Flood incidence and sustainable development planning implications in Santchou, Cameroon

Abstract

While studies on the incidence of flooding exist in several parts of Cameroon, very little empirical evidence has been reported for highly dynamic and urbanizing landscapes in Cameroon. Yet, micro level evidence on flooding and their development planning implications are required to advance theory building in the frame of development planning and hazard mitigation in rapidly urbanizing contexts. This paper bridges the knowledge gap by using the case of Santchou, a highly dynamic landscape, to (a) analyse the spatio -temporal variations in flood incidence, (b) determine the drivers of flood occurrence, and (c) examine their sustainable development planning implications. To achieve these objectives, a representative sample of 141 (n=141) was conducted in five communities within the study area. This was complemented by key informant interviews (n=8) and field observations. Data was collected using using the Kobo Collect android app (Version 2023). The collected data was analysed descriptively using the Standard Package for Social (SPSS version 25) Cartographic data was analysed spatially and presented using maps while statistical data was presented using tables, and bar charts. Based on the analysis, the following conclusions were derived: Firstly, Firstly, Flood occurrence vary spatially in terms of severity, with very high intensity from the south east decreasing towards the north west and western sections of the study area. Flood occurrence also vary over time with the peak of occurrence in the month of July and August which corresponds to the peak of the rainy season Secondly, the most significant effects of floods include the destruction of physical installations such as houses and household items and its impacts on human activities such as the destruction of crops, livestock and the disruption of transport circulation. Furthermore, flood effects are less severe in Santchou Ville and Albatross neighborhoods compared to neighborhood like Madagacar, Bessouck and Kassala Farm where flood occurrences are severe. Thirdly, while planning approaches exist at household, neighborhood and municipality levels, the most effective involves the use of sandbags and the cleaning of water channels. This study recommends that to stem the phenomenon of flood occurrence, proactive measures such as the resettlement of inhabitants to safer areas should be undertaken as a matter of urgency. Future studies should assess the effectiveness of flood management approaches.

Key words: Flood incidence, effects, spatial variations, resettlement, development implications

1. Introduction

The occurrence of natural disasters is as old as humanity. In the history of natural disasters, millions of deaths and immeasurable property damage have been registered. For instance, between 2008 and 2017, over 3751natural hazards occurred, affecting over 2billion people in 141 countries. This caused an estimated damage of about US$1,658 billon (IFRC,2018). Averagely 60,000 people die per year due to natural disasters, with a heavy toll on the poor (Ritchie & Roser, 2019). It is estimated that between 2008–2018, over 157 million persons were directly and indirectly affected by disasters (UNDRR, 2020). Losses linked to weather-related hazards witnessed an increase of 74% and 182% for non-weather-related ones (Pielke, 2019) Furthermore, earthquakes as a natural hazard, accounted for at least 1.3 million deaths between 1990 and 1988 (Alexander, 1996, Smith, 1989). In the year 2001, earthquakes killed 20085 people in India, while in the year 2003, it caused the lives of 31000 people in Iran. In 2008, 88287 died in China, due to earthquakes while in the year 2010, 222570 died in Haiti (EM-DAT 2021). Flooding as a natural hazard accounted for 6.62 million deaths worldwide in the 20th Century (EM-DAT 2021). Jones et al (2022) noted that about $82 billion economic loss occurred due to flood disasters in 1950. On a global scale, it has been reported that floods account for approximately 5000 deaths and10 million internally displaced persons. This phenomenon also led to an estimated USD 40 billion in economic losses each year (CRED, 2020; IDCM, 2020). This analysis show that natural hazards have a significant effect on the human society.

However, there are variations in the occurrence of natural hazards. For instance, Bangladesh is considered to be one of the hardest hit countries in the world in terms of flood occurrence and damage to property and loss of human lives. The World Bank Report of 2021 notes that flooding in Bangladesh caused annual losses of around US $1 billion, which is equivalent to 1% of the country's GDP. The United Nations Development Program pointed out that floods in Bangladesh can damage up to 1,000 kilometers of roads and 300 bridges annually (UNDP, 2019). In 2017, about 3.3 million people were displaced due to flooding (IDMC, 2021).

In the last decade, some African countries have suffered significantly from the effects of natural disasters. The cumulative effect of the last decades indicates that floods and droughts alone are responsible for around 80% of disaster-related deaths and 70% of economic losses (Ndaruzaniye et al. 2010). An average of 500 000 people per year are affected by floods in West Africa alone (Jacobsen et al.2012). Scholars have demonstrated that floods are responsible for major disruptions with widespread implications for economic activities, livelihoods and access to services in different parts of the world (Douglas, 2017). For instance, the floods that occurred in Mozambique in the year 2000, caused the displacement of over 500.000 people with severe damages to social infrastructure such as schools, hospitals, electrical installations and buildings (World Bank ,2000). In sub-Saharan Africa (SSA), statistics from EM –DAT (2010-2015) indicates that over 80 million people were affected by large scale natural disasters and deaths resulting from floods; this amounted to 45733 (Osuteye et al 2017). Sub Saharan Africa lacks strong institutional capacity to manage disasters, and therefore, it is expected that many countries will further experience pervasive flood-related devastation of livelihoods (Balgah and Kimengsi, 2022; Edoun *et al.*, 2015; Usman *et al.*, 2013).

There are however variations, with some region more affected than others. Between, 2010- 2015, floods accounted for 20211 deaths in Somalia East Africa, 4500deaths in Liberia (West Africa), 1307 deaths in Cameroon (Central Africa) and 135 deaths in South Africa (Osuteye et al 2017). The occurrence and variation of floods over space and time is driven by a host of natural and human drivers. While natural factors play a significant role, in other contexts, human factors seem to play a predominant role. Some of the natural drivers include the nature of the topography or relief, vegetation cover and soils (Shi, 2019).The increase in flood disasters have equally been attributed to natural factors such climate change which generates changes in precipitation regimes and intensity (Echendu, 2021; MacLeod *et al.*, 2021; Hua *et al.*, 2020), urbanization (Ajiboye and Orebiyi, 2022; Douglas, 2017; Ahiablame and Shakya, 2016) as well as the level of exposure and vulnerability to flood events (Ramiaramanana and Teller, 2021; Ahiablame and Shakya, 2016). Several studies have focused on spatio temporal variation in flood induced mortality and its influencing factors at global, continental and national scale (Jonkman2005; Jonkman and Kelman 2005; Stevens et al. 2016; Halgamug and Nirmalathas 2017; Hu et al. 2018). The spatial heterogeneity of flood hazards is clearly linked to environmental factors, including terrain, vegetation cover and soils (Shi 2019). By analyzing the cumulative distribution of flood events, Hu et al (2018) reported that floods occur most frequently, in regions with low and flat terrain and along dense river systems.

Studies have demonstrated that, flood risks, flood occurrence and damage is a function of several variables such as flood peak, the geomorphology of the flood plain, the land use, climatic conditions and heavy rainfall, rise in water level in the reservoir and failure of retaining structures (Middelkoop et al. 2001; Grover et al. 2013; Latapie et al. 2014; Spada et al. 2017; Kuriqi and Ardiçlioglu 2018) Additionally, the extent to which floods affect the society, is a function of a host of determinants which may operate at micro levels such as household characteristic, neighborhood characteristics or community characteristics . The macro level attributes include flood planning measures instituted by the government of every country. Furthermore, income levels seem to show a negative relationship with the occurrence of floods while signaling a positive relationship with flood mitigation. This is because high income earners are most likely to have the resources to be able to counter the negative effects of floods. Therefore, household, community, neighborhood and even national level factors tend to determine the severity of flood effects on the society (Mondal et al., 2021).

As the issue of flooding seems recurrent and it seems it will continue unabated, structural and non-structural approaches have been adopted in different parts of the world to mitigate and prevent flood occurrence (Rufat et al. 2015; Shahab et al. 2020). In the United States for instance, flood mitigation approaches implemented at state level include engineering measures such as the construction of levees, dams or nonstructural approaches like land use plans, public information programs, and open space acquisition and preservation. (Samuel et al 2007). Hossen et al (2022) notes that in Bangladesh flood adaptation approaches implemented by state and non-state actors include the construction of embarkments and nonstructural approaches such as awareness and warning procedures and micro flood insurance. Rahman et al. (2015) further highlights that flood mitigation approaches in Bangladesh include the introduction of flood insurance, creating alternative temporary employment opportunities, rebuilding disaster resilience houses, precaution and prevention for disease and changing professions can be viable options for adaptation.

Scholars have theorized on the severity of floods (Saharia, et al 2017; Schroeder, 2016; Sadler, 2018; Khalaf et al., 2018). While previous studies on floods have focused on the determinants of floods, their consequences and coping strategies at macro levels, data context specific studies at micro scale are still lacking. As a case in sub‒Saharan Africa, Cameroon represents a useful epistemological example to understand flood occurrences, their effects as well as well as the planning approaches. This is because, Cameroon, is home to several agro- ecological zones which off course implies variations in terms of its climatic conditions which is likely to trigger flooding. The agro- ecological zones of Cameroon, experience varied intensities of rainfall and therefore prone to varied degrees of flood risk (Awazi et al 2023). Secondly, many Cameroonian towns are witnessing significant urbanization with attendant repercussions such as the increase in flood incidence. While these issues constitute a reality in the Cameroonian setting, specific evidence in several landscapes of Cameroon are lacking. For instance, in the highly dynamic landscape of

Santchou, there is limited evidence on the variations of flooding, the drivers, the determinants and the sustainable development planning measures linked to this event. This therefore validates the need for the present study which seeks to: (a) analyze the spatio temporal variations of. foods (b) explore the determinants of flood effects and (c) discuss the sustainable development planning implications.

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2. Analytical Framework

The phenomenon of flood has been extensively theorized in literature showing that it varies over space and time. The variations in flood occurrence are driven by a host of physical drivers such as the nature of the slope, soil type, and heavy rains, narrow stream channels amongst others (Guo et al., 2019; UNDRR, 2020). Flood incidence in Santchou exhibits daily, monthly and yearly variations. It also exhibits spatial variations in terms of duration, frequency and severity. Similarly, human drivers such as haphazard construction, poor drainage networks, poor urban planning, disregard for legal norms and administrative tolerance has given rise to urban disorder. Floods demonstrate effects at different levels; household effects include the destruction of houses and household items. At the neighborhood level, flood effects include the disruption of circulation, pollution of potable water sources, and the disruption of electricity transmission lines. At the level of the municipality, flood effects include the inundation of offices, shops and at farm levels effects it includes the destruction of crops and livestock.

Over the years, development planning approaches have been introduced to curb the phenomenon of flooding in the study area. Micro scale approaches adopted at household level include the use of sandbags, the building of embankments and the planting of trees. At the neighborhood level, efforts include the widening of stream channels and the planting of trees. At the level of the municipality, development planning approaches to mitigate the phenomenon of floods include the cleaning of drainage channels and the prohibition of waste dumping on stream channels and drainage channels. Non-state actors such as NGOs have adopted proactive and reactive approaches such as education and awareness campaigns, and the provision of material and financial assistance to flood victims, while state actors have equally adopted proactive approaches such as flood alert signals and reactive approaches such as the resettlement of flood victims. This framework (Figure 1) captures the spatio – temporal variability, frequency and severity as key aspects of flood occurrences that advance our understanding of the nexus between flood occurrence and sustainable development planning in the study area.

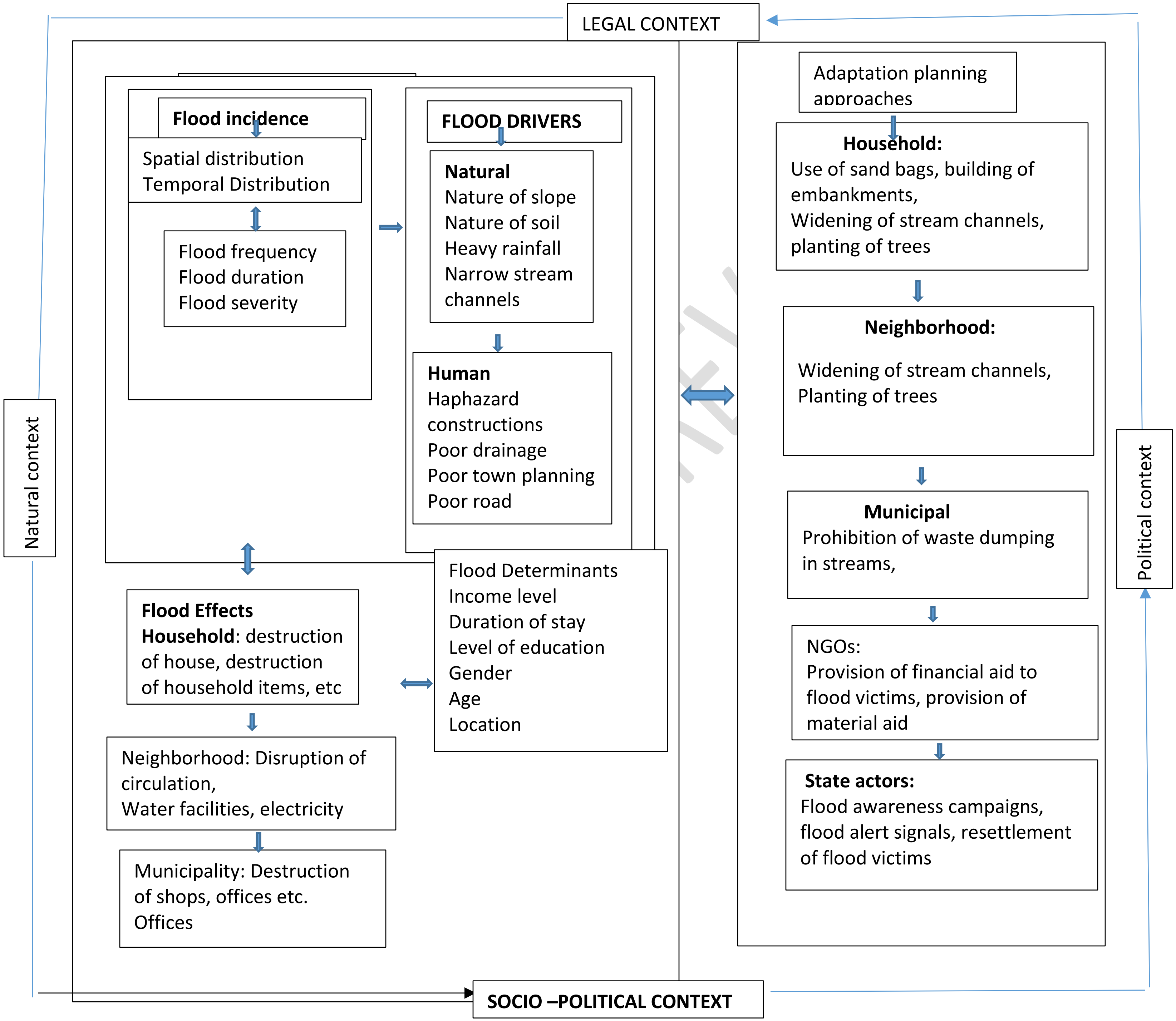

Figure 1: Analytical framework for flood incidence and Development
Source authors 'construct 2024

3. Study area and methods

3.1 Study area

Santchou is one of the most dynamic and rapidly urbanizing landscapes of Cameroon that has not been spared from flood occurrence. It is found in the Menoua Division, West Region of Cameroon (Figure 2.) It is located between latitudes 5°18'0" North and 9054'0" East. Bounded to the north by Mount Manengouba, to the south by the Dschang Cliff and to the east by Kekem, Santchou has an estimated population of 46,249 inhabitants occupying a surface area of 335km^2. The population density of this area stands at 137 persons/km^2(Santchou Council, 2015). Despite the existence of literature on flood incidence in several parts of Cameroon, very little has been reported about floods in highly urbanizing and dynamic landscapes such as Santchou. This suggests the need to provide development planners and policy maker with empirical evidence on flood incidence for strategic development planning and policy implementation in the study area and areas with simar characteristics. It was based on this consideration that Santchou was chosen for this study. (Figure 2).

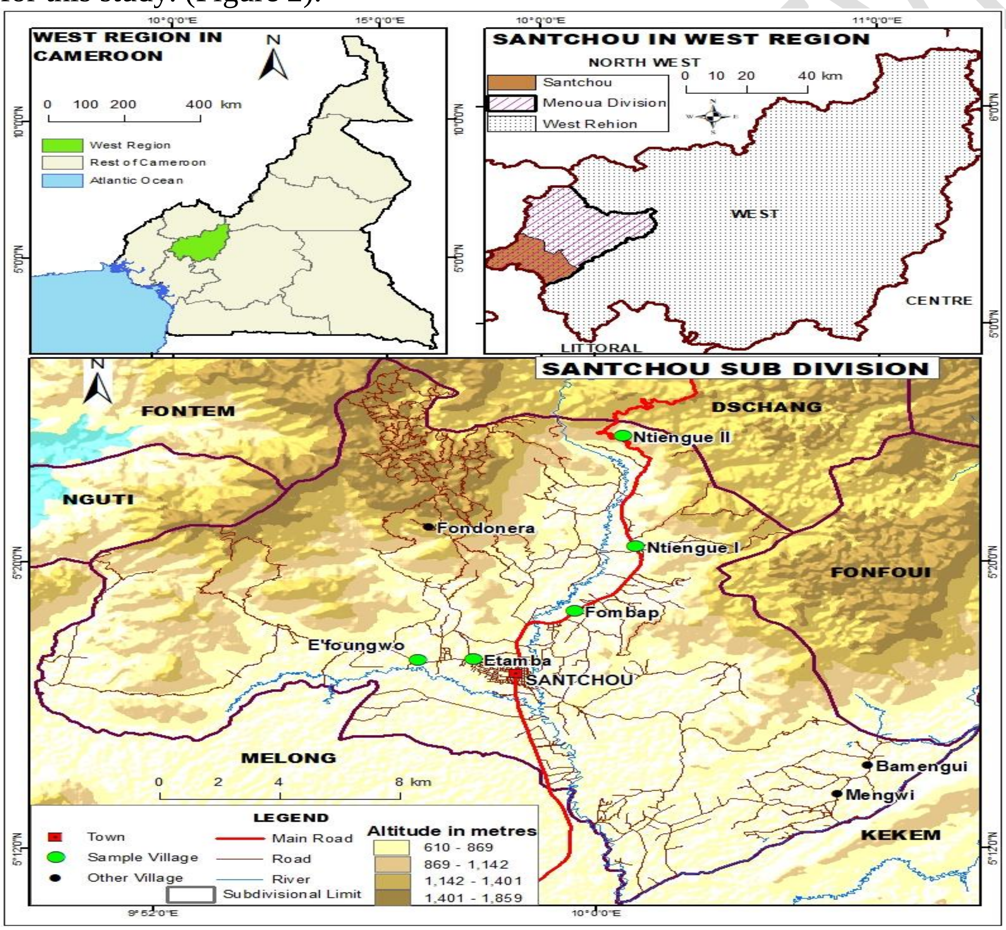

Figure 2 Location of the Santchou

3.2 Materials and methods

Data for this study was collected in the month of May 2024. Prior to the data collection, a structured interview guide was developed. The informant guide was designed to capture information related to the socio – demographic characteristics of the respondents such as age, gender, household head gender, level of education, occupation, neighborhood, origin and occupation. It further captured information on the flood characteristics such as the frequency of occurrence and severity in terms of damage recorded. Such information was required to establish the spatio temporal variation of flood incidence in the study area. The guide was also designed to capture information related to the drivers of flood occurrence as well as the planning approaches adopted by the stakeholders concerned. A pre-test was performed with five households in a nearby community. Validity was ensured through an assessment of the questionnaire by the co- authors of this study. After brainstorming and criticisms of the items on the questionnaire, corrections were made and adopted for the study proper. The household questionnaire was complemented with field observations and interviews with stakeholders such as quarter heads, representatives of NGO, local councilors. In this regard, we interviewed 8 key informants: 5 quarter heads, 1 NGO representative and 2 councilors. Each Interview session lasted between 20 to 25 minutes. The structured interviews were aimed at collecting data related to the drivers of flood occurrences and flood management approaches adopted by the stakeholders concerned. A sampling fraction of between 5-8% was adopted for all the five communities under study.

Two enumerators were recruited and trained on the data collection procedure. With the assistance of two community members who have lived in the study area for at least 10 years, our research group was able to identify five communities which were targeted for this study (Bessouck, Kassala Farm, Madagascar, Behind Albatross and Santchou Ville). These communities were identified on the basis that the inhabitants of these communities have been victims of floods over the years. Random sampling was adopted for the study in which an ad-hoc household numbering process was performed to determine the number of households to be sampled. We proceeded with raffle draws to randomly select the number of households that correspond to 141. The selected households guided the identification of the precise households for data collection. Data was collected using the kobo collect android app version (2023) from 141 households (Table 1). The structured interview guide led to the sampling of households in five communities as follows: Santchou Ville (31), Madagascar (38), Besouck (44), Behind Abatros (7) and Kasala Farm (21) representing a total of 141 (Table 1).

Table 1: Distribution of Questionnaires

Locality	**Number of respondents**	**Frequency**
Santchou Ville	31	22.0
Madagascar	38	27.0
Bessouck	44	31.2
Behind Abatros	7	5.0
Kasala Farm	21	14.9
Total	**141**	**100**

Subsequently, the spreadsheets were downloaded and exported to the Statistical Package for Social Sciences (SPSS Version 25) where frequencies and percentages were calculated. The results were presented using tables and figures like bar charts, pie charts. Spatial analysis was performed using GIS and cartographic tools.

The cartographic database was acquired from the National Institute of Cartography (NIC) and the National Institute of Statistics (NIS) Yaoundé which constitute part of the Geo database of Cameroon for 2024. The acquired data was displayed in QGIS 3.6, for further analysis. Further cartographic data like the hydrographic network, and delimited areas depicting the varied electricity supply situation were generated from Google earth in the form of KML Data. Complementary cartographic data was obtained from Open Street Map (OM) and the data extracted from this source was transformed into shapefiles in QGIS 3.6. Required elements like the built up and buildings were then extracted and imported into ArcGIS 10.8 to overlay the settlement pattern and other elements to finalize the maps which were exported in jpg format. The GPS data was generated with the use of the KOBO Tool and the analysis of the numerical data was done in SPSS, before importing into ArcGIS 10.8 to symbolize it and produce a map on the spatial variations in flood severity.

Ethical consideration was ensured through voluntary prior informed consent of all respondents before proceeding with the interviews. The research team explained the motive of the study to each respondent and in situations where some were reluctant to participate, they were freely allowed to decline.

4. Results

The results are structured as follows: socio- demographic characteristics of the sampled population, spatio- temporal variations of floods, drivers of flood occurrence and sustainable development planning implications.

4.1 Socio demographic characteristics of respondents

The components of socio- demographic characteristics captured in this study included: the location of the respondents, gender, household heads, level of education, origin and occupation (Table 2). The results show that of the 141 respondents sampled, 53.9% were household members while 46.1% were household heads. In terms of gender composition, 54.6% were females while 45.4% were males. As concerns household heads, 73.1% were males while 27.0% were females. Educational attainment showed that 45.4% of the respondents had secondary school qualifications, 27.0% primary school qualifications, 16.3% had vocational training, 6.4% had university qualification and 5.0% had no formal education. Field data also indicated that out of the 141 respondents, 56.0% were migrants while 44.0% were natives. The main occupation of the respondents is farming carried out by 56.7% of the population. However, other occupations in the study area included: petite trade 9.9%, bike riding 7.8%, government employees 11.3%, private employees 4.3%, sand mining 1.4% and non-specific occupations 5.3% (Table 2).

Table 2: Socio- demographic characteristics of the respondent population

S/N	ITEM	Categories	Freq	%Freq	N
1	Santchou Community	Ville	31	22.0	141
		Madagaskar	38	27.0	
		Besssouck	44	31.2	
		Behind Albatros	7	5.0	
		Kasala Farm	21	14.9	

2	Respondent Position	Household head	65	46.1	141
		Member	76	53.9	
3	Gender	Male	64	45.4	141
		Female	77	54.6	
4	Household head Gender	Male	103	73.0	141
		Female	38	27.0	
5	Level of Education	No formal	7	5.0	141
		Primary	38	27.0	
		Secondary	64	45.4	
		Vocational	23	16.3	
		BSc n Above	9	6.4	
6	Origin of respondent	Native	62	44.0	141
		Migrant	79	56.0	
7	Main Occupation	Farmer	80	56.7	141
		NTFP Collector	3	2.1	
		Bike/Taxi Rider	11	7.8	
		Petit Trader	14	9.9	
		Salary State	16	11.3	
		Salary Private	6	4.3	
		NGO	1	.7	
		Sand Miner	2	1.4	
		Others	8	5.7	

4.2 Spatio-temporal variations in flood occurrence

Flood occurrence in the study area varies over space and time. To understand the phenomenon of flood occurrence in the study area and to analyze its implications, data was collected for two different periods depicting the past situation (2014) and the present situation (2024). Flood severity analysis for five different communities (Madagascar, Santchou Ville, Kassala Farm, Behind Albatross and Bessouck (Figure 3). Figure 3 shows that flood occurrence is very severe in terms of damage to houses and household items, the disruption of transport circulation and the destruction of farms and shops. Flood severity in the Madagascar neighbourhood is explained by the non-respect of urban planning norms, haphazard construction of houses, the disposal of waste into water circulation channels and insufficient drainage pathways. These human drivers are intensified by natural factors such as prolonged rainfall and the relatively plain-like nature of the terrain which favours water stagnation. Flood severity in the Madagascar neigbourhood has significantly increased over the years. Information gathered through interviews and field observation show that in the year 2014, the impacts of flood occurrence in this neighbourhood was severe on physical installations such as pipe born water, road network and electricity transmission poles. In 2024, the effect of flooding on these physical installations have become very severe.

In the Bessouck and Kassala Farm neighborhoods, flood severity in terms of damage to physical installations, such as road network, interruption of traffic and damage caused to houses and household items is moderately severe compared to the Madagascar neighborhoods. Field observations and information gathered through interviews revealed that, in this neighborhood, some efforts have been employed through household, community and neighborhood flood management approaches. This is exhibited by the use of sandbags, the draining of water circulation channels and the planting of trees. In Santchou Ville, flood impacts are less severe in terms of damage caused to physical installation. Also, the destruction caused to houses, road network, shops and offices is less severe. The less severity of flood impacts in this neighborhood is thanks to efforts employed by the municipal authorities to ensure the regular cleaning of water circulation channels, the enforcement of building construction norms and the enforcement of urban planning regulations. The impacts of floods in terms of severity, in the neighbourhood called Behind Albatross is less significant. Field observations and interview reports show that this neighborhood is relatively far away from the River Menoua which triggers flood episodes during period of prolonged rainfall. Furthermore, conscious of the impacts of floods, the inhabitants of this neighborhood have adopted successful flood management approaches some of which include the raising of foundations during construction, the regular cleaning of drainage channels, the use of sandbags and the planting of trees.

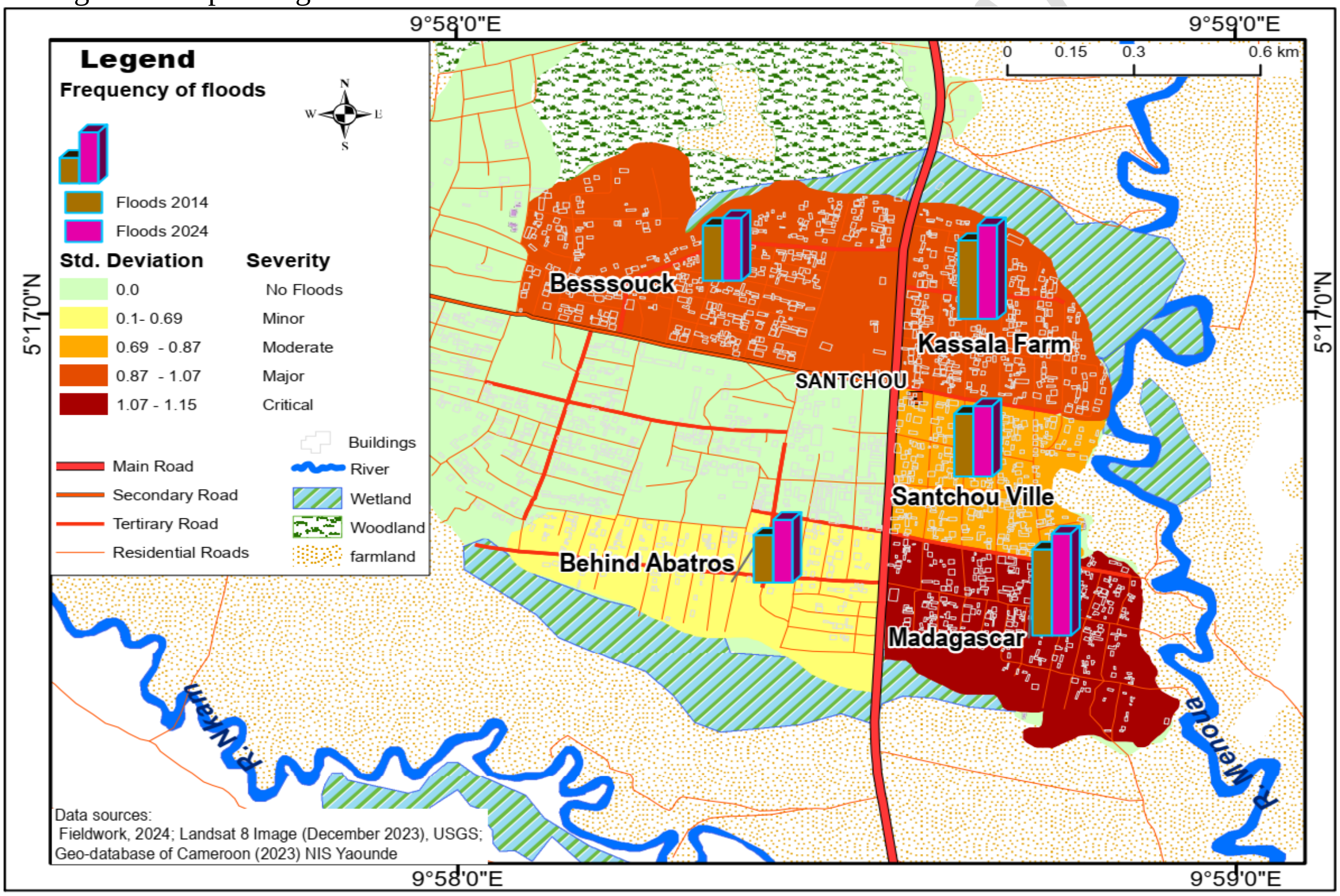

Figure 3 Spatial variation of flood severity in Santchou

4.2 Impacts of Floods occurrence

The impact of floods on physical infrastructure in the study area equally varies in terms of severity of damage caused such as the destruction of houses, the destruction of household items, the disruption of transport circulation, the destruction of farms, shops, offices livestock and crops. Over time, flood occurrence in the study area has had significant effect on physical installations such as housing. Neighborhoods like Madagascar, Bessouck and Kassala Farm have experienced significant losses in terms of houses and the destruction of household items (Table 3).

Table 3 the impacts if Floods Occurrence

S/N	ITEM	Categories	Past (2014)		Present (2024)	
			Freq	%Freq	Freq	%Freq
1	Destruction of Houses	Less Severe	11	7.8	1	.7
		Fairly Severe	51	36.2	28	19.9
		Severe	51	36.2	58	41.1
		Very severe	28	19.9	54	38.3
2	Destruction of Household Items	Less Severe	16	11.3	3	2.1
		Fairly Severe	45	31.9	27	19.1
		Severe	38	27.0	55	39.0
		Very severe	42	29.8	53	37.6
3	Disruption of Transport Circulation	Less Severe	32	22.7	9	6.4
		Fairly Severe	36	25.5	32	22.7
		Severe	30	21.3	51	36.2
		Very severe	43	30.5	46	32.6
4	Destruction of Farms	Less Severe	16	11.3	3	2.1
		Fairly Severe	44	31.2	23	16.3
		Severe	38	27.0	45	31.9
		Very severe	43	30.5	69	48.9
5	Destruction of Shops	Less Severe	35	24.8	21	14.9
		Fairly Severe	64	45.4	54	38.3
		Severe	32	22.7	45	31.9
		Very severe	10	7.1	21	14.9
6	Destruction of Offices	Less Severe	49	34.8	49	34.8
		Fairly Severe	58	41.1	34	24.1
		Severe	21	14.9	39	27.7
		Very severe	13	9.2	18	12.8
7	Destruction of Livestock	Less Severe	29	20.6	16	11.3
		Fairly Severe	56	39.7	33	23.4
		Severe	46	32.6	36	25.5
		Very severe	10	7.1	54	38.3
8	Destruction of Crops	Less Severe	13	9.2	3	2.1
		Fairly Severe	33	23.4	9	6.4
		Severe	37	26.2	36	25.5
		Very severe	58	41.1	85	60.3

Table 3 shows that the 19.9 % of the respondents rated the impacts of floods on houses in the past (2014) as very severe, 36.2% considered the impacts to be severe while 36.2% were of the opinion that the impacts of floods on houses was fairly severe. On the contrast in the present (2024) 38.3% of the sampled population rated the impacts of floods on housing infrastructure as very severe,41.1% indicted that the impacts of floods on houses was severe while 19. % of the respondents considered the destruction of house by flood to be fairly severe. The increase destruction of houses by floods as reported by the respondents in 2024 is attributed to population increase has provoked an increase in the demand for houses. Increased house construction without the respect for urban planning norms and the haphazard construction of houses accounts for the current severity of flood effects on housing.

Regarding to the destruction of household items(Table 3) in the past(2014), 29.8 % of the respondents rated the impacts as very severe while 27.0% of the sampled population, considered the impacts of floods on household items to be severe and 31.9 considered the destruction of household items by flood to be fairly severe.in the present(2024) 37.6% of the respondents rated the impacts of floods on household items as very severe, 39.0% rated the impacts as severe while 19.1% rated the impacts as fairly severe. Overall, a majority of the respondent were of the opinion that in the past floods inflicted significant damage on their household items.

Flood occurrences also have serious implications on transport circulation. Movement by cars, motorbike or on foot are perturbed sometimes for several hours or even days. Intense flood episodes cause serious damage to road infrastructure by wearing off the tarmac surfaces. Where the roads are untarred such as in Bessouck, Madagascar and Kassala Farm, traffic circulation is obstructed as road become muddy making movements extremely difficult. In some flood cases, bridges are destroyed, (Table 3) 30.5% of the respondents reported in the past (2014) the damage caused by bloods to transport circulation was very severe, 21.3% of the respondents considered that the disruption was severe while 25.5% indicated that the disruption was fairly severe. In the present (2024) 32.6% of the responds reported that the damage was very severe, 36.6% were of the opinion that the damage was severe while 22.5% pointed out that the damage was fairly severe. Farmlands and crops are equally impacted by flood occurrence in the study area. During prolonged rainfall, farmlands are submerged by water, given the nature of the topography. Crops are destroyed by water and agricultural productivity is significantly affected negatively (Table 3). Close to thirty-one percent (30.5%) of the respondents rated the destruction of farms that in the past (2014) as very severe, 27.0% considered the destruction to farms by floods as severe while 31.2% considered the destruction as Fairley severe. In the present (2024) 48.9% of the respondents rated the destruction as very severe, 31.9% considered the destruction as severe while 16.3% pointed out that the destruction was fairly severe.

In the urban fabric of Santchou municipality where business activities are concentrated, the occurrence of floods sometimes submerge shops and offices located in buildings whose foundations have not been raised., Given the generally flat nature of the terrain of Santchou, prolonged and intense rainfall often lead to floods (Table 3). In the past (2014), 7.1% of the respondent reported the destruction to shops as very severe, 27.7% and considered the destruction to shops as severe while 45.5% indicated that the destruction to shops fairly severe. In the present (2024) 14.9% of the respondents rated that destruction to shops 31.9% as severe and 38.3% as fairly severe. The increased severity of floods on shops and offices outcome of poor urban planning and the suffocation of urban drains with municipal wastes As concerns offices, the 9.2% respondents reported that in past (2014) damage to office by floods was very severe, 14.9 %o of the respondents indicated that destruction of offices by flood severe while 41.1 % rate the destruction to offices to be fairly severe (14.9%) In the present (2024) 12.8% of the respondents reported that the destruction to shops was by floods was fair. For livestock in the past (2014), 7.1% of the rated damage to livestock by floods as very severe. While32.6 considered that the damage as severe and 39.7% indicted that the damage was fairly severe. At present (2024), 38% of the respondents rated the damage as very severe 25.5% as severe and 23.4% as fairly severe. With regards to flood damage caused to crops in (2014), 41.1% of the respondents rated it as very severe 26.2% as severe and 23.4% as fairly severe. In (2024) however, 60.3% of the respondents rated the damage as very severe 25.5% indicted that the damage was severe 6.4% indicted that the damage was fairly severe. Over all the impacts of flood destruction on human activities such as farming, transport circulation and on physical installations such as houses, road network, electricity, pipe borne water have significantly increased in the present (2024) compared to the past (2014). This increase is attributed to a combination of natural drivers such as increased and prolong rainfall, the generally level nature of the topography and a host of human drivers such as haphazard construction of houses without the respect of planning norms, wastes disposal into water circulation channels, poor farming practices and increased rates of deforestation.

4.2 Temporal variation of flood occurrence

To determine flood occurrence over time, data was collected for two different periods; the past depicting the year 2014 and the present depicting the year 2024. Considering monthly variation, the months of July and August were reported to be the months of intense flood incidence both during the past (2014) and in the present (2024). This is understandably so because, Santchou as a transitional zone between the coastal landscape of Cameroon and the humid montane landscape of the Western Highlands of Cameroon experiences intense rainfall during this period. The high amount of rainfall is explained by the equatorial climate and the fallouts of the effects of orography triggered by the montane attributes of the Western Highlands. Intense prolonged rainfall does have the potential to increase water volumes in neighboring rivers like the Menoua which is also a potential source of flood. It also constitutes a natural factor that reinforces the human factors which all have the potentials to cause floods. In the months where rainfall is intense such, as July and August, flood floods occur twice a week. This was reported for the past (2014) and present (2024) situation during the household survey in all the five neighborhoods under study.

4.3 Drivers of flood occurrence in the study area

Flood occurrence in the study area is a function of natural drivers such as rainfall intensity, nature of the slope as well as human driver such as the dumping of wastes on water circulation channels, haphazard construction, poor farming practices and rapid deforestation. The natural drivers of floods occurrence in the study area include (heavy rainfall, nature of the slope and the nature of the soils) as shown in Figure 4.

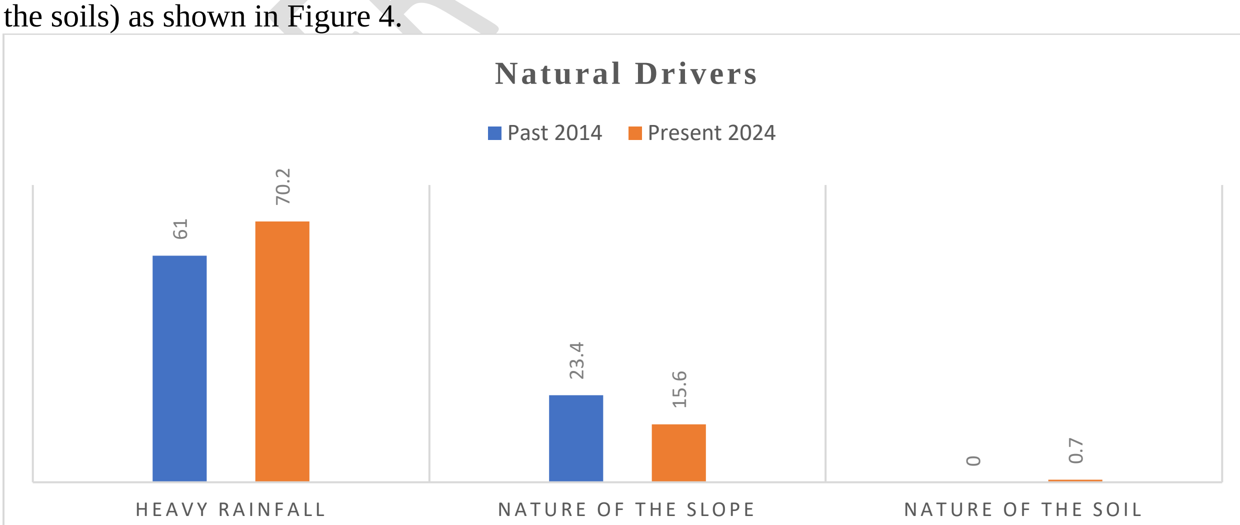

Figure 4: Natural Drivers of Floods occurrence

In Figure 4.61% of the respondents reported that in the past (2014) heavy rainfall was the most significant driver of floods in the study area, followed by the nature of the slope reported by 23.4% of the respondents and the least natural driver was the nature of the soil. On the other hand, in the present (2024), 70.2% of the respondents affirmed that heavy rainfall is the most significant driver of flood occurrence, followed by the nature of the slope as reported by 15.6% of the respondent and the nature of the soil as indicated by 0.7% of the respondents. Human drivers such as the dumping of wastes into river channels, hazard construction of settlements, deforestation and poor farming methods (Figure 5) have equally contributed significantly to flood occurrence and its severity in the five neighborhoods considered for this survey.

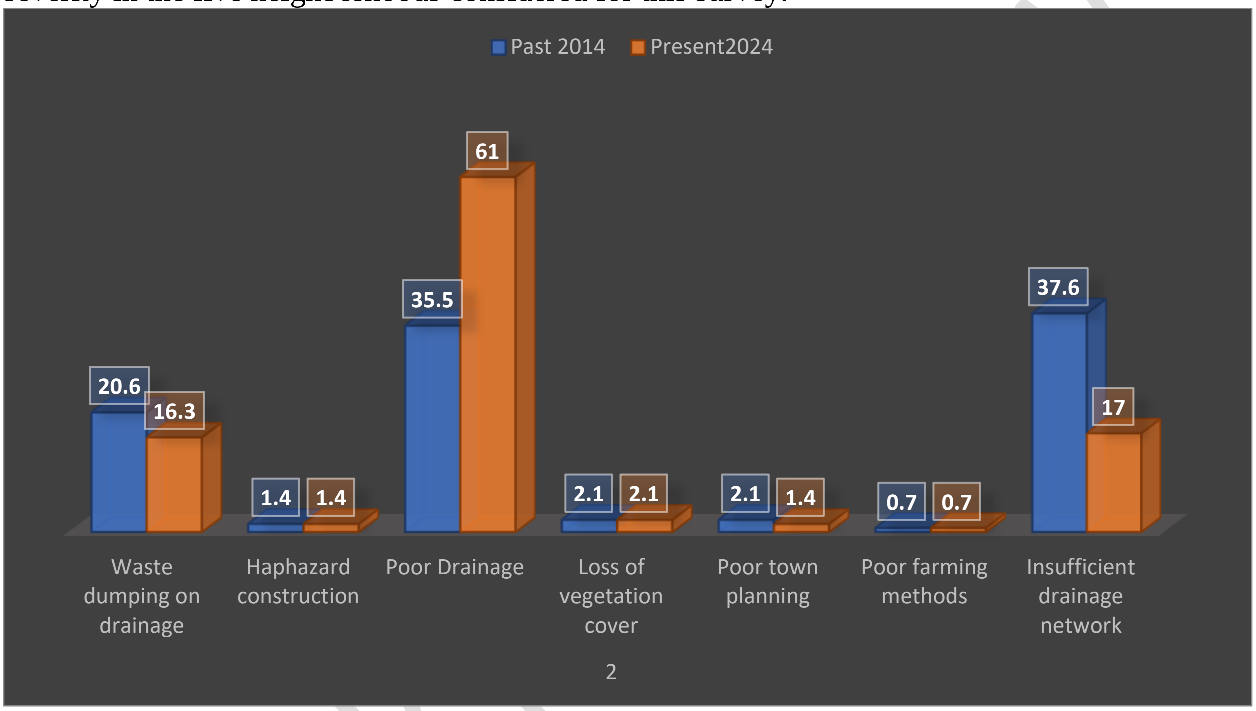

Figure 5: Human Drivers of floods occurrence

Figure 5 shows that in the past (2014), insufficient drainage was the most significant human driver of flood as reported by 37.6% of the respondents, closely followed by poor drainage as indicted by 35.5 % of the respondent. Twenty-one percent (20.6%) of the respondents indicated that that the dumping of wastes into water circulation channels equally contributed to flood occurrence while 2.1 % attributed the cooccurrence of flood to loos of vegetation and poor town planning. In the present (2024) 61% of the respondent attributed flood occurrence to poor drainage while 17% indicted insufficient drainage network.16.5% attributed flood occurrence to the dumping of wastes into water circulation channels while 2% indicted loss of vegetation as a contributory factor to flood occurrence. Overall, poor drainage, insufficient drainage network and the dumping of wastes into waster circulation channel stand out as the most significant human drivers of floods in the study both in the past and in the present. This is understandably so because of urban planning lacuna on the part of the municipal authorities. Additionally, dumping water circulation channels are suffocated by wastes dumps and the insufficient and poor drainage systems on work together to favour flood occurrence during heavy rains.

4.4 Sustainable Development Planning approaches

As a response to flood occurrence and its impacts on human activities including physical installations, several management approaches have been adopted including household level, neighborhood, and municipal flood management approaches. Household flood management approaches include a series of mitigating measures such as the use of sandbags to prevent flooding, the building of embankments or stone walls, the raising of foundations during construction, the cleaning and widening of stream channels, and the planting of trees amongst others (Figure 6).

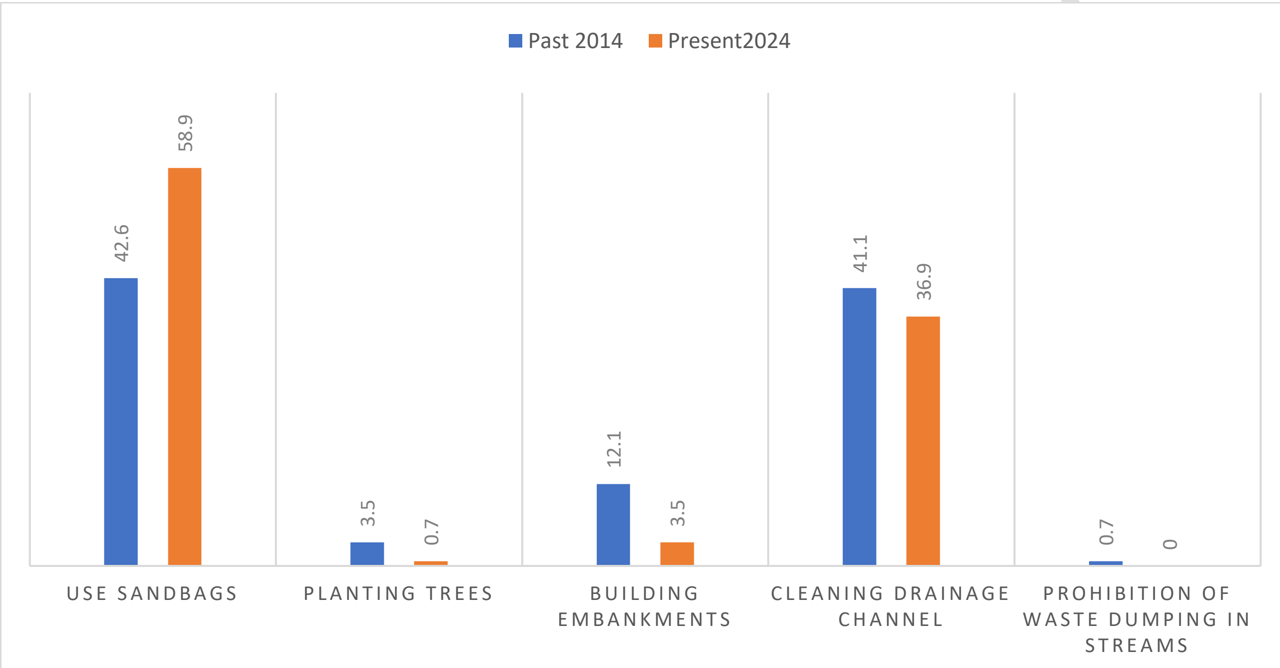

Figure 6: Household Approaches to Flood management

From Figure 6, it is observed that in the past (2014) the use of sandbags was the dominate strategy adopted by the inhabitants to fight against flood occurrence as reported by 42.6% of the respondents. This strategy was closely followed by the cleaning of drainage channels as indicated by 41.1% of the respondent. Other approaches adopted ta the level of household though insignificant included the building of embankments as reported by12.1% of the respondents and the planting of trees as indicted by 3.5% of the respondents. In the present (2024), the use of sandbags was equally identified as the dominant flood control measure as pointed out by 56.9 % of the respondents, followed by the cleaning of drainage channels as indicated by 36.9% of the respondent. Othe approaches adopted by the inhabitants included the building of embankments as indicted by 3.5% of the respondent and the planting of tree as pointed out by 0.7% of the respondents. In 2024, the use of sandbags as a flood mitigation measure has always been the practice. However, over time, most of the inhabitants while increasingly adopting the use of sandbags, do so alongside other measures including the raising of house foundations, the building of embankments and the planting of trees. These human efforts have paid off significantly especially in the Santchou Ville neighborhood and Behind Albatross where flood severity is near insignificant. Neighborhood approaches to flood management include the use of sandbags, the planting of trees, the building of embankments, the cleaning of water circulation channels, media communication, education and the organization of awareness seminars on flood risks (Figure 7).

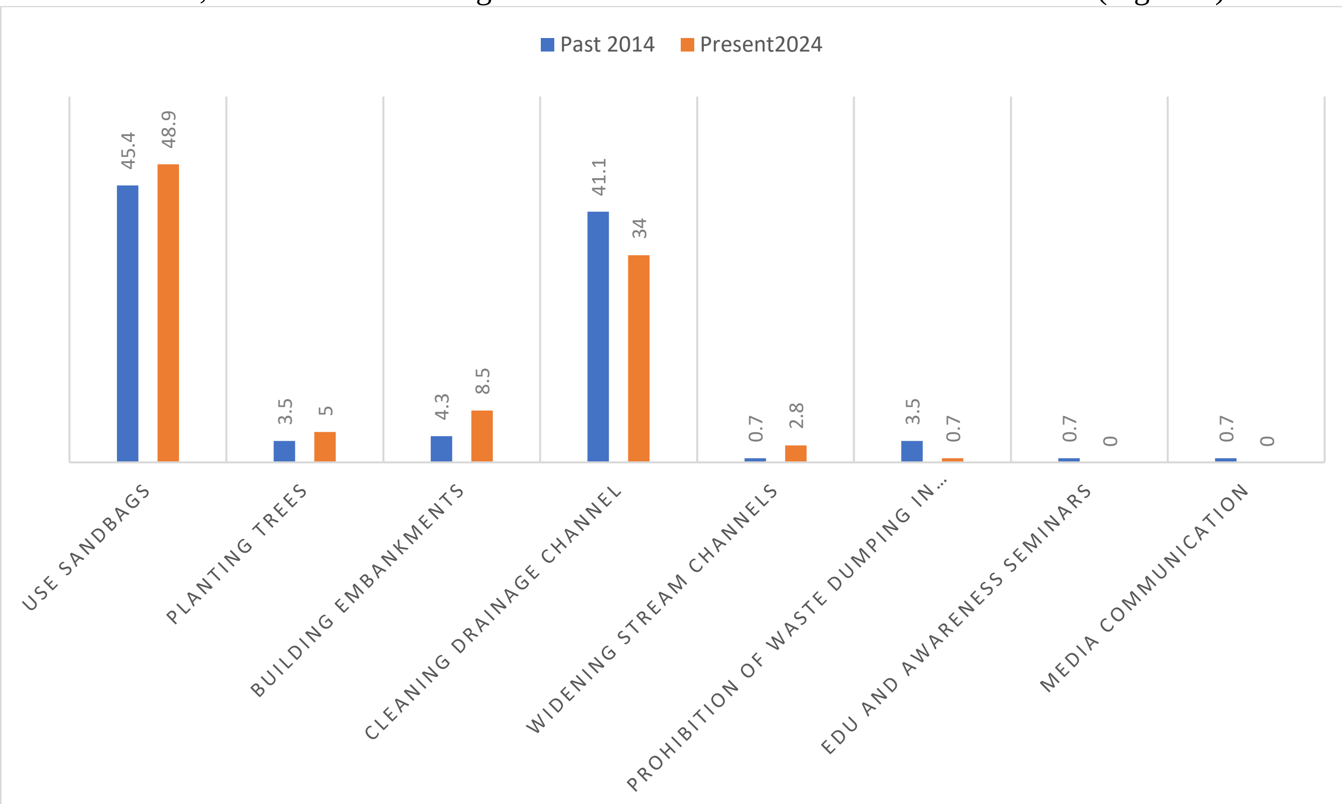

Figure 7: Neighborhood approaches to flood management

Figure 7 shows that with regards to neighborhood approaches to flood management in the past, 45.4% of the respondents indicated that the use of sandbags adopted at neighborhood level. This approach was closely followed by the cleaning of drainage channels as reported by 41.1% of the respondents, other approaches included the building of embankments channels as indicted by 4.3% of the respondents and the prohibition of waste dumping in water circulation channels as pointed out by 3.5% of the respondent and the planting of trees. In the present (2024), the most significant flood mitigation strategy adopted at neighborhood level include the use of sandbag as reported by 48.9% of the respondents, followed by the cleaning of drainage channels as pointed out by 34% of the respondents, building of embankments by 8.5%, planting of trees, by 5%, widening of stream channels 2.6 and the prohibition of waste dumping into water circulation channel as reported by 0.7% of the respondents These neighborhood approaches have been quite successful particularly in Santchou Ville and Behind Albatross were the impacts of floods on human activities and physical installations have been reduced to very minimal levels.

At the level of the municipality, flood management approaches that have been adopted include the use of sandbags, the planting of trees, the building of embankments, the prohibition of waste disposal into water channels and the cleaning of water ways and pavement channels (Figure 8).

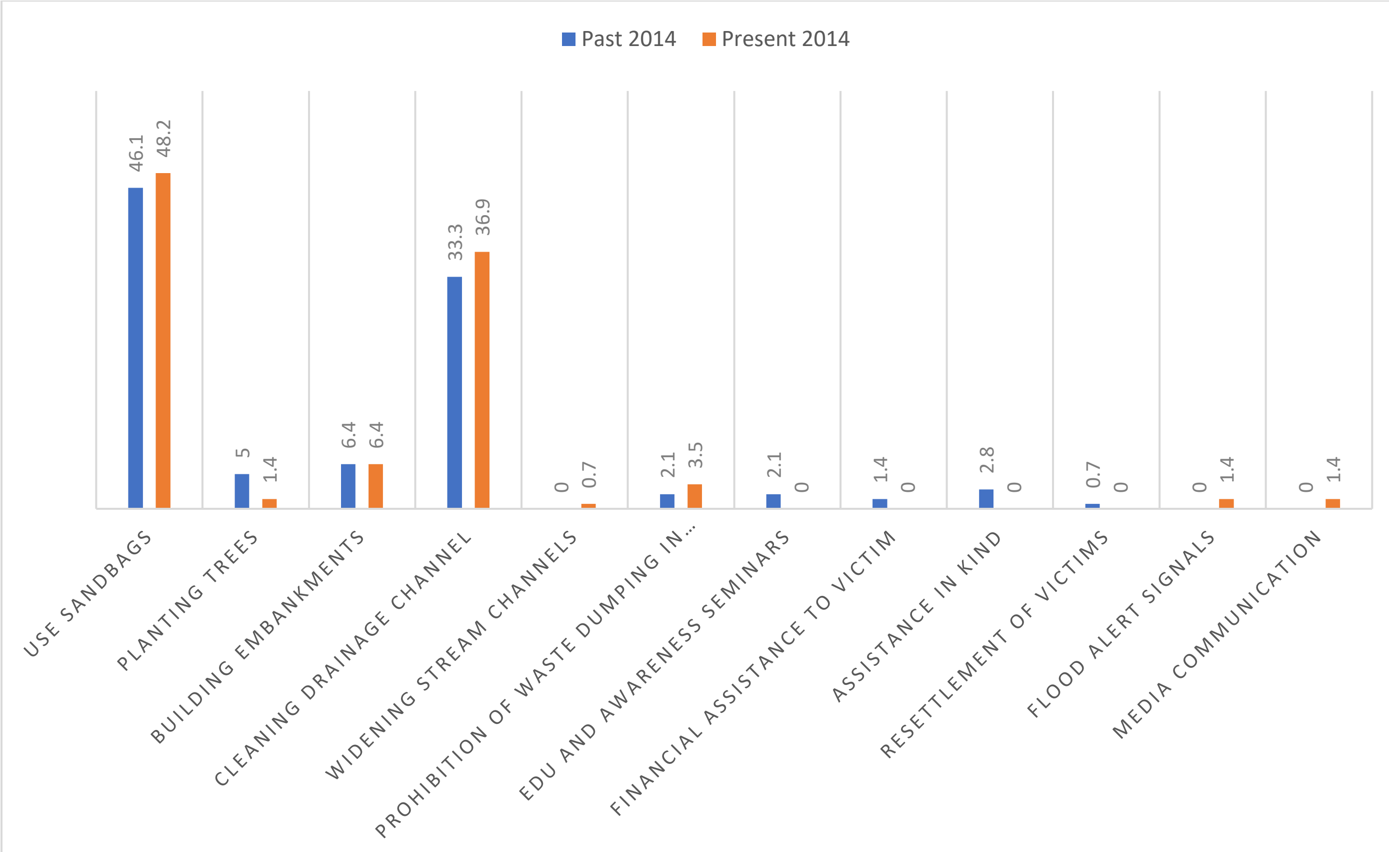

Figure 8 Municipality approaches to Floods Management

Figure 8 indicates that in the past (2014), the most significant approach adopted at the level of the municipality to counter flood occurrence was the use of sandbags as reported by 41.6% of the respondent. This was closely followed by the cleaning of drainage channels as pointed out by 33.3% of the respondents, the building of embankments 5.4%, planting of trees as pointed out by 5% of the respondents, assistance in kind to flood victims by 2.6% and education and sensitization as reported by 2.4%. In the present (2024) the use of sandbags was reported by the respondents as the most dominant and efficient strategy adopted at the level of the municipality to counter floods. The approaches include the cleaning of drainage channels as indicted by 36.9% of the respondents, building of embankments by 6.5%, prohibition of waste dumping into water circulation channels by 3.5% of the respondent and the planting of trees by 2.5% of the respondents. These approaches, at the household, neighborhood and municipality levels have significantly reduced the impacts of floods throughout the study area.

5. Discussion

5.1 Spatio-temporal variations in flood occurrence

Flood severity varies in intensity from the Southeast towards the Northwest of Santchou. In the Southeast flood occurrences is very severe in terms of damage caused to physical installations such as houses, road network, pipe born water facilities, electricity transmission lines and on human activities such as transport circulation, farming and livestock. The most affected neighborhood is Madagascar found to the Southeast of the study area. In the event of flood occurrence, the inhabitants of Madagascar neighborhood experience significant damages to their property. Food severity in the Madagascar neighborhood is attributed to the fact that, Madagascar is very closed to River Menoua which is a potential source of floods. Flood severity reduces in intensity toward the North West in neighborhoods such as Bessouck, Kassala Farm The intensity of flood reduces from fairly severe to less severe in neighborhood such as Santchou Ville, and less severe in the neighborhood call Behind Albatross, These findings concords with those of Lecce (2000) who found out that the northern half of the Gulf States of (Tennessee, Mississippi, Alabama, and Georgia) in the USA experienced a higher proportion of floods in winter, while spring floods dominate in the southern half of the region. Lecce (2000) also argued that the Carolina Region (Virginia, North Carolina, and South Carolina) is characterized by a more uniform monthly distribution of annual floods than elsewhere. Gamble (1997) identified Georgia Coastal Plain region (southeastern Georgia and northern Florida) with a bimodal flood regime. Hirschboeck, (1991) summarized the role of climate in flooding across the continental US. This study also reveals that flood occurrence in Santchou varies over time. Considering monthly variation, the months of July and August were reported to be the months of intense flood incidence both in the past (2014) and in the present (2024). These findings are consistent with the studies of Lecce (2000) who pointed out that flood regime in the Florida Region is bimodal with high frequencies in late summer and early fall (54% in August–October) In Cameroon there is an increase in the frequency of flooding in all agroecological zones (MINEPDED 2015). The agro- ecological zones of Cameroon, experience varied intensities of rainfall and therefore prone to varied degrees of flood risk (Awazi et al. 2023).

5.2 Effects of Flood Occurrence

Comparing the past (2014) and the present (2024) impacts of floods scenarios on human activities and physical installations, this study reveals that overall, the impacts have significantly increased in the present. For instance, 32,6% of the respondents rated the impacts of floods on houses in 2014 as very severe and t 41.1 % rated the impacts on houses as very severe in 2024. This suggests that many people have witnessed more damages to houses and other physical installations resulting from flood scenarios in 2024 than in 2014.The increased destruction of physical installations by floods is attributed to the increased intensity of natural and human drivers which have had a corresponding increased effect .For example, 35.5% of the respondents reported that poor drainage contributed significantly to flood occurrence in 2014 while 61 % pointed out that poor drainage contributes significantly to flood occurrence. Generally, poor drainage and other human drivers act together to induce flood incidences. This finding concords with the findings of (Middelkoop et al. 2001; Grover et al. 2013; Latapie et al. 2014; Spada et al. 2017; Kuriqi and Ardiçlioglu 2018) who argued that flood occurrence and damage is a function of several variables such as flood peak, the geomorphology of the flood plain, the land use, climatic conditions and heavy rainfall, rise in water level in the reservoir and failure of retaining structures. The increase in flood disasters have equally been attributed to natural factors such climate change which generates changes in precipitation regimes and intensity (Echendu, 2021; MacLeod *et al.*, 2021; Hua *et al.*, 2020), urbanization (Ajiboye and Orebiyi, 2022; Douglas, 2017; Ahiablame and Shakya, 2016) as well as the level of exposure and vulnerability to flood events (Ramiaramanana and Teller, 2021; Ahiablame and Shakya, 2016).

5.3 Sustainable Development Planning Approaches

Approaches to mitigate flood incidence in the study area have been adopted at the level of household, neighborhood and at the level of the municipality. Some of these approaches include, the use of sandbags, cleaning of water circulation channels, the building of embankments, raising of house foundations amongst others. The dominant approach adopted by the inhabitants is the use of sandbags. For example, at household level in 2024, the use of sandbags was equally identified as the dominant flood control measure as pointed out by 56.9 % of the respondents, followed by the cleaning of drainage channels. Similarly at the neighborhood level, in 2024, the use of sand bags was reported by 48.9% the respondents as the most dominant approach adopted by the inhabitants, followed by the cleaning of drainage channels as indicted by 36.9% of the respondents, building of embankments by 6.5%, prohibition of waste dumping into water circulation channels by 3.5% of the respondent and the planting of trees by 2.5 % of the respondents level of the municipality use of sand bags was reported by the respondents as the most dominant and efficient strategy adopted at the level of the municipality to counter floods followed the cleaning of drainage channels as indicted by 36.9% of the respondents, building of embankments by 6.5%, prohibition of waste dumping into water circulation channels by 3.5% of the respondent and the planting of trees by 2.5 % of the respondents. The dominant use of sandbags as an effective measure of floods mitigation, is explained by its ready availability of sand given that Santchou is a plain, sedimentation frequently occurs. These findings agree with previously existing literature,). In the United States for instance, flood mitigation approaches implemented at state level include engineering measures such as the construction of levees, dams or nonstructural approaches like land use plans, public information programs, and open space acquisition and preservation. (Samuel et al 2007). Hossen et al (2022) notes that in Bangladesh flood adaptation approaches implemented by state and non-state actors include the construction of embarkments and nonstructural approaches such as awareness and warning procedures and micro flood insurance

6. Conclusion

Flood occurrence and its effects continue to trigger scientific curiosity in evolving towns of sub-Saharan Africa. This paper used the case of Santchou in Cameroon to (a) analyse the spatio - temporal variations in flood incidence, (b) determine the drivers of flood occurrence, and (c) examine the development planning implications. Based on the findings, the following conclusions are derived: Firstly, Flood occurrence vary spatially in terms of severity, with very high intensity to the Southeast decreasing towards the northwest and western sections of the study area. Flood occurrences also vary over time with the peak of occurrence in the month of July and August which corresponds to the peak of the rainy season. Secondly, the most significant effects of floods include the destruction of physical installations such as houses and household items and its impacts on human activities such as the destruction of crops, livestock and the disruption of transport circulation. Furthermore, flood effects are less severe in Santchou Ville and Albatross neighborhoods. Thirdly, while planning approaches exist at household, neighborhood and municipality levels, the most effective is at the level of the municipality and it involves the use of sandbags alongside other measures such as the cleaning of water circulation channels, the building of embankments and the planting of trees. This study recommends that, local approaches to flood management at the household, neighborhoods and municipal levels should be encouraged through financial support from the state and civil society organizations such as NGOs. Furthermore, proactive measures such as the resettlement of inhabitants to safer areas by the state from areas of high flood intensity of Santchou and other areas in Cameroon with similar flood characteristics should be undertaken as a matter of urgency. Education and awareness seminars on the causes and consequences of floods as well as mitigation strategies should frequently be organized through media outlets such as community radio stations, the print media, billboards and through school programs from basic, secondary to tertiary education and religious institutions. Future studies could focus on the assessment of the effectiveness of flood management approaches in Santchou.

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