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THE VULNERABILITY OF THE LIMBE POPULATION TO THE EFFECTS OF FLOODS AND MASS MOVEMENT (1985-2018)

A dissertation submitted in partial fulfillment of the requirements for the award of a Master's Degree in Geography

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June 2024

DEDICATION

To my beloved mother Mrs. Etta Felicia who is of blessed memory.

ACKNOWLEDGEMENTS

The realization of this piece of work is thanks to the efforts of some personalities and I really want to acknowledge their wonderful contributions. My utmost appreciation goes to Professor Clement Anguh Nkwemoh who not only being the supervisor of this work but also as a father, supervised the work from the beginning, giving me directives and counseling without reservation.

I also express my heartfelt gratitude to all the lecturers in the geography department of the University of Yaounde 1, most especially, Dr Ndi Roland who helped me with pertinent information in my study area and all those who helped me in one way or the other from level one to this master's. I highly appreciate the effort of Professor Paul Tchawa, professor Ngoufo Roger, Professor Tchindjang Mesmin, late Professor Kengne Fodouop, professor Amougou Joseph, Professor Moupou Moise, Professor Mougoue Benoit, late Professor Ndongmo Jean Louis, professor Yuta Happi, Professor Dzana, professor Ojuku Tiafack, Professor Oboesolo Samuel, Dr Tende Renz, professor Mediebu Rose, Professor Enchaw Gabriel, whose class room work served as a reference for the progress of this dissertation.

Furthermore, I acknowledge the contribution of all the members of the Etta's family , my loving father Mr. Etta Peter, my beloved mother Etta Felicia in loving memory, my elder brothers, Manyor Celestine, Manyor Innocent, my elder sister, Eta Isabel, who laid up a good foundation for my education not forgetting my foster parents Professsor Agbor Gabriel and his Wife H.E Professor Sarah Agbor Anyang , my In-law, Anyang Jacob who in all instances did all within their powers to support me financially and morally in my studies and the realization of this dissertation .

I want to also thank the DO's for Limbe 1and 3, Mr. Casmir lyonga the director of urban development at the Limbe City Council, the delegate of Urban Development and Housing, Mr Ndumbe, quarter head of unity quarters, Mr Tanyi Adolph, Mr Arrey quarter head of Bonjo, I also appreciate, Dr Emanuel Kenmoe, Doctor Tumi, Doctor Leonard Nkimih Chop for their technically support in statistical methods of data analysis that served as a catalyst for this dissertation. Thanks to all the local population in Limbe who provided information through response to questionnaires, interviews or group discussions that provided an inside for the realization of this dissertation.

I also appreciate the collaborative efforts of my class mates which gave me the courage that kept the zeal in me.

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LIST OF ABRIVIATIONS

ARGV: Unit for Volcanological and Geophysical Research

ASL: Above Sea Level

BUCREP: Central Bureau for Censuses and Population Studies

CAC: Computer Assisted cartography

CDC: Cameroon Development Corporation

CISD: Coordination and Prevention Sub-Directorate

CV: Coefficient of Variation

DCP: Directorate for Civil Protection

DEM: Digital Elevation Model

DM: Disaster Management

DO: Divisional Officer

DRR: Disaster Risk Reduction

EMAS: Emergency Medical Assistance

EOP: Emergency Organization Plan

FG: Force of Gravity

FN: Normal Force

FS: Share Force

GIS: Geographic Information Systems

IFRC: International Federation of Red Cross

IPCC: Inter Governmental Panel for Climate Change

LAT: Latitude

LCC: Limbe City Council

LONG: Longitude

LULC : Land Use/ Land Cover

LUP: Land Use Plan

MINDUH: Ministry of Urban Development and Housing

MINENP: Ministry of Environment and Nature Protection

MINNAT: Ministère d'Administration Territorial

MINTA: Ministry of Territorial Administration

MNLO: Mabeta Newlay Out

Mt Mount Cameroon

NCPC: National Civil Protection Council

NCPSD: National Council for Planning and Sustainable Development

NDPMP: National Disaster Prevention and Management Programme

NIC: National Institute of Cartography

NRO : National Risk Ob[servation

P S: Plan Secteur

POS: Plan d'Occupation de Sol

RAI: Rainfall Index

RL: River Limbe

RM: Risk Management

SDO: Senior Divisional Officer

SONARA: National Refining Company

SP: Sector Plan

SPSS: Statistical Package for Social Science

SPU: Studies and Prevention Unit

SUP: Summary Urbanization Plan

TV: Television

UMC: Urban municipal Council

UMP: Urban Master Plan

UN: United Nations

UNCEF: United Nations Children Emergency Fund

UNDP: United Nations Development Program

WMO: World Metrological Organization

ABSTRACT

Recurrent floods and mass movement attracted our attention to the coastal city of Limbe. Floods and mass movement have become a major issue in contemporary studies due to their impact on the society. This research is aimed at assessing the factors responsible for the occurrence of flood, and mass movement in Limbe and also assesses the degree of exposure and susceptibility of the population to these hazards as well as the strategies that have been put in place by both the local population and the state to cope or mitigate these hazards.

To attain the results in this research, the methodology was guided by data from primary sources and secondary sources. Data collected from Secondary sources were gotten through the consultation of both published and unpublished documents in libraries, government offices, N.G.O's, and the internet. A random sampling method was used for the collection data from primary sources. A sample of 280 households, from the ten most vulnerable quarters in the city responded to a questionnaire, focus group discussions, eye observations and interviews were other methods employed in this research. Other data was gotten from topographic maps and aerial photographs. Data from this research was analyzed using statistical tools such as SPSS, MS Excel. Maps were drawn with the help of CAC programs such as, ArcGIS, QGIS adobe illustrator.

The results of this research show that there is a great manifestation of floods and mass movement with the most frequent form of mass movement being landslides. It also indicates that the physical environment offers a great contribution in the occurrence of this hazards while man through his modification of space had also contributed enormously in aggravating this hazard. Also, LULC classification revealed a drastic change within the study period. Build-up increase from 9.9% in 1985 to 43.69% in 2018, crop land from 10.38% in 1985 to 24.97% in 2018. On the contrary, forest cover and water body witnessed a decrease from 79.53% to 30.96% and 0.8% to 0.4% respectively in favor of buildup. This have led to the increase in frequency of the occurrences of floods and mass movement. The research shows that the return frequency of these hazards is annual with over 100 deaths recorded within the study period, and factors such as uncontrolled expansion of the city, lack of emergency services, poor urban sanitation systems, and population pressure are the main aspects responsible for the vulnerability of the population to floods and mass movement. In addition to the above, both the government and citizens have adopted both proactive and reactive adaptation strategies to cope with the risk that they are exposed to. The research concludes that despite the numerous impacts of these hazards in the city, the government and the population strategies to adapt to this risk are more reactive than proactive.

For effective DRR in Cameroon in general and Limbe in particular, a permanent disaster management with regional and local structures should be put in place independent of MINAT (DCP). Also, to mitigate risk, the resettlement plan for the population in the areas at risk should be enforced.

Key words: **Vulnerability, Population, Effects, Floods, Mass movement, Limbe.**

RÉSUMÉ

Les inondations récurrentes et les mouvements de masse ont attiré notre attention sur la ville côtière de Limbé. Les inondations et les mouvements de masse sont devenus un enjeu majeur dans les études contemporaines en raison de leur impact sur la société. Cette recherche vise à évaluer les facteurs responsables de la survenue d'inondations et de mouvements de masse à Limbe et évalue également le degré d'exposition et de sensibilité de la population à ces aléas ainsi que les stratégies qui ont été mises en place tant par la population locale que par l'institution étatique afin de faire face ou d'atténuer ces aléas.

Pour atteindre (atteindre) les résultats de cette recherche, la méthodologie a été guidée par des données provenant de sources primaires et de sources secondaires. Les données collectées à partir de sources secondaires ont été obtenues grâce à la consultation de documents publiés et non publiés dans les bibliothèques, les bureaux gouvernementaux, N.GOS, Internet. Une technique d'échantillonnage aléatoire a été utilisée pour la collecte de données à partir de sources primaires. Un échantillon de 280 ménages a été choisi parmi les dix quartiers les plus vulnérables de la ville pour l'administration d'un questionnaire, des discussions de groupe, des observations oculaires et des entretiens étaient d'autres méthodes employées dans cette recherche. D'autres données ont été obtenues à partir de cartes topographiques et de photographies aériennes. Les données de cette recherche ont été analysées à l'aide d'outils statistiques tels que SPSS, MS Excel. Les cartes ont été dessinées à l'aide de programmes CAC tels que ArcGIS, QGIS adobe Illustrator.

Les résultats de cette recherche montrent qu'il existe une grande manifestation d'inondations et de mouvements de masse, la forme la plus fréquente de mouvement de masse étant les glissements de terrain. Il indique également que l'environnement physique offre une grande contribution dans la survenue de ces aléas alors que l'homme par sa modification de l'espace a aussi énormément contribué à aggraver cet aléa. De plus, la classification d'occupation du sol révélé un changement radical au cours de la période d'étude. La zone construite est passée de 9,9% en 1985 à 43,69% en 2018, les terres cultivées de 10,38% en 1985 à 24,97% en 2018. Au contraire, le couvert forestier et le plan d'eau ont connu une diminution de 79,53% à 30,96% et de 0,8% à 0,4% respectivement en faveur de l'accumulation. Cela a conduit à l'augmentation de la fréquence des occurrences d'inondations et de mouvements de masse. La recherche montre que la fréquence de retour de ces aléas est annuelle avec plus de 100 décès enregistrés au cours de la période d'étude, et des facteurs tels que l'expansion incontrôlée de la ville, le manque de services d'urgence, les mauvais systèmes d'assainissement urbain et la pression démographique sont les principaux aspects responsables de la vulnérabilité de la population aux inondations et aux mouvements de masse. En plus de ce qui précède, le gouvernement et les citoyens ont adopté des stratégies d'adaptation proactives et réactives pour faire face au risque auquel ils sont exposés. La recherche conclut que malgré les nombreux impacts de ces aléas dans la ville, les stratégies du gouvernement et de la population pour s'adapter à ce risque sont plus réactives que proactives.

Pour une RRC efficace au Cameroun en général et à Limbe en particulier, une gestion permanente des catastrophes avec des structures régionales et locales devrait être mise en place indépendamment du MINAT (DPC). Aussi, pour atténuer les risques, le plan de réinstallation de la population dans les zones à risque devrait être appliqué.

Mots clés: Vulnérabilité, Population, Effets, Inondations, Mouvement de masse, Limbe.

GENERAL INTRODUCTION

I. GENERAL CONTEXT

At this period when humanity seems to have certain control of the planet earth, a certain number of natural phenomena continue to destabilize the intelligence of man bringing about millions of victims every year. In the range of these phenomenon, we can site; floods, mass movements, earthquakes, volcanic eruptions, tsunamis, bush fire, epidemics, cyclones, lahar, hurricanes etc.

In terms of countries which have witnessed the highest number of victims, Bangladesh has registered close to 300000 to 500000 victims in 1970 in the course of a tropical cyclone; China with close to 550000 victims in the course of an earthquake and land slide of 1920 and 1976, the floods of 1949 and those of 1954; there is also the case of the USA and Mexico that witnessed earthquakes and tropical cyclones. In Africa, Morocco witnessed an earthquake in 1960 that claimed 12000 lives (Allegre; 2001).

Within the period of 1980 to 2019, about 4 million lives were taken by the occurrence of natural catastrophes. In the rank of this catastrophe, earthquake comes the first with about 50%, followed by floods and typhoons responsible for 30% and 17% respectively. Volcanic eruption and landslides contribute 3% each. For what concerns the geographic distributions in terms of victims, we have as: 85% for Asia and south west of pacific, 7% for Europe, America represents 7%, 0.5% for Africa and 0.5% for Oceania (CRED; 2019, UNDRR; 2019).

At the beginning of the 21st century, the situation has not changed. In average, between the year 2000 to 2019, 4.03 billion persons were affected by natural catastrophes and a total death toll of about 1.23 million persons. It is also worth noting the biggest disaster within the last 20 years is the 2004 Indian Ocean Tsunami provoked by a 9.1 Earthquake which claimed the lives of over 226400 people in twelve Asian and African countries, followed by the January 2010 7.0 Richter earthquake in Haiti with more than 52 continues shocks for over 10 days Durrheim;(2016). This earth quake claimed about 222000 lives with millions of people left homeless. Other damages were recorded in the Dominican Republic and Cuba (EM-DAT, CRED; 2019, UNDR; 2019.).

The occurrences of floods and mass movement have affected almost every sector of life and as such individuals' communities, nations, civil societies, and organizations have seriously engage in finding long lasting adaptation and mitigation solutions to the advert effects of these hazards

for instance the floodings in Limbe, floodings in Far North of Cameroon, Huracan's in the United state. International conferences have been held; agreements have been reached at. All in a bit to reduce the current trend of and it subsequent environmental impacts.

A mapping of natural risks in the world shows that ¾ of the world population lives in areas considered to be at risk; because already affected at least once by a harmful phenomenon. The period 1990-2000 was consecrated by the UN as an international decade for the prevention of natural disasters. The second Wednesday in October each year is observed as the international day for the prevention of natural disasters. Increasingly, the international community is funding research in the area of risks in order to find effective ways to limit economic and social damages caused by this natural hazards. After a conference held in Yokohama (Japan) from May 23 to 27, 1994, several recommendations were given to the participating states for reducing vulnerability and increasing the adaptive and resilience capacities of the exposed populations.

Africa and the rest of the continents are prone to natural hazards, although the frequency is diverse and the consequences different. Natural hazards manifest themselves in the spatiotemporal scale and each in a specific way. This is justified by the situation geography, climate, soil conditions, population density and level of economic development. Extreme temperatures, droughts, Cyclones and other Hydro-meteorological hazards play a crucial role the in the present situati0on of Africa. With a changing climate these factors are projected to worsen and have even more negative effects on Africans, their socio-economic situations and their ecosystems. Africa is also affected by geophysical hazards such as earthquakes and the eruptions of active volcanoes, McBean;(2016). In terms of economic loss and human sufferings, desertification and droughts represent the greatest natural hazards in Africa Countries. How ever, there is a significant loss of property and Human live to other Natural hazards each year such as floods, Cyclones, Mass movement. Amongst these hazards, we can cite the September 10th 2023 floods in Libya that claimed the lives of 11 000 people, the floods in Democratic republic of Congo and Rwanda April 2023 with a death tole of 574 people, the Algerian Wildfire in 2023, the Mozambique march 11th cyclone that claimed the lives of 1434 people.

Cameroon that is considered as the African in miniature, also harbors divers forms of natural hazards causing devastating economic and human loss every year. The geographic situation of Camerron presents a heterogenous relief features, biogeographical and climatic conditions that favor the occurrences of Natural hazards. The most recurrent types of hazards in Cameroon are floods and Landslides and every year each region is touched by one on these hazards apart from

the far North that has a combination of droughts and floods. Within period of the 20th centuries, Cameroon has recorded total of 7 volcanic eruptions that occurred within the Mount Cameroon region; Zoogning et al; (2000). Added to this, we can cite the 2012 floods in the far North region which claimed 30 lives and caused more than 37 thousand displaced persons, 2019 Landslide in the West Region with a death toll of 43 people, the 2022 landslide in Yaounde that recorded 14 deaths.

In sum, it can be seen that there is a significant present of natural hazards in the world, Africa and Cameroon. These sparked our interest in studying the specific case of Limbe which is a coastal town in Cameroon with the presents of numerous forms of hazards in other bring out sustainable adaptation strategies. You can't stop the earth from shaking or a volcano from erupting, but you can lessen the damage. It is this order of ideas that guides all risk disaster management strategies today.

This question is to knowing the causes of floods and mass movement in Limbe. Diverse factors account for the vulnerability of African towns to these hazards, they are linked to the notion of urbanization that is high densities, an unplanned demographic growth, and uncontrollable urbanization. To comment these hazards are linked to climatic and bio-physical and anthropic background.

II. DELIMITATION OF RESEARCH THEME

II.1. Spatial Delimitation

Limbe is a seaside city located along the coastal areas of Fako division in the south west region of Cameroon. It is located at latitude 4º.02' 00" N of the equator and longitude 9º.21' 00" E of the Greenwich Meridian and it is situated at an elevation of 69 meters above sea level. The town of Limbe is bordered to the north by Buea, to the south by the Atlantic Ocean, to the east by Tiko and to the West by the coast of the Atlantic Ocean. Limbe is inhabited by people from different political, religions, and socio-cultural background making it a cosmopolitan town. With a total surface area of 545km2, its population is currently estimated at 120,000 inhabitants, (Cameroon National Institute of Statistic projection; 2015) Limbe is one of the dense towns in Cameroon with a population density of 220 persons per square kilometer. The town of Limbe is made up of three council areas which are the Limbe1, Limbe 2 and the Limbe 3 councils. The area is highly delimited by water bodies such as the Atlantic Ocean, the Limbe River and its affluent. Figure1 below shows the map of the study area.

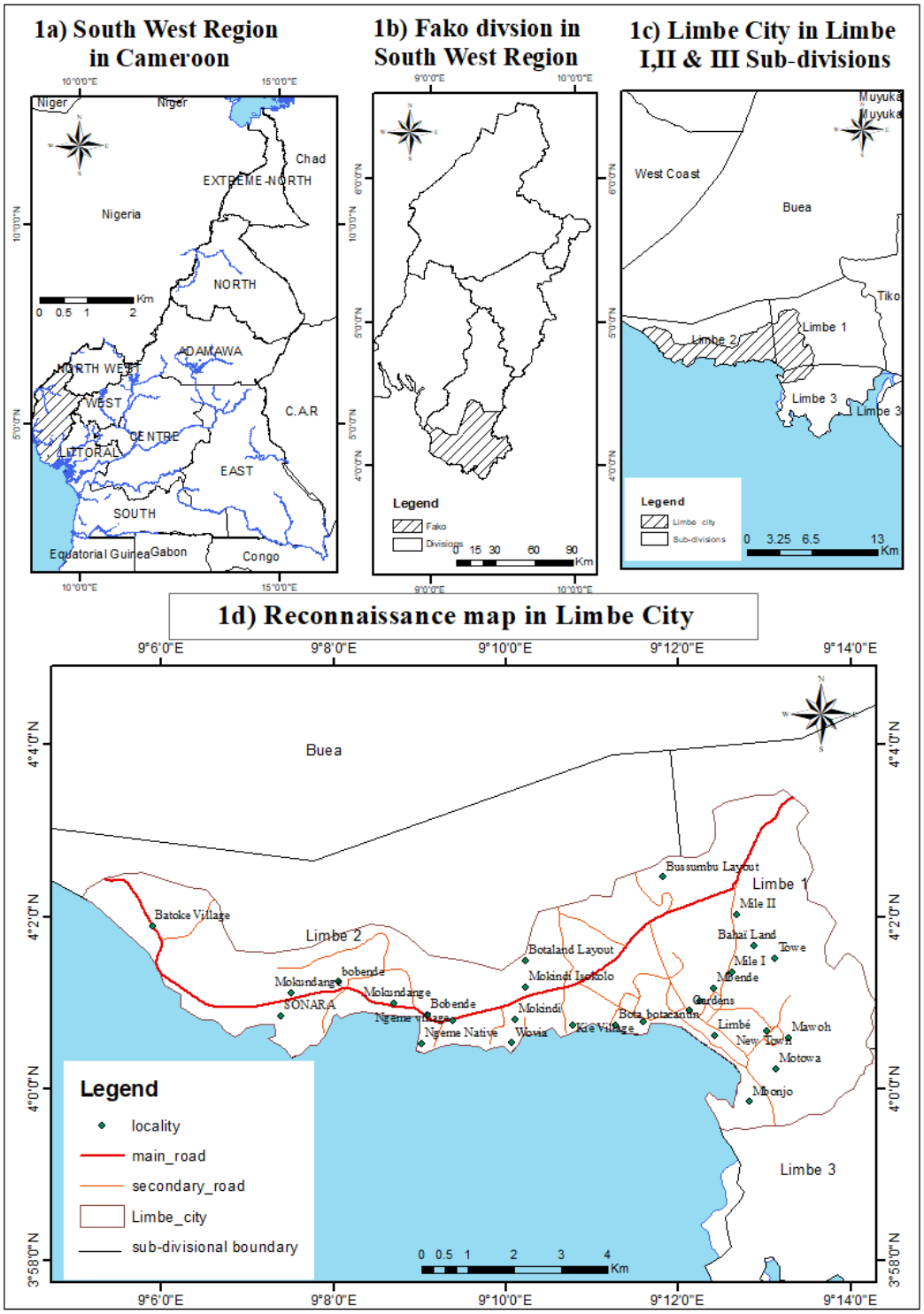


Figure 1: LOC ATION MAP OF LIMBE
Source: NIC 2017, LANSAT

II.2. Thematic delimitation

This research work is based on floods and mass movement, vulnerability of population and the adaptation strategies put in place by the population in other to improve resilience. It thus focuses on the occurrence of floods and mass movement and their effects on the population of Limbe. It also comprises of the analysis of the vulnerability of different sectors to the observed effects of floods and mass movement. Vulnerability to floods and mass movement therefore form the central theme of this research. With respect to this, the work analysis the causes of floods and mass movement and their impact to community over the study period.

II.3 Temporal delimitation

This study covers the period between the years 1985 to 2018. This period is chosen because of the following reasons:
Firstly, the occurrences of floods and mass movement in this zone were highly noticed in this period and it is in this period that extreme floods and mass movement cases occurred in the Limbe locality.

Secondly, this period is seen to be the era which man took into consideration the need to reduce the effects of the natural hazards. With a fast-Changing Climatic system, the natural environment has also been in a dynamic with the manifestation of natural hazards induced by Urbanization.

III. STATEMENT OF THE RESEARCH PROBLEM

Vulnerability to floods and mass movement that is the exposure and sensitivity of the population and their properties to risk of natural origin is a reality in the world and in coastal areas and areas with steep slopes in particular. The case of the city of Limbe is not exempted from the demographic context of a majority of African cities characterized by strong growth. The population of Limbe, increased from 27,016 inhabitants in 1976, to 97103 inhabitants in the year 2005 and up to 120000 inhabitants in the 2015 (Limbe Master plan, 2011). Such urban population growth is accompanied by an unprecedented occupation of space. Land speculation and the relative weakness in land tenure system greatly contributing to the development of spontaneous and unsanitary housing. In this light, it should be noted that there is an undeniable absent of town planning documents which are likely to contribute to the planning of the

occupied space. Added to these, the negligence of competent administrators linked to obsolete land and property legislation which is unsuitable for current pace of urban population growth greatly contributes to the proliferation of precarious houses.

Limbe a colonial city founded in 1858 by a British missionary Sir Alfred Saker of the London Baptist Missionary society was mainly settled by the indigenous population, this city is highly appreciated for its remarkable fertile volcanic soils suitable for agriculture and the presence of the Atlantic Ocean which facilitated movement from one place to another. This town in recent years have witness a tremendous increase in population and a remarkable expansion. Given the socio-economic and demographic conditions marked by abject poverty, and the noncompliance with the urbanization rules, the city of Limbe like most of the cities in sub-Saharan Africa has expanded to non-constructible areas marked by morphological and geological instability, especially areas with steep slopes, marshy lowlands. This situation generally leads to risk such as floods and all forms of mass movement.

The current climatic condition of the city worsens the situation. The intensity and volume of rainfall most especially in the months of June, July and August marked by unstable rainfall; high frequencies of rains, episodes of abundance and aggressive down pour that last for a number of days. This is to say rains of high intensity that fall makes the city of Limbe one of the most exposed cities in Cameroon to floods and Mass movement.

Deforestation is one of the key factors triggering environmental instability in the city of Limbe. The rate at which large extend of forest and wood land has disappeared has become a major problem. The cutting down of the forest by the population either for fuel wood, establishment of farm lands, or settlement is a serious problem to the environment. The rate at which the forest is cleared in Limbe is very unsustainable because cutting exceeds natural growth. Forest represents one of the most variable hubs for biodiversity. By destroying the forest human activities are putting the entire ecosystem in danger, creating natural imbalances and putting life at risk. Tree leaves act as canopies intercepting rain water, reducing the rate at which the rays of the sun hit the ground not forgetting the role of roots in holding the soil particles firm and reducing the rate of erosion that washes away the top soil marking the soils loose and expose to soil creep. Deforestation weakens and degrades the soil. As a result, deforestation causes the soil to become increasingly fragile leaving the area more vulnerable to natural disasters such as floods, landslides, mudflows, rock falls, soil creeps just to name a few.

Limbe, a city along the Cameroon Volcanic Line, rocks in this area range in composition from pyro-basalts and basalts through intermediate compositions to phonolite and rhyolite. The sediments here have been derived from weathering of volcanic cones and are characterized by alternating layers of volcanic ash and blocky lava (Che; 2011). Soils are immature with hardly any distinct horizons development Limbe has and undulating landscape with altitude ranging from zero at the shores of the Atlantic Ocean to a chain of horse shoe hills measuring up to 240m (Ndille et al; 2014). These geomorphological characteristics of Limbe expose her to the occurrences of various types of floods and mass movement such as landslide, rock fall, soil creep, mudflow etc.

Furthermore, the city of Limbe is surrounded by numerous streams and the Atlantic Ocean that highly floods their plains during the rainy season. The presents of these streams that border nearly all the quarters is a limiting aspect to urban expansion as an attempt made in increasing the space is met by proximity to water bodies leaving the population in danger of potential floods during the rainy seasons, also, these streams increase the rate of evaporation in this area leading to the formation of clouds that intend bring heavy downpour that acts as a lubricant to the soils causing it to move in different forms and frequencies.

Floods in the city of Limbe which are mainly seasonal are a great problem to the population located at the low altitude areas in the city. After every heavy downpour of rain that last for long, majority of the quarters in Limbe most especially the quarters along streams and the Atlantic Ocean such as down beach, Clerks' quarters and all the quarters of new town are submerge inside water causing numerous damages ranging from loss of lives and other valuable properties of the population. This situation makes life hard for the population during the rainy season as majority of the houses in the areas are flooded by either rain water of water coming from flooded rivers leaving the population homeless. Floods are also posing a serious socio-economic threat in this city as during the occurrence of floods most functional areas of the city that is the administrative and, economic and social activities of the city are put into a halt because of the flood waters.

The manifestations of different form of mass movement in this city are undeniable and this poses a major threat to the population and their goods.

Landslides that are the most common form of mass movement in Limbe have caused a serious havoc to the population and the natural environment. Landslides have become a very recurrent

natural disaster in Limbe with a return frequency once every year. This hazard has put the entire community into a state of uncertainty making them to be restless during the rainy season in fear of the occurrence of a surprising landslide since landslides don't announce when about to occur. Deforestation have greatly increased the rate of Landslides exposing the natural milieu to the agents of denudation such as wind and water erosions. Landslides in Limbe are also followed by food scarcity as these landslides occur on farm lands destroying crops that have been cultivated for either family consumption or commercial purposes these is typical of the July 2001 landslide in Mabeta new layout, the Mbonjo 2005 and 2018 landslides.

Mass movement in Limbe is also manifested through mud flows. During and after landslides events the debris from the slide is often transported down slope to houses found at the foot of the slopes. This situation is a great problem to the population that are located at the foot of the hills causing them to be affected by the landslide of which they were not initially affected by the original event. Piles of mud flow from landslide areas to destroy houses down slope this is the case of the Bonjo landslide in 2005.

Another form of mass movement in Limbe is soil creep. Dry and loose soil particles are transported down slope by the force of gravity or sometimes by wind since the particles are dry and light in weight. The displacement of this soil particle poses a problem to the crops that depend upon the availability of soils to grow. When the soil creeps, tree stems are left bare sometimes crops are exposed and the roots are suspended causing mal nutrition as the roots can't get enough nutrients for the growth of the plants. This intends reduces crop yield and sometimes exposing trees to wind effects as any slightest increase in wind speed will eventually push the trees down.

Mass movement in Limbe is also manifested through rock falls though not very regular. The brutal exploitation of space by the population exposes rock pedals that are loose and finally ending up in people houses causing remarkable damages to both the population and their properties which in this case houses and other home valuables.

The question that is posed is that aimed at knowing the role of the physical milieu and the anthropic actions in the occurrences of these hazards and the vulnerability of the population to floods and mass movement in the city of Limbe. Floods have become a global problem it occurs regularly in Cameroon specifically in the city of Limbe, Maroua, Yaounde, Douala, Bamenda. Within the year 2001 to 2018, precisely in the months of June and July, spectacular floods touched the city of Limbe provoking numerous deaths and many displace persons. But for each

case, the local conditions are not the same. They are the same in terms of consequences in terms of damages, lives lost, and material lost. This study is proposed to determine the particular characteristics of the causes, factors that increase vulnerability to floods and mass movement in the city of Limbe, and to propose long lasting solutions that will increase resilience to floods and Mass movement in Limbe.

IV. RESEARCH QUESTIONS

IV.1 Principal research question

What is the degree of vulnerability of the Limbe population to the effects of floods and mass movement

IV2. Specific research questions

- How has the physical and human background of Limbe influenced the occurrence of floods and mass movement in Limbe?
- How are floods and mass movement in Limbe?
- How vulnerable is the population of Limbe to the effect of floods and mass movement?
- What are the adaptation strategies put in place to manage floods and mass movements in Limbe?

V. RESEARCH HYPOTHESIS

V.1. Principal research hypothesis

- The population of Limbe is highly vulnerable to the effects of floods and mass movement

V.2. Specific research hypothesis

- The physical and human environment in Limbe highly favors the occurrence of floods and mass movement
- There is a high manifestation of floods and mass movement in the city of Limbe.
- The population in the city of Limbe are highly vulnerable to the effects of floods and mass movement.
- The population of Limbe have built strategies to manage floods and mass movement.

VI. RESEARCH OBJECTIVES

VI.1. Principal research objective

This work is aimed at showing the level at which the population of Limbe is vulnerable to the effects of floods and mass movement and the state at which they adapt to these hazards.

VI.2. Specific Research objectives

- To present the physical and human environment of Limbe
- To show the manifestation, causes and effects of floods and mass movement in the city of Limbe.
- To show how the population of Limbe city is vulnerable to floods and mass movement.
- To examine the efficiency of adaptation strategies put in place in Limbe in other to increase resilience of the population of Limbe.

VII. INTEREST OF THE STUDY

This study is significant to the local population, the national level and global level or the scientific level.

VII.1. At the local level

To the local community, this study is interested in the creation of awareness. This is to reduce the level of the vulnerability of the population to the effects of these environmental hazards.

The study is also interested in educating the population on the new and more reliable adaptation measures to floods and mass movement in the city Limbe.

Furthermore, this study is also in sensitizing the local population on the existence of building laws and the fact that some areas are restricted from construction Limbe.

VII.2. At the National Level

This research work will provide the government with vital information about the study area to evaluate the various activities carried out by the indigenous population. This is going to help the government in formulating good policies that when well applied will bring significant results both to man and the environment. This research will also help the government in decision making regarding the land use of the study area. It will also help the government to map out

control strategies and delimit risk zones sensitizing the population on effective waste management strategies.

VII.3. At international level.

These study at the international level will help the international weather observatory to forecast flood prone areas and bring out the necessary adaptation measures through the consultation of this study as literature for better understanding of the risk phenomenon in the city.
In all, this study is to help write an academic master's thesis which can act as a spring board to other studies.

VIII. Conceptual and Theoretical frame work

VIII.1. Conceptual framework

VIII.1.1. Vulnerability

The concept of vulnerability is the condition determined by physical, economic, social and environmental factors which increases the susceptibility of a community to the Impact of a hazard (UNDRR; 2015). According to (Alexander; 2013), vulnerability presence the potential harm incurred by a person, asset, activity, or assemblage of items that is at risk. Vulnerability is defined as the measure of the extent to which a community, structure, service or a geographic area is likely to be damaged, affected on an account of its nature, location by the impact of a particular hazards, disaster or risk. In our work, the notion of vulnerability has been exploited in terms of the physical, environmental, economic and socio-cultural situation of the population of our study area. Mathematically, vulnerability can be presented in an equation that is

$$\text{VULNERABILITY} = \boxed{\text{EXPOSITON}} + \boxed{\text{RESISTANCE}} + \boxed{\text{RESILIENCE}}$$

Equation 1: mathematical representation of Vulnerability

Table 1: Conceptual representation of Vulnerability

Concept	Dimension	Variables	Indicators
Vulnerability	Physical	- Quality of Building - Infrastructure - Population density - Location in Hazard prone Areas - Housing type and Tenure	- % of poorly constructed or unsafe buildings - Condition of roads, bridges, and utilities - Number of people per square kilometer - % of population living in floodplains, coastal zones, or seismic areas - % of informal settlements or temporary housing
	Sociocultural	- Age - Genda - Education - Access to Services	- % of population under 5 and over 65 - Female-headed households, gender disparity - Literacy rate, average years of schooling - % without access to clean water or healthcare
	Economic	- Income level - Employment - Access to Financial Services	- % of population living below the poverty line - Unemployment rate, proportion of informal workers - % with access to savings, credit, or microfinance
	Environmental	- Ecosystem degradation - Climate Change - Land Use - Pollution and Waste Management - Geography	- % of deforested areas, soil erosion rates, loss of wetlands - Intensity and frequency Of Rainfall - % of land converted to urban or agricultural use - Levels of water - Relief, Slope, Water bodies
	Institutional	- Legislative and policy - Disaster Preparedness Plan - Coordination among agencies	- Presence of laws and regulations related to building codes, land-use planning, and disaster risk management - Existence and enforcement of disaster risk reduction (DRR) policies and plans - Level of coordination between government, NGOs, and international bodies during crises

Source: Adapted From Birman 2014

VIII.1.2. Risk

It is the combination of the probability of an event and its negative consequences (UNDRR; 2009). It is a confrontation of a hazard and a geographic zone where there exist some précised stakes.

According to (Veyret; 2006); natural risk is the perception of a possible more or less predictable danger to a social group or an individual exposed to it. A natural risk is a natural phenomenon (earthquake, flood, drought, volcanic eruption, and landslide) that presents a danger to humans. It is mathematically calculated as:

$$\text{Natural Risk} = \boxed{\text{Hazard}} + \boxed{\text{Vulnerabilty}} + \boxed{\text{Stakes}}$$

Equation 1: mathematical representation of the concept of Risk

VIII.1.3. Hazard

A hazard is a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury, other health impacts, property damage, loss of livelihood and services, social and economic disruptions, or environmental damage. (UNDRR 2009).

A hazard is characterized by an even whose occurrence is condition by chance. It designates the probability of occurrence of a phenomenon, and it's measured by taking into account the intensity of the phenomenon, its duration and the space in which it occurs. The intensity of a hazard corresponds to the magnitude of the hazard. The probability of a hazard is expressed either in a temporal of spatial scale. The probability of the spatial occurrence is link to the specific geographic area that the hazard might occur; that is, there are specific areas in the globe that are more vulnerable to natural hazards than others. The temporal probability of occurrence corresponds to the frequency of the hazard. There exist four types of natural hazards.

- Geologic or lithological hazards: they include earth quakes and the seven forms of volcanic activities.
- Geomorphological hazards: these are hazards produce by a disruption in the external geodynamic system. They include all forms of mass movement.
- Climatic or Hydro-meteorological hazards: these are natural hazards that are linked uniquely to the climate. They include either too much rainfall, drought, cyclones, floods.

- Biologic hazards: these are epidemic hazards that affect the health system directly, and food security.

In our study, we are most interested in hydro-meteorological and geomorphologic Hazards that is; hazards of both geomorphologic and climatic origin (floods and mass movement).

VIII.1.4. Resilience

The ability of a system, society, or community exposed to a hazard to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions (UNDRR, 2009). Resilience means the ability to bounce back from or spring back from a shock. For a community to be resilient to a particular natural hazard, many elements are taken into consideration such as the economic and financial capital, infrastructural capital, organizational, and socio-cultural capital. All these elements are vital when in good standard for the population and ecosystem or an individual's flexibility or capacity to maintain its original state after an occurrence of a natural event.

VIII.1.5. Mass Movement

Mass movement describes the movement of weathered materials downhill including soils, loose stones and rocks in response to the forces of gravity this occurs when the force of gravity exceeds the forces of resistance of the slope, eventually slope failure occurs and materials begin to move downward.

A slope is an open system that is open to changes and it is affected by biotic, climatic, gravitational, groundwater and tectonic inputs which vary in scale and time. The amount, rate and type of movement depend upon the degree of slope failure.

Though by definition, mass movement refers to the movement of materials downhill through the influence of the forces of gravity, in reality water is present and assists in the process. Mass movement can be grouped using the speed of movement and also the amount of moisture present as basis for differentiating the various types.

VIII.1.6. Floods

Floods are an overflow of water on lands which are usually dry. Floods can occur as an overflow of water from water bodies such as rivers, lakes, or oceans in which the water overtops resulting in some of the water escaping its usual boundaries or it may occur due to accumulation of rainwater on saturated ground in an area. The concept of flood risk is used in different senses. The explanation of flood risk can be from two points of view: hydrological or geographical. In the first case, emphasis is placed on the flood zones, identified using hydraulic models and which are the places where river floods are likely to occur. In the second case, the combination of geographical conditions and environmental and socio-economic factors are used to determine areas with a high probability of damage. In this study we are going to focus on the second aspect of explaining floods which is the combination of geographical, environmental and socio-economic factors in the context of flooding in our area of study

VIII.1.7. Adaptation

The inter government panel on (IPCC; 1995) in the first impact and adaptation to addressed the concept of adaptation and in 2001 defined adaptation as adjustments in natural or human systems in response to actual or expected climatic stimuli with moderate harm or exploit beneficial opportunities. Various types of adaptation can be identified which include: anticipatory, reactive, autonomous, planed, public and private adaptation. Adaptation consists of developing divers options aimed at limiting the negative impacts and avoiding important damages taking into account the indirect consequences in a long run (ONERC2007, PNUD2008). The notion of adaptation is as old as the world. The perception of adaptation differs from one to another and it depends on the means of existence of the population and the level of development of the country.

In some, we can distinguish many types of adaptation; each type depends on the strategy and the means at the disposition of the population. Adaptation can be anticipatory that is adaptation taken before the initial impacts are observed. This form of adaptation is in a proactive approach; aimed at reducing exposure to future risk. Adaptation can also be reactive this type of adaptation involves the changes that most natural and human systems will undergo in response to changing conditions. It is considered to be those methods of adaptation that take place in response to the initial impacts of a climatic stimuli. A reactive is aimed at alleviating impacts once they have occurred, and as such the estimates are used in impact and vulnerability assessment.

Adaptation to floods and mass movement in our study area will be defined as the capacity of the local population to cope faced with these natural hazards. In other terms, to say the various means that they have applied to anticipate or those put in place to reduce the damages of floods and mass movement. The higher the adaptation capacity, the lesser the vulnerability.

VIII.2. THEORETICAL FRAME WORK

VIII.2.1. Equilibrium Theory of Landform Development

According to Robert Muller and Oberlander (1974), the formation of landforms by erosion depends on the relationship between the slope gradient, the slope angle and its material. Both authors emphases the form, of land to equate the energy of erosion process and the resistance of the materials they attack. They identify two forces that put material in motion on slopes. This includes the down slope gravitational stress and the shear stress.

The down slope gravitational stress is proportional to the slope angle. They demonstrated it by using the example of a table with an object on it. When the table is tilted at a certain angle, the object slid off when the down slope component exceeds the frictional force between object and the table top. The second force which is shear stress is the oblique downward and forward force exerted by one material rubbing against or flowing over another material. Water, ice or wind moving over any surface exerts shear stress (abrasion, ablation) forces which causes loose particles on it to move. The exerted stress is related to the slope angle. The lower the angle of the slope, the lower the gravitational stress on the material forming the slope as well as an increase in the slope angle increases the gravitational force and shear stress is imposed on by an erosional agent. This is shown in figure 4 below

Figure 2:The Equilibrium Theory of Landform Development
Source*: *Robert A. M and Oberlander (1974)

The gravitational force (A) exerted on the particles can result into the downward slope force, (B) which in turn causes downhill motion, and a force directed into the surface (C) which in turn holds the material against the surface. The steeper the slope, the greater the downhill slope (B) compared to the force resisting movement (C). The loose particles at the left remain in place (C) is greater than (B) and vice versa when turned to the right. This theory explains the relationship that exists between the nature of the slope and its materials. The materials behave as solids or viscous masses, and may be consolidated (compacted and cemented) or unconsolidated (loose and uncemented). Movement occurs when the forces of gravity exceed the resisting force (slope stability). Slope stability is determined by:

- ✓ The strength and cohesiveness of the slope material(s)
- ✓ Internal friction between grains
- ✓ And any external support of the slope.

Limbe Sub-division is characterized by and undulating landscape with altitude ranging from zero at the shores of the Atlantic Ocean to a chain of horse-shoe hills measuring up to 240 m. The sediments have been derived from weathering of volcanic cones and are characterized by alternating layers of volcanic ash and blocky lava. Soils are immature with hardly any distinct horizon development. When the soils are stressed, coupled with the rain that saturates the soils adding weight to it that in turns facilitates the movement of material down the slopes.

VIII.2.2. The Penck's theory of landform development

According to the German geomorphologist Walther Penck in the 1920's, the characteristics of landforms of a given region are related to the tectonic activities of that region.

Penck put forward his view that geomorphic forms are an expression of the phase and the rate of uplift in relation to the rate of degradation. Where it is assumed that the interaction between the two factors; uplift and degradation that has been or is in effect and not a stage in progressive sequence. Penck holds in his main premises on his model of landscape development that the morphological characteristics of any region of the earth's surface are a result of competition between crustal movement and denudational processes. He continued by pointing out that upliftment and erosion are coexistence.

This theory is indispensable in our research topic because our research topic discusses mass movement which is highly explicable by the theory that has clearly spelled out the relationship that exist between highlands and erosional processes that are the driving forces of mass movement.

VIII.2.3 The theory of possibilism

This is a school of thought led by Vidal de la Blanche was developed between 1845 and 1918 and became popular in the year 1913. The theory of possibilism holds upon the assumption that environment sets certain constrains or limitation but culture is otherwise determined by social conditions. This theory says that the true and only geographic problem is that utilize possibilities. The essence of this theory is that nature provides possibilities and man utilizes them according to his culture, tradition and level of socioeconomic development. The range of possibilities in every region is limited by the price man is willing to pay of what he wants than by the dictates of the environment. This could be demonstrated through the facts that even in very environments, man has a number of choices that is; the type of house to build, when and where, what crop to grow. This theory is linked to my research topic in that they both agued and looked for possibilities on how man survive on risk prone areas. This research topic holds a similar view point with the ideas of positivism as it looks at possibility to adapt to the effects of floods and mass movement.

VIII.2.4. The theory of determinism

This theory was brought about by the German geographers like FREDERIK RATZSEL, HUMBOLD AND KARL RITER in the 1860s. The theory holds that the environment is largely responsible for the behavior of man. This is to say that the physical environment influences human activities (physical geography influences human geography). For instance, climate may

have influence over, agriculture, settlement, and health which man highly depends on. Where temperatures are extremely high as in the deserts, irrigation for agricultural purposes may be rendered difficult or impossible due to shortage of water in desert milieus.

IX. LITERATURE REVIEW

IX.1. Literature review on floods

According to the work of Roland and Johannes; (2014), which was aimed at assessing the what the state of Cameroon is doing in terms of disaster risk reduction through policies and actions during and after the occurrence of major catastrophes especially in the case of the Limbe floods and landslides of 2001.but we are going to examine the causes of floods and mass movement in the urban town of Limbe and also evaluate the level at which the population of this town is vulnerable to these hazards and how adaptive the population is faced with this natural hazards.

According to Zogning, (1994); in the town at the foot of the mountain, floods are caused by a combination of many factors such as heavy rainfall, the effects of sea tide and an uncontrollable level of urbanization. He carried out an inventory of flood risk in the Limbe locality in the 20th centuries but we are going to carry out an inventory of the existence of floods, bringing out the causes of this hazard in Limbe and also evaluate the level at which the population is exposed to these hazard and also the effects of these catastrophe to the population and also how the population had adapted to these hazards and also propose possible solutions to these hazards, and what has change from the 20th century to the 21st century.

According to Nott, (2006), the causes of floods are broadly divided to physical such as climatological and human through deforestation and urban development. In our research, we are going to study all the physical factors that amplify floods such as the geology of the, hydrology, and geomorphologic factors and also those of the anthropic origin such as population pressure, and examine the impact of the floods to the population Limbe. Nott also continued by clearly pointing out that a normal level of flood even is not considered a natural hazard unless there is a threat to human life and properties. Here in our study, we are going to study the floods in Limbe as natural disasters.

As for Lind et al; (2008), there loses in the case of floods has many dimensions. In addition to Economic lose, and loss of lives and injuries, there may be an irreversible loose of land of historical and cultural values and loss of nature or ecological valuables.

A study carried out by Borrows et al; (2006), indicated that amongst natural catastrophes, floods have claimed more lives than any other single natural catastrophes. That in the decade 1986 to 1995, flooding accounted 31% of the global economic loss from natural catastrophes and 55% of the casualties. Their study was carried on a global scale but our study is focus in a specific area which is Limbe. We are going to evaluate the impact of these floods in Limbe.

Carey (2005) in a study said that the human populations worldwide are highly vulnerable to natural hazards. That certain conditions such as geographic location and income level of the population can affect the degree to which natural disasters affect the livelihood of the population. In our study we are going to examine the extern to which the geographic location of the town of Limbe and the income level of its population have contributed to their vulnerable nature to floods.

IX.2. Literature review on mass movement

According to Vivian et al; (2011) who analyzed the behavior and mobility of some major elements during the physical and chemical development of soils in landslide prone arrears in Limbe, also elaborating the causes of landslides in Limbe which for them were mostly geological that the formation of soils forgetting the geomorphological nature of this area and the hydrological and anthropic factors that provoke landslides. Our work is not only going to examine the geologic nor geomorphologic factors that causes landslides and mass movement in Limbe but also the hydrological and anthropic actions that provoke mass movement and how the population is vulnerable to these natural hazards and their effects on the population and how the population is coping faced with these hazards.

According to Achou; (1989), in human interface and environmental stability, addressing the environmental consequences on urban growth in Bamenda, they discussed the impact of upland urban expansion and showed how surface occupation in the city of Bamenda is the brain behind the ecological and social impact. This expansion has placed great stress on forest land and water ecosystems. A bulk of the city's rapid population growth has been accommodated on informal settlements that are on steep slopes and flood prone areas with limited attempts being

made to limit the risk of landslides, rapid erosion and flash floods. This study was based on human occupation of land but ours is going to examine both the human and physical causes of floods and mass movement.

The works carried by Zogning (1988); Canillus, Lambi and Ngwana (1991), are indispensable here. They examined landslides within the Mezam division laide emphasis on the role played by human interfaces that contributes the proximal phenomenon. They suggested some measures that could be applied to minimize the effects of this hazard in the tropics. They carried out their studies in Mezam division but ours is in the city of Limbe. Never the less this work will serve as a base for our research.

According to Nkwemoh (1991) environmental degradation, in particular deforestation due to demographic pressure, agriculture and animal husbandry are at the origin in increase in landslides.

According to Ngoufo (1988), he mentioned that the relief and the Nebelwald dense forest are in danger due to human influence. More detail, he affirms that the degradation of the natural milieu of the Caldera is intense due to human activities on the high Southern slopes. By (Veyret et al ; 1998), in the same light said man by modifying the vegetal cover of the soil can contribute in causing or aggravating certain procedures which leads to the erosion of the slopes down the talwegs.

Tchotsoua (1989), equally attributed the cause of erosion to demographic pressure, anthropogenic activities and the mode of soil usage. These works will act as a base for our research as we are going to examine the influence of these factors in Limbe.

According to Tchindjang;(1996), the influences of man on his environment through agro-pastoral activities have led to the passage from a natural landscape to a transformed landscape and finally to a degraded landscape where the weight of human constrains are high. In the same reasoning, Tchawa et al;(1999) without leaving out the protective role of sylviculture and forestation added that certain tree species like the eucalyptus are the origin of serious environmental degradation in the agrarian landscape in the Bamilike region. Their work was carried out in the west region but ours is in the south west and precisely Limbe and wont only end at the examining the causes of landform degradation but added to it, floods and their Impact on man.

In a study by Valentine et al; (2008) said deforestation is an important factor determining erosion and mass movement in tropical regions. Ndoh; (2000), UNDEP-GTZ (2004) reports notes that the environmental situation of the North West province is fast changing due to poorly adapted human activities and accelerated erosion.

On the second phase, majority of literature on mass movement (landslides) say, the soil is not only carried down slope through splash saltation flux and runoff but also by various forms of mass movement. Although most landslides occur from some factors such as crustal instability, overloading of the slope top soil or destabilization at the base,

Lambi;(1988) noted that the clearing of vegetation opens up pore holes that are exploited by percolating water which infiltrates into the soil increasing soil weight and eventually causing landslides. He added that water passing through permeable weathered debris on steep slopes reaches withstand the force of gravity and are forced to move downwards.

IX.3. Review on vulnerability

D'Ercole at al. (2009) completed his study vulnerability of an individual and the vulnerability of a society. The vulnerability of a society explains the capacity to resist in its assemblage in a given risk. The exposition of infrastructures, public services like the market, hospital, roads, emergency services, tec. put's the role of and the necessity of this stakes. So many questions of vulnerability in the context of developing countries, so many authors real the weakness or the urbanization system. Ledoux (1995) confirms that the rate of urbanization in the countries of the south is good evidence of vulnerability in the measure that where the processes of urbanization are linked to a rural urban migration and a strong demographic growth. The population install in their masses in towns and doesn't give time for infrastructures to welcome them.

Blackie et al (1994) described vulnerability as a measure of a person or group exposed to the effects of natural hazards including the degree to which they can recover from the impact of that event

Nick Brook (2003), based his study on presenting a tentative conceptual framework for studies of vulnerability and adaptation to, then went further to bringing out the various types of vulnerability and distinguishing among them he evoked social vulnerability and biophysical vulnerability. The work concentrated on the relationship between biophysical. Vulnerability

and social vulnerability's, risk adaptive capacity and adaptation. He then summarized the differences between biophysical and social vulnerability. This work clearly brings out the aspects of the concept of vulnerability and it's going to act as a base for our study.

According to Arasen; (2002), natural hazards are indeed biophysical evens, such as earthquakes land sliding, volcanic activities and flooding they have characteristics of posing danger to the different social entities of our planet never the less this dangers are not only the result of the process per natural vulnerability, it is the result of the human systems and their associated vulnerability towards them she continued by adding that there are two main factors responsible for the occurrence of natural disasters in the developing countries which are, firstly there is a relation with geographical and geological-geomorphological settings. The second reason is linked to the historical development of these countries, where the economic, social political and cultural conditions are not good her work was aimed at incorporating geomorphologies into the national, regional and local groups of experts to establish adequate strategist of risk assessment and management. Our research is carried out in a define area and in a small scale which is Limbe in Cameroon and also to evaluate the degree of exposition of the population to this natural hazards.

X. RESEARCH METHODOLOGY

X.1. Data collection

This involves the assemblage of information with respect to its source which are secondary and primary data collection.

X.1.1. Collection of data from secondary sources

In this domain, a good number of documents have been consulted with respect to the history of floods and mass movement and their respective impact on man and the environment. These documents include text books, dissertations, thesis, journals, articles, newspapers, magazines, reports, and also materials drawn from the internet.

These documents have been gotten from places like ministries (Ministry of urban development and Housing, ministry of territorial administration, ministry of decentralization, ministry of environment and nature protection), National Institute of Statistics(NIC), Libraries (library of the faculty of arts, letters and social sciences of the university of Yaounde1, the library at the geography department of the university of Yaoundé1), Limbe city council, the

Limbe sub divisional councils, N.G'Os, topographic and hydrologic maps of the town of Limbe, satellite images.

X.1.2 Collection of data from primary sources

Data collection here involves field investigations it comprises of Observation, interviews through individual and focus group discussions with the use of questionnaires. Field trips that enabled direct observation on the site and appraisal with intensions of attaining objectives and confronting written literatures and conceived ideas with the field realities. Primary data was collected from 10 selected quarters in the city with respects to the occurrence of floods and mass movement.

X.1.3 Field observations

This comprises of the appraisal of the first-hand information through a personal eye observation of the situation on ground concerning the subject on study.

X.1.4 Administration of questionnaires

Questionnaires represent one of the basic methods of acquiring information. The questionnaire was structured in four different headings which included; personal identification, risk and causes, vulnerability, and adaptation strategies. The number of questionnaires designed were 374 copies but those actually responded where 280 copies (74.9%). The questionnaires were not administered 100% because of certain reasons. Some copies were misplaced or destroyed by some households who choose to fill the questionnaire at their convenience in my absence (Appendix 1). All quarters were infiltrated and questionnaires carefully administered. In this light, the detail information about the natural risks, its causes, how the population is vulnerable and how they have adapted to the phenomenon was gotten. These questionnaires were administered to households and the total number of questionnaires administered in each quarter was dependent upon the total number of households.

The sample size was drawn from the 9343 households in the study area following the population and household projection 2015. The choice of the household facilitated the easy asses of information by the researcher through the administration of questionnaire.

The 4% sample size of this study was selected as a fraction of the total population to the total number households using formula:

Sample population = $\frac{Total\ population}{\text{Total Number of Houeholds}}$

$= \frac{\mathbf{40333}}{\mathbf{9343}} = 4$

Equation 2: population sample

Therefore, total number of questionnaires = 4 % of the total number of household (9343).

Which implies?

4/100*9343= 374 copies of questionnaires.

The reason for the choosing of 4% as the sample size of this research is accordance with Nwana (1982). Who stipulated that?

If the population of a study is in hundreds, then 40% or more should be used for the sampling,

If it's in several hundreds, then 20% can be used,

If it's in few thousands, 10% will do,

And lastly if it's in several thousands, 5% or lesser can represent.

Table 2: A descriptive table on the distribution of questionnaires among individual quarters

Name of quarter	Number of households	Number of questionnaires
Unity quarter	1795	30
Upper Mawoh	574	25
Motowoh	1415	29
Mabeta new layout	509	26
Lower mawoh	408	27
Cassava farms	2272	33
Mbonjo	813	27
Down beach	276	25
Mbende	1089	28
Lumpsum	192	30
TOTAL	9343	280

Source 2020 field investigation

X.1.5 Focus group

This is another method that was employed during the acquisition of primary data. Specific topics were discussed in group sessions with respect to the subject of research. This was carried out in all the ten quarters that we choose to represent the city. It was made up of five to eleven participants. These groups were comprised of members of the quarter councils.

These groups comprised of people from different background that is agriculturalist, health workers, administrators, members of NGOs concerned with risk management business men. Generally, I brought the topic of discussion and allowed them to discuss ideas, issues, insights and experiences amongst themselves and using my checklist, tracks of topics discussed were kept for further exploitation. The topics discussed were designed to help in understanding of group perception about risk, its impacts and what mode of adaptation is best in coping with the risky nature of their quarters so as to increase resilience.

X.1.6 Interview

This consisted of dialogue with some resource persons who provided both quantitative and qualitative information about the subject under study. In this perspective, we sorted out quarter heads, mayors, members of quarter associations, the D'O, divisional delegate of the ministry of Housing and Urban Development (MINHDU), Limbe city council, divisional delegation for environment and nature protection, health officials, and host of other personalities. Information gotten was carefully inserted in a notebook. This provided important ideas and insights for the realisation of this work.

X.2 Research data analysis

Following all data collection strategies, specific processing methods were required for each type of data to achieve the result represented in this research.

For the data collected from the field, SPSS (Statistical Package for Social Science) and Microsoft excel 2010 were used for counting questionnaires and generation of frequency tables and realization of charts.

The climatic data retained within the frame work of this research was gotten from the reading of the station of the CDC located Bota Limbe. The data contained the monthly rainfall amounts, number of rainy days per month, monthly average temperatures within the period of our study which is in this case 1985-2018. Statistical tools such as; standard deviation was calculated which an indicator of variation using the formula below:

$$SD = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

Equation 3: standard deviation

Where; x is the value of the year under study, $\bar{x}$ the mean annual, and n the number of years in the series.

Also, the calculations of reduce centered abnormalities which main objective was to plot the different trend curves.

For cartographic data, Maps were drawn with the help of computer assisted cartography and GIS programs such as adobe illustrator, ArcGIS. MAP INFO. To delimit our study which the urban space (the city of Limbe) a Google Earth map was used to define the borders of the city.

In order to quantify the risk and delimit the spaces according to the severity and frequency of the risk, we used the risk matrix fig 5

Niveau de Fréquence	Valeur de Probabilité / unité
5	$10^{-3} < P < 10^{-2}$
4	$10^{-4} < P < 10^{-3}$
3	$10^{-6} < P < 10^{-4}$
2	$P < 10^{-6}$
1	$P < 10^{-8}$

Figure 3:Risk Matrix (source : Tchinjang, 2012)

Interpreting this figure, the risk areas are divided into three main categories based on their severity.

The red spaces correspond to areas with high-risk probability and also very frequent. The seriousness of risk in this area in related to the nature of damage caused which includes common material lose to the loss of lives. The frequency of the risk is linked to the probability of return which is annual for the case of the city of Limbe. The red spaces are inn constructible according to law n^{o} 2004/003 of April 21st 2004 governing town planning in Cameroon.

The orange spaces represent the areas in the city with medium probability of the risk. The impact here is mostly limited to material losses and the frequency of return of the risk is shifted to several number of years. These are difficult to set out and require high techniques to cope with what so ever risk present in the area.

The green spaces in this area represent the areas where the risk remains present but the frequency and severity is well reduced. Catastrophic events here are rare and the damages are generally easily repairable. These areas are areas with total risk acceptance.

Using this risk Matrix to identify areas at flood risk took into consideration a hydro-geomorphological method (Mett and Mate; 1996) by incorporating the slope map and the hydrologic map. That is, the red zones correspond to areas drained by a water body with very low slope angle. In general, these areas have a high frequency of floods and the damages are generally catastrophic with lost of human lives. The orange zones represent areas drained by secondary streams with moderate altitudes. The risk here is generally reduce with a low frequency with generally moderate adaptable damages mostly properties. The green areas are the areas with rare cases of floods, they correspond to areas with higher altitudes and drained by ephemeral streams. The causes of floods in these areas are mostly from anthropogenic.

For the map of mass movement, we integrated the pedologic maps (Guedjeo et al; 2012) on the slope map. That is the red zones which are high risk zones correspond to areas with very high slopes (20^{o}-57^{o}) the orange zones areas with moderate slopes (10^{o}-20^{o}) and the green zones areas with low slopes (0^{o}-10^{o}).

X.3 Data presentation

The data gotten during our field research was analysed and is represented on tables, synoptic charts, pie charts, line graphs, histograms, using cartographic techniques, data is presented in form of maps, photographs, these has help to paint a clear picture of the information analysed for easy interpretation.

X.4. Difficulties encountered

The first difficulty encountered during this research was the issue of the naming of quarters in Limbe. The delimitation and naming of quarters by official document were not mastered by the local population. The local population gave various names of their quarters that were best known and accepted by them. This situation made it difficult for the administration of questionnaires. As a result of this, the general quarter names were compared with reference to both administrative naming and the local appellations.

The second difficulty encountered was getting to gather the people for group discussions. The councilors and some other civil servants and farmers who made up the focus groups did not attend the discussions as in some cases a group of about ten people mostly only a few of about 4 to 6 persons made it possible to the meeting place

The third difficulty encountered was the fact that some population refused to fill the questionnaires as the miss interpreted the reason of the research. This was very common among the illiterate population as well as the educated as one high school teacher a holder of 'DIPES' who had done a similar exercise refused to fill the questionnaire that it will be used against her.

Furthermore, the issue of ghost town and the Crisis in the south west region did not exclude Limbe as during our research we witness a number of them. Because of this challenge the field survey lasted more than the planned period as any day set aside as ghost town was highly respected by the population. On such days we did not work.

Lastly, the problem of Covid-19 played a role in delaying our research as communication was greatly hampered by the various prevention methods and also adding to the cost of the research.

Table 3 : A synthetic matric of the research

Principal Research Questions	**Principal Research Hypotheses**	**Principal Research Objectives**	**Theories**	**Methodology**
What is the degree of exposition of the population to the effects of floods and mass movement and what is the role of physical and anthropic factors to the occurrences of floods and mass movement in Limbe?	The population of Limbe is vulnerable to the effects of floods and mass movement and the physical and anthropic factors are at the origin of these hazards	To study the causes and effects of floods and mass movement and the adaptation strategies	Diffusion of innovation, possibilism, erosional cycle, development, tectono-geomorphic Determinism, EIA Possibilism, Landform development, determinism, diffusion of innovation	**Descriptive and inferential methods** Data collection primary and secondary methods Data analysis descriptive and inferential methods
Specific Research Questions	**Specific Research Hypotheses**	**Specific Research Objectives**	**Concepts**	Data Collection
Q1. What are the causes of floods and mass movement in Limbe?	**H.1.** There is a high manifestation of floods and mass movement in Limbe	To study how floods and mass movement are manifested in Limbe	Population, vulnerability, risk, resilience, mass movement, floods, adaptation, Vulnerability, floods, mass movement	Data collection from primary sources: field observation, questionnaire, interviews and focus data group data discussion.
Q2. How vulnerable is the population of Limbe to the effect of floods and mass movement in Limbe?	**H.2.** The population in the city of Limbe are highly vulnerable to the effects of floods and mass movement	To show how the population is vulnerable to floods and mass movement	Vulnerability, adaptation, resilience	Collection of data from Secondary sources: we consulted text books, dissertations, thesis, journals, articles, newspapers, magazines, reports, and also materials drawn from the internet. We also made use of maps and satellite images.
Q3. What are the adaption strategies put in place to manage floods and mass movement?	**H.3.** The population has greatly adapted to floods and mass movement	To show the various adaption strategies put in place	Vulnerability, adaptation, flood, mass movement	**DATA Analysis** The data collected was analyst with the help of software such as; Excel, SPSS, Adobe illustrator and ArcGIS. The data was presented in form of tables, graphs Histograms and charts
Q.4. What are the adaptation strategies put in place to manage floods and mass movements in Limbe?	**H.4. The population of Limbe have built strategies to manage floods and mass movement.**	To examine the efficiency of adaptation strategies put in place in Limbe in other to increase resilience of the population of Limbe.		

CHAPTER ONE
AN AREA WHERE THE PHYSICAL AND HUMAN BACKGROUND FAVOUR THE OCCURRENCE OF FLOODS AND MASS MOVEMENT

1.1.0. A PHYSICAL MILIEU THAT FAVORS FLOODS AND MASS MOVEMENT

1.1.1. Relief

The city of Limbe is characterized by a diverse form of relief structures composed of variant altitudes. The city has a monotonous relief characterized by a low laying coastal plain, rising to a chain of horseshoe shape slopes with the highest point measuring 362m above sea level (Njabe and Fobang; 2006). Revelations from field observation and the use of topographic map of Limbe at 1/50000 shows that the town is developed on an Amphitheatre made up of chains of volcanic hills in the form of semi circles from East to West: Green hills, Mabeta Hills(295m), Mawoh hills, Motowoh Hills (362m) and the Bonjo Hills. The site of the city is accentuated by some hills Bakoko and Alpha club Hills, White man Hills and the Botanic Garden Hills. These Hills are built up at 140m at the Bakoko Hills. The city is also dissected by interfluves and hills on the slopes, generally convex and separated one from another by wide valleys of about 5 to 100m. It is the case of the Limbe River that flows from mile two to the Ocean in a large flat bed.

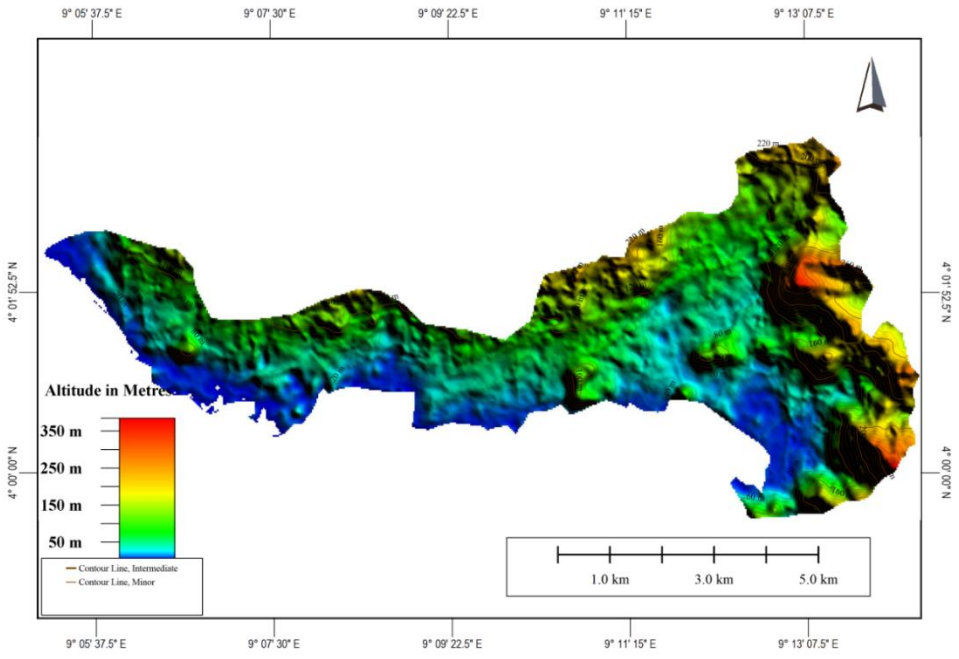


Figure 4:The Relief of Limb:
Source: NIC Shape file

Risk linked to external geodynamics are caused by relief. The relief place a major role is setting erosive patterns. Floods and all forms of mass movement in the city of Limbe are highly accounted for by the relief of the city. Some convexo-concave areas are found in the valley heads of amphitheaters around the south eastern part of the city (quarters like MNLO, Mawoh, Mbonjo) and are generally linked to landslide. Their average depth varies between 30 to 80m and average slope inclination between 5º and 27º, those that link hydrographic networks are at times steep and superior to 35º (45º on the south slope of Bakoko hills towards Middle farms). This morphology plays a great role in city susceptibility to mass movement. The areas in the south of the city along the Atlantic Ocean and the major river channels (valley bottom) in the city with general slopes generally inferior to 5% are prone to floodings.

1.1.2 Hydrology

The city of Limbe has a dense hydrographic network, drained by many ephemeral streams most of which flow only during the rainy season. And a few perennial streams (Limbe and Djenguele) whose discharge seasonally varies dramatically, emphasizing the contribution of surface runoff in shaping the landscape. The streams provide the area with a parallel to dendritic drainage pattern. figure 7 shows the hydrology of Limbe.

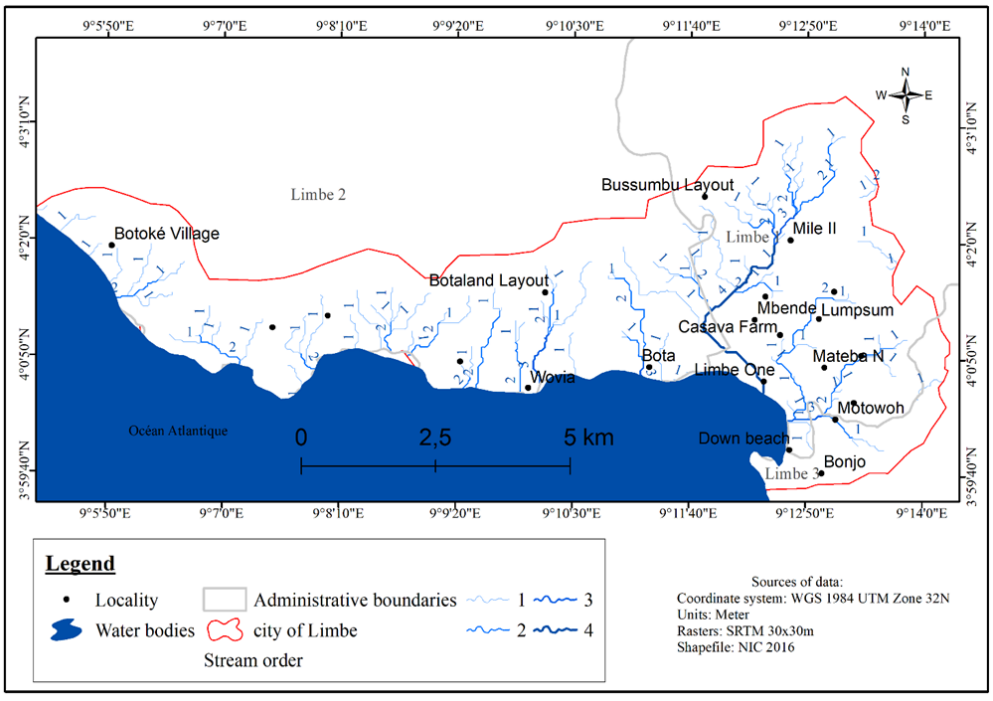


Figure 5: The Hydrology of Limbe
Source: SRTM 30 x30m, NIC Shapefile, 2016

The map above shows hydrologic nature of Limbe with the presence of many water bodies. The map demonstrates the type of streams present in the city. The 1st order streams which are mostly seasonal and the 4th order streams which are the perennial rivers that flow in many quarters in the city. We can clearly see that the area around the south east which is our zone of study has the highest number of stream order machining the area susceptible to the occurrence of floods. The construction of this city along these streams and the presents of marshy areas that are today reclaimed for construction are high factors that increase the level of vulnerability to floods. The hydrography of Limbe has made her very vulnerable to floods. The presents of some areas with water depth less than 1m is a tread to the inhabitants of the area as any little rain that falls fills the ground so fast that houses are flooded.

1.1.3 Geology

Limbe a city in the Fako division south west region of Cameroon is located at an active volcanic area south east of the mount Cameroon with a dynamic coastal zone that is characterized by a variety of natural hazards such as geomorphological, geophysical and climatological hazards (Kometa, 2010, Zogning et al,2009). It is also found at the Cameroon Volcanic Line (CVL) a 1600km y-shaped chain of tertiary and recent volcanic rocks (Ubangoh et al, 1998; Zogning et al, 2009). The CVL is a South-West, North-East volcano- tectonic trend that straddles the continental margins. Its externs some 900km across Cameroon from Bui and Adamawa plateaus to Mt Cameroon, and Equatorial Guinea in the Gulf of Guinea. It continues seaward to about 00km from the coast through the Atlantic Islands of Principe, Sao Tome and Pagalu (Ubangoh et al 1998). The Limbe area is made up of igneous (basalt and pyroclastic materials) and sedimentary (mudstone and alluvial deposits) rocks. The basalts in this area are of three kinds that is Vesicular (fine-grains and compacted with vesicles), fine-grains (highly compacted with no traces of weathering) and porphyritic basalts. The fine-grain basalt in this area results from the fast cooling of hot magma. The Porphyritic basalts in this area are either Olivine (usually not greater than 1mm in size) or Augite in origin. Basalts weather to dark reddish soils which form the best arable land (Onege, 1998).

The major rock types in this area are Tertiary to Recent alkali basaltic lava flow deposits, pyroclastic deposits commonly occurring as cones of diverse shapes (circular, elliptical and asymmetric) and sizes, mudflow (lahar) deposits and alluvial deposits confined within stream channels and flood plains. Pyroclastic deposits include volcanic bombs and vesiculated scoria (or cinders) and tephra. Tephra particles range from ash (< 2 mm) through lapilli (2 - 64 mm)

to blocks and bombs (> 64 mm). These materials are either laid exposed at the surface or are covered by dark brown, reddish brown and/or pale yellowish-brown sticky, clayey soils derived from the weathering of these materials.

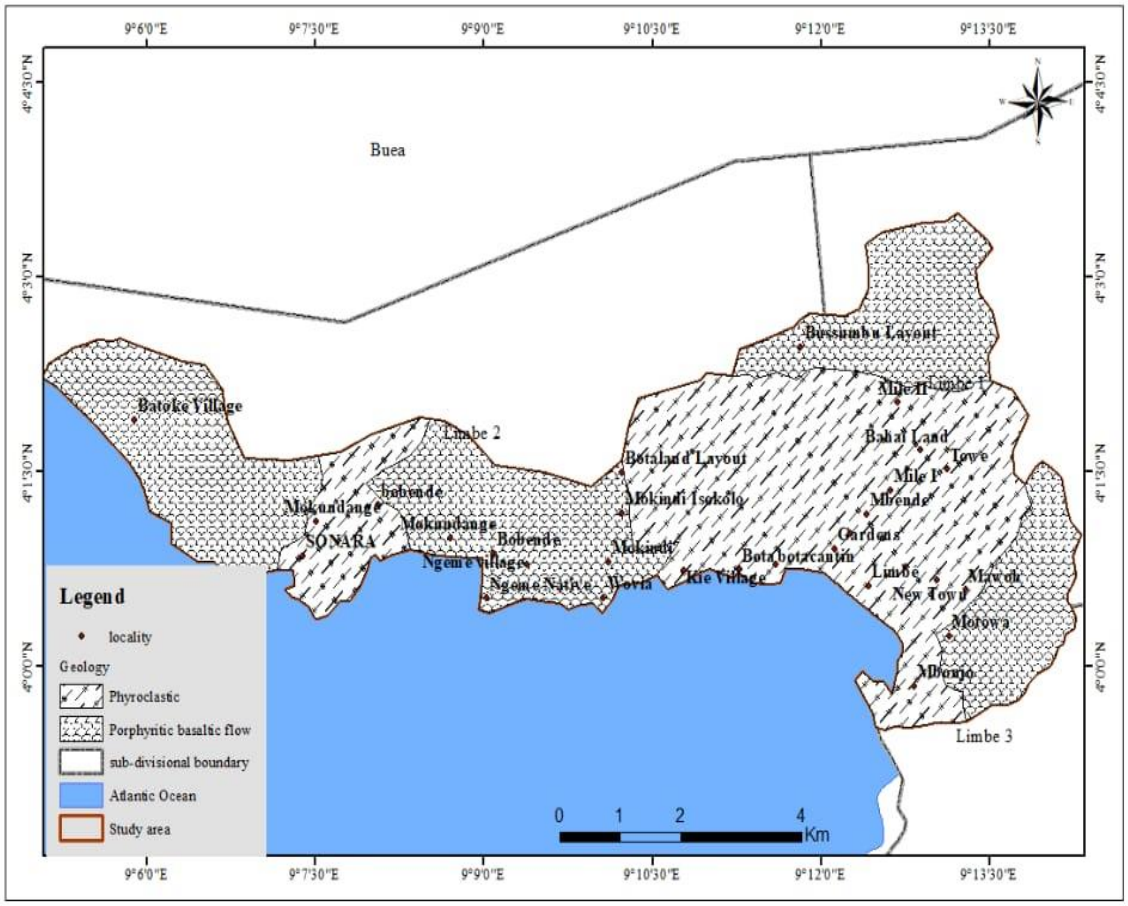


Figure 6: The Geology of Limbe
Source: NIC Shapefile, 2016

The Pyroclast in this area are made up of fragmented volcanic materials blown into the atmosphere by explosive volcanic activities. They come from volcanoes with highly viscous lava and can be consolidated or unconsolidated.

Mudstone is fine-grained sedimentary rock with clay and mud as the original constituents. It has grain size up to 0.0625mm and the individual grains are too small to be distinguished without a microscope. This is deposited on basalts before pyroclasts. It is brittle and dark in color and contains some amount of organic material.

Alluvial deposits are loose unconsolidated sediments which can be re-shaped transported by water. They consist mainly of sand, silt and organic materials. These geologic characteristics

of the city has exposed her to all forms of mass movements as the rocks in this area weather to produce soils that are very vulnerable to mass movement and floods.

1.1.4. Soils

The fundamental processes of soil formation in the city of Limbe is a result of the combination of many factors such as the humid tropical climate characteristic of the area, the age and the weathering processes of the volcanic region, relief and altitudes are major factors to be considered in the process of identifying soil units in the area. The volcanic cones account for the present of the loose unconsolidated alluvial deposits which consist mainly of sand and silt, and also organic materials brought downstream by water to occupy the flood plains or the river valleys. The main soil types in this city are clay soils and volcanic soils. The soils within the study area also indicate the presence of loamy soils which are a combination of clay, silt and sand developed on lahar deposits at elevations above 650m above sea level (a.s.l) of which very clayey soils occur below 450m a.s.l forming a chrono-topo sequence (Van Rants et al 1990). This area is covered by dark brown, reddish brown or pale yellowish-brown sticky, clayey immature soils with hardly any distinct horizon development derived from the weathering of this parent material. (Fig 9)

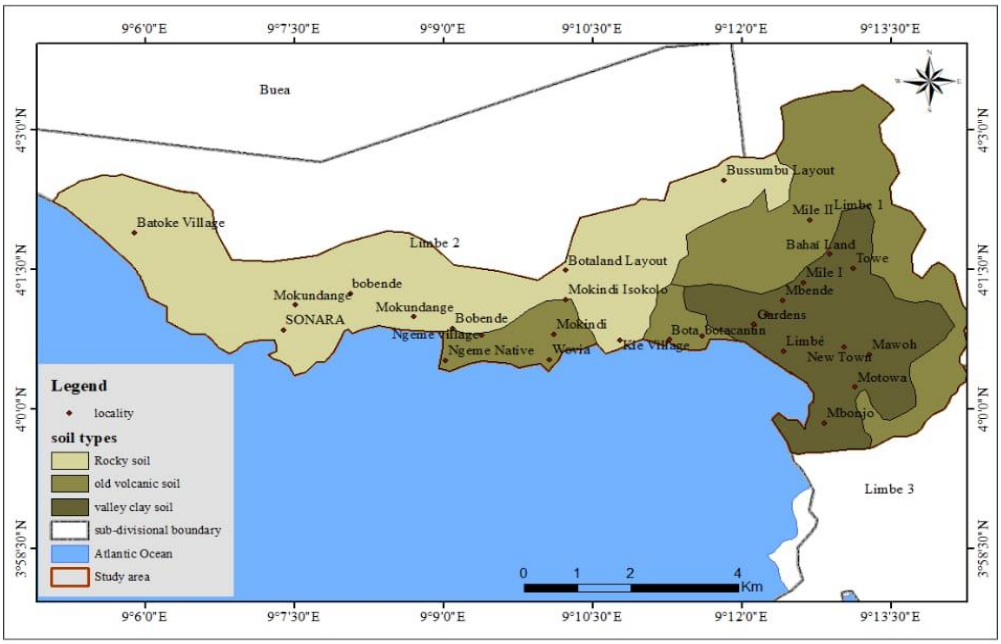


Figure 7:Soil types in Limbe

Source: NIC Shape file, 2016

From figure 9, the city of Limbe is made up a combination of rocky soils, clay soils, volcanic soils. The south and eastern part of the city where our study was carried out is dominated by

volcanic clay soils. In Quarters like Mbonjo, Mawoh, M.N.O highly dominated by clay soils are highly susceptible to landslides. Clay soils are not the sole reason for the occurrences of landslides but a combination of both physical and anthropic factors. The abundant rainfall in the city of Limbe increases the rate of weathering of the rock masses and also increases the water content of the clay soils leading to a reduction in the stability of the slopes and eventually resulting to the movement of debris down the slopes following the gravitational direction. Clay soils are also very impermeable, with limited infiltration capacity. In this light, rain that falls flows surface runoff recharging surrounding water caused in fewer hours which eventually lead to fluvial floods. On the other hand, the high-water retention of clay soil soils makes them susceptible to pluvial floods.

1.1.5. Vegetation

The original forest of Limbe compose mostly of the dense forest, mangrove, montane forest that exist in the summit of the hills. This original vegetation has been affected by human activities alongside urban growth, traditional agriculture and agro-industries implemented by the CDC that has greatly transformed the vegetal cover in the town and its environs. The secondary forest had gradually replaced the ever-green forest not forgetting the high transformation of the original tree cover of the area to palm plantations. The Bonjo area still presence an area with a remarkable presence of the mangrove forest. Notwithstanding, remnants of the old original forest are found in two reserved forests that is; the Limbe Botanical Garden, the Bimbia Bonadikombo community forest.

The Limbe botanical and zoological garden is 52 hectares of land created in the 1892 by the German. This reserve has more than 23 plants species and over 17 animal species, more than 30 000 herbs and more than 15000 ecological riches.

The Bimbia Bonadikombo forest reserve is spread over 37 hectares planed forest managed by the Bimbia Bonadikombo natural resource management council an NGO created in 1997. This reserve is a host of more than 1500 plant species. Some of the traces or remnant of the original forest can also be viewed on hill summits that are difficult for human accessibility either because of its steep nature or the long nature according to its agglomeration some mangrove forests still subsist in the Limbe three council areas, notably on the creeks found to the west of Bimbia. The present of this vegetation reduces the occurrence of natural hazards as the environment is covered by tries and the reverse is true if the forest is cleared.

Figure 8:Vegetation of Limbe
Source: NIC Shape file, 2016

From figure 10, there are three types of forest in the Limbe area; closed evergreen forest, deciduous woodland and the mangroves located around the coast of the Atlantic Ocean. There has been a serious transformation of the vegetal cover in the area. Urbanization of the city has led to a drastic deforestation of the area leaving the ground bare and loose and susceptible to all forms of hydro geomorphological hazards such as floods and mass movement.

1.1.6 Climate

The climatic condition in Limbe is as a result of its relief and the hydrology of the area. The distribution of the weather elements such as precipitation, temperature, humidity, and wind in the city of Limbe can be explained by the relief and hydrographic characteristics of the area. The climatic characteristic of the city of Limbe just as the other towns in the south west region and a majority of the Cameroonian regions show two distinct seasons, the dry and the wet seasons. The dry season begins from late October to mid-march while the rainy season begins from mid-march to early due to climate variation; it has become very difficult to predict the approach or end of a season. The occurrences of risk in this area follow seasonal variation as

the manifestations of floods and mass movement is mainly in the rainy season though some form of mass movement is manifested both in the rainy and the dry seasons this is typical of soil creep.

Limbe has a humid tropical climate characterized by two distinct seasons, the rainy season that last between mid-march and early November with average annual rainfall close to 400mm associated with a mean annual temperature of 26° to 27°c. The wettest months in the rainy season are the months of June, July and August with the highest been the July with precipitation amounts close to 1200mm.

This high amount of rainfall is influenced by the mount Fako, Mount Etindi, the surrounding hills and the action of the West African monsoon wind (humid air masses coming from the sea) which causes heavy rains. This is due to the position of Limbe in the Winward side of the mountains that blocks moisture from the Atlantic Ocean increasing condensation and eventual rainfall.

Also, the proximity of the city to the Atlantic Ocean that bring about high moisture and hence abundant rains for several months leaves the population in severe danger of floods and mass movement. In this study we are going to show the various precipitation trends and to a lesser extern temperature trend in the city of Limbe.

1.1.6.1. Annual Precipitation

A chronological time series data on the annual amount of precipitation from 1985 to 2018 provides a general view of the behavior of rain fall in the city of Limbe. In a general sense, the inter-annual average precipitation is 5198.7 mm of rain. Looking at this figure, there is high variation around this average. As can be seen from the data, 2010 represents the wettest year within the study period with a total annual precipitation of 9130.1 mm of rain, while 2003 represents to least wet year in the series with an annual total summing to 3303.4 mm of rain. This reflects the unstable and very changing nature of rain fall in the city of Limbe. Figure 11 below shows the precipitation levels over the study period.

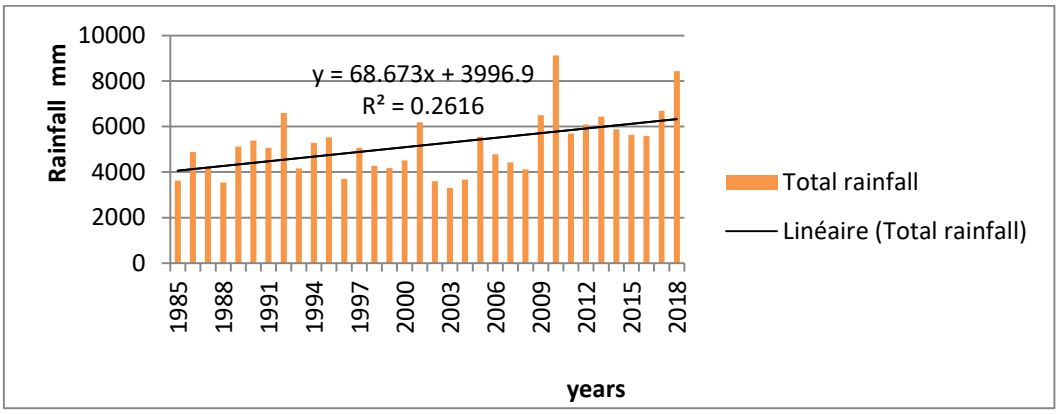


Figure 9: Inter-annual evo;ution of rainfall in Limbe
(source: CDC Bota)

Figure11 above indicates a fluctuation in the amount of rain fall within the series. From the data above the mean inter- annual precipitation trend (1985-2018) was gotten which shows a gradual increase in the inter-annual mean precipitation trend represented in figure 12.

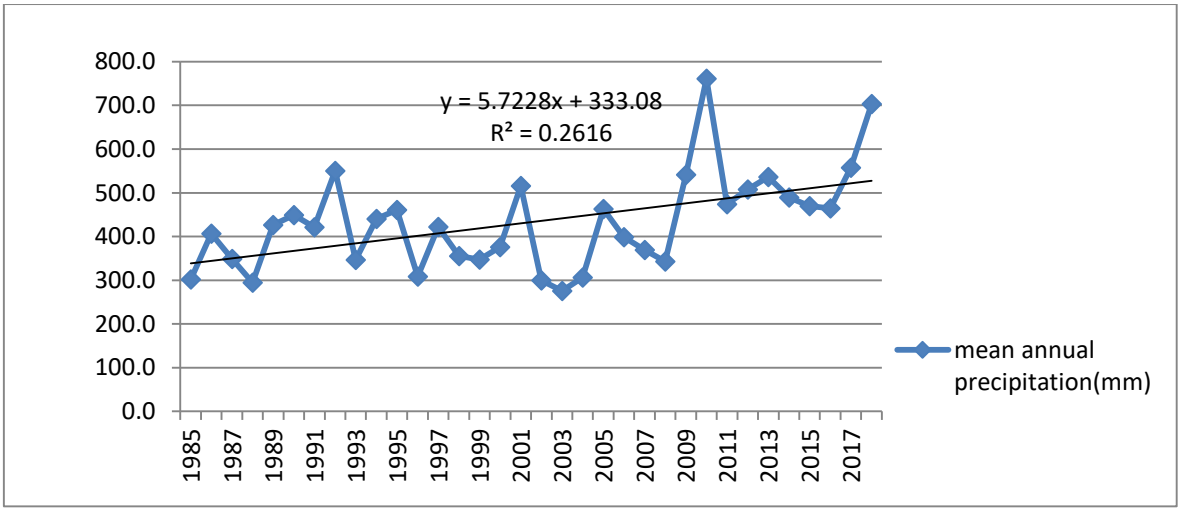


Figure 10:Observed Inter-annual Variation in Mean Rainfall in Limbe
Source: (CDC Bota Limbe)

The increase is indicated by the positive regression line and the positive value R^2 though a small value for the coefficient of determination.

1.1.6.2. Observed Decadal moving mean rain fall

A study of the decadal moving rainfall averages permits to realize an increase in the decadal rainfall from 1985 to 2018 (Figure 11)

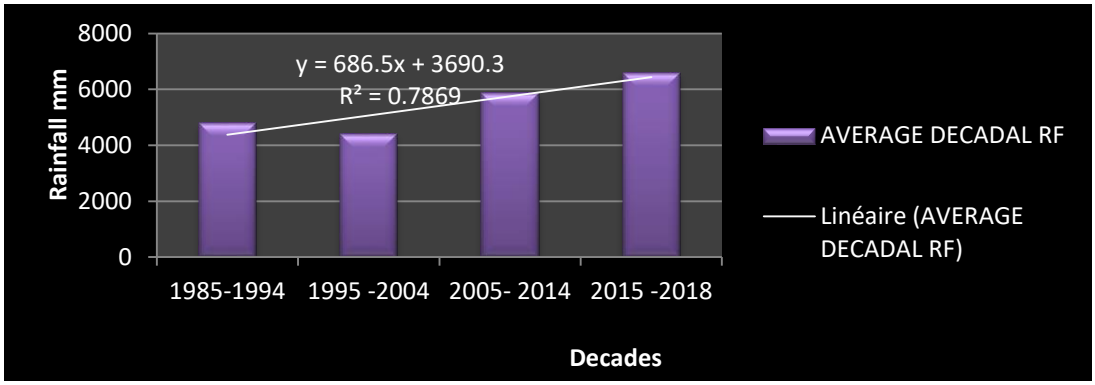


Figure 11: Average Decadal Rainfall in Limbe (1985-2018) (*Source: CDC Bota Limbe)*

From the figure 11 above, we can see that the highest decadal rainfall was recorded at the 3rd (5859.1 mm) of average decadal rain fall. The 2nd decade recorded the least amount of rainfall. The last bar is a 4 years period since the study period could not be effectively divided by 10 and it constitutes the highest observed average rain fall but it's only a sub decade.

1.1.6.3 Rain fall Anomalies

This statistical tool makes it possible to determine a statistical series of the years with excess rain fall (years with annual cumulative rain fall greater than the inter-annual average) and years with deficit rainfall (years in which the annual cumulative is less than the inter- annual average). It was observed that there were both negative and positive anomalies. Analysis of rainfall anomalies from the CDC Bota station Limbe (Figure14)

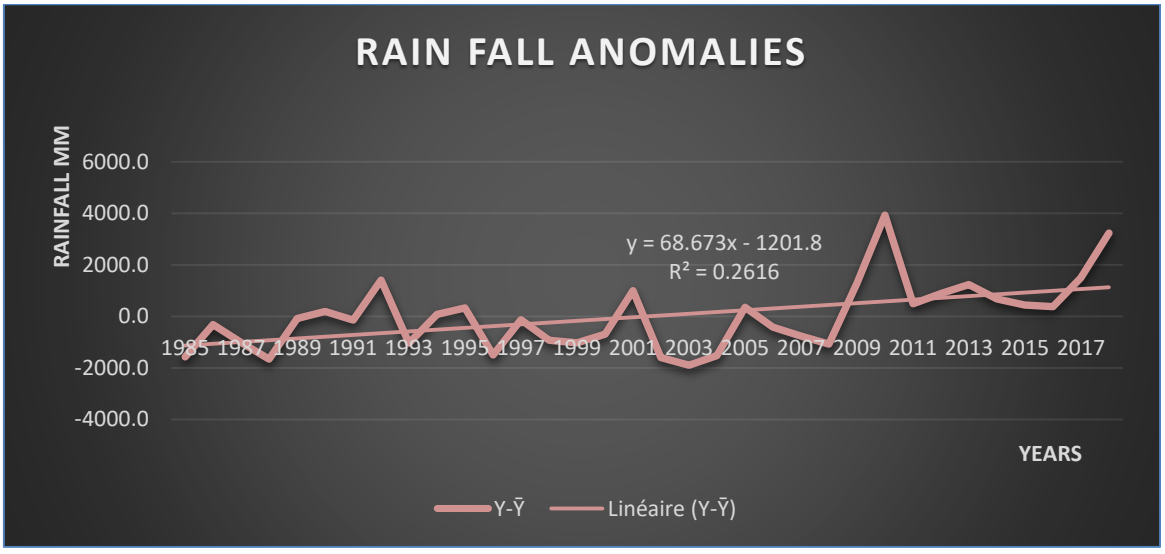


Figure 12:Rainfall Anomalies

Source: CDC Bota Limbe.

The positive values observed figure16 represents rainy of wet years and the negative values observed represents the dry years, with different degrees of intensity. The occurrence of 15 years in the series with positive rainfall index, varying from extremely wet to humid and 19 years with a negative RAI, varying between very dry and dry was observed. In addition, the last nine years of the period were marked by pronounce surpluses that is from the year 2009 to 2018 with the year 2010 been the rainiest and wettest year in the series with an amount of +3931.4mm. The year that recorded the highest deficit was the year 2003 with an amount of -1895.3 mm. This increasing tendency explains the general upward trend in precipitation especially in recent years.

1.1.6.4 Number of rainy days and inter-annual mean rainfall

To show periods of excess and high concentration of rainfall, data pertaining to the inter-annual mean rainfall and number of rainy days are analyzed in figure15 with this information we are able to deduce years with excess rainfall over a short period of time and years with deficient rainfall amounts over a long period of time.

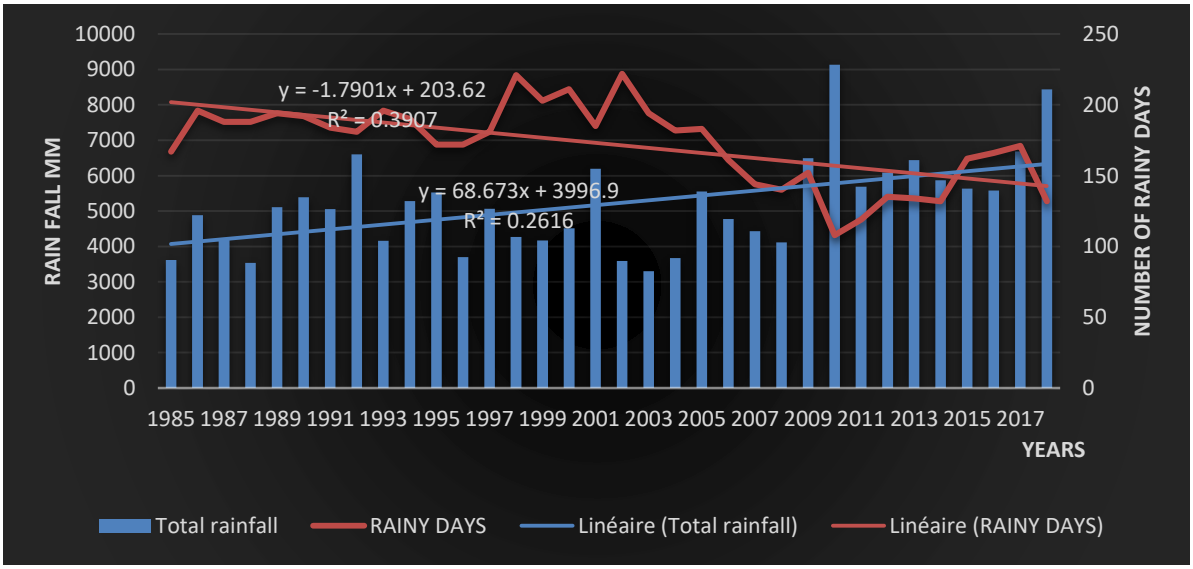


Figure 13:Total Number of Rainy Days
Source: CDC Bota Limbe

From the figure above, we could observe years of high and low concentration of excess and deficient rainfall amounts. From the line of regression, we can notice a reduction in the number of rainy days and an increase in the amount of rainfall. This therefore indicate that the area is exposed to the risk of floods and mass movement as more rainfall takes place within a fewer number of days.

1.1.6.5. Analysis of temperature data

1.1.6.5.1 Observed Mean annual temperature trends

Temperatures are highly variable in an inter-annual scale in the city of Limbe with an average of 26.21 °C for the study period; the hottest year in the series was 2007 with an annual average of 27.3 °C. The year 1987 and 1994 registered the lowest mean annual temperatures for period of study with an annual average of 24.8 °C. It is worth noting that after the year 1987, the temperatures have been in an increase.

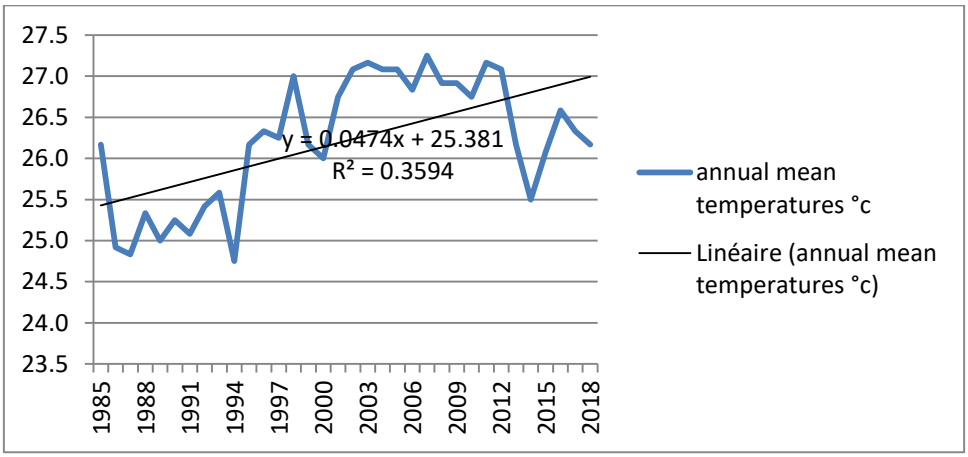


Figure 14: Observed Mean Annual Temperatures
Source: (CDC Bota Limbe.)

As observed from the figure 16 above, the large variations correspond to a large global trend described by IPCC (2007). From the year 1994, temperatures have been in a constant increase. This trend shows the evident of global warming in the city.

1.1.6.5.2. Observed mean decal temperature trends

In comparing temperature variability within the study period, an analysis of the decadal mean temperatures was been made to show the variation from one decade to another. Figure17 show the variation in temperatures within the three decades of the study period.

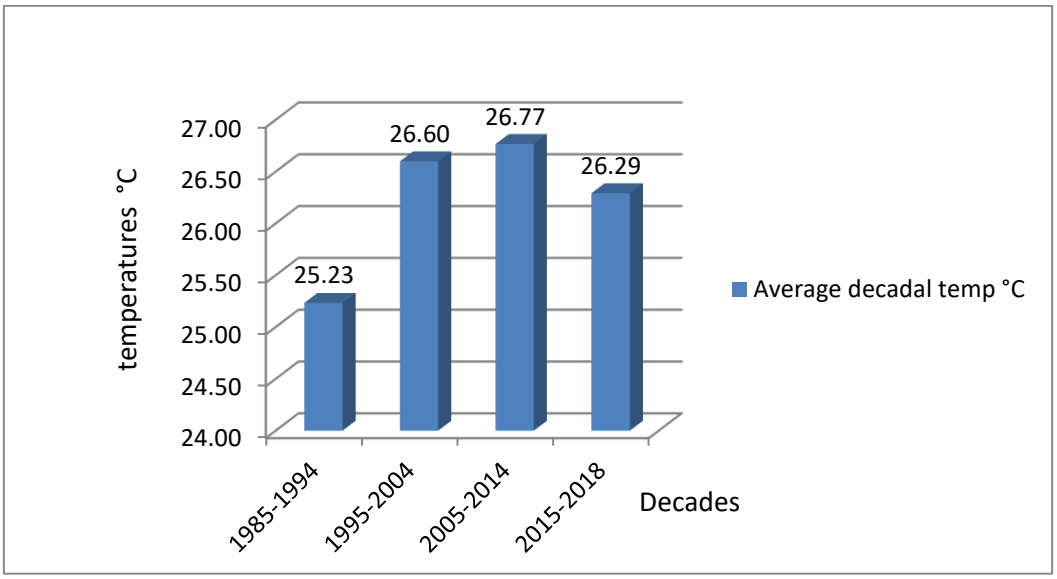


Figure 15: OBseved Mean Decadal Temperatures

Source : CDC Bota Limbe

As could be seen from the figure above, there has been a drastic increment in temperatures in Limbe between the years 1985 to 2018. The first decade recorded the least mean decadal temperature which stood at 25.23ºC; as the years increased, so too the temperatures. The third decade recorded the highest mean decadal temperatures (26.77ºC). The last four years were not up to a decade but registered a significant average of 26.29ºC. The third decade (2005- 2014) that recorded a high average decadal corresponds to the period in which the city of Limbe had recorded a numerous event of climatic origin with high return frequencies.

1.1.6.5.3. Climatic Seasons

Limbe a city in the south west region situated along the coast of the Atlantic Ocean characterized by an abundant precipitation and moderate temperatures. The city has a tropical monsoon climate, its annual average temperature is 27ºC and an annual average rainfall of 400mm. the city has two distinct seasons which are the dry and the rainy seasons. The diagram below (figure18) represents the variation in mean temperature and mean rainfall between the period 1985 and 2018.

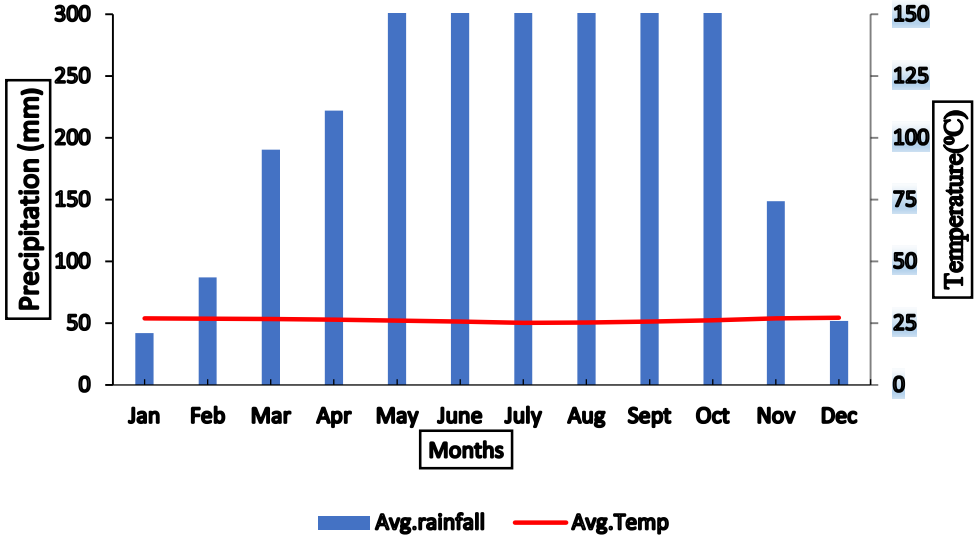


Figure 16: Ombrothemic Diagram for Limbe

Source: CDC meteorological station Bota Limbe.

Reading from the Climograph above, we can view a great variability of the two climatic parameters between different months of the years. The months where the temperature graph is above the rainfall graph indicates period of the dry season which spans from the late October to mid-March with very little or no rainfall. The rainy season is the period of the year when the precipitation graph crosses the temperature graph and typical for the months of June, July, August and September. This rainy season is the period of the when the natural hazards are manifested in our area of study most especially for the month of June and July with records of over 1500mm.

From the analyses of the climatic parameters above it can clear be said that the acceleration in the variability in precipitation and temperature has increased the frequency of occurrence of floods and mass movement and the vulnerability of the population to natural hazards.

Climate is an indispensable factor when studying vulnerability to any natural hazard as it acts as a modifying factor to the environment through different parameters. The changes in the trend of precipitation bring about the modification of new flood areas that limit the flood risk perception of the population. The populations of the city of Limbe already limited in the perception of risk are much more confuse with the aspects of the effects in their area. The increase in the amount of annual rainfall and the rise in the level of water courses and ground moisture is the cause of floods and mass movement in areas where the population is not

prepared. It is worth noting that all these irregularities play a major role in the adaptation efforts of the population, especially the poorest who are unable to face new challenges.

The development of an area at risk is very difficult. The structures in charge of the management of urban space in the city of Limbe have very limited resources. Thus, an increase in the frequency of risk poses a new challenge. This management which requires both human and financial resources is a very big challenge to the Limbe city council. For example, to better manage the space, there is a need for a constant production of the LUP taking into account highly variable nature of the climatic parameters. This brings about extra expenditure in funding and the development of new skills for in-depth research on the current trend and future state of the vulnerability of the population to. This aspect of highly visible to the population of Limbe as even the quarter (Bonadikombo) that was considered safe for the MNLO resettlement project now experiences constant flood episodes.

1.2 Human Background that favors the occurrence of floods and mass movement

1.2.1 Demographic Appraisal

The first people to settle in this area were the freed slaves from Fenando-po who later joined the Bakweri, the Bimbia the Kru, and the Wovia. Nowadays, the population of the North West and the west regions constitute and important part of immigrant to the town. Majority Foreigners are Nigerians who carry out Fishing along the coast of the Atlantic Ocean.

The population of Limbe is estimated at 120000 inhabitants on a surface area of 545km^2. This city has a population d4ensity of 220 persons per kilometer square. This population highly dominated by the female population which stands at 51.02%. To continue, age wise the Limbe population represent a majority of a youthful population. The population of the youths stood at 63.6% of the total population and the age population of just 4.1% of the population.

The population is made up of farmers, commercial, civil servants, and artisans. The population of Limbe is compose of mostly low-income earners whose salaries are hardly above 50000frsCFA with a majority of them being been holders of either the First School Leaving Certificate or a secondary school certificate.

1.2.2. Population distribution

The population in our Area of study is greatly heterogeneous. From the data gotten from the field and BUCREP estimated at 120000 inhabitants is unequally distributed over the city. In

this aspect we can distinguish two categories of inhabitants which are the autochthons who are highly represented and the immigrants whom a majority of them are from the North West and the West Regions. It's worth noting that the population disparities in the city of Limbe are greatly observed in the quarters and also the domination of certain groups in specific quarters. The most populated quarters are the ancient popular quarters with a good number of them occupied by the autochthons and situated in the Limbe one council area. (Cassava farm, mile, New town). The table 3 below shows the distribution of population in the city of Limbe per quarter.

Table 4: population distribution in the study area

	TOTAL HOUSEHOLD	MALE	FEMALE	Total POPULATION
CASSAVA FARMS	2272	4488	4729	9217
DOWN BEACH	276	618	716	1334
LOWER MAWOH	408	1026	966	1992
LUMPSUM	192	391	422	813
MABETA NEW LAYOUT	509	1270	1218	2488
MBENDE	1089	2018	1907	3925
MOTOWOH	1415	3158	3174	6332
UNITY QUARTER	1795	3991	3930	7921
UPPER MAWO	574	1203	1260	2463
MBONJO	813	1871	1977	3848

Source: field observation November 2020 and population projection 2016

From the table above, it can clearly be seen that the quarters that are most at risk are the most populated especially for the case of cassava farm which is susceptible to both the risk flooding and mass movement. There is a high population pressure in most areas that have registered at least an episode of either a devastating flood event of landslides. The pressure exerted on these areas is an indispensable factor in the causes of these natural hazards and also the leads to an increase of the population exposed to these hazards. Therefore, it's necessary to create new and save quarters where some of the population can be resettled.

1.2.3. Land Tenure System

It's a determinant element in the causes of natural risk in Limbe. Both the inhabitants and the state have developed interest in land. According to law n^{o} 73- 3 of July 1974 the state enacted three ordinances that established the rules governing land tenure in Cameroon. That is state owned land and appropriation procedures. This law presented the state as the sole owner of land

with the indigenous population being the guardians of the land which the state can use at will for national development or a common goal.

Also, land in Limbe is considered as the secret property of the village and this has resulted into several inter family conflicts. Land in Limbe is acquired through inheritance, appropriation, conquest and gift. However, the traditional council still reserves the rights to access over landed properties for specific community development irrespective of the owner of the land. The occupation of land in Limbe is as a result of two principal methods, the legal and informal procedures. Customary land proprietors always obtain their lands following the traditional rules. This is because of the supper position of laws that make the application of legal land tenure difficult. The unwanted, difficult and confusing situation of dividing land full with problems and the supper position of laws has brought a remarkable Land insecurity. The status of most of the new land occupants remains confusing and dangerous. These components in the appropriation of land in the city of Limbe best explains the typology of settlement in the city. This ambiguity in the legal procedure for the acquisition of land has given way to the traditional uncontrolled method of land appropriation. Due to scarcity of constructible land because of the presents of numerous morphological risk areas and the fact that CDC owns about 50% of the Land in the city has brought about a high land speculation fixing the price of a M^2 between 3000frscfa and 6000frscfa. This mismanagement in the proper distribution of land has left the population with no choice than to buy from the traditional land owners. This issue has led to the selling of the hilly areas which are susceptible to landslides at very cheap prices to poor population who cannot afford a plot of Land in areas defined save for construction. This is typical of the residence of the hilly areas in Bonjo.

1.2.4. Economic activities

The Limbe area represents the primary, the secondary and the tertiary sectors of the economy. The activities in Limbe are highly diversified with both the formal and the informal sectors. The town is highly dominated by the informal. Limbe is new growing industrial zone in Cameroon.

1.2.4.1. Primary sector in Limbe

In the city of Limbe, there is a diversification in the primary sector activities that is; agriculture, Fishing, forestry and mining.

The agricultural sector is highly developed with both the subsistence, extensive and mechanized farming. The subsistence type of agriculture is mostly practice by the indigenous population most especially the people of the Limbe 3 council area who are both urban and rural. It involves the cultivation of food crops. In general, the population practice mixed cropping with the predominance of tubers. The methods of faming are strictly traditional with the utilization of crude tools such as hoes, pickaxes, cutlass and spades. The main crops cultivated are cassava, plantain, yam, cocoyam, banana, maize, groundnuts and small varieties of fruits trees such as oranges, pawpaw, mangoes, coconuts, lime, plums just to name a few

Never the less, this subsistence farming by individuals, has a class of average producers which is being developed recruiting locals with farm sizes of over 10 hectares which operate as small plantations. With the cultivation of oil palm, cocoa, and to a lesser extend rubber.

In addition to the above, agriculture in Limbe is also extensive-mechanized (industrial agriculture) dominated by CDC. Oil palm and coffee are the main cash crops cultivated in Limbe. \Apart from large scale exploitation of industrial plantation by CDC, cash cropping is also practiced by average producers and small family exploiters.

Furthermore, in the primary sector we can identify fishing activities. Fishing constitutes one of the main activities of the Limbe population. The fishing activity in Limbe is mostly traditional with just a minor presence of specialized fishermen (industrial Fishing) using motorized boats. This activity is dominated by foreign experts from countries like Nigeria (68.2%), Benin (8.1%), Ghana (6.7%), and other (0.4%); (Limbe city council 2011). Fishing in Limbe is organized in two capacities in function of the mode of operation. That is;

Small scale or artisanal fishing: this form is carried out by local population using rudimentary tools such as nets lines, and canoes. It's essentially along the shoes of the sea. The fishermen don't adventure fishing in open sea or high tides. The catch are especially bass and other small size fishes sold fresh to customers and some dried and used for exchange of other food products.

The second class of fishing in Limbe is the semi-industrial fishing which provides most of the fish and other sea products commercialized in Limbe. Industrial fishing needs maximum investment which is not within the reach of the small-scale fishermen. Large motorized boats, nets and other working tools. The semi-industrial fishing is mostly carried out by foreigners. The fishermen in this category exercise a full mastery of the activity with the utilization of well-

developed mechanized equipment's such as motorized boats that permit them to go fishing in open sea.

1.2.4.2. Secondary sector of activities

The city of Limbe is endowed with numerous resources for the development of industries. These includes; a functional port infrastructure, good urban roads network, sufficient electricity energy, and an efficient Tele-communication system. The industrial sector in Limbe is well developed with the presence of large industries, medium industries and not forgetting also the dominant artisanal industries. The large industries in Limbe are represented by Hydrocarbon, Agro-industries, Shipyard, and the plastic industries.

SONARA is of the biggest commercial enterprise installed in Limbe with a capacity of treating 2million tons of crude petrol a year occupying a surface area of over 54 hectares of land. The installation of the lone state petrol refinery in Limbe has a remarkable impact on the development of the city notably the banking, commercial and housing facilities.

Apart from SONARA, there is a remarkable presence of Agro-industries with CDC being the leading and main Agro industry. The main industrial activity in the south west and Limbe in particular is the Agro industry. CDC was created in the year 1947 and its head office is in Limbe. It has a running capital over 15.6 trillion with a total number 13 000 workers marking them the second employer after the public service of the state. CDC producers palm oil and tea sachets. They also process banana and rubber for exportation.

Added to the large industries are the activities of the METROPOLITAN PLAST created in the year 1976 and specialized in the fabrication of articles using plastic materials in Limbe. There are some giant industrial projects on going in Limbe. These include, the Shipyard project, the Cement factory.

Beside the large industries, there is the existence of some medium size industries which are involved with production and transformation in smaller quantities. Here we can site transformation of food products, bakeries, production of non-alcoholic drinks, wood transformation and building construction.

To continue, the artisanal sector in Limbe is also involved in the transformation to semi-finish and finish goods. There is transformation of wood to furniture, and the building of canoes. There is also the processing of fish at down beach and Bonjo. This fish is smoked and packaged for external markets.

1.2.4.3. The tertiary sector

The most dominated economic sector in Limbe is the tertiary sector. A majority of the activities in this city are dominated by services. Limbe being a historical town from the colonial era with the situation of ancient colonial monuments such as the Alfred Saker the slave trade village, the Man O'war bay and the presence of the Atlantic Ocean with its beautiful sandy beaches which attracts tourists from all parts of the country and the world at large. Eco tourism facilities are highly developed in the city with tourist visiting the Limbe Botanical Garden, the Bimbia Bonadikombo reserve forest that represents the extinct while life and plant species of the area. There is also a high influx of people into the town for business purposes especially for petrol and other marine products

The commercial sector in Limbe is highly developed with the presence of numerous markets such as the mile one market, the new town market, and the big market at half mile. Also, this section is express through the presents of many small and big boutiques.

The banking activities can't be neglected in the city when discussing the tertiary sector as it's one of the most visible activities in the area. Most banks in Cameroon have installed their branches in Limbe. A majority of these banks are situated in the down beach area.

Also, the city has a good transportation network with the presence of good interurban road links. Road that connects the city to other cities such as Douala. Transportation in Limbe is both maritime and inland. The presents of the Limbe port have facilitated maritime transport most especially connecting the city to neighboring countries such as Nigeria and Equatorial Guinea.

To continue, in the tertiary sector we can find well developed educational infrastructure in the city. This is attested by the presence of numerous school establishments primary, secondary and highly institutes in the city.

Furthermore, the health sector in the city cannot be left out as it remains one of the most developed and functional sectors in the city. There is a presence of large hospitals, clinics, and health care centers. The presence of the South West regional hospital, the Limbe district hospital and numerous pharmacies in the city help in improving the medical services in the city.

Limbe is not just a commercial or touristic city but also an administrative town. Limbe being the capital of the Fako division makes her most popular in the administrative perspective. Every ministry in Cameroon has a delegation in Limbe. For example, SDO, the DO's, MINDUH, MINDEF, MINSANTE etc.

These activities attract population in search of either administrative or commercial jobs hence an accelerated population pressure on the natural milieu which is also saturated. With the scarcity constructible land in the city, the new population are most likely to settle in the hilly areas where land is available making them vulnerable to all types of mass movements and also the increasing the frequency of occurrence.

CHAPTER TWO:
MANIFESTATION AND CAUSES OF FLOODS AND MASS MOVEMENT IN THE CITY OF LIMBE

INTRODUCTION

The city of Limbe a coastal town located at the south eastern (S.E) flanks of the mount Cameroon (MC), active volcano in the Fako division, south west region is characterized by an undulating landscape with altitudes ranging from zero at the shores of the Atlantic Ocean to a chain of horse shore hills. It is also characterized by a dense hydrographic network with abundance precipitation. All of these physical aspects contribute to the numerous risks that occur every year. These threats are aggravated by an inconsistent occupation of space and the unscrupulous attitude of the inhabitants of this city which include deforestation, dumping of waste in water courses, construction on hills and narrowing the water bed which in returns worsens the manifestation of floods and movement in Limbe. This chapter highlights the types of floods and mass movement and the causes of each of the type of risk are discuss separately and also the effects of the risks are added.

2.1 FLOODS A PERMANENT THREAT IN THE AREAS WITH LOW ALTITUDES IN THE CITY OF LIMBE

2.1.1 Manifestation of the phenomenon

Floods are one of the most recurrent and devastating hazards in the city of Limbe. During our field work in the it was noticed that some quarters are particularly vulnerable to this hazard. Generally, floods are manifested in different ways depending on their causes and origin of the water:

In the city of Limbe, low intensity coastal flooding is common in the dock yard quarters and its environs this occurs often when the city experience a severe rainfall. These types of floods are very dangerous as it takes fewer minutes for the sea water the cover the surrounding environment. This flood type causes a lot of both economic and human loses.

Fluvial floods: a fluvial flood or river flood occurs when the water level in a river, lake or stream rises and overflows unto the surrounding banks, shores and neighboring land. The water level rise could be due to excessive rain or snowmelt. The severity of a river flood is determined by the duration and intensity (volume) rainfall in the catchment area of the river. Other factors that influence fluvial floods include; soil water saturation due to previous rainfall

and the terrain surrounding the river system. In flat areas, flood water tends to rise more slowly and be shallow and it often last for days. In the hilly or mountainous areas as is the situation in Limbe, floods occur within minutes after a heavy rain, drain very quickly and causes damage due to debris flow this situation can be associated to the June 27 2001 floods in the city of Limbe. The damage from river floods is widespread as the over flow affects other smaller rivers downstream. The photo 1 below shows an example of fluvial floods of the Djenguele River at Lumpsum quarters.

Photo1: over flooded Djenguele River around the holiday in resort Lumps;

Source :(Robert 2019)

- Point ‘a’ shows the holiday Inn Resort which flood water from river Djenguele has made it inaccessible.
- Point ‘b’ shows flooded Djenguele River covering the Bridge.
- Point ‘c’ shows flooded motor able road leading towards holiday Inn Resort.

Pluvial floods: It occurs when an extreme rainfall event creates a flood independent of an over flowing water body. With pluvial floods you don’t need to be located beside a water course because pluvial floods can occur in any location urban or rural even in areas with no water in its vicinity. There are two common categories of pluvial floods. We have the surface water floods which occur when an urban drainage system is overwhelmed and water pill off into the streets and nearby structures. It occurs gradually which give people enough time to relocate to save location. The level of water here is usually shallow hardly above 1m deep. It creates no immediate threat to human lives but can cause significant economic damage. On the other hand, we have the flash floods characterized by an intense high velocity torrent of water triggered by

torrential rain falling within a short period of time on a nearby elevated terrain. They can also occur via sudden release of water from an up-stream levee or a dam. Flash floods are very dangerous and destructive not only because of the force of the water but also the hurtling debris that is swept up in the flow. These pluvial floods are experienced every year during the peak of the rainy season in many quarters in Limbe found in the low altitudes (areas with altitudes inferior to 5m a.s.l. areas such as lower cassava farm, church streets, clerk's quarters, receive high level of rain water that is drained downward from the caterpillar hills, the Mabeta hills and from the mile one high altitudes. The quarters found around the surrounding plains of the Atlantic Ocean are the most vulnerable to the effects of floods. The areas from half mile to down beach- the manga William Bridge are often affected by flood water every rainy season as shown on photo 2.

Photo 2: flooded down beach 2018 (*source:* *Bezaine 2018*)

- a, shows a house submerged in water after a heavy down pour
- b, shows fence that is practically showing the height of flood water acting as a barrier
- c, shows flooded motor able road total covered by water making the area inaccessible

2.1.2 Causes of floods in the city of Limbe

2.1.2.1 Natural causes of flooding in the city of Limbe

2.1.2.2. Relief

The city of Limbe is characterized by a diverse form of relief features composed of variant altitudes. The city has a monotonous relief characterized by a low laying coastal plain, rising to a chain of horseshoe shape slopes with the highest point measuring 362m a.s.l (Njabe and Fobang 2006). The city is also dissected by interfluves and hills on the slopes, generally convex

and separated one from another by wide valleys of about 5 to 100m. It is the case of the Limbe River that flows from mile two to the Ocean in a large flat bed.

To continue, the area from the Ocean moving upward into the city right up to half mile is characterized by low laying plains with altitudes inferior to 26m above sea level. This area is that which is highly susceptible to various types of floods that are flash floods around the river banks and land floods that are as a result of low altitudes (See figure 4 page 31).

2.1.2.3 A dense hydrographic network

The city of Limbe is characterized by a dense hydrographic network. It is drained by many small streams that flow into larger drainage channels that converge into the main rivers such as river Limbe (R.L), river Djenguele, wohmanghe that empty themselves in the Atlantic Ocean. These rivers frequently over flood their banks in the rainy season causing floods in the low laying areas that are only about 1.2m a.s.l. The R.L rises from four springs in the steep thick soils colonized ash and scoria hills to the north east and crosses the entire city of Limbe about 3.5km before joining the Atlantic Ocean. The presence of this rivers in nearly every street in the city is an advantage but during the rainy seasons especially in the months of June, July, August this rivers and streams become a tread to the entire population of the city as they constantly flood their banks causing floods that last for hours which intend puts the activities in the city on a halt (see figure 5 pg32).

2.1.2.4 Soil type

The soil type in Limbe is a mixture of clay, volcanic soils. Clay and tuffs are mostly found in low lying areas such as Cassava farms, Clerks quarters, Down Beach and Motowoh. These soils have a high-water retention capacity while scoria is mostly found in the volcanic cones with low water retention capacity. Thus, when rain falls, water easily drains as through-flow from these cones to the low lands which worsen the situation, making the area vulnerable to flooding. For most of the time, the ground is permanently moist and the rain that falls generally does not infiltrate but rather flows on the surface as overland flow. (See figure7). From the aforementioned map above its seen that the area east, SE, NE, North and south of the city which are the area that have registered floods and Landslides contains clay and volcanic soils which are prone to all forms of risk.

2.1.2.5. Abundant rainfall

The climate of Limbe is characteristics of the Gulf of Guinea tropical equatorial climate of hot, moist and dry conditions. It is characterized by abundant rainfall with over 5201mm of rain on yearly average. The rains are concentrated mostly within three months (June, July, and august) which registers nearly about ¾ of the yearly totals the table below shows the MEAN monthly rainfall for the study period (1985-2018).

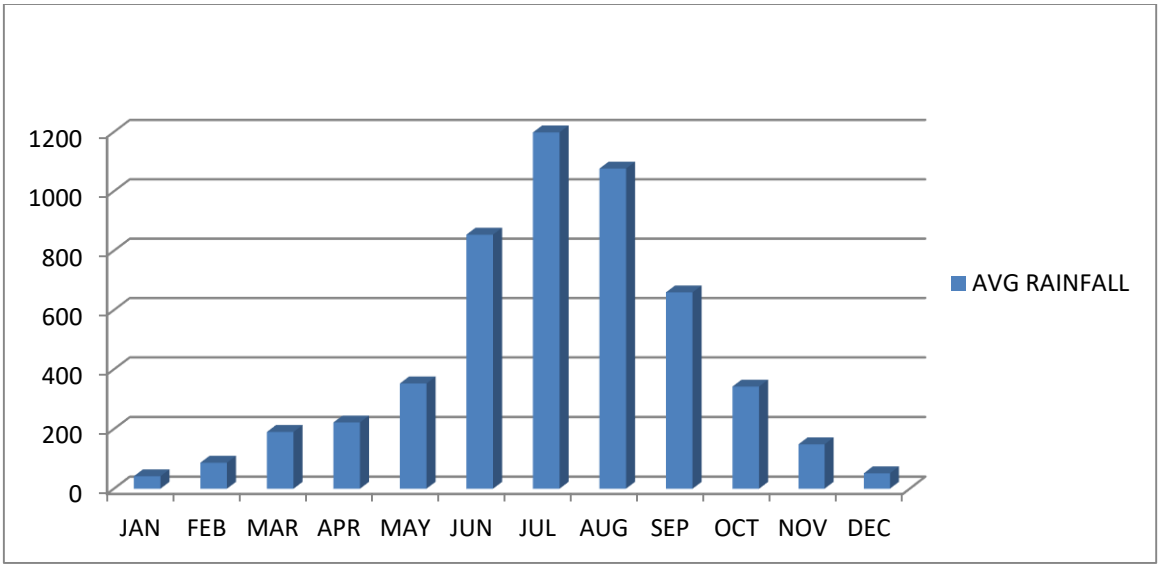


Figure 17Average Monthly Rainfall (1985-2018)
Source: CDC, Bota Limbe

From the histogram above, it can be seen that rainfall is concentrated within a short period of four months with July the most catastrophic month registering the highest inter annual mean rainfall. These high values justify the relationship between the occurrence of floods and rainfall.

2.1.2.6 The anthropogenic causes of flooding in the city of Limbe

The inconsistent occupation of space, the poor calibration of drainage structures and poor management of urban waste and sanitation are anthropic factors which impacts on floods is undeniable.

2.1.2.7 Inconsistent occupation of space

Lack of land use plan (LUP) in the city of Limbe coupled with poor urban planning and non-respect of laws relating to land ownership are at the origin of the gravity of floods observed

in the city of Limbe. The following factors are a clear definition of poor and inconsistent occupation of space.

2.1.2.8 A reduction of the river beds

The city of Limbe with an average population density of 220 persons per kilometer square, there is coverage of the space on both sides of the flow channels of the rivers and streams that drained the city. This could be seen especially in the Mawoh, cassava farm, church streets where many families have spread their plots on major river bed(photo3).

Photo 3: A building at cassava farm showing a total narrowing of the stream bed.

Source: field work November 2020; Eti 2020

- Point ‘a’ shows the initial width of the river birth
- Point ‘b’ is showing the fence of a house constructed within the width of the river bed reducing the channel width.
- At point ‘c’ the river is forced to meander and take a different direction this poses a problem in the flow capacity of the river. Hence any excess water will lead to the flooding of the surrounding environment.

2.1.2.9. Human encroachment on river channels

Taking advantage of the negligence of the local authorities, some of the generally poor are building on river channels and reclaimed marshy areas prone to flooding. Due to the fact that construction laws and urban planning laws are less effective, the high population pressure that had let to expansion in the demand for housing has left the population especially the low-income earners to purchase cheap land in marshy areas prone to flooding. Though the population has carried out some improvement on the lands (filling) before settling, in the period

of floods it's very difficult to avoid flooding especially in the recent years marked with precipitation and increase flows indicated by the inhabitants.

Photo 4: Building on flood zones at down beach.

Source: field work November 2020; (source: Bezaine 2018)

We can notice the construction of houses on reclaimed marshy lands with no proper drainage. In the event of rain, water is forced to stagnate since there is no outlet eventually over flooding the houses around.

2.1.2.10 under sizing of urban drainage structures

The problem of non-respect of designed projects by the contractors and also the non-taking into consideration of all the parameters by the authorities before designing projects in the field of civil engineering in Cameroon and Limbe in particular is a major problem. Despite the sensitivity of the urban milieu, poorly carried out works has been observed particularly with respect to the construction of bridges and gutters(photo5). This is either as a result of poor feasibility studies before the design of a project or by the contractors' non respect of designed projects due to no follow-up of awarded contracts by the municipal or administrative authorities.

Photo 5: showing under sizing of a bridge at lower Mawoh.

Source: photo by Eti November 2020

- 'a show a hip of dirt beside the stream that not been evacuated by the HYSACAM
- 'b' shows the initial size of the stream,
- 'c' shows the size of the bridge is smaller than the width of the stream.

From the photo above, we could depict a narrowed bridge which in case of any heavy rains, the amount of water supplied by the channel will be greater than the capacity of the bridge to carry hence water will be left to overflow the banks of the stream. Furthermore, the present of the dust bin which is not emptied beside the water course is a tread to the population as when it rains, this loos dirt's will be swept into the channel which can cause a problem in the speed of flow of the water or permanently blocking drainage that will eventually result to floods.

3.1.2.11. Dumping of wastes in streams

In the city of Limbe, it's not only the problem of poor construction of urban sanitaria systems but the population living the areas drained by streams mostly choose to dispose their wastes on water bodies thinking that the water will transport the wastes but this wastes on the contrary end up blocking water channels. This issue has been a major challenge to the LCC as its priority is to keep the sanitation of the city. During the field work, we interviewed personnel of the LCC who accounted that the floods that occurred in Limbe are mostly caused by the population through their non-respect of the urban sanitation systems. That even when the LCC keeps trash canes at regular spots, the population still prefer to empty their garbage in streams. This situation was also accounted for by the population who gave reasons for emptying their trash in streams because sometimes the LCC trash canes get full and are left for days without

evacuation and it smells in the neighborhood so they prefer to throw where it will be evacuated automatically. These areas that throw wastes on water courses are those areas that are not planned with merely any motor able road so trash cans are kept in distance places where the council trucks can reach so a majority of the population see it as a kind of stress to move to about 500m just to throw dirt's when there is a stream which is just about 5m from the house. When this water channels are blocked water ends up in buildings for example Motowoh and Church Street as seen on photo 6.

Photo 6: showing the dumping of dirt in Stream at Motowoh (photo by Eti November 2020)

At 'a' we can see the presents of dirt in the stream

At 'b' is a wall build to protect the area from flood water

At 'c' we see can a pile of mud present in the stream channel. This has greatly reduced the channel width.

3.1.2.12 Deforestation

Deforestation which is the act of cutting down trees plays several roles in flood events. In the city Limbe deforestation has gained grounds as the forest is highly exploited to meet up with the urban demand for wood either for construction, fuel wood of for charcoal. During our field work, the population around the Mawoh quarter that constantly experience the flood risk accounted that these floods are due to the cutting down of trees from the forest of the Mabeta hills for charcoal. The absence of trees in an area is a tread to that environment because tree roots absorb water from the soil making the soil drier and able to store more water and also holds the soil in place reducing the movement of sediments that can shrink the channels downstream. Furthermore, trees act as an interception of precipitation reducing the strength at which rain water reaches the surface all of the above functions of trees go a long way reducing the rate at which water runs from the watersheds into the rivers. The faster water runs from the watersheds into the river the higher the floods will be. This could be said to be the principal

cause of the June 27th 2001 floods in Limbe as tree trunks and sediments from the volcanic cones landslide blocked gutters producing floods along the low-lying coastal parts of Limbe.

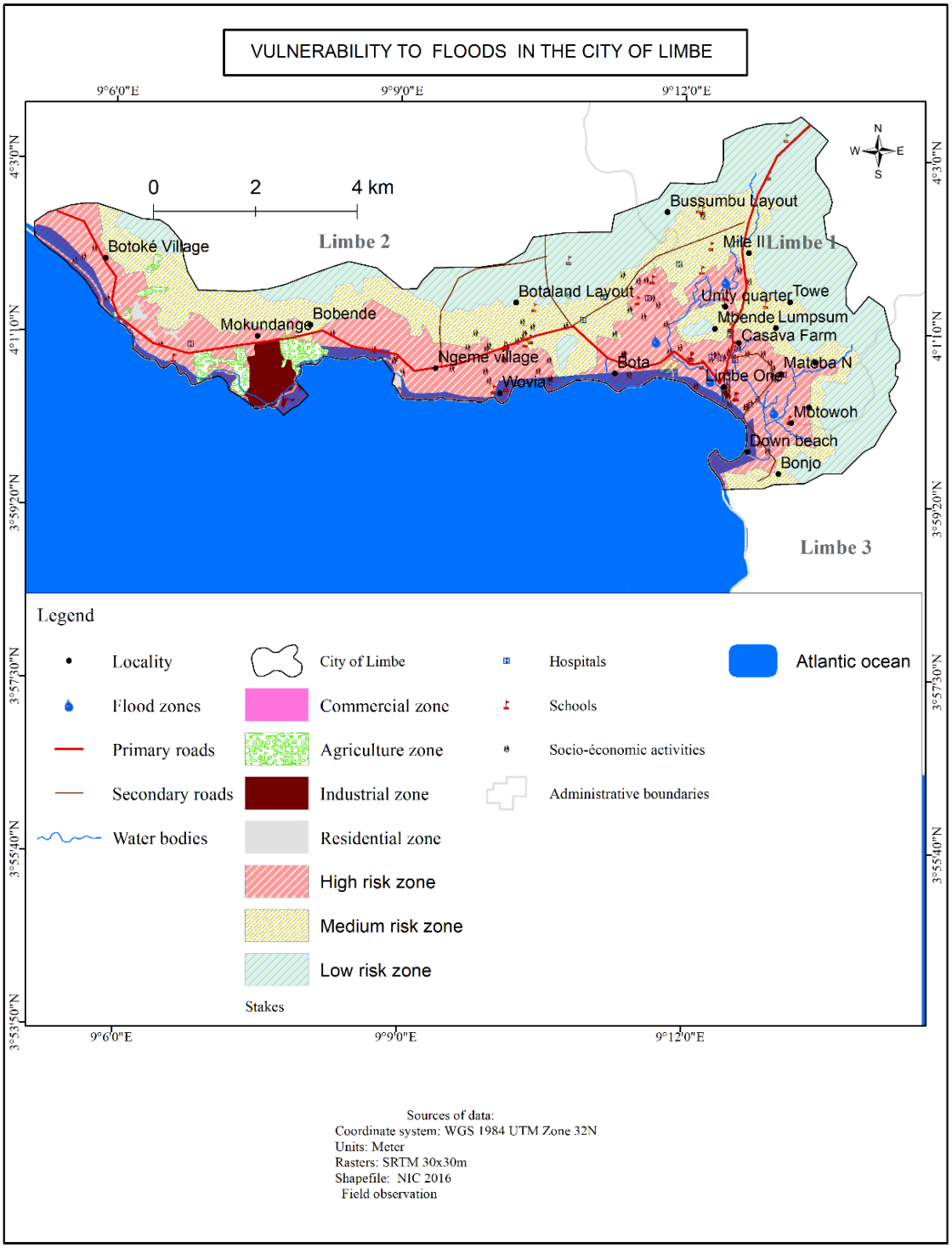
3.1.3. An inventory on the manifestation of floods in the city of Limbe

The history of flooding in the city of Limbe can be traced from the period when there was a rapid growth in the population that during the late 1980's. As the population of the city kept on increasing, the excess population in quest for land for settlement had to inhabit the flood prone valleys. The flood even in Limbe has amplified after the 1989 flood evens. It has been a recurrent phenomenon that strikes on yearly basses during the rainy seasons. The city now records several flood evens in the long of rainy season every year that is from the month of June to the month of August and sometimes right up to the months of September and October. As reported by the population during our field work, the month of August is the month with highest number of recorded evens. That sometime in the long of the month there about four to five manifestations of floods though with weak intensities and less damage. Rainfall in this month was highly accused for the manifestation of floods in this month during interviews with the locals of the community.

With lack of data on the occurrences of floods in the city of Limbe, just a few of the manifested flood evens in the city of Limbe had been recorded. Those that has been recorded are those considered catastrophic and had a huge negative impact on the population and their properties. From the numerous flood evens in Limbe we can sight the 1990, 2000, 2001, 2007, 2018 floods that caused havoc in the city.

2.1.3.1. Flood areas in the city of Limbe

From the information on the occurrences of floods in the city of Limbe, it is evident that some quarters are particularly vulnerable to this hazard due to their geographic location. Figure 21 depicts the areas affected by floods in the City of Limbe



Equation 4: Map depicting the flood affected areas in Limbe

The flood regimes in the city of Limbe are modeled on the general hydrography and topography of the city. As many of the river's flow from the north to south, it's the areas in the southern part of the city that are susceptible to the occurrences of floods in the city. The areas

located in the valleys which are from the half mile area right down to the shores of the Atlantic Ocean are the areas affected by floods and also the valleys of the caterpillar field. This is either explained by the fact that the valley areas of the city are confluence areas of the various tributaries or the fact that these areas are the low laying surfaces that all precipitated water from the hills accumulates.

3.1.4 SOCIO ECONOMIC AND SOCIAL IMPACT OF FLOODS IN LIMBE

Table 5: impacts of floods in Limbe

ITEMS	1990	2000	2001	2007	2013	2018	TOTAL
Deaths(humans)	10	14	30	12	3	5	74
Displaced persons	32	79	233	63	46	67	520
Reported health issues	19	20	197	62	-	-	298
Buildings	16	33	154	83	14	6	222
People rendered unemployed	51	107	438	79	-	-	575
Animals/ fowls	206	147	835	244	-	-	1432
Road and bridges	7	5	9	4	6	3	70
Electricity and water sources	15	8	54	6	-	12	85

Source: field survey (November 2020), Limbe urban council 2000, 2001.

Since the late 80s, floods have been an indispensable environmental hazard in the city of Limbe from the above table summary of the most dreaded floods events in Limbe, it should be noted that floods affect the city on yearly bases causing a drastic loss of lives and properties not forgetting the stagnation in commercial activities in the valley areas of the city. Information concerning the occurrence of floods is very limited as only flood events that claim at least a live are recorded. From the year 1990, floods have caused a significant damage both in the social and the economic dimensions.

In a sociocultural view point, floods have been a tread to lives of the inhabitants of the valley areas in Limbe. It is worth mentioning that since 1990, at least 2 to 3 lives are lost annually as a result of flood. It should be noted that the poor and the less privilege are those who habit in the flood prone area marking their already poor conditions worst. Floods in Limbe has caused so much in terms of social amenities from the destruction of schools, hospitals and rendering the population home less for several days. This psychological torture influences the physical behavior of man hence vulnerable to mental and cardiovascular diseases such as

hypertension. Floods also sponsor the spread of water bone diseases such as cholera, Diarrhea, dysentery etc. the permanent presence of water in homes during and after flooding also favor the multiplication of vector diseases such as malaria.

In an economic appraisal, floods are a constant enemy to the economic wellbeing of the population in Limbe from the destruction of houses, roads, electrical and water supply systems and even a delay in economic and political activities in the whole tow. The table 6 below shows an example of the severity of flood event in the year 2005 and 2010.

Table 6: heights of flood water in some quarters in Limbe

Location	**2005**		2010	
	Height in (cm)	**Duration (hours)**	**H**eight in (cm)	**Duration (hours)**
Cassava farm	90	**5**	1120	7
Motowoh	75	5:30	100	5
Down beach	80	7	80	5
Church street	40	5	80	2
Lumpsum	80	2	75	4
Bonjo	80	7	40	1
mawoh	75	5:30	40	1
Dock yard	60	6	30	1
Clerks' quarters	75	7	30	1

Source: adapted from Robert N and Simbo. T (2010). Wung. G (2005)

From the table above we can clearly evaluate the impact of flood water in the functioning of both commercial and administrative activities in the capital city of the Fako division. Notwithstanding, floods have also affected road and buildings in the city.

In every rainy season, about three houses are destroyed and at least a total of 100 houses are flooded annually and the most devastating effect of flooding was recorded in the year 2001. The photo below shows a house destroyed in Limbe by floods.

Apart from the destruction of houses by flood water in Limbe, roads are also highly affected by floods either blocking the circulation of people and vehicles or collapse of roads. The floods of June 2001 caused a huge damage on the road network in Limbe. It was recorded that in two localities at the down beach tared roads were destroyed and also closed to the

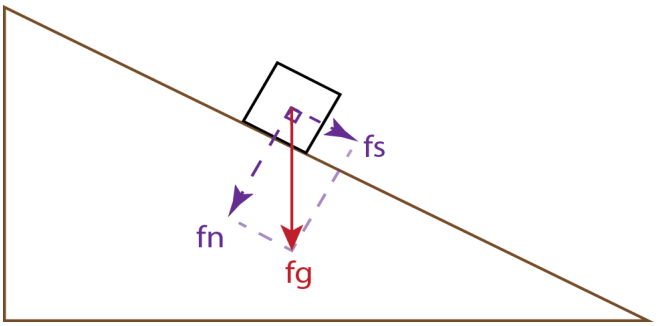
provincial office of public works at Lat 4° 00’ 30” N and Long 9° 12’ 61” E about 140$m^3$of tarred road was destroyed by flood water.

2.3. MASS MOVEMENT A PERMANENT THREAT IN THE CITY OF LIMBE

2.3.1. Types, causes and manifestation of mass movement in Limbe.

Salt Lake community college defined mass movement or mass wasting as the downhill movement of rocks and soil material due to gravity.

Mass movement occurs when a slope fails and slope failure occur when the slope is too steep and unstable for existing materials and conditions. Slope stability is solely determined by two principal factors: the slope angle and the strength of the underlying material. The force of gravity which plays a role on mass movement is Constant on the earth for most parts though they exist a little variation depending on the elevation and density of the underlying rock. The figure below is an illustration of Mass movement where a block of rock situated on a slope is pulled down towards the earth center by the force of gravity (fg23).



Equation 5: An illustration of mass movement
(Source: An introduction to geology by chis Johnson et al)

The gravitational force acting on a slope is divided into two components: the shear or driving force (fs) that pushes the block down the slope, and resisting or normal force (fn) pushing into the slope which produces friction. The relationship between shear force and resisting force is known as shear strength. When the shear force exits the resisting force material is forced to move downslope and vice versa. When a mountain becomes too steep through the removal of soil and or rocks at the base, bedrock masses break free, falling or sliding to new positions of rest due to the continues downward pull of material by gravity. (AN Strahler, 1972). The types of mass movement include: Landslides, soil creep, mud flow, earth flow or landslips,

rock fall and debris avalanche. The above-mentioned types of mass movement are often classified in three ways that the type of material that failed e.g. bed rock or unconsolidated sediments, the mechanism of the failure that is the way the material moved as it failed, and also according to the speed of movement of the material that is fast or slow movement. But the most common criteria used in classifying mass movements is the speed of movement of the material. Rapid or sudden movements are the most dangerous and usually causes more damage and are triggered by exceptional factors such as heavy rain falls. Slow movements are as a result of a combination of several factors that causes a gradual failure. The slow movements are less dangerous and cause less harm as they provide maximum time for the population to seek refuge in safer places. However, it is necessary to put early warning systems to alert people in time before a risk occurs. Among the above-mentioned types of mass movement, the most prominent in the city of Limbe are; Landslides, mudflow, soil creep rock fall.

2.3.1.1 Types, Causes and manifestation of mass movement in the city of Limbe

2.3.1.2. Landslide

Landslides are the most noticeable and spectacular form of mass movement occurring on the hills and slopes of Limbe.

Landslides are a rapid downward movement of materials or slide of weathered materials or masses of rocks. This type of mass movement is characterized by the removal of superficial material or layers of earth/rocks and transported without any remarkable disarrangement or distortion of its structure and vegetation and most elements remaining intact. Landslides are classified into two distinct types according to the nature of sliding that is rotational landslides and translational landslides.

A rotational landslide is a slide in which the surface of the rapture is curved concavely upward and the slide movement is roughly rotational about an axis that is parallel to the ground surface and transvers across the slide. It is characterized by a deep rapture zone due to the overload linked to anthropogenic development particularly the construction of roads and building. This type of landslide is very common in the city of Limbe where constructions on steep slopes go through major slope modification processes such as excavation, which creates voids and destabilize the entire structure upslope. A typical example of a rotational landslide is the Bonjo landslide of July 2005

A translational landslide is a downslope movement of material that occurs along distinctive planar surface of weakness such as a fault, joined or bedding plane. Some of the largest and most disastrous landslides on earth are translational slides. These landslides occur at all scales and are not self-stabilizing. They can be very rapid where discontinuities are steep. Translational slides occur on curved slip surfaces where the upper surface of the displaced material may tilt backwards towards the scarp and the commonly trigger debris flows. They are mostly caused by heavy rains. This type of mass movement is very common in the city Limbe and causes maximum damages on yearly bases. Below is cross examination of the manifestation of some major landslide in Limbe within the study period.

2.3.1.3 The Bonjo rotational landslide of July 2005

This translational slide that occurred on the 21st of July 2005 at Banjo on the road leading to man on war (military camp) with a geographic coordinate of Lat: 3 59’ 43.14” N and Long: 9 12’ 55.09” E, on a 22° slope with well-defined scarp and margins.as shown on plate 1 shows the Bonjo 2005 land slide as seen on plate 1 below.

On plate A,

‘a’ shows the depth of the slide.

‘b’ shows the direction of flow.

On plate B,

‘a’ shows the width of the slide scar.

‘b’ the main road leading to Bonjo which was blocked with debris.

‘c’ shows the pile of debris that was cleared from the road.

A 120mm of rain was recorded at karater located approximately 4.5km from Bonjo. The crown of the slide was characterized by a tensional crack approximately 0.3 to 1m wide (Che v. 2011). The scar was 25m wide, 24m long, with a scarp height of 2.8m resulting in and estimated volume of approximately 10^3 m^3 and a total run out distance of 35m. Debris from this slide blocked the road for two days before its being removed. The debris that was removed from the road was piled up on the right side of the road and latter remobilized by intense rainfall that followed a few days after the slide causing tremendous damage to building located some few meters down slope. During our field survey, the population attested that landslide within their area a mostly generated by the mobilization of excavated debris to construct foundations.

2.3.1.4 The Bonjo 2008 reactivation slide

Between the period June to August 2008 just three years after the 2005 Bonjo landslide on the same spot that caused significant damage, there was a reactivation of the slide which moved the scarp 5m backward giving it retrogressive character. The height of the slide increase to 3.2m and the crown still showed tension cracks. The reactivated slide showed a rotational and a flow type failure with a run off distance of 24m

The Bonjo slide can be classified as a complex slide according to the classification scheme of (Cruden et al; 1996). Construction works on the Limbe man on war bay exposed the well-developed sections of the soil profile. Plate 2 shows the soil profile of the Bonjo landslide area.

Plate 2: The Bonjo 2008 reactivation slide

Source: Vivian Che, 2011

From the exposed section, it's observed that rocks that make up the slope are intensively fractured, weathered and shows a heterogeneous weathering pattern. The thickness of the soil around the Bonjo area measures over 10m.

2.3.1.5 The Mabeta new layout translational slides of June 27th 2001

In the afternoon of June 27th 2001, a translational landslide occurred on the degraded pyroclastic cones of MNLO with slope gradients ranging from 30 to 40. This event occurred with numerous slides recorded can be geographically located at Lat 3 59' 37" N and Long 9 13.9' 19"E. The photo 7 shows the MNLO landslide of June 2001.

Photo 7: The Mabeta new lay out landslide of June 2001.

Source: Photo by Jemba, 2001.

- Point 'a' shows the head scarp of the slide
- Point 'b' shows the direction of flow and debris released from the slide.
- Point 'c' is showing a how situated about 7m from the slide area.

The depletion zone of the slides had well-defined scarp which was approximately 7m high and a margin which is made up of a mixture of mottled dark red to dark brown soils and weathered vesicular porphyritic basaltic pyroclastic rocks. (Che. V, 2011). The W of individual slides ranges from 12 to 43m the L 17 to 58m and the H from 2 to 7m. The estimated run out distance of individual slides was 350 for the largest slide and 100m for the main slide. Together, these two slides damaged six houses and killed fourteen persons either by burying or by the collapse of houses.

Before the occurrence of this landslide, eye witnesses attested that there was a prolonged and intense rainfall for about a day. The population located downslope also experienced water coming out of foundations and a numerous muddy runoff a few hours before the sliding. This shallow translational landslide later transformed to debris flow due to the mixture with surface runoff and ground water released from at the sleep surface. These observations can be used in risk awareness creation for future events and in understanding the processes that led to the sliding.

2.3.6 Mud flow

This is a stream of fluid consistency that flows down canyons in mountainous regions mostly after the occurrence of a landslide. In areas attacked by landside mudflow is bound to occur after a heavy rain. They are highly fluid and high velocity mixture of water and sediments that occur on steep slopes and can travel at a speed of one kilometer an hour (1km/h).

The Mabeta new layout landslides on the 27th of June later developed into mudflow where over 100000m3 of soil turned to mud rain and groundwater displaced in quasi north-south direction for some 250m (Che;2011).

Mud flow was noticed at Bonjo after the 2018 landslide. In the case of the Bonjo mudflow, it began with a landslide that deposited regolith that was later mixed with water which later flowed down stream.

The city of Limbe is highly vulnerable to mud flow especially the areas found on the foot of the hills. Mud flow was highly noticed at lower cassava farm where the foundation of many buildings and walls are being buried on yearly bases during rainy seasons due to the flow of mud from the cassava farm hills. During the start of rainy season, violent local storms produce rains with abundant runoff water much faster than could be absorbed by the bare hill slopes which have been after the unfavorable dry season sun and human activities. As the water flows from the slope, it carries the soils that form a thin mud which flows down canyon floor. Following stream courses, the mud continues to flow until it becomes thick and forced to stop.

2.3.6.1. Soil creep

On almost all the soil covered slopes of Limbe, some evidences are found of extremely slow downward slope movements and overburden.

This process of a slow and unnoticeable movement of soils on slopes is known as soil creep. It is a form of soil displacement down the slope that can be only noticed after a long period of time when a significant quantity of loose soil particles has been moved causing a major impact. The main cause of this is the heating and cooling of the soil, trampling, burrowing by animals and alternate drying and wetting of the soil corresponding to dry and rainy seasons. Because gravity exerted on a downhill pull on such rearrangements and modifications that takes place, the particles are forced to move progressively downslope. During the process of soil creep, small steps are produced known as terraces. The number of terraces seen in this area (plate3) indicates the frequency of this phenomenon in the area.

Plate 3: Evidences of soil creep (source: Eti November 2020)

- At 3Aa, we can identify a curveted coconut tree at unity quarters
- At 3Ba, is a karabot house on a hill at unity quarters
- 3Bb is showing the exposed foundation of the house due to the downward creep of the soil.
- At 3Bc is a clear view of the movement of soils down the hill.

From the plat above, it can be testified through the curvature tree that there is an occurrence of soil creep in the city. Photo b shows a potential danger as the soil is gradually moving down exposing the foundation of the building.

2.3.6.2 Rock fall

From our field observation, it reveals that Rock fall is the least form of mass movement that exist in Limbe.

Rock fall is a rapid collapse of a rock mass that had undergone mechanical or chemical weathering. This form of mass movement is not very common and occurs only around high rock pedestals. There exist walls of rock which stand about some meters high from the surface above its immediate surroundings in the city of Limbe like those at Bakoko in Unity quarters and Mbende. Rock fall is the most rapid form of mass movement processes and it's the free falling or rolling of single masses of rocks from a steep cliff. When large rocks disintegrate and fall in small particles, a scar is left on the position and the fallen rock particles are swept away by runoff water in the form of debris avalanche. This form of mass movement is caused by a combination of so many endogenous and exogenous factors. Never the less, not all the factors are responsible in a single case but vary according to the physical milieu and the bio climatic conditions. In several cases this provokes slope failure and eventually causes landslides in the areas concerned. The risk of rock fall is very limited or even rare in the city of Limbe unless provoked by man through construction works. Plate 4 shows an example of rocks that were provoked during the construction of the unity quarters to police station that later resulted to the disastrous rock falls.

Plate 4: Rocks at unity quarter provoked during constructions.

- At 4A(a) is the initial state of the hill,
- At 4B(a) detached rock pedestals

2.3.7. Natural and anthropogenic factors responsible for the occurrence of mass movements in the city of Limbe.

The physical factors that cause mass movement are almost the same in all regions of the world but a little bit different when we bring in the bioclimatic factors. The main physical factors

responsible for the occurrences of mass movements are; force of gravity, slope, nature of the soil and excess precipitation. In the city of Limbe, there are a range of anthropic factors that increase the frequency of severity and damage capacity.

3.7.1. Physical causes of mass movement

3.7.1.1 Gravity

Gravity is the main force responsible for mass movement. It is a force that acts everywhere on the earth surface, pulling everything in a direction towards the center of the earth. On a slope, the force of gravity can be resolved into two components that is a component acting perpendicular to the slope, and a component acting parallel to the slope. The perpendicular component of the force of gravity helps to hold the objects in place on the slope while the parallel component of gravity acting on the slope causes shear stress parallel to the slope and eventually helps to move the objects in the downslope direction. On a steeper slope, the component of gravitational force acting on the slope increases and the perpendicular component of the force of gravity degrease. When the shear stress becomes greater than the combination of forces holding the object on the slope, the object is bound to move downslope. However, it should be noted that, downslope movement is favored by steeper slope angles (increasing the shear stress) and anything that reduces the shear strength such as reducing the cohesion among the particles or reducing frictional resistance.

2.7.1.2. Slope

The general topography of Limbe is not that favorable to settlement. The slope or the general inclination of the surface is an indispensable factor in the occurrence of any mass movement phenomenon. The steeper the slope the more likely material will be force to be in motion. In the city of Limbe we can distinguish slopes with different gradients and amongst these slopes the level of risk is not the same. Figure 28 shows the various slope levels in Limbe.

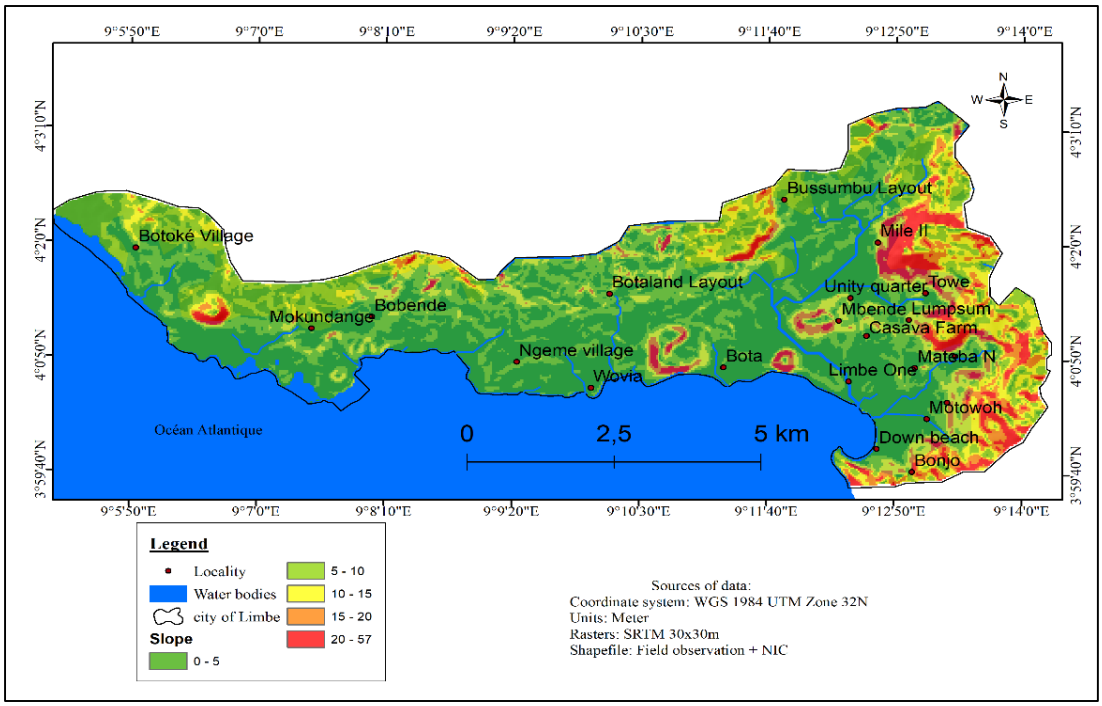


Figure 18:Slope Levels in the city of Limbe. Source: Aster digital elevation model

On this map we can distinguish areas with low slopes ranging from 0-5°, which are generally not susceptible to any form of mass movement, slopes with medium gradient 10° to 15° and high slopes with gradients ranging between 20° and 57°. These areas with very steep slopes such as Bonjo, MNLO, cassava farm, Mbende are those highly susceptible to frequent manifestation of mass movement and have at least recorded one or two events with serious casualties. The low slopes are less dangerous and their consequences can be negligible while the medium, and the very steep slope are likely to have events of mass movement and their effects are devastating. There are several excavation activities in Limbe that permit the population who are in search of cheap land to habit the steep slopes that are vulnerable to mass movement.

2.7.1.3. Seismic activities

Seismicity around the MC region is monitored by the Unit for Volcanological and Geophysical Research (ARGV) located at Ekona. Local seismicity for the period preceding the 1999 eruption averaged 15 events per month (Aka, 2001). This increased from more than 15 recorded seismic events in March 26th to over 200 seismic events on the 27th and 28 of March 1999. An intensity VI earthquake on March 28th was felt over a 100km radius around the

mountain and destroyed houses in Buea and environs. This indicated the start of the March 1999 eruption of the volcano. A macro seismic study of the earthquake activity in Limbe showed that it was felt more by people living up slope in the hillside than by those living on the valleys (Aka Festus, unpublished work). The June activity is characteristic of the very regular (9-15 events per month) low magnitude (2.8 ± 0.1) sub crustal earthquakes of the southeast flank of MC (Ateba and Ntepe, 1997). These are not usually felt even at their epicenter in Tiko. Views of the seismic activities in the period before the June 2001 landslide due to the lack of increase in the number of events, it can be accepted that seismicity is not a major triggering mechanism of the June 2001 landslide in Limbe. This is supported by field observation as the population in Limbe attested that they did not feel any earthquake before the landslide. However, seismicity probably played an indirect role in that the widespread and intense pre-1999 eruption shaking perhaps exacerbated the opening up of cracks in the hills around Limbe, which would have facilitated the infiltration rate of rainwater.

2.7.1.4. A triggering factor rainfall

The displacement of large masses of debris is mostly triggered by heavy and prolonged precipitation. Over 90% of mass movements that occur in the world are landslides. The most experienced type in the city of Limbe is mudslides. The mixture of water and soil give an extra weight making it unstable especially as it is the high slope areas. The distance and speed of every mudslide is determined by the quantity of water present. The city of Limbe like other coastal cities in Cameroon experiences equatorial rain fall characterized by an upward trend from the dry season to rich a pick in the mid rainy season and a drastic reduction getting towards the dry season. It is evidently viewed that these landslides occur between the months of June and August were the area registers the highest amount of rainfall (Fig 17).

2.7.1.5 Deforestation

Deforestation is the act of cutting down trees leaving the soil bare exposing it to degradation and eventually the movement of the loose soil particles down the slope. When trees on slopes that help keep the soils in tack through their roots that hold soil particles firm and their leaves that act as canopies intercepting rain and reducing the impact of rain droplets are cut down, the soil is left expose to the ample heating effect of the sun and cooling and saturation by the rains. These exposed soils in case of any form of vibration or weight on the soils, movement of particles is said to occur. The town of Limbe that has witnessed and accelerated

level of population growth and urbanization since the late 80s had also remarkable evidence in the rate deforestation to create space to accommodate its growing population. Never the less, deforestation on the steep slope of Limbe can not only be accounted for by urbanization and population growth but also deforestation for agricultural activities. There is a high level of wood exploitation in the Limbe urban area for industrialization, fuel (firewood and charcoal) and for constructions. It should clearly be noted that the population of Limbe greatly accuses deforestation as one the major cause of the 27th June 2001 Mabeta New layout land slide in Limbe**.** The famous charcoal that is highly demanded in the nearest urban centers such as Douala and Buea has brought about a significant increase in the rate of deforestation.

2.7.1.6 AGRICULTURE

A majority of the Limbe population are farmers. Farming is one of the most land degradation factors in Limbe. The cultivation of cassava, plantain and yams on unstable volcanic cones in Limbe have greatly reduced the soil cohesion subjecting it to all forms of denudation activities. Cassava a tuberous food plant that is cultivated by famers in Limbe increases the ability of the soil to absorb water. During harvesting of cassava, the soil is left loos with many openings and in case of any rainfall water, there is a huge amount of water infiltrated and when the soil absorbs this water and become thick and heavy, when the is supporting force of cohesion down slope, the soils are forced to move. Also, tilling for the cultivation of yam renders the soil particles loose hens a high possibility of sliding when the soil absorbs more water and becomes heavy. It should be noted that agriculture is the most caused of land degradation in the tropical and sub-tropical regions. The stripping away of the top soil leaves the soil bare and vulnerable to all forms of mass movement.

Photo 8: farming in MNLO
Source: Eti November 2020

- At ‘a’, we can see demarcation of the heads scarp of the slide already covered with crops
- ‘b’ shows a casava farm on the 2001 landslide scar.

2.7.1.7 Anarchical constructions on hills

The aspect of construction of infrastructures on steep slopes renders them weak and expose to occurrence of mass movement. Construction on steep slope that does not respect planning majors in Limbe leave the environment fragile and exposed to all form of mass movement. Since the town of Limbe is made up of an undulating topography planning is difficult as even road constructions that are carried out in the city are potential causes of landslides. A typical example is the construction of the Limbe to Man on War Bay in the year 2009 that led to the collapse of a wall that was excavated and left loose destroying houses at Bonjo.

Photo 9: Anarchical construction at Mabeta new lay out.
Source: Vivian 2011

- At ‘a’, we can see an excavated area, cut into slope to provide space for construction without any stabilization measures put in place.
- At ‘b’, is the material excavated which is a potential tread to the buildings located down the slope. This case, any slightest weight that is added to the material by absorbed rainwater or any shaking the grown is forced to move downslope.
- Point ‘c’ is a house constructed at the summit of the hill
- ‘d’ is a slope that is created by the construction work.

2.7.1.8 Inventory, consequences and delimitation of mass movement in Limbe

Inventory of mass movement in Limbe

Mass movement is one of the major and most destructive hard in Limbe. The table 7 below presents some illustrative events that the field survey and the review of literature on the subject have permitted us to trace.

Table 7: Some registered landslides and their impacts in Limbe.

Location	Year	Human casualties	Material damage
Cassava farm	October 1989	No death	Houses, farm lands
Limbe	1991	1	One house destroyed
Bonjo	July 1994	2	One house destroyed, blocking of roads, many displaced
M.N.L. O	27 June 2001	23	Six houses, 240 displaced persons, farm land destroyed
Bonjo	2005	0	Two buildings destroyed
Bonjo	June 2008	0	No major casualties
Unity quarter	30th June 2009	2 deaths	3 houses destroyed
Bonjo	August 2009	0	1 house destroyed
Bonjo	25th July 2018	5 deaths	1 house destroyed

Source: Field survey and literature from (Ayonghe 1996)

In addition to the events recorded in table 7 above, it should be noted that landslide cause several damages in the city of Limbe. Through the observation of the development of the city of Limbe, it can be noted that landslides started in the 1980s because of the demographic pressure in those years. Furthermore, the fact that there was lack of urban planning from the early 2000s to check constructions in the growing city aggravated the situation.

It should be noted that not all the evens of mass movement were documented as even the population showed resistance in responding to interviews during the field survey. As they were skeptical of the fact that they don't own a construction permit neither a land tittle or also being serve a warning notice asking them to quit the environment because of this, the population chose to hide the occurrence and damage they face from this natural hazards. A typical example is families that lost their house to landslide in Mawoh but refused to accept even when the wife tried to talk the husband constantly ask her to stay tight-lipped.

2.7.1.9. The effects of Landslides in the city of Limbe

Landslides have caused massive destruction in the city of Limbe since its commencement in the area. The impacts of mass movement in the city of Limbe can be classified into three main categories which are; Physical economic and functional damages.

At the level of the physical damage, we enumerate the impact on direct human life and other forms of attacks on the physical integrity of the population. According to our field survey and other related literature on the subject I study, thought limited documented information, we can clearly estimate the loses caused by landslides in the life of the population though we bring out the average annual lost but we can enumerate that from the 1989, at least 33 persons lost their lives in the events of landslide during this period especially the case of 27th June 2001 at M.N.L.O that saw 23 of persons at the sport and many in the city through the floods that occurred after the landslide. 240 persons were displaced as a result of these landslides and so many hospitalized.

On the economic perspective, there has been a numerous damage of houses and roads and farm lands not forgetting livestock. We can mention that at least 20 houses have been destroyed through the direct impact of landslides and many as a secondary impact after the slides. So many roads destroyed that which we can side is the Limbe Man on War Bay Road after the 2005 Bonjo landslide.

On the functional aspects, we can talk about the activities within the city. The major functional loose of landslide in the city of Limbe is traffic jams. Masses of material detached from the slopes end their course on the roads. The case of Bonjo in 2005 that blocked the road for two days before the debris was cleared. The city was at a halt for days after the Bonjo landslide especially the affected quarter.

Areas in the city that are exposed to mass movement

In the city of Limbe, mass movement is a permanent problem that is faced by the neighborhoods in the sloping areas. The map below shows the intensity of the risk in each of the neighborhoods in the city as seen on figure 29 below.

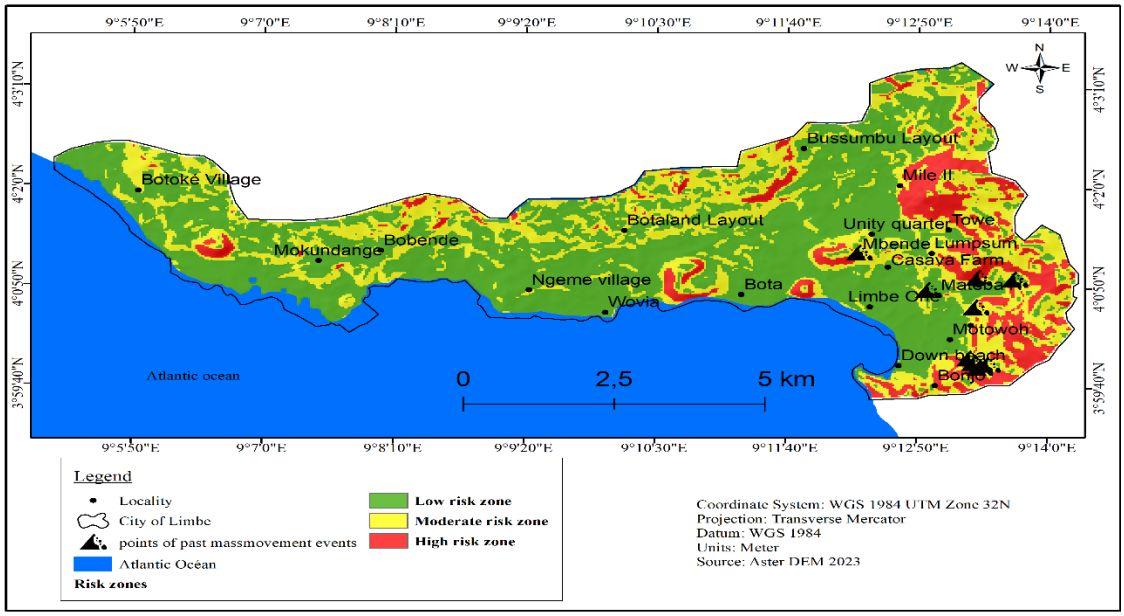


Figure 19:Areas of Mass movement in the City of Limbe

From the figure 29 above, we can clearly be seen that the areas situated at altitudes of over 23m and above are those susceptible to landslides and these areas make more than 40% of the total surface area of the city. It should be noted that landslides in the city of Limbe are mostly caused by developmental projects.

It emerges from the study that floods and landslides are the most recurrent risk that affect the population of Limbe. Rock fall in this city is very rare as what could be is considered often as provoked by road construction on specific quarters. Though nature itself has not been so favorable for this space, man also by his occupation of space has worsened the matter. Thus, while the population in the low lands are confronted with floods, those in the slopes are faced with mass movement. In the city of Limbe, there is no part that is totally preserved. An area is either strongly, moderately, or slightly expose to natural risk. There is no part in the city that is safe. In terms of damage caused by these hazards, the lack of risk observation units in the city makes it difficult to have information to evaluate the risk over several years. In addition to the above, the state security agencies in the city of Limbe only show up when there is a major event especially when human casualties are recorded.

It’s worth mentioning that apart from Natural risk (floods and mass movement), the city of Limbe is also exposed to other urban risk such as; fire, accident, insecurity and social circulation.

At this point, after identifying the different hazards that occur in the city of Limbe, it's worth evaluating the second component of the risk equation which is vulnerability that is to say the exposure and susceptibility of the population in the city of Limbe

CHAPTER THREE:
ANALYSES OF VULNERABILITY TO FLOODS AND MASS MOVEMENT IN THE CITY OF LIMBE

Understanding what is exposed to a hazard event through readily available, comprehensive and consistent national exposure information allows government, state and territorial jurisdictions and emergency Management and planning agencies to make informed evidence-based decisions to prepare, respond and recover from any event. Vulnerability to natural hazards is an integral factor in understanding the true extern of Risk. In addition, analysis of vulnerability makes it possible to refocus actions in order to limit damage in any risk event. In this chapter, it's a question of making a qualitative analysis of the concept of vulnerability by (D'Ercole and Thouret;1996) by taking into account the geographical, socio demographic, economic, institutional, political, functional and cultural factors. Just to highlight, thanks to a summary mapping of the areas in the city that are highly susceptible to natural risk and they combine several factors of vulnerability and where the consequences damages caused by natural risk are likely to be higher.

3.1. The creation of the city: site and situation

In 1858, a missionary of the Baptist church named Alfred SAKER, decided to open a missionary post at the boarders of the Atlantic Ocean at the interior of the Ambas Bay of which he decided to give the name of Queen Victoria. The town carried the name till the 16th of May 1982 when a presidential decree renamed the town which then became « Limbe », the name of the large water channel which crosses the town from north to south (the Limbe River). The name of this river itself is derived from Limburg, a German engineer who constructed the first bridge at the entrance of the town. From its creation, the Victoria station reduced to a stretch of land situated along the sea. After the Berlin Conference of 1885 during which colonial powers defined the zones of influence in Africa. Victoria became the German administrative center of which the area of influence extended to the surrounding plantation zones. It is during this period that the Beach quarter developed and became the administrative center.

In 1911, the construction rules published by the German administration prohibited constructions with temporal materials (wood and thatch) in Beach quarter. This measure will favor the development of « New Town », a quarter situated about 1 km at the north-east of Beach, after the swampy and low-lying zones situated at the borders of the later. It consists of

a housing estate in squares which will be put in place at the disposal of the population on a field extending right up to the foot of hills situated east of the town.

During the British period after 1914, the town started it extension to the west. Residential quarters for British administrative staffs were created at Bota, locality situated at 1.5 km on a long stretch of accidental land initially used for agricultural research. Today, this zone still conserves it character as a residential quarter of high and average standards and has low population density. Well after the British period, two large camps of agricultural workers were constructed at the north and north east of Bota some 2.5 km from Beach. These are CDC camps (Middle Farm Camp and Limbe Camp).

Its these installation of the Germans around the coast and the opening of plantations that brought about a centripetal movement of the population to the city in search of jobs and business along the coast. It due to the German construction laws that the population has to build about a km far from the then administrative center to the north eastern path of the city which is today very vulnerable to floods.

Land use land cover change (LULC).

Land cover change is one of the most essential aspects to be considered when discussing vulnerability to natural hazards such as floods and mass movement. It is worth noting that the frequency of occurrence of natural hazards and the magnitude of damage is as a result of the interaction between man and his natural environment. The LULC (Urbanization, Deforestation and Cultivation) through mechanisms such as reduced infiltration capacity, lower/increase soil porosity. Landsat images of 1985, 2000 and 2018 were classified using ground truth information and visual interpretation into built up, water body, cropland, and vegetation. The results of image classification conducted for 1985, 2000 and 2018 for this study are presented in Table 8.

Table8: Analyses of LULC distribution (1985-2018)

	LULC class	1985			2000			2018	
		area (km2)	%		area (km2)	%		area (km2)	%
1	build up	4.76	9.92		10.0459	20.62		21.13	43.69
2	closed ever green forest	38.16	79.53		33.25	68.23		14.97	30.96
3	cropland	4.98	10.38		5.35	11		12.08	24.97
4	Water body	0.08	0.8		0.08	0.16		0.18	0.4
	Total	47.98	100		48.7	100		48.35	100

From the classification above, the results in 1985 indicates that Build-up occupied 9.92% of the total surface area. Vegetation has the highest area 79.53% this can be explained by the fact that the city was occupied mostly by the indigenes and the white men. Crop land was the second highest occupying 10.38% and water body was the least with 0.8% of the total land. In the year 2000 build-up occupied 20.62% this was as a result of increase in population and development associated with urbanization. Crop land increased from 10.38% to 11% this can be explained by the increase in population and high need for food. Vegetation reduced dramatically from 79.53% to 68.23% this can be explained by the high deforestation for the construction of new quarters. Water body reduce by 0.64% (figure 30, 31 32) this can also be expressed in terms of quest for constructible land, land reclamation started by the population.

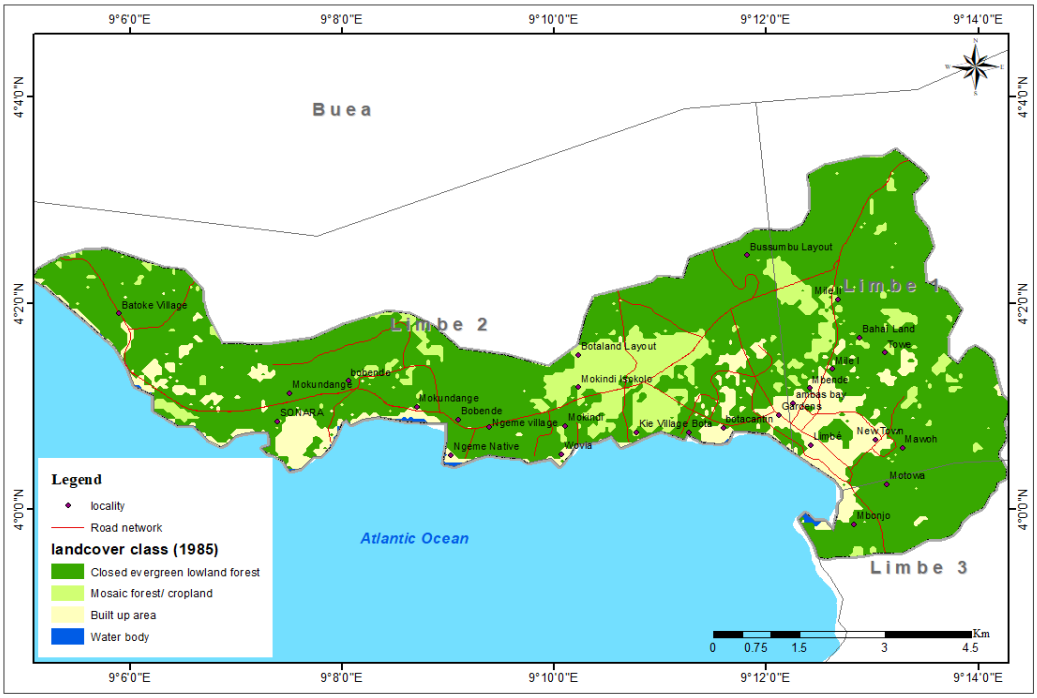


Figure 20:Land use/Land Cover 1985

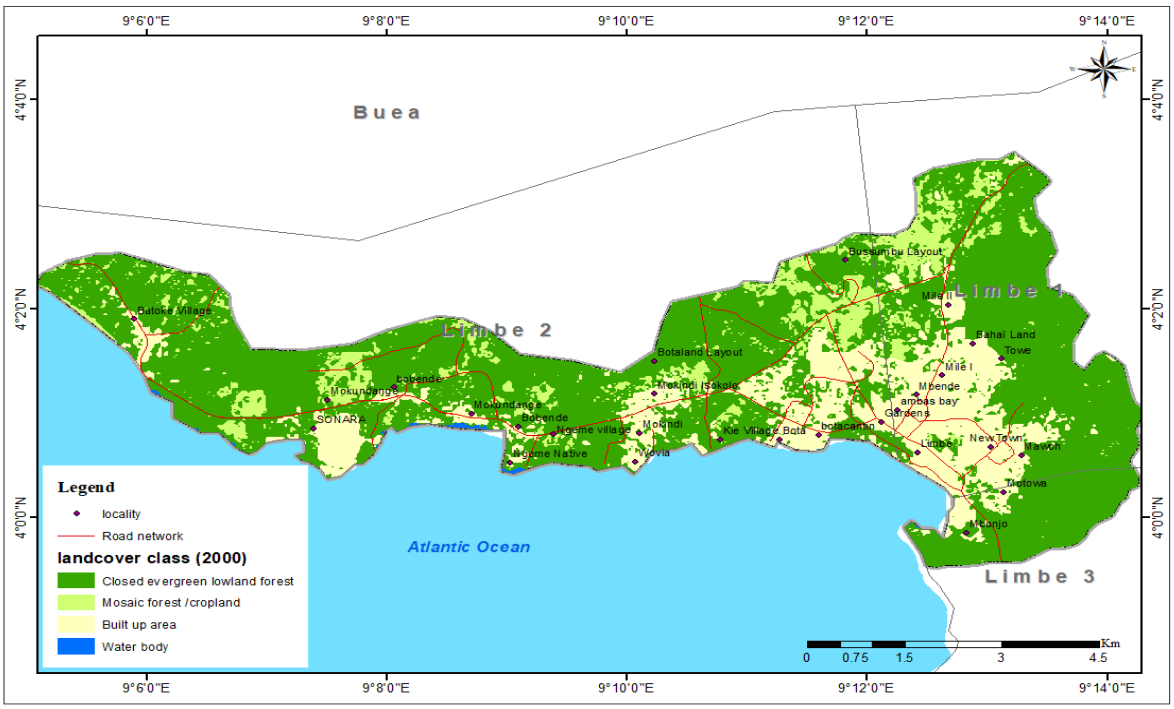


Figure 21: Land Use/ Land cover 2000.

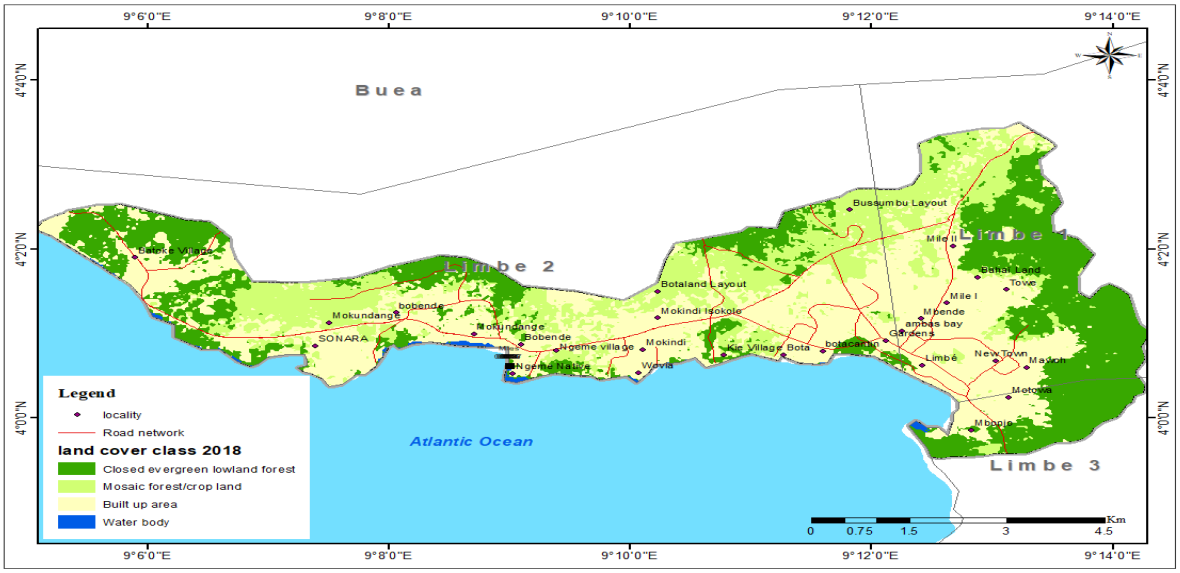


Figure 22: Land Use/ Land Cover 2018

Source: Landsat Image ETM+

By 2018, build-up areas occupied the highest space of the land 43.69% this based on the high level of development that is the establishment of schools, good roads, social amenities good security most especially during the peak of the Anglophone crises where many people left the rural areas to seek safety in the city of Limbe which was the most secured. Crop land increased to 24.97% because of increase in population and increase demand for food and rural exodus. Vegetation also reduces over half of its space in 2000 which was 68.23% to 30.96% in 2018 this could be as a result of development associated with urbanization, construction of low-income houses, creation of lay outs, stadia and development of roads. At this time, water body also reduced to 0.4% as result of the population reclaiming land from the marshy areas in favor of constructions. The drastic deforestation, local land reclamation and the increase in build-up are at the center of the causes of all forms of risk putting the population and land is a serious vulnerable state.

3.2 SOCIOECONOMIC, DEMOGRAPHIC AND PSYCHOLOGIC ASPECTS OF VULNERABILITY IN LIMBE

3.2.1 Expansion of the city from Independence to present

At the beginning after independence, the town was concentrated halve mile at the roundabout of the road to Tiko and Buea to the streets coming from new town and Bota. In this zone, huge portions of land belonging to private titles were owned by native proprietors.

The creation of infrastructures such as schools, hospitals and roads, has led to a strong attraction of people to the region. The influx of the population was greatly motivated by many socio-economic factors. During the period of the founding fathers of the city (the British) there was an accelerated movement of population from the interior and the rural areas in search of jobs. The development of the CDC plantation in this area is one of the pull factors of the population from the northwest and west regions to the area in search for jobs at the plantation. Furthermore, the creation of the Tiko – Victoria Road gave it an opening to the Douala that also encourages a huge number of migrants to the area for business. To continue, its worth mentioning the fact that there is a sea port in Limbe and the creation of SONARA in 1976 the lonely Cameroon oil refining company greatly influenced the inward movement of population to this region. In the recent years, that is from 2016 there has been an accelerated rated movement of the population to this region as it's seen to be the safest town in the Southwest because of its security. Limbe firstly a rural municipality then urban municipality, capital of the Fako division is set up as a real administrative, political and economic center with several markets. The continuation of immigration at a sustained rhythm brought about the densification and proliferation of spontaneous quarters. They henceforth occupied the peripheral spaces (Mabeta, Mawoh, Motowoh, Isokolo…), but also central urban areas considered till now to be non-constructible (hydromorphic zones, steep slopes like at Mbende, Mile One, Mbonjo, etc.). The map below (fig 33) shows the evolution in the construction of the city.

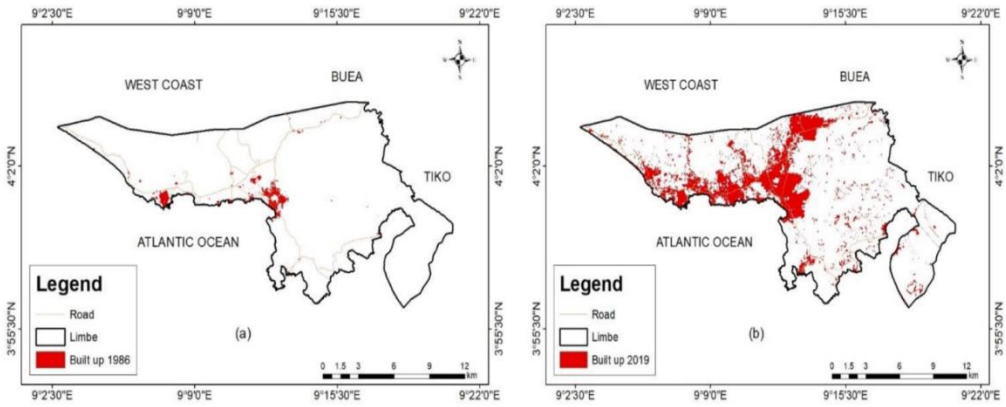


Figure 23:Urban Expansion between the Year (a) 1986, (b) 2019
Source: LANDSAT 5 TM 1986, LANDSAT 7 ETM 2019.

From figure 29 above it can be clearly seen that around the year 1986 the population was concentrated along the banks of the Atlantic Ocean with a very few buildings precisely at the down beach area where the present SDO's office is located at this period, there had been no remarkable risk as compared to the situation that is on ground now. We also note the extension

of the city to the high hills in the North, the East, SE, SW and NE of the city these areas from the map of mass movement and floods represent the areas prone risk. There should be a proper and well-defined town planning documents to check the expansion of this city the slope and development should be encourage in the western part of the city as it represents the area with low altitudes free from floods and mass movement.

3.2.2 Proximity to a water course or standing water and hills

From the questionnaires administered in the field, more than 35% of the houses are located beside a watercourse. In effect, the distance that separates the houses from water bodies range between"1 meter for the houses which are very close, to about 500 meters". Here vulnerability varies in function of the distance between the houses to water courses. The closer the house to a water course the more vulnerable it is that is the houses situated at about 1m to the water course are more vulnerable than houses situated at about 500 meters because in a very small down pour the waters flood the surrounding environment. This is highly manifested by the occupation of the minor and major river beds. This situation is the same for mass movement as the houses that are most closed to the hills are most likely to be affected in an occurrence of minor landslides that is a landslide with a minor intensity. The proximity to standing water is an indispensable factor in the assessment of the vulnerability of the population to flood water. This is because the standing waters act as a home for mosquitos and micro pathogens responsible for the cause of Malaria, water borne diseases. Part of the down beach area, cassava farm, and Bonjo permanently has standing water throughout the year and this can be explained by the low altitudes in these areas and the presents of highly impermeable soils.

Plate 5: (a)proximity to standing water at down beach **(b) proximity to a water course at church street.**

(Source Eti November 2020)

5Aa shows a house beside standing water

5Ab is the presents of standing water in the month of November which is within the dry season period. With such a situation in the dry season, it is doubled in the rainy season as the locals confined in us that with just a small rain the whole of their houses are inundated making them constantly subjected to floods throughout the rainy season.

At 5Ba is a planted about two meters away from a flowing river.

5Bb the channel of the river.

3.2.3 A very strong demographic growth

The demographic growth of the city of Limbe is modeled on the general context of the urban growth of the countries of the south. The lack of jobs in the countryside leads to a surplus migration to the cities. The population of Limbe increased from 15,800 inhabitants in 1953 to 27,016 inhabitants in 1976, 44, 561 inhabitants in 1987 to reach 73,673 inhabitants in 1998. Between the 1953 and 1976 the annual population growth rate as per the figures stood at 2.3% in 23 years as against the period between the years 1976 and 1987 which was 4.5% in 11 years annual growth rate. In the year 2005, the population census that was carried out showed that the population of the city increase to 84,223 inhabitants as shown on figure34.

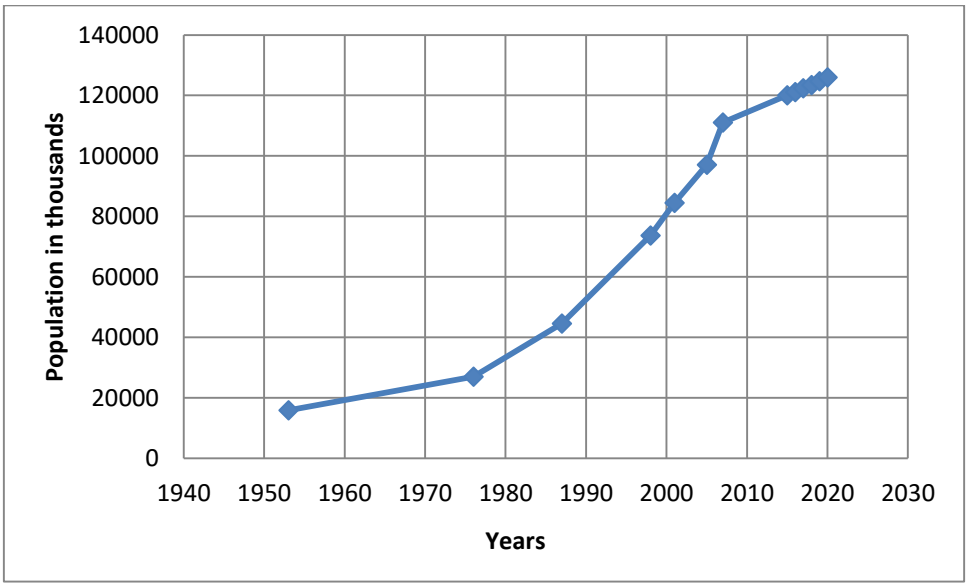


Figure 24: Population Evolution from 1953 to 2020.
(source: BUCREP2005& population Projection 2015)

3.2.4. Age-sex structure of the population.

According to the 2005 demographic census, the total population of Limbe was 118,210 inhabitants. In this population, there were 33,987 rural duelers and 84,223 living in the urban areas. This uneven population distribution between the urban and the rural areas, that is 71.24% urbanization Rate and 28.75% rural population. In these 84,223 urban populations, 41249 are men and 42974 are women that are a femininity rate of 51.02%. In addition, the composition of the population by age group shows a high proportion of children and young people (63.6%) and an elderly population of 4.1%. The latter are mostly unemployed and depend on the support of their parents. The high proportion of the dependent population increases the poverty level of the families and increase in vulnerability. However, the implementation of DRR in schools will go a long way to reduce the susceptibility of the population to damage during crisis. Moreover, the high proportion of women is a factor likely to increase vulnerability especially when they are the head of family. In generally women are physically weak and possess some social characteristics that are fragile to stress.

3.2.5. Composition of the population (ethnicity)

Limbe is a cosmopolitan city located along the coast of the Atlantic Ocean in the south western part of Cameroon Fako division. The immigrants in Limbe are from different regions of Cameroon and foreigners from her neighboring Nigeria who leave together (figure 35). The majority of the migrants are from the North West region and other parts of the south west region and the west region. It's worth noting that the city of Limbe represents a general landscape characterized by steep slopes and very deep valleys which make it difficult for the population to find safe plots for construction. However, the population that first settled in this town are the most vulnerable to floods due to the fact that then the constructed regarding the administrative function of the city. Some of the population that acquired land after the year 2001 were lucky to have acquired land in safe places due to the fact that they have been a heavy disaster in 2001 that claimed the lives of many and properties and the wounds were still fresh in the minds of people. During our field survey it was notice that the majority of the people habiting the risk prone areas are influence by cultural, poverty, nearness to job side and family ties. These highly seen among the Nigerian migrants who carry out fishing along the coast and chose to stay close to the sea (in the most vulnerable quarter to floods Dock Yard) it was also noticed that even the new arrivals chose to stay in these areas due to the fact that they want to be close to their

families. It was also recorded during the survey that majority of the population leaving in the hilly areas that are highly exposed to landslides are from the North West and the west region. These make the non-indigenes to be more vulnerable than the natives of Limbe. Some of the population interviewed confirmed to us that it's not easy for a stranger to get a piece of land in the safe places are the natives of Limbe are keeping the area declared safe for construction for their children and the areas non fit for construction are sole to the people they consider as strangers who want to come and over thrown them in their home land. These diverse mentality as of were to construct make the people more vulnerable to natural hazards. It will be very wise for the government to put a local coordination in the distribution and also to discourage hate speeches especial from local chiefs.

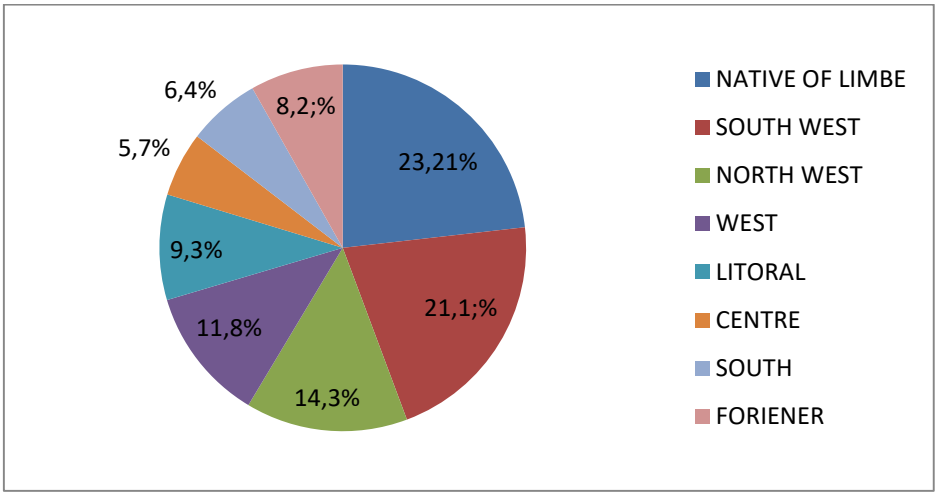


Figure 25: Origin of the Population.
Source: Fieldwork, November 2020

3.2.6. Socioeconomic characteristics of the population

Poverty both in terms of monetary or non-monetary dimensions are persistent in Limbe. According to the World Bank, poverty is defined as deprivation in well-being and it comprises of many dimensions. Poverty includes low income and the inability to acquire basic goods and services necessary for survival. Poverty also compasses low level of health and education, poor access to clean water and sanitation, inadequate physical security and insufficient capacity and opportunity to better one's life (World Bank 2001).

In this study we defined poverty using the binary categories- the poor and the non-poor based on monthly per capital income. The majority of the population sampled in Limbe leave below

the poverty line which stands at 931fcfa (INS 2014). Figure 26 and 27 below shows the household income and educational level of the population.

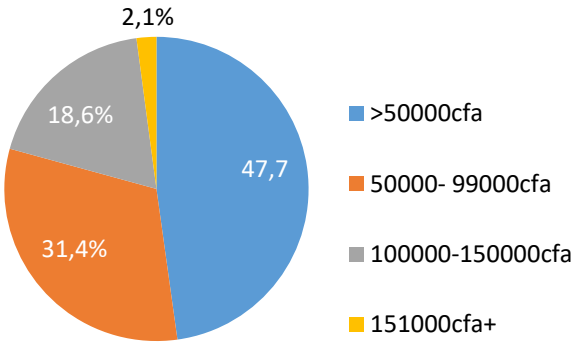


Figure 26Monthly Income

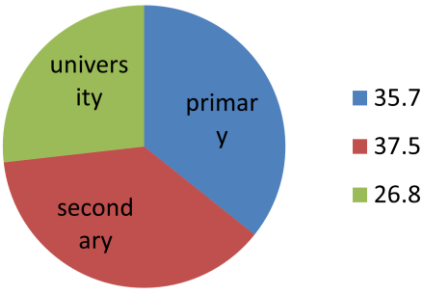


Figure 27: Level of Education

Source: Fieldwork, November 2020

Reading from the charts above, it is clearly seen that a majority of the sampled population had a very low monthly salary. 47.7% of the population ending a salary less than 50,000fcfa, which can barely take care of their basic needs, talk less of investing in requested disaster preparedness technologies. Also looking at the household expenditure, it shows a less investment in the education for most of the households (35.7%) end only in the primary school. This brings about a lesser number of people who are educated up to the University level (26%). There is considerable evidence of a link between disaster risk and poverty. Findings from worldwide consultations with the poor (World Bank 2000), the UNDP's (2004) report on mutual links between disaster and development, and the UK Department for International Development's (Department for International Development 2004) explanation of the links between development and disasters in view of the long-term impacts on poverty trends have all pointed to relationship between disasters and poverty.

It is widely acknowledged that the poor often live on marginal lands and in poorly constructed houses, and often have poor access to water and sanitation for example, 80 per cent of the poor in Latin America, 60 percent of the poor in Asia, and 50 per cent of the poor in Africa live on marginal lands characterized by poor productivity (World Bank 1997). According to White et al. (2004), people living in such conditions generate a range of immediate unsafe conditions. Such conditions make the poor more sensitive to disasters and exacerbate their poor economic status. While those better-off may choose to live in higher risk areas, the poor often have no other choice. Poor thus live in poorly constructed houses, have poor access

to water and sanitation, and often do not have food and nutritional security. Living in poverty thus increases their sensitivity to natural risk. Given limited income and limited financial savings (if any), the ability of the poor to respond to and recover from disaster is limited. Further, the poor cannot easily adapt to disaster by investing in options such as disaster-proof technology, relocating to less hazardous areas, replacing lost items or even taking out insurance (World Bank 1997) and this increases their vulnerability to floods and mass movement.

3.2.7 Inappropriate Emergency services

In the city of Limbe, the largest relief structure is the fire brigade unit. A Local Committee o f the Cameroonian Red Cross also exists. In times of crisis, the help of the various hospitals (p ublic and private) could also be required to assist the populations.

The presence of all these structures in the city gives the impression of a good availability of help. However, the situation is quite different because of several factors:

Lack of communication: A majority of the Limbe population ignores the existence of the relie f units present in the city. The Red Cross, for example, is associated with sporting activities ac cording to the population interviewed; it is only at a sport event ground that we see the res cue volunteers during sporting activity. As for the firefighters, the populations hardly consider them as an asset, because they act only in very serious cases when the totality of nationa l and international actions are mobilized. In addition, the toll-free number of the fir e brigade (118) is not known or ignored by a majority of the population. Hospitals, on the ot her hand, are for-profit companies that come to the aid of those with significant economic p ower.

- Lack of resources: interventions in the field require significant technical and logistical resou rces. However, the city presents a lack of structures for coordinating interventions in the event of a crisis which could mobilize all the city's resources to make them available for intervention s. Only large hospitals have a few ambulances, most of them in poor condition. The Red C ross presents a glaring lack of logistical materials which does not allow them to make prompt i nterventions in the neighborhoods. The equipment of the national fire brigade is more geared t owards extinguishing fires which are certainly major problems in the city but which should no t mask the other risks. In Limbe, the population rely more on mutual aid between neighbors in the occurrence of a hazard in their environment. In addition, the isolation of risk areas in Limb

e Especially as there is no fire brigade in the city except that present at SONARA and the othe r in Mutengene makes any relief intervention difficult. It would therefore be appropriate to create rescue units in the various neighborhoods and also to organize from time to time firs t aid training to strengthen the capacities of the population to take charge of themselves in t he event of a disaster.

3.2.8. Poor quality of infrastructures

To access information concerning the quality of buildings in the city of Limbe, a questionnaire was sampled to the households regarding the material used for construction. It was seen that o nly a few houses in the area are constructed with finished material. Figure 38 below shows th e details of household response concerning the type of materials used for construction.

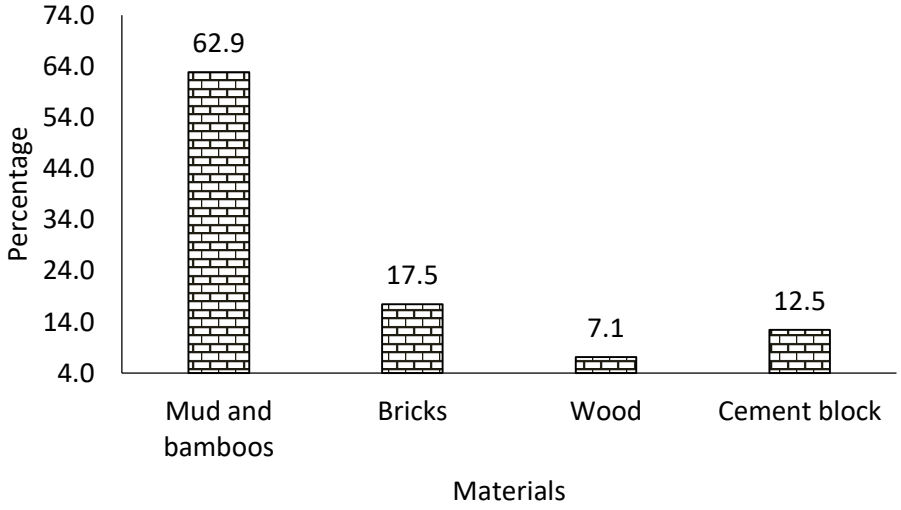


Figure 28: Type of Building Material
Source: Fieldwork, November 2020

3.2.9. Poor quality of building

In the city of Limbe, constructions don't respect the environmental situation of the are. This is highly noticeable in the risk prone areas in the city. The city in its topographic setting generally represents a problem. Steep slopes in the city of Limbe occupy more than 25% of th e buildup space and the flood prone valleys 20% to 25% of the buildup spaces in the city. To c onstruct in such places requires a special planning from the population. However, only about 30 to35% of the houses built in these areas are built with final material (cement) while 65% t o 70% are constructed with either bamboos or plank (karabot). This situation can be attributed

to the poverty nature of the majority of the population in the city. Photo 10 below shows a typi cal example of poor building quality in the flood prone valleys of lower cassava farm.

Photo 10: Poor quality of building
Source field work November 2020

- 'a' shows standing water in front of house.
- 'b' shows a cemented veranda of the house.
- 'c' shows shits of zinc that are used in constructing the walls.
- 'd' is plank wall.
- From photo 9 above, we can see a house constructed on planks with very low foundati on level surrounded with standing water in mid-November. In case of any rain fal l the house is bound to submerge in water. In such marshy areas, floods are inevitable as the smallest amount of rain can cause serious floods.

It should be noted that it would be quixotic, unrealistic to claim a total elimination of n atural risk but we can considerably reduce the sensitivity of the population. In many countrie s in the world facing numerous environmental challenges, people have developed strategies to live the risk by adapting their buildings to the environment they live in. The case of constructi on on stilts is a solution that can be considered in floods in the flood plains in the city of Lim.

3.2.10. Poor quality of roads

The city of Limbe is linked by national road number three (N3) and connected to the provincial road number thirty-two(P32) that link her to Buea the capital city of the south west region This N3 road axis crosses through many quarters in the city towards the coastal town of Edenau. The road situations in Limbe are not different from the general road typology

in Cameroon marked by poor standards. The roads in Limbe that are mostly in good states are the roads that connect the city to other regions and town in the south west region. We can classify roads in this according to their functions that is the primary roads, the secondary roads and the tertiary roads. The primary roads are the roads that link the town to other towns this includes theN3 that links the city to Tiko and Douala in the n Littoral region, the communal section of the regional road R32 that connect the city to Buea and some cross roads within the city that connect some major villages. These road structure the urban zones well and link them to the locality of the rural zones. The roads are mostly tarred and generally in good conditions with a predominant of coatings except for the rural parts.

To add to the above, we have the secondary roads which are also tarred linking quarter, ensuring traffic closer to those of the primary roads. Most of the inter quarter linkages are done by the primary roads. This is due to the fact that the secondary roads are limited in the city of Limbe.

Furthermore, the tertiary roads which are service roads inside quarters are essentially on poor conditions and mostly in accessible except for motto bikes and predominantly on foot. Adding to the above, apart from vergers and pavements of the primary roads, there are no pedestal tracks. In Limbe, there are specifically no cycle tracks as all the roads ensure polyvalent traffics.

With respect to the road conditions in the city of Limbe photo 11, the areas which are most susceptible to all kinds of risk; quarters like cassava farm, Motowoh, Lumpsum that are situated in the heart of the flood water lack a good road system. The areas built on the hills are on the other hand left out of the other parts of the city without connecting roads. In this hilly quarters, roads are mostly foot parts created by the population with the use of rudimentary tools. This situation hinders movement of people and properties resulting to heavy casualties and damages in the event of any hazard. The photo 11 below shows an example of a constructed area in Bonjo that is practically in accessible.

Photo 11: An inaccessible location at Bonjo

- 'a' shows the bush track leading the built area
- 'b' shows a house that is practically inaccessible

3.2.11. Local toilets an aggravating factor

In the city of Limbe in general and the risk prone areas in particular, there is a high pre sence of dilapidated buildings. It's clearly seen that there is a predominance of locally build to ilets (pit toilets) with no covering. Majority of the population in the flood prone areas w ith karabot buildings usually dick a pit out of the main house wish is used for excreting. The se toilets are mostly exposed not covered or sometimes with no walls. These uncovered toilets in any event of flooding, the neighborhoods are highly affected. The population is exposed to health risk through the contamination of water sources resulting to high prevalence of water b orne diseases. Studies have proven that most of the poor urban dwellers are increasingly expo sed to hazards due to the poor conditions they are subjected to. From the survey in the field, i t showed that more than 39% of the households questioned uses pit toilets and up to about 1 7 to 18% uses buckets to defecate which is later emptied either in a pit toilet or a water course . The figure 39 and plate 6 below shows the situation of sanitation in the city.

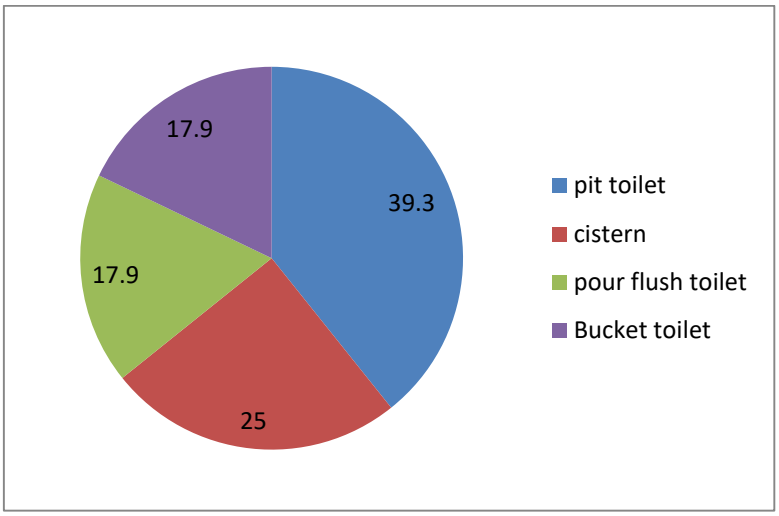


Figure 29 : Types Of Toilets (Source field survey November 2020).

Plate 6: photos showing a pit toilet at lower Mawoh

- A 'a' shows the newly covered area with loin cloths of the toilet after the collapse.
- B 'a' shows the second hole of the toilet which is not covered.
- B 'b' shows the collapsed toilet wall.

3.2.12. Traffic jams: an aggravating factor

Due to the high population density in the city of Limbe, there is a significant congestion on the roads especially during the peak hours. Most of the cross road (Half mile) experience remarkable traffic jams. Motorcycles, taxis, intercity, taxi is and pedestrians dispute the different roads. Traffic jams in the city of Limbe are as a result of the several factors such as:

- Insufficient urban roads
- Pour condition of most of the city roads
- The absence of traffic lights in the city

- The small size of the roads (5-7m) of the carriage ways of most of the roads
- The high concentration of services in certain places such as the half mile area, church streets where there are several businesses and administrative office school establishment.
- The absence of pedestrian track

All of these factors increase the movement time from one point to another under these conditions, in the event of a crises, the damaging effects are likely to worsen. Especially as the roads that link the risk prone areas are cross roads of the main traffic areas. Most of the roads that link the risk zones pass through the half mile junction which is also a permanent floods side and even for the fire bridge to access this risk zones they have to pass through the whole city. This increases the intervention time to solve the problems posed by the hazard. It is necessary to establish emergency services in all the districts of the city especially the risk zones for a rapid and effective intervention in the event of a crisis because it would be unrealistic to claim the total elimination of traffic jams.

3.2.13. Weak intervention of the media

In both prevention and operational risk management, communication plays an important role. Firstly, in creating awareness to the population of the risk, which they are exposed. National and local radios, televisions and newspaper agencies should play an important role in raising awareness of the local population. In times of crises and in the absence of early warning systems, local radio station are the main tools necessary for informing the population in order to avoid panic which generally aggravates the damage. Most of the popular local media concentrate on dealing with sensational news that people crave and that which they end income from. It will be very useful to introduce programs on local and national radio and TV stations on risk prevention in the city this broadcast could inform the population on urban regulations, particularly building regulations and also first aid trainings.

3.2.14. Poor perception of the risk

To assess the way the population perceives the risk they are exposed to, a questionnaire survey was carried out in the most vulnerable neighborhood in particular. Mabeta new lay out, Bonjo, cassava farm, unity quarter, Mawoh, Lump sum, down beach, Motowoh, Mbende, Lower Mawoh of the risk which they are exposed to particularly floods and mass movement.

The questionnaire also made it possible to appreciate the opinion of the population on the causes of risk in their area.

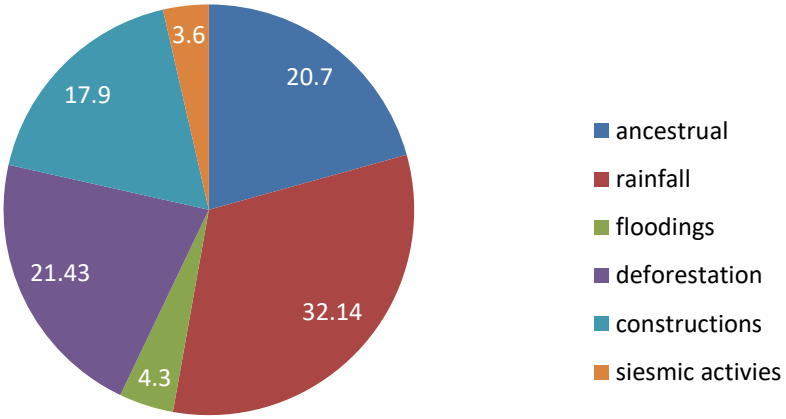


Figure 30 : Perception on the Causes of Risk
(field investigation **November** 2020)

From the questionnaires distributed it emerges that a great number of the population in the risk areas have a poor understanding of the causes of the risk they are exposed to 20.7% of the sample household think that the natural risk which occur in their area are linked to ancestral anger or to witch craft. This belief by the population is due to their strong attachment to their local traditional beliefs. A part of the Christians in this city explains the causes of the risk as sign of end time some die heart Christian who were questioned spoke with a lot of certainty about the signs of end that was promise by God coating bible verses such as Rev 16:18 from the book of John's revelation to the Christians. They made us to understand that these phenomena occur everywhere in the world and the floods are a reminder that the bible is still relevant and Jesus Christ is real. The local population attached to traditional beliefs noted that the Gods are angry (upset) because of the human abuse of space (environment). The green spaces which served as shelters for the gods (shrines) has for the most parts been erased. It should be noted that the population that attribute the causes of their natural hazards to precipitation, construction, or other causes don't have any means to mitigate this hazard in general view, meteorological stations in the country are obsolete and limit themselves to simple reading during the rains and are not able to assess the quantity of water contained in the cloud in order to predict torrential rains.

3.2.15. Risk acceptance

Risk acceptance means the fact of accepting an identified thread without taking any action in order to reduce the risk because the impact is acceptable. The strategy of risk acceptance is always applied when it turns as to be the most economical option. Nelkin D, 1989 and Ogden J, 1995 concerted that you can't address risk out of the social and cultural frame work in which the population operate. They showed the impact of psychological predispositions such as acceptance and habituation to risk. In the city of Limbe, the population living in the dangerous areas shows a degree of acceptance to the risk that they are exposed to. It's worth mentioning despite the numerous warnings by the state to the population habiting the risk prone areas especially the steep slopes, through public statements or relayed through local radio stations about the danger involve in habiting such areas. Most of these areas have been declared in constructible not withstanding there is spontaneous increase in constructions in those areas. The aspect of risk acceptance in the city of Limbe is greatly a psychological issue as majority of the population are driven by traditional believes that the risk is not natural and others on the point that the accept to live risky environment because a plot of land in these areas is ten times less expensive as those in the relocation sides that has been created by the city council. The state of affairs in these areas leads to great uncertainty. Due to this when there is an event of flood or land slide, these population bare the loss. This is because they accept their responsibility. In the city of Limbe, the population habiting the risk zones had shown a great acceptance by the fact of the risk they are exposed. This is illustrated by the fact that in the occurrence of some events they don't report to the administration or even asking for helps. They accept the total losses incurred. However, it should be noted that the degree of acceptance is measured in terms of the losses the population is willing to accept. The losses or damage to properties (houses, material losses) but it's difficult for the population to accept when the hazard affects life for its difficult for people to accept misfortunes.

This chapter was focus on assessing the level of vulnerability of the population of the city of Limbe to floods and mass movement. The use of socio- demographic, economic and physical data gotten from our field survey made it possible to highlight the exposure and sensitivity of the population of some quarters to floods and mass movement and also to the sensitivity of the entire population in a city with damaging phenomena.

The analysis in this chapter shows that due to the geographical characteristics of the city (topography, pedology, hydrography and climate), the city of Limbe has many neighborhoods

expose to natural risk with a population highly exposed to damage. In addition to the above, the strong demographic growth coupled a high level of poverty increases the sensibility of the population and hence reduces their resilience. Also, the inability of the urban authorities to produce maximum infrastructure for better management of the urban spaces increases the vulnerability of both the population the authorities.

3.3. Cartographic Summary of Vulnerability to Floods and Mass Movement in the City of Limbe

From the different factors of vulnerability discussed above, has permitted us to represent the susceptibility of the deferent areas in the city to natural hazards. This comprises of physical, socio-cultural and economic aspects of the city and the occurrences of natural hazards represented in figure 40.

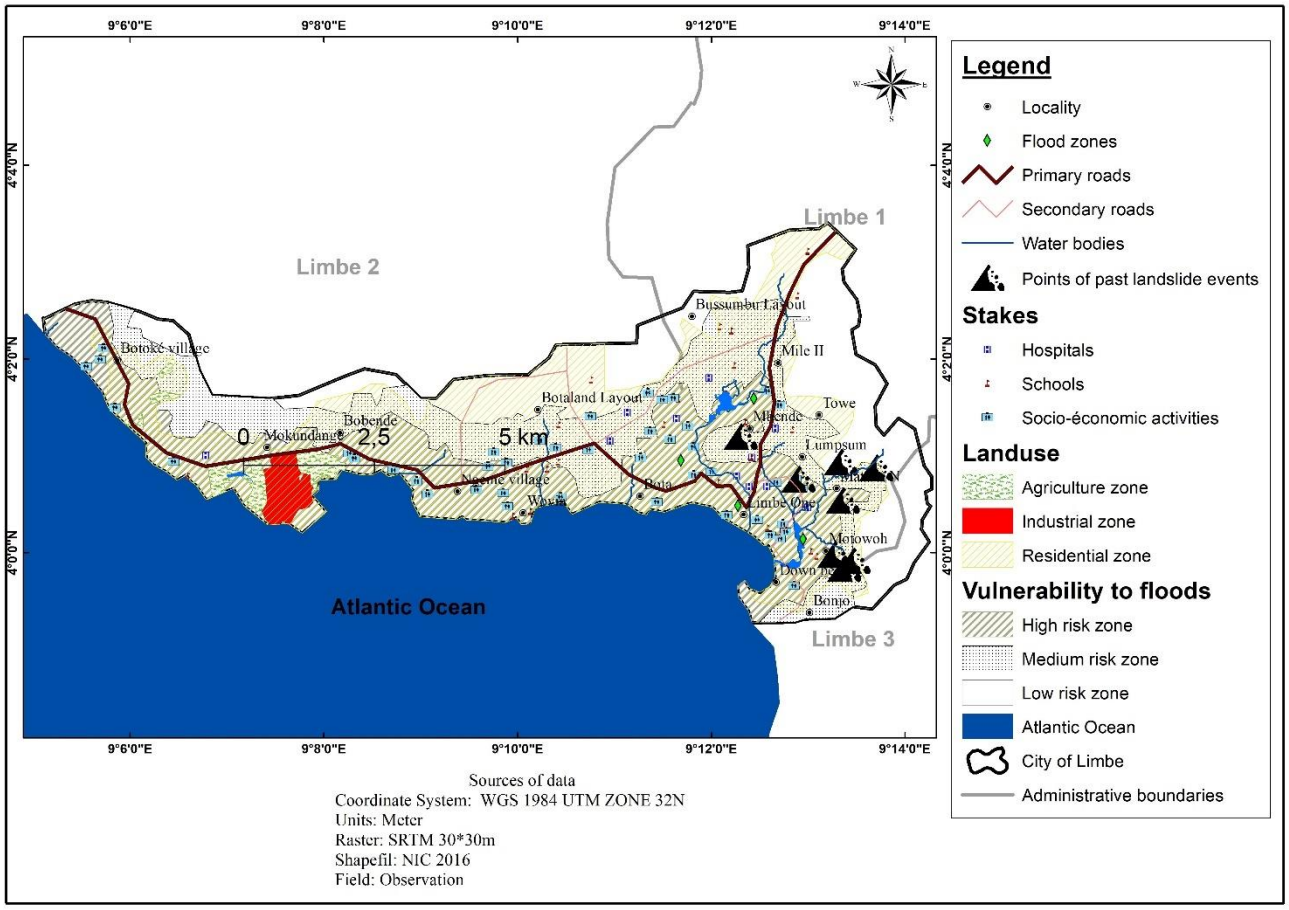


Figure 31 : Vulnerability to Floods and Mass movement in the City of Limbe

From the map above we can observe the most constructed areas in the city of Limbe, are those most vulnerable to natural hazards. The quarter at the coastal and the river banks with very low

altitudes are most susceptible to floods due to their topographic and hydrographic characteristics while areas in the East, South Eastern and Central of the city with high slope level are those highly vulnerable to all forms of mass movement.

It can be clearly noted that each area in the city of Limbe is either susceptible to a particular natural hazard or both for example quarters like MNLO, Mawoh and Bonjo have registered both landslides and floods of high magnitude. This is so because of her topographic, climatic, pedologic, geologic and hydrographic settings.

In sum, the city is highly susceptible to Natural hazards hence a thorough review of the planning of the city is required to avoid further occurrences and negative impacts of these hazards to man and his environment.

CHAPTER FOUR
STRATEGIES FOR THE ADAPTATION TO FLOODS AND MASS MOVEMENT IN THE CITY OF LIMBE

Administrative wise, the Cameroon Government has a legal regulatory arsenal in the field of planning and civil protection. The objective of which is to encourage the entire nation to get involved in the avoidance of national risks. In addition to laws, institutions exist at both central and local levels to urge people to behave responsibly.

4.1 STRATEGIES APPLIED BY THE AUTHORITIES

4.1.0. Proactive measures

4.1.1 General regulatory and legislative context

The layout designates the way of arranging and distributing activities, equipment and people in connection with the available space. In Cameroon, the proper use of the national territory is the responsibility of the National Council for Planning and Sustainable Development. This institution issues" opinions and suggestions on the orientations and conditions for the implementation of the policy of planning and sustainable development of the territory by the State and the Decentralized territorial Collectivities. Law n^{o} 201/008 of 06 May 2011 on the orientation for the planning and sustainable development of the territory in Cameroon defines several strategic tools according to the different scales concerned.

- The national regional planning and sustainable development plan is the central tool enabling the State to dispose of the entire national territory in an equitable manner. This plan emphasizes the promotion of economic growth and the development of employment., the preservation of the environment and the fight against the harmful effects of, support for certain specific areas, in particular areas with fragile ecology, unstructured urban areas etc. The creation and networking of urban and rural development poles
- The national planning and sustainable development plan contain a documentary set made up of literal statements and graphic expressions.
- The regional planning and sustainable development plans of the territory define for each region of Cameroon the priorities in the field of development and serve as a transition between the national or central level and the sectorial and local level.

- Sectorial development plans, they are established in accordance with the national plan for land planning and sustainable development. They relate to a precise sector characterized by a certain number of elements which makes its specificity. The sectorial development plan aims to define priorities in order to give a better orientation to the actions to be undertaken.
- The local planning and sustainable development plans for territory translate at the municipal or inter-municipal level the regional planning and sustained able development plans for the territory. The initiative for local plans belongs to the administrative authorities, in particular at the department al or district level.
- The plan contract is a development strategy negotiated between the State and a region or a decentralized local authority. The contract plan defines in detail the sharing of responsibilities with a view to the harmonious execution of a development action program during a determined period.

Even if spatial planning does not explicitly define risk prevention as a major priority, the allocation of spaces takes into account the topographical and geological nature and even the climatic and hydrological context, hence the definition of hilly areas and lowlands liable to flooding as unsuitable for habituation and reserved for other developments. Considered as a particular development sector, the urban environment is also subjected to specific regulations.

4.1.1.2. The specific development of the urban environment

In urban areas, the development is known as urbanization. Urbanization is perceived by specialists as being one of the most spectacular phenomena at the start of the third millennium. At the national level, urbanization is regulated by Law N^{o} 2004/003 of April 21, 2004. With 136 articles, this text sets the general rules for the development of urban agglomerations as well as the construction rules for all cities within the national territory. The excerpts below can support our vision in this work.

After the first section which defines the general provisions of this law, section II emerges some rules relating to the prevention of natural risks in urban areas.

- Are declared as unbuildable except special prescriptions, the land exposed to a natural risk (flood, erosion, landslide, earthquake, etc.)
- Town planning studies must integrate environmental impact studies
- Any building plot must allow the intervention of emergency and road services (fire fighters, sanitation, household waste removal etc.).

- The land use coefficient may not exceed 0.6. unless expressly provided for in the urban planning documents
- The mayor ensures the dissemination and application of the provisions provided for in the general planning and construction rules
- Urban planning documents prevent natural and technological risks, as well as pollution and nuisance of all kinds.

It should be noted that specifically the urbanization of an agglomeration is based on these various urbanization documents which have the particularity of taking into account the specificities of each city. The most important of these documents is the Urban Master Plan (UMP) popularly known in its French acronym as (PDU). It fixes the fundamental orientations of the development of an urban territory. The PDU initiative belongs to the Minister of Urban Development and Housing and carried out under the authority of a government delegate or the mayor for urban municipalities. The city of Limbe now has a UMP Master plan of Limbe city 2011-2022". This document presents an assessment of the current situation of the city before opening some perspectives on the:

The specified document for the use of spaces is the Land Use Plan (LUP) or Plan d ’Occupation de sols in French (POS). It fixes «the land use and the rules which govern it for the medium term (10 to 15 years). It defines the perimeter of each of the land use zones and issues, for each of them, the specific rules, restrictions and easements for the use of the land". In a city, the POS (LUP) can be developed by each of the urban municipal councils (UMC) or in French Communes Urbaines d’Arrondissements (CUA) in French. In the city of Limbe, land use provides for "in constructible" spaces in accordance with Article 9 of Law No. 2004/003 of April 2004 governing town planning in Cameroon. This article declares unbuildable any land exposed to natural hazards (Floods, Erosion, Landslides, and Seismicity). In this city, there are steeply sloping areas along the volcanic cones and flood-prone valleys.
The Sector Plan (SP) or Plan Secateurs in French (PS) defines in detail the organization and technical modalities of land use. Thus, the sector plan facilitates the implementation of the LUP in a specific sector of a city. The Summary Urbanization Plan (SUP) is a simplified and provisional document which sets out the land use terms in accordance with the UMP.

These various documents must be produced with the close involvement of populations and civil society. In order to ensure the strict application of the provisions contained in these various texts, any operation of occupation of a space in an urban environment requires obtaining

a certain number of permits and certificates, all of which are issued by the urban community or the mayors of urban municipalities, apart from the authorization to subdivide which is issued only by the Divisional officer. We distinguish:

- The Town planning Certificates; it fixes the town planning rules and indicates the right to enjoy, provides for the conditions of use of the land.
- Layout Authorization. It is issued to allowed the subdivision of a land property
- The Permit to Establish. It is issued for all constructions not eligible for a building permit, in particular summary, precarious or temporary constructions.
- The Building Permit, it authorizes constructions after checking its conformity with the rules of the art and the rules of town planning.
- The certificate of Conformity, it makes it possible to destroy a building without endangering population, public goods or the direct environment…
- The certificate of Conformity, it makes it possible to verify compliance with the requirements of the building permit with the work carried out.

It should be noted that in the city of Limbe as in all the urban centers of Cameroon, these regulatory provisions are trampled underfoot by the populations and the complacent authorities who generally react too late, that is to say after an event of a flood or a mass movement. In addition, only a few large agglomerations have up-to date urbanization documents. This is how we see visual navigation in most cities.

4.1.1.3 Institutions involved in sustainable spatial planning and natural risk management

4.1.1.3.1. MINAT and the Directorate of Civil Protection

Civil protection is the set of means to be implemented to ensure the protection of the civilian population, property and means of economic production before, during and immediately after a large-scale crisis situation. In Cameroon, civil protection is a service of the Ministry of Territorial Administration. This is the Directorate of Civil Protection (DCP). It is organized into two structures, the Studies and Prevention Unit (CEP) and the Coordination and Interventions Sub-Directorate (SDCI). The definition of the missions of the civil protection department has been the subject of several official texts. In particular, the law of 1973, the law No 86/016 of December 6, 1986 relating to the general reorganization of the civil protection

and more recently the decree No 2005-104 of April 13,2005 relating to the organization of MINATD. Its mission is as follows:

- General organization of civil protection throughout the national territory
- Study civil protection measures in peacetime as in wartime, in conjunction with the administration concerned,
- Ensure relations with national and international civil protection organizations,
- Prepare training courses for civil protection personnel in conjunction with the Human Resources Sub-Directorates,
- Examine requests for compensation and financial aid from people who are victims of calamities,
- Control the use of aides,
- Coordinates the means of implementation for civil protection, in particular relief, rescue, logistics, the use of auxiliary and auxiliary forces,
- Transfer bodies in the event of a disaster,
- Monitor the management of aid

It should be noted that as a service of the Ministry of Territory Administration, civil protection is provided in the regions by the governors, the senior divisional officers (SDO) in the Divisions and the Divisional officers (DO) in the sub divisions. These managers are each responsible for coordinating the resources available in the event of a crisis. The Civil Protection Department works in close collaboration with several other private, public national or international organizations.

- The National Civil Protection Council (NCPC), it is a consultative body placed under the authority of the Secretary General of the Presidency of the Republic,
- The National Risk Observation (NRO) responsible for collecting, processing, storing and disseminating information on risks
- The National Disaster Prevention and Management Program (NDPMP), which is an organ developed in partnership with the UNDP whose objective is to strengthen the managerial, material and logistical capacities of the Government in terms of planning, prevention and disaster management,
- International facilitation institutions (UNDP, UNICEF, WHO, IFRC)

All these institutions have their representations in the city of Limbe. Their actions have been observed several times in the field, either in raising of awareness of the populations

in relation to their vulnerabilities or in times of crisis to provide assistance to the victims and facilitate their social integration.

4.1.1.3.2. The Limbe Urban Community and its Sub Divisions

Cameroon is generally considered in Sub-Sahara Africa as one of the rare countries whose urban landscape is distinguished by a relatively equilibrated multipolar structure.

Despite of its character as an essentially rural country undergoing urban and industrial mutations, the government of Cameroon always singularize itself from other African countries through a strategy of urban development that does not only privileged Douala and Yaounde as metro poles, nor secondary centers such as Garoua, Bamenda, Bafoussam and others, but also regional centers like Limbe. Administratively, its decree n°2008 of 17 January 2008 created in the Limbe agglomeration, an urban community known as « The Limbe Urban Community » with the head office at Poh. The Limbe Urban Community is called “Limbe Town” It is made up of 3 sub divisions:

- The Limbe I sub divisional council with head office at POH whose territorial limits are those of the Limbe I sub division;
- The Limbe II sub divisional council with headquarters in MOKONDANG whose territorial limits are those of the Limbe II sub division;
- And the Limbe III sub divisional council with head quarter in BIMBIA with it territorial limits being those of the Limbe III sub division.

The urban community of Limbe and the various Sub divisions are the organs in charge of the urbanization of the city. Their mission is to supervise the development of the city with strict application of the urbanization rules provided by the urban planning codes in Cameroon of 2004 or other prospective texts carried out under the authority of the Ministry of Urban Development and Housing (MINDUH).

With regards to RM, these decentralized local authorities are charged with the duty of ensuring follow-up in accordance with the codes governing urbanization and construction in Cameroon. As structures issuing the recommended documents (the town planning certificate, Building permit, the certificate of conformity etc.) Prior to the occupation of any urban space, the local decentralized authorities are versed with the powers of prohibiting by all means any

human installations on high-risk areas. In this case, flood prone valleys and steep slopes are prohibited by the councils.

Looking at the city of Limbe, there is a significant resignation of the various authorities especially between the late 20th century and present during which the city has experienced an anarchic ex tension towards the in constructible sectors of the Mabeta new lay out, mile two, Banjo, Mawoh and others. The surveys carried out in these districts have revealed a certain explanation for this situation that can be observed in many parts of Cameroon.

4.1.1.4 Acts of reprisals

All the texts in Cameroon for sustainable development and town planning provide measures making it possible to imposed strict respect for the regulations on the population. Thus, after the official notice procedure by the authorities to the population, the national security services or the municipal police are used to carry out acts of sanctions on the ground. According to law n$-^{o}$ 74/23 of December 5th 1974 on municipal organizations in Cameroon precisely in its article 72 empowering the mayors to demolish any building built in violation of the urban planning laws. Thus, the mayor has the powers to demolish any house built in an in constructible zone defined by law n$-^{o}$2004/003 of April 21st 2004 relating to the urban planning codes in Cameroon restricting any construction in areas exposed to natural risk (floods, landslides, earth quakes, volcanic mountains). Cartographic analyses of the city of Limbe shows certain build up areas are highly exposed to natural risk. To be précised the valley areas along the Djenguele river or river Limbe that are exposed to constant flooding on yearly bases and the high slope areas of the volcanic cones and the hilly areas such as Bonjo, M.N.L.O, mile two, unity quarters, Mawoh etc. It's worth mentioning that the administrative head in the city of Limbe has done much in terms of evacuations though not as some major cities in Cameroon like Yaoundé. There is a great effort put in place by the urban authorities in terms of restricting the construction on risk zones. This is clearly seen by an 'X' marked on buildings that doesn't respect building codes.

It should be noted that in the city of Limbe there is a certain level of understanding among the various classes in the society. A town like Limbe with about 85% of her population living on poverty with a low standard of living makes the authorities feel pitiful hence the difficulties in putting families on streets.

4.1.1.5 Building of improved drainage systems

In recent years in the city of Limbe and most especially in the flood prone neighborhoods, the have been numerous works on the drainage systems. The construction of wide and deep gutters eases the flow of water to the main channels. The building of gutters in the cassava farm communities has greatly helped in directing the water that is collected from the cassava farm hills to the main river channels. The photo 12 below shows the view of a wide gutter at cassava farm.

Photo 12: gutter build at the lower cassava farm

- At ‘a’ we can a solid wall of the gutter constructed with stones and concrete
- At ‘b’ is the high way where can equally see a speed break which is aimed limiting the speed of cars in other to reduce accidents.
- At ‘c’ we can clearly see the width of the gutter which is sufficiently wide and clear of any dirt making the flow of rain water easy.

(Photo by Eti, November2020).

From the picture above, the size of the gutter can be seen clearly. The population in this area attested during our field survey that since the construction of this gutters there have been a reduction in the intensity and frequency of the floods.

4.1.1.6. CLEANING OF DRAINAGE AND WATER COURSES

In order to ease the flow of water, the Limbe city council and sometimes the municipal councils cleaning of the water gutters and river beds. In the city of Limbe majority of the floods are been caused by blockage of water drainage systems. In poor and in accessible

neighborhoods were the households a lack waste collection service of the urban council has let the population to deposit waste in drainage channels for water to transport. To avoid flooding during the rainy season, the authorities usually clean the drains to prevent the uncontrollable overflow of water that end up in people houses. It should be remarked that this strategy is one of the best preventive measures of disaster management which is one of the missions of the NRO and also the decentralized local authorities.

4.1.1.7. Dredging, widening and straightening of the River Beds

The Limbe city council has of recent taken actions in the prevention of floods. There has been the dredging. Deepening, widening, and straightening of the regularly flooded rivers. This act in the past years have shown a positive result as the have been a limited effect of floods. When a river channel is straightened, water is force to much faster and freely as compared to when the river channel is meandering. When a river channel is meandering, the water doesn't flow free and the flood intensity is high especially when the rains are intense. Getting rid of the mud and rubbish obstructing the flow of water increasing the depth, width of the river hence giving it space to flow freely. A vivid example of this action is the April 29th to May 2nd 2016 dredging of the Djenguele River. This work is usually done during the early May before the beginning of the rainy season. Follow up shows that after several years of misery from floods, the population who occupy these areas hasn't experience floods from the year 2016 and 2017. It was a big sight relief for the people who benefited from the action. The mud removed from the dredge river was deposited as levees on the banks thus reclaiming vast patches of land that had turned to wasteland by being flooded every year.

Photo 13: Dredged Djenguele River at cassava farm.
Source: (Photo by prosper Eti July 2021

- ‘a’, shows the straighten Djenguele river channel.
- ‘b’ shows the mud that was excavated from the river channel.
- ‘c’ shows the widen river channel.

4.1.2. REACTIVE MEASURES

4.1.2.1. Assistance and evacuation of victims in an event of a hazard

As provided by the law, giving assistance and relief aides to the victim population is one of the major duties of the DCP. To add to the above, assisting the affected population is a national solidarity and it’s a moral obligation. It’s generally established that it’s because of the stubbornness of the population in respecting building laws that they always find themselves being affected by hazards and that they are responsible for their misfortunes. These acts of assistance are often seen in the field whenever a serious flood or landslide happens. It’s worth mentioning a few of the aides such as the aid provided by the state to victims of the June 27th 2001 floods and mass movements that claimed lives in several neighborhoods in the city of Limbe. The reaction of the SDO for Fako through the Governor of the south west region informed all administrative levels of the situation as law demanded. He through prefectural order n$-^{o}$94/2001 of July 2001 created a crisis commission that comprised of members from deferent field of works including the delegate for urban planning and housing, Del mines, water and energy, Del MINENP etc. It relied of a team of 725 persons of 230 were volunteers from humanitarian organizations. Financial resources of $65,000 were made available and material resources. Trucks of food items taken to SASSE where the destitute where relocated. Concerning the case of 2018 landslide Bonjo that claimed five lives at the spot can’t be forgotten as one of the victims during our field research accounted that the sum of 100,000frs CFA was given to him by the government in compensation of the loses encored.

4.2 The measures of adaptation and prevention employed by the population to cope with the type of risk they are exposed to

With regards to our field survey, more than ¾ of the population living in the risk zones in the city of Limbe are aware of the existence of the risk either before installation or when already installed. To be resilient in such an environment, the population had developed several strategies to prevent or to confront the risk. It worth noting that the best means of managing natural calamities is to avoid the environments that a subjected to the risks but nevertheless,

when such risk occur, some parts of the environmentalism theory or possibilism are bound to be applied.

4.2.1. Proactive measures applied by the population

4.2.1.1. Building of retaining walls in sloping areas

Retaining walls are a form of private adaptation strategy that is very popular with the population in the City of Limbe living on steep slopes. It's a concrete wall build to avoid landslides. The wall is built between the house and the area susceptible to collapse which is a mass of earth liable to slip. The plate below (plate7) shows and example of a retaining wall constructed at Bonjo about 50m from the side of the 2018 landslide.

Plate 7 : Retaining wall at Bonjo
Source: photo by Eti, November 2020

7A 'a': the front view of the house having the retaining wall.

- 7A 'b' is showing well slanted surface before construction.
- 7B 'a' showing maximum space between the retaining wall and the main building
- 7B 'b' showing a two-step retaining wall at Bonjo.

When retaining walls are properly constructed like the one above, they are highly effective in controlling landslides. It should be noted that the construction of retaining walls is highly expensive and greatly increases the cost of construction as a wall such as the one above can cost more than a million francs CFA which is a big amount that the poor population consider can build them a two room's apartment house. The low-income level of the population doesn't allow such investment.

4.2.1.2 Construction of flood dykes

To contain the water and prevent uncontrolled water invasion, the population habiting the swampy areas and closed to water bodies have built blockages along the rivers. Though this local dyke constructed by the population are often destroyed by flood waters but sometimes they are of very good help to the population and the level water that invades the houses is reduce due to the presents of the dykes. The plate 8 below shows barrier built along the Ongene River at lower Mawoh quarter in Limbe.

Plate 8: Barriers on the course of the Ongene river at Mawoh
Source: (photo by Eti November 2020)

On plat 8A,

- 'a' is showing a barrier constructed with car tyres filled with stones.
- 'b' shows the channel of the frequently flooded Ongene river
- 'c' shows a concreted flow to hold the tyres firm not to be wash away by flood waters.

On plate 8B,

- 'a' shows a concrete wall constructed to block water from flowing into houses and the road.
- 'b' is showing the regularly flooded bridge at the Ongene river at Mawoh
- 'c' is showing a cocoa nursery that has been destroyed by flood water.

Plate 7A shows a barrier raised with tires filled with stones and tires with concrete up stream of the regularly flooded Ongene River and plate 7B shows a concrete water barrier downstream of the same river to prevent water from invading the houses around. As per these barriers, we

were assured by the population during our field survey that since the building of the barriers there has been no major actuality in the rainy seasons.

4.2.1.3 Reduction of slope

Slope reduction is one of the methods used is ensuring slope stability. This method is widely used by many environmentalists especially road engineers and local inhabitants of risk prone areas. The height of a slope, its mass and its inclination are important determinants of mass movement. The steeper and longer the slope, the higher the risk of downward movements and vice versa. Slope reduction technics are applied on most of the Limbe high land areas. The most common slope reduction technic used in Limbe is the cut and fill method. This method involves the cutting of the higher slope levels to fill the lower parts. This widely practice in Limbe by the population of MNLO. Bonjo, Mbende, unity quarters who construct houses on steep slopes where they have to create a flat platform for their structure.

4.2.1.4. Terraces

It's an old technology long practiced in the hilly areas to solve the problem of mass movement. They are flat surfaces constructed on the across the slope in a horizontal form which forms a platform for reception of debris and crustal materials from the hill tops and slopes. The construction of this terraces firstly reduces the steepness of the slope and stabilizers the soil from other forms of mass movement. This is the most effective means of slowing the rate of soil creep and landslide since the altitude of the slope is reduced. (Nkwemoh, 1999, Lambi 1990, Fogwe 1997) photo 14 shows a typical example of terraces at the MNLO used for constructions on the volcanic cones.

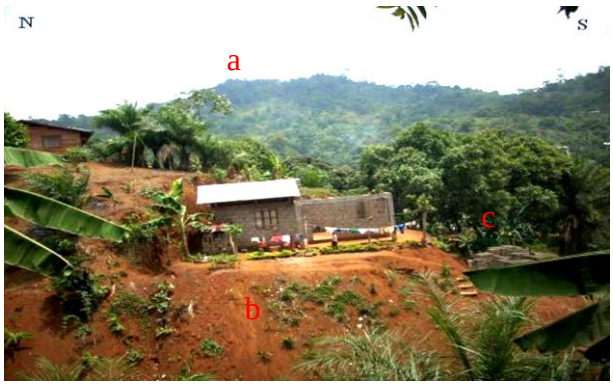


Photo 14: terrace on a hill at Bonjo (photo by Vivian che 2011)

- At ‘a’, we can see a terrace cut into slope to provide space for construction without any stabilization measures put in place.
- At ‘b’, we can the ground that was curt from the hill deposited without any support to hold it firm.
- At ‘c’, we can see steps that are arrange leading to the houses in the area.

4.2.1.5 Raising of foundations in the low land areas

In the city Limbe with more of its buildup space susceptible to floods, the population who can’t build in stilts which is the best means to live with floods turn to increase the height of the foundation of their houses. This is usually done by filling mud on the plot before construction. Some population who first build without predicting the flood events in the nearest future usually add embankments to their foundations and sometimes fill the surrounding environment of the house.

Plate 9: High foundation at Bonjo and clerks’ quarters to cope with floods (Source: Eti November 2020)

On plate 9A,

- ‘a’ shows a house that is still at the foundation level at Bonjo.
- ‘b’ is showing the length of the pillars.
- ‘c’ is showing very deep and large pillars holes that are filled with stones before planting the pillars.

  On plate 9B,
- ‘a’ is showing a barrier that is added to the raised foundation on the house at plate 9A.

- ‘b’ is showing the filled part of the house at plate 9A
  On plate 9C,
- ‘a’ is showing a raised foundation in a story building at clerks’ quarters.
- ‘b’ is an added barrier to in front of a house to prevent flood water from entering the house
- ‘c’ is showing wet ground that confirms that the area is constantly invaded by flood water.

For the population to construction on flood prone areas most especially on the marshy areas, they design the strategy of raising their foundations, this is typical to the population around the down beach areas and Bonjo as could be seen on the plat above a house constructed in a partially water area. This is very expensive to the population as just the mud that is used to fill such a foundation cost hundreds of thousands talk less of the cause of the pillars to support the house.

4.2.1.6. Escape from Danger

In the recent years, the intensification of the impact has led to the amplification of the occurrence of natural hazards most especially floods and landslides. The frequent occurrence has made many of the adaptation strategies ineffective. To totally be free from the devastating effects of this hazards, some of the population abandon their homes to seek refuge in safer quarters. This practice is very common with the inhabitance of the flood prone valleys in Limbe. Some quarters in Limbe are seasonally populated due to the environmental conditions of the quarters. During the rainy seasons, many people abandoned their houses and look for houses in safe quarters. There is a new in coming of the population to the quarters prone to flooding in the dry season by the population who are not aware of the situation on ground. The plate 10 below shows abandoned houses in the Mawoh farm area and the clerks’ quarter due to floods and an abandoned uncompleted building at Bonjo after 2018 landslide.

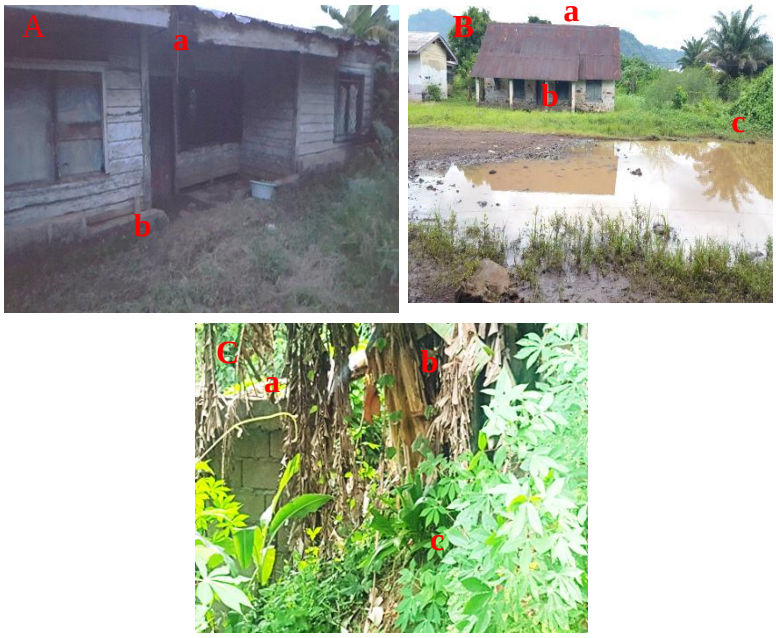


Plate 10: abandoned buildings due to floods and mass movement in Limbe

on plate 10A,

'a' is showing an abandoned plank house at Mawoh

'b' is showing a barrier built to stop floods which didn't work forcing the owners to leave the house.

On plate10B,

'a' is showing an abandoned block house at clerks' quarters Limbe

'b' is showing a barrier added to the foundation is other to stop flood waters from entering the house which did not still help the situation.

'c' is showing standing rain water beside the house at the middle of the road.

On plate 10C,

'a' shows a house that has been abandoned half way few about 2m from a slide at Bonjo after the 2018 landslide.

'b is showing stems of banana cultivated at the Bonjo landslide scar.

'c' is showing the Bonjo 2018 landslides scar that cause the lives of five persons.

Source : photo by photo Eti ; November, 2020

Plat showing abandoned houses (a) an abandoned house at the down beach quarter because of regular flooding, (b) an abandoned building without roofs some five meters beside the 2018 landslide in Bonjo.

From plate b above, the neighbors reported that the house was at completion before the occurrence of the 2018 landslide and the owner of the house willingly abandoned the structure because of the landslide event.

4.3. Limitations to risk management

The special development of the city of Limbe and risk management are confronted with several obstacles that destroy the efforts made by various actors. The lack of resources, the lack of proper planning, the absence of relief and the ambiguity of the administration are among others the Achilles hills with catastrophic impacts

4.3.1 The limits of state institutions

4.3.1.1 Insufficient planning

"Prevention is better than cure". This popular proverb also applies in risk management. To repair damages caused by hazards is generally beyond the capability of the population and even the authorities. However, a few majors or decisions taken by the authorities would help to avoid the risk. The city of Limbe due to its very difficult topography requires a certain rigor in its planning and the supervision of the horizontal extension. The city of Limbe has spent more than a decade without a master plan. The urban municipality of Limbe produced its first master plan in the year 1973 and the projects and planning envisaged in the plan were not realized which led to the production of another master plan in 1980. Coupled with the acceleration in population growth and the high level of urbanization, it was only in the 2011 that the document was renewed which is approximately 31 years later. This period of emptiness was marked by a visual navigation of the decisions of the urban authorities because of the lack of a general framing. All this accounts for the laissez-faire attitudes of the population in terms of constructions, the Is visible evidence as its clearly seen the extension of the city the areas at risk such as MNLO, Bonjo, mile two just to name a few.

4.3.1.2 LACK OF EMERGENCY ORGANIZATION PLAN (EOP)

The EOP is an emergency plan for disaster management. This plan constitutes for a country, a region, a division or a city an organizational plan set up in advance to face any kind of crisis that can threaten the lives or the properties of the population. In general, and EOP is organized into five departments according to the nature and ex tern of the event.

- First aid and rescue; provided by the firefighters, Red Cross Volunteers or any other rescue organization.
- Medical care and mutual Aid; provided by the UMAS and all other hospitals through the emergency service.
- Police and Information provided by the National security and the National Gendarmerie,
- Links and transmission, provided by the services of the inter-ministerial department for information and communication systems;
- Transport and works, provided by the delegation for Public works the administrative council of the district involved.

The plan is coordinated by the SDO or the governor through the management of the administrative part. The coordinator is advised by a representative from each of the departments. In Cameroon the EOP initiative belongs to the Ministry of Territorial Administration controlled by the DCP. According to decree $n - o$ 98/031 of 9 march 1998 providing for the creation of the Emergency Organization Plan. To date only a few Divisions, have an EOP or ORSEC in French. The Fako division is still waiting to be equipped with this device.

4.3.1.3 AMBIGUITY AND OVERLAPS OF JURISDICTION

A divisional headquarter, the city is divided in to three sub divisions. Thus, the authorities of different others interact in the management and development of the city. It quite true that the objectives of the administrators and stakeholders are the wellbeing of the population of the city but the recommended methods may differ. The presents of both elected and non-elected administrators in the city make developmental decision difficult this is expressed by the presents of endless quarrels among the administrators. At the level of the urban community then the government delegate is appointed all the mayors of the three sub divisional councils are elected. This cohabitation makes things difficult as the philosophy of the administrators are contrary on the ground, this situation is manifested by the constant contest of the administrative authorities by the majors. The blocking of the mayor's initiatives by the D.O. this state of affairs is aggravated by the lack of precisions of law n°87/015 of July, 1987 establishing the urban communities. For example, this law attributes competences in environmental management to both the Urban council and the sub divisional councils without specifying the field of interventions, scale or even less the possibilities of relay of competence between this institution.

This confusion renders any planning initiative in the city in effective and any synergy of the different stakeholders becomes impossible. Regarding the anarchic extension of the city of Limbe, to a greater extern can be accused to the collaboration of the sub divisional councilors and the population in other to secure a favorable position in the coming elections. With the implantation of the decentralized system of administration there by replacing the position of an appointed government delegate with an elected city mayor we hope that there will be a change in the management and development strategies in the city.

Furthermore, prior to crises or disasters, inter-sectorial coordination between DM agencies at the national, regional, and local levels is minimal. Senior disaster managers who were interviewed during our field survey indicated that supportive agencies and ministries to Cameroon's DCP rarely organize risk reduction related preparatory activities. Indeed, stakeholder agencies are requested to help mostly during crisis situations. At that moment, they struggle to provide their services because there have not been sufficient preparatory time and simulation exercises allocated to crisis planning. In these circumstances, agencies redefine their role to suit what they can offer, and not what they ought to offer. Agencies concerned with risk monitoring and assessment, logistics, and relief and rescue services fall within this bracket. A senior disaster manager, for example, mentioned specifically that officials' adherence to key texts also meant a corresponding restriction on the encouragement, level, and intensity of inter-sectorial cooperation. This was especially relevant in cases where DM planning documents, plans, and texts did not specifically stipulate in what form such cooperation should take place, demonstrating notable instances of inertia limitation.

4.3.1.4 LACK OF RESOURCES

By the end of the 1980s, Cameroon was confronted by a serious economic crisis which dealt a fatal blow to the whole country. This crisis has kept all sectors alert. During this crisis there was a downward revision of all budgets and a reduction in the income of the population. During this period, many structures were not able to keep their specifications there by reducing their services to the simplest expression. In the field of urbanization, the population has indulged in a laissez faire attitude.

Findings on the limitations in the provision of resources fall into three categories: insufficient human capital resources, insufficient financial resources, and insufficient material resources. The structural provision for disaster managers is not sustainable. The problem of lack of

professionally trained disaster managers at all levels of the DM system. Skilled disaster managers who can make strategic policies and plans on DRR in the country are not available. In reality, government administrators at the national, regional, and local levels (ministers, governors, divisional officers), who double as disaster managers (albeit without DM training) as well as other members drawn from diversified sectors of the society are all expected to assist during crises. A respondent further explained that such members, whose main jobs may be remote from DM, can be transferred to work in other regions of the country. As a result, the entire team may not be available when they are needed. They stressed that without disaster managers who can be deployed to work in particular locations on a permanent basis, probably based on their skills, and recruited and paid by the state, human resources for DM will always be lacking. To continue, transcribed interviews reveal key limiting factors exist around financial and budgetary aspects. In particular, that budgetary allocations for DRR and DM as a whole are not enshrined in legislation, are unavailable to cooperating DM agencies, and not even explicit within the operating budgetary provisions of the DCP.

The respondents highlighted that stakeholder ministries and agencies are reluctant to make any budgetary provision for DRR/DM because they do not consider disaster issues as part of their respective responsibilities. When a crisis occurs, the government pledges to provide financial support to the affected area, which in many instances is very limited, and many promises that involve huge funds are not kept. Because the DCP is not financially able to handle most crises, the presidency always intervenes to provide support. This lack of adequate financial resources heavily impacts disaster preparedness, and especially affects negatively on contingency planning for risk reduction, as the focus is more on crises management, when more resources are made available. Further findings also show that the provision of material resources for DRR is an issue. Respondents with technical DM knowledge and specialist responsibility criticized the lack of vital equipment needed for risk reduction activities. They mentioned that some key services lack the 4-wheel drive vehicles needed for fieldwork in remote areas. The lack of resources affects every service involve in civil protection such as the Emergency Medical Assistance Service (EMAS) which was created in Cameroon in the year 2004 charged with the mission of transporting and taking care of not only victims of accidents and disaster victims but also of other emergency patients to more equipped hospitals using ambulances containing medical equipment and quality emergency personnel. The EMAS gets the essentials of its resources from the contributions of the various member hospitals which are already struggling

to meet their needs. Hence the lack of deployment of these services to most towns in Cameroon and Limbe in particular.

4.3.1.5. DELAY IN DECISION MAKING AND ADMINISTRATIVE BOTTLENECK

One of the ways in which delays in decision making occur that was regularly cited among respondents relates to the desire for disaster managers to conform exactly and prescriptively to guidelines or written instructions on what actions to take before and during a crisis situation. The DM legislation is narrow, not explicit, and lacks clarity on responsibilities. Several reasons for this were cited. These include that local disaster managers did not have access to the respective texts, have not been empowered to understand the legislation, or simply did not bother to find out. At best, these tendencies represent the prevalence of top-down, hierarchical, and differential organizational behavior, adapted to and based on a highly legal-bound and document-based decision-making culture in DM. the issue of administrative bottleneck is evident in the fact that communication in pre-crisis and in crisis situations, bottom-up communication with and among institutions and disaster managers is not straightforward. Information goes through a long evaluation process, and is also hampered by complicated reporting procedures. The fact that that in an event of a crisis decisions cannot be taken by the decentralized local authorities it cumbersome for rightful decisions to be reached at most especially the administrative authorities making the decision do not know the exact situation on ground. In Cameroon, in the event of a crisis, the district administrator informs the senior district administrator who also informs the governor who interns informs the minister of territorial administration who finally informs the presidency about the event for decisions to be made. In the same manner in the response to the crisis, information leaves the presidency and follows the same procedure to reach the administrators in the field. This situation increases the time in which information reaches the decision makers hence in case of any even the is a possibility of an increase in the number of casualties.

Plate 11: structure of the disaster responds in Cameroon.

Institutions	Duties
PRESIDENCY OF THE REPUBLIC (The National Commission on Civil Protection, NCCP)	Defines policies, sets up the NCCP; harnesses national and international relief efforts
MINAT (DDES)	National supervisory authority of relief efforts; custodian of national disaster and emergency fund
REGIONAL GOVERNORS (Economic and Social Service; Regional Delegation of Social Affairs)	Coordinates disaster relief at the regional level.
SENIOR DIVISIONAL OFFICERS (Divisional Delegation of Social Affairs)	Supervisory authority at the divisional level, sets up local crisis commission with the approval of the Regional Governor
Sub divisional Officers/Municipal Councils/Local NGOs, and so on	Implement relief efforts

Source: adapted from Ndille and Belle

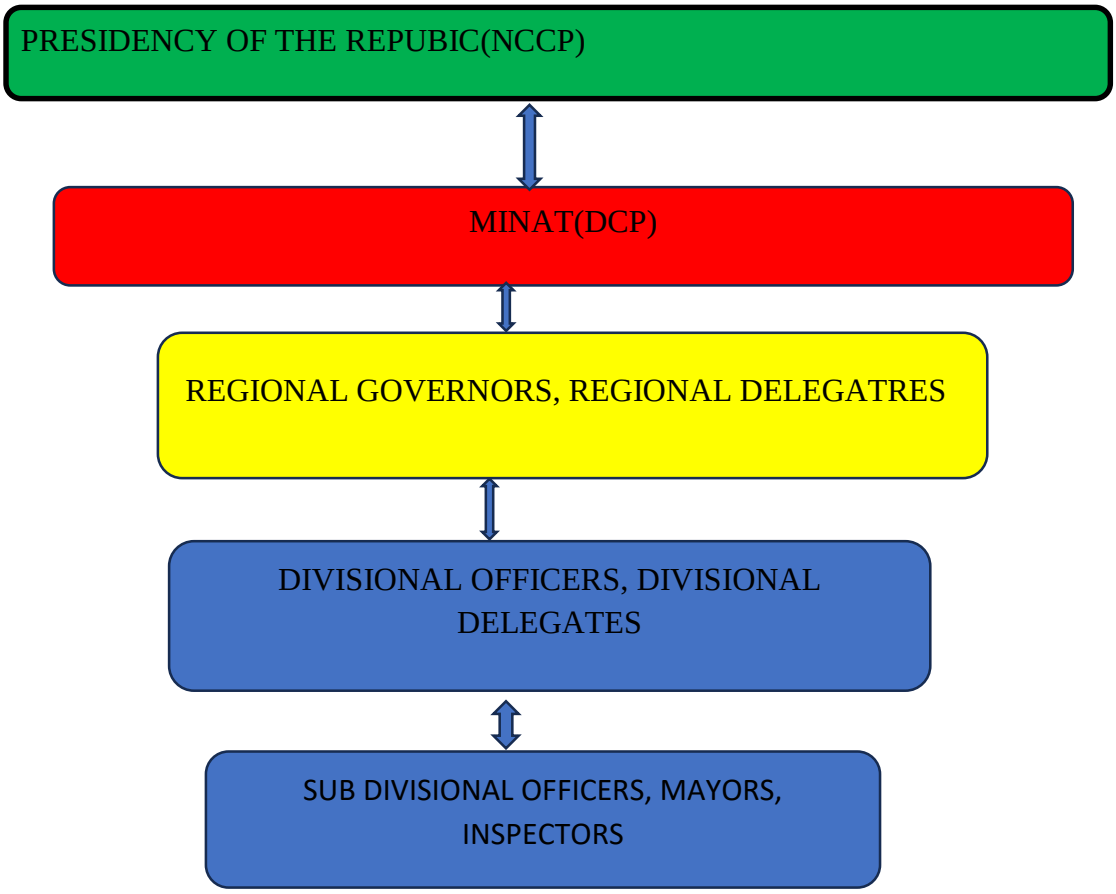


Figure 32 : Organigramme of DRM in Cameroon

4.4. Barriers Faced by the Population in taking adaptation and mitigation measures

In the city of Limbe where a majority of its population leaves in poverty, makes it very difficult for such a population to engage in an adaptation technic that is financially costly. From the questionnaire administered to households during our field investigation revealed several factors are responsible for the attitude of the population.

GENERAL CONCLUSION

Cameroon a country located in the tropical zone is characterized by a diverse relief feature which makes her a country with Numerous natural hazards that can be found in most African countries. The country from North to South presence a heterogenous terrains with each region experiencing at least on type of hazard. In this light we can cite floods and droughts in the Northern part of the country, floods, Landslides and volcanic activities in the southern, western highlands and coastal regions off the country. The occurrence these hazards are accounted for mostly by the physical milieu, the hydrology and the Changing climate. Notwithstanding, Man through his different land use practices have contributed to the occurrences of these hazards.

The objective of this study was to show how the Population of Limbe are Vulnerable to the effects of floods and mass movement.

This research was guided by a mix research method that comprised the administration of questionnaire, interviews and the consultation of documents from the internet and libraries.

From our study, it emerges that there is a high manifestation of floods and landslides in the city of Limbe and the population are highly vulnerable to these hazards, most especially the population inhabiting these risk zones that are highly expose to the harmful effects of this hazards.

It's worth recalling that the main risk (floods and Landslides) is in function of the physical milieu that is taking into account the topography, hydrographical conditions of the areas. The areas in the city that are marked by steep slopes such as Mbonjo, Mbende, Mawoh quarters are known for the frequent manifestation of mass movement while the valley areas that also have a very low altitude drained by many rivers such as the Down Beach, Motowoh, Clerks quarters and Dockyard are areas exposed to flood risk. The risk in this city is mostly rain fed as they occur mostly during the heart of the rainy season between the months of June and October. It is observed in this research that the main causes of floods and mass movements are nature based that is aspects such as the relief, the soil type, presents of numerous water bodies, the un predicted nature of rain fall but also man has in the recent years through his different methods of land exploitation has modified this physical environment that provoked the recurrent occurrence of these hazards.

In terms of the impact of natural hazards in the city of Limbe, floods have caused a total recorded number of 74 dead between the year 1989 to 2018 and landslides have also caused the dead of 33 persons which are majority of woman and children between the 1990 and 2018.

These loses range from human lost to material damages and it's difficult to provide the details on the impact of natural risk in the city due to the fact that there was limited data concerning the occurrences and casualties most especially as the population even hide the occurrence of some landslides in their area for fear of the authorities.

The damages caused by natural hazards in the city of Limbe are an outcome of the vulnerability of the population. The vulnerability to natural hazards in the city of Limbe is linked to socio-cultural, economic, institutional and political factors. The natural environment itself in which the city is sitting makes her very vulnerable added to this, poverty, poor risk perception, high demographic pressures, lack of road infrastructures poor construction, lack of emergency service are among others the indicators that have guided the study of vulnerability in this city. The above-mentioned aspects have put the city of Limbe at risk of damage in the occurrence of any hazard especially the poorly constructed neighborhoods.

In other to reduce vulnerability and increase resilience, the government through her institutions and laws have set out guides and regulation for the development of the urban spaces (Law n^{o} 24/003 of 21st April 2004), mapping of risk zones, also she is also carrying out reactive measures during the occurrence of risk. The population on their side are also involved with different adaptation strategies which are either proactive or reactive in other to cope with the risk they are faced with. Actions such as the raising of foundations, the escapes from risk, building of barriers to flood waters and retaining wall for landslides, are among others at the forefront of the adaptive measures put forth by the local population. The main fear hear is that all these strategies employed take into account only the present conditions without considering the dynamics that are involved in our societies which make them obsolete. All stakeholders are invited to a renewed commitment to sustainable land use planning and adaptation to natural hazards to avoid an upsurge in damage in the nearest future.

As perspective we aspire to use the scientific work as a base for our further Research that will cover a wider scope in the future.

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APPENDIX

UNIVERSITÉ DE YAOUNDÉ I
****
FACULTE DES ARTS, LETTRES
ET SCIENCES HUMAINES
****
DEPARTEMENT DE
GEOGRAPHIE
****

THE UNIVERSITY OF
YAOUNDÉ I
****
FACULTY OF ARTS, LETTERS
AND SOCIAL SCIENCES
****
GEOGRAPHY DEPARTMENT
****

APPENDIX 1

Questionnaire to household

This questionnaire is intended to acquire information to establish a thesis on ''The vulnerability of the population to the effects of floods and mass movement in Limbe''. Any information obtained will be used exclusively for this purpose. Place a tick in the appropriate boxes.

QUESTIONNAIRE N°_____

Date _____

(A) IDENTIFICATION OF THE RESPONDENT

1, Name and surname: ----------

2, sex: Male ☐ female ☐

3, Age: (i) <19 ☐ (ii) 20-39 ☐ (iii) 40-59 ☐ (iv) 60^{+} ☐

4. Marital status(i) Single ☐, (ii)Married ☐, (iii) Divorced ☐

5, Religion (i) Catholic ☐ (ii) Muslim ☐ (iii) protestant ☐

other; (specify) _____

6, Level of Education:

(i) Educated ☐ (ii) Uneducated ☐

7, If educated, identify the highest level of education. (i) primary ☐ (ii) secondary ☐ (iii)high school ☐ (iv)university ☐ (iv) others;(specify) _____

8, Main occupation of the correspondent

(i)Agriculture ☐ (ii) commercial ☐ (iii) Artisan ☐ (iv) civil servant ☐

(v) others specify_____

9, Monthly revenue: (i) <50,000 ☐ (ii) 50000-99000 ☐ (iii) 100000-499000 ☐

(iv) 500000+ ☐

10, which aspect corresponds to your highest monthly expenditure?

(i)Health ☐ (ii) feeding ☐ (iii) rents ☐ (iv) education ☐

(v) others; (specify) _____

11, Are you a native of Limbe? (i)Yes ☐ (ii) No ☐

12. if no where do you come from? (i) NW ☐ (ii) Centre ☐ (iii) Littoral ☐

(iv)West ☐ (v) South ☐ (VI) East ☐ (vii) North ☐ (viii)Far north ☐

(ix) Adamawa ☐ (x) SW but not Limbe ☐ (xi) out of Cameroon

(please specify) _____

13,If (11), how long have you stayed in Limbe? (i)Month ☐ (ii) years ☐

14, Is this your first residence since your stay in Limbe? Yes ☐ (ii) No ☐

15, If no, where were you living? (Please specify name of Quarter)

_____

16, what reasons made you to leave your previous quarter (i) expensive ☐ (ii) far from work ☐

(iii) others; specify _____

17. Why did you choose this Quarter?

(i) Cheap ☐ (ii) close to job site ☐ (iii)close to Family ☐

(iv) others(specify) _____

18, Are you the owner of this land (i) Yes ☐ (ii)No ☐

19.If yes, how did you acquire the land? (i)Purchase ☐ (ii) Inheritance ☐ (iii) Give ☐

(iv) Others (specify) _____

20. Do you have a land tittle? (i) Yes ☐ (ii) No ☐

21. If no why (please specify) _____

22. Do you own a construction permit? (i) Yes ☐ (ii) No ☐

23) Source of drinking water? (i) SNEC ☐ (ii) bow holes ☐ (iii) Wells ☐ (iv) stream ☐

(v) others; specify_____

24.If SNEC, is the supply regular? (i) Yes ☐ (ii) No ☐

25. Do you participate in quarter association? (1) Yes ☐ (ii) No ☐

(B) Risk and Causes

(I) mass movement

26. There is recurrent Landslide in your quarter

(i) Strongly agree ☐ (ii) Agree ☐ (iii) Indifferent ☐ (IV) Disagree ☐
(v) Strongly disagree ☐

27. There is recurrent Rock fall in your quarter

(i) Strongly agree ☐ (ii) Agree ☐ (iii) Indifferent ☐ (IV) Disagree ☐
(v) Strongly disagree ☐

28. There is recurrent Mudflow in your quarter

(i) Strongly agree ☐ (ii) Agree ☐ (iii) Indifferent ☐ (IV) Disagree ☐
(v) Strongly disagree ☐

29. Soil creep is very common in your quarter

(i) Strongly agree ☐ (ii) Agree ☐ (iii) Indifferent ☐ (IV) Disagree ☐
(v) Strongly disagree ☐

30. There is a recurrent of rotational movements in your quarter

(i) Strongly agree ☐ (ii) Agree ☐ (iii) Indifferent ☐ (IV) Disagree ☐
(v) Strongly disagree ☐

31. Do you Know / had an idea about the Risky nature of this quarter before your installation?(i) Yes ☐ (ii) No ☐

32.If yes, why did you still choose to install here?

(i) Cheap ☐ (ii) close to job site ☐ (iii)close to Family ☐ (iv) others; specify_____

33) What is the frequency of occurrence of this risk? (i) Every year ☐ (ii) ½ a year ☐
(iii) Others, specify; _____

34. Digging of sea walls greatly causes landslides

(i) Strongly agree ☐ (ii) Agree ☐ (iii) Indifferent ☐ (IV) Disagree ☐

35. According to you what are the causes of landslide in your quarter? (i) Prolonged intense precipitation (ii) ☐ Volcanic eruption ☐ (iii) flooding ☐ (iv) deforestation
(v) constructions ☐

(II) Flooding

36. Flood is very common in your quarter (i)strongly agree ☐ (ii) Agree ☐ (iii) indifferent ☐ (iv) disagree ☐ (v) strongly disagree ☐

37. Do you Know / had an idea about the Risky nature of this quarter before your instal☐ion?(i) Ye☐ (ii) No

38. If yes, why did you still choose to install here?

(i) Cheap ☐ (ii) close to job site ☐ (iii)close to Family ☐ (iv) others ☐;

specify_____

39) What is the frequency of occurrence of this risk? (i) Every year ☐ (ii) ½ a year ☐

(iOthers, specify; _____

40. What is your means of waste disposal?

(i) Recycling ☐ (ii) Bury in the ground ☐ (iii) in a water course ☐

(iv) In the bushes ☐ (v) others; specify_____

41. In which period of the year does this risk occur?

Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec

42. According to you what are the causes of floods in your quarter? (i) poor drainage system ☐ (ii)Heavy rains ☐ (iii)lack of vegetation ☐(iv) over flowing rivers ☐ (v) sea tides

© **Vulnerability**

43. The position of the house (i) On a hill (ii) On a flatland ☐

(iii) Beside a water course ☐ (iv) On a swampy area ☐

44. What is the material use for your floor?

(i)Soils ☐ (ii) Cement ☐ (iii) Tiles ☐ (IV) Planks ☐

(v) Others (specify) _____

45) What is the material use for construction (i) Mud and Bamboos ☐ (ii)Breaks ☐

(iii)Planks☐ (iv) cement blocks ☐ (v) Others; specify_____

46. what is the material used for roofing? (i) concrete ☐ (ii)zinc ☐ (iii) Tiles ☐

(IV)Others; specify _____

47) Number of rooms ☐

48) Number of persons ☐

49. Who are the people that are most affected in the occurrence of this phenomenon?

(i) Old ☐ (ii) women☐ (iii) men ☐ (iv) Children ☐

50. What are the objects affected in this city by mass movement?

(i) Roads ☐ (ii) building (iii) farm lands ☐ (iv) commerce ☐

(v) others; specify _____

51. What are the objects affected in this city by mass movement?

(i) Roads ☐ (ii) Houses (iii) farm lands ☐ (iv) bridges ☐

(v) Others; specify_____

52. Do you know any person that has left this quarter because of floods?

(i)Yes ☐ (ii) No ☐

53. Are there any abandoned houses in your quarter?

(i) Yes ☐ (ii) No ☐

54. If yes, why did they leave the houses?

(i) Floods ☐ (ii) mass movement ☐ (iii) Relocation ☐

(iv) Others; specify _____

55. Which type of toilet do you use ?

(i) pit toilet ☐ (ii) cistern toile ☐ (iii) pour flush toilet ☐ (iv) Becket toilet ☐

(D) Different adaptation strategies

56. Are you victim of mass movement? (i) Yes ☐ (ii) No ☐

57) If no, how do you manage not to be affected?

My house is located far from the risky zone ☐ (ii) build a wall ☐ (iii) maintain vegetation ☐

(iv) others; specify_____

58. If yes, have you taken any disposition to stop the risk? (i)Yes ☐ (ii) No ☐

59) If no, why? (i) I don't have an idea on how to prevent mass movement ☐

ii) expensive to prevent ☐ (iii) others; specify_____

60) If yes can you explain to us how? _____

_____

61. Are you victim of floods? (i) Yes ☐ (ii) No ☐

612) If no, how do you manage not to be affected?

My house is located far from the risky zone (ii) build a wall (iii) maintain vegetation

(iv) others; specify_____

63. If yes, have you taken any disposition to stop the risk? (i)Yes ☐ (ii) No ☐

64) If no, why? (i) I don't have an idea on how to prevent floods (ii) expensive to prevent

(iii) others; specify_____

65) If yes can you explain to us how? _____

_____

66. In terms of Risk (Floods/mas movement) have you ever received an external Aid?

(I)Yes ☐ (ii) No ☐

67) If Yes, from who? _____

68) What kind of Aid? (i) Financial ☐ (ii) Material ☐ (iii) Moral ☐

(iv) Others specify_____

69) Do you Know organizations in town specialized in the management of Risk?

(i)Yes ☐ (ii) No ☐

70. If yes, can you list them?_____

71. Have you ever receive help from them? (i) Yes ☐ (ii) No ☐

72. Do you know persons who have benefited from their services? Yes ☐ (ii) No ☐

73. Has actions been taken in your quarter to limit the effects of floods and mass movement?

(i)Yes ☐ (ii) No ☐

74. If yes, what are the actions**? (i) Planting of trees ☐ (ii) Building of barriers ☐**

(iii) Putting of early warning systems ☐ (v) Building of good drainage system ☐

75. If No, why? _____

_____

76. Have you noticed any change in the effects of floods and mass movement due to adaptation strategies? ☐(i) Yes ☐ (ii) No

77. if yes can you estimate the change? _____

78. What are the barriers you face in taking adaptive measures? Choose from the table below:

Barriers to adaptation	Put a star on the main barriers and a tick on others that you face
Lack of information about the causes of floods and mass movement	
Lack of knowledge concerning appropriate adaptation	
Inadequate finances	
Shortage of facilities	
Others if any (please specify)	

Appendix 2

REPUBLIQUE DU CAMEROUN
Paix – Travail – Patrie

REGION DU SUD-OUEST

DEPARTEMENT DU FAKO

PREFECTURE DE LIMBE

No. ...../G.37/.../...../VOL...../3AP

REPUBLIC OF CAMEROON
Peace – Work – Fatherland

SOUTH WEST REGION

FAKO DIVISION

DIVISIONAL OFFICE, LIMBE

Limbe, the 05 NOV 2020

The Senior Divisional Officer, Fako

TO:

Mr. ETTA PROSPER ETI,
Department of Geography
Faculty of Arts, Letters and Social Sciences
University of Yaounde I
-Yaounde -

Subject: **AUTHORISATION TO CARRY OUT ACADEMIC RESEARCH**

Following your application dated 3rd November 2020, soliciting for an authorization in relation to the above subject matter,

I hereby convey my approval for you to carryout research on "**Vulnerability of the population to the effects of floods and mass movement in Limbe-Fako Division**" for a period of three (03) months beginning from the **November 2020 to March 2021.**

However, you shall always contact the Divisional Officers of the area for close follow-up (Limbe I, Limbe II and Limbe III) of your activities.

Copy:
- GSWR/Buea
- DO'S/Limbe I, II & III
- FDS/Fako
- File/Chrono

FOR THE SENIOR DIVISIONAL OFFICER
FOR FAKO AND BY DELEGATION
THE THIRD ASSISTANT S.D.O

BIYELE NOAH JOEL
SECRETAIRE D'ADMINISTRATION