Analysis of Vulnerability Hotspots in Landcover for Momo Division, North West Cameroon

Tassah Ivo Tawe[1*], Ndifon Franshua Becha[2], Henri Yambene Bomono[3]

[1]*Department of Economics and Environmental Science, National Centre for Education,Ministry of Scientific Research and Innovation, Yaoundé-Cameroon*

[2]*Department of Environmental Sciences, University of Buea-Cameroon*

[3]*National Centre for Education, Ministry of Scientific Research and Innovation, Yaoundé-Cameroon*

[*]*Corresponding author*

Abstract:-**There is an overwhelming andcompelling evidence that land cover mutation is a substantial contributing threat to the vulnerability of land resources to levels where, the cost of restoration has become too colossal and in some cases almost impossible. This paper establishes an early warning signal that uncovers a key constraint contributing to the vulnerability in social-environmental systems in land resource dependent communities. It provides a baseline that draws the attention of development stakeholders and land resource users to sustainable land resource exploitation and planning for rural development.**

Landsat images with the help of Geographic Information System applications combined with ground truth verifications formed a valid approach to ascertain the nexus in land cover types and threat in vulnerability in land parcels across the landscape. A mapping design was established to illustrate the vulnerability hotspots within each Sub-division.

Results indicates that, the hydrological cover, montane forest and built-up land respectively are faced with the greater threat to vulnerability. Stressors initiating changes in the land parcels were observed to be population pressure, the size of land cover, climate variability, farming practices, weak policies and institutional regulationsamongst others increases the susceptibility of land parcels to fragility and vulnerability. The study reveals that, land resource exploitation practices are largely subsistence and the area is void of any land use planning. The proportion of land parcels exposed to threat of vulnerability are expanding since most of the landscape presents a fragile status and land resource users persist with impunity, practices that are unsustainable. Multiple socio-environmental challenges are gaining prominence in the area thus, reducing the viability for livelihood enhancement, sustainable growth and development.Therefore, prioritizing policy recommendations indicate that more concern should be focused on the hydrological cover, montane forest and built-up land respectively. Land use planning and sustainable land management is recommended for integrated rural sector development by all stakeholders especially in this era of decentralization in Cameroon.

Keywords: **Analysis, Vulnerability hotspots, land cover, Momo-division, North West Region, Cameroon**

I. INTRODUCTION AND THE PROBLEM

Land cover mutations according toLal et al.,(2012) is a challenge affecting at least a quarter of the global land area and seriously undermining the livelihoods of poor and vulnerable people in all agro-ecologies in the world (Nkonya et al.,2011).Currently, the degradation of this vital life support system has attained a crisis level in which the current state of affairs has been vaulted to the top of global economic, social and political agenda due to the unprecedented and untold consequences recorded in the recent past (Tassah and Atemkeng, 2019). The global effects of this change, however, varies significantly between developed and developing countries of the world. Whiledeveloped countries seems to have better response strategies, African countries south of the Sahara arereported to be the least prepared to the vagaries ofshocks fromvulnerability to land cover mutations as a function of high dependence on degradation enhancing practices, wide spread land mismanagement,poor or week institutional regulations on land use governance and inefficient adaptations and mitigation strategies amongst others which have far reaching implications on the climate, hydrology, ecosystem services and agricultural productivity.All these have increased the vulnerability threshold of the local people to land cover change.The current response strategies and climate finance in this sub regionare unable to match with the rate of oscillations in the climatic cycles which have further aggravated the situation. The worst case scenario has been the burgeoning population as it has been projected to 1.4 billion people by 2030 (Workshop "Implementing Land Degradation Neutrality in Africa" (LDN) (2018). This means that the resource base which represent the natural capital will be overstressed to provide for the needs of the growing population since a bulk of the population still depend absolutely on nature to give life a meaning (Tassah 2018). This therefore signal a growing threat that might plunged the population into the abyss of poverty and untold misery. Some compelling realities alreadyobserved have been the advancement of the Sahara desert to the sahelian margins, significant drop in the surface hydrology and the visible appearance of ephemeral streams that are at the mercy of climatic caprices, decreasing trends in rainfall patterns with a corresponding increase in the number of sunny days whose effects have been observed to be a drop in the agricultural output, scourged and thirsty soils, mass movement of people in search of water and agricultural havens and the intensification of hunger and conflicts which now represent the occupational landmark in this sub region.

At the national and local levels in Cameroon, these effects seems compelling due to the continuous increase in the population of the country and the reliance on the natural capital as the major source of wealth generation and poverty alleviation. Current projections indicates that the country has26,545,863 million people witha growth rate of 2.59%.The population is expected to increase to 50.000.000 people by 2050 indicating that almost 600.000 people are added to the population per year(World Population Review, 2020). With the projected population growth rate for Cameroon that has been heightened by natural increase and migration from the rural areas, the natural resource base therefore will continue to surfer the bruntdue to the changing patterns of human consumerism and the quest for better livelihoods.

To address the challenges in land cover mutations on both the international and national levels, policy makers often need information about areas of severe vulnerability in order to prioritize national budgets and plan strategic interventions. It is in this light that examining some of the changes experienced at a local scale in the land cover parcels in Momodivision of the North West Region of Cameroon becomes imperative. This is in view of identifying the most vulnerable land parcels that are already under pressure and would likely face more threat of vulnerability as the population continue to intensify with impunity obsolete practices in the exploitation of land to meet their livelihood requirements. In this light therefore, mapping out the most vulnerable land parcels within Momo division will enable policy makers to prioritized strategic interventionsespecially in this era of drive towards effective decentralization where local councils are given the mandate to tackle local development.

II. METHODOLOGY

This study used satellite imageries to ascertain the status of the various land parcels in Momo division for 2016.The choice of 2016 rest on the current socio-political atmosphere that has engulf this zone since 2017 to present date. This has forced many of the inhabitants to seek refuge in other neighboring countries like Nigeria while many have migrated to the French speaking parts of the country. Therefore, 2016 represent the year where marked variations in the land cover could be observed. Landsat images for the study area were obtained from the National Institute of Cartography in Yaoundé. The processed information was done by way of computer based image treatment procedures and techniques using specialized softwares. The principal soft wares used in processing this data were ERDAS IMAGINE 9.1, specialized in the processing of remotely sensed imageries and ARCGIS 10.5, a geographical information system platform that enhances the layout quality of images treated in ERDAS. Equally, a Google Earth images of the study area were obtained from Microsoft student Encarta 2009 for two different period for better visualization of the changes experienced in the land cover types. The various land cover types brought under investigation were; forest land, built-up land, savannah and bare land surfaces, hydrology and the montane forest land.

III. RESULTS

Results of the land cover situation for Momo division as at 2016 indicates that some land parcels have already been affected significantly depicting increasingly high levels of vulnerability with far reaching implications on climate, hydrology, and agricultural productivity.Equally, differences in vulnerability and exposure to risk factors arising from non-climatic stressors and multi-dimensional inequalities also play a crucial role. According to Smith et al. (2001), rural communities and their populations are likely to suffer disproportionately from this impacts based on local peculiarities and exposure to risk factors.In Momodivision, recent and continuing evolution in land use and land coverhas created differences in the spatial productivity of agriculture based on local differences and exposure to risk factors in the different zones. This requires or necessitates a new policy drive enshrined with adaptive measures most suited to tackle the specific threats to land resources within the different zones in Momo division faced with eminent threat of vulnerability.

In assessing vulnerability in land use and land cover change in Momodivision, the study area has been divided into five zones according to the various Sub-divisions which are Mbengwi, Batibo, Widikum-Menka, Ngie and Njikwa. The following land cover types were placed under investigation for the year 2016 in order to analyze the spatial extent occupied by each land parcel in the various Sub-divisions. These are Forestland, Savannah/Bare land, Built-up land, Hydrology and Montane forestland (Table 1).

Table 1,indicate statistics of the spatial extent occupied by the various land cover types obtained from the Enhanced Thematic Mapper (ETM+) Landsat images. This landsat has a spatial resolution of 15m beyond which certain ground truth features are not visible. Therefore to capture significant details of the land cover characteristics, this was followed by ground truth verifications during field visits to match the captured image data to field realities with regards to land cover characteristic across the landscape of Momo division. Some of the differences observed on ground especially with the hydrological coverthat could not be captured by ETM+ were mostly due to the sparse hydrological network density, land use practices and climatic caprices that have reduced most of the streams in the area.

Table 1: Spatial extent occupied by land cover parcels under investigation for 2016 in Momo division

Land use / Land cover type	Mbengwi		Batibo		Widikum-Menka		Ngie		Njikwa	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Forestland	8.827	18.77	19.729	56.76	37.928	86.26	12.562	54.28	14.299	45.59
Built-up land	2.486	5.29	4.820	13.87	1.368	3.11	765	3.31	642	2.05
Savannah/ bare surfaces	32.716	69.59	10.181	29.29	4219	9.59	8.090	34.96	15.620	49.80
Hydrology	5	0.01	25	0.07	182	0.41	13	0.06	5	0.02
Montane Forest	2.981	6.34	4	0.01	271	0.62	721	3.12	795	2.53
Total	47.015	100	34.759	100	43.968	100	23.141	100	31.361	100

Source: Derived from land cover map of Momo-division, (2016)

In establishing the vulnerability hotspots in land use and land cover changes in Momodivision, the study area as aforementioned was divided into different zones based on the various Sub-divisions. Figures 1.1, 1.2, 1.3, 1.4 and 1.5 indicate percentages occupied by each land parcels under investigation in the different Sub-divisions for 2016.

After a proper analysis on the evolution of land use/ cover change and trends for Momodivision, the researchers resorted to identifying the most vulnerable areas affected by land use and land cover changes.In this case, the spatial extent occupied by each land parcel under investigation in the different Sub-divisions for 2016 became important. A critical look at the percentages occupied by each land cover type in the different Sub-divisions as at 2016 after undergoing changes indicate that these land parcels do not occupy the same surface area either in hectares (Table 1) or in percentages as projected on Figures 1.1 to 1.5. These indicate that some of the land parcels have been under pressure in terms of land use than the others.This were on the basis of proportion covered (abundance) of each land parcel, population pressure, methods of exploitation which escalate threat to vulnerability, present state and predicted future state of the land cover types, decline in the potential in given land cover or land parcels classes. Thus, the tendency of land parcels to become less productive.

Figure 1.1 indicate percentages occupied by the various land cover types for 2016 in Mbengwi Sub-division. Projections indicate that with a total land cover of 47.015 hectare (ha), Savannah/Bare lands occupy the greatest area 32716ha (69.59%) followed by Forestland 8827ha (18.77%). Montane forest 2981ha (6.34%), and Built-up lands occupy 2486ha (5.29%) while hydrology occupies 5ha (0.01%).

Looking at the population figures for Mbengwi, the total population was 31,591 inhabitants as per the third General Population and Housing Census of 2005 published in 2010 with an annual growth rate of 2.1% (BUCREP, 2017). With this estimated growth rate, it shows that from 2005 to 2016, an estimated 7297 persons have been added to the population within a period of 11years which now puts the population of Mbengwi at approximately 38,888 inhabitants. With the overwhelming growth in the population and the high dependence of the community to land resources, the pressure for exploitation of the land resources to meet up with livelihoods needs is unbearable. In this case therefore, some of the land parcels are becoming more vulnerable due to the increasing threat pose by the population.

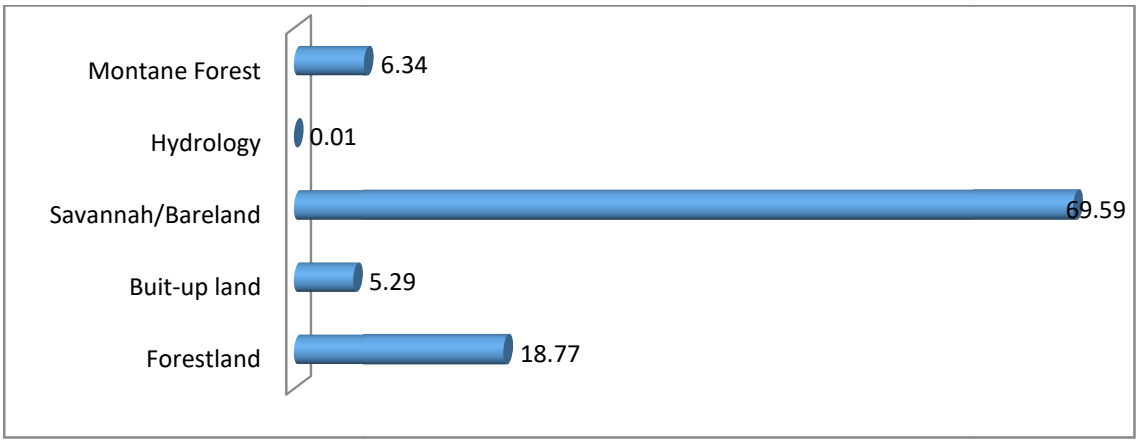


Figure 1.1: Percentages occupied by various land parcels in Mbengwi as of 2016

Source: Adapted from Table 1.1

Figure 1.2 shows percentages occupied by land cover types in Batibo Sub-division as of 2016. Projections indicate that out of a total land cover of 34759 hectare (Table 1.1), forestland occupied 19729ha (56.75%), savannah/ bare land 10181ha (29.29%) while Built-up lands 4820ha (13.87%), hydrology 25ha (0.07%) and Montane forestland accounted for 4ha (0.01%). According to the 2005 Population Census Reports, Batibo had an estimated population of 74,362 inhabitants with an annual growth rate of 3%. With the estimated growth rate, it shows that from 2005 to 2016, an estimated 24530 persons had been added to the population for a period of 11years which puts the population of Batibo at approximately 98892 inhabitants.

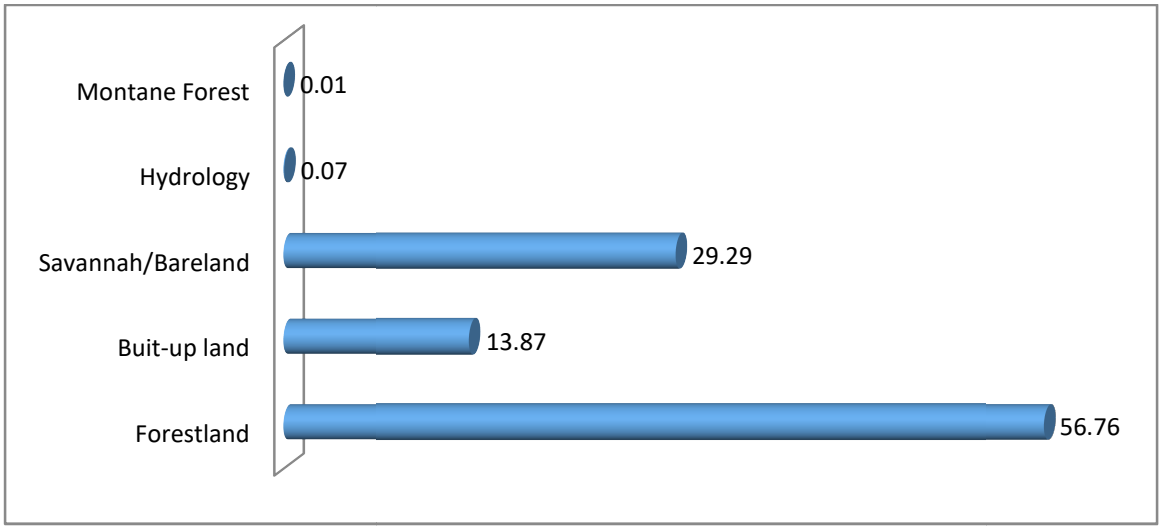


Figure 1.2: Percentages occupied by various land cover types in Batibo 2016

Source: Adapted from Table 1.1

In the Widikum-Menka Sub-division, much of the forest cover appears to be very high and still very much in place. Out of a total land cover of 43968 hectare, forestland occupies 37928ha (86.26%), followed by savannah/bare land with 2419ha (9.59%). Built-up land occupies 1368ha (3.11%), Montane forest 271ha (0.62%) while hydrology make up 182ha (0.41%). According to the 2005 Population Census, Widikum Sub-division had a total population of 38000 inhabitants in 2005 with a growth rate of 2.9% per annum. (Annual Reports of Sub-divisional office, Widikum, 2005). From 2005 to 2016, the population has been projected to 50122 inhabitants within a period of 11 years.

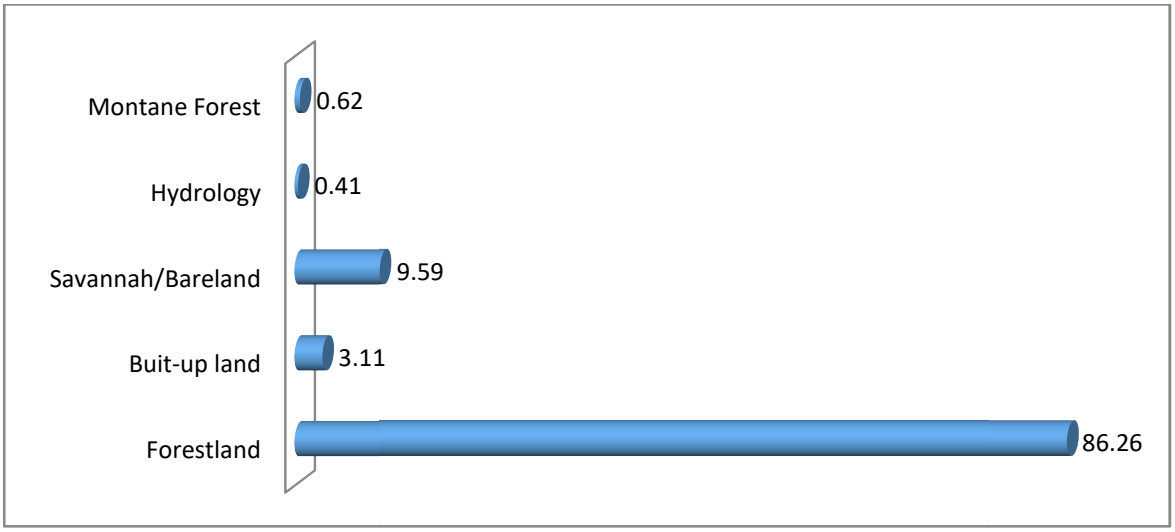


Figure 1.3: Percentages occupied by various land cover types in Widikum-Menka 2016

Source: Adapted from Table 1.1

The situation for Ngie Sub-division indicated that out of a total land cover of 23141ha, forestland occupy 12562ha (54.28%), savannah/bare land 8090ha (34.96%), built-up land 765ha (3.31%) while Montane forest 721ha (3.12%) and hydrology occupy 13ha (0.06%) Figure 4.13. Population data as of 2005 census reports puts the population at17697 inhabitants with an annual growth rate of 2%. From 2005 to 2016, the population has been projected to 21590 inhabitants within a period of 11 years.

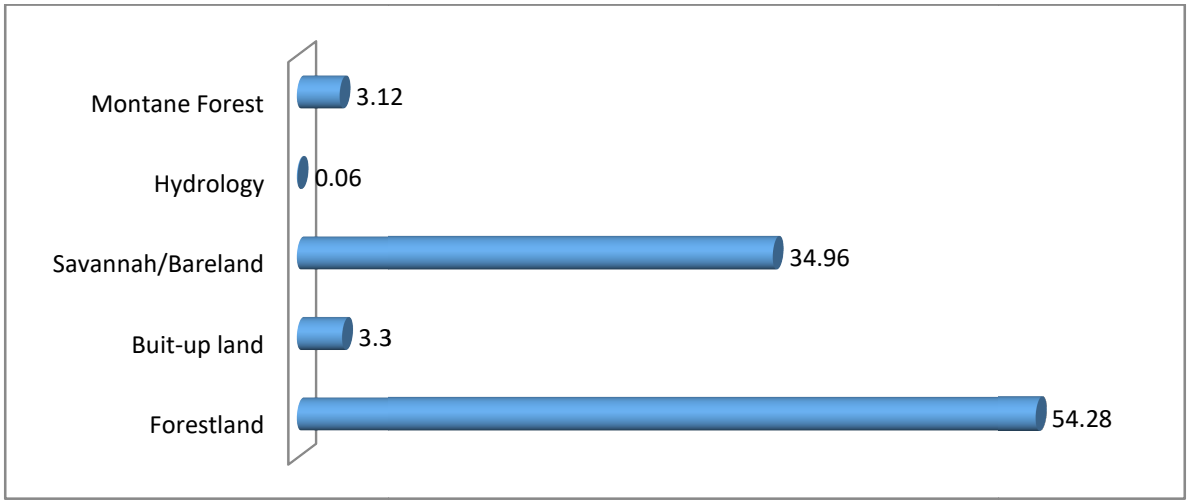


Figure 1.4: Percentages occupied by various land cover types in Ngie 2016

Source: Adapted from Table 1.1

In the Njikwa Sub-division, out of a total land cover of 31361ha, Savannah/bare land occupies the greatest land cover with 15620ha (49.80%), Forestland 14299ha (45.59%), Montane forest 795ha (2.53%) while Built-up land occupies 642ha (2.05%) and hydrology 5ha (0.02%). Population figures for Njikwa as of 2005 census reports shows that the area has a total population of 16634 inhabitants with an annual growth rate of 2%. The projected population for Njikwa from 2005 to 2016 puts the population at 20286 inhabitants for a period of 11 years.

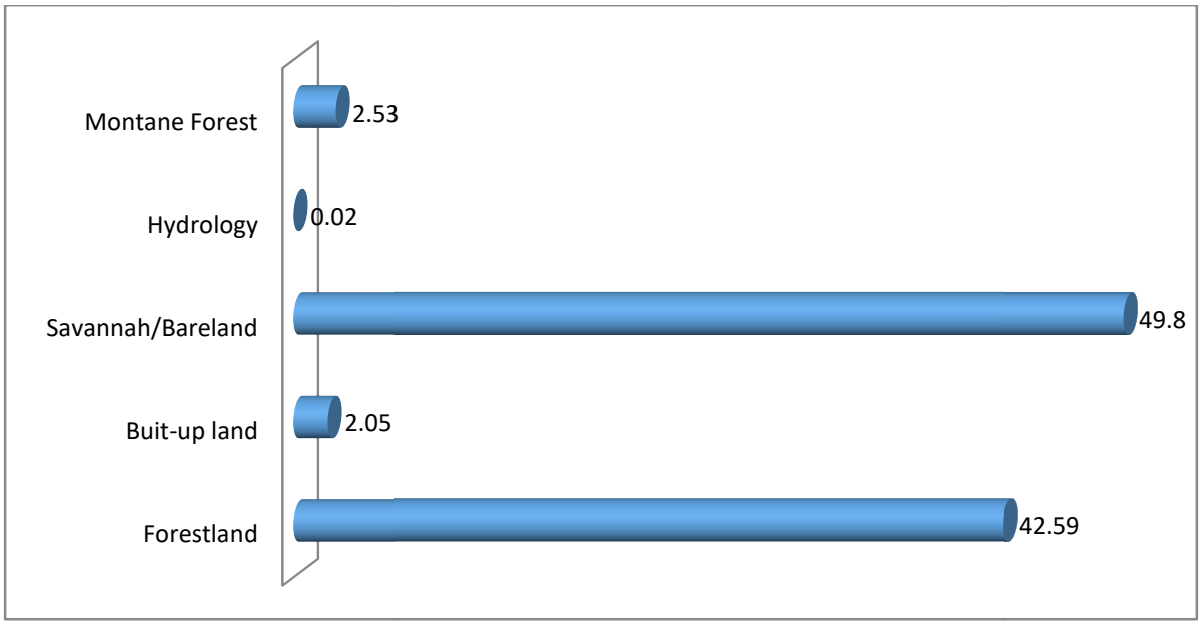


Figure 1.5: Percentages occupied by various land cover types in Njikwa2016

Source: Adapted from Table 4.4

Table 1.2: Population pressure on areas occupied by each land parcel under investigation in the various Sub-divisions of Momo for 2016

Sub Division	Land use/ cover type	Aerial extent for 2016 (ha)	Total population for 2005	Growth rate 2005	Projected population for 2016	Population density on land parcel.
Mbengwi	Forest land	8827	31591	2.1%	38888	4.40
	Savannah/bare land	2486				15.64
	Built-up land	32716				1.19
	Hydrology	5				7777.6
	Montane forest	2981				13.05
Batibo	Forest land	19729	44619	2.7%	45928	2.40
	Savannah/bare land	4820				9.53
	Built-up land	10181				4.51
	Hydrology	25				9185.6
	Montane forest	4				11482
Widikum	Forest land	37928	28152	2.9%	37128	0.99
	Savannah/bare land	1368				27.14
	Built-up land	4219				8.80
	Hydrology	182				204
	Montane forest	271				137
Ngie	Forest land	12562	17697	2%	21590	17.19
	Savannah/bare land	765				28.22
	Built-up land	8090				2.67
	Hydrology	13				1660.77
	Montane forest	721				29.94
Njikwa	Forest land	14299	16634	2%	20286	1.42
	Savannah/bare land	642				31.59
	Built-up land	15620				1.29
	Hydrology	5				4057.2
	Montane forest	795				25.56

Source: Derived from land use/cover map for Momo Division (2016) and National Institute for Statistics (2017)

Table 1.2 shows population pressure on the areas occupied by each land parcel under investigation in the various Sub-divisions of Momodivision for 2016. Based on the results presented, it indicate that the intensity of the exploitation of the various land parcels vary considerably over the study area. This is based on the intensity of stressors which in this case were identified to be population pressure and land use practices.

Generally, it is observed that the hydrology is the highest land cover type that has been under intense pressure in the whole of the study area than the other land parcels. Statistics from Table 1.2 indicates that in the Mbengwi Sub-division, 7777.6 inhabitants depend on a hydrological cover of 5ha as of 2016. In this case therefore, a 1% increase in the population of Mbengwi will further lead to a significant decrease in the hydrological cover. The same situation was noted in the Widikum basin where 204 inhabitants depend on a hydrological cover of 182ha. Ngie with 1660.77 inhabitants depending on a hydrological cover of 13ha and Njikwa with 4057.2 inhabitants depending on 5ha of hydrological cover. It is only in the Batibo Sub-division that the pressure is more on the montane forest with 11482 inhabitants depending on 4ha of montane forestland followed by the hydrological cover with 9185.6 inhabitants depending on 25 ha. From these statistics, it shows that the hydrological cover is highly vulnerable to changes in the whole of Momodivision than the other land cover types under investigations. This is closely followed by montane forestland and built-up land respectively. Figure 1.6 indicate that the intensity of vulnerability of the various land parcels under investigations to agents of land cover transformations remains compelling. From the linear regression equation in figure 1.6, the vulnerability trend line indicate that with a coefficient of determination $R^2 = 0.536$, the vulnerability of the various land parcels to undergo changes increases on average by a gradient of 4444.6 with a negative constant of(-6723.3). Therefore, prioritizing policy recommendations indicate that more concern should be focused on the hydrological cover, montane forest and built-up land respectively.

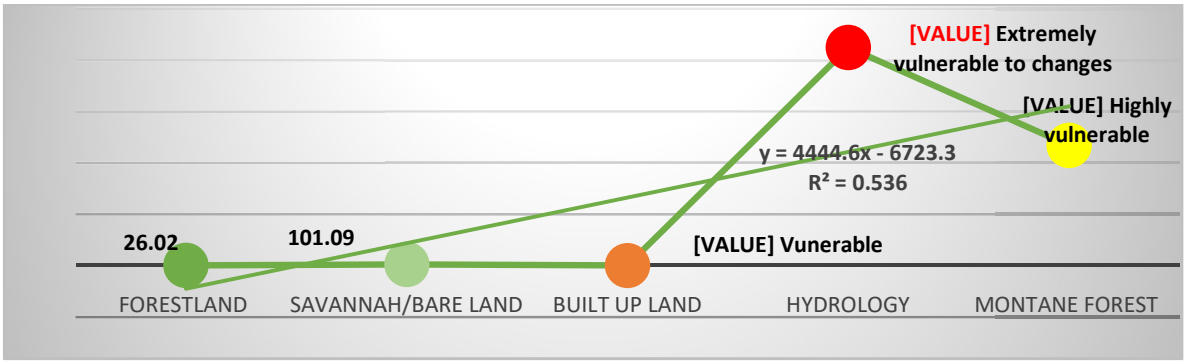
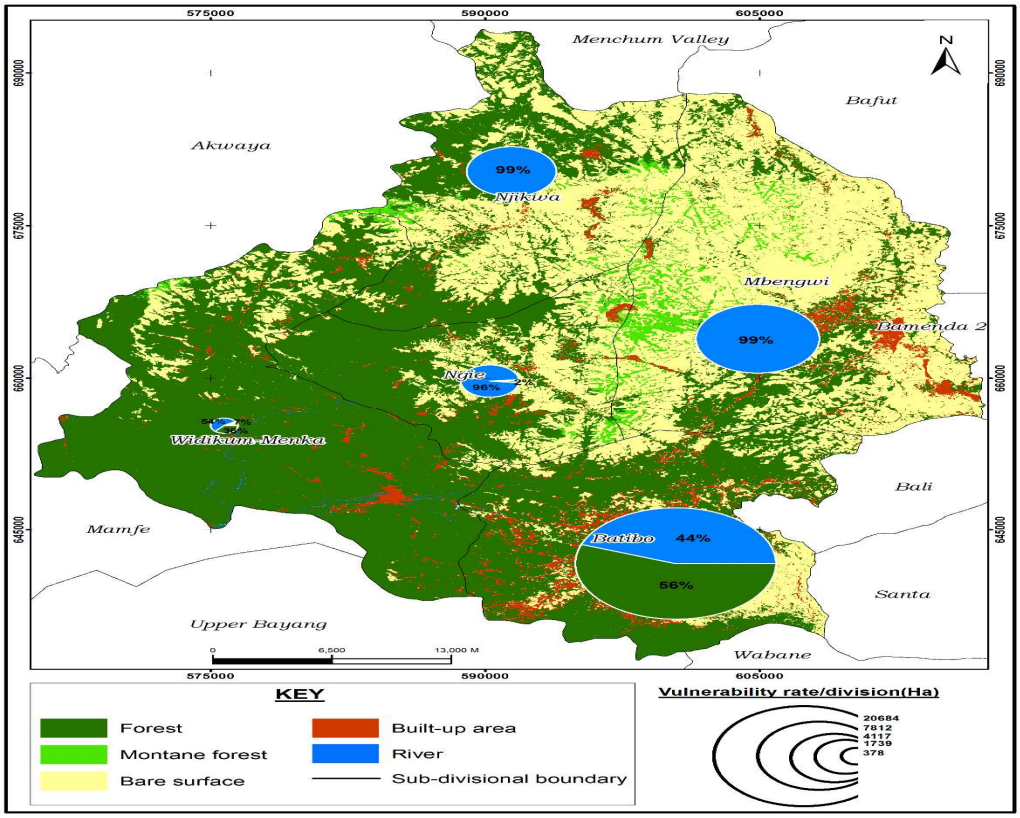


Figure 1.6: Trend lines indicating vulnerability hotspots in land cover for Momo-division 2016

Source: Derived from table 1.2

Field investigations indicate that the vulnerability of these land parcels to changes has been orchestrated by population pressure, unsustainable land use practices and oscillations in theclimatic cycles.

In an attempt to carry out ground truth investigations in the various land parcels under study, a high resolution Google Earth Map was obtained from Microsoft Student Encarta 2009, version 9.1. The various land covers were identified on Map 1 and the corresponding field realities on the ground. Ground truth investigations indicated that a significant proportion of what is considered as forest land in the Widikum-Menka area, Batibo and Ngie is made up of cultural covers specifically palm trees. In this case, it was difficult for the Enhanced Thematic Mapper (ETM+) to discriminate between the natural forest and the cultural covers since they were almost of the same height with the same spectral resolution.Therefore, though the forest seems to be less under pressure as indicated on the linear regression equation, these forest areas are more of cultural covers such as palms and other fruit trees. In this case, only patches of the natural forest could be observed through ground truth investigations.



Map 1: Vulnerability map of the various land cover types under investigation in Momo Division for 2016

Source: Adapted from Table 1

Ground truth investigations equally showed that the hydrological cover is more in the Widikum basin than the other areas in the Division. Rivers identified in this basin include River Momo, Tanjoh, Emom among a host of others. These rivers take their rise from Njikwa, Ngie and part of Batibo Sub-divisions and therefore constitute the largest drainage basin in the whole of the study area. Equally, despite the significant increase observed in the savannah/bare land surfaces, the rangelands which are cattle grazing zones have rather been on a decrease as a significant proportion of these highlands have been invaded by the bracken fern and the other unpalatable species of grass needed by the cattle. Ground truth realities equally indicated that what is considered as forest in the Widikum-Menka Sub-division is largely transformed or secondary forest refugia constituting cultural covers like palms, cocoa and coffee small holder plantation farms and not the natural forest cover.

IV. CONCLUSION

Attempts to halt and reverse land degradation at both the national and international scenehas been a challenge to development stakeholders. This is premised on the fact that the land degradation process is still faced with significant challenges by ways of perception and varied definitions existing in the global land restoration agenda. As noted by Blaikie and Brookfield (1987),whilst deforestation may be seen as degradation by ecologists, cattle ranchers may perceive it as increasing the productivity of land. This has been the driving force to the enhanced degradation despite efforts to contain the situation by national and international development actors. The 2015 Paris Agreement on climate change and sustainable development therefore present pathways through which some of these challenges could be obliterated by providing opportunities for countries to set forth Nationally Determined Contributions (NDCs) based on domestic realities.

To address some of these challenges especially in the land cover mutationsat a national level in Cameroon, this paper has analyzed some of the land parcels that are under severe threat of vulnerability at a sub-regional level in Momo division of the North West Region of Cameroon by providing early warning signalsthat uncovers a key constraint contributing to the vulnerability in social-environmental systems in land resource dependent communities. This is to enable policy makers who often need information about areas of severe vulnerability in order to prioritize national budgets and plan for strategic interventions in the process of meeting up with NDCs.

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