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Human Adaptation Practices in Mountainous Regions: The Case of the Kom Highlands North West Region of Cameroon

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ABSTRACT

This paper examines the indigenous adaptation practices used by the inhabitants of the Kom highlands and questions the sustainability of such practices. This investigation was motivated by the environmental degradation signposts observed in the study area such: as extensive soil erosion, rapid rates of deforestation, landslides and other forms of mass movements seemingly provoked by human exigencies on nature through farming, settlements and road construction. Data for this study was collected mainly through field observations, interviews, structured questionnaires and focus group discussions. The findings revealed that though nature may have its own role to play, human pressures on the fragile mountainous topography have a fair share of the blame. It is against this backdrop that environmental friendly practices such as reforestation, improved agricultural practices and geological surveys before the construction of houses and roads in certain parts of the study area have been strongly recommended.

KEYWORDS: *Adaptations, Environmental Degration, Sustainability.*

Introduction

Highland regions are generally regarded as marginal lands given their enigmatic characteristics of barrenness, steep and rugged slopes (Pratap, 2001). They do not hold plenty of promise for socio-economic development. In difficult and harsh inhospitable areas like the cold bleak mountainous regions of the Arctic and Antarctica, the Rockies of North America, the Andes of South America, the Himalayas, the Alps, the Adamawa Highlands, the Western Highlands of Cameroon and other marginal lands, human adaptations remain man's greatest challenge. Highlands characterized by steep slopes, skeletal soils, adverse climatic conditions and geological variability present enormous difficulties particularly to the poor peasants who most often lack the required technology to offset the limitations imposed on their socio- economic activities by nature (Gardner, 1996).

Furthermore, highland regions are liable to a variety of hazardous processes such as earthquakes, landslides, snow avalanches, floods, debris flows, and fires. These hazards may cause injury, damage or destruction and even death to mankind. Hence sustainable adaptations to these hazards remain a fundamental requirement for man's survival in such environments (Hewitt,1982). The dynamic bio geophysical environment and intensified human occupation of highlands has increased the vulnerability of mountain inhabitants to geomorphic and environmental hazards. The ability of mountain inhabitants to build resilience against hazards is an important factor in their long-term sustainability (Gardner& Dekens, 2006).

Despite the difficult and inhospitable nature of mountain environments, they remain a home for some hardy populations around the world who have no option than to adapt their activities to such environments. Mountain environments, play host to over 700 million people in the world (Kamiljon, Bingxin & Shengen, 2010). In developing countries, mountain environment are a home to over 600million person, 75% of these people live in rural area and depend on farming as a source of livelihood. Asia and the Pacific regions play host to more than half of the world's mountain population. the Caribbean, the Middle East, North Africa, and Sub-Saharan Africa, each host at least 100 million people in Mountain environments(Huddleston et al. 2003). In relative terms, mountain populations vary across the regions of the world. For example, 11% of the population in Asia and the Pacific regions live in mountain environments,while in other parts of the world like in Latin America and the Caribbean up to 25% of its total population live in mountainous environment (Kapos *et al*. 2000; Huddleston *et al*. 2003; Price, Jansky &Latseni, 2005).

Lambi,(2010)noted that throughout human civilizations, man has sometimes, gone in conquest of steep mountainous slopes in order to provide farmlands in otherwise harsh ecological environments which call for appropriate technologies that relate to land-use and conservation. The worldwide mountainous regions which are homes of some hardy farmers are very well known for such adaptations. The "Kirdis" who inhabit the bare rugged granitic hill slopes of the Mandara of North Cameroon, have braved the harsh ecological realities of this environment through indigenous adaptations. In the Mandara and the rest of the Sudano-Sahelian Zone, nature has conspired with its capricious elements to render livelihood difficult for the simple subsistent population who fight incessantly for bare survival (Lambi, 2001).

Highlands are sensitive ecological settings that require sustainable adaptation strategies. Mountain dwellers typically live on the economic margins as nomads, part-time hunters and foragers, small farmers and herders, blacksmith craftsmen and loggers. Given the imperative to survive, these people have acquired unique knowledge and skills by adapting to specific constraints and advantages of their fragile and inhospitable environments. They pose millennia of experience in shifting cultivation, terraced fields, and medicinal use of native plants, migratory grazing and harvesting of food, fodder and fuel from the forest (Pratap, 2001).

Recent concerns about commitments to ensure environmental sustainability can be traced back to the World Commission on Environment and Development (WCED) in 1987, the United Nations Conferences on Environment and Development (UNCED) in Stockholm in 1972; Rio de Janeiro in 1992 (The Earth Summit), Rio+10 in Johannesburg, 2002 and Rio + 20 back in Rio de Janeiro). One of the core tasks of these global meetings was to incorporate all knowledge systems including indigenous knowledge into protecting and sustaining the environment. In spite of these guidelines for the incorporation of indigenous knowledge, few countries have put in place institutional frameworks to assess the role of indigenous knowledge in sustainable development. Very little of this knowledge has been recorded yet, it represents an immensely valuable database that provides mankind with insights on how numerous communities have interacted with their changing environments (Warren, 1992, in Ndenecho, 2012).

The Kom-highlands are some of such areas of the world where indigenous knowledge has served as a mechanism for adaptation to some of the prevalent environmental hazards over the years. However sustainable human adaptation strategies remain a big challenge in this area. Highlands particularly in the low latitude areas are densely populated perhaps because of their mild climatic conditions. This is the case of La Paz (3640m), Quito (2850m), Bogota (2550) and Mexico (2355m) (Whynne-Hammond, 1988). In Cameroon, the Western Highlands, (North West and West Regions) are all densely populated and the inhabitants of these mountainous regions have over the years put in place indigenous adaptive mechanisms in their livelihoods. Though harsh and inhospitable, highland regions of the world remain important components of the global ecosystem and their importance is underlined by the fact that they cover 24% of the earth's land surface and 26% of the global population live in or very close to them (Price et.al, 2005).

Highlands have ecological significance in that they are sources of water, food, timber and minerals. Mountainous areas also provide many opportunities for recreation and tourism. They are also centres of biological and cultural diversity and religious significance. They are, in fact, representatives of virtually every terrestrial ecosystem, as well as many examples of unique communities in mountainous areas. There are several unique species of plants and animals in the mountains, which are sometimes the last surviving members of species extinct elsewhere. In addition to more or less complex arrays of distinctive habitats, ecological features reflect comparative isolation for many species, problems of movement or colonization within, into and between mountain massifs and their role as refugia during quaternary climatic changes (Hewitt, 1997).

According to Bingxin et al, (2010), most rural mountain people depend on farming as a source of livelihood. Mountain environment play host to several resources including, wildlife, forest and non-timber resources. However in some mountain ecosystems of the worls such as in Central Mexico and Central USA,crop based farming systems have been introduced.The principal crops cultivated in such areas are maize and beans In the Ethiopian Highlands perennial crops are cultivated and it is common to find rice and wheat on the Himalayan range (FAO, 2002, Huddleston et. al, 2003).

Mountain ecosystems are subjected to a variety of drivers such as increasing pressure due to economic growth and increase in population numbers. The fragility of mountain ecosystems has direct consequences for the socio-economic vulnerability of mountain people estimated at 720 million or 12% of the world's total population. Nearly 90% of the mountain population of 663 million people live in developing countries (Huddleston & Ataman, 2003) and of these, half live in the Asia-Pacific region and one-third in China.

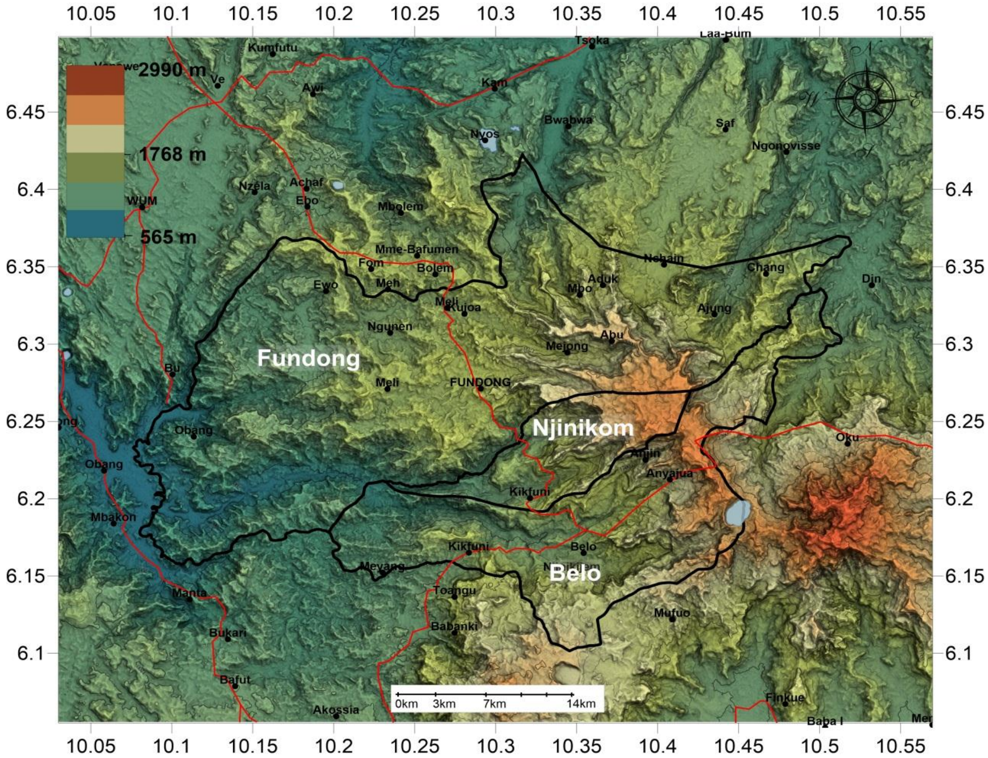
The physical conditions and ecological diversity of mountain lands are also associated with an extraordinary variety of human cultures. Many surviving indigenous peoples are found in the mountains. Their adaptations to these habitats, their cultures and environmental knowledge are of interest and value for sustainable practices. Distinctive ecological and human attributes of mountain lands involve adaptations to these landscapes, climatic and hydrological conditions (Hewitt, K 1997).

At the same time, mountain people and mountain environments are particularly threatened by global environmental change and economic forces. The world's mountains are vital regions for all of humanity, providing a wide range of services to their inhabitants, to those living nearby or downstream, and to the hundreds of millions who visit them. Despite the difficulties imposed on human developmental activities by the mountainous topography, mountains are repositories of biological and cultural diversity and provide vital services with a tangible economic value such as water, power, tourism, minerals, medicinal plants and fibre to mountain communities and even more importantly, to the often heavily populated lowlands (Millennium Ecosystem Assessment, 2005).

Cameroon is characterized by four major highland units, the Southern Low Plateau, the Adamawa Plateau, the Mandara Highlands of the Far North and the Western Highlands (Neba, 1999). These relief regions have in several ways influenced the socio-economic development of the country. The Adamawa Highlands for example, consists of faulted and upraised blocks of the basement complex composed mainly of granitic rocks, which are covered with basaltic flows from the volcanic eruptions that occurred on this massif. The volcanic outpourings have formed some sizeable peaks, the major ones being Tchabal Gangha, (1923m), Tchabal Mbabo (2460), and the Mambila Mountains (2418m). Human activities in these highlands are only a reflection of man's continuous struggle against the whims and caprices of nature. How successful man has been in taming and colonizing mountain areas in Cameroon remains an important subject of investigation.

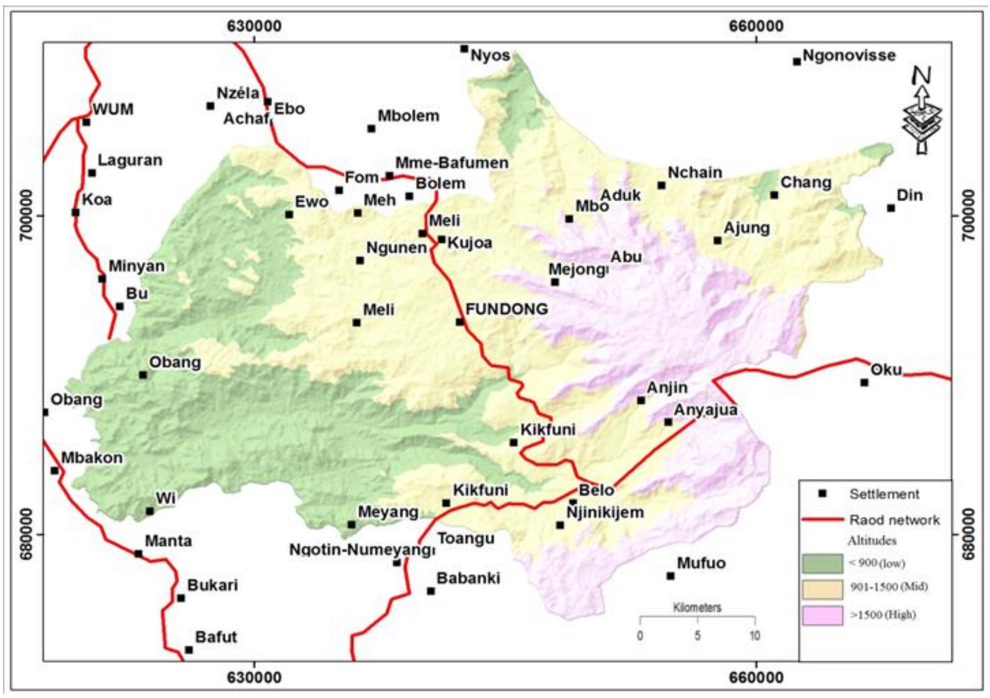
The Kom-highlands are characterised by a complex undulating topography, steep slopes, and extensive escarpments, deep and narrow valleys/ (Tosam &Fombe 2015). To the west, the topography is low-lying, generally less than 900m but it rises towards the east and culminates in the formation of the Oku mountain (3000) and the Ndawara Highlands(2850m) (Figure1) The topographic configuration of the Kom-highlands hinders human activities like agriculture, settlements, road construction and the putting in place of educational, health facilities, pipe borne water and electricity. However, since man must live in such environments human adaptations that ensure a sustainable livelihood becomes a fundamental human challenge.

Figure 1. Relief of Kom-Highlands



Source: Derived the Land sat images of the study area

Figure 2. Topography of the Kom-highlands



***Source*: Field work (2019)**

Over the years, the inhabitants of the Kom -highlands have developed a close and unique connection with the environment in which they live and carry out their livelihood activities. They have established distinct systems of Knowledge, innovations and practices, relating to the use and management of biological resources. Soil erosion prevention techniques such as terraced cultivation, cover cropping and the use of contour bunds are practiced on the steep slopes while soil fertility is maintained through agro forestry and fertilizer applications. However, the question that comes to mind is how sustainable are these indigenous adaptations? This question is asked against the backdrop of the rapid rate of environmental degradation, food shortages and the frequent occurrence of environmental hazards in the study area.

Settlements are perched on steep slopes and at times the pressure of such human occupation on very steep slopes trigger mass movements. Furthermore, debris generated from such slopes silt up the river beds provoking floods in the adjacent lowlands; and mountain slopes have been excavated to obtain building materials like sand and stones. Hence, the natural environment has been transformed to meet the human exigencies of food and shelter. As a result, the region is highly susceptible to natural and man induced hazards like landslides, soil erosion and climate change. Fogwe (1997) noted that a total of 40 landslide hazards were recorded in the Kom-highlands along the Mbingo-Fundong road segment, 11 rotational slumping, 9 earth falls and 1 rock fall. These hazards which are partly natural and partly induced by anthropogenic activities remain the greatest challenge to sustainable development in the study area. Poverty and low level of technology have limited the inhabitants to the use of indigenous adaptation strategies in their struggle for survival against the "unholy hand of nature." The mountainous topography of Kom is equally characterized by climatic variation, which means that particular crop types may be suitable at specific altitudes, but the indigenes with their subsistence farming habits have been practicing mixed cropping wherever they believe crops can grow.

According to Hawkins and Brunt (1965), andLetouzey (1968) the moist montane forest of the Kom-highlands was climax natural vegetation. Successive phases of intense deforestation by anthropic activities that began since early historic times have ruined well over half of the area and resources of this forest (Nkwi & Warnier, 1982).

Study Area, Materials and Methods

The Kom-highlands are a cluster of mountainous blocks whose topography is a succession of deep valleys and volcanic peaks. The terrain is deeply dissected by a dense network of streams, which follow the dendritic pattern.Kom-highlands constitute a unique geomorphic unit where the dissected relief, and slope gradients combine with the seasonal torrential rainfall (2200 to 3000 mm) to trigger rapid geomorphic changes (Fogwe & Tchotsoua, 2010). The cultural landscape is dominated by small parcels of subsistent farms on steep slopes. Large-scale mechanization is nearly impossible given that about 75% of the landscape is dominated by highlands with slopes of over $30^{o.}$

Administratively, it consists of three of the four Sub-Divisions that make up Boyo Division (Belo, Njinikom and Fundong). The study area is limited to three of the four subdivisions that make up Boyo Division (Belo, Njinikom and Fundong Sub-Divisions). The study covers the three Subdivisions of Boyo which span over an area of 1,592km2. The ethnographic characteristic of the study population was considered in delimiting the study area The Kom-highlands lie between latitudes 6° 7'/6° 24' N and longitudes 10° 41'/10° 31' E. It shares territorial limits with Menchum and Bum Sub-Divisions to the West and North West, Noni Sub-Division to the North East and Tubah Sub-Division to the South West (figure 3&4). The highland has a total surface area of 1,592 km2 with an estimated population density of 67.2 inhabitants/km2 unevenly distributed across the entire surface area (BUCREP, 2010).

Figure 3. Location of the study area

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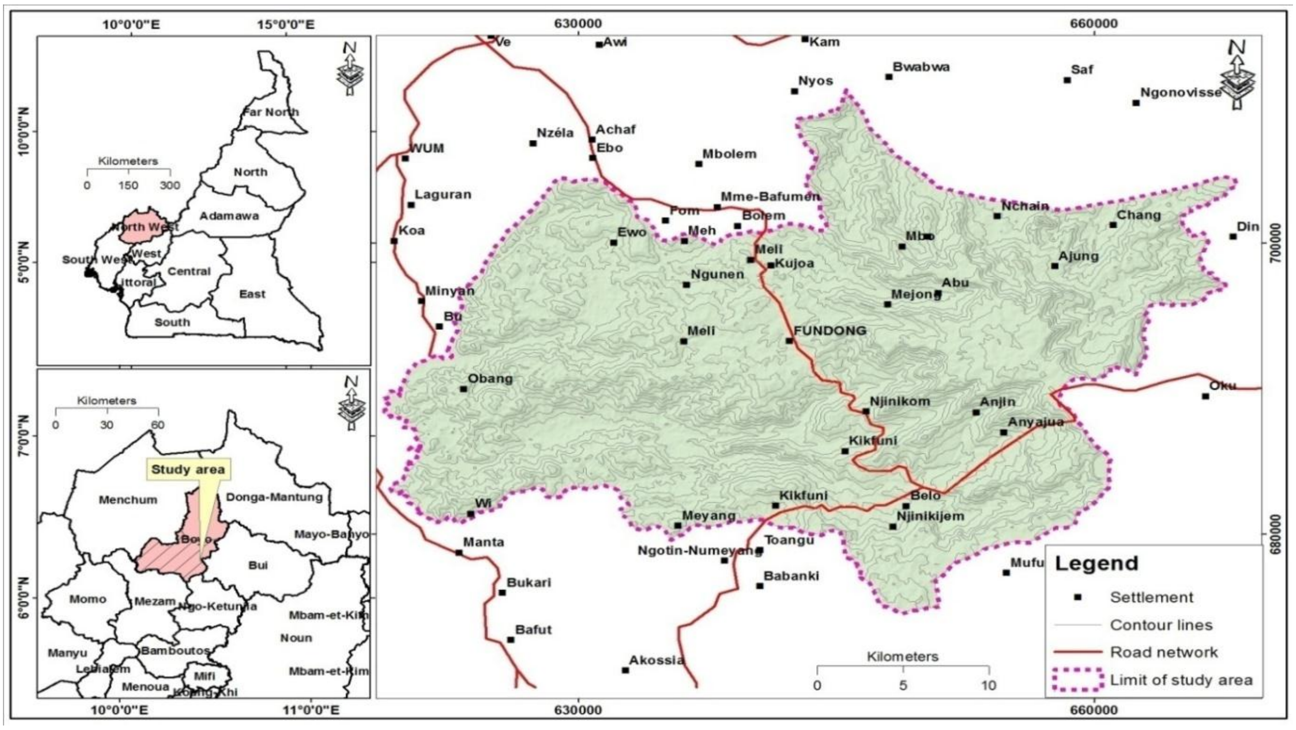

Source: Adopted from Tosam (2020)
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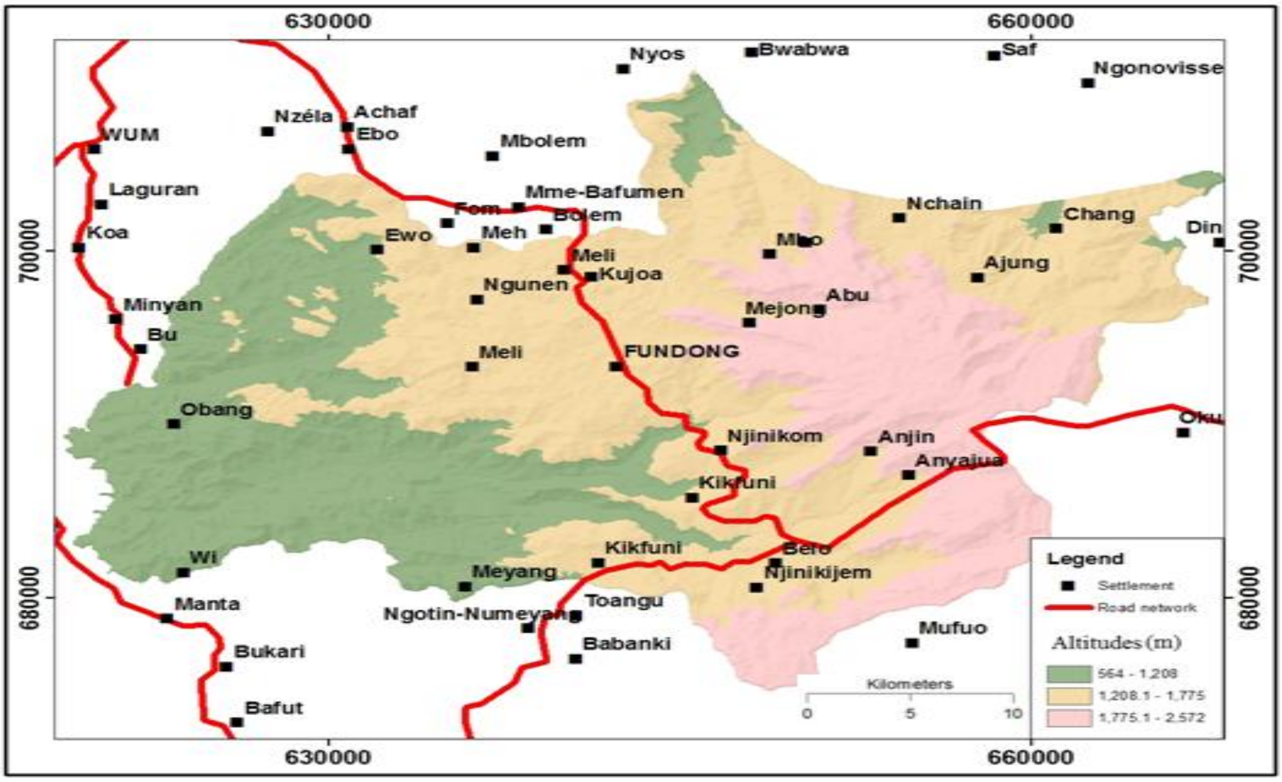
Figure 4. Layout of the Kom-highlands



Source: Derived from the Political Map of Cameroon

Sampling Size and Techniques

The research involved three Sub-Divisions of Boyo (Belo, Njinikom and Fundong)(Table 1). The choice of this matrix was based on ethnographic considerations, the diverse and contrasting relief characteristics of these area and its significant impact on livelihoods activities particularly agriculture, settlements and transportation. Within this geographical limit, people of all socio-economic class whose livelihood were considered to be influenced by biophysical factors constituted the target population. Although the selection of the sample size was done in respect of three administrative Sub-Divisions of the study area the guiding principle for this selection was rather highly based on the altitudinal differentiations and population density considerations than on the strict political delineations per se. These delineations, however, were not overlooked for the purpose of spatial representation of data and inter-Sub-Divisional comparisons.

Table 1. The population of the Sub-Divisions inthe Study Area by sex

Boyo Division	Total	Male	Female
Belo	40757	18314	22443
Fundong	45831	20531	25300
Njinikom	20461	9068	11393
Total	**124887**	**56512**	**68375**
Total study population	**107049**	**47913**	**59136**
Effective study population*	**60,376**	**27,023**	**33,353**

Source: Bureau Centrale des Recensements etdes Etudesdes Populations (2010)

The Sample size was estimated using sample calculation for one proportion with the support of EpiInfo 6.04d (CDC, 2001).

$$n=\frac{NZ^2P(1-P)}{d^2(N-1)+Z^2P(1-P)}$$

Where N=total population, Z= Z value corresponding to the confidence level, d= absolute precision, P=expected proportion in the population, n effective=n*design effect.

For a total study population of 60376, the estimated sample size at 95% CI was estimated at 420. Based on the sample size estimation, the study area was segmented into nine altitudinal zones with three zones of low altitude (Baicham, Mbueni and Mbonkisu), three of mid-altitude (Belo, Njinikom and Fundong) and the last three of high altitude located on steep gradients (Tumuku, Muloin and Abuh)(Table 2).

Table 2. Sampled Populations

Altitudinal Zone	Locality	Number of Questionnaires	Returned	Sub-Division	%
<900M Low	Baicham	47	36	Belo	76.5
	Mbueni	47	41	Njinikom	87.2
	Mbonkisu	47	37	Fundong	82.9
901-1500M Mid	Belo	47	44	Belo	93.6
	Njinikom	47	40	Njinikom	85.1
	Fundong	47	41	Fundong	87.2
>1500M High	Tumuku	47	39	Belo	82.9
	Muloin	47	44	Njinikom	93
	Abuh	47	42	Fundong	89
TOTAL		423	364		86.05

Source: fieldwork 2019

Field observations, Focus Group discussions (FGDs) and interviews. Supplementary data was gathered through topographic maps, and satellite images. Other cartographic information such as geographical coordinates required for the geo-referencing of features on the field and representing them on maps were captured with the use of a global positioning system

Field Observation

Observation involved watching events or phenomena and obtaining first-hand information relating to particular aspects such as people, events or situations. In line with this view a structured observation guide was developed to facilitate the identification of biophysical factors that influence human activities in the study area and the potentials for development. The Structured observation technique permitted the researcher to identify the biophysical factors and the type of hazards predominant at the low, mid and high altitudes in the study area as well as the corresponding measures used by the inhabitants to respond to such biophysical factors. In order to collect data that assessed objectively the views of the inhabitants, focus group discussions were conducted in all the three subdivisions that make up the study area. These discussions provided the additional information that was used to complement data collected through field observations, interviews and questionnaires.

Findings

Landscape challenges

The Kom-Highlandsare an extremely diverse, heterogeneous and complex landscape. The landscape is interspersed with numerous ridges characterized by steep slopes, deep and narrow valleys, extensive escarpments and rock outcrops. The climate, soil and geological settings vary from low to high altitude. The varied physical environment poses a range of challenges that undermine the development pathways in the area. The complex and fragile mountainous landscape and the dynamic socio-ecological landscape strongly influence development patterns.

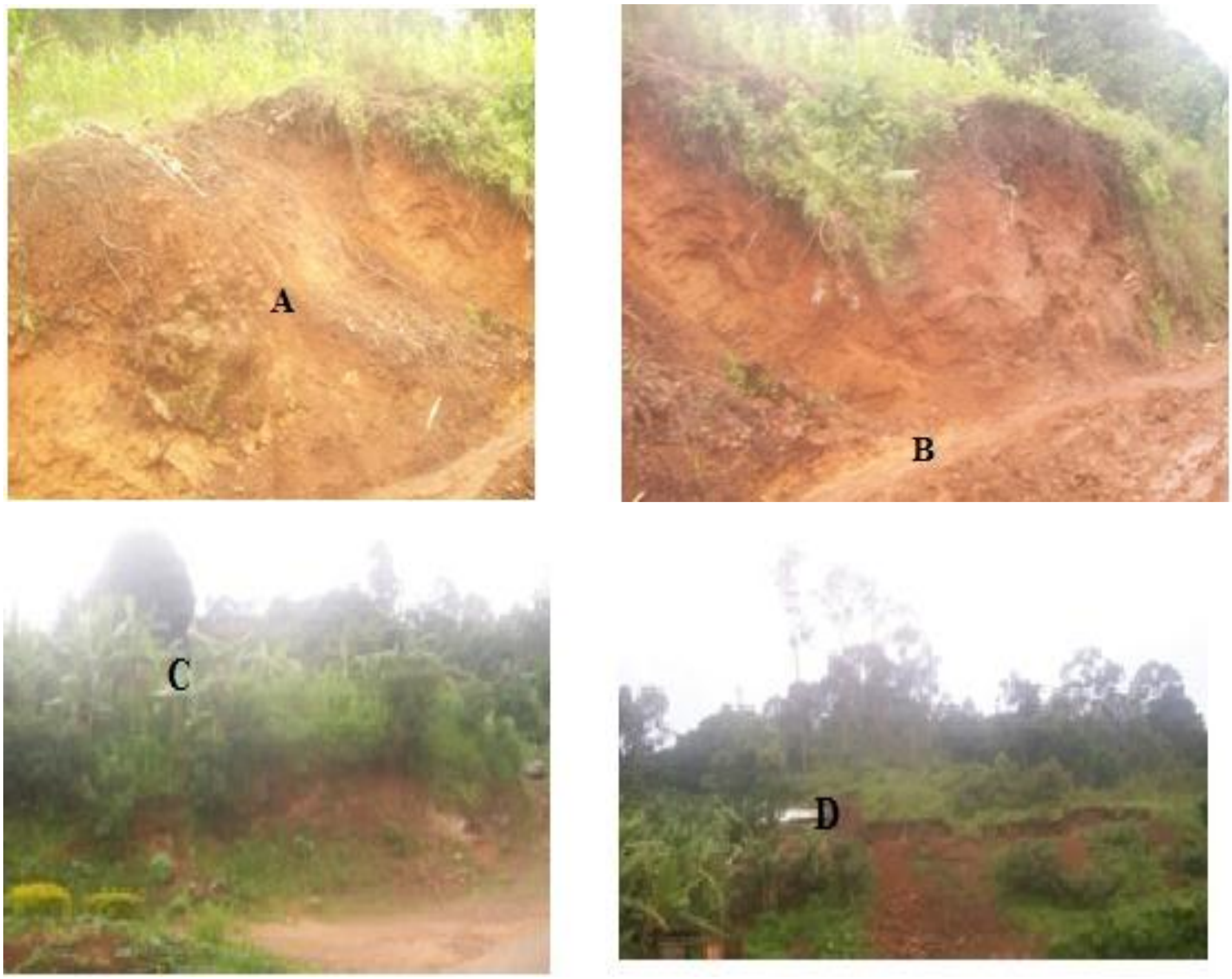
The steep slopes of the study area accelerate soil erosion due to the influence of gravity with the result that the soils become skeletal. Climatic variation with altitudinal change is a challenge that must be addressed through proper adaptation strategies given that mountain ecosystems are not only fragile but very sensitive to climate change effects. At altitudes, above 2,000 metres where the mountain environment is really harsh and less suitable for agriculture and infrastructural development, pastoralism is the most common livelihood adaptation strategy

The geology and geomorphology of the study area must be considered when constructing settlements and road network. This is a major challenge to the inhabitants who still depend on the factors of chance for farming, settlement and road constructions in hazard prone environments such as mountain slopes.

Mountain environments have a significant impact on development infrastructure such as settlements and road construction. In the study area, settlements and road infrastructure are concentrated in the mid altitude areas of (901m -1500m) while high altitude areas, sometime considered as marginal lands are occasionally farmed with crops such as beans and Irish potatoes. These are crops that are highly adapted to high altitude environment.

The steep nature of slopes means that landslides and other forms of mass movements are accelerated by gravity and human activities such as farming, pastoralism housing and road construction

Figure 5. Landslides occurrence due to gravity B. Landslides occurrence due to road construction, C: Lands slide due to agriculture, D: Landslide due to settlement construction.

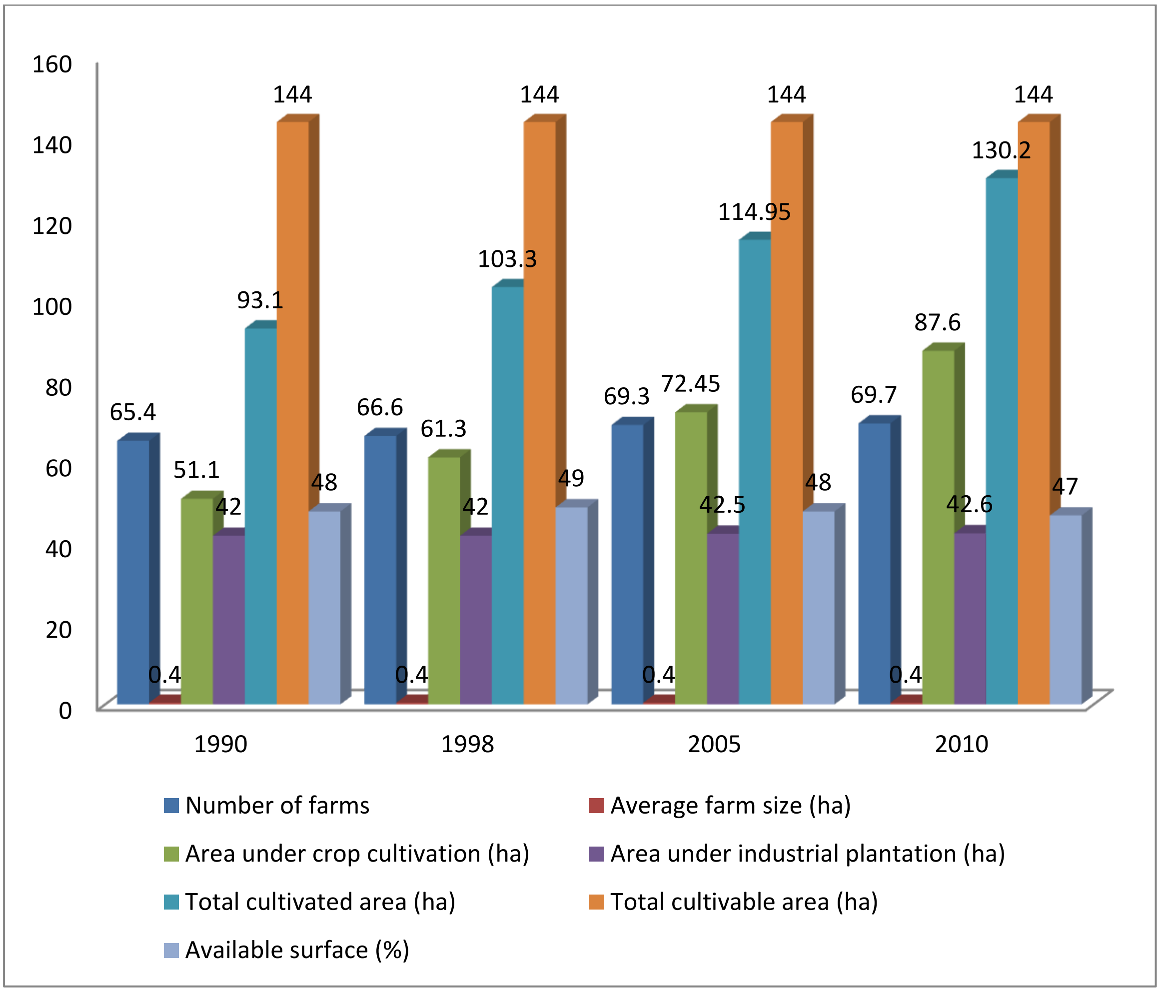


Source: Fieldwork (2019)

Land scarcity

Considering agricultural land as an indispensable resource to the largely agricultural society, therefore, its availability and viability is only based on its capacity to maintain agricultural productivity at levels acceptable to ensure sustenance in food supply and the satisfaction of other social obligations of the population. The viability of agricultural land was visually assessed from the expanse of potential agricultural land under grass cover, and statistically from the productivity of farms cultivated mainly on natural soil fertility conditions with little expenses on external inputs. When viability is no longer assured as a result of pressure on agricultural land from the rapidly increasing dependent population, the relationship between the farmers and the land is modified and this then calls for a reflection and trail of various strategies that are thought of by the farmers themselves. Information gathered from the divisional delegation of MINPAT showed that out of the estimated 144ha cultivable land area, 93.1 has already been put under effective cultivation

Figure 6



This leaves the study area with only 50.9 ha of land that can potentially be cultivated. Given the rapid rate of growth, there are clear signs that that if proper adaptation measures are not used, cultivable land under the current state of technology will soon get exhausted the and problems of food shortages may become more serious than are currently experienced.

A locational analysis of most of the existing arable land reveals that farmland are found at considerably far off distant locations. This renders most of them unreachable by a great proportion of the population that is compelled to concentrate on the nearby already exhausted and scarce land. The limiting function of distance nullifies the effect of the abundance of arable land on the growing needs of the increasing population thereby compelling this population to depend mostly and continuously on the immediate land within their reach. It is for this reason that a significant percentage of the population 85.11 considers that land is a scarce resource in the study area and therefore constitutes a major hindrance to agricultural productivity area.

Table 3. Land scarcity as a constraint to development

Locality	Is land scarcity a constraint to development where you live?		
	No of questionnaires	**Yes**	**No**
Mbueni	47	37	5
Mbonkissu	47	31	8
Belo	47	35	9
Njinikom	47	45	1
Fundong	47	36	7

Tumuku	47	30	9
Muloin	47	36	6
Abuh	47	36	6
Total	423	320	57
%		85.11	14.89

Source: Field work (2019)

Only 14.89% of the population claimed that land scarcity is not a problem in the study area.

They based their argument on the fact that large expanses of mountain slopes are yet to be cultivated. This is an undeniable fact but such land requires huge capital investments in which for now are far beyond the reach of the subsistent farmers.

Land scarcity in the study area may not be blamed only on the physical characteristics but as well on the rapidly growing population which has resulted in excessive pressure on natural resources. According to the 1976 population census of Cameroon, the population of the Kom-highlands was estimated at 91,065. Eleven years later, the population had risen to 101,605 and in 2010, the population of the study area was estimated at 107,049 persons (Bureau Centrale des Recensements et des Etudes des Populations-BUCREP, 2010), indicating a yearly increase of 1.3% on an essentially uncongenial agricultural environment.

In a study in which 9 villages that were sampled based on their GPS coordinates to represent three villages at each altitudinal zone (the low altitude, mid and high altitude) of the study area where 423 inhabitants were sampled to obtain their views on the extent to which the biophysical constraints affect human activities in the study area, using a likerd scale classification the following information was obtained.

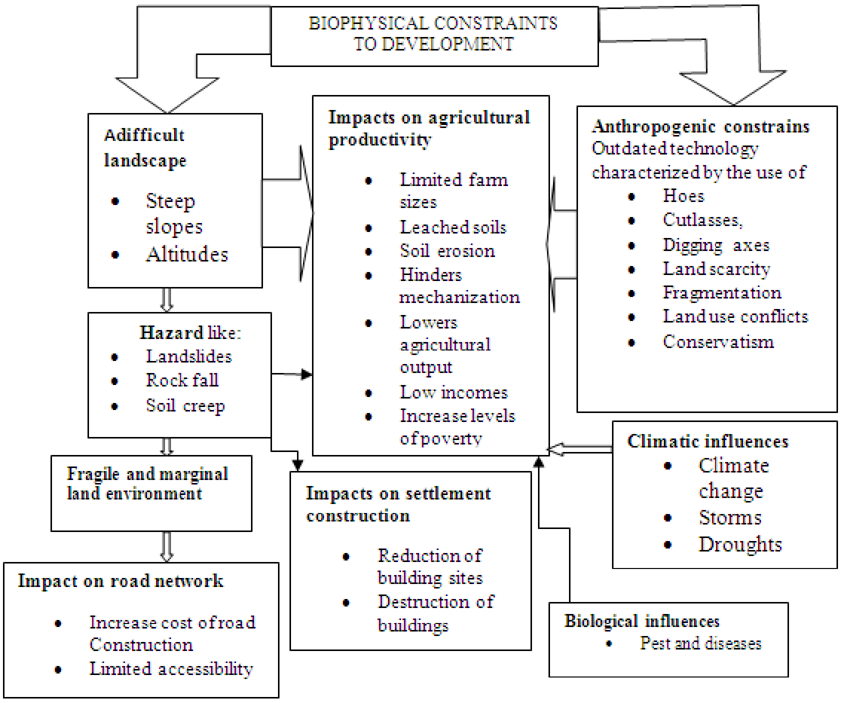
Table 4. Environmental controls on infrastructural development in the study area

Hazard types	Level of damage to building					Level of damage to other impact categories							
	Wood	Cement block	Mud house	Thatched houses	Bamboo houses	Level of damage to road	Level of damage farms	Level of damage to water	Level of damage to forests and	Level of damage to air quality	Level of damage to industries	Level of damage to human life	Level of damage to the economy in general
Landslide	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
Top soil erosion	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
Climate change	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH
Loss of biodiversity	-	-	-	-	-	-							VH
Water degradation	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH	VH

Source: Computed from questionnaires VH Very High

At all altitudes zones of the study area over 80 % of the respondents admitted that landslides, soil erosion, climate change the loss of biodiversity and the degradation of water catchments were major environmental concerns. The impacts of landslide on agriculture, settlement and road infrastructure were rated as very high at a percentage range of 75-100. The inhabitants also reported that soil erosion was a major concern rating its impact on agriculture and development infrastructure to be over 80-100 %.

Figure 7. Biophysical influences on development



Source: Fieldwork (2019)

Human Adaptation Strategies

The livelihood of the majority mountain people in the Kom-highlands revolve around agriculture. The highland has a total surface area of 1,592 km^2 with an estimated population density of 67.2 in habitants/km^2 unevenly across the mountainous landscape; the actual pressure on slopping hills and mountains on the agricultural land is much greater to support food security and livelihood of the mountain people. The problem of shrinking agricultural land is getting compounded with the rapid of urbanization and land use competition which has resulted in diverse conflicts. The management of the marginal lands is getting increasing priority with the increasing population pressure, poverty, soil erosion, and loss of natural resources in the hills and mountains for economic growth and environmental protection

It is important to note that peasant farmers most often lack the adequate technology to face by challenges posed both by nature and by man particularly in hilly and mountainous landscapes such as in the Kom area. It is also important to note that agricultural innovations that fail to consider the biophysical specificities of given environments are not likely to achieve the desired results.

The need for sustainable livelihood in the study area is crucial because of the rapid demographic increase, the increase rate of land degradation, declining crop yields, and the threats linked to climate change. The improvement in agricultural productivity in the Kom-highlands therefore greatly depends on how well the natural environment is understood and managed by the inhabitants. Furthermore, the natural controls on agricultural patterns in the study area are reinforced by economic and cultural control, all of which require specific adaptation strategies.

Indigenous Adaptation

Faced with a difficult and steep topography, the inhabitants of the Kom-highlands who essentially depend on agriculture for a livelihood have adopted some coping mechanisms as means of overcoming the adverse farming conditions over the precipitous slopes of the study area. Some of the indigenous farming practices observed in the study area include: contour ploughing, agro forestry, mixed cropping, use of fertilizers and shifting cultivation.

Contour Ploughing

The steep and hilly topography have forced the inhabitants to resort to contour ploughing. Given that soil erosion is greatly accelerated on steep slopes under the influence of gravity, contour ploughing seems to be an appropriate response to this phenomenon and it is widely practiced in the area. This method is practiced alongside the "Ankara ridge system" which involves the gathering and burning of organic matter in ridges (Figure 8)

Figure 8. Contour ploughing on the slopes of Nkoyne

Source : Field Work (2019)

Figure 9. Contour ploughing and vertical ploughing at Abuh

Source: Field Work (2019)

Contour bunds are an enlargement of the ridging technique that has been in practice for several years. The necessity of this technique has been born from the increasing cultivation of steep slopes because of scarcity in arable land. Very steep slopes that cannot withstand the force of running water with the use of traditional small size ridges of 35 cm wide and 20 cm high require the construction of special large ridges known as contour bunds at particular intervals on the farm plots. Very steep gradients require several contour bunds to be able to counter the effects of and contain running water on the farm. These hold rainwaters in place thereby increasing the amount of infiltration, reducing runoff and the rate at which soil is eroded away from the farm.

The contour bund technique is practiced in association with the cross bar technique. The cross bar technique involves the construction of tiny ridge-like elevations perpendicular to the main ridges at an interval of about one meter apart across every furrow in the farm. These techniques all aim at containing rainwater on the farm and at increasing the infiltration capacity of the soil. This creates possibilities for an increase in the area put under cultivation and contributes to increases in yield to meet with the increasing demands of the population. The desire to increase yield explains the colonization of the steep slopes by farmers and the choice of steep slopes is explained by the scarcity in arable land on gentle slopes and on flat lying areas that have been taken up by the increasing population needs and, therefore, the employment of these new techniques is a function of population pressure.

Mixed Cropping

Mixed cropping is the most common practice throughout the study area sometimes over seven different kinds of crops are grown on the same plot. In all the three altitudinal zones that were surveyed for this study, the shortage of land was the principal reasons for this system of farming Farmers also advance the reason that, less time, labour and money is used to grow most of their food and cash crops on one plot. The inhabitants practice mixed cropping technique not simply as a way of maximising the use of land but as a means of guaranteeing continuous food supply throughout the year. This enables them to avoid the risk of depending on a single crop in case of crop failure and to avoid famine. Although it is advantageous and perhaps profitable to farmers given their traditional state of art, mixed cropping system hinders the rapid introduction of modern technologies which are based mostly on monoculture. More so intensive mixed cropping with poor tools and little productive inputs (fertilizers, pesticides and improved planting materials) rapidly impoverishes the soil. This method however, brings in the problem of crop competition for nutrients. In a mixed farming system where crops are planted at much close range, competition for water, sunlight and soil minerals often results to poor yields.

Shifting Cultivation

Shifting cultivation also referred to as *swidden* cultivation, is a practice whereby the forest is cleared for limited period of cultivation after which the natural vegetation is given room to sufficiently regenerate itself before a future period of cultivation is re-introduced. There is also a tendency of cultivating many farms within a year by a single farmer. This extensification of agriculture is predicated on the hilly topography and the frequent slope failures which are in them barriers to the cultivation of one extensive farmland. Furthermore, farmers are depended on natural fertility of the soil in an environment characterized by a difficult terrain which influences the suitability of different crops. Lambi, (2001) noted that this adaptation strategy is meant to ensure that whenever nature is harsh for agricultural production on the intensely humanised hill slopes, man can still cultivate his high altitude environments when there are no compensatory agriculturally attractive lowland areas which hold promise for additional agricultural production. This practice though disappearing is still tenable in the area of study.

Slash and Burn Tillage System

The slash and burn tillage system of agriculture is still common in the Kom highlands. Field observation revealed that in all the three agro ecological zones of the study area, peasant farmers practice this system of cultivation. This system of cultivation often results in numerous negative environmental (deforestation, soil erosion, increased rain-water run-off, reduced infiltration.

Cultivation on hillside

Due to population pressure and land scarcity, farmers in some areas are increasingly adopting intensive cultivation methods on hillside areas. Without adequate soil and water conservation techniques in place, such as terraces, grass strips, and reduced tillage, cultivation on slopes steeper than ten to 30 percent can have significant impacts on *soil conditions*. Erosion occurs in cultivated areas without proper conservation techniques in place, leading to soil degradation. As rainfall hits loose or unprotected soil on cultivated sloping land, soils erode and carry away sediments and nutrients

Crop Rotation

Crop rotation is another soil management technique practiced in the Kom-highlands though only in some isolated locations particularly around semi urban centres like Belo, Njinikom and Fundong. Crop rotation involves seasonal change in crops cultivated on the same piece of land This mostly involves the rotation of maize, soya beans, potatoes, yams and cocoyam on the same plot. It was observed that all farmers associating and practicing a couple of these techniques have witnessed a two or threefold and even fourfold increase in the agricultural production, which makes it possible for them to ensure food self-sufficiency. It was also noted with satisfaction that marginal lands are being used in a sustainable manner for farming thanks to new techniques. This enables farmers to produce for longer periods on the same plots, to avoid close interval clearing or fallow practices and this shortens the time for regeneration and population movements in search of arable land, which creates conflict among resource users.

Recommendations

Soil Conservation Strategies

Soil conservation strategies are of critical importance in the Kom-highlands given that the steep nature of slopes, increased population and climate change makes the area very vulnerable to food shortages in case of poor soil management. To this effect measures to conserve the soil and improve agricultural productivity include: the use of organic or green manure, application of fertilizers, agro forestry, and mixed farming

Application of Animal Dung

The three ecological zones of the study area (72.34%) depend on animal dung. The number of farmers who depend on animal dung as a measure of improving soil fertility is explained by the fact that most of the farms are found on hill slopes which also serve as grazing land. The grazing areas provides possibilities for farmers who happen to be operating here to gain access to cattle droppings freely from grazing land or negotiated for it from the grazers who could allow it to be collected from the paddocks either freely or with some form of material or financial compensation. In the low land areas, most farmers using animal manure depend very much on droppings deposited by animals like pigs, goats and fowls in confined paddocks around homestead

Agro-forestry

Agro-forestry which is the association of some environmentally friendly tree species with crop cultivation is increasingly practiced first as a soil water enhancing technique and then as a soil fertility boaster as well as a feed supplement to animals. While some farmers concentrate on income generating species such as eucalyptus, some farmers are more interested in soil enriching trees such as the *Sesbania sesban, Cajanus cajan, Caliandia, Leuccana, Acaccia augustissima and Cassiaspectabilis*. These trees while contributing in soil water enhancement and soil fertility enrichment equally provide large quantities of wood highly needed by farmers for various domestic uses. This limits the time spent by farmers to get into distant forests to fetch wood as well as the extent to which the population encroaches into the forest to harvest wood in the wild that results in forest loss.

Agro-forestry also involves the planting of tree species that serve as feed to animals and produce flowers that provide nectar needed by bees for the production of honey. Some tree species are adapted to and appropriately planted in catchment areas to protect them from erosion and increase their permeability to rainwater. Some of these include *Maesopsis, Vitex, Soreidia, Canarium, Mahogany, Caliandra, Vocanga, Albizia*, etc. This also provides favourableconditions for bee farming that is increasingly gaining ground in the agricultural and forest management landscape of the region. The choice of agro forestry, therefore, has significant environmental advantages as concerns the planting of green manure species and those that enhance water catchment. The practice of agro-forestry primarily for economic purposes involves the planting of trees such as eucalyptus that are environmental damaging and agriculturally unproductive. Agro forestry systems contribute simultaneously to buffering farmers against slope failure and changing climates, and to reducing atmospheric loads of greenhouse gases because of their high potential for sequestering carbon.

Fertilizers

Due to a rapid loss in soil nutrients resulting from leaching and soil erosion, farmers have resorted to the use of chemical fertilizers. There is unfortunately, the abusive use of such chemicals as some farmers apply more than the prescribed quantity with the hope of expecting better yields. Over application of these fertilizers is poisonous to the plant as well as pollutes the soil and underground water resources on which the population depends for their daily water needs. Although chemical fertilizers have been in use in the study area for quite some time, its use was restricted only to coffee and other tree crops. The application of chemical fertilizer on food and short cycle crops is an innovation in the soil fertility enriching techniques, which has come as a result of increase demand for this food by the rapidly growing population. The difference in the use of chemical fertilizers is significantly great between the low, mid and high altitude agro ecological zones. Some of the farmers in the low and high altitude regions said the cost of a bag of fertilizer at 20000francs is far beyond their financial strength consequently they prefer to rely on organic techniques which are within their reach.

Geological surveys

It is also recommended that the council authorities should employ experts to identify and map out risk zones in the study are, such areas once identified should be prohibit any form of land use in these areas. Furthermore, geological surveys should be carried out in order to determine the type or nature of land use activity that can be practised in the study area. The above recommendations if effectively implemented as it is the hope of this study will go a long way to reduce the rapid rate of environmental degradation in the fragile mountain ecosystem of the Kom highlands which remains the home for sons and daughters of this area today and tomorrow.

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