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Urban dynamic Stressors in the Sisia-Menteh Watershed of Bamenda, North West Region Cameroon

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ABSTRACT

While anthropogenic activities such as bush fire, cultivation of crops, housing construction continue to exert pressure on urban catchment areas within the Bamenda grassfields, the watersheds are becoming largely unsustainable. This paper looks into the anthropogenic activities and it consequences on the catchment area with emphases around some headwaters of the Bamenda Urban Metropolis. The main objective was to assess the effect of human activities on catchment while testing the significant effects of human activities on catchment areas. The researchers employed primary and secondary sources in data collection using a mixed design method which combines quantitative and qualitative approaches to gather data on anthropogenic activities in the study matrix. Purposive sampling technique was used to select the population needed for the study. A total of 79 households were selected within the catchment areas of Sisia and Menteh for questionnaire administration. Data generated were analysed descriptively and inferentially using Statistical Package for Social Sciences (SPSS) version 20. All statistical tests were determined at 0.05 significant levels. The results indicate that anthropogenic activities significantly exert negative effect on the urban catchment areas. Plants and animal extinction, disappearance of fresh water as well as reduction in vegetation cover were remarkably noticed. Linear regression statistics results showed that the calculated p-value .001 was below the significant level of .05 used for the study. This therefore accepts the fact that anthropogenic activities significantly have adverse effects on catchment areas on the headwaters of the Bamenda metropolis. Base on the findings, it is strongly recommended that the authorities concerned, through municipal councils should carry out capacity building and sensitization campaigns on the importance of conserving watersheds given the urban development process.

Key words: Urban dynamic, stressors, urban watershed, urban metropolis, Bamenda, Cameroon

Introduction and study area

1.1. Introduction

It is impossible to overstate the importance of humankind's clearing of the forests and consequently his role in forest and catchment area degradation. Interaction between forest ecosystems and water quantity and quality has been central to ecosystem and hydrological research for the past century. The role of forest in water cycle regulation can no longer be over emphasised (Ellison *et al*, 2017; Jones *et al* 2019). The transformation of forested lands by human actions represents one of the enormous forces in global environmental change and one of the great drivers of water loss. The impacts of people have been and continue to be visible in most watersheds. Forests are cleared, degraded and fragmented by timber harvest, conversion to agriculture, road building, human caused fire, and in countless other ways which constitute development frontiers (Lambi, 2010, Gray, 2010, MEA, 2005b). The effort to use and subdue the forest has been a constant theme in the transformation of the earth in parts of the world. Deforestation and or land degradation has important implications for life on this planet, Barrow, 1994).

Recent studies revealed that, forests cover more than one quarter of the world's total land area, excluding Polar Regions. Slightly more than 50% of the forests are found in the tropics and the rest are temperate and boreal (coniferous northern forest) zones (Olson, 2001). Sufficient evidence is available that the whole world is facing an environmental crisis on account of heavy deforestation. For years ruthless destruction of forests has been going on and we have not been able to comprehend the dimension until recently. However, it is obvious that the area of tropical rainforest is diminishing and the rate of tropical rain forest destruction is escalating worldwide and consequently affecting water catchment areas, despite increased environmental activism and awareness, Nigel, 1998).

Forest degradation refers to the reduction of the capacity of a forest to produce goods and services, (ITTO, 2002). Capacity includes the maintenance of ecosystem structure and functions, ITTO, (2005). A degraded forest delivers a reduced supply of goods and services from a given site.

Sheng (1990), considered a degraded watershed as one that has lost its value over time, including the productive potential of land and water resources. It is usually accompanied by marked changes in the hydrological behaviour of a river system resulting in inferior quality, quantity, and timing of stream flow. This may have resulted from the interaction of physiographic features, climate, and poor land use, deforestation, inappropriate land cultivation, disturbance of soil and slope by mining, construction and improper

diversion, storage, transportation, and use of water. A healthy watershed (catchment) is one that can recover from perturbation, being economically viable and environmentally self-sustaining.

Catchments are instrumental in the effective functioning of hydrological systems, as they ensure ground water recharge and a steady supply of water for multiple uses (Kimengsi *et al*., 2018). A great number of water catchments (Warner, 2007) characterize African water resources. In Cameroon, there are many regional and locally shared catchments being the watersheds of the western Highlands of Cameroon (Amawa, 2009, Ndenecho, 2007), Adamawa plateau (Amawa, 2009), and the southern plateau (Neba, 1999). At the local level, several communities depend on water resources which require proper management. Therefore, balancing economic growth and development with water resources is essential and can only be achieved through a sustainable management of catchment areas. Over the years, considerable efforts have been made to protect catchments in order to ensure a continuous supply of potable water.

Deforestation of catchment areas is expanding and accelerating into the remaining areas of undisturbed forest, and the quality of the remaining forests is declining. Most studies have examined global patterns in deforestation, assess the human and ecological costs of forest loss, and discuss some of the steps that can help to correct this alarming situation. While a number of studies have explored urban development and land use change issues in Bamenda (Kimengsi et al., 2017; Balgah and Kimengsi, 2016), there is very little information on the implications of catchment management on city water supply in the primate city of Bamenda.

1.2. Study Area

The study area comprises of the headwaters of Bamenda Metropolis covering some 7293.51ha of the Bamenda Highlands to the Southeast of the town (Fig. 1). It comprises of some five water catchments; Mendakwe, Abangoh, Mendakwe -Sisia, Bangshie and Menteh.

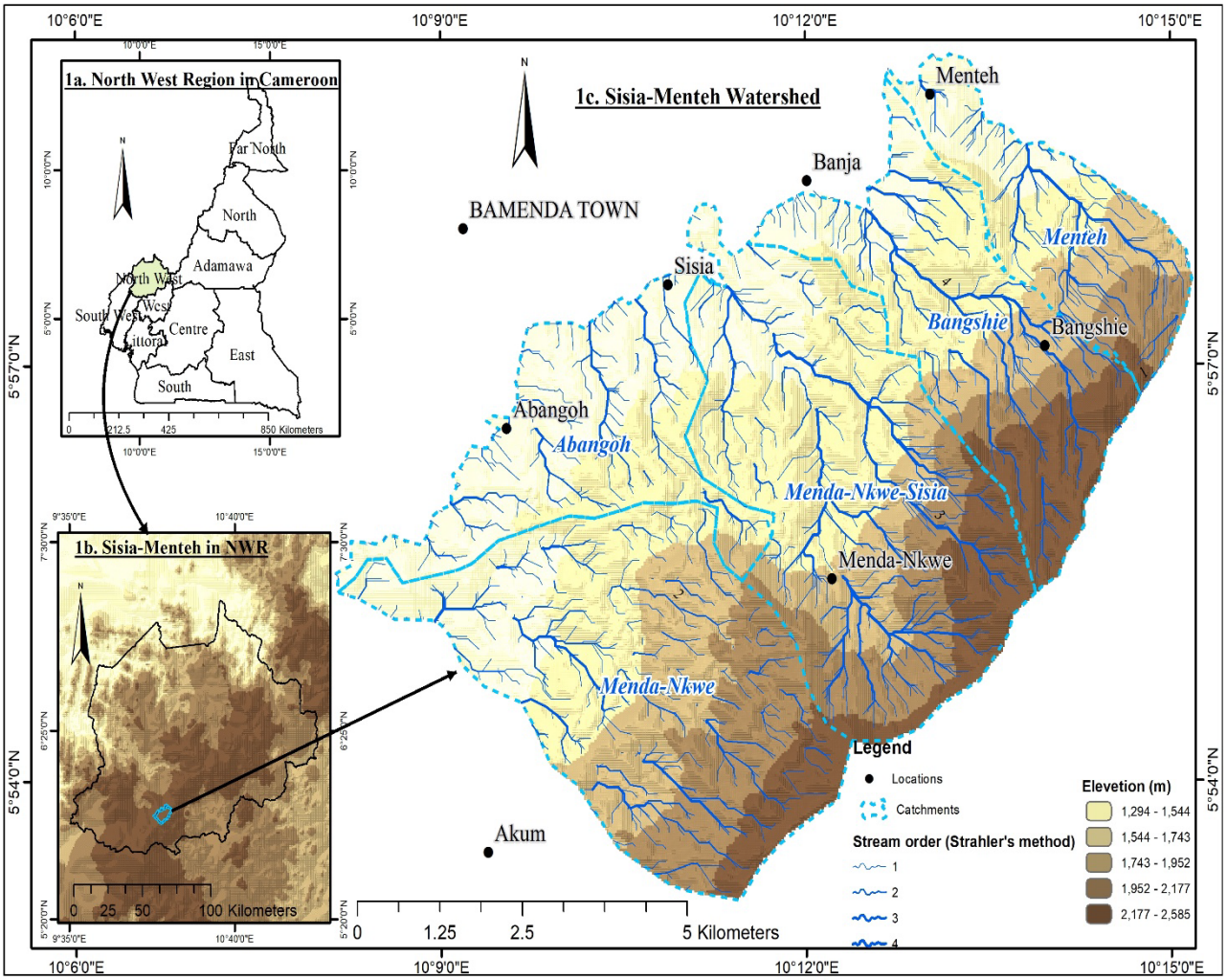

Figure 1- Location of Bamenda Sisia-Menteh Urban Watershed

A look at the hydro-morphometric characteristics of the watershed, the streams are many and varied, from 1st order (intermittent streams) to 4th order (principal stream), as in table 1.

2. Materials and Methods

The study adopts a quantitative and qualitative research design to explore data on anthropogenic activities within the water catchment areas located at Sisia-Menteh Southeast of Bamenda town. The research utilised both primary field observation and questionnaires and secondary (institutional records, journals, dissertations) sources to collect data and information related to the study. The study adopted purposive sampling procedure. The decision to sample only the inhabitants within the water catchment was based on the subjective discretion of the researchers to select areas or elements from the population, which met the criteria established to attain the results of the study.

2.1. Change detection of watershed dynamics

Remote sensing image processing provides proxies from which watershed change dynamics were modelled. Of the plethora of methods and indices used for watershed land use dynamics modelling is land cover/use change detection. This method has the ability to revealed land cover transformations by anthropogenic stressors both quantitatively and qualitatively. In modelling watershed degradation driven by anthropogenic stressors by means of land cover/use change detection, the area changes in forest and/or secondary forest cover is often used as a proxy data to infer change dynamics and watershed health. Table 1 shows the remote sensing data used for land cover/use change detection within the Bamenda urban watershed.

Table 1: Remote sensing data used in this study

Platform	Sensor	Acquisition date	Resolution (m)	Source
Landsat 5	TM	1984-12-31	30	NASA
Landsat 8	OLI_TIRS	2013-12-31	30	NASA
Landsat 8	OLI_TIRS	2020-01-07	30	NASA
AW3D30	ALOS	2019	30	JAXA
MCD14DL	MODIS	2000-2020	1000	NASA

Operational Land Imager Thermal Infrared Radiometer (OLI_TIRS) , Enhanced Thematic Mapper Plus (ETM+), Thematic Mapper (TM)

ALOS World 3D 30m Digital Surface Model at 30m spatial resolution was used to extract study areas and the hydrological and morphometric characteristics of the watershed. To further ascertain anthropogenic stressors, active fire dynamics used by slash-and-burn crop farmers and sedentary graziers was established using MODIS (MCD14DL) 1km active fire product archive point data from 2000-2020.

2.2. Field survey

The quantitative method involves the use of a survey where semi-structured questionnaires were applied to the sampled population, field observations on the small scale industrial sites in the study area. For the purpose of in-depth analysis of the results from the quantitative analysis, a further approach called the qualitative method included informant interviews with stakeholders of the municipality such as the mayor was carried out. Data collected from the field were summarized using descriptive and inferential statistics. The descriptive statistics is presented in the form of tables, charts frequencies, percentages, graphs and maps. The hypothesis used in the work was tested with simple linear regression using Statistical Package for Social Science (SPSS), version 20. Non-parametric correlation and regression statistics

for the hypothesis stated to understand impact of anthropogenic activities on watershed stressors in the study. The simple regression formula was given as:

$t = \frac{rs\sqrt{n-2}}{1-rs2}$ where

t = Student's t statistic; under the null hypothesis of independence t is a random quantile of the t-distribution with (n − 2) degrees of freedom,

r_s = the Spearman correlation coefficient,

n= the number of bivariate observations

3. Results and Discussion

The Western Highlands and Bamenda City in particular is endowed with good number of water catchments, rivers and streams which flow through the escarpments and hilly valleys to the surface areas in the different Municipalities. In Bamenda City, the three sub-divisions get its waters from the Bamendankwe Highland which is the main watershed of Mezam Division. Here, most of the watersheds, rivers and streams take their rise from the Up-station escarpment situated in Bamenda I sub-disional coulcil area.

3.1. Human activities at catchment area in Sisia-Menteh

Serious human activities for the past years have been visible which continue to degrade the catchment sites of Menteh and Sisia despite state authority's prohibition of any form of human activity. Most people turn blind eyes and as a result, farm work, construction and logging or deforestation have not been controlled in and around catchment zones. Table 2 describes sample reactions on the type of practices at the catchment sites.

Table 2: Human activities at catchment area in Sisia- Menteh in Bamenda III

Variables	Agree	%	Disagree	%	Total effective	Total %
Farm work	79	100.0	00	00	79	100
Livestock grazing	73	92.4	6	7.5	79	100
Fuel wood collection	76	96.2	3	3.8	79	100
Hunting	65	82.3	14	17.7	79	100
Bush fire	72	91.1	7	8.9	79	100
Settlement extension	78	98.7	1	1.3	79	100

Source: Fieldwork, 2020

Field observation revealed that farming activity is highly practiced at the catchment sites. This was further confirmed by 79 (100%) sample households selected for the study. Majority of the farmers expressed that the on-going "Anglophone" crisis have forced them to farm at the catchment as they no longer travel over long distances to farm. Livestock rearing

especially goats, cattle, sheep and domestication of fowls and pigs was also strongly expressed by 92.4% sample households as being practiced around the catchment areas.

Fuel wood collection in the area was strongly agreed by 96.2% sample households, 3.8% disagreed. Hunting activities was accepted to be practiced by 82.3% sample households while 17.7% refuted. As well, bushfire was accepted to be practiced by 91.1% sample while 8.9% refuted. Another activity strongly accepted by the sample households that facilitated catchment degradation in the areas was illegal settlement extension which was confirmed by a sample majority of 98.7% and rejected by just 1.3%.

Overall, table 2 have revealed that anthropogenic activities especially farming, livestock rearing, fuel wood collection, hunting, bush fire and settlement extension significantly degrade the Sisia- Menteh catchment areas and as such has a negative impact on the quality and quantity of the catchment.

3.1.1. Effect of human activities on the catchment sites

From survey and as presented on table 3, anthropogenic activities such as farming, hunting, fuel wood harvest and building construction have greatly reduce the watershed to near extinction especially the catchment area at Sisia.

Findings showed that due to human activities, the catchment has witnessed a high degree of plants and animal extinction, and this was confirmed by 91.1% of those who were sampled. 8.9% of the population believed that the catchment has not been tampered upon despite the on-going human activities. 94.9% of the households were of the view that fresh water sources within the catchment have disappeared due to constant human activities especially farming and bush fires.

Table 3: Effect of human activities practices at catchment areas (Menteh-Sisia)

Variables	Agreed	%	Disagreed	%	N	Total %
Plants/animal extinction	72	91.1	7	8.9	79	100
Disappearance of fresh water sources	75	94.9	4	5.1	79	100
Forest ecosystem distortion	76	96.2	3	3.8	79	100
Reduction of vegetation cover	78	98.7	1	1.3	79	100
Encroachment of farmland into watershed areas	75	94.9	4	5.1	79	100

Source: Fieldwork, 2020

Also, 96.2% of the sample households held that the catchment areas of Sisia- Menteh have witnessed forest ecosystem distortion as a result of deforestation for farming activity; rampant hunting of bush meat as well as bush fires especially the slash and burnt method. Another prominent effect on the catchment that was observed during field investigation and confirmed by a sample majority of 98.7% was the reduction of vegetation cover around the

catchment area. Finally, 94.9% of the sampled households revealed that farm land have greatly encroached onto the watershed areas thereby limiting the function of the catchment to supply good drinking water to the population.

3.1.2. Land cover/use changes (1984-2020)

To further capture the extent to which the catchment areas have been destroyed by human activities, land use maps were needed to demonstrated the land use changes that have taken place within the area (Table 4). Consequently, land use maps of 1984, 2013 and 2020 were used for the purpose.

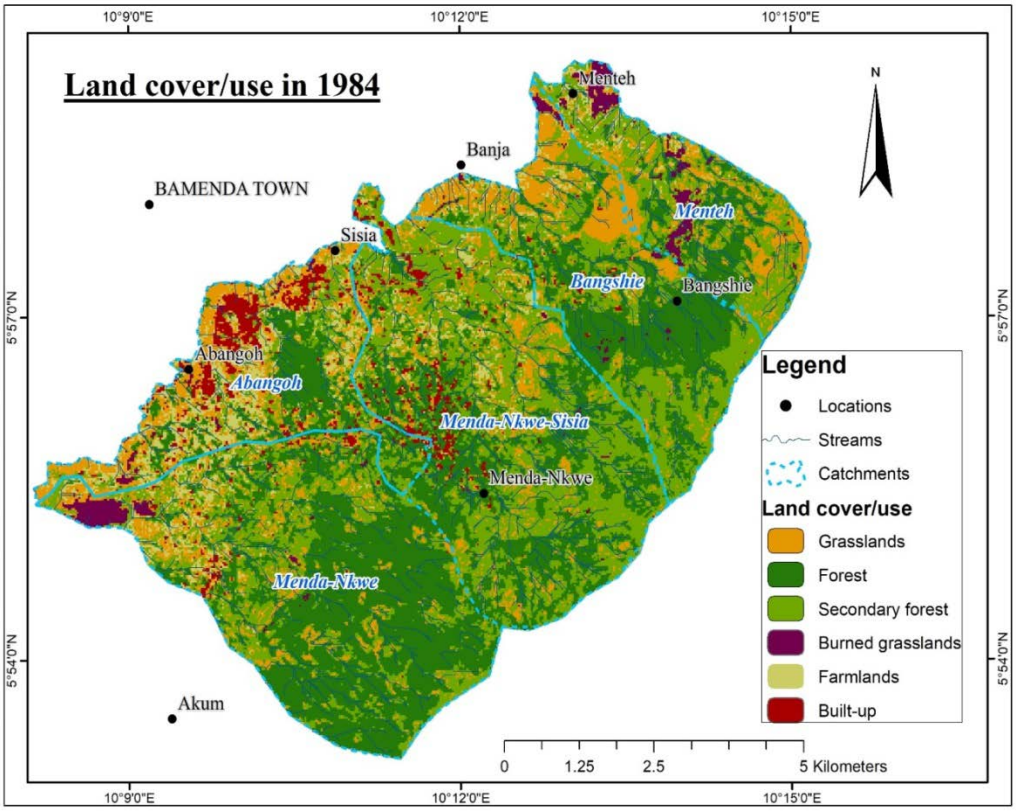

Figure 2: Land cover/use in 1984 in the urban watershed

Table 4: Land cover/use changes (1984-2020)

Land cover/use	1984		2013		2020	
	Ha	%	ha	%	ha	%
Built-up	247.32	3.3	848.52	11.6	966.06	13.2
Forest	2679.93	36.7	1137.51	15.5	1129.59	15.4
Secondary forest	2596.05	35.5	1623.33	22.1	1193.67	16.3
Farmland	441	6	1523.25	20.8	1107.9	15.1
Grassland	1185.93	16.2	1941.57	26.6	2597.04	35.6
Burned grassland	143.28	1.9	34.46	0.47	-	-
Eucalyptus	-	-	183.87	2.5	299.25	4.1
Total	7293.51	**100**	7292.51	**100**	7293.51	**100**

Change detection of land cover/use of the study area from 1984-2020 showed 143.28ha and 34.92ha of burned areas for the periods of 1984 and 2013 respectively (Fig. 2 and 4). As humans increasingly dominate the Earth system during the Anthropocene (Malhi, 2017), four anthropogenic drivers are causing rapid vegetation change across the African savannah, threatening biodiversity and ecosystem services. Such issues are very real on the Sisia-Menteh Watershed in Bamenda. These are: (1) land/cover change and transformation, (2) human induced changes to fire, browsing and grazing regimes, (3) climate change and (4) rising atmospheric CO_2 (Osborne *et al.*, 2018).

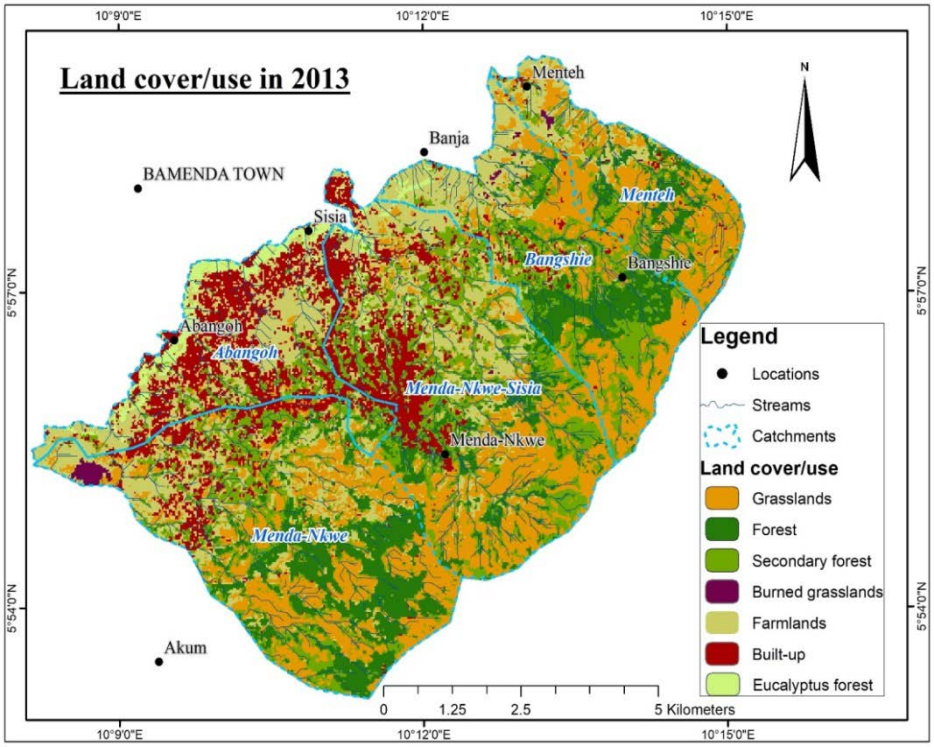

Figure 3: Land cover/use in 2013 in the urban watershed

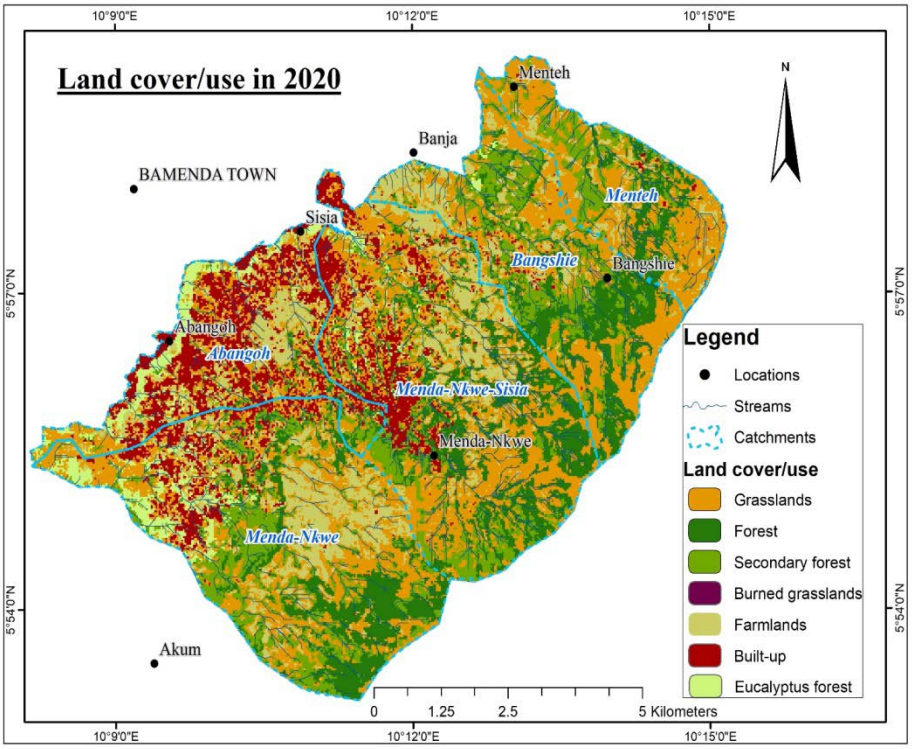

Figure 4: Land cover/use in 2020 in the urban watershed

4. Anthropogenic fires and landscape dynamics

It has been widely reported that tropical savannah ecosystems have been fashioned by repetitive human-induced fires. Fire is used both in the slash-and-burn culture and for rangeland management by the sedentary pastoralists. Figure 5 shows human-induced active fires captured by MODIS 1km (MCD14DL) sensor from 2000-2020.

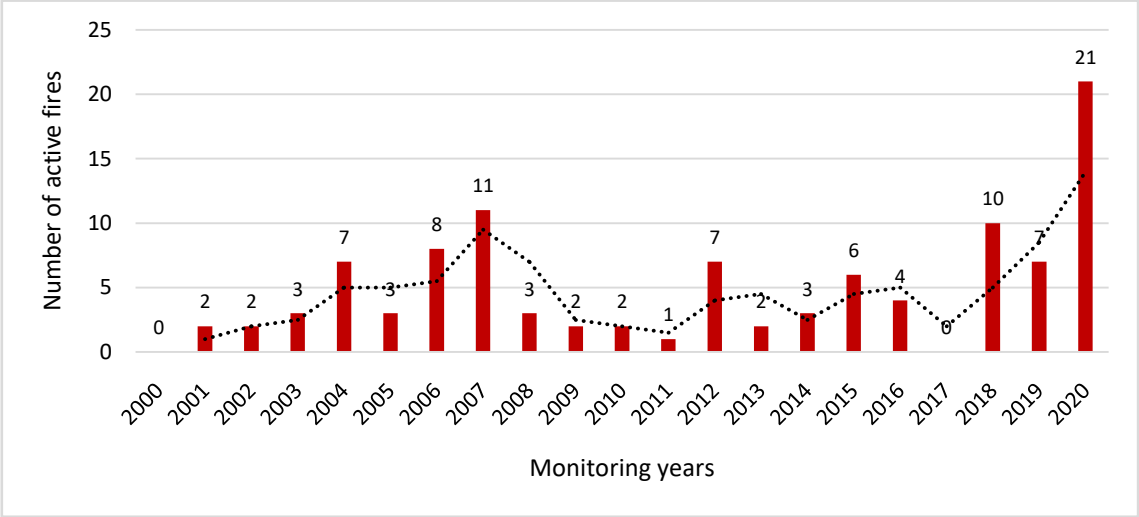

Figure 5: **Anthropogenic fire dynamics (2000-2020) within the study area**

Source: MODIS Active fire product (NASA, 2020)

Inter-annual dry season pastoralists-induced fires have been a palliative for pasture regeneration and rangeland management within this area. Fire dynamics show a rise-fall trend

from 2000-2020. This spatial distribution of archive active fires from 2000-2020 by MODIS active sensor over the watershed is shown in figure 6.

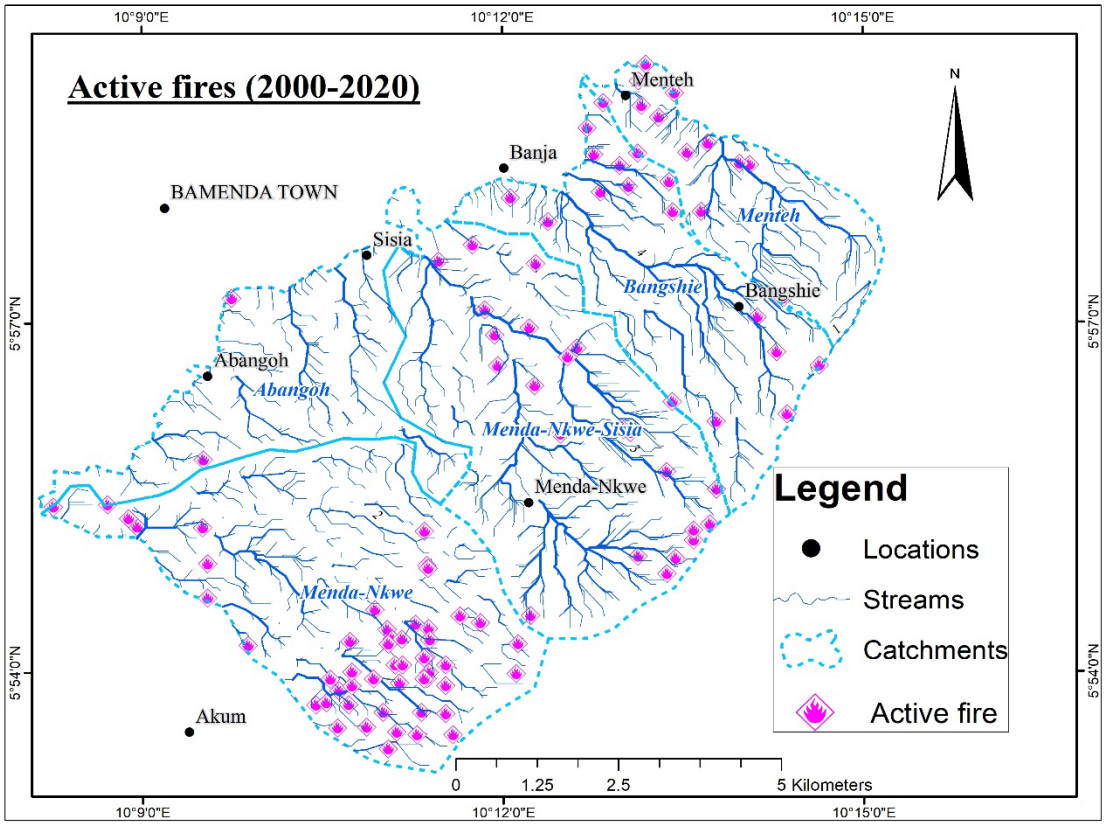

Figure 6: Active fires over the urban watershed from 2000-2020

Fires destroy the forest species and promote the growth of shrubs and grass species which are not suitable protective land cover for watersheds. Constant use of fires on the highland areas is reported to have adverse effects on the landscape through increase surface runoff and attendant soil loss due to reduction in soil water repellent capacity and/or hydrophobicity.

The hypothetical linear regression statistics at .05 levels of significance revealed that anthropogenic activities have a significant effect on catchment areas in Bamenda. In the pair wise correlation coefficient results on table 5, the anthropogenic activities correlate perfectly with catchment areas effects at 1.000. The calculated p-value was .001 anthropogenic activities and .001 for catchment areas which was not up to the critical level of significance (.05) that was used for testing the hypothesis. Base on the results, it implies that anthropogenic activities exert significant effects on catchment areas in Bamenda.

Table 5 : Pairwise Correlation for Anthropogenic activity effects on catchment areas in Bamenda III

Items		**Anthropogenic Activities**	**Catchment Effect**
Pearson Moment	Anthropogenic Activities	1.000	.922

correlation	Catchment Effect	.922	1.000
Sig. (1 tailed)	Anthropogenic Activities	.	.000
	Catchment Effect	.000	.
N	**Anthropogenic Activities**	**79**	**79**
	Catchment Effect	**79**	**79**

Source: Author's fieldwork computation, 2020

To further confirm the hypothesis, the summary model was tested as described on table 6. The result shows that the coefficient for R was .922[a], the R-Square was .851 and the adjusted R-Square was .849 given a better measure of goodness of fit for the regression analysis.

Table 6: Summary of the model[b]

Model	R	R-Square	Adjusted R-square	Std. Error of the Estimate	Change statistic				
					R-Square Variation	F Variation	ddl1	ddl2	Sig. of F
1	.922[a]	.851	.849	.44266	.851	438.378	1	77	.000

a. Predicted value : (constant), Catchment Effect
b. Dependent variables : Anthropogenic Activities

Source: Author's fieldwork computation, 2020

The significant F variation was given at .001 which was not up to the significant level of .05 placed for the study.

4.3. Discussion of findings

The results from this study were purely based on field survey and the data generated through questionnaire, supported by literature. The major findings revealed that anthropogenic activities such as farm work, settlement extension, hunting and pasture have exerted negative effect on catchment areas of Sisia-Menteh in Bamenda. As evident from sample households, a significant majority revealed that plants and animal extinction have been witnessed around the catchment sites, disappearance of fresh water sources as well as reduction in vegetation cover.

Kaptoyo and Athman, (2005) shared similar views with the current findings. They outlined that the underlying issues which have worsen the conservation and degradation of catchment areas are unregulated human activities which are detrimental to vegetation cover, undermining conservation, and community participation in forest management. This is seen in this work where illegal extension of settlements, farmland and livestock rearing is

rampantly practiced around the watershed areas of the study location. Though, MEA (2005), claim that this happens as humans struggle to meet their daily needs, especially in local communities were subjected to forests, woodlands and grasslands for livelihood sustainability.

Pickett *et al*. 2001, Liu *et al*. (2018) bring into focus the concerns of rapid urbanization which have motivated urban dwellers to construct more houses even at the expense of catchment areas to absorb the rural-urban influx. Vitousek *et al*. 1997, Alessa and Chapin, 2008 considered this as one of the major forces threatening biodiversity and ecosystem services provided by biological communities within catchment areas. This is exactly the scenario taken place in Bamenda where influx of rural population have pushed the inhabitants to illegally extend settlement construction at risky zones and nature protected areas such as the catchment at Sisia and Menteh. In the assessment of Sharma *et al*. (2001) and Miller *et al*. (2002), their studies predicted that land use changes due to human activities especially at catchment affect water discharge, with severe consequences of water scarcity.

Conclusion

Water is life and the existence of catchments have sustained most water sources around the world and most especially in developing countries where some rural communities still depend on springs and streams for drinking water. In some communities like that of Bamenda, the International Corporation like Non-governmental Organizations in partnership with Municipal councils, catchments like that of Menteh and Sisia have been developed to supply clean water to the population. However, human practices on the landscape have subjected these catchment areas to near extinction. This is exactly what the Bamenda urban catchments have witnessed within the last few years as a result of human activities on the landscape. The results from the study have indicated that all calculated p-values were .001 less than the stated significant level 0.05. Therefore, human activities such as farming, pasture, fuel wood collection, hunting, bush fires and settlement extension have exerted negative impact on the catchments in Bamenda. The study therefore strongly recommends that the government through municipal councils should carry out capacity building and sensitization campaigns on the importance of conserving watersheds and catchment areas.

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