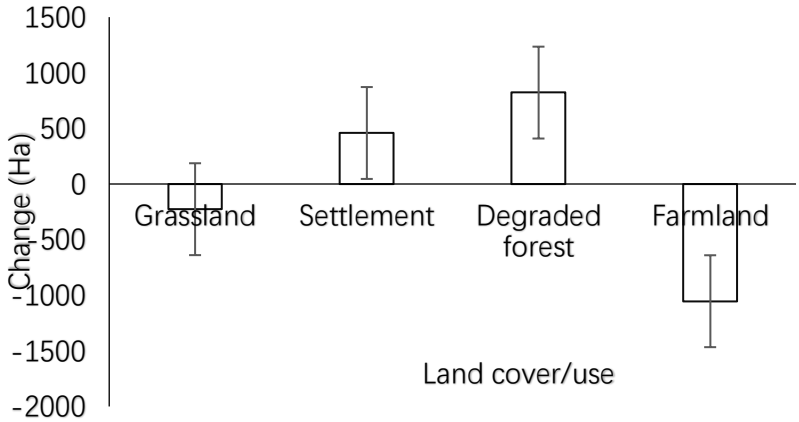

Figure 6: Relative land use/ cover change (1986-2022)
Source: Landsat 5 (NASA, 1986-2022)

Land cover/use patterns are continuous in modification in Bamenda III. The natural environment stresses from anthropogenic activities. While grassland dwindles, the rate of forest degradation soar at the expense of settlement expansion and densification (figure 6). The importance of the water resources has been reduced due to inadequacy. This is because it does not only serve as habitat for aquatic organisms; it also protects and sustains the human environment.

3.2 Impacts of land use change on water resources

Water resources in many parts of the world especially in developing countries are degrading. Human settlements and other forms of land use now occur at the expense of urban ecosystems. The city of Bamenda is no exception to this as rapid and unplanned urbanization that started since the early 1980s, has led to the progressive degradation of ecosystems services like wetlands, ponds, and catchments. Consequently, stream flow characteristics and the supply of potable water to the expanding population of Bamenda have been severely affected triggering a higher risk of water resources degradation and/or disappearance and health challenges in the city.

The presence of settlement around watercourses results to the destruction of river banks and streams, the reduction in river depth and an increase in the shallowness of rivers/streams, Example include the river/ streams that flows through Sisia, Old Town Food, Mile 4 Nkwen, Ntasen are disrupted by the inhabitants close to them. Most people deposit their wastes in these streams and rivers increases the risk of floods, unpleasant odor, visual pollution and mosquitoes within the city.

Modern agronomy, plants breeding, the use of fertilizers and pesticides in this area has led to increase in crop production, but at the same time, they have cause widespread ecological damage such as water eutrophication and pesticide poisoning. Unsustainable farming activities around water shed and along water courses in this area are a triggering factor for water resource reduction and degradation. Most watersheds have been deforested and most wetlands encroached upon. The Miles VI area around the MAGZI zone portrays a clear picture of wetland encroachment by agricultural and settlement land uses probably because the lower portion of the area is relatively cheaper than the upper portion extending towards mile 4 area. This has drastically reduced the integrity and resilience of the ecosystem. Aquatic habitats in this wetland have been destroyed contrary to the Ramsar convention of 1971. The increasing population of the Bamenda III municipality coupled with the need to farm and feed the increasing mouths has left the researcher with the doubt on the future of water resources in this area.

Deforestation activities are a common phenomenon plaguing water resources in this area. This is because man needs not only food but also shelter as more and more people are added to the world population. There is an increasing demand for settlement construction. Most landscapes have been colonized, including marshy lands reclaimed and watersheds degraded all in a bid to provide the much-needed space for human habitation. A once quiet environment now gives way to settlement and other land uses.16 million hectares of natural forest disappears yearly across the globe. The effects of deforestation are devastating and hazardous. These include the

loss of biodiversity, soil erosion, landscape degradation and desertification. Figure illustrates. The forest is very important in their role in carbon storage and water retention. Several water catchments have been degraded due to land use changes especially settlement land use.

The environmental implications of land use change on water resources remains a challenge over the years in Bamenda**.** Currently, Bamenda III Sub-Division is undergoing expansion. There is an extension of its built-up area or infrastructure in general from the city towards the rural areas. Rapid urbanization in Bamenda is impacted with overcrowding and homelessness. the city of Bamenda has become overcrowded since the homes and housing facilities were originally designed to fit a certain number of people. Lack of adequate housing is causing an increased in slums as many rural folks who move to Bamenda are creating their own settlements to get shelter. Some of these settlements takes place at water courses and wetlands. This affects quantity and discharge (Figure 7).

Figure 7. Impacts of unlawful housing development on water quantities and channels characteristics in Ntene Ntene and Sisia

Housing development in Bamenda III occurred without the benefit of physical planning. Most developments are characterized by substandard and irregular structures and patterns. This invalidates sustainable urbanization. Water quantities are continuously being affected especially by in-hygienic conditions and closeness to water channels. Refuse disposal, poor waste management methods, littering among others becomes a challenge. These has affected the quantities harnessed especially for domestic consumption. As a result, alternative sources of water supply are being sought like well drilling and boreholes in Bamenda III Sub-Division (Figure 8).

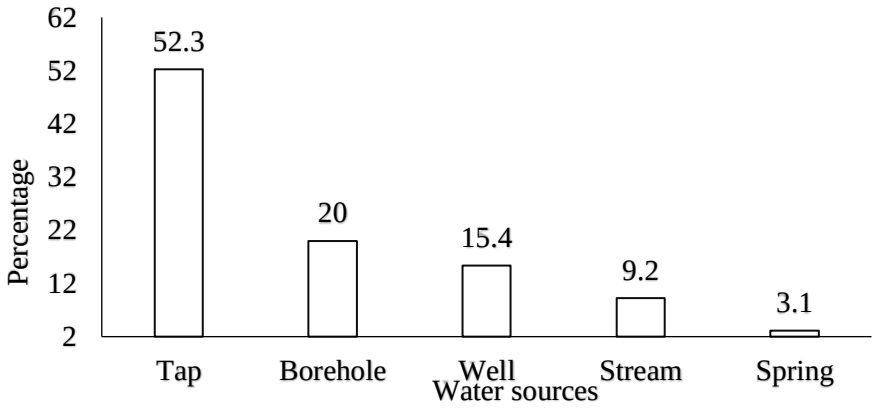

Figure 8. Sources of water supply in Bamenda III Sub-Division

The population of Bamenda III Sub-Division depends on a variety of water sources for various purposes. This is mainly due to the irregularity in the supply of portable tap water. 52.3% of the population depends principally on tap water, 9.2% depends on stream water, 20.0% depends on borehole, while 15.4% depends on well and 3.1% depends on spring. Despite the numerous sources of water supply in this area, the area still experiences severe water scarcity.12.3% of the population experience severe water scarcity in the rainy season, while 15.4% experience water scarcity in the early dry season and 72.3% in mid dry season.

Water sources in Bamenda III are often prone to disease outbreaks. In recent times, malaria and cholera have been catastrophic illnesses in Bamenda as it spreads like wildfire due to congestion caused by rapid urbanization. Bamenda III Sub-Division is constantly changing and reshaping under geologic, climatic, biologic and anthropogenic forces. This has a direct consequence on the growing awareness of its environmental problems, such as global warming, floods, desertification, pollution, ozone layer depletion, all caused primarily by human activities. Industrialization, deforestation, agricultural development. These are all human induced factors of global warming and climate change. This leads to temperature rise and changes in rainfall patterns (Figure 9). This increases the frequency, duration and intensity of extreme weather events such as floods, drought, shrinking of water sources.

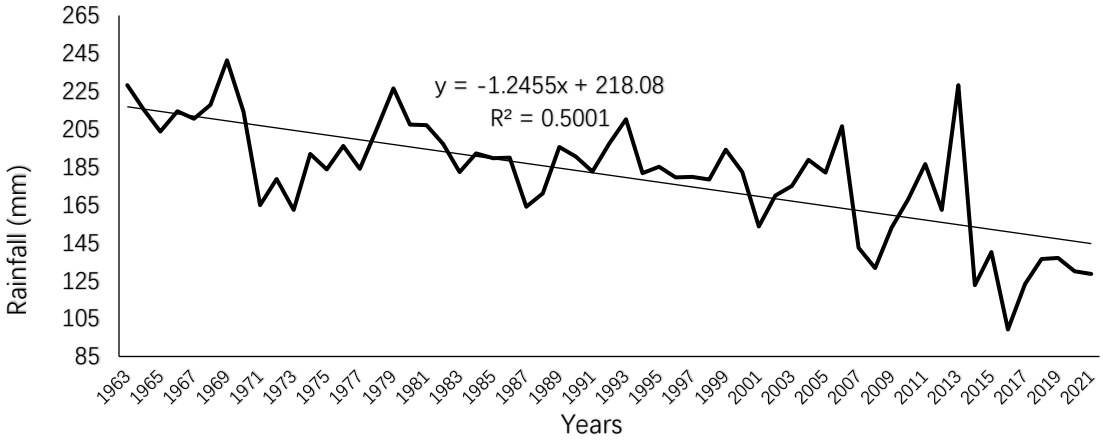

Figure 9. Pattern of rainfall in Bamenda III Sub-Division (1963-2021)
Source: Regional Meteorological service Bamenda

3.3 Future planning implications of land use patterns for Bamenda

Changing urban landscapes from its present unsustainable forms and patterns to livable and ecological based for city dwellers within the Bamenda III municipality is a very challenging process. Not only does this require a change in urban form, transportation systems, water resources management, wastes and energy technologies, but a total reform of the Bamenda III value system as well as processes anchoring urban governance and planning. To ensure a sustainable agenda for Bamenda III Sub-Division, future planning implications of land use patterns on water resources is essential. This requires especially the protection of the municipality's natural areas, thus, constituting the framework in which future urban development is embedded and must operate to improve on the availability and accessibility of water resources in Bamenda III Sub-Division.

The role of the Bamenda city council and the Bamenda III council in water resources protection is significantly inadequate, portraying discontent in a rapidly expanding urban area. Field evidence revealed that discontent in water availability and accessibility stems from improper land use planning and altered urban ecosystem services. The expansion of the urban space exposes the inadequacy in the availability of water for various uses, thus requiring the need for urban renewal. A majority of the population were discontented with the council's role in water supply, while others perceived their performance as poor, others very poor. Others indicated satisfactory performance. In spite of the degrading nature of water resources in this area, the council has put forth measures to effectively manage water resources in this area. The promote the planting of environmentally friendly trees especially around catchments to retain and sustain the quantity and quality of water resources in the area. (12.7%), also the council is constructing new catchments especially at Menteh to enforce old once (46.2%). Apart from this, a lot of sensitization are done on catchment management and to all land users on the proper management of land uses to curb and maintain the state of available land uses both in quantity and in quality (38.5%). moreover, there exist operational instruments for water resources protection (Table 3) in the municipality.

Table 3. Rules and regulations watercourse Reserves

Type of Water body	Distance from water body
Large rivers	25.0m
Rivers	15.0m
Seasonal streams	10.0m
Brook/run-off	5.0m
Slopes	> 0-1%

Source: Bamenda III Council Five Year Strategic Development Plan, 2009-2013

The putting in place of operational instruments for effective and sustainable ecosystem services constitutes a fraction of measures for livability and ecological based urban landscapes. For example, the putting in place of a five-year strategic development plan to conserve water resources by effective land use management. All land uses around large rivers should respect a setback of 25.0m from the water course. Land uses around rivers should respect a setback of

15.0m, seasonal streams should respect a setback of 10.0m and brooks/runoff should respect a setback of 5.0m from the course, while on slopes a setback of >0-1% should be respected. Water resources stand the risk of degradation if the above development plan is not respected or fully implemented. Nevertheless, how effective are these conservation or water protection measures in Bamenda III area in terms of implementation? Most water resources have been tempered with by the changing patterns of land uses. Some settlements are constructed along water courses contrary to the strategic development plan. Also, some farming activities around water courses tend to extend in to the banks of water courses reducing the volume and quantity of water available.

3.4 Management of the Bamenda III Council Urban Space

The urban space within the council area cuts across the main quarters of Ntabru, Sisia, Upper and Lower Bayelle, Ntambang, Mbelem, Menda, Mugheb, Ntasen, Mbesi, Niboung, Mbefi, Bujong, Ntefinki and Ntakondia. These are the areas where economic activities are booming and about 85% of the total population is settled. The management plan provides a better understanding of land utilization and also helps in formulating policies and programs needed for town planning and development in a sustainable manner. Urban planning and development is a continuous process involving stakeholders especially administrators, planners, investors and inhabitants so that the available land within the urban space is used rationally. The main controllers here are the Divisional Delegation Housing and Urban Development (MINHDU) and the Bamenda City Council.

Land is mostly used for agriculture, settlement, grazing commerce, recreation and road construction. In this light, most of the land is gradually being used for the construction of roads, houses, shops, parks, fuel stations, markets, amongst other economic infrastructure, at the expense of agriculture which happens to occupy a good portion of the municipal land. Grazing land takes the next greater portion, mostly around the infertile lands and cattle only reach the fertile lands in the dry season during which there abound farmer-grazer conflicts. Then, there is also settlement land, swampy areas, and water bodies like streams, and rivers.

Within the Bamenda III Council urban space, the following classes of land uses are identified; the built-up area and Settlement, Forest, Agriculture (Farming and grazing), Grassland, Water bodies and other features. The urban space also forms the core of commercial activities in the Council area. Famous infrastructures include the Mile 2 main market, Mile 4 Motor Park, churches/ mosques and institutions of learning. These infrastructures are widespread in the urban space with no specific plan on land use. There are about 103 Basic Education Establishments and 19 Secondary Education Establishments. There are numerous healthcare units and more than 11 administrative units spread within the council area. All these structures are located haphazardly without following land use norms. However, Bamenda III council has no effective land use plan at the moment

4. Conclusion

Tremendous changes in the pattern of land uses have been observed in Bamenda III. This is brought about by population growth, economic development and urbanization. Variations in

land use affects water quantity and quality. Water resources in Bamenda III stand the risk of continuous degradation due to land use expansion and multiplication and replacement. However, an increase in effective planning measures and implementation mechanisms increases the resilience and sustainability of water resources and the Bamenda III urban ecosystem. Moreover, the physical planning and protection of water resources through the effective design of public and private spaces in Bamenda III municipality is essential for livability and sustainable urbanization. The role of urban actors in the implementation of strategic development plans, is critical, together with respect of setbacks from water sources as stipulated in operational instruments regulating urban development. re-strategized measures should be reinforced to monitor and control development from wetlands and limits land reclamation and wetland degradation. This may include limiting the issue of land certificates and implantation permits to wetland owners or developers. Sensitization programs are therefore essential for the urban dwellers.

References

Balgah, S.N., & Kimengsi, J.N. (2016). Land use Dynamics and Wetland Management in Bamenda: Urban Development Policy Implications. *Journal of Sustainable Development,* 9(5) 1–11.

Bamenda III council (2012). Council development plan (main document), Nkwen, Bamenda.

Defries, D., & Eshleman, K.N (2004). Land-use change and hydrologic processes: a major focus for the future. Wiley Online Library. *Hydrological Processes*. 18(11), 2183-2186. https://doi.org/10.1002/hyp.5584

Goldewij, K.K (2001). Estimating global lan use change over the past 300 years: The HYDE Dabase. *Global Biogeochemical Cycles*, 15(2),417-433.

Gwan, A.S. & Kimengsi, J.N (2020). Urban Expansion and the Dynamics of Farmers' Livelihoods: Evidence from Bamenda, Cameroon. Sustainability.

Gurnell, A., McGregor,H.M., Gosling, S. Jones, A (2008). A baseline of water-dependent ecosystem services, The roles they play within Desakota livelihood systems and potential sensitivity to climate change. Center for environmental Assessment & policy, and department of geography. King's college London.

Kometa, S.S., Ashu, M., Ebot, T.O.T (2012). watershed degradation in the Bamendjin Area of the Northwest Region of Cameroon and its implications for Development. journal of sustainable development 5(9). Doi:10.5539/jsd.v5n9p75

Mbanga, L.A (2018). Human settlement dynamics in the Bamenda III Municipality, North West Region, Cameroon. Center for research and urbanism, Journal of settlements and Spatial planning. 9(1), 47-58. https://doi.org/10.24193/JSSP.2018.1.05

Shrivastava (2019). Land Use Change and its impact on Water Resources. *Journal of Environmental Science, Toxicology and Food Technology*, 13.4 51-53.

Semwal, R.L., & Saxena, K.G. (2004) Patterns and ecological implications of agricultural land

use changes: A case study from central Himalaya, India. Volume 102, Pp 81—92.

Sahin, V., & Hall, J.M (1996). The effects of afforestation and deforestation on water yields. Environmental science. *Journal of Hydrology*. 178 (1) 293-309, 4https://doi.org/10.1016/0022-1694(95)02825-0

Thenail, C., & Baudry J. (2004) Variation of farm spatial land use according to the structure of the Hedgerow network (bocage) landscape: A case study in Northern Britain. 101, 53-72.

Tume, S.J.P., (2021). Impact of Climate Change on Domestic Water Accessibility in Bamenda III Sub-Division, North West Region, Cameroon. *Journal of the Cameroon Academy of Sciences,* 17(2), 131-145, https://dx.doi.org/10.4314/jcas.v17i4.3

Tume, S.J.P. & Kongnso, M.E. (2022). Standardized Precipitation Index Valuation of the Impact of Climate Variability and Change on Domestic Water Accessibility in Bamenda III Municipality, North West Region, Cameroon. *Journal of Science Frontier Research (H), Environment and Earth Science,* 22(8), 1: 39-55.

Verburg, P.H., & Bouma, J. (1999): Ecological modelling, a spatial explicit allocation procedure for modelling the patterns of land use change based upon actual land use. 116, 45-61.

Weatherhead, E.K., & N.J.K. Howden. (2009): The relationship between land use and surface water resources in the UK. 265, 5243-5250.

William, B. M., & Turner. (1994) Changes in land use and land cover: A Global perspective. Volume 4, Cambridge university press.

WRF Project. (2016). Integrated land use and water resources: planning to support water supply diversification.

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