Received: 25 October 2022 | Accepted: 11 February 2023

DOI: 10.1002/wwp2.12098

RESEARCH ARTICLE

WILEY

# Vulnerability assessment to flood hazards of households in flood-prone areas of Kasese District, Western Uganda

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**Abstract**

The study evaluated the level of household vulnerability to flood hazards in Kasese Municipality, Kasese District, Uganda. The municipality is divided into three divisions (viz., Central, Bulembia, and Nyamwamba). The study utilized both secondary and primary data. Secondary data were obtained through an extensive literature review, and primary data were obtained through household survey. Seventy households were systematically randomly selected from each division. The study used an indicator-based methodology. The indicators under the different categories were broken down into different classes basing on their features. The indicators were then normalized, and weights were assigned to different indicators using principal component analysis (PCA). The variables normalized were multiplied with the weights assigned to develop the indices for the components of vulnerability. Indices of vulnerability were created at the home level and aggregated at the division level. A chi-squared test at a significance level of 5% was used to test for differences in the level of household vulnerability. The results revealed that the Nyamwamba division was most exposed whereas the Central division was least exposed to floods. The Central division was also found most sensitive whereas the Bulembia division was least sensitive to floods. The

  

Central division had better capacity to cope with floods whereas the Bulembia division had the least capacity. The study further revealed a significant difference in the level of households' vulnerability across the divisions. However, overall, the Nyamwamba division was found most vulnerable and the Central division least vulnerable to floods. About 43.8% of the households in Kasese Municipality were found highly vulnerable to floods. To reduce the high levels of exposure, households nearer major flooding river should be relocated to safer places and restrict settlement in flood-prone areas. To reduce the high levels of sensitivity and enhance adaptive capacities, the local government and other stakeholders should give jobs/income-generating opportunities to enhance the income levels and savings of the households in the flood-prone areas. To reduce the high levels of vulnerability, government and other stakeholders should develop policies and allocate funds for disaster risk reduction and adequately respond to flood disasters at the lowest administrative units of villages and subcounties.

**KEYWORDS**
adaptive capacity, exposure, floods, Uganda, vulnerability

## 1 | INTRODUCTION

Like much of the world, floods are common in Uganda (Ogwang et al., 2012; Tibara et al., 2021a). Besides causing death, floods destroy public health facilities, schools, and various infrastructures among others (Department of Disaster Preparedness and Management [DDPM] & Office of the Prime Minister [OPM], 2011). Between 1997 and 2007, floods affected close to one million people in Uganda (DDPM & OPM, 2011). Kasese Municipality, Western Uganda, is plagued by natural disasters, particularly floods that occur every year causing catastrophic damage to property and human lives (Jacobs et al., 2017; Tibara et al., 2021b). For instance, in 2013, a flash flood ravaged Kasese Municipality and left eight people dead with severe destruction of properties including agricultural farms and road infrastructure (Jacobs et al., 2017). The Intergovernmental Panel on Climate Change (IPCC, 2014) estimate that in many locations, intense and frequent extreme precipitation events, like floods, will occur more frequently, and therefore the need for disaster risk reduction and management. Further, Kasese Municipality has experienced at least three major flood disasters in the last decade. These flood disasters will continuously impact people in the area by enormously damaging property and infrastructure, substantially causing loss of lives and livelihood of people (Kasese District Local Government [KDLG], 2020b). Integrating disaster risk reduction and climate change adaptation within local disaster management policies is, therefore, required in order to reduce vulnerability and enhance resilience to natural disasters (Shah, Ye, et al., 2018) and improve the awareness level to increase knowledge and preparedness for future floods (Shah et al., 2020).

The continuous exposure to flood disasters especially in Kasese Municipality affects household vulnerabilities, which, in turn, affect capacities to respond to the consequences of natural hazards. This is critical given that 97.4% of the households in Kasese are not living in decent dwellings, 44% lack clean and safe water, and 81.1% engage in crop growing (Uganda Bureau of Statistics [UBOS], 2017), which are affected more by flood disasters. Additionally, a study in Kasese revealed that extreme flooding increases the risk of the spread of malaria (Boyce et al., 2016), and 73.5% of households have no access to health facilities and about 101,065 lives in Kasese Municipality (UBOS, 2017). The Belgian Technical Cooperation (BTC) and KDLG (2012) reported that the Nyamwamba and Bulembia divisions have a majority of extremely poor households. The poor are disproportionately affected by natural disasters because they lack the resources to prepare for and deal with their effects. Household's exposure, and vulnerability to flood disasters, has increased over time, and policymakers therefore need to pay serious attention to building effective mitigation and adaptation plans in order to reduce flood damages.

Although there are studies on the climate change vulnerability of rural farmers, flash flood reconstruction, exposure impacts, weather shocks, urban livelihood alternatives, and temporal rainfall variation in Kasese (Akampumuza & Matsuda, 2016; Berman et al., 2015; Cooper & Wheeler, 2017; Jacobs et al., 2017; Tibara et al., 2021b), no study had precisely focused on vulnerability assessment in Kasese Municipality, which is important in determining the level of community vulnerability to floods and possible risk reduction measures and developing appropriate adaptive strategies (Cooper & Wheeler, 2017; United Nations International Strategy for Disaster Reduction [UNISDR], 2015), which this study addressed. The assessment focused on three main indicators, that is, exposure, sensitivity, and capacity. Several authors have discussed the concepts of vulnerability in terms of exposure, sensitivity, and adaptive capacity and their interrelationship (Bhattacharjee & Behera, 2018; Shah, Shaw, et al., 2018). The research questions that guided the study were as follows: What is the level of household exposure, sensitivity, and adaptive capacity to cope with flood hazards in Kasese Municipality? What is the level of community vulnerability to flood hazards in the three divisions of Kasese Municipality?

This paper consists of five sections. Section 2 presents the literature review. Section 3 presents the methodology used for the study. Section 4 describes the research findings and discussions. The concluding remarks are presented in Section 5.

## 2 | LITERATURE REVIEW

Natural disasters like floods and landslides are occurring with increasing frequency and are causing severe levels of property and financial damage to affected communities (Ahmad et al., 2020; O'Neill et al., 2016). These disasters constantly affect peoples' lives and livelihoods (John-Nwagwu et al., 2014; Salam et al., 2017; UNISDR, 2007). In the recent past, the frequency and gravity of large-scale flood disasters have increased globally, resulting in casualties, destruction of property, and huge economic loss (Salami et al., 2017). For instance, from 1998 to 2017, more than 55% of all fatalities worldwide occurred as a result of floods, affecting approximately 2.5 billion people (Emergency Events Database [EM-DAT], 2015).

Disaster risk management was born out of a desire to mitigate the consequences of climate change on the built environment (Etinay et al., 2018). According to IPCC (2018), disaster risk management involves developing, implementing, and evaluating strategies, policies, and measures. The Sendai Framework highlights the need for a comprehensive strategy that incorporates prevention, readiness, response, and recovery for managing risks related to natural and human-caused disasters (Maini et al., 2017; UNISDR, 2015). A disaster happens when a risk encounters a weak system. Managing flood hazards is required because they cannot be entirely eliminated (Nasiri et al., 2016). Establishing or evaluating the condition of the system is necessary to lessen the community's or system's vulnerability to floods (Tingsanchali, 2012).

When a hazard event (such as a flood, cyclone, and drought) occurs, triggering a loss of life and damage to infrastructure, it highlights the reality that society and its assets are vulnerable to such events. A disaster highlights the geographical area (where the community is settled is exposed to such a hazard), the society (including individuals) and its infrastructure, assets, and other processes as well as services that may have experienced damage or destruction. People's vulnerability (i.e., how much they lose when they are hit) is a critical determinant of the impacts of natural disasters (Shah et al., 2019). When poor people are affected, the share of their wealth lost is two to three times that of the nonpoor, largely because of the nature and vulnerability of their assets and livelihoods (Hallegatte et al., 2017). Therefore, the commitment of the international community to tackle disaster risk reduction and disaster resilience building in the framework of sustainable development and poverty eradication (UNISDR, 2015). However, catastrophic risk and development are intimately related because development processes play a significant role in determining the assets and people at risk, as well as their capacity and vulnerability (Thomalla et al., 2018).

It is important to note that vulnerability depends on individuals' and society's ability to cope with, and adapt to, the negative impacts of the hazard. The more limited a community's or society's adaptive capacity to hazards, the more vulnerable it will be (Shah, Ye, et al., 2018). The adaptive capacity of an area to flood hazards can be very limited due to among others lack of awareness about advance mitigation options and financial and resource constraints. In an ideal situation, there should be high resilience and low vulnerability to floods. In order to reduce the high vulnerability and to develop adaptive policy, information on the level of vulnerability and adaptive capacities of an area or community is key (Shafique & Khan, 2015). Local institutions can as well play an essential role in providing firsthand rescue and support to communities in reducing the impacts and vulnerability to natural disasters such as floods (Shah, Shaw, et al., 2018).

## 3 | MATERIALS AND METHODS

### 3.1 | Study area

The research was undertaken in Kasese Municipality, Kasese District, Uganda, East Africa. The municipality covers a land area of 93.4 $km^2$ and lies on latitude of 0°28′ S, longitude of 30°35′ E, and an average altitude of 1441 m. The municipality consists of three divisions, namely, Central, Bulembia, and Nyamwamba (Figure 1). These divisions fall under the hazard-prone area where households have been ravaged by flash flood disasters (International Federation of Red Cross and Red Crescent [IFRC], 2013) and therefore provided a good study site for this assessment. Kasese District lies between latitudes 0°12′ S–0°26′ N and longitudes 29°42′ E–30°18′ E and is bordered by the districts of Bundibugyo in the North, Kabarole in the North East, Kamwenge in the South East, Rubirizi in the South, and the Democratic Republic of the Congo in the West (KDLG, 2016).

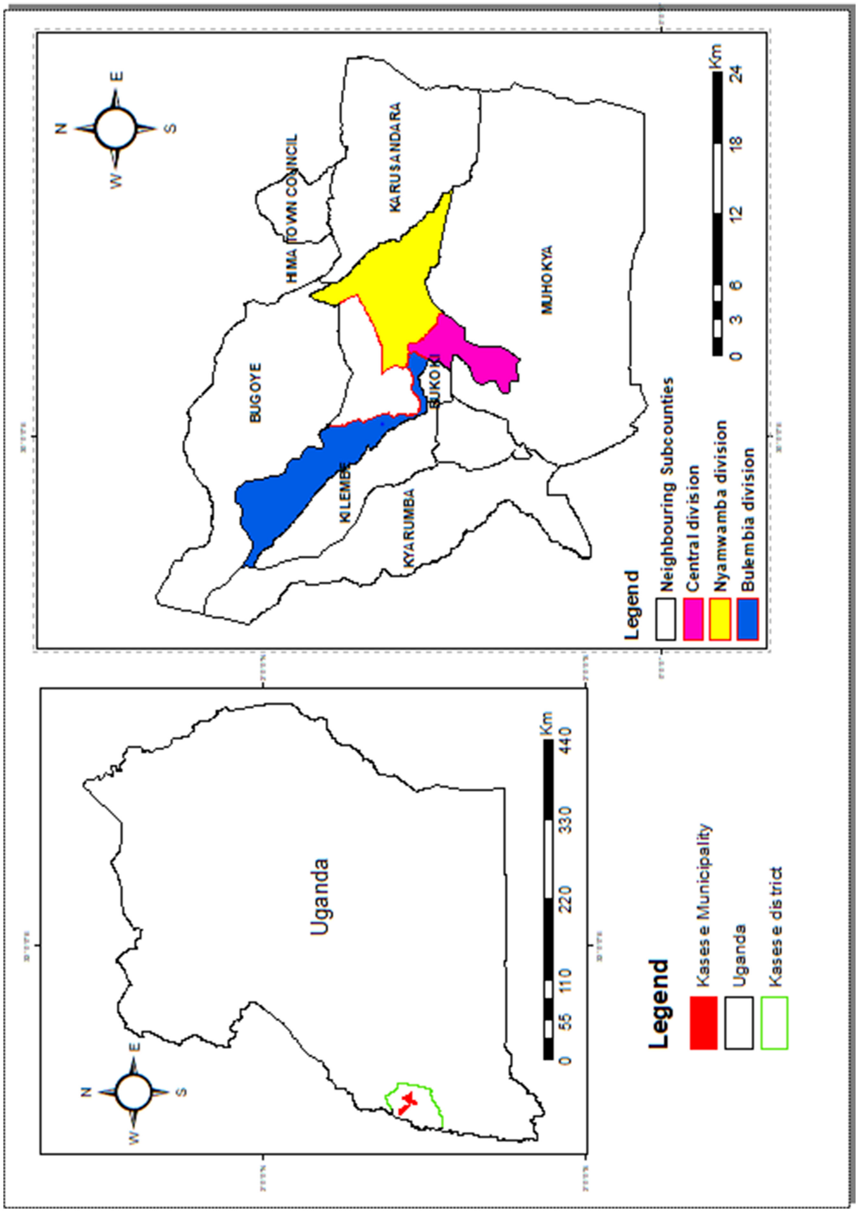


FIGURE 1 Map showing the study area.

Kasese Municipality was chosen because it is highly plagued by natural hazards, particularly flash floods that occur every year causing catastrophic damage to property and human lives (Jacobs et al., 2017). The municipality has experienced at least three major flood disasters in the last decade that have left trail destruction of properties (IFRC, 2013; KDLG, 2020a).

Kasese Municipality experiences bimodal rainfall. The initial rains are brief but intense, falling between March and May, whereas lengthy, light rains fall between August and November. The annual rainfall ranges from 800 to 1600 mm, and altitude has a significant impact. The temperature in Nyamwamba catchment in which Kasese Municipality is located changes depending on elevation, from 0°C to 25°C at a high altitude and from 8°C to 30°C at low altitudes (Directorate of Water Resources Management [DWRM], 2012).

## 3.2 | Research design

For this study, a cross-sectional survey was used. This was because of the limited time frame of the study, which necessitated gathering information on a small sample population at a single point in time. The level of household vulnerability to flood hazards in Kasese Municipality was evaluated using an index-based technique. This approach gives a more precise overall flood vulnerability. A quantitative method was employed in the study, and a quantitative method was used to collect data on the selected household indicators under exposure, sensitivity, and capacity. Using a semi-structured questionnaire uploaded on a GoSurvey app, primary data were gathered. For each division, the exposure, sensitivity, and adaptive capacity indices were calculated, and thus, each division's overall vulnerability indices were computed.

## 3.3 | Methods of data collection

This study utilized both primary and secondary data. Primary data were obtained from the field from household respondents. During primary data collection, before the interviews began, each respondent was informed of the objective of the study by the locally trained field assistants. The confidentiality of the research was explained to the respondents, and they received assurances that the data would only be used for research. Consent was sought before the interview. The respondents had the right to decide whether to participate and could withdraw at any stage of the interview process.

Secondary data were obtained through an extensive literature review. A literature review was conducted on books, scientific articles, and reports, and the combination of various literature types was vital in focusing on the study, improving the methodology, identification of the different indicators under the different components of vulnerability, and identification of knowledge among others.

## 3.4 | Sampling framework, sampling technique, and sample size

Kasese Municipality is divided into three divisions, namely, Central, Bulembia, and Nyamwamba.

At least one flood occurred in each of these divisions over the past 10 years (KDLG, 2020a), and they are, therefore, vulnerable to floods. Further, BTC and KDLG (2012) reported that Kasese Municipality has the majority of extremely poor households. The poor suffer the brunt of natural disaster impacts due to inadequate resources to respond to the effects of the shocks (Wahab & Falola, 2016).

According to UBOS (2017), the municipality had 25,497 households. The study's sample size was calculated using Cochran's (1977) method for determining sample size (Equation 1).

$$\text{Sample size (SS)} = \frac{Z^2(P)(1-P)}{e^2} \tag{1}$$

where $P$ is the percentage picking choice given as a decimal (0.5 is utilized for the necessary sample size), $e$ is the precision value ($0.07 = \pm 7$), and $Z$ is the confidence level ($\pm 1.96$ at 0.95).

This method was used because it provides a small sample size that is reliable and representative of a larger population. From Equation (1), a sample size of 196 households was obtained from the three divisions and therefore 65.3 households from each division. For comparative purposes across the three divisions, a total of 210 samples were collected, that is, 70 households from each division. In each division, one ward was selected, and from each ward, two cells were purposefully selected. These were cells that had experienced floods in the last decade according to the information by the local authority. Thirty-five households were systematically randomly selected from each cell to avoid bias in the study. The household survey was undertaken using a GoSurvey app, which was installed on android mobile phones. The survey was undertaken face-to-face by trained field assistants who interviewed household respondents, explaining questions for clarification as required. Because it was expected that household heads would have clear, accurate, and reliable information about their households, the study specifically targeted them as respondents. Additionally, the questionnaire was written in English and given out by trained field workers who could translate the questions into some respondents' native tongues (Lukonzo) especially those who did not know and understand English.

## 3.5 | Methods of data analysis

An indicator-based method was used for the assessment (Balica et al., 2009; Nasiri et al., 2016; Rana & Routray, 2018; Rehman et al., 2019). Several authors have used this method in assessing vulnerability (Balica et al., 2013; Bhattacharjee & Behera, 2018; Kablan et al., 2017; Munyai et al., 2019; Rana & Routray, 2018; Shah, Shaw, et al., 2018).

The indicator-based method depends on indices, and therefore, the vulnerability index was based on three operational component indicators: exposure, sensitivity, and capacity (Cendrero & Fischer, 1997; Nasiri et al., 2019). The vulnerability index was computed from Equation (2).

$$\text{Vulnerability index (VI)} = (E + S) - AC \tag{2}$$

where $E$ represents index for exposure, $S$ represents index for sensitivity, and $AC$ represents index for adaptive capacity (Balica et al., 2009). However, sometimes resilience is interchanged with capacity (Balica et al., 2012; Turner et al., 2003). In addition, qualitative and quantitative data were collected.

Indicators on the vulnerability component are presented in Tables 2–4. The indicators under the different categories were then broken down into different classes basing on their features. The classes were developed, illustrating the level of variation available in the respective variables.

The indicators were then normalized using Equation (3) to make them comparable.

$$x_{ij} = \frac{X_{ij} - \text{Min}X_{ij}}{\text{Max}\,X_{ij} - \text{Min}\,X_{ij}} \tag{3}$$

where $x_{ij}$ represents the value standardized for indicator $i$ of the unit/household $j$; $X_{ij}$ represents the indicator $i$ value corresponding to the unit/household $j$; and *Min* and *Max* represent the minimum and maximum scaled values of indicator $i$, respectively (Nhuan et al., 2016). Weights were assigned to different indicators using principal component analysis (PCA).

After well weight appropriation to classes for different indicators, the variables normalized were multiplied with the weights assigned to develop the components of vulnerability as in Equation (4).

$$I_j = \sum_{i=1}^{n} b_i \left[ \frac{a_{ji} - x_i}{s_i} \right] \tag{4}$$

where $I$ represents the index value for each component, $b$ represents the loadings from the first component from PCA taken as weights for each indicator, $a$ represents the value of each indicator, $x$ represents the average indicator value, and $s$ represents the standard deviation of the indicators (Kimani et al., 2015; Piya et al., 2016). The composite vulnerability index for the each/respective division was then determined using Equation (2).

The household survey data were processed using descriptive and inferential statistical methods. Descriptive research accurately characterized the households, and inferential statistics was used in testing the hypothesis. To test the hypothesis, Pearson's chi-squared ($\chi^2$) test at a confidence level of 95% was used.

## 4 | RESULTS AND DISCUSSION

### 4.1 | Household's exposure to flood hazards

#### 4.1.1 | Socio-economic features of respondents

The household field survey was carried out in three divisions (viz., Central, Bulembia, and Nyamwamba) of Kasese Municipality in which 210 respondents were randomly selected. Table 1 presents descriptive statistics of sampled households interviewed. A majority (52.6%) of the respondents were of female gender and 78.1% were married. Most (41.0%) respondents were in the age range of 30–39 years, a majority (39.0%) of which had secondary education and only 10.5% had tertiary education.

#### 4.1.2 | Household's exposure to flood hazards

Table 2 presents six indicators that were considered under exposure. A majority (99.5%) of the households had at least experienced floods in the last 10 years and most (32.4%) of these had experienced floods three times in the last decade. A majority (67.1%) of the households were in a nucleus family setting and only 14.8% were extended families. Most (58.6%) of the households in the Bulembia division had member(s) who had experienced injury/death in the previous flood events and was least (40.0%) in the Nyamwamba division. Most (96.7%) of the households across the divisions had houses constructed with bricks. All the households surveyed in the Nyam-

TABLE 1 Socio-economic features of the respondents.

| Socio-economic features | | Percentage |
|---|---|---|
| Gender | Male | 47.4 |
| | Female | 52.6 |
| Marital status | Single | 9.0 |
| | Married | 78.1 |
| | Separated/divorced | 5.7 |
| | Widowed | 7.2 |
| Age (years) | 18–29 | 38.1 |
| | 30–39 | 41.0 |
| | 40–49 | 14.3 |
| | 50–59 | 5.2 |
| | 60 and above | 1.4 |
| Highest education attained | No formal education | 13.3 |
| | Primary education | 36.7 |
| | Secondary education | 39.0 |
| | Tertiary education | 10.5 |
| | Others | 0.5 |

*Source*: Fieldwork (August 2020).

wamba division were found within 2 km of river Nyamwamba, one of the main reasons why households were highly exposed to floods.

The household size and the number of times households experienced floods in the last 10 years had weights of 0.534 and 0.094, respectively. The average household size for the three divisions was five persons per household, and the average household size for the Central, Bulembia, and Nyamwamba divisions was 4.8, 4.5, and 5.8 persons, respectively. The greater the average household size, the more the household exposure.

All the indicators had a positive relationship with exposure except the type of dwelling/house structure for the household and households that received any form of warning about previous flood events as indicated by their negative weights (Table 2). Therefore, the type of dwelling/house structure for the household and households that received any form of warning about previous flood events reduced the level of exposure.

Further, the household index value of exposure varied from −15.643 to 2.495 in the Central division, −2.1423 to 1.972 in the Bulembia division, and −1.371 to 2.601 in the Nyamwamba division. Despite the variations in the index levels, there was no significant difference in the level of household exposure ($\chi^2 = 16.195$, $p = .335$). The exposure indices for each division are presented in Figure 2.

The composite exposure indices varied between −16.12 and 35.15. The Nyamwamba division had the highest exposure index (35.25), whereas the Central division had the least index (−15.64). The Bulembia division was ranked the second most exposed division to floods (Figure 2).

The Nyamwamba division was found most exposed to flood hazards, followed by the Bulembia division, and the Central division least exposed. The higher exposure in the Nyamwamba division might have been partly due to the larger household size and the type of family. This is because majority of the households in the Nyamwamba division were under extended families and thus had higher exposure due to the larger household size associated with it. The higher household exposure to floods can also be associated with the lack of an early warning system in place because most (85%)

TABLE 2 Exposure indicators across the divisions and their respective weights.

| S/N | Indicator | Classes | Weights | Aggregate ($n = 210$) | Central ($n = 70$) | Bulembia ($n = 70$) | Nyamwamba ($n = 70$) |
|---|---|---|---|---|---|---|---|
| | | | | Percentage | | | |
| 1 | Type of the household family | Extended family | 0.510 | 14.8 | 10.0 | 10.0 | 24.3 |
| | | Nucleus family | | 67.1 | 70.0 | 67.1 | 64.3 |
| | | Single family | | 18.1 | 20.0 | 22.9 | 11.4 |
| 2 | Households with member(s) who experienced any loss of person/injury in the past floods | No | 0.026 | 50.0 | 48.6 | 41.4 | 60.0 |
| | | Yes | | 50.0 | 51.4 | 58.6 | 40.0 |
| 3 | Type of dwelling/house structure for the household | Brick walls with iron/tile sheet roof | −0.137 | 96.7 | 92.9 | 100.0 | 97.1 |
| | | Mud walls with iron/tile sheet roof | | 3.3 | 7.1 | 0.0 | 2.9 |
| 4 | Households that received any form of warning about previous flood events | No | −0.168 | 85.2 | 100 | 100 | 55.7 |
| | | Yes | | 14.8 | 0 | 0 | 44.3 |
| 5 | Household size | | 0.534 | | | | |
| 6 | Number of times households experienced floods in the last 10 years | | 0.094 | | | | |

of the households surveyed never received any warning about the previous floods. A study by Rai et al. (2020) revealed that early warning systems were found to reduce the impact of floods and thus the exposure. Furthermore, the higher level of exposure was linked to the proximity of the households to major flooding rivers, that is, the Nyamwamba River. All the households surveyed in the Nyamwamba division were found within 2 km of the river, which increased their exposure to flood hazards. The finding is consistent with a study that found that household vulnerability is inversely related to the distance from the river to the household shelter (Hossain, 2015). In addition, the effect on housing structures by floods was found influenced significantly by their distance to water bodies in Grahamstown, South Africa (Dalu et al., 2018). Similarly, a fifth of the Municipality of Eldoret in Kenya was found highly prone to floods due to nearness to flooding rivers (Ouma & Tateishi, 2014).

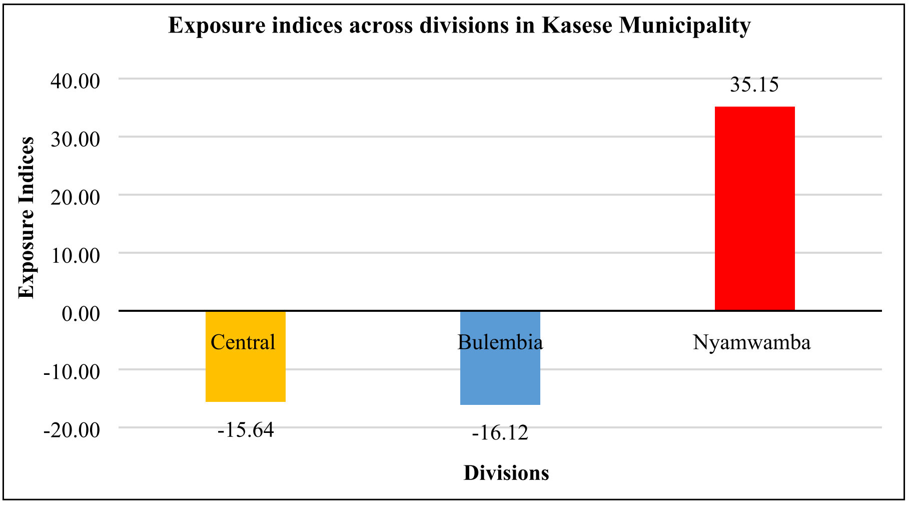


FIGURE 2 Exposure indices across the divisions.

TABLE 3 Sensitivity indicators across the divisions and their respective weights.

| S/N | Indicator | Classes | Weights | Aggregate ($n = 210$) | Central ($n = 70$) | Bulembia ($n = 70$) | Nyamwamba ($n = 70$) |
|---|---|---|---|---|---|---|---|
| | | | | Percentage | | | |
| 1 | Household head | Husband | 0.589 | 86.7 | 87.1 | 87.1 | 85.7 |
| | | Wife | | 8.1 | 4.4 | 7.1 | 12.9 |
| | | Son | | 3.8 | 7.1 | 2.9 | 1.4 |
| | | Daughter | | 1.4 | 1.4 | 2.9 | 0 |
| 2 | Number of family members in the household that had chronic illness/ disability | 0 | −0.006 | 79.5 | 80.0 | 78.6 | 80.0 |
| | | 1 | | 20.5 | 20.0 | 21.4 | 20.0 |
| 3 | Average monthly household head income (Ugx) | 50,000–340,000 | 0.189 | 85.2 | 80.0 | 92.9 | 82.9 |
| | | 350,000–640,000 | | 14.8 | 20.0 | 7.1 | 17.1 |
| 4 | Distance to the nearest medical facility/ center from the household | (i) <1 km | −0.130 | 54.8 | 1.4 | 100.0 | 62.9 |
| | | (ii) 1–5 km | | 45.2 | 98.6 | 0 | 37.1 |
| 5 | Dependency ratio | | −0.528 | | | | |
| 6 | Length of time households had lived in the community | | −0.025 | | | | |

## 4.2 | Household's sensitivity to flood hazards

Table 3 presents the six indicators that were selected under sensitivity. The weights allocated

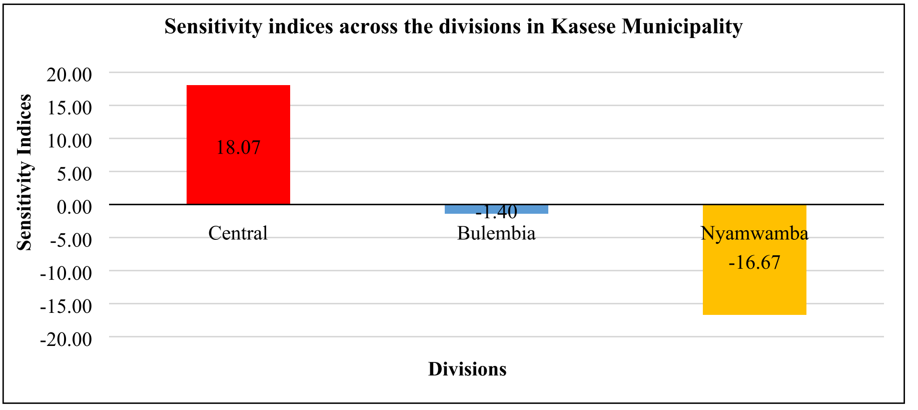


**FIGURE 3** Sensitivity indices across the divisions.

to dependency ratio and length of time (in years) households had lived in the community were −0.528 and −0.025, respectively. About 11.4% of the households had stayed in the area for at least 15 years and 29.0% had stayed in the areas of study for over 7 years. The average length of time (in years) households had lived in the Central, Bulembia, and Nyamwamba divisions was 4.1, 3.9, and 7.6 years, respectively. A majority (86.7%) of the households were headed by husbands, and most (79.5%) of the households did not have family members with chronic illness/disability. However, the majority (85.2%) of the households had their average monthly income between 50,000 and 340,000 Uganda shillings.

Household heads and average monthly household head income increased susceptibility to floods as indicated by their positive weights. The dependency ratio (i.e., household size/number of infants, children, and elderly in the household) for the Nyamwamba, Bulembia, and Central divisions was 0.56, 0.48, and 0.45, respectively.

The household index value for sensitivity was from −1.023 to 3.959 in the Central division, −1.268 to 4.220 in the Bulembia division, and −1.230 to 4.220 in the Nyamwamba division. The mean value of sensitivity was 0.258 in the Central division, −0.238 in the Nyamwamba division, and −0.020 in the Bulembia division. In addition, statistical results revealed a significant difference in the level of household sensitivity among the divisions ($\chi^2 = 24.180$, $p = .033$). The sensitivity indices across the divisions are presented in Figure 3. The Central division was the most susceptible to floods (18.070), followed by the Nyamwamba division (−16.670), and the Bulembia division was the least susceptible (−1.400). There was also a significant difference in the household sensitivity indices and the number of years households had lived in the different divisions ($\chi^2 = 10.238$, $p = .047$).

The results show variations in the household vulnerability levels in the different divisions. The Central division was found to be highly sensitive to floods, and this was attributed to the length of time households had lived in the community, the household dependency ratio, and the distance from the medical facilities. In the Central division, majority (72.9%) of the households had stayed in the area for less than half a decade and therefore assumed to have had less experience with floods. This is because the more the number of years households had lived in the community, the less was the sensitivity to floods. Households that have lived in the community for a long time are assumed to be more aware of evacuation routes and geography and more experienced with floods (Rana & Routray, 2018; Walker et al., 2014). However, the Central division had the lowest household dependency ratio. This is contrary to studies by Hamidi et al. (2020) and Liu and Li (2016) in which they revealed that the more the ratio of dependence, the higher the burden on the mean

**TABLE 4** Capacity indicators across the divisions and their respective weights.

| S/N | Indicator | Classes | Weights | Aggregate (*n* = 210) | Central (*n* = 70) | Bulembia (*n* = 70) | Nyamwamba (*n* = 70) |
|---|---|---|---|---|---|---|---|
| | | | | Percentage | | | |
| 1 | Highest level of education of the household head | No formal education | 0.359 | 11.5 | 11.4 | 11.4 | 11.4 |
| | | Primary education | | 20.5 | 20.0 | 14.3 | 27.1 |
| | | Secondary education | | 49.0 | 55.7 | 52.9 | 38.6 |
| | | Tertiary education | | 19.0 | 12.9 | 21.4 | 22.9 |
| 2 | Type of main occupation of the household head | Civil/public service | 0.363 | 8.6 | 7.1 | 8.6 | 10.0 |
| | | Trading | | 40.4 | 48.6 | 38.6 | 34.3 |
| | | Farming | | 24.3 | 20.0 | 24.2 | 28.6 |
| | | Professional/private | | 26.7 | 24.3 | 28.6 | 27.1 |
| 3 | Household's number of sources of income | 1 | 0.229 | 57.6 | 55.7 | 62.9 | 54.3 |
| | | 2 | | 42.4 | 44.3 | 37.1 | 45.7 |
| 4 | Number of family members having earnings in the household | >2 | 0.058 | 24.8 | 11.4 | 27.1 | 35.7 |
| | | 2 | | 74.8 | 87.1 | 72.9 | 64.3 |
| | | 1 | | 0.4 | 1.5 | 0.0 | 0.0 |
| 5 | Households with any form of savings | Yes | 0.235 | 61.9 | 82.9 | 71.4 | 31.4 |
| | | No | | 38.1 | 17.1 | 28.6 | 68.6 |
| 6 | Average monthly household savings | 50,000–340,000 | 0.074 | 99.5 | 98.6 | 100 | 100 |
| | | 350,000–640,000 | | 0.5 | 1.4 | 0.0 | 0.0 |
| 7 | Households with land or house outside the affected areas | Yes | −0.043 | 43.8 | 50.0 | 38.6 | 42.9 |
| | | No | | 56.2 | 50.0 | 61.4 | 57.1 |
| 8 | Households with relatives outside the affected area | Yes | −0.095 | 99.0 | 98.6 | 100 | 98.6 |
| | | No | | 1.0 | 1.4 | 0.0 | 1.4 |
| 9 | Households with members/relatives with jobs out of the area affected | Yes | −0.041 | 95.7 | 97.1 | 98.6 | 91.4 |
| | | No | | 4.3 | 2.9 | 1.4 | 8.6 |
| 10 | Households that had gone to any local authority for some assistance in the past 1 year | Yes | 0.213 | 32.9 | 18.6 | 55.7 | 24.3 |
| | | No | | 67.1 | 81.4 | 44.3 | 75.7 |

**TABLE 4** (Continued)

| S/N | Indicator | Classes | Weights | Aggregate ($n=210$) Percentage | Central ($n=70$) | Bulembia ($n=70$) | Nyamwamba ($n=70$) |
|---|---|---|---|---|---|---|---|
| 11 | Households that own or rent land for farming | Own | −0.094 | 42.9 | 51.4 | 38.6 | 38.6 |
| | | Rented | | 32.9 | 28.6 | 32.9 | 37.1 |
| | | Do not have | | 24.2 | 20.0 | 28.5 | 24.3 |

working-age persons and therefore the high susceptibility to floods. Similarly, the larger number of households headed by sons (7.1%) in the Central division in comparison to the 2.9% and 1.4% in the Bulembia and Nyamwamba divisions respectively contributed to the highest sensitivity. Additionally, distance to the nearest medical health facility from the household was also another factor that contributed to the higher level of sensitivity to floods because 98.6% of the households in the Central division were living between 1 and 5 km from the nearest health facility. According to Boyce et al. (2016), extreme flooding increased by 30% the risk of a person getting malaria in the aftermath of flood in Kasese District. This is a challenge because serious illness of a household member affects the morale and spirit of other household members, and in line to economic attachment, it has a less desirable and substantial effect on household income (Pham et al., 2020).

## 4.3 | Household's capacity to cope with flood hazards

Eleven indicators were selected under adaptive capacity (Table 4). The type of main occupation of the household head and the highest attained level of education of the household head had the highest weights, that is, 0.363 and 0.359, respectively. The majority (49.0%) of the household heads across the divisions had at least secondary education and only 19.0% had tertiary education. Similarly, most (40.4%) of the households across the divisions were traders and most of the households had only one source of income (57.6%). A majority (74.8%) of the households across the divisions had two members having earnings and most (61.9%) of the households had some savings. However, their savings were as low as 50,000 to 340,000 Uganda shillings. Most (67.1%) households did not go to the government authority offices for some assistance (either in kind or money) in the past year.

The household index value under capacity ranged from −2.048 to 2.361 in the Central division, −2.121 to 1.893 in the Bulembia division, and −2.121 to 2.010 in the Nyamwamba division. The mean capacity value was 0.158 in the Central division, 0.049 in the Bulembia division, and 0.109 in the Nyamwamba division. Despite the variations in the adaptive capacity levels across the different divisions, there was no significant difference in the level of household capacity among the divisions ($\chi^2=26.852$, $p=.190$). In relation to this, however, the Central division had the highest capacity index (11.07), followed by the Nyamwamba division (−7.66), and the Bulembia division had the least (−3.41) (Figure 4).

The higher capacity in the Central division was due to the type of the main occupation in which the majority (48.6%) of the households were traders and less in farming (Table 4). This is because farming is more vulnerable to floods (Gain et al., 2015). Most households in the Central division (44.3%) also had two sources of income, and 87.1% of the households had at least two family members having earnings, 82.9% had some forms of savings, and 50% had land or house outside the affected community area. Households with some jobs and several sources of income

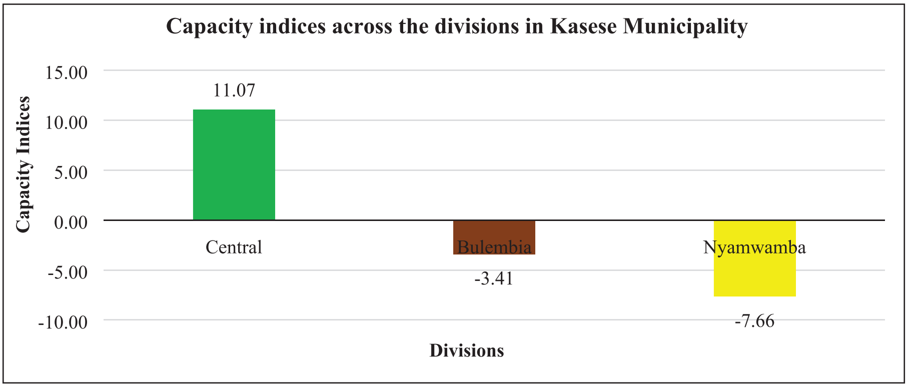


**FIGURE 4** Capacity indices across divisions.

are less vulnerable (Hamidi et al., 2020). Households in the Central division had also a higher capacity with floods, and majority (81.4%) of these households had not sought any assistance in the past 1 year. The highest attained level of education of the head of household, the type of main occupation of the household head, the household's number of sources of income, and households with savings and the size of savings were the major contributors to resist, cope with, and absorb the effects of flood disasters.

However, across the communities, it was revealed that 81.4% of the households had not taken measures to protect their houses against floods. This must have been because the majority (77.6%) of the households surveyed lived in rented houses and most (85.2%) of the households had their average monthly household head income very low between 50,000 and 340,000 Uganda shillings. However, a significant relationship between the highest level of education of the household head and households with relatives employed outside the community-affected areas was revealed. Reduction in household food consumption was also among the coping strategies for flood disaster effects. A majority (96.4%) of the households that had been affected by previous floods reduced food consumption in the post-disaster period as a coping strategy. This is in line with a study by Helgeson et al. (2013) in Oyama and Kapchorwa districts of Uganda in which households reduced food consumption to cope with the effects of natural disasters.

Similarly, a majority (71.0%) of the households had not received any information on how to respond and manage floods. This raised a serious question on the local institution's efforts toward disaster risk management and or preparedness. The more the knowledge on flood disaster risk management, the less the vulnerability (Liu & Li, 2016). However, there was a significant difference between the highest attained level of education of the household head and households that had gone to the local authority some assistance in the last 1 year. Households with a certain level of education are able to absorb certain levels of shocks because education levels enhance individual resilience in dealing with disaster risks (Shah et al., 2019).

## 4.4 | Vulnerability to flood hazards

Table 5 presents the summary of the composite exposure, sensitivity, capacity, and the respective vulnerability indices across the divisions. The household vulnerability index value ranged from −2.664 to 3.370 in the Central division, −2.926 to 3.331 in the Bulembia division, and −2.841 to 3.765 in the Nyamwamba division. The mean value of vulnerability was 1.113 in the Central

**TABLE 5** Summary of index scores for vulnerability components across the divisions.

| Divisions | Exposure | Sensitivity | Capacity | Vulnerability |
|---|---|---|---|---|
| Central | −15.643 | 18.072 | 11.072 | −8.642 |
| Bulembia | −16.118 | −1.400 | −3.415 | −14.104 |
| Nyamwamba | 35.154 | −16.672 | −7.657 | 26.139 |

division, −0.201 in the Bulembia division, and 0.373 in the Nyamwamba division. There was a significant difference in the level of household vulnerability across the divisions ($\chi^2 = 60.940$, $p = .025$). The Nyamwamba division had the highest vulnerability index (26.139), followed by the Bulembia division (−14.104), and the Central division had the least vulnerability index (−8.642).

The highest exposure coupled with higher sensitivity and lower capacities caused the highest vulnerability of the Nyamwamba division. This is in tandem with a study (Nguyen & Van Nguyen, 2019) in which villages in Mai Hoa Commune in Vietnam with high level of vulnerability had higher exposure and susceptibility with low resilience to cope with floods. Similarly, the lower exposure coupled with the highest sensitivity and capacity made the Central division least vulnerable to flood hazards. The Bulembia division on the other hand, despite having the lowest sensitivity index value, ranked the second most vulnerable owing to its higher exposure index and lowest capacity index. The analysis indicated a significant difference in the households from the different divisions. About 43.8% of the households were found most vulnerable to floods in Kasese Municipality. There was also a significant difference in the household distance from the major flooding river (river Nyamwamba) and household vulnerability index levels. Households nearer to river Nyamwamba were found more vulnerable to flood hazards. This is consistent with a study in which differential vulnerabilities were observed with nearer river zones being highly vulnerable (Das et al., 2020).

## 5 | CONCLUSIONS

Given that some households had experienced floods at least three times in the last decade, flood hazard is a major risk in Kasese Municipality. The continuous exposure to flood disasters affects household vulnerabilities, which affect capacities to respond to the consequences of natural hazards. Household's exposure and vulnerability to flood disasters has increased over time, and policymakers need to pay serious attention to building effective mitigation and adaptation plans in order to reduce flood damages. It is important to note that vulnerability depends on individuals' and society's ability to cope with, and adapt to, the negative impacts of the hazard. The more limited a community's or society's adaptive capacity to hazards, the more vulnerable it will be. The study focused on the assessment of the household vulnerability to floods in the three divisions of Kasese Municipality (viz., Central, Bulembia, and Nyamwamba). Vulnerability is a factor of sensitivity, exposure, and adaptive capacity. Different households and communities have different levels of exposure, sensitivity, and adaptive capacity and thus different vulnerability levels to flood hazards. Assessing the vulnerability levels of a system is an initial step toward disaster risk reduction to disasters.

Whereas cross-tabulation of household exposure indices showed no significant difference in the household exposure level to floods, the Nyamwamba division was found most exposed, followed by the Bulembia division, and the Central division least exposed. Households that had larger household sizes and lived within the proximity of the flooding river were found highly exposed to floods. Households that had lived longer in the community were found less sensitive to floods. Statistical results showed significant difference in the level of household sensitivity. The Central division was the most susceptible to floods. Further, the Central division had a better capacity to cope with floods and the Bulembia division had the least capacity. Households with at least two sources of income and with some form of savings had a better capacity to cope with floods. In addition, majority of the households across the divisions had not taken measures to protect their houses against floods, and this was attributed to most households living in rented houses and having a lower average monthly household income. The study further revealed significant difference in the level of household vulnerability among the divisions. The highest exposure coupled with higher sensitivity and lower capacities made the Nyamwamba division most vulnerable to floods and the Central division least vulnerable. The Bulembia division on the other hand, despite having the lowest sensitivity, ranked the second most vulnerable owing to its higher exposure, meaning that the three components of vulnerability occur at different levels in each area. About 43.8% of the households were found vulnerable to floods in Kasese Municipality.

To reduce the higher levels of exposure, households near major flooding river should be relocated to safer places, and early warning system should be installed to reduce their exposure to floods. To reduce the high levels of sensitivity and increase adaptive capacities, the local government and other stakeholders should give jobs and other related opportunities to enhance the income levels and savings of the households in the flood-prone areas and be able to support the dependents. To reduce the high levels of vulnerability in the Nyamwamba division, government and other stakeholders should relocate all the households living nearer the flooding river and restrict settlement in flood-prone areas. Government should develop policies and allocate funds for disaster risk reduction and adequately respond to flood disasters at the lowest administrative units (i.e., cell/village and subcounty). Besides, given that the government cannot alone adequately protect flood-prone households due to limited resources available, individual households should at least take precautionary measures voluntarily to protect their properties from floods.

## ACKNOWLEDGMENTS

This paper was prepared based on the MSc dissertation submitted by the first author to the Department of Environmental Management, School of Forestry, Environmental and Geographical Sciences, Makerere University, Kampala, Uganda, funded by Albertine Investments Limited and the German Academic Exchange Service (DAAD).

## CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest.

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**How to cite this article:** Tibara, Y., Wasswa, H., & Semakula, H. M. (2023). Vulnerability assessment to flood hazards of households in flood-prone areas of Kasese District, Western Uganda. *World Water Policy*, *9*(2), 221–241. https://doi.org/10.1002/wwp2.12098