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Population Mitigation Strategies to Geomorphic Hazards in Limbe West Coast, South West Region of Cameroon

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Environmental hazards are one of the main problems affecting humanity, especially human settlement in hazard prone zones. The study investigates the population strategies to mitigate geomorphic hazards in Limbe within the past 20 years. Data collected through a sample of 200 questionnaires and interview, were analyzed using both qualitative and quantitative statistical techniques. The results reveal that geomorphic hazards have been recurrent in Limbe particularly in the months of June, July and August where the average number of days for rainfall is 27 days in a month. The frequency of hazards occurrence is very often and is highly significant at P=0.000. It also reveals that mitigation measures such as raising foundation, use solid structures and embankments, vary from one area to another within the selected sample sites. Thus, the management strategies to mitigate geomorphic hazards are still lagging behind as there is lack of sensitization/education, good rehabilitation schemes on the part of the authorities to make

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population avoiding flood and landslide prone zones. Therefore, there is need of management plan for geomorphic hazards in particular and disaster risk management in general that should integrate all stakeholders for a co-management between the Limbe city council and the communities in risk prone areas.

Keywords: Geomorphic hazards; population vulnerability; mitigation strategy; Limbe West Coast.

1. INTRODUCTION

Many geomorphologic disasters such as landsliding, and/or flooding take place threatening the environment and humans. These geomorphologic events are natural hazards. They occurred simultaneously with the appearance of the human system, when human beings began to interact with nature [1]. The term natural hazards are phenomena which threaten or act hazardously in a defined space and time. Different conceptualizations of natural hazards have not only evolved in time, they also reflect the approach of the different disciplines involved in their study. Natural hazard has been expressed as the elements in the physical environment harmful to man [2].

By examining the different definitions of natural hazards and natural disasters, it is clear that the conceptualization has changed from a perspective of a merely physical or natural event, towards the integration of the human system. Recently, attention has been paid to the prevention, reduction and mitigation of natural disasters by creating a Scientific and Technical Committee of the International Decade for Natural Disaster Reduction (IDNDR). As such, much literature has been written on the mitigating strategies of various geomorphic hazards throughout the world. The World Conference on Disaster Reduction (WCDR) held in Kobe, Japan in January 2005, was an excellent opportunity to take stock [3,4]. The Hyogo Framework for Action agreed on during this conference gave the mandate and set the direction for professional, scientists, individuals and institutions alike. Among other priorities, it defines the development of indicator system for disaster risk and vulnerability as one of the key activities enabling decision makers to assess the possible impact of disaster. In the case of Limbe, decision makers are slow in the implementation of these policies to manage hazards. Eze [5] also added that there has been a general and rising interest among nations and states on environmental issues most especially environmental protection since after the United Nations Conference on Environment and Development (UNICED), Municipal Councils have created departments concerning environmental protection. This is in line with curbing most of the environmental effect on man and development.

For sustainable management of environmental effect on man Bang et al. [6] emphasized that for flood risk in Africa the government urgently needs to review its disaster management policies to be more proactive and strategic in flood and landslide management in order to enhance human security and prevent permanent change to livelihood at the micro economy regions. According to IFRC [7], flood and landslide management is at the top of many government agenda as a result of climate research which indicated that the number of days of extremely heavy rainfall is raising by between 1 per cent to 2 per cent each decade there by contributing to an increase in the frequency and intensity of floods and landslide worldwide.

In an attempt to present an inventory of landslide and risk zone along the Rio Grande basin in the Central Andes of Mendoza, Espizua and Bengochea [8], mapped landslide risk zones in view of natural hazards and the degree of loss to show that the first step in mitigating geomorphic hazards is by identifying or calving out the areas prone to risk. Therefore, Ciurean *et al.* [9] indicated that many efforts should be made to engage more proactive approach, involving mitigating and preparedness strategies. According to World Bank, Natural Disaster Risk Management [10], experience has shown that the disaster management system tends to rely on a response approach. However, studies indicate that efforts are being made to engage more proactive approaches, involving mitigation and preparedness strategies. The capacity to anticipate and avoid being affected by an extreme event requires different assets, opportunities, social network, and local external institutions from capacity to deal with impact and recover from them [4]. The emphasis should be put on the capacity to anticipate risk, capacity to respond and capacity to recover. He added that capacity to reduce risk prevention and reduction may be understood as a series of elements, measures and tools directed towards intervention in hazards and vulnerabilities with objectives of

reducing existing or controlling future possible risk. According to IFRC, [7], effective response requires substantial preplanning as well investment in disaster preparedness and early warnings (not necessary in terms of financial cost but particularly in term of awareness raising and capacity building). The capacity to recover is not only dependent on the extent of a physical impact but also on the type of socio-economic activities.

On the management of disaster in Cameroon, Bang [11], noted that civil administrators who act as chief disaster managers in their areas of jurisdiction at the national, regional and local level, frequently do not have the necessary disaster management training or skills. He added that compounded by the hierarchical top down power structure for the governance of disaster risk, such personnel will inevitably struggle to manage flood and landslide risk. In the same vein, Forgwe and Asue [12] and Tchotsoua, Aboubaka, and Fotsing [13] suggested the lasting mitigating measures should become an urban governance.

With the frequent occurrence of landslide and flood in Limbe within the few past years, management of these hazards is one of the top priorities of the government. Therefore, to understand clearly natural hazards and the efficient management of natural hazards, this study investigates the population mitigation strategies to geomorphic hazards in Limbe within the past 20 years. Geomorphic hazards are threatening events occurrence frequently in Limbe west coast of Cameroon and they are causing damage to the physical and social space where they take place not only at the moment of their occurrence, but on a long-term basis due to their associated consequences. It is the consequences of their major impacts on society and/or infrastructure that call for attention to the vulnerability of the populations by assessing the mitigation strategies of the inhabitants facing the unforeseen.

2. MATERIALS AND METHODS

The study of the population strategies to mitigate geomorphic hazards was carried in Limbe located between 4°20'-4°57' N and between 9°06'-9°14' E (Fig. 1). This area is situated on the coast of Atlantic Ocean at the foot of mount Cameroon.

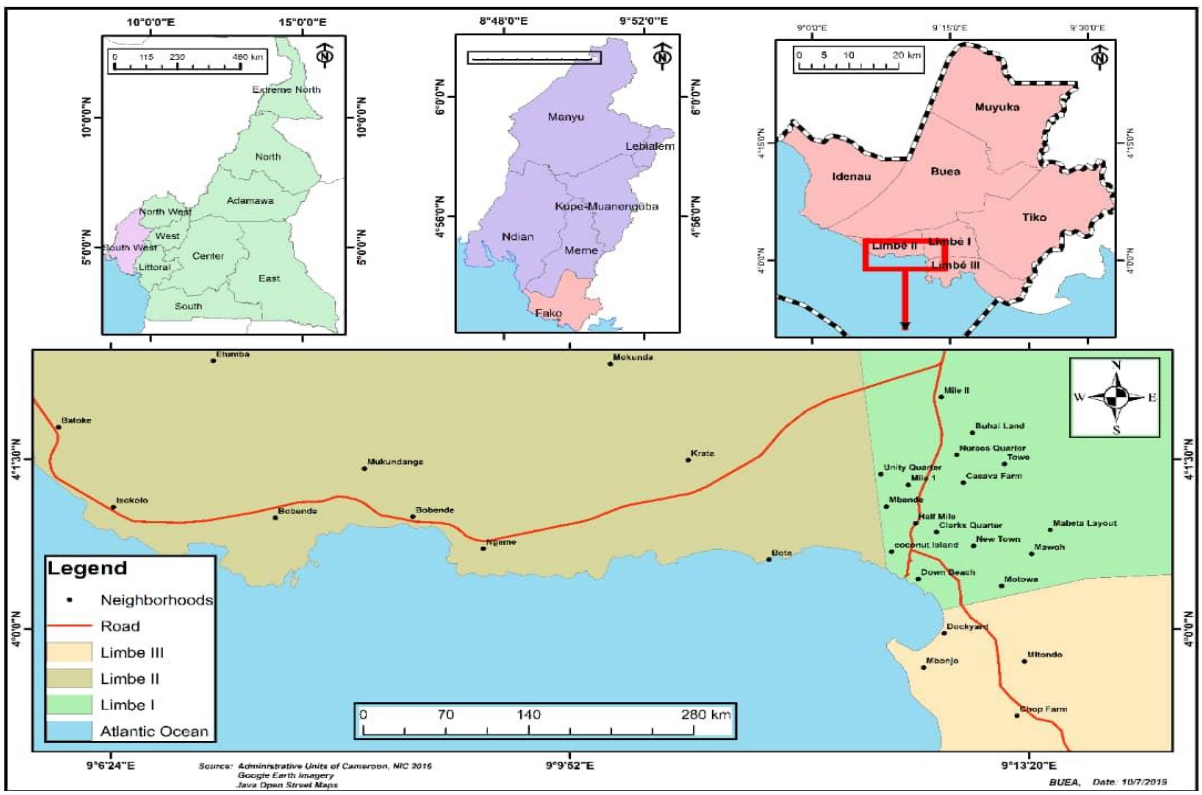

Fig. 1. Location of study area

Source: Extracted from Administrative Map of Cameroon, NIC, 1985

To investigate the population mitigation strategies to geomorphic hazards, the study uses an approach based on population perception by administering a questionnaire to a sampled population determined from the Krejcie and Morgan [14] sample size determination. This sampling technique used help to extract from the target population a sample of 200 respondents to whom questionnaires were administered (Table 1). The samples were not uniformly distributed but according to the nearness to hazard prone zone. The areas were systematically selected among the areas of floods and landslides based on the occurrence evidence of floods and landslides in the sites. Information on the occurrences of hydro-geomorphic hazards, their factors, the population strategies and the management techniques of floods and landslide were obtained from the risk zones of Limbe.

Firstly, to investigate the geomorphic hazards in Limbe, data were collected through field observation of the occurrences of floods and landslides. Geomorphic hazards were categorized based on the frequency and severity of effect on the inhabitants in the study area. Consultation of secondary data from the Council and the Delegation of Environment and Nature Protection was undertaken to know the number of times floods and landslides have occurred Limbe.

Secondly, to characterize the measures to mitigate geomorphic hazards in Limbe, data were collected mainly through field observation as well as quantification of strategies such as; raised foundations, number of solid structures, embankments, number of river channels that were widened, creation of awareness and average rehabilitation strategies in the selected sample sites. Interviews were done with the officials of the Council in charge of the environmental protection, the Divisional Delegate of Housing and Urban Development (on land management in Limbe), and personnel of the Divisional Delegation of Environment and Nature Protection in Limbe. This was to assess the measures put in place within the study area and by International Institutions to mitigate floods and landslide in the study area.

Data obtained on the occurrence of geomorphic hazards were analysed using the descriptive statistical techniques. This involved the use of frequency tables and graphs in analysing and interpreting the data on hazards developed to show the frequency of occurrence of floods and landslides as well as pictures to show the manifestation of the phenomenon.

Base on the measures to mitigate the effects of flood and landslide, analysis was geared towards comparing the mitigation measures with the Sandai Declaration Framework on Disaster Reduction, mainly based on “creation of awareness”. For this statistical analysis through descriptive techniques used such as frequency tables to present the classification of the various measures, and the adopted measures by International Organizations. There was the calculation of percentages from the observed frequencies and calculation of p-value to know the level of significance of each indicator. Presentation was on bar graphs and pie charts to show the clear illustration of the various structural and non-structural measures put in place to mitigate hazards in the study area. Pictures were taken of some of the measures put in place by the inhabitants and stakeholders to manage geomorphic hazards in Limbe.

Table 1. Selected sample sites for questionnaire administration

Hazard Types	Sampled Sites	Number of questionnaires	Percentage (%)
	Mbonjjo	25	12.5
	Down Beach	20	10
Floods areas	Clerks Quarters	25	12.5
	Church Street	15	7.5
	Cassava Farms	15	7.8
Sub-total		100	
	Mabeta Hill	20	10
	Mbende Hill	25	12.5
Landslides areas	Coconut Island	15	7.5
	Mbonjo HILL	15	7.5
	Mile 2 Hill	25	12.5
Sub-total		100	
Grand Total		**200**	**100**

Source: Fieldwork (2022)

3. RESULTS AND DISCUSSION

3.1 Characteristics of the Area and Occurrence of Geomorphic Hazards in Limbe

Relief characteristics of Limbe: The study site is characterized by Steep slopes 58.2%, marshy soil 36.0%, creeping soil 27.5% and sedimentation 20.6% (Fig. 2). Steep slopes are in areas of landslide and is a major problem because it retards construction and movement and also contribute highly to landslide together with high rainfall and human impact. Marshy soil is mainly in the low-lying areas affected by flooding and this has witnessed the sinking of most houses in the area particularly where houses are constructed on the marshy soils like in the case of Clerk's quarter, Mbonjo and Down Beach.

Though with the geomorphic characteristics of these areas which is not favourable for home construction and settlements, the inhabitants have continued to put on structures on these marshy lands and which have witnessed sinking to some degree and tilting. Sedimentation is a common environmental problem particularly in flooding areas where sediments are eroded from the highland areas and deposited in low lying areas. The heavy torrential rains of the months of August to July erode and carry soil particles from steep and unconsolidated slopes which is accumulated in great significance in the river channel at low land areas. This leads to reduction in the depth of river channels and filling of the narrow- storm drain constructed.

This phenomenon of sedimentation is very much common in Cassava Farms and Mbonjo where soil particles are eroded and carried from the Cassava Farms Hill and Mbonjo Hill and deposited in the low-lying parts as well as in some river channels and storms drains, thereby reducing the depth of rivers and covering the foundation of most houses.

An inhabitant in Cassava Farms testified that: "the *foundation of his house is gradually covered by ground brought by flooded water in the rainy season*". The hazard occurrence was confirmed by field observation and interview with the personnel of Delegation of Environment and Nature Protection. Flood occurrence is the most common particularly in the months of July and August where any heavy down poor on daily bases leads to inundation in the city. This therefore demonstrate the occurrence of geomorphic hazard in Limbe. With respect to hazard type, marshy soils and sedimentation are the main environmental issues faced in flood area with more severity.

However, as presented on the Fig. 3, flood was significantly more recurrent than landslide with proportion of 93.1% of those that perceived for landslide as against 2% for those that perceived very often for landslides.

Fig. 2. Factors of geomorphic hazards in Limbe
Source: Fieldwork, 2022

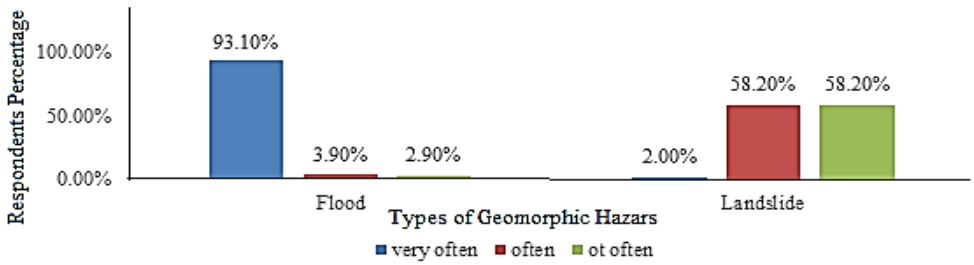

Fig. 3. Geomorphic hazard occurrence within a year
Source, Fieldwork, 2020

It is observed that geomorphic hazards are recurrent in Limbe as they occur often particularly the case of flood which occur every rainy season in most areas within the town. Since the hydro-geomorphic hazards are observed to be recurrent, it therefore implies that it would affect the inhabitants more severely as there is no settlement control in hazard prone areas within the town.

Occurrences of geomorphic hazards in Limbe: The frequency of hazard occurrence was used based on the view of respondents and observation. The respondent view was on how often hazards occur, whether very often, often and not often (Fig. 4).

Based on the frequency of occurrence within a year, hazards happen very often, often and not often with a proportion of 48.5%, 30.5% and 21.0% respectively. The often occurrence of hazards was confirmed by field observation and interview with the personnel of Delegation of Environment and Nature Protection. Flood occurrence is the most common particularly in the months of July and August where any heavy down poor on daily bases leads to inundation in the city. This therefore leads to high perception on the often occurrence of geomorphic hazard in Limbe.

However, as presented on the Fig. 5 flood was significantly more recurrent than landslide with proportion of 93.1% of those that perceived for landslide as against 2% for those that perceived very often for landslides (Fig. 5).

It is observed that geomorphic hazards are recurrent in Limbe as they occur often particularly the case of flood which occur every rainy season in most areas within the town. Since the geomorphic hazards are observed to be recurrent, it therefore implies that it would affect the inhabitants more severely as there is no settlement control in hazard prone areas within the town.

The impacts of floods and landslide in Limbe, is illustrated on plate 1 which clearly shows some of the destruction caused geomorphic hazards.

Some effects of hazards were observed in the study area. Destruction of houses as was observed at Mbende hill (A), and other landslide areas like Mabeta and Mbonjo Hill. Roads destruction/blockage by landslide were noticed at Mbonjo Hill (B) and in some severe landslide areas. Some houses were observed to be sinking as a result of flood and mostly abandoned in Clerk's quarters, Mbonjo, and Down Beach (C). Farms, particularly gardens around the houses are most at times covered by flood water as noticed in Banjo, Clerk's Quarter and Down Beach (D).

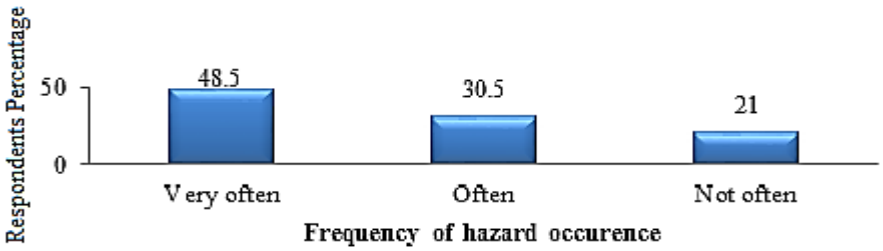

Fig. 4. Occurrence of hydro-geomorphic hazards
Source: Fieldwork, 2022

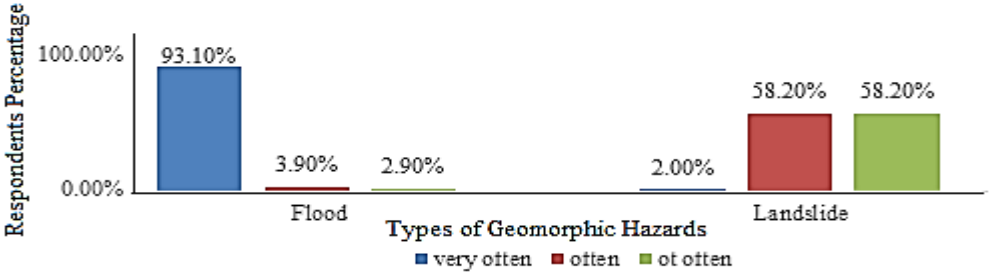

Fig. 5. Frequency of hazard occurrences within a year
Source, Fieldwork, 2022

Plate 1. Some effects of hydrogeomorphic hazards
Source: Fieldwork, 2022
a) Destruction of a house by landslide. b) Road blockage by rockslide.
c) Abandoned house because of floods. d) Floods covering houses' yard.

The impacts of geomorphic hazards in Limbe is a call for concern as if affects all aspect of life directly or indirectly. Field observation and respondents revealed the impacts of geomorphic hazards on the major categories, notably destruction of vegetation (98%) because vegetation is covered by both flood and landslide any time it occurs, destruction or blockage of roads (91.0%) and this is at a result of frequent occurrence of flood mainly in town, which often block movement, destruction of farmland (87.5%) and this is mainly observed by the very people who own and work farm, destruction of blockage of bridges (63.2%). Dead though not highly pronounced was not absent (27.5%). Dead is mainly caused by landslide and is not common as other destructions, the same with health problems (27%) because the inhabitants hardly perceive health problem but field observation revealed some cases of health problem caused by hazards (Fig. 6).

This indicates that hazards occurrence has impact on man directly and indirectly as proven by the various categories of social and environmental effects. As such, the inhabitants keep on facing problems as the intensity and frequency of hazards continue to increase over the years. However, this can be ameliorated by respecting the environmental roles and maintaining environmental stability.

3.2 Population Mitigation Strategies to Geomorphic Hazards in Limbe

Geomorphic hazards are mitigated in various ways. The measures adopted in the study area were examined to know whether really there are sustainable and efficient to cope with frequent occurrence of hazards in Limbe.

Awareness of mitigating measures: 96.5% of the respondents are highly aware of hazard mitigation as against 3.5% for none awareness. It therefore implies that the inhabitants are more aware of hazard as well as measures to mitigate the hazard in their localities. This is good because awareness can reduce vulnerability if appropriate measures are put in place for mitigation.

Though the inhabitants are more aware of hazard mitigation, there is still a variation in the level of awareness between the hazard types at a significant difference of P=0.271. More people perceived awareness for landslide at the proportion of 98.0% as against 95.1% perception for awareness for floods. This is simple because to construct on steep slopes there must start with embankment which is the common strategy. While for flood areas many still construct without taking in to account the occurrence of flood due to easy topography for construction.

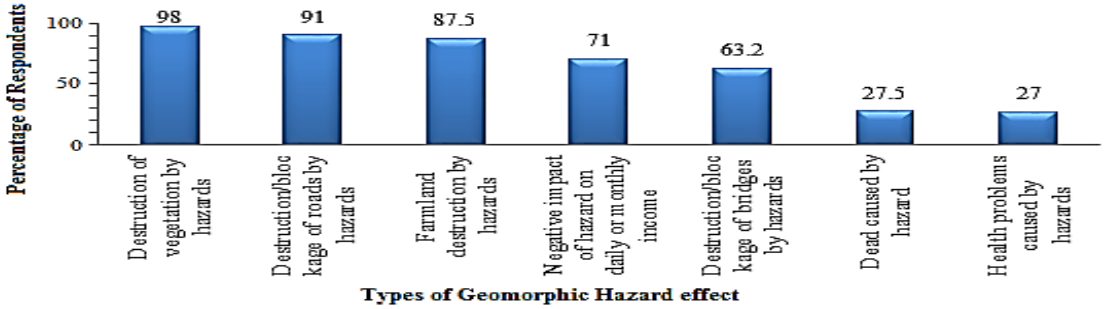

Fig. 6. Effect of hazards on inhabitants indicated by participants
Source: Fieldwork, 2020

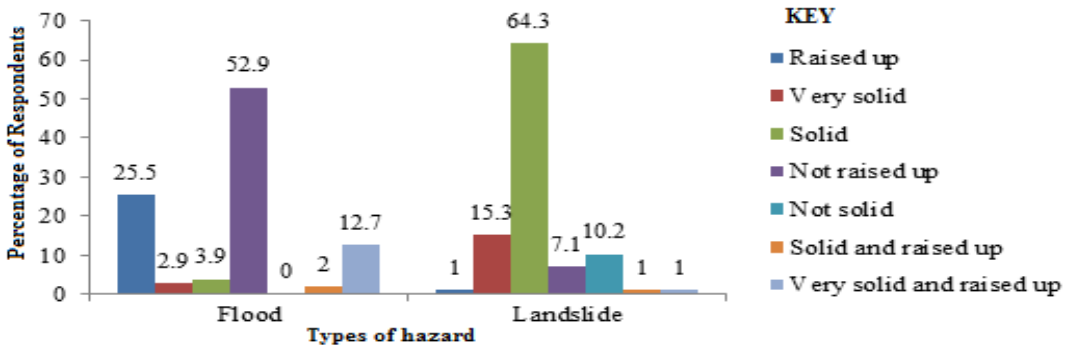

Fig. 7. Nature of the house foundation with respect to hazards
Source: Fieldwork, 2022

Nature of house foundation/structure of houses: Nature of house foundation as a measure to mitigate hazard vary from raised up, very solid, solid, not raised up, not solid, solid and raised up and very solid and raised up. The nature of foundation varies with the type of hazard. For flood hazard, 52.9% perceived that house foundation is not raised up and 2.9% indicated that it is very solid. While for landslide 64.3% perceived not raised up. Since the strength of the house to withstand hazard depends on the nature of the foundation, it is therefore observed that mitigation for flood hazard based on foundation is lagging for flood as up to 52% perceived for not raised up foundation implying that water will always enter in to most houses (Fig. 7).

The nature of foundation is also related to the structure of house. The structure is classified into plank house and block house. This condition was observed to vary across hazards types. For flood hazard, more for block houses was perceived with the proportion of 80.4% as against 19.6% for plank house. While for landslide perception for block house was also high but lower than for flood, with the proportion of 75.0% as against 25.5% (Fig. 8). Though the nature of houses in the flood and landslide zones are block houses, the foundations are not all raised up and are not all very solid to fully mitigating flood and landslide hazard.

Since about 70% of houses are block, it means the inhabitants have realised the advantage of block structures over plank structures as people are gradually replacing the existed plank structure with bock which is more solid to combat flood and landslide. This is a common strategy adopted by the inhabitants to reduce the impact of flood and landslide. The indigenes adopt different ways of combating flood and landside. Plate 2 shows the various ways adopted by the indigenes to combat flood in the affected areas within the town of Limbe.

Some of the observed measures put in place to combat flood in Limbe include channel modification (A) which has to do with construction of stone wall along the river channel course in order to contain flood water. Sinking houses which are refilled and raised up again (B) to solve to the problem of flood water entering the house. Raised foundation and scoria deposit

filling (C) in down beach to combat flood water. There is also storm drain enlargement and paving in cassava farm (D) to increase the carrying capacity of the channels (Plate 2).

Landslide is also combated particularly by building very solid embankment to hold the unconsolidated soil (Plate 3). However, this is not very common as it is very expensive and only the "well to do" can carry on with that. This therefore has forced the poor to construct weak embankment which often collapse at time with heavy rainfall.

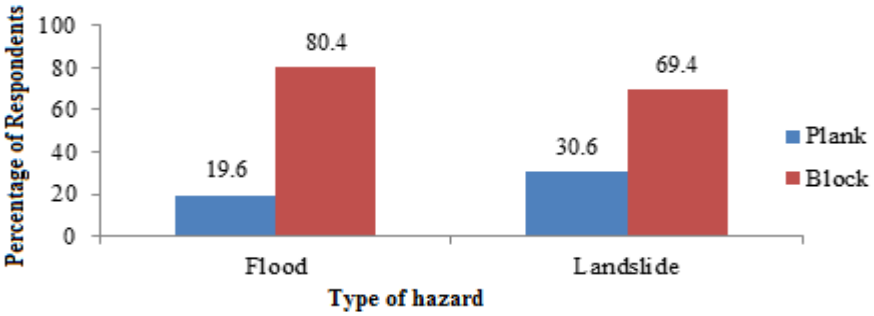

Fig. 8. Proportion of respondents on structure of house with respect to hazard type
Source: Fieldwork, 2022

Plate 2. Some Flood control measures in Limbe
Source: Fieldwork, 2022
a) Widened channel to content river flow. b) Refilled and Raised up of house foundation.
c) Use of volcanic scoria to fill and raise up depressed land. d) Widened gutter beside paved road.

Plate 3. Other strategies against landslide and floods
Source: Fieldwork, 2022
a) Solid embankment to Combat landslide coconut Island, Limbe
b) Raised verandas to combat flood at Clerk's Quarter Limbe

Construction of solid embankment is a very good strategy commonly used within the Landslide areas in Limbe to combat Landslide. However, this kind of engineering work required much financial cost which few can afford for it because of their low level of income. Though most flood inhabited areas are declared as risk zones, the majority who persevere to stay there particularly in Clerk's Quarter for cheap houses have involved in raising of the verandas as an indigenous way of reducing the impact of floods (Plate 3).

River channel modification: The modification of channel to reduce the risk of flood hazard was observed. It was mostly seen that there is no channel widening with the proportion of 93.5% against 6.5% for channel widening. This confirms that there is no channel widening in the area. However, there is river channel cleaning (dredging) to maintain the depth of river channels and storm drains, done by the Municipal Council and Community Work in various quarters (Table 2).

The absence of river channel widening implies that there will be high risk of flood. River channel widening is difficult to carry on because inhabitants have constructed so close to the banks. The insignificant level of channel widening together with increasing population accompanied by increased human activities along the channel, makes management of flood difficult.

Rehabilitation scheme on hazards: Just like sensitisation there was almost no rehabilitation scheme. It was mostly perceived that there is no rehabilitation scheme with the proportion of 99.0% as against 1.0% for rehabilitation scheme. This implies that people are still very much exposed to hazards as it keeps occurring every year with little or nothing in terms of rehabilitation scheme for the inhabitants in hazard prone areas of the city.

It is very clear that there is a complete absence of rehabilitation and because of this people continue to inhabit the declared risk zone. For an area to be considered and declared a risk zone, there should be a good strategy to rehabilitate the inhabitants and the absence of this makes it very difficult to control human activities in the area. This lack of rehabilitation scheme or strategy for inhabitants of flood and Landslide prone zones makes management inefficient.

Inhabitants in flood areas indicated with the proportion of 52.0% to remain in the area against 48% to leave the area if better option is given. For landslide, wish to leave the areas was higher with the proportion of 54.1% against 44.95 for wish to remain if better option is given (Fig. 9). This implies that more people will prefer to leave the landslide areas if better option is given than in flood zones. This can be explained by the fact that most people in flood areas are business people and prefer to battle with flood than to leave for other areas though most do not really enjoy staying there but do not want to leave. Some also fear to miss their social ties.

The desire to stay in flood prone zone in Limbe indicates that the inhabitants have invested much in the area and prefer battling with hazards than to leave to another area to start it all over again. Another reason is as a result of affordable land compared to hazard free areas within the city. This unwillingness to move out of the area is also accounted for by lack of good rehabilitation schemes. The end result of this desire is inefficiency in the management of geomorphic hazards in the city of Limbe.

3.3 Management of Geomorphic Hazards in Limbe

The frequent occurrence of hazards in Limbe over the years has put everybody awake to ensure human safety. Both the local population and the authorities have all been involved at different scales.

Actions carried out by the inhabitants to mitigate geomorphic hazards: In order to combat hydro-geomorphic hazards in Limbe, the local population have been actively involved in so many ways particularly those in hazards prone areas (Table 3). The various efforts by the inhabitants is manifested in various ways through organised community works within the various quarters and individual efforts. The efforts of this class of the population cannot be under estimated as they have played a big role alongside the authority in combating hazards in a bit to guarantee safety.

Table 2. River channel modification in floods sites in Limbe

Sites	Number of times for river channel dredging a year	Degree of river channel widening	Concerned authority
Clerk's Quarter	04	Lesser degree	. City Council . Community work
Church Street	04	Less degree	. City Council . Community work
Mbonnjo Quarter	04	Less degree	. City Council . Community work
Down Beach	04	Less degree	. City Council Individuals
Cassava Farms	01	Insignificant	. Community work . Individuals

Source: Fieldwork, 2020

Table 3. Thematic analysis of disaster management when it occurs

Code	Code description	Grounding	Percentage	Quotations
Flood				
Evacuate the area	Evacuate the area temporary when there is flood to return back when it is over.	11	**24.4%**	"Evacuate flood area" "Leave the place for some time".
Suspend house item up	Suspend house items up not to be affected by flood water when it enters the house.	13	**28.8%**	"Items suspend up". "Suspension of properties".
Stop activities	Activities are stopped during flood as nothing can be done when flood occur.	5	**11.1%**	"Activities are stopped" "Remain indoors"
Cleaning of gutters	Cleaning of gutters when flood occur to create easy passage of flood water.	5	**11.1%**	"Remove debris from gutters" "Opening of gutters"
Push out flood water from the house	Flood water is pushed out from the house during flood occurrence to create way in the house.	11	**24.4%**	"Push water out of the house" "Drain water out of house"
Total		**45**	100	
Landslide				
Removal of grounds and debris	Ground and debris are removed from the site that has been affected.	38	**59.38**%	"Removal of ground" "Removal of debris" "clear the mud"
Embankment	Construction of embankment which stabilized walls to contain the ground from moving.	6	**9.38%**	"Building of embankment"
Evacuate the area	Leave the area to another suitable place when affected.	6	**9.38%**	"leave the site" "Change of environment"
Reinforcement of Embankment	Reinforcement of embankments when affected.	11	**17.18%**	"Reinforcing embankment" "Add level of embankment"
Planting trees	Planting of trees to hold the soil firm from moving.	3	**4.8%**	"Tree planting"
Total		**64**	**100**	

Source: Fieldwork, 2022

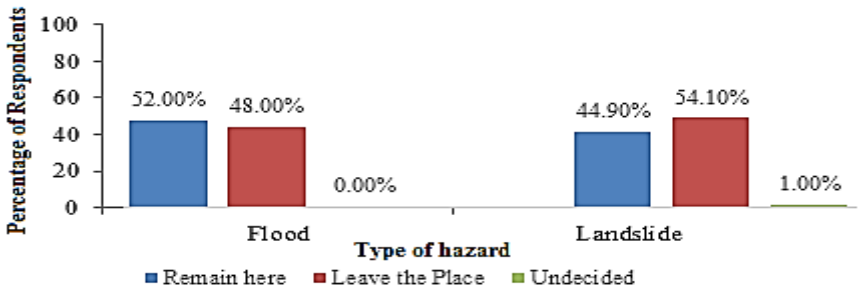

Fig. 9. Proportion on decision to stay or leave the area
Source; Fieldwork, 2022

Community members managed flood in various ways as indicated by some respondents (Table 3):

- Suspend house items up not to be affected by flood water when it enters the house (28.8%). This is the common method use by indigenes during flood event in Limbe. This is done before any other strategy is taken.
- Evacuate the area temporary when there is flood to return back when it is over (24.44%) been the second most adopted coping strategy implemented by the affected inhabitants.
- Stopped activities during flood as nothing can be done when flood occur (11.11%). Many people prefer to stay home to check the reaction of water as measure to reduce it impact.
- Flood water is pushed out from the house during flood occurrence to create way in the house (24.4%). This is another common indigenous method commonly practiced especially with poorly constructed or low foundation houses.
- Cleaning of gutters when flood occur to create easy passage of flood water was also scaled (11.11%). Community work is organised to clear gutters to create free access for water. Individual also do this around their home copping strategy.

As for landslide, the following methods are used:

- ✓ Ground and debris are removed from the site that has been affected (59.38%). This is the common strategy when landslide occurs in the area.
- ✓ Reinforcement of embankments when affected (17.18%). This is when the already exiting embankment is altered by landslide event and cannot withstand another event of hazard.
- ✓ Leave the area to another suitable place when affected (9.3%). This is done when the event of landslide is severe and the removing of ground cannot help at that time.
- ✓ Construction of embankment which stabilized walls to contain the ground from moving (9.38%). This is done when an area is affected and the need for an embankment is realised and is constructed immediately.
- ✓ Planting of trees to hold the soil firm from moving (4.8%). Though being a long-term strategy, but is triggered sometimes by a severe event which force some affected people to immediately start planted trees as defensive measure.

To know the degree of effectiveness of the indigenous copping strategies to mitigate hazard, the level of sensitization was used to test this hypothesis. This is because people's awareness of a particular hazard is at the base of any disaster preparedness, prevention and response strategy.

There is inadequate sensitization on hazard in the study area. It was mostly observed that there is little sensitization at the proportion of 1.5%. Moreover, out of the three administrators (Delegate of Housing and Urban Development, a Head of Service at the Divisional Delegation of Environment and Nature Protection and the Head of Department of Civil Protection at the Limbe City Council) that acknowledged the existence of sensitization on hazards, only one person said it was efficient.

This clearly shows that there is no effective management of geomorphic hazards in Limbe as

every management of hazards begins with proper sensitisation for the creation of awareness for effective and efficient management. This lack of sanitization or education could be perceived at different level, people not willing to resettle though conscious of the hazards, not following any building norm or acquiring building permits, throwing dirt in water channels or building too close to water channel. Much still need to be done to create awareness on the occurrence as well as possible effects of hazards in the study area to reduce vulnerability.

Proactive measures carried out by the inhabitants to mitigate geomorphic hazards: So many proactive measures to combat hazards are carried in Limbe. The inhabitants suggested so many of such proactive measures which according to them can help to reduce the occurrence of flood and landslide in Limbe (Fig. 10).

The inhabitants acknowledged various proactive ways to control the occurrence of floods and it impacts in the various flood prone zones in Limbe. The most outstanding measures indicated include raising of foundation (19.23%) and cleaning of water channels (18.47%). Channel widening, improvement of drainage and construction of artificial levee (12.31%) (Fig. 10). Since the people have no other choice than to stay in flood areas, there should therefore embark on raised and solid foundation to avoid water from penetrating in to houses, while the authority concerned should work on drainage system by widening the channel to increase their carrying capacity thereby reducing frequent occurrence of floods and its impacts on the inhabitants.

In the landslide areas, inhabitants suggested also proactive measures (Fig. 11). The respondents feel that if these measures are adopted, the impact of landslide and the frequency of occurrence will reduce.

The impacts posed by landslide on the inhabitants of landslide prone areas have forced them to think and start making adjustment on their various activities on the slopes. The suggested measures they think if implemented can ameliorate the frequency of landslide so far. For the measures, construction of embankment was highly suggested at 29.81% and closely followed by settlement control at 25.96%. Sensitization of the population was also suggested at 19.23% and followed by planting of trees at 18.27%. Soil assessment was also considered by some as a measure at 6.73% (Fig. 11).

Most of the houses in flood risk zones of Clerk Quarter, Mbonjo, Church Street, and Down Beach are not on raised foundation and majority are plank houses too. It is the same situation on the inhabited steep slopes of Mbende, Mile Two, Mabeta New Layout and Mbonjo where only about 30% of the houses are with solid embankment to hold the moving ground (Fig. 11).

It was acknowledged by the inhabitants that strong embankment is the major measure if people should construct on the steeper slopes of Limbe. The management of landslide in Limbe, thus need the control of the Council to ensure the appropriate measures. The structural management is not really a successful management strategy in Limbe because it is only limited to the “well to do”, (Table 4) who can afford the means. Such structures demand much financial cost and the majority of the inhabitant in such risk zone areas in Limbe who are the poor, still construct houses which cannot withstand the flood and landside and thus increasing the possibility for risk.

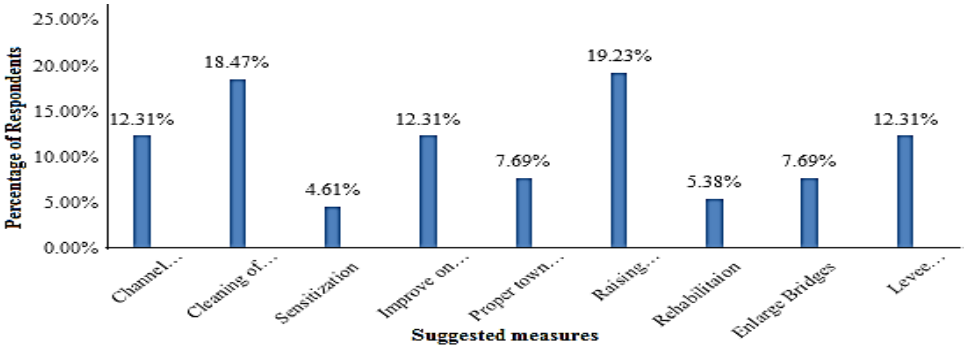

Fig. 10. Suggested proactive measures to solve the problem of flood
Source: Fieldwork, 2022

Table 4. Thematic analysis of suggested flood and Landslide disaster control

Code	Code description	Grounding	Percentage	Quotations
Floods				
Channel widening	Channel widening to increase the carrying capacity of the channel	16	12.31%	"Widening of river channel" "Increase channel width"
Constant cleaning of gutters and river channels	Constant dredging or cleaning of gutters to create access way for water passage, to maintain the carrying capacity of river channels	24	18.47%	"Cleaning of storm drains" "Cleaning of gutters" "Dredging of river channels" "Cleaning river channel"
Sensitization of the people	Sensitization of the people on the occurrence and effect of flood hazard	6	4.61%	"Creation of awareness" "Sensitization of the inhabitants"
Improving the drainage system	Improve on the drainage system to control excess water within the town	16	12.31%	"Drainage system improvement" "Increase drained system"
Proper town planning	Proper town planning to avoid areas liable to flood	10	7.69%	"Controlled settlement" "Demolition of houses close to rivers"
Raising house foundation	Raising the house foundations to reduce the amount of water entering the houses	25	19.23%	"Raised verandas" "Protect the veranda" "Foundation raised up"
Rehabilitation of the people in flood zone	There should be rehabilitation scheme to evacuate those in flood zones to more suitable areas	7	5.38%	"Evacuate the people" "Resettlement of the inhabitants"
Construct bridges	Construct large and open bridges that cannot be easily blocked by dirt during flood	10	7.69%	"Construction of large bridges" "New and large bridges"
Construction of artificial levee	Construction of levee along the banks of major river to hold excess water	16	12.31%	"Levee construction" "Construction of dykes"
Total		**130**	**100%**	
Landslide				
Embankment	Construction of embankment which stabilized walls to contain the ground from moving	31	29.81%	"Construction of embankment" "build strong embankment"
Sensitization	Sensitizing the population on disaster	20	19.23%	Sensitize the population"
Settlement control	Settlement control by preventing people from building in risky areas, or stopping construction on very stop slope to reduce the effects of landslide on the inhabitants	27	25.96%	"Restrict construction in vulnerable areas" "Checking settlement" "Stop construction on steep slopes" "No construction on steep slopes"
Soil assessment	Assessing the soil whether it can contain buildings	7	6.73%	"Assess the soil for construction"
Planting of trees	Planting of trees to hold the soil firm and to reduce the risk of landslide	19	18.27%	"Tree planting" "Develop thick vegetation"
Total		**104**	**100%**	

Source: Field work, 2022

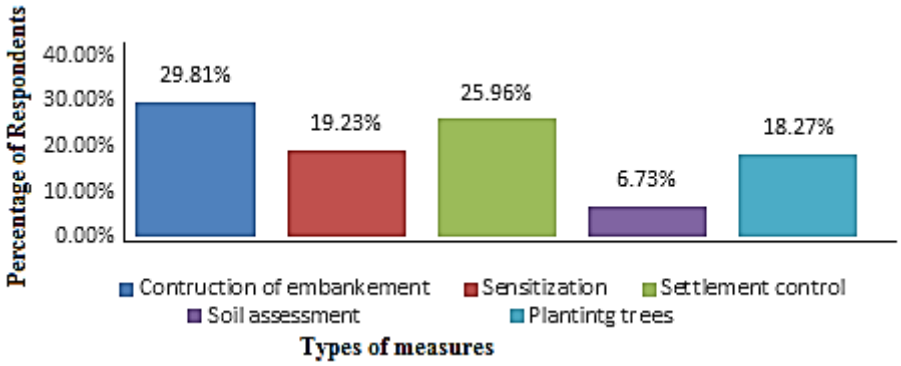

Fig. 11. Suggested proactive measure to control Landslide in Lime
Source: fieldwork, June 2022

4. CONCLUSION

The inhabitants and the authorities in the town of Limbe have not just folded their arms to watch this happens. Though much is being blamed on the population of Limbe or the inhabitants of these risk zone areas, they are still within their limits struggling to mitigate the effects of hazards. Their attempts to conquer the natural hazards of flood and landslide may not be sustainable enough but can reduce to an extent the effects. These barrier measures implemented by the inhabitants like the suspension of verandas, raised foundation, building of embankments require much capital and engineering expertise which is still limited to the very few rich and the poor continue to embrace the effects.

Awareness which should be the first step towards hazard management is near zero in the city as there is no sensitization of the masses on geomorphic hazards, which is very recurrent in the city with much negative effects. The authority has fallen short in their strategy as much of their efforts are on response measures which still is lurk warm. The authorities and the population together in their actions to curb flood and landslide still need much to be done and have to revisit their strategies putting in place the safety of man first. However, all is not loss as there is still chance for the people of Limbe particularly those in flood and landslide areas together with the authorities and other stakeholders to rethink, develop a good proactive strategy, implement them and also follow up for sustainable urban development.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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