

## *Original Paper*

# Drivers of Watershed Degradation and its Implications on Potable Water Supply in the Menchum River Basin of Cameroon

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### ***Abstract***

*Current anthropogenic stresses on natural systems in the Menchum River Basin of Cameroon have remained the major contributors to watershed degradation in the region. This study examines the various drivers of watershed degradation in the basin and their implications for potable water supplies. It gives an assessment of the spatio-temporal changes in land use and its effect on water yield and erosion rates, and also assesses the probable interaction of global climate change and anthropogenic factors on water yield. The study employed a combination of field observations, informal interviews and the consultation of secondary data to investigate these drivers. The data obtained were analysed using descriptive statistical techniques, and presented in both qualitative and quantitative terms. A series of maps and photographs were used to portray land use and land cover changes in the basin. It was observed that population pressure and incompatible land use changes account for watershed degradation in the basin. The implications have been increased runoff and surface overland flow, a reduction in potable water quality and quantity resulting to frequent water cuts. The paper recommends the sustainable management of watersheds whereby, all critical components need to be included into the planning process for the watercourses and their catchments.*

### ***Keywords***

*drivers, land use, land cover, watershed degradation, potable water supply*

## 1. Introduction

The watershed has been widely acknowledged to be the appropriate unit of analysis for many water resources planning and management problems. However, many of the environmental processes and socio-economic activities occurring within a watershed system are simply too complex, dynamic, and spatially variable to be precisely monitored and thoroughly understood. As population grows, continued human encroachment into natural systems seems inevitable, with expanding communities needing increased water supplies to carry out various development activities in the watershed. Paradoxically, both water shortage (drought) and overabundance (flooding) have proved to be even more problematic for many communities. Yet human expectations remain high for using water as a means of socio-economic development and ecosystem conservation and enhancement (McKinney et al., 1999).

Most developing countries largely depend on their natural resource base for development, and therefore, comprehensive information on their natural resources is key in implementing poverty alleviation strategies, improving human conditions and preserving the biological systems (Onywere et al., 2007). Watersheds are complex systems where water, soil, geology, flora, fauna, and human natural resource use practices interact. Hence, watershed degradation has environmental and socio-economic effects far beyond the more obvious on-site and downstream impacts (Salah et al., 2008). For the same reasons, watershed management interventions may bring local, regional, and global environmental benefits. The need for up-to-date and timely information on the drivers of watershed degradation in most watersheds is crucial for sustainable development and planning. The concerns on land use and settlement trends affecting riparian communities in most watersheds reflect high levels of degradation. Rapid population increase and incompatible land use practices around watersheds have reduced their effectiveness in regulating water catchments. Their influences are complex and interrelated. For example, trees and leaves have a function of intercepting part of the precipitation while fallen leaves and branches provide an environment for micro fauna and micro flora. Decayed roots help maintain and improve the infiltration capacity of the soil. Forests create deep storage for soil water by transpiration. A forest cover and the litter it produces detain surface runoff and allow more time for infiltration to take place. Forests equally shade and reduce surface evaporation and delays snowmelt. In some situations, forests can increase the water available to the watershed by condensing atmospheric moisture. By cutting down these forests in an unsustainable manner implies that all these functions are jeopardised thereby putting more stresses on ground water regeneration and consequently the supply of potable water to the community.

The economic potentials and human settlement patterns are closely linked to the agro-climatic characteristics of the basin. The Menchum River Basin, for example, has very high potentials for agriculture. This basin constitutes an agricultural cornucopia for the North West Region because of the multitude of crops cultivated in this region all year round. The Menchum Valley is blessed with a lot of

fertile soils that favour all-year-round cultivation. It supports a large population leading to an immense land use competition and conflicts. This land use pattern has disregarded the land potentials, its carrying capacity and limitations of land resources as well as their diversity and distribution. The problem is compounded further by its rapid population increase, increased poverty levels as well as the limited institutional capacity to deal with land use challenges.

The degradation of watersheds in recent decades has brought long-term reductions in the quantity and quality of land and water resources, as it is the case of the Menchum River Basin of Cameroon. These changes in watersheds have resulted from a range of natural and anthropogenic factors, including natural soil erosion, changes in farming systems, the over abstraction of water, over-grazing, deforestation, and pollution. The combination of environmental costs and socio-economic impacts has prompted investment in watershed management in many developing countries. River basin, variously described as drainage basin or catchment, is a hydrological, geomorphological unit that is made up of both physical and human components, namely, vegetation, faunal population, soil, water and the human landscape. Therefore, the interaction between and amongst these components results in the functioning of the basin as a system (Kometa, 2011). Watershed is not just a geographical area where water drains to a common point; it is also a landscape where communities living within it make a living from the available local resources within the watershed. Watershed degradation is a phenomenon by which the potentiality of the watershed is getting reduced, which can be confined to the forest loss and the rate of soil erosion increment, if other factors are negligible. There has been a global concern for environmental degradation especially in the present century and this has emerged as one of the major threats for human survival. Increasing human population and technological advancement have however, facilitated major interventions in the regular functioning of the river basin system. The understanding of the nature, magnitude and dimension of each intervention on the hydrology, hydraulics and morphology of the river basin is very crucial, and this makes data collection, processing and storage a very important component in the sustainable management of river basins.

The Menchum River Basin has for many years witnessed the rapid degradation of its watersheds as a result of the interaction of both the natural and the human environment. This is evident in the reduction of some of the most important streams in the basin and the cueing up of people around the major taps with some of the minor rivers and streams completely drying up of in the heart of the dry season. Taking into cognizance the fact that this basin constitutes the heartbeat of the inhabitants of Menchum Division as far as agriculture is concerned, it is the aim of this study to examine the different drivers behind this environmental dilemma and to propose better solutions as far as a sustainable watershed management is concerned. Also, the Menchum Fall is located in this basin with a lot of potentials for the generation of hydro-electricity which could serve the whole of the North West Region and some parts of neighbouring Nigeria. But with the rapid rate of degradation of these watersheds through in

compatible land uses, it is therefore only germane that the drivers of watershed degradation and their remedial measures be identified.

## 2. Research Methodology

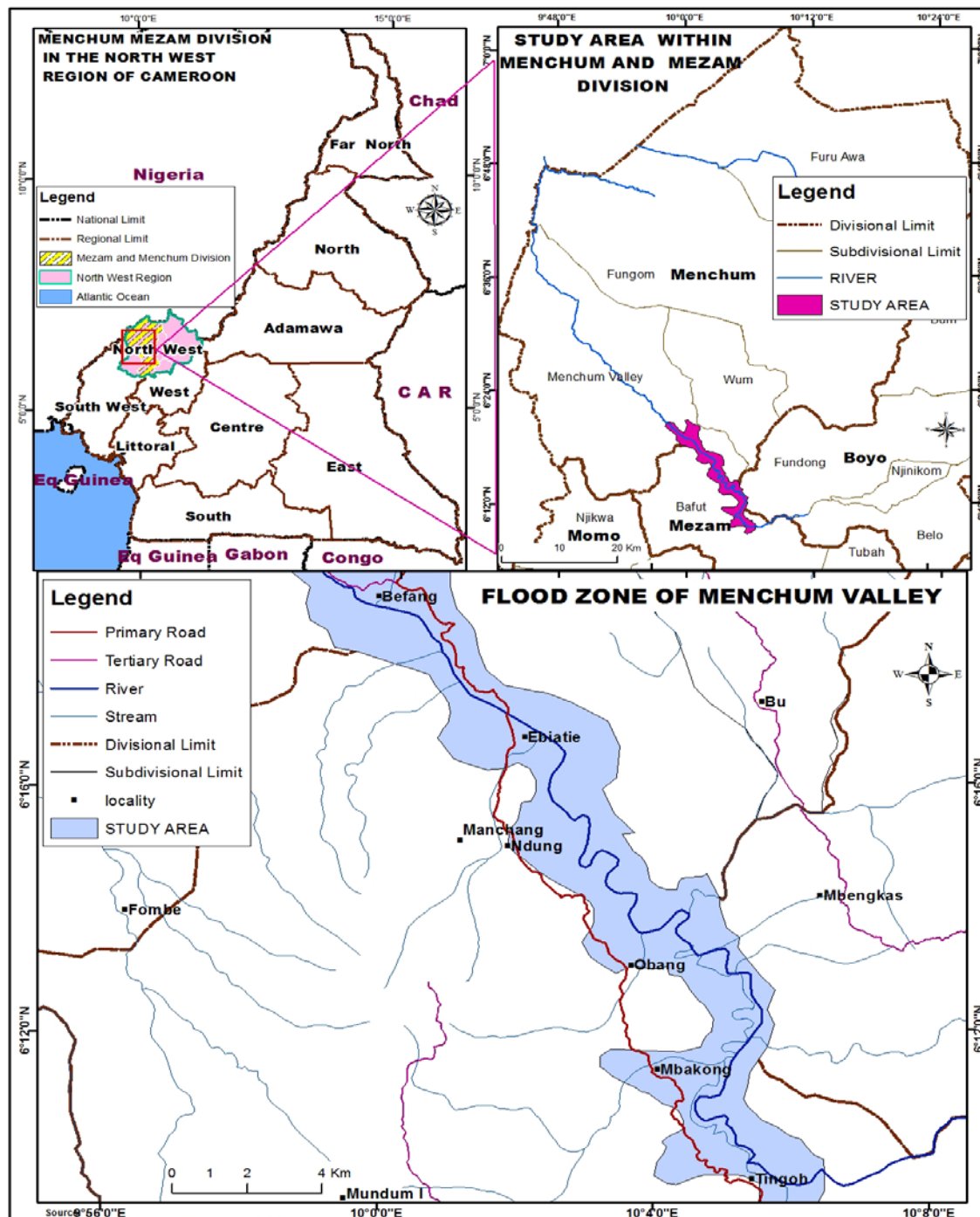
### 2.1 Location of Study Area

Found in Menchum Division of the North West Region of Cameroon, the Menchum River basin lies between latitudes  $5^{\circ} 25'N$  and  $6^{\circ} 15'N$  and longitudes  $9^{\circ} 7'E$  and  $10^{\circ} 21'E$ . The approximate basin surface area is  $2525 \text{ km}^2$ . This is the largest river basin in the region which constitutes an important entity for development. The Menchum River Basin is bordered in the North East by Wum Central Sub-Division, to the North West by the Menchum Valley Sub-Division, to the South West by Bafut Sub-Division and to the South East by Boyo Sub-Division. It has an approximate surface area of  $2116 \text{ km}^2$  (Ndenecho, 2007). Figure 1 presents the location of the basin.

### 2.2 Climatic Evidences

The series of erosion surfaces in the river basin, often separated by steep escarpments have led to the emergence of distinct temperature regimes. These have been described by Hawkins and Brunt (1965). Temperature inversions are common in the Bafut-Bali-Mankon Plateau, where cold air drains from the High Lava Plateau onto the low lying undulating surfaces. Working from inadequate meteorological data, mostly, incomplete rainfall, humidity and temperature data, Hawkins and Brunt (1965) identified the following climatic zones in the basin:

- **Hot and Humid Zone:** The Menchum valley below Bafut at an altitude of 500-800m. It is characterised by a mean annual temperature of  $25^{\circ}$  to  $27^{\circ}C$  with a high humidity all year round. The mean annual rainfall is 2413mm at Befang and 2717 mm at Modele.
- **Warm and very Wet Zone:** This climatic zone extends over the heavily settled area from Bali, Mbengwi, Bafut, Mankon to Kom and Issu. It has a considerable variation in temperature because it lies between  $21^{\circ}C$  to  $30^{\circ}C$  while the mean minimum lies between  $11^{\circ}C$  to  $14^{\circ}C$ . The mean annual rainfall varies between 2286 mm to 3048 mm.
- **Cool and Misty Zone:** This is found in the upland watersheds of the High Lava Plateau at elevations between 1250 and 2250 m. The Mean annual maximum temperatures lie between  $16.7^{\circ}C$  and  $18.9^{\circ}C$  and mean annual minimum temperatures are between  $8.9^{\circ}C$  and  $10.6^{\circ}C$ . The mean annual rainfall is 3048 mm. The relative humidity exceeds 80% in July-August and it is lowest in January-February (45 to 52%).



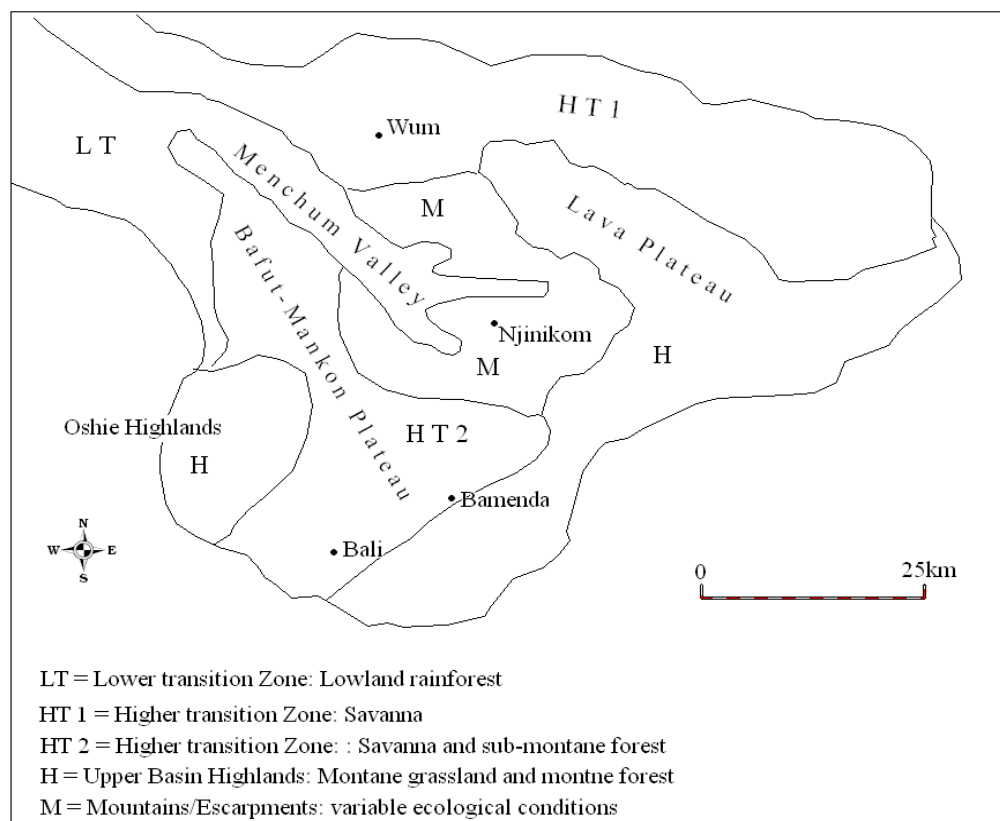
**Figure 1. Location of Menchum River Basin in the Menchum Valley Sub-Division**

Source: Administrative units of Cameroon; 2011 Yaounde Geo-Data base.

The climatic circumstances along the escarpment zones are variable. But in broad terms, the climate of the river basin is characterised by a montane and sub-montane monsoon types of climate of the sub-tropical type. Given the diversity in relief, the orographic factor influences both the rainfall and

temperature regimes. The seasons are controlled by the seasonal movement of the North East Trade Winds and the South West Monsoon Winds. The dry season starts from mid-October to mid-March while the wet season runs from mid-March to mid-October. There are however, local variations which are due to aspect and other orographic factors. For example, the dry season in Befang, Bafut and Wum lasts 3 months (December to February), while in Bamenda on the slopes of the High Lava Plateau, it lasts 4 months (November to March). The above climatic characteristics for the basin are summarised in Figure 2. Few meteorological stations exist in the area and available data for most weather elements are either not complete or not recorded. This is due to the lack of instrumentation.

The climatic setting for the basin has given rise to different ecological zones with different vegetational types that favour various types of activities. This explains the reasons for the varied land use practices within the basin. Figure 2 presents the different ecological zones for the study.



**Figure 2. The Ecological Zones of the Menchum River Basin, North West Region of Cameroon**

Source: Ndenecho, 2003.

Field observations were carried out in order to identify the different land uses taking place in the area and their implications on watershed degradation. Photographs from the field studies showed the degree and the magnitude of degradation in the study area. They show a transformation of the vegetation from forest to savannah grassland vegetation. Focus group discussions as well as interviews were also conducted with the local population and the authorities of the Ministry of Water and Energy Resources for the area in order to identify the kinds of land uses and their implications on water yield.

To comprehend this primary data, secondary data were also used to obtain information. To assess the degree of land use changes in the area, the study used the concept of change detection which is the methodology of identifying contrasts or discrepancies in the state of object phenomenon by observing it at different times. This involves the ability to quantify temporal observation and transformations using multi-temporal data sets over the same location on the earth's surface. Remote sensing is therefore ideal in observing this change (Patrick, 1991). Change detection therefore studies and recognises the biotic and abiotic components of multi-spectral and multi-temporal variations that are occurring within the ecosystem (Mont et al., 1993). These were based on two types of techniques which are map-to-map comparison and image-to-image comparison. Map-to-map comparison is a method that relies on the identification of the differences between two or more maps of different data sets of the same location. This study therefore made use of three different maps for purposes of comparison. These were the 1965 maps, 1987 and the 2005 maps respectively of the Menchum River Basin. Image-to-image method on the other hand relies on the identification of two or more imageries of different data sets of the same location. These images taken during field observation brought out the changes in land use and their implication on the flow of rivers and streams in the basin.

Data on water yield (discharge) of the Menchum River was also collected at the Agulli River Gauging Station for the period 1965 to 1987. The data were then correlated with the identified land use changes documented for the same period. The data were then analysed using descriptive statistical techniques in order to obtain the response of the river regime to land use changes. The study assessed the influence of rainfall variability on the river regime. It equally used empirical methods to measure runoff responses to land use change with reference to the rational formula. The use of this method is justified because it is not reliant on field measurement and can be calculated from maps and hydrological evidence, such as rainfall data, a parameter which is most important in runoff estimation. Other parameters require site specific observations which can be easily quantified. The rational formula according to Norman Hudson (1983) was calculated as follows:

Where  $Q$  = Peak rate of flow ( $m^3/s$ )

$C$  = the dimensionless runoff coefficient

$I$  = rainfall intensity (mm/hr)

$A$  = catchment areas (hectares)

### 3. Results and Discussion

The study set out to identify the main reasons for watershed degradation in the Menchum River Basin and the implications on potable water supply. The first section looks at the drivers and implications while the last section brings out remedial measures to curb this problem. The drivers include the probable interaction between natural and human factors.

#### *3.1 Anthropogenic Activities and Watershed Degradation in the Menchum Basin*

Human influence in the basin exacerbated through different land use practices have been the main reasons behind watershed degradation in the Menchum Basin. As the population increases, the desire to meet up with the needs of the growing population equally doubles on a limited resource base, hence, an encroachment into the watershed areas.

##### *3.1.1 The Urbanisation Process*

The population of the Menchum Basin has been increasing over the years as a result of natural increase and the impact of immigrants from neighbouring Nigeria for business purposes. The increase in population means that there is need for space for settlement and other activities that go along with human settlements. As a result, the urban system tends to survive only by importing food from external plant growing ecosystems or rural areas. Urban food requirements or demands generate the rate of food production in rural areas and therefore partially determine the intensity of use of rural land resources for production. In this way, Bamenda town has exerted a lot of pressure on the surrounding villages of the Menchum Basin for the provision of water, animal protein, plant resources and energy and charcoal for cooking from rural areas. Increasing urbanisation of space within the Menchum drainage basin has well documented hydrological implications which include some of the following: the proliferation of impervious urban surfaces which reduce the soil infiltration of water consequently reducing groundwater storage and the time to peak of surface runoff in stream channels; drainage reticulation systems equally reduce the time to peak in natural channels; drainage and the reclamation of flood plains and the wetlands in urban landscapes generally tend to eliminate the natural functions of these topographic sites. The widespread destruction of the existing vegetation has resulted in increased runoff, less infiltration of water into the soil, increased soil erosion especially along steep slopes, increased sedimentation of streams and rivers, increased flood events and the general drop in water yields within the Menchum Basin. The basin has experienced increased urbanisation over the past 45 years.

##### *3.1.2 Deforestation and the Planting of Eucalyptus Trees*

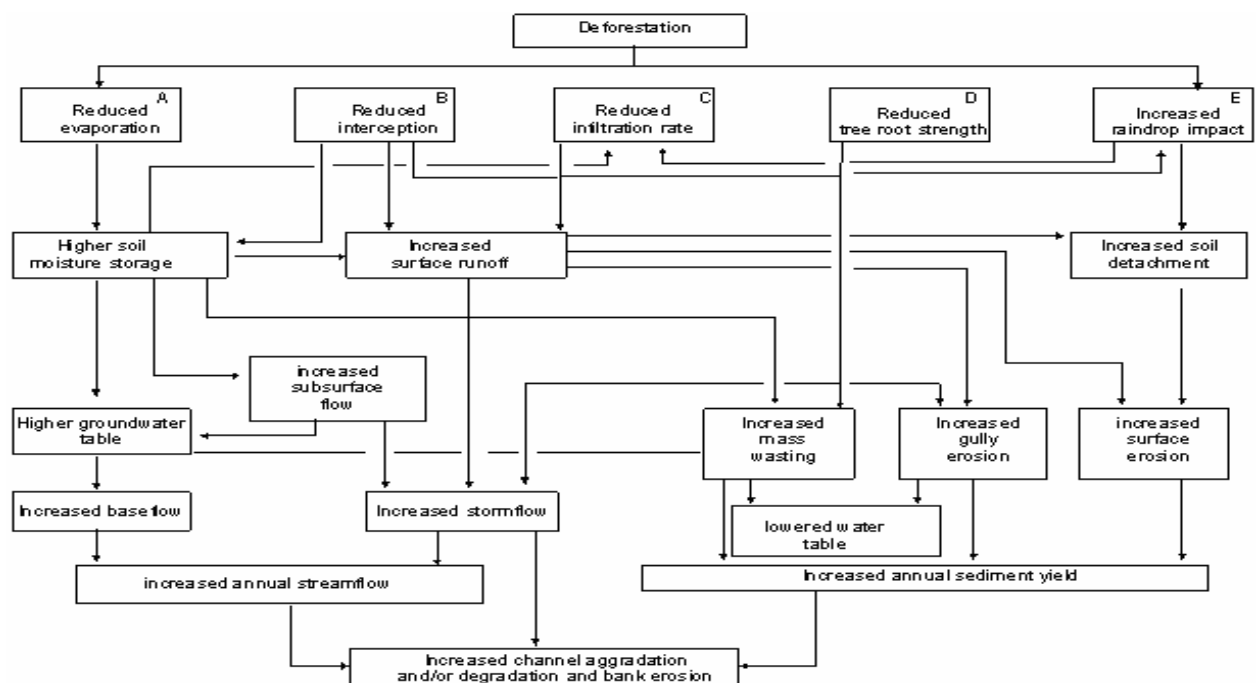
Forests, often found in headwater regions, do not only improve the annual retention capacity of the soil and thus help to provide a stable discharge rate which is crucial for increased water supply, but they also help to decrease the risk of flash floods and thus severe erosion after heavy rains. It was realized in the basin that there is a lot of deforestation for various purposes such as fuel wood harvesting, construction/building materials, the harvesting of non-timber forest products amongst others. This



deforestation has seriously affected the flow of water in the basin. This problem has been further compounded by the planting of thirsty eucalyptus trees in some watersheds and poor irrigation practices in the upland areas. The deforestation of watersheds results in the consequent savannisation processes, increased runoff rates, increased soil erosion, increased flood events, the sedimentation of streams and a general fall in water yields. Figure 3 presents some hydrological changes that could result from deforestation.

### 3.1.3 Overgrazing

The grazing of cattle has always been a culture of the Fulani people of the North West Region from time immemorial. They kept cattle as a cultural heritage as their position in the society depends on the number of cattle they have. During the rainy season, cattle are grazed upland because of the availability of vegetation. But in the heart of the dry season when the vegetation is completely dry, the herdsmen move the cattle down the valley where there exists green pasture for the grazing of their cattle. This natural way of life of the Fulani in the past did not have any great impact on the land with respect to degradation especially as the cattle were not grazed around the major watersheds.



**Figure 3. Some likely Hydrological Changes following River Basin Deforestation (Clifford, 2001)**

Population increase over the years in the basin has exerted a lot of pressure on the existing natural resources. This coupled with the economic crisis of 1982, has forced many people into keeping cattle on a limited resource base thereby exceeding the carrying capacity of the land. Cattle rearing is no

longer only the tradition of the Bororos alone but the non Bororos are becoming interested in the keeping of cattle because of the profit involved. As a result, they keep too many cattle without taking into cognizance the carrying capacity of the land. Overgrazing therefore occurs when the number of livestock on a unit of land is too large. The overall result of this overgrazing is the destruction of the natural vegetation as well as soil compaction and erosion. Figure 4 shows the grazing of cattle during the dry season. Agriculture and grazing on the same land leads to the farmer-grazier conflicts for which this area is well known.

Because of pressure on the land and the keeping of many cattle, there have been further encroachments into the watershed areas. This grazing encroachment into the montane and sub-montane forests in upland watersheds whereby cattle graze freely in some upland watersheds, threatens some of the remaining forests. Goats and sheep equally graze freely too. They are voracious feeders and inhibit the natural regeneration of forest species. Also, the lack of a grazing plan which includes the rotation of grazing ground, and, moreover, the lack of a national land use plan may contribute to overgrazing. Like overexploitation, overgrazing can result in various degradation features such as the alternation of discharge, change of soil moisture and gully erosion, increased surface runoff rates and landslides.

#### 3.1.4 Poor Agricultural Practices

The Menchum Basin constitutes a hub for different types of agricultural activities thanks to the availability of fertile volcanic soils within the basin. This is an agrarian economy that depends on the valley for upland rice cultivation and market gardening products all year round. Demographic pressure in the basin on land for different agricultural practices has forced mankind to encroach into the watershed areas which are supposed to be conserved. This agricultural encroachment in watersheds and riparian areas is an actual and potential threat to forests.



**Figure 4. Dry Season Vegetable Cultivation and Grazing of Cattle on the Same Field at Obang-Bangwe Flood Plain (Kang, 2016). This Is Part of the Cause of the Farmer-Grazier Problem in the North West Region of Cameroon**

The increase in population combined with increased market access has meant that farmers are cropping more intensively than before and the traditional system of bush fallowing for 10-15 years is faltering. The result is that soil fertility is becoming exhausted and crop yields are poor. Hence, forest lands are therefore being cleared to augment the existing farms of declining fertility. This practice has been identified as the major reason for forest destruction in the Menchum Valley.

Studies also reveal that bad agricultural practices have contributed significantly to the water problem in the basin. The burning practice in farming such as the burying of dead vegetation in mounds and burning it ("Ankara") has a devastating effect on soil fertility. Whilst it produces an initial injection of rich ash, its effects are short-lived. It depletes micro-organisms and soil organic matter, which act as a slow release fertilizer and water-holding sponge. It also breaks down soil structures and causes hard pans to develop. Thus, it reduces the degree of soil infiltration capacity, increases surface runoff and consequently sheet and gully erosion. Furthermore, the periodic uncontrolled fires pose a threat to the remaining forest. In recent years, these have been intensified by unusually dry weather during the dry season. These fires usually leave 50 to 80% of the tree canopy dead. The fire-damaged forests are eventually turned into the cultivation of food crops. This slash and burn system is a bad agricultural practice in Menchum Basin.

The drainage and reclamation of the wetlands in the Mezam and the Menchum Basins are certainly influential in the fluctuations and even the reduction of the flow regime of the Menchum River. Gallery swamp forests and flood plain areas have been reclaimed for urbanisation, market gardens, riziculture and crop fields. These wetlands play an important role in maintaining the hydrological cycle. They hold up excess water during floods and during the wet season, and during the dry season, they slowly release this water to recharge surface and groundwater resources. The reclamation of these wetlands and their transformation into settlements and agricultural fields has been the main architect behind the degradation of these watersheds. The increased degradation rate will lead to an increase of sediment load of the river as well as a reduction of the soil's retention capacity, which will result in an alternation of the discharge rate, resulting in longer dry periods and an increased risk of flash floods. Figure 5 presents some of the gallery swamp forests that have been transformed into rice fields.



**Figure 5. Transformation of Floodplain into Rice Fields in the Menchum Valley**

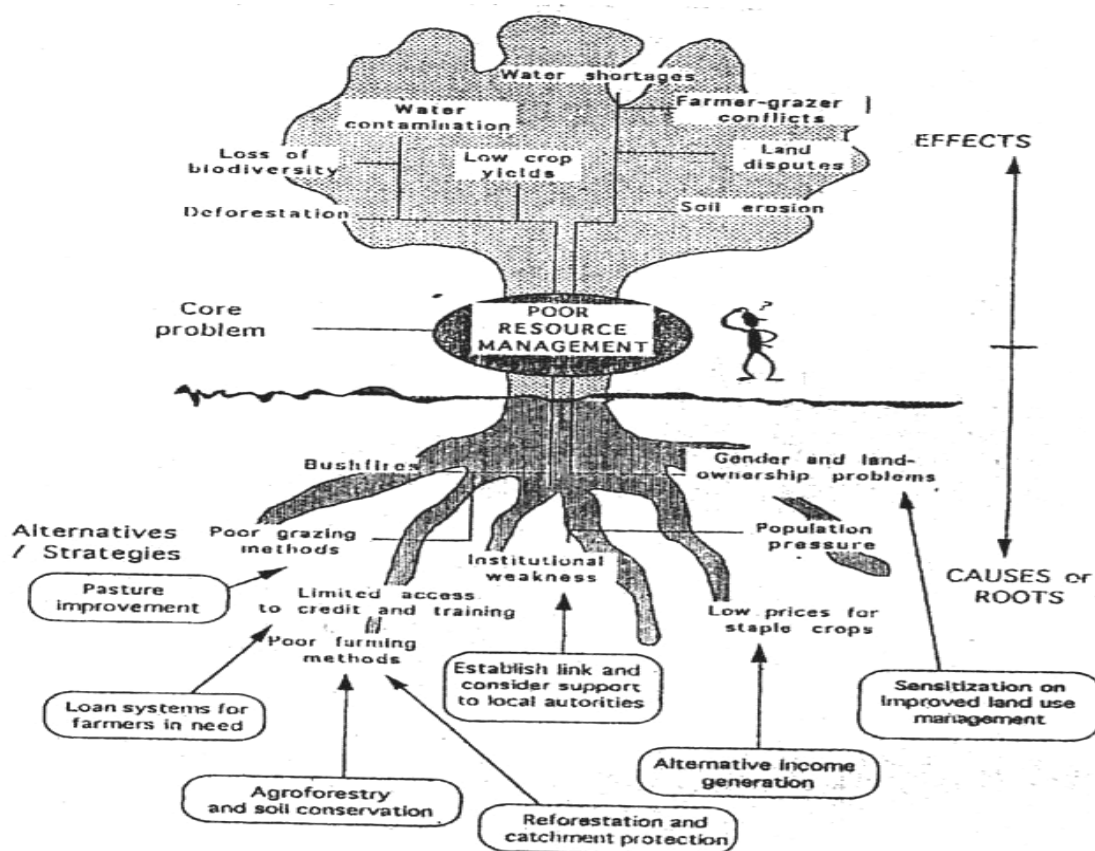
Source: Fieldwork, 2017.

### *3.2 The Impact of Climate Change on Water Yield*

Changing climatic conditions in the Menchum basin has influenced the supply of water negatively. The impact of global warming and its effects on water yields cannot be isolated. According to Pierre Hale, the Minister of Environment, Nature Protection and Sustainable Development (2008), climate change, a nagging problem for the government, has a negative effect on water conservation. He made this statement in Yaounde, in 2008 as he chaired commemorative activities ahead of the 2013 World Wetlands Day in February, on the theme, “Wetlands: Protect our waters wet”. He also added that the challenge facing Cameroon and other countries is the worldwide phenomenon of climate change, which is affecting all spheres of life, including water resources. “This means that as we are struggling to

conserve our current resources, climate change comes in to reduce the volumes of water that we have around the world”, the Minister said. To combat this, efforts are on-going to make water adequately available in the dry and wet regions. “In the North, we have a Green Sahel Project for the planting of trees, which is a good step in managing water. It seeks to stop the desert from advancing, but also to retain some water in the soil by covering the surface”.

In the basin, it was realised that there are increasing mean annual temperatures of less than 2° C for the period under consideration and that the inter-annual variability of rainfall is characterized by an increasing intensity of drought seasons and variable rainfall characterized by high intensity storm events. The observed decrease in inter-annual rainfall is probably related to the concurrent slight increases in temperatures over the basin and then a slight reduction in the number of rainy days. These observed climate change trends and anticipated changes together with human-related stresses affect the normal functioning of the hydrological cycle at the basin scale. These interactions are complex but have been established from empirical evidence. Figure 6 illustrates the root causes of watershed degradation and their impact on water supply in the basin.



**Figure 6. Problem Analysis of Underlying Causes of Watershed Degradation (Zimmermann, 1996)**

The study observed the following environmental and hydro-geological consequences of climate change and anthropic impacts in the basin.

- The drying up of perennial springs in land unit H (Lava plateau and granitic mountains).
- Inter-annual variations in water yields in the Menchum River.
- Experienced heat waves by human beings in urban areas during the dry season.
- Sedimentation of water catchments and reservoirs for rural water supply schemes. Water delivery pipelines are often congested by sediments and there is the failure of the water filtration structures based on the use of simple sand filters. Typical examples include the Bambili water schemes, Belo water scheme, Akum water scheme amongst others.
- Drying up of perennial wetlands in flood plain zones and gallery swamp forests.
- Drying up of ox-bow lakes in the Menchum River flood plains. These are visible on the 1987 aerial photographs of the area but are observed to be absent in the field now. All these lead to a reduction in stream flow and river discharge.

The study equally observed the gradual transformation of the landscape from forest through a semi deciduous to savannah vegetation. As the concept of change detection clearly puts it, the 1965 maps, 1987 and the 2009 maps respectively of the Menchum River Basin were used to assess the degree of forest degradation in the basin. This was complemented with photographs taken in the field. From here, it could clearly be seen that there has been the transformation of this vegetation from forests to savannah and consequently grassland vegetation. The small upland watershed in the urban field has since 1930 moved from moist, evergreen sub-montane forest to farmland and rough pastures. These areas and flood plain zones have been invaded by squatters with varied hydrological consequences of urbanisation.

The land use tables of the study from 1985 to 2009 show that there has been a transformation of the natural forests to cultural landscapes following man's excessive activities on the land. From these tables and the major watershed maps of the study area, major calculations were made in order to determine the percentage change in land use and the degree of degradation of the various watersheds over the years. This is shown in Tables 1 & 2.

**Table 1. Change in Forest Cover and Land Use in randomly Selected Upland Watersheds: 1960 to 2009**

Watershed		Forest Area (ha)		Land use systems in 2009			Total (ha)
		1960	2009	Farms	Pastures	Fallow	
Mbueh	Ha	600	0.0	200	400	0.0	600
	%Δ	100%	0.0%	33.3%	66.6%	0.0%	
Bambui	Ha	750	200	100	250	200	750
	%Δ	100%	26%	13.3%	33.3%	26%	
Ntambang	Ha	1400	240	200	959	1.0	1,400
	%Δ	100%	17.1%	14.2%	68.5%	0.07%	
Belo	Ha	1,610	156	1,065	5,176	0.0	6,397
	%Δ	25.2%	0.02%	16.6%	80.9%	0.0%	
Njinikom	Ha	2,550	1,850	2,550	700	0.0	5,100
	%Δ	50.0%	36.3%	50.0%	13.7%	0.0%	
Laikom	Ha	5,760	2,485	4,780	416	0.0	7,681
	%Δ	74.9%	32.3%	62.2%	5.4%	0.0%	
Akum	Ha	6,789	1,725	6,384	4,234	0.0	10,543
	%Δ	64.4%	16.4%	60.6%	40.2%	0.0%	
Pinyin	Ha	12,449	4,000	11,812	5,062	0.0	20,874
	%Δ	59.9%	19.2%	56.6%	24.3%	0.0%	

Ha = Hectares, %Δ = Percentage change

Source: Calculated from Figure 7.

From these Tables, it is evident that different land use practices in the Menchum River Basin have degraded the major watersheds and hence the implications for development.

**Table 2. Degradation of Upland Watersheds between 1960 and 2009: Percentage Change in Forest Cover in the Menchum Drainage Basin**

Watershed	1960 Forest Area (ha)	2009 Forest Area (ha)	Percentage Change (%)
Mbueh	600	0.0	-100
Bambui	750	200	-73.3
Ntambang	1,400	240	-82.8
Belo	1,610	156	-90.3
Njinikom	2,550	1,850	-27.4
Laikom	5,760	2,485	-56.8
Akum	6,789	1,725	-74.5
Pinyin	12,499	4,000	-67.9

*Source:* Calculations from the various watersheds.

### *3.3 Impact on Potable Water Supply in the Menchum*

Increased land use practices within the basin have led to the degradation of major watersheds. This degradation has implications in terms of water supply. The degradation of the Tubah Upland watershed for example, adversely affected the supply of water to the dependent villages. It was reported by Zimmermann in 1996 that during the rainy season, the stream in the catchment area has an average discharge of 6 litres per second while the season is characterised by extreme flood events producing poor water quality as it was charged with eroded sediments. The consequences are the sedimentation of reservoirs, the clogging of the main water delivery pipelines and general water shortages during the rainy season. On the other hand, during the dry season, most of the first orders tributaries dry up and water yields are reduced to 2 litres per second. This necessitates the rationing of water due to a breakdown in pressure. Children travel over long distances to fetch water for various domestic activities. The implications of these land use changes on the hydrological resources of upland watersheds necessitate the initiation of sustainable management programmes in view of the benefits to be derived.

### *3.4 Implications for Development*

The world is rapidly converting forests, wetlands and other critical habitats into agricultural lands and also diverting major rivers to produce food in order to meet the growing demands. How to produce more and better food and maintain or improve critical ecosystem services without further undermining



our environment has been a major challenge. This calls for the assessment of watershed development and management approaches with a view to addressing the biophysical, socio-economic, institutional and policy issues.

The study points to the fact that intra-annual and inter-annual flow regime of tributary rivers and the Menchum River is variable and unreliable. This can be attributed to the interaction of climate change factors and land use changes. Variable peaks have implications for flood recession agriculture in the flood plain and the supply of potable water to the entire community. Changing flood regimes are anticipated to continue in future, particularly as the human activities are continuous. There is a need, however, to protect the critical forests and grasslands in the upland watersheds and the riparian areas in order to forestall devastating floods that could alter the existing downstream economic activities. At the same time, the projected global climate change would increase the unreliability of flow regime and this can be compounded by the human inadvertent manipulation of the remaining vegetation.

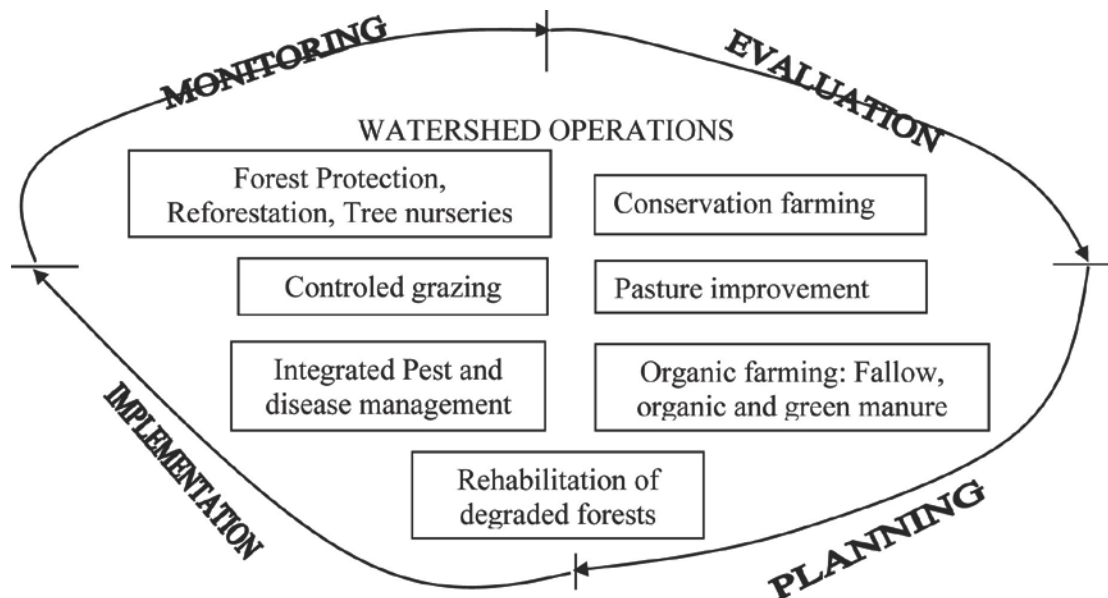
The Menchum Fall in the basin has a lot of potentials for the generation of hydroelectricity for the North West Region. The potential for the generation of hydroelectricity can be jeopardized by the interaction of human-related and climate-change related factors. It is therefore important to restrict these unsustainable practices around the watersheds in favour of reforestation for forest regeneration. A comprehensive approach, multi-disciplinary and multi-spatial approaches are therefore required for the development of the drainage basin resources. The current autonomous adaptation may not sustain livelihoods in the future. There is also a need for planetary adaptation through capacity and resilience building. This can be achieved through the awareness of climate change and economic diversification. The protection, improvement and rehabilitation of mountain and/or upland watersheds are of critical importance in the achievement of the overall development goals. Recognizing this, many developing countries are turning increasing attention and resources to the field of watershed management.

#### 3.4.1 The Integrated Watershed Management (IWM)

According to Forch (2009), modern water laws favour integrated solutions at basin level, which allow comprehensive solutions acceptable to all stakeholders and flexible targets for managing the process with regard to institutional capacities and human capabilities. There is an urgent need for a comprehensive water sector reform in Cameroon with a focus on participatory sub-catchment management planning. This is an essential tool for sustainable management including conflict transformation between competing users of watershed resources. For one thing, upstream users can refer to the doctrine of absolute local rights or sovereignty in which they have exclusive right to use and dispose of the natural resources in their domain or sectors. On the other hand, the downstream settlers tend to emphasise another principle, namely, the doctrine of absolute regional or national integrity according to which the lower riparian people are entitled to unaltered volumes of water as well as the quantity. These contrasting doctrines or perceptions over the use of water resources in many

water-stressed regions make conflicts sometimes inevitable. The solution to this problem is the integrated watershed management concept which takes a holistic view of the catchment by adopting a multi-sectoral approach for all resources, that is, soil, water, biomass and energy, and at the same time, taking into account both human and environmental needs. Its main concerns are water resources development for rural water supply including small scale irrigation, and protection of available water resources against overuse and pollution. The overall aim is to improve local livelihoods and community-based resilience against natural disasters.

The Integrated Watershed Management (IWM) concepts can play an important role for rural communities to adapt to impacts of climate change (Figure 7). The holistic concept of resource management that refers to a watershed or a hydrologically defined planning area follows a systematic approach with a major focus on many techniques. Perhaps the most important of these is that the farmers should learn to assess the potentials as well as the challenges of their watershed, and they should collectively work together to improve soil moisture recharge as well as groundwater recharge by the various watershed development measures. In view of the current high degree of degradation, this watershed protection remains an urgent priority. Furthermore, there is also a need to reduce the over-abstraction of resources and also a necessity to ameliorate resource utilisation efficiency. Serious efforts should be directed towards bridging the resource gap between the rainy and dry seasons by limited water storage facilities which are managed by the local communities and new water saving irrigation techniques. These improvements ameliorate their resilience towards natural disasters resulting from anthropic stresses and climate change impacts. Furthermore, in order to drastically reduce their vulnerability to risks, there is a need for the diversification of their sources of revenue by reducing their dependency on just one income factor.



**Figure 7. Integrated Watershed Management Programme Cycle (Helvetas Cameroon, TZ, 1994)**

The study adopted a multi-sectoral approach for the management of the drainage basin resources: soil, water, biodiversity, energy, which at the same time provide ecosystem services and guarantee sustained well-being. The main sectors of activities of a Watershed Resource Management Authority together with management objectives, strategies and functioning were indicators. These watersheds are upland or hilly watersheds with combinations of forests, cultivated or grazing lands and are inhabited mostly by subsistence farmers or graziers. In implementing the IWM, the watershed manager must possess a great deal of foresight, imagination and patience because results can only be expected after several years when stakeholders understand the necessity for sustainable management and the protection of the watershed as a source of local livelihoods. They will also require a good knowledge of soil stabilisation processes such that visible improvements are achieved such that the stakeholders are satisfied with the benefits of their work. Based on the lessons drawn from the Bambui Watershed Management Project, a watershed management programme must carry out a relatively intensive effort in a watershed in order to be effective. Such a watershed therefore has to be carefully studied and selected. It is an essential precursor that the watershed planner should be aware of new approaches and strategies in flora, fauna, soil and water conservation, land use management, farm development, agro forestry, and community forestry. He or she has to realize that although the identification and selection of priority watersheds is made at the central level with downstream interest in mind, that is, drinking water, it is the upstream land user who is effectively the watershed manager through his or her land use decisions. The challenge therefore is to harmonise the interest of all land users living in the watershed and find approaches in which farmers will participate actively because of the demonstrated and anticipated benefits of

improved land use management and crop management practices. Figure 7 presents the activities involved in the integrated watershed management programme cycle.

The design of the concept of farming, grazing and other land use systems must bear in mind the objectives of conserving plants, soil, water and animals and the demands of ecosystem services and sustainable income and employment for local livelihoods. Planning, implementation, monitoring and evaluation of watershed activities are a continuous process of learning, adaptation and decision-making.

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