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# Effects of river flooding on human population: A case study of Kyarumba Sub-county along River Nyamuhasana in Kasese District

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## ABSTRACT

A natural occurrence that can have catastrophic effects on human populations is river flooding. This study looked at how the flooding of the Nyamuhasana River affected the livelihoods of those who lived close to the river in Kyarumba sub-county. The primary aim of the research was to evaluate the effects of alterations in land use in the catchment areas of the Nyamuhasana River in Kyarumba sub-county, Kasese district. The study also aimed to determine the degree of awareness among the community regarding their impact on the rising frequency of flooding in the Nyamuhasana River. The study also assessed the effectiveness of flood mitigation strategies being implemented by Kyarumba sub-county residents near the Nyamuhasana River. The study used both primary and secondary data and the methods used for data collection were; interviewing, observation, use of questionnaire, focus group discussion, and use of geographical information system (GIS) and remote sensing. The study's conclusions showed that changes in land use within the river Nyamuhasana catchment zones have greatly raised the frequency and severity of flooding incidents. The community's lack of awareness of its impact on the rising frequency of Nyamuhasana flooding was another finding of the study. The study also discovered that the flood mitigation strategies used by the people living in the Kyarumba sub-county, which is next to the Nyamuhasana River, are mainly ineffective. The study suggests that to lessen the negative effects of river Nyamuhasana flooding on the way of life for people living in the Kyarumba sub-county, a thorough flood control plan should be created and put into action. Reducing land use changes within river catchment zones, increasing community understanding of flooding causes, and putting in place practical flood mitigation strategies should all be part of the strategy.

**Keywords:** River flooding, land use changes, flood mitigation, livelihoods, Kyarumba sub-county, river Nyamuhasana.

## INTRODUCTION

River flooding is a natural occurrence and can have a big influence on the neighboring human populations. Concern over the potential consequences of river flooding has risen in recent years in Kyarumba Sub-County, which is located along the banks of river Nyamuhasana[1]. This study aims to look at how river flooding affects the residents living adjacent to the banks of river Nyamuhasana in the Kyarumba sub-county. This study will seek to obtain a better understanding of the difficulties residents face during and after flooding events and to explore potential measures to lessen the impact of floods in the future by looking at the experiences of the residents of the Kyarumba sub-county adjacent to the banks of river Nyamuhasana. Major flooding of the river has been registered during the months of intense rainfall, especially from October to December. Over the last ten years, there has been a significant global trend in research on ways to deal with the effects of climate change-related extreme weather events on agriculture. The impact of extreme weather connected to climate change, such as droughts and floods, on agriculture and food security has been the subject of numerous studies [2–4]. One of the most devastating natural disasters in the world is flooding. Flood hazards have been an issue that bothers most communities across the world even in the past decades. However, this scenario has escalated in the 21st century due to rapid climate change across the globe [5–8]. Floods are the most common disaster and ubiquitous natural hazard in the world, according to the UN-disaster report. With an average of 20,000 deaths each year from disasters, only a few countries are immune to floods. Asia is the location of more than half of all flood damages. Socio-hydrological areas close to significant river systems are vulnerable

to the destructive consequences of hydrological disasters but also draw habitation because there are fertile fields for agriculture. Despite being regularly devastated by floods, one such area is Assam's Brahmaputra floodplain in Northeast India [9, 10]. There has been regular and catastrophic flooding in some communities in West Africa especially Kogi states in the north-central part of Nigeria due to the temperature rise. Catastrophic flooding with its associated negative effects has continued to become a significant barrier to human security, environmental sustainability, and development of the area [11]. Frequent flooding in Northern Cameroon is being brought on by climate change and climate variability, with disastrous effects on food security and rural livelihoods. The region's food security and assets used for generating a living are at risk due to the expected increase in temperature and rainfall [12]. Poor sustainable anthropogenic activities carried out by humans on the environment in East Africa have been registered as the driving force behind continuous flooding. This has been witnessed along Nyando wetland on the eastern shores of Lake Victoria in Kenya, where an uncontrollable and excessive harvest of wetland papyrus has taken place, leaving huge chunks of wetland land bare and limiting the ecosystem service of wetland in controlling or regulating water runoffs, hence accelerating flooding in the downstream streams of the area. [13].

In Tanzania, flooding has been so common in most urban centers, like Dar es Salaam. Flooding in such cities has lowered the quality of drinking water due to increasing depositions of pollutants like heavy metals, sewage, and oil that come along with the surface runoff and deposit into the nearby surface water bodies, which are water sources for drinking water. The poor population in the areas has been exposed to high risks of water-related diseases like typhoid and cholera since they always depend on the water from such contaminated water bodies [14].

Additionally, in Dares sa-laam, a great number of people—about 210000 people have been exposed to the risks of flooding since 2005, and their assets have been damaged due to extreme events of flooding. It is estimated that about a loss of assets worth up to US$ 35 million were damaged in 2005, and if extreme flooding is not well managed, the loss might rise up to US$10 billion by 2070 [15]. Temperature increases, droughts, floods, rising sea levels, and storm surges are some of the effects of warming temperatures that are already being felt in Tanzania's Mchungu hamlet, which is located on the shore of the Rufiji District. In terms of fish catch and agricultural productivity, these have an impact on household food security [16]. In the Tanzanian Rufiji delta, important factors linked to a changing climate include rising temperatures, coastal floods, and the frequency of sea level rise. Fish breeding grounds have been harmed, climate regulation has changed, and coastal protection and flood control have decreased as a result of the perceived climatic stressors. The primary effects on community livelihood have also been identified as declining agriculture, fish, and honey output [17]. The River flooding along the Nyamuhasana River in Uganda - Kyarumba Sub-County in Kasese district has gotten worse and more regular in recent years. In many aspects, flooding has had a very bad effect on the local human population, including eviction, property loss, economic disruption, and a rise in disease risk. In light of these repercussions, it is vital to understand how the local human population is affected by river flooding. By conducting a case study of Kyarumba Sub-County, researchers can gain additional insight into the particular problems faced by communities along the Nyamuhasana River and explore realistic solutions for reducing the effects of future flooding events. Flooding has the potential to obstruct the accomplishment of Goal 2 of the SDGs because it puts more communities in food insecurity hot zones that would require long-term assistance to manage [18]. Increased awareness of flood consequences on human systems is the result of recent record rainfall and flooding disasters. For humanitarian groups, information about flood effects on food security is crucial, and it is especially relevant across Africa's rural areas that contribute to regional food supply [12]. For the human populations residing along the banks of the River Nyamuhasana in Kyarumba Sub-County, river flooding is a natural occurrence that has turned into a concern. In this town, flooding has had devastating repercussions that have resulted in fatalities, property damage, evictions of residents, and disruptions of economic activities. To gain insight into the community's level of susceptibility and propose solutions for reducing the effects of this natural hazard, the purpose of this research is to investigate the effects of river flooding on the human population in Kyarumba Sub-County. This study will examine the socioeconomic effects of river flooding on the Kyarumba people, the coping methods used by the community, and the efficacy of current flood management strategies through the examination of primary and secondary data.

## METHODOLOGY

### Research Design

This study employed a case study research design to explore the effects of river flooding on the human population in Kyarumba sub-county. Both qualitative and quantitative research methods were used to collect and analyze data. A survey was done by the researcher around river Nyamuhasana for her to be able to easily observe the geomorphological make of the river regime.

**Description of the Study Area.**

One of the sub-counties in the Kasese district is the Kyarumba Sub County. Its landscape is typical of mountains, and it is situated in Bukonzo County. Democratic Republic of the Congo (DRC) borders its 48 square kilometer territory on the north and west, Kyondo Sub County on the west, Mahango Sub County on the east, and Lake Katwe Sub County on the south [19]. Five parishes make up the local administration of Kyarumba sub-county and these include; the Parish of Kalonge, the Parish of Kaghema, Kihungu Village, the Parish of Kitabu, the Parish of Kabirizi. According to the national population census of 2014, Kyarumba sub-county has a total population of 48000 inhabitants [19]. Kyarumba sub-county has a tropical climate with warm temperatures and high levels of precipitation with fertile soils. This is more prevalent along river Nyamuhasana and due to the presence of pasture growth along the river banks in the lower zones of the river, massive animal grazing has taken place and this has further contributed to degradation of the river banks.

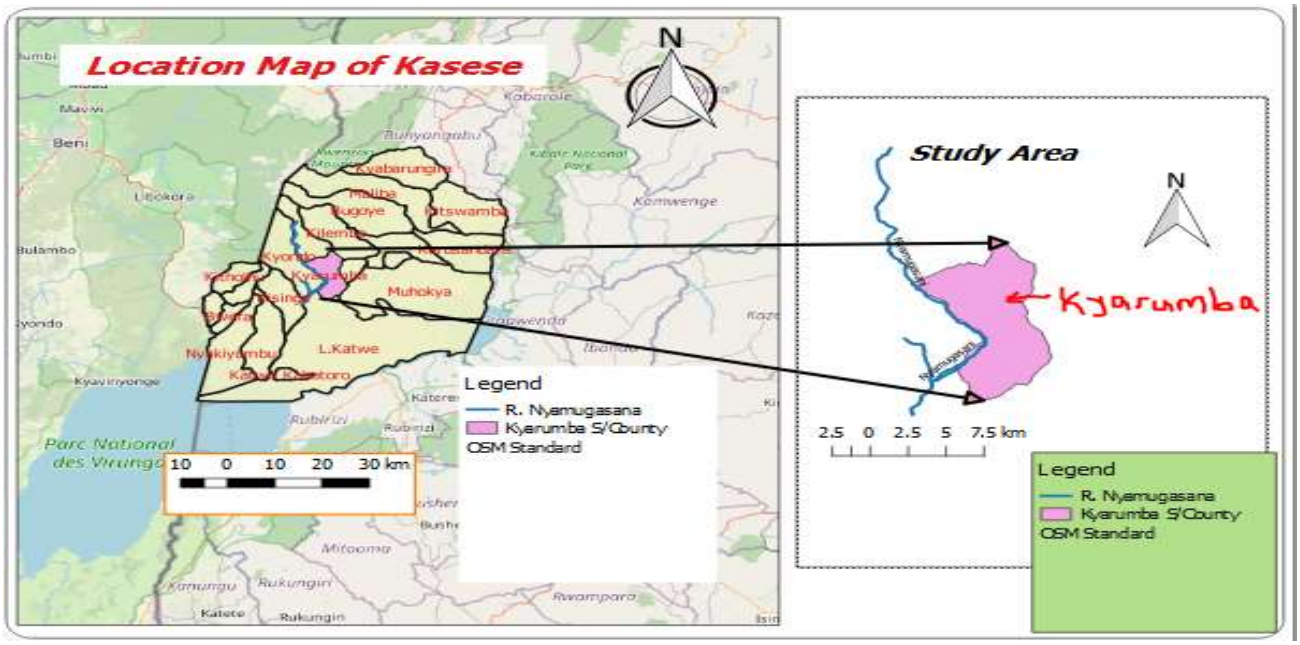


**Figure 1: Map showing the location of river Nyamuhasana in Kyarumba sub-county.**
**Source: Field researcher, 2023.**

### Research Instruments

The study used both primary and secondary data collection tools. The primary data collection tools or methods included; interviewing, observation and recording, use of structured questionnaires, and focus group discussion.

### Interview Method

In this method, semi-structured questions were prepared by the researcher to cater to those respondents who may be illiterate and could not be able to read and write but could become important in this study process. The interview method also involved a face-to-face discussion/interaction between the researcher and the respondents, where the interviewer (researcher) asked some questions regarding households' perception and their experience of past flooding of river Nyamuhasana in the language that respondents understood very well. Key informant discussions at both sub-county and district levels were also conducted by the researcher with various key stakeholders including civil servants like the district environment and natural resource officers, engineers, extension workers, NGOs, and CBOS staff for purposes of acquiring data that was supposed to be obtained from technical experts in the field of water resources.

### Observation

The researcher also employed the observation method where she used her naked eyes to see the features and other parameters of river Nyamuhasana flooding. Through this method, instruments/tools like cameras among others were used to take photographs of the flood-hot sports locations such that detailed information could be captured to make a genuine inference from the study about flooding of river Nyamuhasana in Kyarumba sub-county in Kasese district Uganda. As soon as a change in the physical parameters of the environment as a result of the river flooding was seen, the researcher would take note of it and record it for further analysis after the actual study to reach an inference.

### Questionnaire Method

The data here was collected using a standard semi-structured questionnaire with multiple choice and open-ended questions to allow respondents to deliver secret feedback on their knowledge and insight which was important to the researcher. It also allowed for the investigation of trends that describe what has been happening in real-life situations. Both open-ended and close-ended questions were used to produce data that the researcher processed to reach vivid interpretations and inferences for her to attain the stated research objectives.

### Focus Group Discussion

Here, the researcher holds meetings with certain groups of key stakeholders within the study area and each group would have a total number of members that does not exceed 12 people. Key stakeholders that were engaged in the study through this method included; the sub-county chiefs, clan leaders, local council representatives, and the sub-county environment technical staff representatives. About four groups were formed and each group with a group leader was assigned a topic to discuss along with the researcher. This method also allowed participants in the study area to have a chance to express their views, feelings, and perceptions/experiences about the flooding of river Nyamuhasana.

### Geographical Information System (GIS).

The GIS technique was used by the researcher to obtain the geospatial data concerning the land use and land cover changes that have been occurring in the study area over a given period, and therefore, this data was used to determine whether there is any correlation between the land use and land cover changes and river flooding.

### Secondary Data Tools

**Tools** used to collect secondary data include government reports and data, especially weather data; Uganda National Meteorological Agency (UNMA) rainfall data for the Kyarumba region, including historical trends and flood frequencies; and academic and scientific literature. Peer-reviewed articles: Search for publications in academic journals and scientific databases that explore the impact of river floods on human populations, with a focus on environmental and economic contexts similar to socio-economic status. Books and chapters, See related books and chapters on river floods, disaster management, and community resilience. Research reports and research papers: Access research reports from NGOs, international organizations, and research institutes that have researched the impact of floods in Uganda or other countries.

### Study Population

The target population for this study included local community members of Kyarumba sub-county who live along the river, the sub-county local leaders, cultural and religious leaders, CBOs, and NGOs among others. These target groups of people were selected using both purposive and random sampling techniques.

### Sample Size Determination and Distribution of Target Samples

### Sample Size Determination for the Study

The number of people or observations that were included in a study or experiment is referred to as the sample size for this study. It resembles a little version of the broader population that a researcher was interested in. The sample size was considered crucial by the researcher since it affects the accuracy and reliability of the study outcomes/results. Therefore, for the researcher to be able to derive the actual sample size for this study, she used the Slovene formula of 2004 which states;

$$n = \frac{N}{1 + Ne^2}$$

Where; n = the desired sample size.
N = Total population size of the entire area
e = Margin of error (at 95% confidential, e = 0.05)

According to the Uganda Bureau of Statistics (web-2020), Kyarumba sub-county has a total population of about 48000 people. Using this information;

$$n = \frac{48000}{1+48000(0.05)^2} = 399.99 = 400 \text{ respondents}$$

n = 400 respondents

Therefore, the study employed a sample size of 400 respondents.

**Table 1: Distribution of the determined sample size**

| Selected unit | Target respondent (Samples) | Gender | | Sampling technique |
|---|---|---|---|---|
| | | Males | Females | |
| Kyarumba s/county | Farmers | 95 | 120 | Random sampling |
| | Business people | 72 | 50 | Random sampling |
| | Local leaders | 27 | 17 | Random sampling |
| | Civil servants | 05 | 02 | Purposive sampling |
| | NGOs and CBOs | 07 | 05 | Purposive sampling |
| **Total** | | **206** | **194** | |

**Source: Field researcher, 2023.**

### Data Analysis

The study data collected was coded and analyzed using IBM Statistical Package for Social Sciences (SPSS) version 20 after data cleaning and analyzed using quantitative methods involving descriptive statistics and MS Excel computer packages. Descriptive statistics to be used included; frequency distribution tables, bar graphs, pie charts, and cross-tabulations.

### Ethical Consideration

For the researcher's activities in the region to be legally recognized, during the initial stages of the research, a letter of introduction from the School of Natural and Applied Sciences at Kampala International University was obtained. The researcher then presented this letter, along with a valid university identity card, to the relevant authorities in Kyarumba sub-county and Kasese district. The need to explain the study's goals and importance to the respondents was another crucial factor to consider. The chosen respondents participated in this study willingly; therefore, no participant was expecting to receive anything material in exchange. Participants had the option to stop taking part in the study whenever they chose, and all participant identities were kept in strict confidence by allowing them to enter serial numbers rather than their names when completing the structured questionnaires. The data collected from research participants was only used for academic purposes.

## RESULTS

### Demographic Characteristics of Respondents

### Gender of the Respondents

Out of the total respondents that were engaged in this study (N = 400), the majority were male respondents; about 51.5% (206). Females were about 48.5% (194) which gave a male-to-female ratio of 1.1:1.0. This shows that the study was gender sensitive where both male and female respondents were engaged and therefore, all gender views, perceptions, and thoughts were addressed allowing the researcher to have results that are free from gender bias.

**Table 2: Participants' distribution by sex/gender.**

| Gender | Frequency (N) | Percentage (%) |
|---|---|---|
| Males | 206 | 51.5 |
| Females | 194 | 48.5 |
| **Total** | **400** | **100** |

**Source: Field researcher, 2023.**

### Respondents' Marital Status

The majority of the respondents to this study were married; about 68.4% (250). This was followed by the single and widowed respondents about 20.7% (75) and 16.7% (60) respectively. Others were acknowledged by very few percentages of individuals about 4.2 % (15) as in **Table 2** and ***Fig 1*** below.

**Table 3: Marital status of respondents to the study**

| Marital status | Frequency (N) | Percentage (%) |
|---|---|---|
| Married | 250 | 68.40 |
| Single | 75 | 20.70 |
| Widowed | 60 | 16.70 |
| Others | 15 | 4.20 |
| **Total** | **400** | **100** |

**Source: Field researcher, 2023**

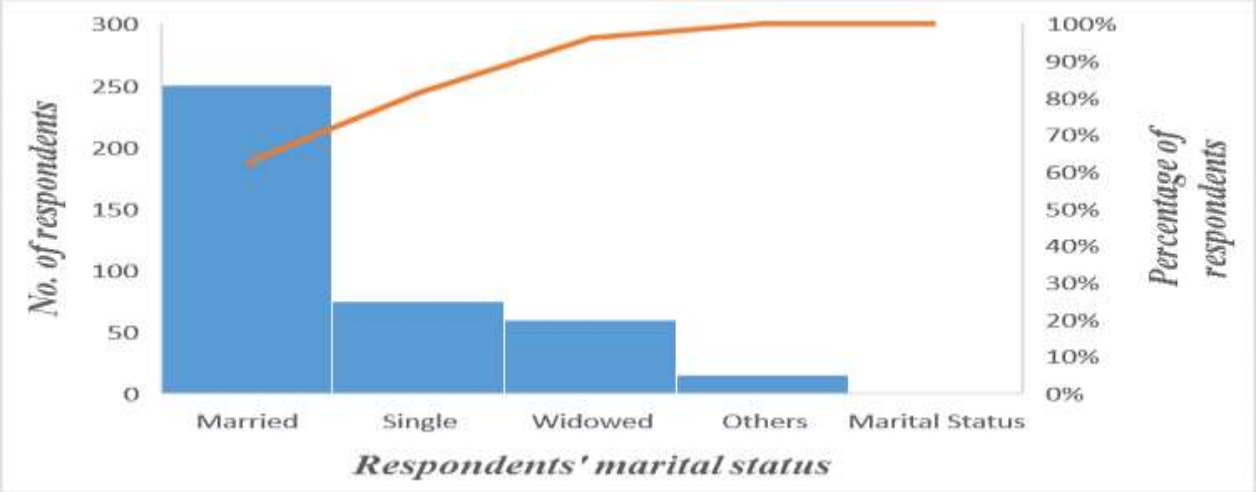


**Figure 2: Marital status of respondents to the study**
**Source: Field researcher, 2023.**

The results show that the majority of the population (68.4%) is married. This suggests that marriage is a common social institution in this population. The mode of distribution is married, which further supports this conclusion. This can further indicate the influence of human activities like farming in the catchment areas of the river to increase food production for the families. The percentage of widowed individuals (16.7%) is also relatively high, which may be due to the rapid occurrence of river flooding. The percentage of single individuals (20.7%) is relatively low, which may be due to factors such as cultural norms or economic conditions. The percentage of individuals in the "other" category (4.2%) is relatively small, which suggests that this category is not very common in this population.

**Respondents' Level of Education**

The results of the study show that the majority of participants about 50%, (200) had completed secondary education. This was followed by those that had obtained tertiary; about 20% (80) and primary level of education, about 18.8% (75). Only a few respondents had an informal level of education, about 11.2% (45) as in Table 2 below.

**Table 4: Distribution of Study Respondents by Education Level**

| Education level | Frequency (N) | Percentage (%) |
|---|---|---|
| Informal Education | 45 | 11.2 |
| Primary Education | 75 | 18.8 |
| Secondary Education | 200 | 50.0 |
| Tertiary Education | 80 | 20.0 |
| **Total** | **400** | **100** |

**Source: Field researcher, 2023.**

Generally, the findings submit that the study inhabitants are moderately knowledgeable, with the majority having finished minimally high school. However, there is still a significant fraction of people with simply prime training or informal education. Therefore, this data can be used to inform future

research and interventions aimed at improving educational attainment in the study population.

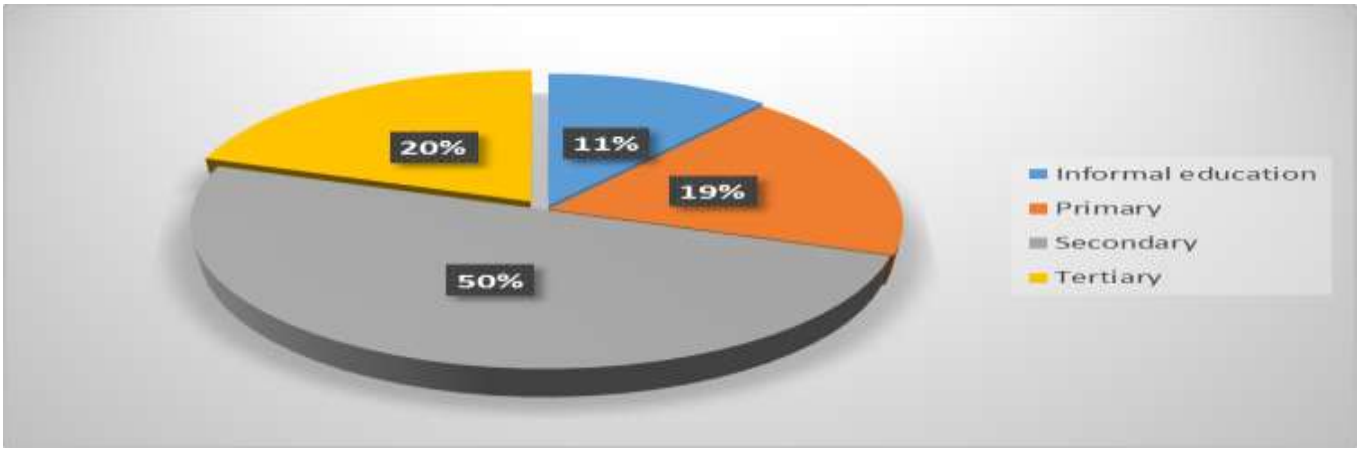


**Figure 3: Participants' level of education**
**Source: Field researcher, 2023.**

**Main Occupation of the Respondents**

The results of the study indicate that the majority of participants (53.75%) were farmers, followed by business people about (30.5%). Local leaders, NGOs and CBOs, others, and civil servants were the least occupation that constituted a smaller percentage of respondents; (8.75%), (2.25%), (3.0%) and (1.75%) respectively as in Table 3.

**Table 5: Distribution of Participants by their Occupation**

| Occupation of respondents | Frequency (N) | Percentage (%) |
|---|---|---|
| Farming | 215 | 53.75 |
| Business | 122 | 30.5 |
| Local leader(s) | 35 | 8.75 |
| Civil servant(s) | 7 | 1.75 |
| NGOs & CBOs | 9 | 2.25 |
| Others | 12 | 3 |
| **Total** | **400** | **100** |

**Source: Field researcher, 2023.**

This demonstrates that the study population is primarily involved in agronomic actions. Local leaders, civil servants, NGOs & CBOs, and others constituted a smaller percentage of the participants, signifying that these livelihoods are less dominant within the study population.

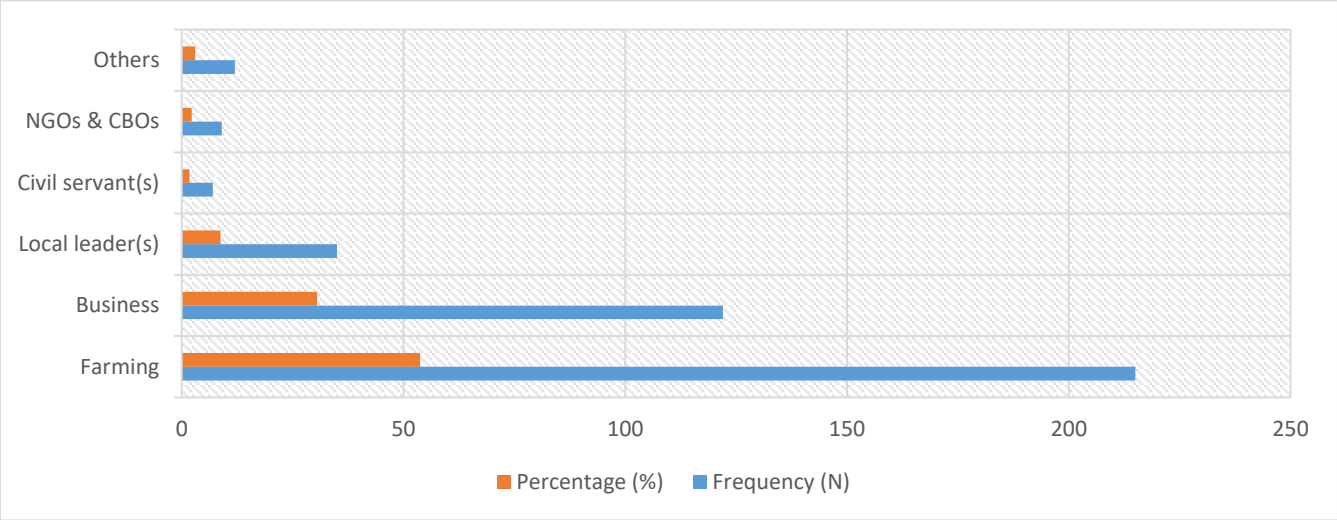


**Figure 4: Indicates respondents' distribution by their main occupation**
**Source: Field researcher, 2023.**

**Distance of the Household of the Participants from the River**

Among the total (N = 400) respondents that were engaged in this study, the majority acknowledged the distance of their house to be ≥ 0–1 km, or about 53% (215). This was followed by ≥ 2-3km, about 39% (158), and ≥ 4-5km about 6% (25). A small percentage of respondents' households were found at a very distant place from the river, ≥ 6 km, about 2% (10) as in Table 5.

**Table 6: Participants' household distance from the river.**

| Distance of the household from the River (Km) | Frequency (N) | Percentage (%) |
|---|---|---|
| ≥ 0 - 1 | 215 | 53 |
| ≥ 2 - 3 | 158 | 39 |
| ≥ 4-5 | 25 | 6 |
| 6 ≥ | 10 | 2 |
| **Total** | **400** | **100** |

**Source: Field researcher, 2023**

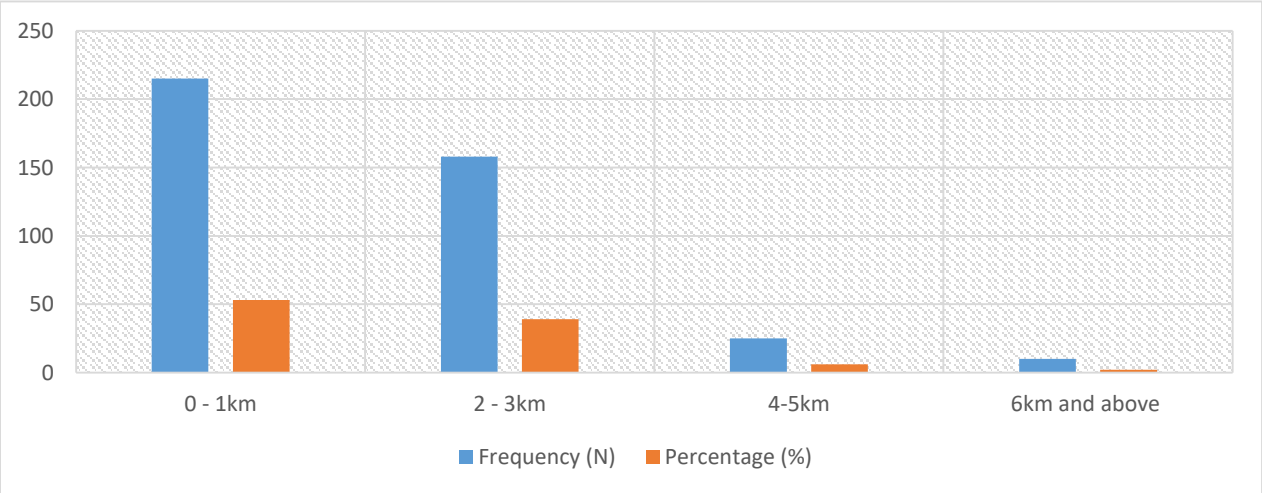


**Figure 5: Respondents' responses about the distance of their homes from the river**
**Source: Field researcher, 2023.**

Measures of Central Tendency (Mean = 1.54 km
Median = 1.5 km Mode = 0-1 km).

The results show that the majority of households (53%) are located less than 1 km from the river. This shows that the river is an important source of water supply for these households. The average distance to the river is 1.54 km, and the median distance is 1.5 km. This shows that the distribution of distances between households is skewed to the left, with most households being closer to the river. The standard deviation of 1.25 km indicates a moderate variation in the distance between households and the river.

The proximity of households to the river may have several impacts. For example, households located near rivers may have easier access to water for drinking, washing, and irrigation. However, they may also be more exposed to flooding and water-borne diseases. The distribution of distances between households and rivers can be influenced by several factors, such as land availability, the topography of the area, and the location of roads and other infrastructure.

**Participants' Years of Residence in the Study Area**

Of the total respondents (N = 400) that were involved in this study, a great percentage had stayed long in the study area. About 62.5% (250) have been staying in the study area for a period of 15 and above years. This was followed by those that had stayed between ≥10-15 years and ≥5-10years, about 23.75% (95) and 7.5% (30) respectively. Only very few respondents stayed in the study area for a shorter period. I.e. between 0-5 years, were about 6.25% (25) (table 6 and fig 4).

**Table 7: Years of residence of participants in the study area**

| Years of residence in the study area | Frequency (N) | Percentage (%) |
|---|---|---|
| 0 - 5yrs | 25 | 6.25 |
| 6 - 10yrs | 30 | 7.5 |
| 11 - 15yrs | 95 | 23.75 |
| 16 and above | 250 | 62.5 |
| **Total** | **400** | **100** |

**Source: Field researcher, 2023.**

From the findings in the table above, it is indicated that the majority of respondents (62.5%) have lived in the study area for 15 years and above. This proposes that a pronounced percentage of the study populace has a long-lasting link to the study area and may have an inherent awareness of its antiquity, beliefs, and communal changing aspects.

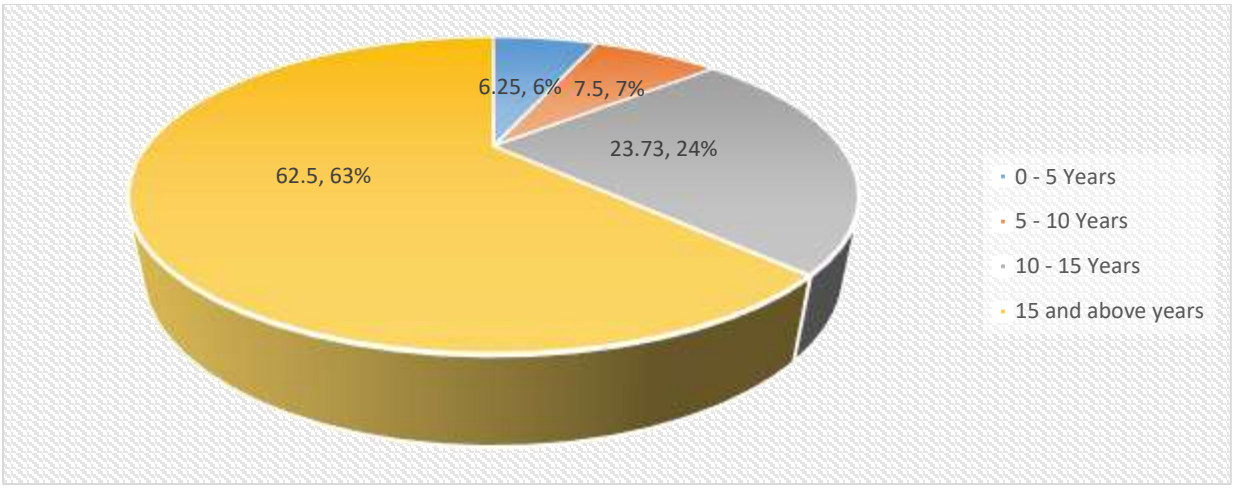


**Figure 6: Years of residence of participants in the study area.**
**Source: Field researcher, 2023.**

**River Flooding**

According to the problem of the study, flooding on the Nyamuhasana River occurs rapidly daily, and therefore the objective is to find out various problems behind this catastrophic event and among the problems solved during the process of research, including changes in land use and land area in the river basin, the effects of flooding on surrounding communities, and some measures taken to mitigate

rapid attack. The rapidity of this river flood and its negative impacts on society are the objectives of the study.

**Causes of River Nyamuhasana Flooding**

During the study, it was revealed that flooding of this river is both man-made and natural causes. However, during an interview that was held by the researcher with the district and sub-county technical staff, it was argued that the rapid occurrence of river flooding in this study area has been induced by man's actions.

A great percentage of the respondents about 98% acknowledged that man-made activities (land use and land cover changes) have greatly influenced the rapid happening of river flooding in the area. Only 2% acknowledge natural causes of the river flooding (***fig 6***).

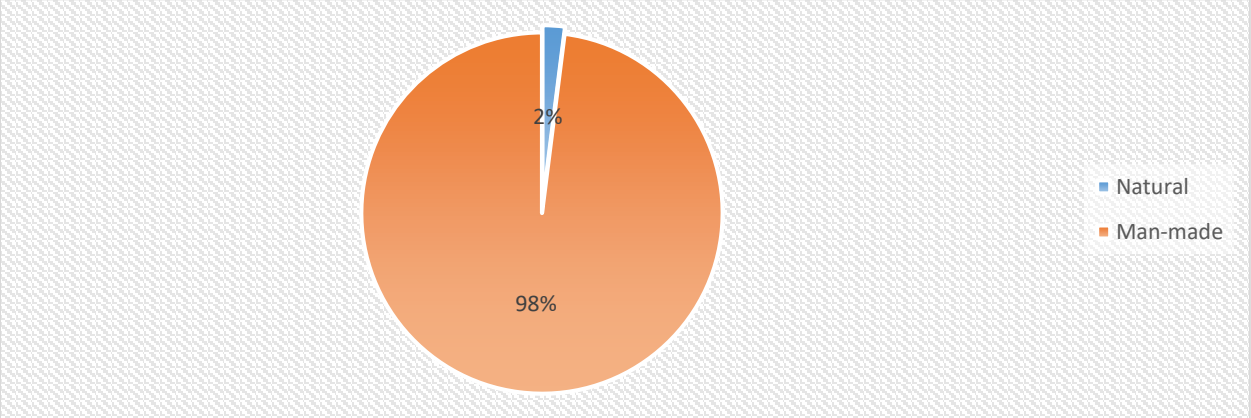


**Figure 7: Causes of River Nyamuhasana flooding**
**Source: Field researcher, 2023.**

The finding that 98% of river flooding in a study area is attributed to man-made causes, while only 2% is due to natural factors, highlights the significant impact of human activities on altering natural hydrological processes and increasing flood risk. This suggests that human interventions in the landscape have played a dominant role in exacerbating flood events, overshadowing the influence of natural factors.

**The Man-made Causes of River Nyamuhasana Flooding**

The study findings indicated that unsustainable farming is the most significant man-made cause of River Nyamuhasana flooding, with about 38% (150) of respondents acknowledging the issue. This was followed by deforestation at about 25% (100), poor drainage infrastructure at 12% (47), and overgrazing; at 9% (35). The list of land use activity causing flooding was river channel alteration which was acknowledged by very few participants, about only 6% (23) as in **Table 7**.

**Table 8: Distribution of respondents' views on man-made causes of River flooding**

| **Man-made causes (Land use changes)** | **Frequency (N)** | **Percentage (%)** |
|---|---|---|
| Deforestation | 100 | 25 |
| Urbanization | 45 | 11 |
| Over-grazing | 35 | 9 |
| Unsustainable farming | 150 | 38 |
| River channel alteration | 23 | 6 |
| Poor drainage infrastructure | 47 | 12 |
| **Total** | **400** | **100** |

**Source: Field researcher, 2023.**

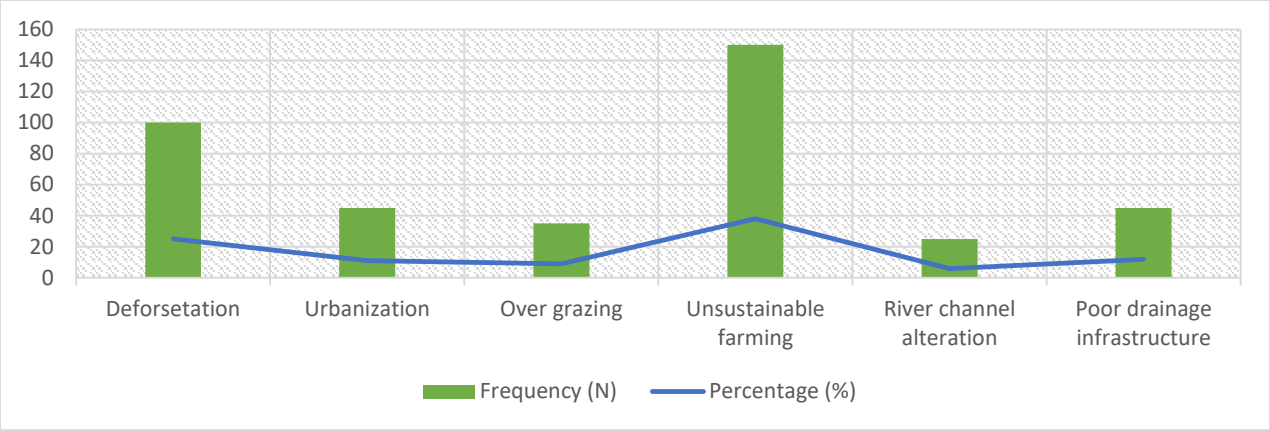


**Figure 8: The respondents' views on man-made causes of River flooding**
**Source: Field researcher, 2023**

These findings highlight the need for sustainable land management practices to mitigate flood risks in the Nyamuhasana River basin. Unsustainable agricultural practices, such as excessive tillage and inadequate soil conservation practices, can lead to soil erosion and increased runoff, contributing to flooding. Deforestation removes vegetation that absorbs and regulates rainwater, exacerbating the risk of runoff and flooding. Poor drainage infrastructure and urbanization also contribute to increased flood risk. Improper drainage systems can be flooded by heavy rain, leading to localized flooding. Urbanization increases impermeable surfaces, such as roads and parking lots, which prevent storm water from seeping into the ground and instead contribute to runoff. Channel changes, such as straightening or narrowing river channels, can increase water flow speeds, making downstream flooding more likely. Overgrazing can degrade soil quality and reduce its ability to absorb water, further increasing the risk of runoff and flooding. The observation of these factors was supported by the land use and land cover maps of the study area indicated below.

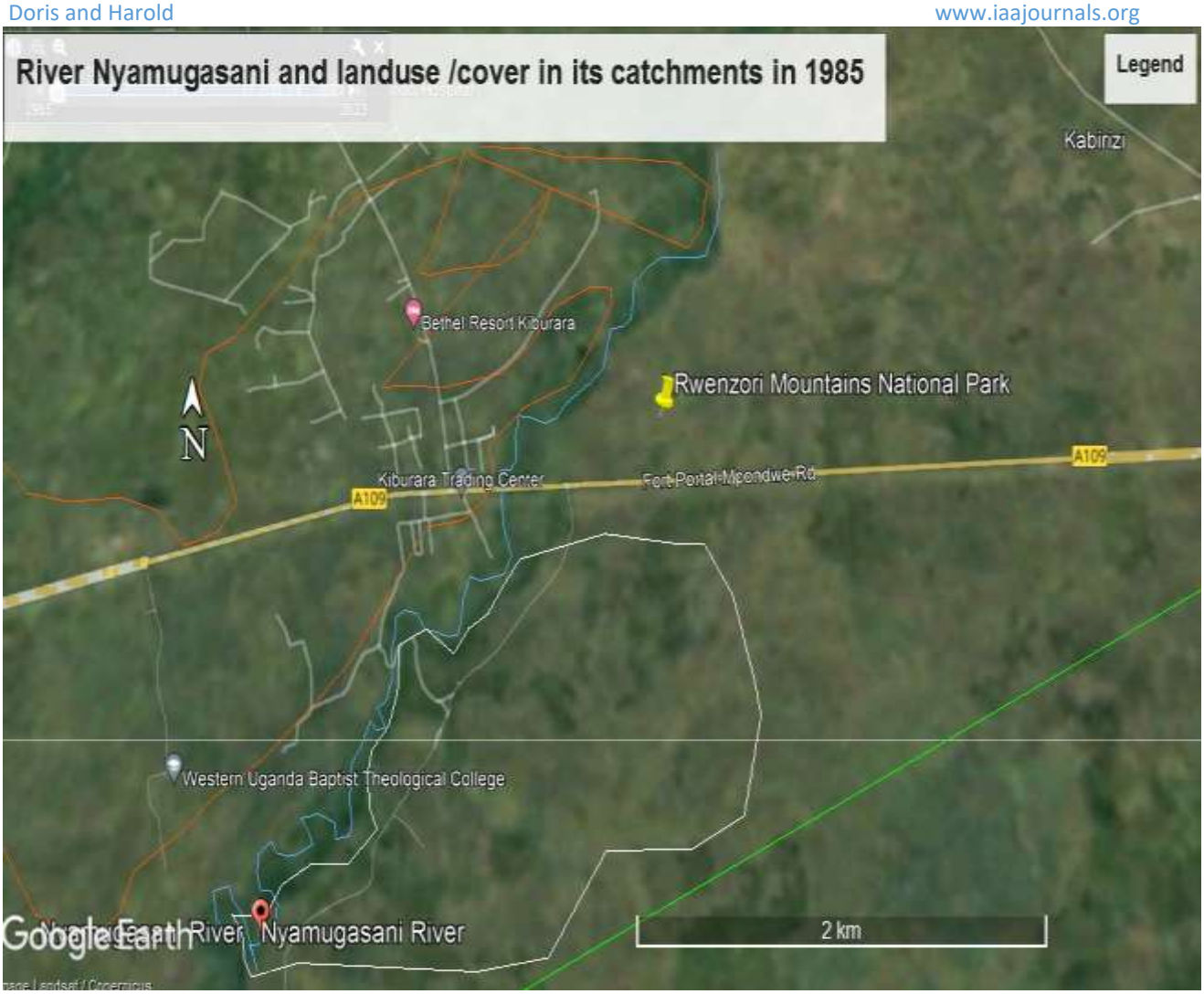


**Figure 9: Indicates the LULC map of the river Nyamuhasana in 1985.**
**Source: Field researcher, 2023.**


**Figure 10: Shows the LULC changes in the catchment area of River Nyamuhasana in 2023.**
**Source: Field researcher, 2023.**

From the map above, it is demonstrated that man's activities like horticulture and urbanization have intensely infringed on the waterway banks, and this may well be a factor in the fast event of waterway flooding within the area. The uncovered land cleared out at the banks of the stream, as seen from the map above, energizes fast siltation through erosion into the waterway, which subsequently contributes to shallowing the depth of the waterway and disabling it to hold the expanding volumes of water when it intensely downpours within the region, thus quickening the expanding rates of river Nyamuhasana flooding within the study area.

By comparing the two maps of 1985 and 2023 Land Use and Land Cover (LULC) changes, it is indicated that man has severely destroyed the natural vegetation cover along the catchment zones of river Nyamuhasana.

**The Natural Causes of River Nyamuhasana Flooding**

In an interview with environmental officials and district climatologists, it was revealed that increased rainfall and rising temperatures in the area had caused rapid flooding in the district, including the Nyamuhasana River. Increasing rainfall on Mount Rwenzori, which is the source of the Nyamuhasana River, has contributed to increasing the amount of water that the depleted river cannot contain, thereby bursting its banks and flooding neighboring communities such as business centers, especially the

Kyarumba trading center (town council).It was further stated that due to increased temperatures in the area, especially during periods of extreme heat, the Nyamuhasana River as well as all other rivers originating from Mount Rwenzori are flooded even when it is sunny (when there is no rain). This is especially observed during July to October when temperatures in the region are highest. In a discussion held in the parish, environmentalists argued that the increase in temperature appears to have caused ice and snow on mountain tops to melt rapidly, as most mountain peaks, like Margarita, are the home of snow. Melting ice also contributes to increasing the amount of river water originating from the mountains and causing serious flooding downstream. The increasing temperatures have contributed much to the variation in rainfall patterns received in the study area as in Table 8 below;

**Table 9: Distribution of temperature and rainfall patterns in the year 2022 in the study area**

| Dates (Months) | Temperature (degrees Celsius) | Rain fall (mm) |
|---|---|---|
| January | 30 | 451 |
| February | 31 | 360 |
| March | 30 | 470 |
| April | 29 | 451 |
| May | 28 | 370 |
| June | 29 | 190 |
| July | 29 | 94 |
| August | 29 | 182 |
| September | 28 | 230 |
| October | 28 | 361 |
| November | 27 | 540 |
| December | 28 | 620 |

**Source: Kasese district weather forecast report, 2022-2023 (Secondary data).**

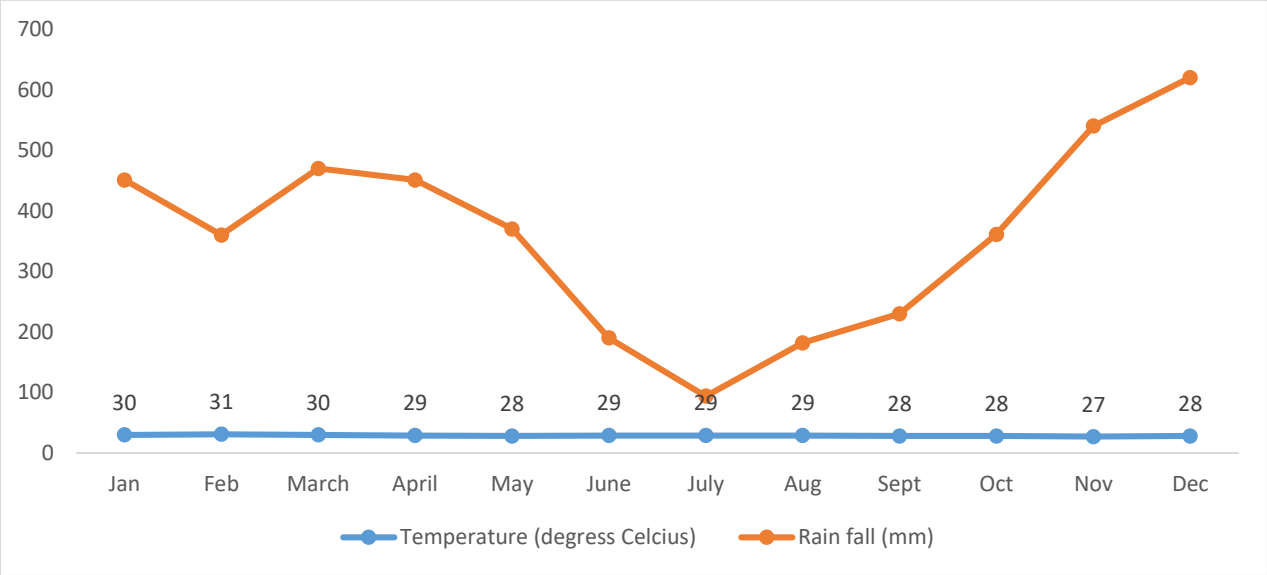


**Figure 11: The distribution of temperature and rainfall in the year 2022 within the study area**
**Source: Field researcher, 2023**

The total rainfall received in the study area is about 4,319 mm throughout 2022, and the average monthly rainfall is 359 mm. December was recorded as the wettest month of the year, with around 620 mm of rainfall in the region, and the least rainfall was recorded in July, with around 94 mm, as shown in Table 8 and Figure 8, respectively. This shows that heavy rainfall is more frequent in the months of April, November, and December, and these three months, especially November and December, are months with catastrophic river flooding. This weather data indicates that the area experiences both hot and rainy seasons, and this is related to information revealed by respondents in a group discussion, suggesting that

rivers sometimes overflow even if 'there's no rain or precipitation. In addition, an environmental student in the study area said rising temperatures could cause the melting of ice sheets (snow) on top of the Mountain of the Moon, commonly known as Mount Rwenzori, the source of the river Nyamuhasana.

**Effects of River Nyamuhasana Flooding**

In a focus group discussion with the local farmers, sub-county chiefs, and CBOs in the study area, it was revealed that flooding of river Nyamuhasana has had detrimental effects on various communities surrounding the river ranging from socio-economic to environmental impacts. This was backed by the information obtained from the office of the district natural resources at the district in an interview that the researcher held.

**The Socio-economic Effects of River Nyamuhasana Flooding**

The majority of the respondents argued that river flooding has caused severe loss of human life and injuries to people in the study area, about 20% (80) respondents acknowledged it. This was followed by loss of crops and life stock (Agricultural products) and displacement of affected people which were also acknowledged by about 19% (75) and 18% (70) of respondents respectively, property and infrastructure damage, about 16% (65) respondents. The least acknowledged effects were disruption of economic activities, increased risks of diseases, and trauma of experiencing floods by about 11% (45), 10% (40), and 6% (25) of the respondents respectively as in Table 9.

**Table 10: Respondents' response on the socio-economic effects of River Nyamuhasana flooding**

| Socio-economic Effects | Frequency (N) | Percentage (%) |
|---|---|---|
| Loss of life and injuries | 80 | 20 |
| Damage to property and infrastructure | 65 | 16 |
| Disruption of economic activities | 45 | 11 |
| Loss of crops and life stock | 70 | 18 |
| Increased risks of Diseases | 40 | 10 |
| Displacement of people | 75 | 19 |
| The trauma of experiencing floods | 25 | 6 |
| **Total** | **400** | **100** |

**Source: Field researcher, 2023**

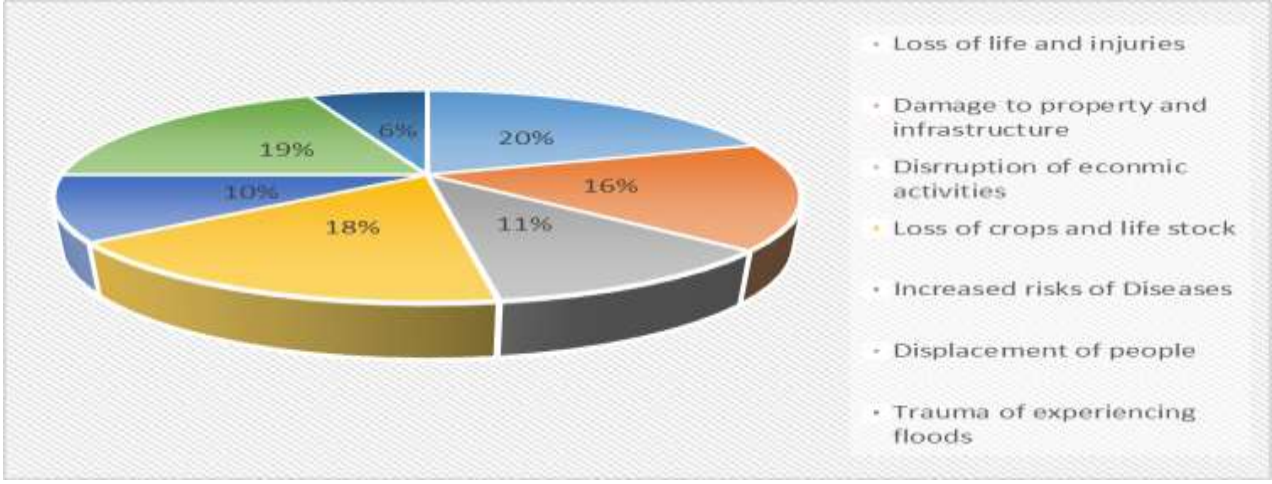


**Figure 12: Distribution of Respondents' responses on the socio-economic effects of River Nyamuhasana flooding.**

**Source: Field researcher, 2023**

**DISCUSSION**

The Nyamuhasana River floods have had devastating socio-economic impacts on communities, especially in areas such as Kyarumba commercial hub and Musasa village, located on the border between Kyarumba sub-county and Kyondo sub-county, where livelihoods are largely based on agriculture and natural resources. The Nyamuhasana River flood illustrates the range of negative impacts on these societies, and among the impacts identified in the study are: River flooding threatens human life, causing drowning, injuries from

debris, and electrocution from falling power lines. The loss of loved ones and the trauma associated with such events leave lasting psychological scars on individuals and communities [20]. Floodwaters damaged or destroyed hundreds of homes, businesses, roads, bridges, and other infrastructure, causing significant economic losses and disrupting essential services.Repair and reconstruction costs could strain already limited resources, hindering long-term recovery efforts. On the other hand, floods also disrupt economic activities, especially agriculture and trade. Crops such as coffee, bananas, cassava, and corn were damaged, and livestock such as cattle, sheep, and goats were damaged. This has contributed to serious economic losses and related impacts such as children dropping out of school, malnutrition, and disruption to transport networks that have severely affected livelihoods, leading to loss of income and food insecurity[21].

During an interview with a group of environmental, ecologists, and conservation experts at the sub-county and district, it was revealed that severe flooding of the river has contributed to the rapid degradation of nature. It was also stressed to the researcher that excessive flooding coupled with runoffs of various pollutants from both agricultural fields, homesteads, and the trading center located at the banks of the river has contributed to rapid pollution of the water with chemicals, heavy metals, and nutrients like phosphorous and nitrates. Additionally, the run-off from homesteads comes with pathogens, especially from the toilets and open defecation. The problem of water pollution has been realized due to the excessive occurrence of water-borne diseases like cholera and typhoid, which have also been proven to be rampant in the study area in the seasons of heavy rainfall when most of the water source (river) for the community bursts its banks. Similarly, another expert (environmental student) from a higher education institution, residing in the study area, also revealed "water quality deterioration[22].

Floodwaters still contain pollutants, debris, and excess nutrients from agricultural runoff, leading to reduced water quality. This can harm aquatic life, increase the risk of algal blooms, and reduce the availability of drinking water for downstream communities [22]. Other ecological impacts mentioned by conservationists and ecologists in the study area include; Habitat disturbance, and flooding of most rivers in the district, including the Nyamuhasana River, has completely changed the physical structure of riverine habitats, causing erosion, sedimentation and Change in water regime and water flow. This can disrupt the delicate balance of aquatic ecosystems, leading to the loss of essential habitat for fish, amphibians, and other aquatic creatures. By changing riparian zones, flooding can inundate riparian zones and transition zones between land and water, affecting vegetation and wildlife that depend on these habitats. Flooding also alters the natural processes of nutrient cycling and sediment deposition in these areas, affecting the overall health of river ecosystems. Disrupting species interactions; floods disrupt the delicate balance of predator-prey relationships, competitive dynamics, and symbiotic interactions in river ecosystems. This can lead to population declines, changes in species composition, and changes in the overall food web structure. The study also revealed that river flooding contributes to the spread of invasive plants and animals to new locations, potentially disrupting native ecosystems and preventing native species from reaching resources. As a result, this has contributed to biodiversity loss and reduced ecosystem resilience.[23, 24]. Long-term changes in ecosystems due to repeated river flooding also lead to changes in river morphology, vegetation patterns, and species composition. These changes have affected the overall productivity and biodiversity of river ecosystems, potentially reducing the system's ability to provide essential services.

During the research process, local leaders in the area said that many written proposals were sent to the government through the District Natural Resources Officer's office for the government to consider building embankments to protect the community living in lowlands or low-lying societies that suffer the most from increased flooding in the study area. In the same vein, a certain LCI from Mugette village added that once the dyke is installed, the communities downstream will be safe from floods and their consequences, as these dykes help stabilize the river banks, and the dyke helps stabilize rivers and helps the river retain a huge amount of water during the heavy rainy season, which seems to contribute to rapid flooding in the study area. Another respondent to the same issue also argued that to effectively control the problem of excessive flooding in low-lying societies, it is necessary to first control upstream river rapids by building dams that can help retain water for a long time before flowing into downstream communities. It was added that the Nyamuhasana II Dam is intended to supply water for hydropower at the under-construction Nyamuhasana II Hydroelectric Power Plant, which **is** expected to help alleviate rapid flooding of the Nyamuhasana River in downstream communities such as the midstream Kyarumba shopping mall. It was also revealed that the local residents have argued and encouraged to stop building, farming, and other activities including stone quarrying being carried along the river banks to stop such that the "river can have a breathing space". Programs like relocations of the families found established in the flood-prone areas and those within the catchment areas of the river to

safer places are underway according to the sub-county leaders. Other measures revealed included; river channelization and dredging, Gabion Installation, Reforestation and Afforestation, Early Warning Systems, Community Awareness and Education, and Integrated Catchment Management [24].

River Channelization and Dredging: Channelization involves widening and deepening river channels to increase their capacity to carry floodwaters. Dredging removes sediment buildup from riverbeds to improve water flow and reduce the risk of overflow. These measures have been implemented along sections of the river (Nyamuhasana) to reduce flooding in Kyarumba town and other adjacent communities that are affected by flooding of the river. Gabion Installation: Gabions are wire cages filled with rocks or other materials that act as retaining walls to stabilize riverbanks and prevent erosion. Gabion structures have been installed along sections of the Nyamuhasana and Nyamwamba rivers to reduce erosion and protect riverbanks from collapsing during floods. Reforestation and afforestation: reforestation involve replanting trees in previously forested areas, while afforestation creates new forests in previously un-forested areas. These measures help reduce soil erosion, increase water infiltration, and regulate water flow, thereby reducing the risk of flooding. Reforestation and afforestation efforts are underway in the Nyamuhasana River basin. Integrated river basin management: This involves coordinating the efforts of different stakeholders to address the root causes of flooding, such as deforestation, poor land use practices, and wetlands encroachment. This comprehensive approach aims to restore the natural functions of the river basin and reduce the overall risk of flooding. Integrated river basin management plans are being developed for the Nyamuhasana, Nyamwamba, and Mubuku river basins. These measures, ranging from structural interventions to community initiatives, represent a multi-pronged approach to addressing river flooding in Kasese district [25, 26]. While challenges remain, these efforts make communities more resilient and better prepared for flooding.

## CONCLUSION

Human activities like deforestation, urbanization, and poor land management have significantly impacted the landscape's ability to retain and control water, making it more vulnerable to flooding. This highlights the need for sustainable land use practices, including reforestation, soil preservation, and careful urban planning. Understanding the impact of these actions on flood hazards can help make informed decisions, reducing the risk of flooding in the Kyarumba sub-county and the district.

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