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Dimensions and drivers of social vulnerability to flood risk in Manafwa catchment, Eastern Uganda

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ABSTRACT

Over the past decade, Uganda has experienced a notable increase in extreme meteorological hazards, yet the country lacks a comprehensive disaster management strategy. Despite the critical role it plays in disaster risk reduction, there is a shortage of approaches that contribute to our understanding of social vulnerability within dynamic contextual conditions. This study therefore offers a comprehensive assessment of both flood exposure and social vulnerability among rural households in the Manafwa catchment area of Eastern Uganda. A cross-sectional household study was conducted in March 2019 and September 2021 using a semi-structured questionnaire, key informants' interviews and focus group discussions. Through multistage sampling technique and utilizing Cochran's formula, a sample size of 210 households was obtained. An index was constructed employing principal component analysis based on the Social Vulnerability Index (SoVI[®]), originally developed for the United States of America. Eight factors, explaining 80% variance, were identified. The primary components impacting social vulnerability levels are Information and Knowledge, and Demographic and Family Characteristics. Values on the index range from >3 (High) to -1.0 - +1.0 (Low). Most households (88.8%) exhibited moderate to high levels of social vulnerability. Understanding the dominant indicators and areas where high social vulnerability and high exposure converge can support municipalities in designing just and equitable interventions toward flood risk reduction by serving as an input to policymaking, investment strategies and civil protection. Future research could delve deeper into exploring how various locations and complex social variables interact to create varying levels of vulnerability to floods in developing countries.

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1. Introduction

Scientists are increasingly recognizing that vulnerability to hazards extends beyond the biophysical and built environment to encompass social aspects at the individual, community or location level (Birkmann, 2013; Cutter et al., 2003). Cutter et al. (2003) contend that vulnerability serves as a gauge of societal resistance or resilience to hazards. The impact of a hazard on a population hinges on both hazard exposure and the sensitivity of the population, along with its capacity to respond and recover. This perspective has given rise to the concept of social vulnerability, along with corresponding indices, becoming a pivotal element in hazards research and various domains at the science-policy interface, with potential applications across governance levels (Fordham et al., 2013).

Social vulnerability refers to the characteristics or conditions of people that influence their susceptibility and increase their likelihood of being harmed when exposed to floods (Dulawan et al., 2024). These conditions encompass social structure, socioeconomic factors and living conditions (Fatemi et al., 2017). Owing to these conditions, vulnerability varies spatially and among social structures (See & Porio, 2015;

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Kuhlicke et al., 2011). Notably, the poor and the disadvantaged are often identified as the most vulnerable, especially in urban settings in developing countries (Erena & Worku, 2019). The Africa chapter of the Intergovernmental Panel on Climate Change's (IPCC) 6th Assessment Report (AR6) showed that 95% of African cropland is rain fed while African economies are disproportionately dependent on climate-exposed sectors, with 55–62% of the sub-Saharan workforce employed in agriculture (Trisos et al., 2022) and high levels of sensitivity to extreme events as reflected in reductions in crop yield qualities and quantities and wider impacts on smallholder livelihoods (Ayanlade et al., 2022). Further, poor and female-headed households in rural Africa face greater livelihood risks from climate hazards (Dzvimbo et al., 2022), while in urban areas, growing informal settlements without basic services increase the vulnerability of large populations to climate hazards, especially women, children and the elderly (Pelling et al., 2021; Trisos et al., 2022). Vulnerability is therefore both a major contributor to climate change risk in Africa and reducing vulnerability is one of the most urgent and effective means for reducing risk in Africa (Ayanlade et al., 2023). While Africa is the focus of the second highest number of adaptation and vulnerability studies among world regions, the geographic distribution of these studies is highly uneven (Berrang-Ford et al., 2021; de Sherbinin et al., 2019). This uneven distribution often mirrors economic factors, such as countries' contributions to regional agricultural output, rather than the spread of potentially vulnerable populations. Most studies are concentrated in Western and Southern Africa (Williams et al., 2018). Although there is a growing focus on vulnerable groups like smallholder farmers, engagement with local perspectives and knowledge remains limited (Williams et al., 2018). Furthermore, despite a shift towards frameworks that emphasize social aspects over hazard-centric approaches (Hagenlocher et al., 2019), there are still significant gaps in the conceptualization, empirical operationalization and implementation of vulnerability assessments (Williams et al., 2018).

Social vulnerability to natural hazards plays a crucial role in shaping disaster-risk reduction strategies (Dintwa et al., 2019). The concept views vulnerability as socially constructed, often characterized by stratification and inequality (Chen et al., 2013; Cutter et al., 2003). Recognizing the underlying social, economic and political context is vital in efforts to reduce vulnerability (Chen et al., 2013), especially given that socially vulnerable populations tend to face higher exposure to risks such as floods (Rolfe et al., 2020). To assess and model various facets of social vulnerability and enhance the comprehension of the social aspects related to flooding, researchers often utilize social indicators, including factors such as poverty, gender and age (Tate et al., 2021). Among these indicators, the poverty level stands out as one of the most widely used measures affecting the social vulnerability of a community (Few, 2003). Typically, impoverished communities are more likely to inhabit flood-prone areas, and their limited resources make it challenging to mitigate the impacts of flooding (Few, 2003; Lindersson et al., 2023) and recover from its aftermath (Kates et al., 2006).

Over the past few decades, various methods to assess or determine hazards and vulnerability to flooding have been developed through continuous research and practice (Erima et al., 2022; Hamidi et al., 2022; Rehman et al., 2019). These methods can be broadly categorized into deterministic modelling and parametric approaches. Deterministic modelling uses physically based methods, such as hydraulic modelling and flood inundation modelling, to estimate the probability and hazard of specific flood events (Erima et al., 2022). These models are combined with damage assessment tools to evaluate the economic consequences, providing a comprehensive flood risk assessment for an area. On the other hand, parametric approaches, like the Flood Vulnerability Index (FVI) (Balica et al., 2013), leverage readily available data to assess an area's vulnerability. This approach considers various factors, including the internal characteristics of a system, global climate change and the political and institutional attributes of a region. Parametric methods focus on vulnerability assessments to mitigate the impact of flooding and enhance system resilience (Balica et al., 2013). In recent years, decision-making approaches have been increasingly applied in flood vulnerability analysis (Lee et al., 2013). Techniques such as the analytical hierarchy process (de Brito et al., 2018), Delphi (Boulomytis et al., 2019), and TOPSIS (Lee et al., 2013; Rafiei-Sardooi et al., 2021) exemplify these approaches. Despite their utility, a significant limitation of these methods is the challenge of identifying interdependencies among factors (Hosseini et al., 2021).

Researchers have widely utilized parametric approaches to measure various dimensions of vulnerability (Rehman et al., 2019). Examples include the Environmental Vulnerability Index (EVI) (Kaly et al., 2004), the Composite Vulnerability Index for Small Island States (CVSIS) (Briguglio, 2003), the Global Risk and

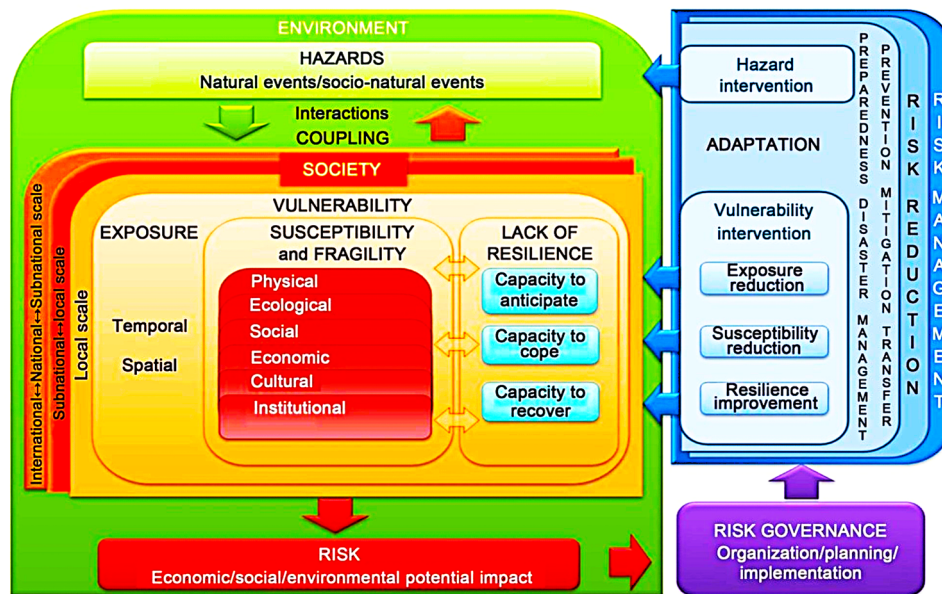


Figure 1. MOVE framework.
Source: Adapted from Birkmann et al. (2013).

Vulnerability Index (GRVI) (UNEP, 2002), the Climate Vulnerability Index (CVI) (Sullivan & Meigh, 2005), the Social Vulnerability Index (SoVI) (Cutter et al., 2003), and the FVI (Balica et al., 2009). According to Balica et al. (2013), deterministic approaches, although scientifically robust, have notable limitations in evaluating vulnerability compared to parametric methods like the FVI. While deterministic approaches provide a solid scientific foundation, their capacity to evaluate vulnerability is restricted (Balica et al., 2013). Conversely, the FVI offers a broader evaluation but is less rigorous, making it useful for determining where a deterministic model might be necessary. In this study, we conducted an integrated analysis by combining an index-based system with geospatial analysis to identify areas with high flood exposure, social vulnerability and their primary drivers. Integrated studies are particularly effective for analyzing and visualizing spatial variations in the linkages between the physical and social dimensions of vulnerability to hazards. Such analyses excel at identifying biophysical and socioeconomic inequalities and predicting potential impacts and losses (Hamidi et al., 2020). They provide a more comprehensive view of the flooding issue and enhance our understanding of vulnerability science (Welle et al., 2014).

Numerous sets of social vulnerability indicators for natural hazards have been developed, such as the SoVI for Disaster Management (Flanagan et al., 2011), the Social Determinants of Vulnerability Framework (Martin, 2015) and the SoVI (Cutter et al., 2003). For flood-specific social vulnerability, examples include the Cologne flood indicators based on the MOVE (Methods for the Improvement of Vulnerability Assessment in Europe) framework in Germany (Depietri et al., 2013), the Social Flood Vulnerability Index in England and Wales (Tapsell et al., 2002) and the Urban Municipality Flood Vulnerability Index in Brazil (Rasch, 2016). The MOVE framework (Figure 1) is designed to be independent of specific hazards while acknowledging their existence. These hazards can be either natural or socio-natural, with society – represented at various levels including international, national, sub-national and local – being an integral part of the environment. Hazards and society exist together and continuously interact with one another (Kablan et al., 2017). Despite extensive research on social vulnerability and resilience indicators, no definitive set of indicators or universal methodology for developing them exists (Cutter, 2016). Indicators are highly context-specific and often vary by region due to differences in human systems and local environments (Cutter, 2016). Additionally, statistical methods like principal components analysis, used to develop these indices and indicator sets, can be influenced by data availability. This complexity makes them challenging for policymakers to understand and difficult to replicate, as the results are only relevant to the specific time period and geographical area analyzed. Nonetheless, summarizing indicators into a single index value can simplify interpretation.

Various models are currently employed to elucidate the diverse facets of social vulnerability to natural hazards. The Hazards-of-Place model (HPM) focuses on the interaction between the geographic context and the social characteristics of society, to produce the overall vulnerability of a place (Cutter, 1996). The Pressure and Release model delineates how vulnerability emerges from unequal access to resources, opportunities and supportive institutions, creating societal pressure (Wisner et al., 2004). The Access model concentrates on people's access to capacities, assets and opportunities (Wisner et al., 2004). The Vulnerability Framework conceptualizes vulnerability as comprising exposure, sensitivity and resilience components, influenced by various contextual factors at societal and environmental levels (Turner et al., 2003). These models generally complement each other rather than conflicting, offering diverse perspectives and focal points on vulnerability (Birkmann et al., 2013). Burton et al. (2018) provide a more comprehensive comparison of vulnerability models.

Numerous studies have examined the spatial distribution of social vulnerability across different regions. Notable research includes studies conducted in the United States (Cutter et al., 2003), Southern Italy (Masia et al., 2018), Norway (Holand et al., 2011) and Zimbabwe (Mavhura et al., 2017). Additionally, researchers have investigated the combined risk of social vulnerability and flood hazards/exposure in Greece (Karagiorgos et al., 2016), Germany (Fekete, 2009), Bangladesh (Hoque et al., 2019), Vila Nova de Gaia, Portugal (Fernandez et al., 2016) and the Hainan Region of China (Yang et al., 2018). While previous studies have made valuable contributions to exploring the 'social context' of risk perception and mitigation behaviour (Babcicky & Seebauer, 2017; Hudson et al., 2020), there has been insufficient integration of social dimensions in both policy and research (Bixler et al., 2021; Cutter et al., 2003; Engle, 2011). There remains limited consensus on how social vulnerability relates to risk perception and flood mitigation action (Bixler et al., 2021).

To our knowledge, there is no comprehensive study that assesses social vulnerability to floods, considering both physical and social dimensions of flood risk, across the entire territory of Uganda. In this study, we applied the SOVI using the HPM (Cutter et al., 2003, 2012). This method allows researchers to integrate biophysical, social and socioeconomic parameters to assess the vulnerability levels of various geographic locations (Fernandez et al., 2016; Khajehei et al., 2020; Tanir et al., 2021). The operationalization of HPM involved a focus on the social vulnerability component, particularly exploring indicators contributing to social vulnerability to floods. The social vulnerability facet of the HPM is particularly well-suited for assessing vulnerability to floods in Manafwa, Eastern Uganda. The advantage of implementing the HPM lies in its applicability for comparing vulnerability across different geographic areas and its capacity to analyze the spatial interaction between social and biophysical factors. Additionally, the HPM incorporates a feedback mechanism that can inform policies and strategies for mitigation programs. This research introduces a novel contribution by examining the impact of neighbourhood social vulnerability, as calculated through the SOVI, on mitigation behaviours. The overarching goal of this research is to provide valuable insights for local policymakers and community stakeholders as they contemplate collective actions to enhance the future health and safety of residents in the Manafwa catchment. The specific objectives are to (1) identify associations between key contextual conditions that render Manafwa catchment communities more socially vulnerable, and (2) construct a simple index incorporating key indicators of social vulnerability. This index can be combined with flood-risk models to offer actionable findings for local decision-makers seeking strategies to reduce social vulnerabilities.

2. Materials and methods

2.1. Study area

The Manafwa catchment is situated in the eastern region of Uganda, near the border with Kenya (Figure 2). Manafwa catchment covers a total area of 502 km² and lies between latitudes 0° 53'0"–1°70'0" N, longitudes 34°5'0"–34°30'0" E (Figure 2). Administratively, there are six districts which constitute the Manafwa catchment namely; Bududa, Namisindwa, Manafwa, Mbale, Tororo and Butaleja. In the study area, the R. Manafwa system is particularly prominent and it flows through the six districts. Bududa district is located upstream of the river, at the foot of Mount Elgon. Namisindwa, Manafwa, Mbale, Tororo and Butaleja are downstream of Bududa on the Manafwa River and Butaleja is the furthest downstream

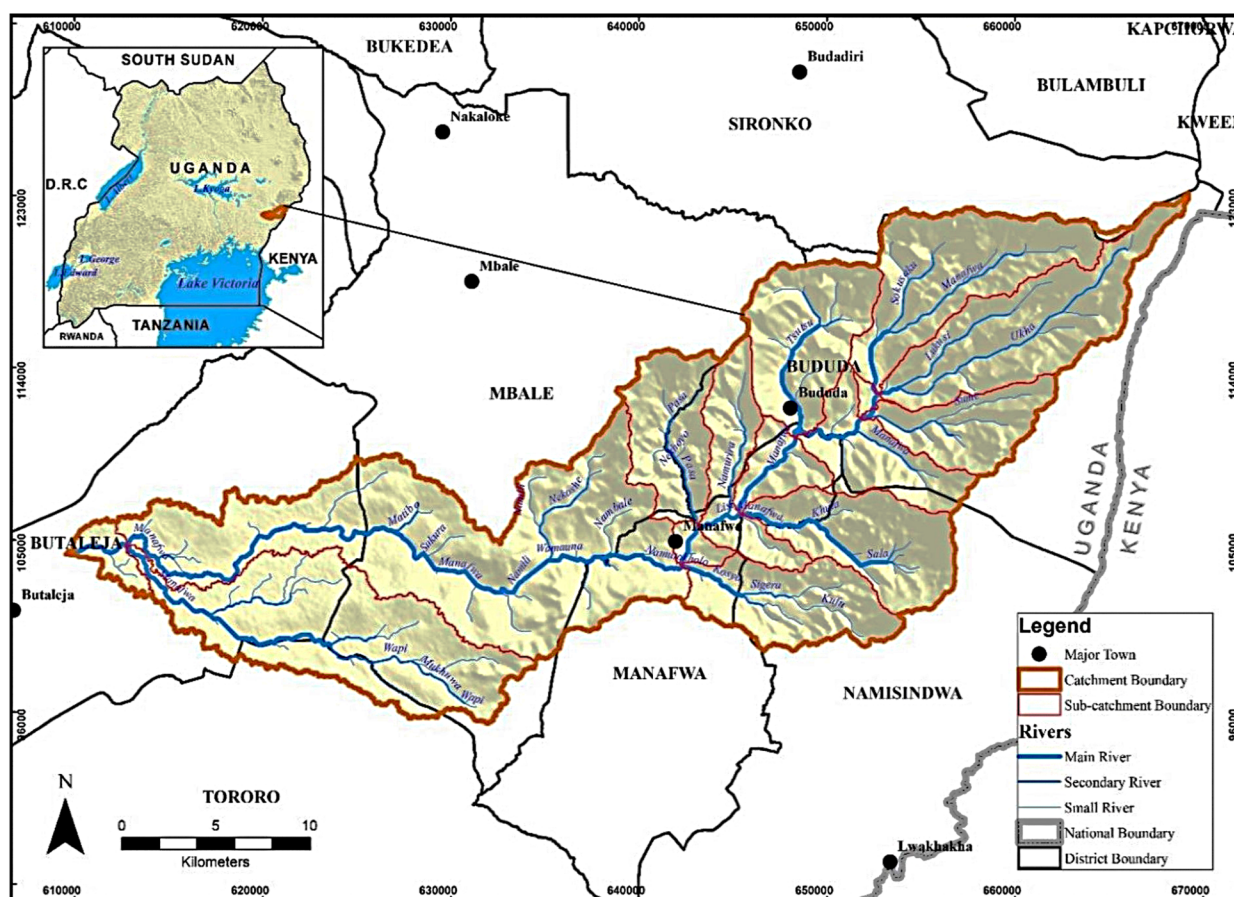


Figure 2. Map of the study area.

and is flooded most often. According to Osuret et al. (2016), the Mt. Elgon region has over the last three decades been reported to have the highest rates of landslides and floods in the country which have negatively impacted the livelihoods of the local communities.

2.2. Sampling and data source

Cross-sectional household studies were conducted using a semi-structured questionnaire (Appendix A), focus group discussions (FGDs) (Appendix B) and key informants' interviews (Appendix C) to discern the patterns of flood disasters and the historical context of flooding in the area (Erima et al., 2023). The semi-structured questionnaire primarily delved into households' observations and perceptions of flood events, past experiences with flood risks or shocks and their adaptation behaviours and decisions (Erima et al., 2023). The criteria to choose study targets was that (1) the household had been affected by flood hazard, (2) the flood hazards had resulted in property damage or loss of life, (3) the family characteristics had to be as different as possible and (4) the residents of the households were able to understand and answer a questionnaire clearly. In all the sampled communities, the head of household was the focal person, however, where the head of the household was not available, efforts were made to interview any adult household member who was knowledgeable about the general livelihood of the household. The study, conducted in March 2019 and September 2021, employed a multistage sampling technique to select study sites and sample households (Erima et al., 2023). In the first stage of sampling, the Manafwa Catchment was chosen, as mentioned earlier. In the second stage, Butaleja (Downstream) district was selected (Figure 3). The third stage involved the selection of two sub-counties within the district based on their exposure levels to flood risks. In the fourth stage, one village was chosen from each sub-county with guidance from locals and local leaders (Erima et al., 2023). Household sampling within these villages was done through simple random sampling. All households within the study area had an

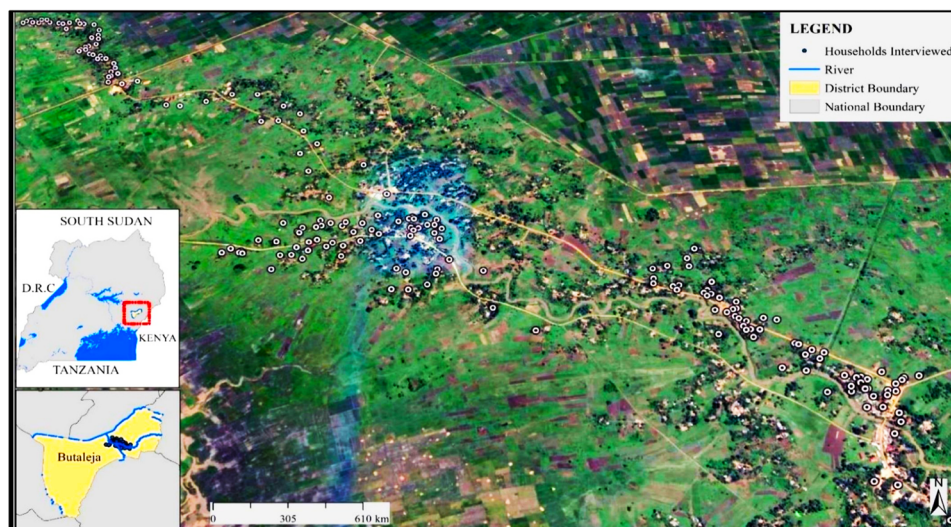


Figure 3. Map showing Butaleja and the households sampled.
Source: Adapted from Erima et al. (2023).

equal chance of being sampled. The sampling procedure ensured that households were at least 150 m apart to reduce the self-styled *herd attitude effect*, where individuals' particular behaviours are influenced by their neighbours. Utilizing Cochran's formula (Cochran, 1977), a sample size of 210 households was calculated with a 95% confidence level and a 5% margin of error (confidence interval). Proportional allocation was then applied to determine the optimal number of households for each sub-county: 123 for Nazimasa Sub-county and 87 for Kachonga Sub-county (Erima et al., 2023). To leverage technological advancements and optimize available resources, the study employed the Open Data Kit (ODK) software for rapid data collection while ensuring quality, integrity and cost-effectiveness. ODK is an open-source survey platform designed as a local application, installable on mobile devices operating on the Android operating system (Erima et al., 2023).

In each of the two sub-counties selected within the district, two FGDs were conducted, featuring adults chosen from the villages. The FGDs centred on how indicators and variables reflected vulnerability to hazards in Butaleja. Participants were invited through local council authorities, and each focus group comprised individuals who had resided in the villages for at least 10 years. The age range of participants in each group was between 24 and 60 years, deliberately selected to include respondents who could provide first-hand accounts of past flood events from an observant perspective. The groups consisted of 6 to 10 people each. The collection of both secondary and primary qualitative data encompassed information related to the occurrence of flood disasters, including the period of occurrence, severity, affected areas, the number of casualties/affected individuals and current and potential socio-economic impacts. Possible factors contributing to damage levels were also explored. Key informants, including institutional representatives such as Environmental Officers and Local Council III chairpersons, provided insights and analyses from the perspective of decision-makers and their respective institutions.

The studies involving human participants were reviewed and approved by Makerere University Institutional Review Board. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements. Additional approvals were provided at district level through Chief Administrative Officer and Local Councilors where fieldwork was conducted. Verbal Informed consent was also obtained from all study participants and this is recorded in the authors field notes. All the information collected has been treated with strict confidentiality, maintaining anonymity. Pseudonyms have been used instead of real names, wherever necessary. However, in certain cases, respondents indicated that their details can be revealed. This was often the case for local elites or officers from government and NGOs. The outputs of the study, however, have not used names of respondents, even where consent was provided. The research, however, had a low-risk rating and did not pose any particular threat to participants at any stage. Participation was voluntary, which was clearly communicated to all participants. All participants were informed about the purpose of the study, why

they were selected, and their right to withdraw their participation at any time. None of the research participants withdrew their participation in the study.

2.3. Principal component analysis

A composite index was formulated utilizing Principal Component Analysis (PCA). Solangaarachchi et al. (2012) perceive PCA as a multivariate statistical technique employed for data reduction. This technique condenses an initial set of variables into a smaller number of linear varieties by discerning patterns in high-dimensional data and unveiling the underlying factors (principal factors) that best elucidate variations in the data (Mavhura et al., 2017). This is achieved through the identification and clustering of variables measuring the same theme (Każmierczak & Cavan, 2011; Mavhura et al., 2017). The implementation of this reductionist technique facilitated the creation of a robust and consistent set of variables that can be monitored over time to gauge any changes in overall vulnerability in Butaleja. Furthermore, the technique supports the replication of variables at the national level and the ongoing monitoring of these variables over time to assess changes in overall vulnerability (Cutter et al., 2003; Mavhura et al., 2017).

The Factor Analysis technique was employed, extracting Principal Components using the Statistical Package for Social Scientists (SPSS) version 20 to discern existing patterns of association among the study's included variables. Factor assigning and weighting were performed using Varimax rotation with Kaiser normalization along an embedded perpendicular system. This choice of varimax rotation aimed to minimize the number of variables with high loadings on a single factor and increase the percentage variation between each factor (Armaş & Gavriş, 2013; Mavhura et al., 2017). The SPSS system determined factor retention based on the Kaiser principle, selecting factors with eigenvalues greater than 1.00. The process yielded a rotated factor matrix with variables showing high loadings on each extracted factor/component. Initially, the Kaiser-Meyer-Olkin (KMO) test assessed sampling adequacy, and the Bartlett's test checked sphericity. A KMO value higher than 0.5 indicates the suitability of sampling data for PCA (Lolli & Di Girolamo, 2015). Varimax rotation was utilized to simplify the structure of underlying dimensions and enhance independence among the factors. The Kaiser criterion (eigenvalues > 1) guided component selection. Components that increased vulnerability were considered positive, while those reducing vulnerability were deemed negative (Mavhura et al., 2017; Solangaarachchi et al., 2012). No variables loaded both positively and negatively on a component. Normalization of the variables was achieved through Equations (1) and (2):

Positive correlation indicators:

$$x_0 = \frac{x_i - \min x_i}{\max x_i - \min x_i} \quad (1)$$

Negative correlation indicators:

$$x_0 = \frac{\max x_i - x_i}{\max x_i - \min x_i} \quad (2)$$

where x_i and x_0 are the original and standard values of indicator i , respectively, and $\max x_i$ and $\min x_i$ are the maximum and minimum values of the selected indicators' values, respectively.

A composite SoVI score was formulated by summing all component scores (factor loadings) with an eigenvalue ≥ 1.00 for each respondent (Mavhura et al., 2017). An equal weighting and additive approach was adopted due to the absence of empirical and justifiable evidence for assigning different weights to components, a practice observed in similar studies (Cutter et al., 2003; Hummell et al., 2016; Mavhura et al., 2017). This methodology treated each factor as having an equal contribution to the village's overall vulnerability, with a focus on spatial variability to enhance the understanding of complex vulnerability explanations. The SOVI scores were categorized to represent high vulnerability, moderate vulnerability or low vulnerability (Table 1). This categorization facilitated the comparison of social vulnerability levels between the two selected sub-counties.

Table 1. Description of the benchmarks of the SOVI scores of Butaleja.

Category	SoVI Score	Description
3: Highly vulnerable	≥ 3	The community is highly vulnerable to flood hazards. There is need to urgently attend to the root causes and dynamic pressures causing fragile livelihoods and unsafe conditions.
2: Moderately vulnerable	1.01–3.00	The community has a moderate level of vulnerability to floods. Resources of the community are failing to sustain the basic needs of people; there is lack of effective institutions to address flood risk.
1: Low vulnerability	≤ 1.0	The community is lowly vulnerable to floods. There is need to continue building community socio-economic capitals and address flood risk.

Table 2. Socio-demographic, housing and residential characteristics of respondents.

Socio-demographic characteristics	
	Percentage
Age (years)	
20–30	40
31–40	18
41–50	17
>51	25
Gender	
Male	41
Female	59
Education qualification	
No formal education	11
Primary	72
Secondary	16
Tertiary	1
Marital status	
Single	5
Married	85
Employment status	
Formally employed	14
Not formally employed	86
Duration of stay in the area (years)	
<11	25
11–19	15
21–29	18
31–39	16
41–49	10
51–59	6
>60	10
Description of housing structure	
Temporary (brick and grass thatched)	2
Semi temporary (mud and wattle under grass thatched)	22
Semi-permanent (mud and wattle under iron roof)	60
Permanent (brick under iron roof)	16
Location of house percentage	
In residential clusters	23
Close to roads	17
Close to the river	35
In the flooded area	25

Source: Adapted from Erima et al. (2023).

3. Results

3.1. Socio-demographic profile of respondents

The results of this study, derived from the returned questionnaires ($n=197$) as presented in Table 2, indicated a higher percentage of female respondents (59%) in comparison to male respondents (Erima et al., 2023). A significant portion (72%) of these respondents had achieved a primary level of education with basic literacy skills (Erima et al., 2023). Additionally, 86% were primarily engaged in agriculture as their main source of livelihood, lacking alternative employment (Erima et al., 2023). The majority of households were headed by males (55%), and the average family size was seven people, exceeding the national average of five people (Uganda Bureau of Statistics (UBOS), 2018). The average monthly income reported was 380,000 Uganda shillings. Notably, more than 85% of household heads were married, and

Table 3. KMO and Bartlett's test.

Kaiser-Meyer-Olkin measure of sampling adequacy		0.6
Bartlett's test of sphericity	Approx. Chi-square	7735.9
	Df	903
	Sig.	0.000

Table 4. Principal component eigenvalues and variance contribution rate.

Principal component	Eigenvalue	Variance. percent	Cumulative.variance.percent
PC.1	2.5	16.8	16.8
PC.2	1.9	12.9	29.7
PC.3	1.9	12.4	42.1
PC.4	1.4	9.7	51.8
PC.5	1.2	8.1	59.9
PC.6	1.1	7.5	67.4
PC.7	1.0	6.8	74.2
PC.8	1.0	6.4	80.6

the majority had resided in the area for over 11 years (75%), as illustrated in Table 2 (Erima et al., 2023). Most respondents lived in semi-permanent houses (60%), constructed with mud and wattle under an iron roof, predominantly located close to the river (35%) and within the flooded area (25%), as indicated in Table 2 (Erima et al., 2023). The demographic composition revealed a predominantly young population, with the majority of respondents falling within the age range of 21 to 50 years (Erima et al., 2023). These demographic trends closely align with the information reported during the 2014 Population and Housing Census (Uganda Bureau of Statistics (UBOS), 2018).

3.2. Results of the SOVI

In this study, the KMO value was 0.60, slightly surpassing the recommended minimum, indicating the suitability of the variables for PCA (Table 3). Furthermore, Bartlett's test of sphericity yielded a highly significant result ($p < .05$, $df=903$ and Sig. = 0.000), indicating that the data were well-suited for component analysis. The obtained p -value of .000 suggests a robust correlation among all tested variables.

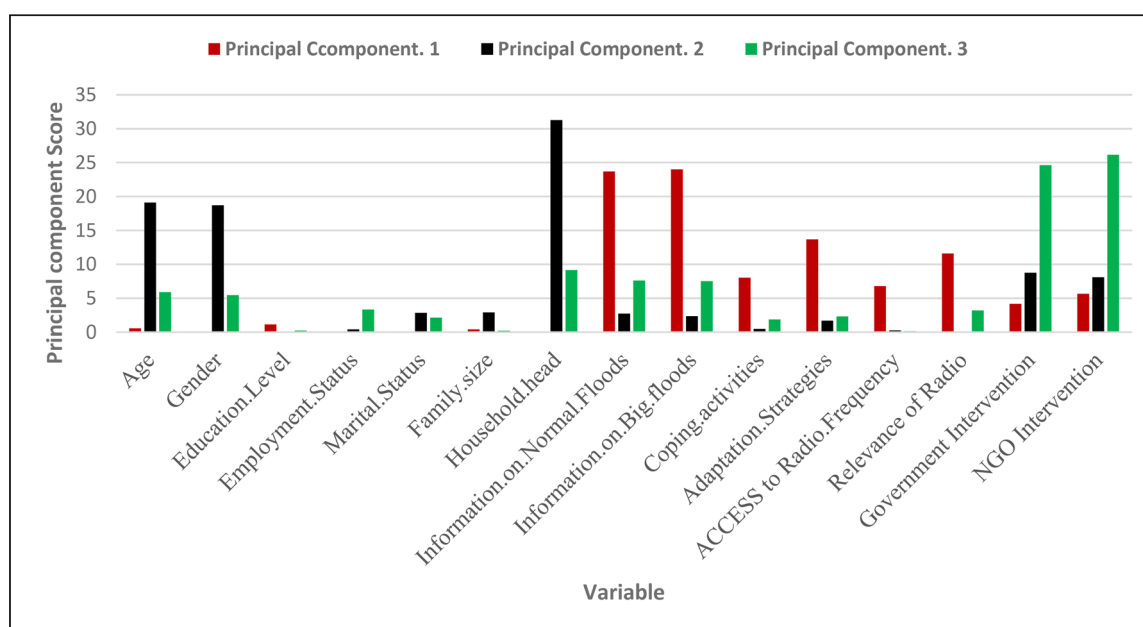
Fifteen indicators exhibited information overlap, and PCA was employed to transform these indicators into more comprehensive ones. Eight principal components were identified, each with eigenvalues equal to or greater than 1 (Table 4). The cumulative variance of these eight components contributed to 80.6% of the total variances, signifying that they encapsulated a significant portion of the information.

The load matrix was established for the eight principal components extracted, and the principal component load matrix, after rotation, was obtained through orthogonal rotation with maximized variance. Subsequently, the principal component score coefficient matrix was derived, as presented in Table 5. Based on the information in Table 5 and Figure 4, the first principal component exhibits high scores on the information about floods, adaptation strategies, and the significance of radio as a communication tool. Consequently, this component was labelled the 'Information and Knowledge' principal component. Support for this component's relevance was found in the FGD conducted at Doho Tiidi, where participants recalled heavy rains in 1997, commonly referred to as 'Somalia', by the respondents and a recurrence in 2010 and 2018. The FGD findings align with statements from the Kachonga Sub-County Chairperson, affirming that floods predominantly occurred in the months of April to May and November.

The second principal component scores high on the Household head, Age and Gender (Figure 4), leading to its designation as the 'Demographic and Family Characteristics' principal component. On the other hand, the third principal component demonstrates high scores in Government and NGO interventions, earning it the title of the 'Rescue and Social Capital' component. Contributions from the FGD at Doho Tiidi enriched the Rescue and Social Capital component. Participants highlighted the valuable assistance provided by social networks during food emergencies, noting that it played a significant role in restoring order in the community's social structure. They also observed that during the 2010 floods, NGOs and the government helped, such as water Jerry cans and food items, although not everyone received these items. In 2018, the government provided 20 kgs of maize flour for the entire village, but

Table 5. Principal component score coefficient matrix.

	PC.1	PC.2	PC.3	PC.4	PC.5	PC.6	PC.7	PC.8
Age	-0.11971	0.607683	-0.33175	0.374083	0.099735	-0.08465	0.152987	0.155089
Gender	0.002379	-0.60137	0.3183	0.47002	0.340721	0.027678	0.261306	-0.00037
Education level	0.171288	-0.03467	0.065252	-0.45382	-0.36719	0.171199	0.574584	0.079496
Employment status	-0.0495	0.090179	0.249212	-0.39712	0.090414	0.568601	0.301316	0.18831
Marital status	-0.0201	0.235622	-0.19947	0.418652	0.542319	0.426809	0.272993	0.046154
Family size	0.104663	0.237708	0.064217	0.289852	-0.26975	-0.49801	0.412769	0.478263
Household head	0.009596	0.77733	-0.41249	-0.11791	-0.06055	0.166624	-0.14112	-0.06747
Information on normal floods	0.772844	-0.23075	-0.37575	0.216751	-0.24432	0.19168	0.031816	-0.10207
Information on big floods	0.778138	-0.21383	-0.37364	0.252333	-0.24203	0.141295	0.012938	-0.11257
Coping activities	0.449857	-0.09715	0.186794	-0.1394	0.175463	0.0004	-0.33758	0.61003
Adaptation strategies	0.58768	0.182266	0.207714	0.010607	0.103099	0.187605	-0.26669	0.294773
Radio frequency	0.414183	0.0701	-0.05362	-0.41082	0.535564	-0.31655	0.106764	-0.14629
Radio relevance	0.541061	0.04731	-0.24396	-0.31003	0.34216	-0.33593	0.219814	-0.14338
Government interventions	0.325034	0.411816	0.675934	0.206848	-0.04602	-0.03208	0.04472	-0.28412
NGO Interventions	0.37829	0.396023	0.696436	0.116909	-0.09555	0.006627	-0.01565	-0.22436

**Figure 4.** Contribution of variables to the principal components.

this measure increased vulnerability as competition for shares ensued. Regarding actions taken during and after events, the FGD at Doho Tiidi mentioned that in 2018, the village Chairperson mobilized every household to contribute 20,000/= for building an embankment on the river bank, although the funds proved insufficient. Another FGD in Doho Hibiila (Kachonga sub-county) described community mobilization during floods to dig water channels and reduce the impact. However, such actions may elevate household social vulnerability due to associated risks, including drowning, injuries, snake bites and the risk of contracting skin diseases.

The results of the PCA-based weights for all indicators are shown in Table 5. For the spatial distribution of the SOVI scores of the households, cumulative scores for the eight Principal components were used to divide the SOVI scores into high, moderate and low vulnerability categories (Table 1 and Figure 5).

As shown in Figure 5, the majority (88.8%) of the sampled households in two Sub counties (Nazimasa and Kachonga) in Butaleja have a moderate to high level of social vulnerability.

Comparatively it was also discovered that more households in Nazimasa Sub-county are moderately vulnerable (80.5%) than households in Kachonga Sub-county (69.6%) (Figure 6) while more households in Kachonga Sub-county are highly vulnerable (15.2%) than households in Nazimasa Sub-county (9.3%).

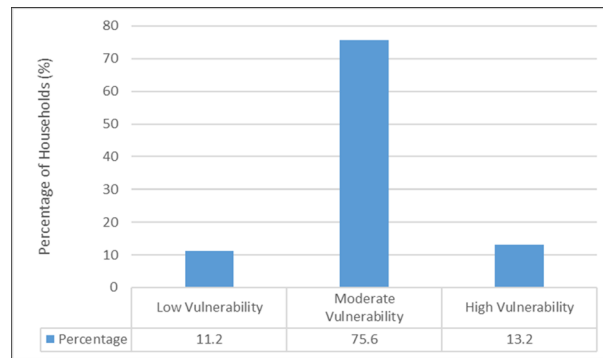


Figure 5. Social vulnerability to flooding in Nazimasa and Kachonga Sub-counties in Butaleja.

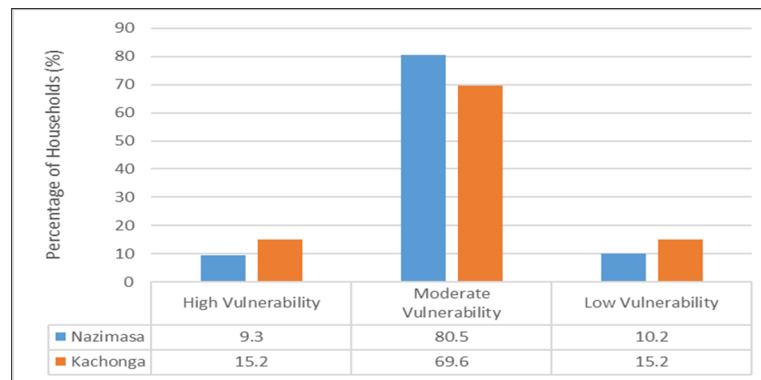


Figure 6. Household social vulnerability scores by sub-county.

3.3. Evaluation of SOVI

3.3.1. Demographic factors that influence social vulnerability

The key individual socio-demographic characteristics influencing the evaluation of the SOVI included age, gender, education, type and location of the house. These factors played a pivotal role in determining social vulnerability.

3.3.1.1. Age. Different age groups within the population were considered as indicators for assessing social vulnerability. The study's findings indicated that respondents aged between 20-30 years were the most socially vulnerable, followed by respondents aged above 51 years (Figure 7). Social vulnerability tends to be elevated in both the very young and the very old, as they may face physical disadvantages and a potential lack of material and economic support (Birkmann, 2007). During the FGDs, participants emphasized that vulnerability levels to floods were highest among women, children, the elderly and the physically disabled.

3.3.1.2. Gender. Apart from age considerations, flood vulnerability is closely tied to gender, with women identified as the most vulnerable in both sub-counties (Figure 8). However, the results reveal a higher vulnerability among men in Kachonga compared to Nazimasa (Figure 8). Factors contributing to increased female vulnerability include restricted movement, limited access to formal education due to religious and cultural beliefs, women often working in low-wage informal sectors earning less than men, and the substantial household responsibilities shouldered by women, encompassing motherhood and caregiving duties for both children and the elderly (Umaru & Adedokun, 2020). Additionally, until recently, many females in the study area dedicated their lives primarily to household activities from an early age, affording them fewer opportunities to engage in educational and social activities compared to males (Umaru & Adedokun, 2020). This significantly heightens the vulnerability of the female population to floods.

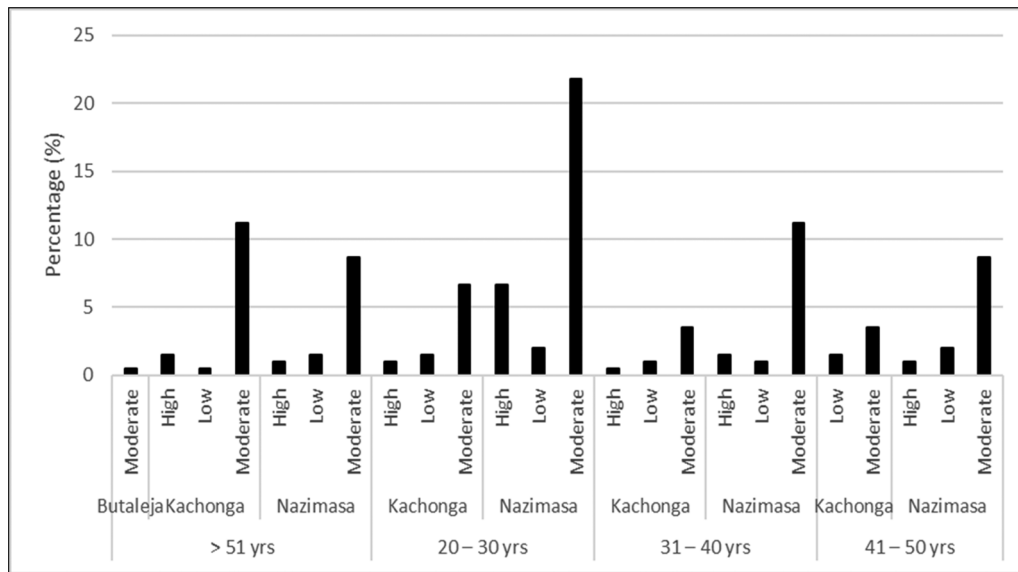


Figure 7. Social vulnerability for different age groups.

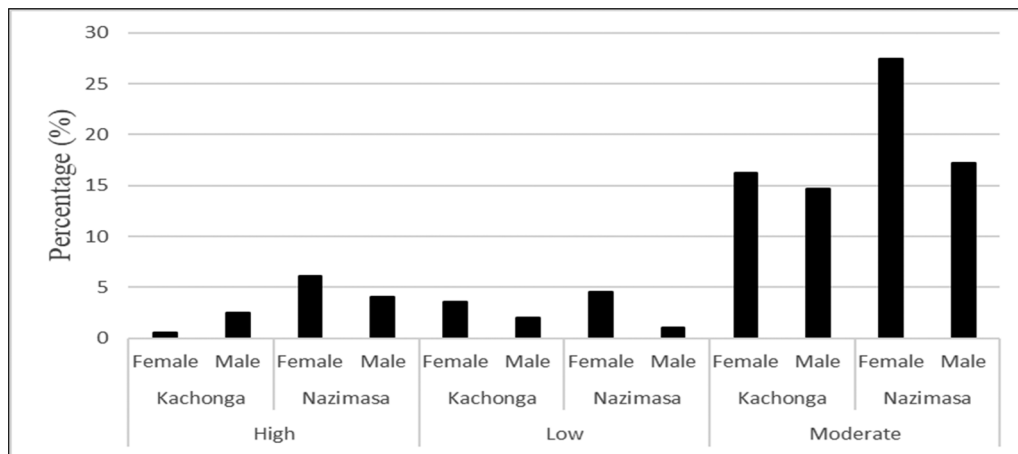


Figure 8. Social vulnerability and gender relationship.

3.3.1.3. Education levels. The majority of respondents have little education and are moderately vulnerable (Figure 9). People with little education lack understanding about hazard cause, trigger factors, severity and effects (Umaru & Adedokun, 2020). They are also ignorant of how to prepare for emergency mostly depending on others to prepare and evacuate themselves during an imminent disaster (Umaru & Adedokun, 2020). Moreover, the limited ability to read or write constitutes a significant difficulty for prompt action during emergency situation (Umaru & Adedokun, 2020).

3.3.1.4. Housing type and location of houses. The study indicates that 82% of the houses in the research area were constructed with mud (Table 2), and 60% of these houses were situated in high-risk areas, such as proximity to the river and flood-prone zones (Table 2). The quality of both cement and mud houses in the study area is substandard, making them susceptible to severe damage during floods (Umaru & Adedokun, 2020). Residents in the study area generally lack a culture of maintenance and renovation, contributing to the prevalence of substandard buildings with a notably high density in floodplain areas. Consequently, the potential damage caused by floods is anticipated to be substantial in the study area, given the pronounced vulnerability of semi-permanent houses (Figure 10) located in close proximity to water bodies and within flooded areas (Figure 11).

The results showed that housing quality were not only poor but mostly situated in high flood risk areas (Umaru & Adedokun, 2020). The great numbers of human lives and properties that reside in such poorly constructed buildings and risk areas are at great risk of flood hazard. The infrastructure and poorly

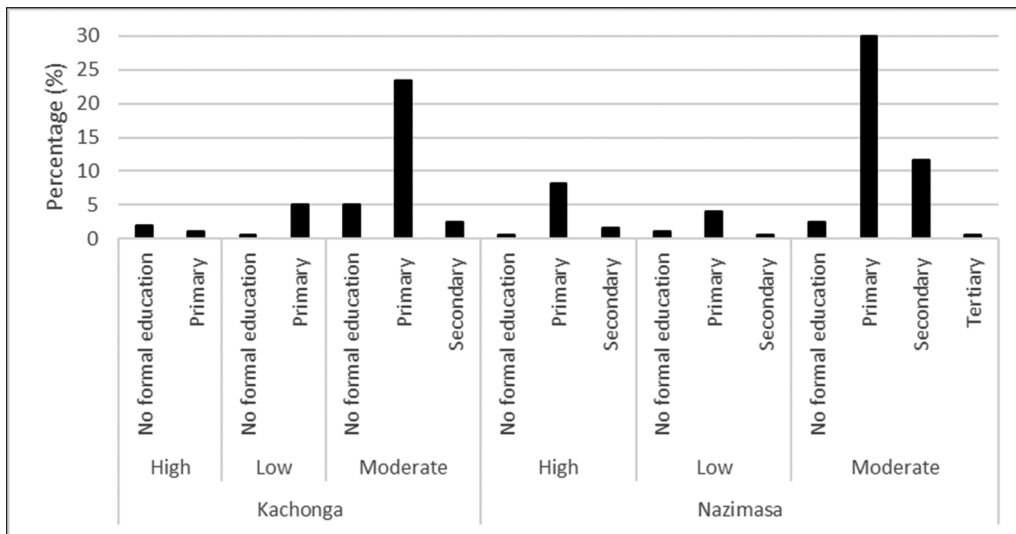


Figure 9. Social vulnerability for the different education levels.

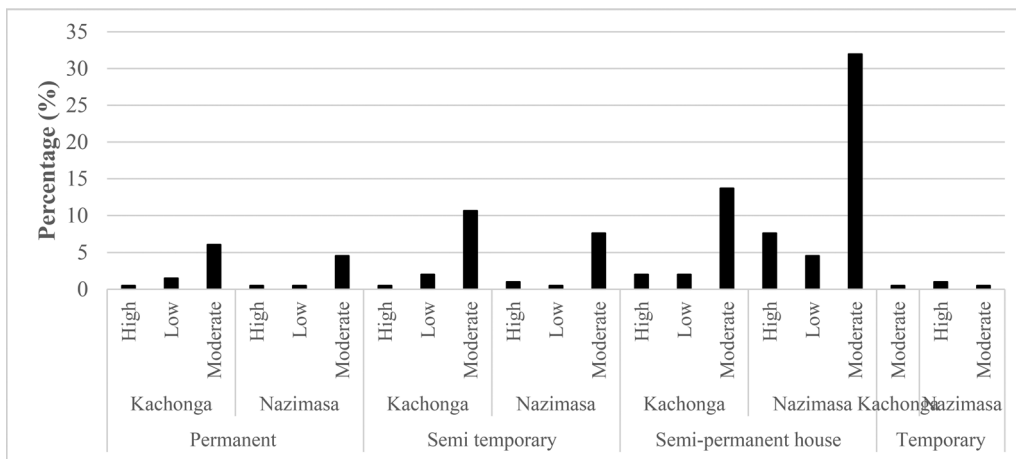


Figure 10. Social vulnerability for the different housing types.

constructed houses in the low-lying places and flood plains of the study area will be easily flooded and damaged during flooding (Umaru & Adedokun, 2020).

4. Discussion

This study drew on context-specific vulnerability variables identified by key informants from the local community, acknowledging that existing literature might not capture all relevant indicators. It highlights that locally generated and validated vulnerabilities are unique to their context. Additionally, the research demonstrates that the sensitivity to hazards in Butaleja is closely tied to the area's challenging socio-economic conditions (Mavhura et al., 2017). In this research, we first developed a SOVI for residents of floodplain areas in Eastern Uganda. Our findings aimed to compare the multifaceted vulnerabilities faced by women and men. Based on empirical evidence, we can make two key assertions regarding the impacts of flooding in Eastern Uganda: (1) women are more vulnerable to floods than men, and both groups experience the effects disproportionately; (2) social disparities are fundamental factors that exacerbate sensitivity and exposure to the devastating consequences of floods.

Age emerges as the primary demographic factor influencing social vulnerability, as indicated by the extensive citations in the literature. The extremes at both ends of the age spectrum impact the ability to relocate to safer areas and elevate the care burden in the aftermath of a destructive event. This is

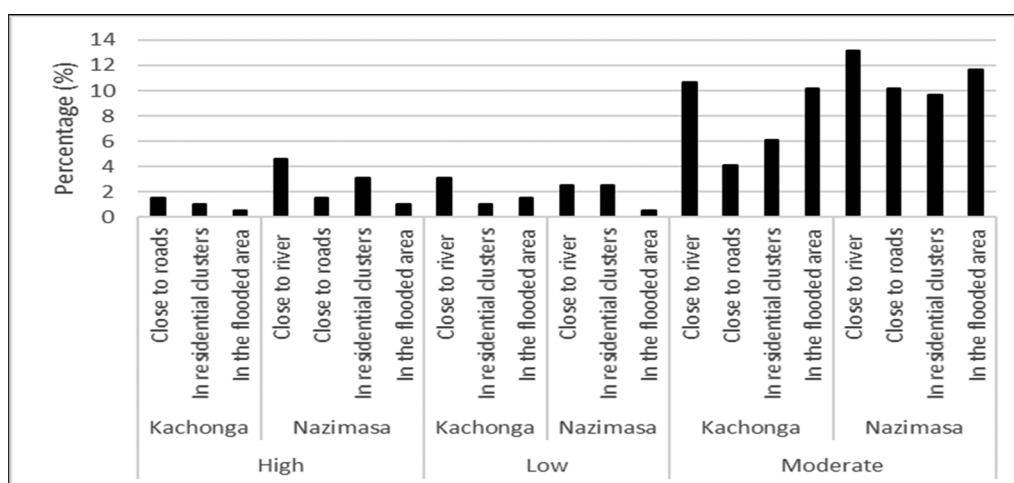


Figure 11. Social Vulnerability and location of house relationship.

partially attributed to service reductions that may complicate recovery, particularly for age-dependent populations (Rufat et al., 2015). Although age's contribution to social vulnerability can be mitigated by prior disaster experience and anticipatory behaviour during the mitigation phase, (Rufat et al., 2015) suggests that only the 'very old' and the 'very young' tend to be more vulnerable due to their dependency status and physical conditions, and only a few linear relationships between age and vulnerability have been identified in studies (Babcicky & Seebauer, 2021). Elderly individuals may also feel distress at the prospect of evacuation (See & Porio, 2015). However, older people are more likely to have insurance coverage (Steinführer & Kuhlicke, 2007) and possess greater disaster experience and anticipatory behaviour (Paul & Routray, 2011; Rufat et al., 2015). Similarly, children can act as a protective factor by fostering community networks through schooling (Babcicky & Seebauer, 2021; Walker et al., 2012) and garnering support for their families (Babcicky & Seebauer, 2021; Kuhlicke et al., 2011; Rufat et al., 2015).

In terms of gender dynamics, households with a higher proportion of female members are generally more vulnerable to flood risks. This increased vulnerability arises from the fact that women often engage in activities that expose them to environmental hazards, such as collecting water and firewood, cooking, managing food and caring for children (Azad et al., 2013). Gender significantly influences social vulnerability, with research indicating that women are typically more vulnerable than men (See & Porio, 2015). This gap is especially evident in countries where women have limited social and economic rights. Women often face a disproportionate burden for two main reasons: (1) they tend to be in a more precarious social position prior to disasters, and (2) they take on additional caregiving responsibilities for children and the elderly (Porio, 2011; See & Porio, 2015). Furthermore, gender affects individuals' likelihood of seeking out mitigation measures. Studies suggest an indirect link between gender, risk perception, and mitigation efforts, with females generally demonstrating a heightened perception of risk compared to males (Bixler et al., 2021; Brody et al., 2017). Our findings indicated that social processes and disparities significantly contribute to heightened sensitivity and exposure to the devastating effects of floods. Moser (1998) asserts that vulnerability to unprecedented events varies based on women's possessions, access to property, opportunities, and the social roles they fulfill. Supporting Moser's perspective, our study revealed that women in floodplain areas face challenges such as a lack of rights to household belongings, limited access to land and decision-making processes, and insufficient access to medical facilities. These unequal opportunities lead to differing levels of exposure to floods, resulting in greater vulnerability among both women and men in Uganda. Other social disparities, such as unequal access to income-generating opportunities, financial assets, and institutional resources, also play crucial roles in creating differential vulnerability between genders (Jerin et al., 2023). These underlying factors disproportionately reshape vulnerability for women and men. Similar results were also found in Bolivia (McDowell & Hess, 2012) and Uganda (Balikoowa et al., 2019). In Bolivia, various social stressors – including unequal landholdings, limited access to financial credit and institutional discrimination – have weakened the adaptive capacity of marginalized farming households, particularly affecting women and increasing their vulnerability to

seasonal rainfall and drought (Jerin et al., 2023). Likewise, female-headed households in Uganda are especially vulnerable to drought due to existing disparities in income, access to technology, and institutional support (Jerin et al., 2023). Our findings further align with other studies highlighting that females and children are particularly vulnerable to mental health disorders associated with disasters in low-resource settings. One study identified low socio-economic status as a primary risk factor for developing psychological morbidities, with gender being the most significant factor. A review indicated a direct correlation between low socio-economic status and post-disaster mental health disorders. Our case study was conducted in an area frequently affected by disasters, characterized by an overall low socio-economic status. Similar disaster-prone or coastal regions are typically low-lying, impoverished and resource-poor, facing heightened risks of post-disaster stress. Gender also plays a crucial role in increasing vulnerability in these areas. Therefore, our findings are pertinent and significant for similar geographical contexts in the country.

Numerous factors contribute to low education levels in Butaleja district, including low income, unemployment, poverty, flooding and reduced productivity in the farming sector. High poverty rates among Butaleja households serve as both an outcome and a catalyst for low educational attainment in the community. Despite the government's provision of free universal education, parents may struggle to send their children to school due to financial constraints. Additionally, low levels of education adversely impact an individual's knowledge and awareness of disaster risk management practices, even in hazard-prone areas. Higher levels of education often lead to better-paying jobs and increased incomes (Rufat et al., 2015), resulting in greater asset ownership. While wealthier households may incur higher absolute costs from flood events, these costs represent a lower proportion of their total income and capital, maintaining a higher coping capacity compared to poorer households (Rufat et al., 2015). In contrast, lower education levels coincide with poverty, overcrowding, unemployment, income inequality and marginalization. Individuals with lower levels of education may encounter limitations in comprehending warning information and accessing recovery resources. Additionally, education is intertwined with socio-economic status, as higher educational attainment often correlates with increased monetary compensation and earnings (Cutter et al., 2003; Porio, 2013). Occupation is closely linked to an individual's education, and certain occupations, particularly those involving resource extraction, may face severe impacts during natural hazards. Workers in fields like fishing, agriculture and other low-skilled service jobs may experience income depletion when their livelihood sources are affected by hazards such as floods (Porio, 2011). Education has also been recognized as a factor influencing flood mitigation actions, with higher levels of education associated with a greater inclination towards mitigation efforts (Brody et al., 2010; Shah et al., 2017).

The employment statistics underscore that a significant portion of Butaleja's population lacks formal employment, rendering them financially deprived. Income plays a crucial role in an individual's or household's ability to plan for and cope with flood disasters (Rebecca, 2016). Consequently, low income contributes to the absence of modern flood-proofing, the use of substandard building materials, low agricultural productivity, and inhabiting semi-permanent houses often located in the flood plain (Mavhura et al., 2017). Inability to access basic needs such as decent shelter, health care, education and transportation to service centres is a direct consequence of low income, impacting the health-seeking behaviour of the population (Mavhura et al., 2017). During disasters, households become more vulnerable. Poverty significantly influences households' vulnerability to hazards, as impoverished households struggle to develop effective disaster-coping strategies. Limited resources force households to rely on external support, exacerbating their vulnerability. This aligns with Muyambo et al.'s (2017) findings that external support significantly contributes to the social vulnerability of communal farmers to drought. Households with economic capital, such as livestock and credit, have greater opportunities for livelihood diversification, enabling them to manage and cope with flooding more sustainably (Weldegebriel & Amphune, 2017). Therefore, prioritizing measures to stabilize household incomes through diversifying livelihoods becomes crucial. Although economically disadvantaged groups may face lower economic damage costs, the relative impact of damaging flood events is generally more severe for low-income groups. Recovery from even moderately damaging events may take years for those unable to afford repair, reconstruction, or relocation costs (Rufat et al., 2015). Poor and marginalized populations not only tend to reside in highly exposed zones with limited employment and housing opportunities but also lack adequate protection from formal institutions providing disaster mitigation and recovery assistance (Mendis et al., 2023).

While Uganda has made strides in disaster risk reduction through the implementation of the Hyogo Framework for Action 2005–2015 and a commitment to the Sendai Framework for Action 2015–2030, the focus on hazard and vulnerability assessments remains centralized, primarily at the national level (Mavhura et al., 2017). This study's empirical application of the SoVI at the sub-national level, specifically in the disaster-prone Butaleja district, provides a compelling rationale for measuring social vulnerability at context-specific spatial scales. The use of SoVI, which simplifies complex phenomena and problems by identifying patterns in high-dimensional data and revealing underlying factors through indicators, offers distinct advantages for policymakers. One notable advantage is the ease of communication regarding identified issues (Birkmann, 2007). In situations like Butaleja, defining where vulnerability reduction is most urgently needed, SoVI can assist policymakers, particularly at the national level, in prioritizing districts for development and humanitarian aid interventions. Like in many other parts of the world, SoVI has not been widely applied in Uganda, making it a crucial tool for informing poverty alleviation initiatives. An empirically based SoVI approach, incorporating multivariate quantification and spatial representation, can support assessments of both proximate and underlying influences on individual and household vulnerabilities.

However, several critiques of PCA-based composite index construction are noted in the social science literature. These include: (1) the lack of a firm consensus on the selection of context-specific variables, statistical procedures and underlying assumptions, and (2) the ongoing debate about factor aggregation and weighting methods. Additionally, some researchers recommend interpreting PCA-based composite index results with caution (Chakraborty et al., 2020). First, an index calculated for one area may not be comparable to or transferable to another area unless the indicators are derived using the same method for international comparison. Second, the index only measures relative social vulnerability between geographical areas and cannot be used to understand absolute levels of socioeconomic and cultural attributes within a community (Chakraborty et al., 2020). Nevertheless, this study highlights several operational benefits of using SoVI scores for Eastern Uganda, building on Cutter's SoVI scores. These benefits include: (1) the SoVI calculation method relies on robust statistical approaches that ensure the reliability and robustness of empirical results in the social science literature; (2) the SoVI is context-specific, focusing on population characteristics that may influence outcomes in environmental decision-making processes and (3) the index scores were calculated using weights of the multidimensional components (or 8 composite factors) based on their respective contributions to the total variance, rather than altering factor signs based on personal judgments and using an additive model to compute summary scores (Cutter et al., 2003).

Economic policies and disaster legislations should address social inequalities and their impact on disaster risk management, including preparedness and response. The SoVI proves versatile across various phases of the disaster management cycle (Solangaarachchi et al., 2012). During the mitigation and preparedness stage, SoVI serves as a proactive tool for planning community-based disaster mitigation activities, prioritizing more vulnerable areas to enhance community resilience. In the response and recovery stages, it acts as a reactive tool for designing early warning and action systems, evacuation plans, and recovery strategies. SoVI enables capturing the dynamics of a community over time. Comparative analyses with new census data can track progress in reducing social inequalities that contribute to vulnerability in hazard-prone regions. Thus, SoVI analyses, applicable at multiple scales, provide a valuable policy tool for identifying and monitoring vulnerability trends in areas of concern (Abson et al., 2012). Beyond assessing vulnerability, SoVI analysis guides investment decisions and facilitates the efficient allocation of resources (Boruff & Cutter, 2007). Adopting SoVI in flood risk management policies can tailor strategies to enhance community resilience, thereby increasing the capacity of people to resist, cope with, and recover from the impacts of flooding (Thieken et al., 2007). It is crucial to adopt a portfolio of policy instruments, including flood mitigation measures, regulations, economic incentives, and comprehensive geospatial data analysis, to effectively reduce flood risk (Hegger et al., 2018).

5. Conclusions

Social vulnerability in the Manafwa catchment is primarily influenced by coping mechanisms and risk perception, as revealed in the study. The overall flood risk perception among respondents in the surveyed area is moderate, evident in the high household vulnerability scores falling into the moderate category. Effectively mitigating hazards and responding to emergencies requires a nuanced

understanding of how the social, economic, and political fabric of society generates significant disparities in vulnerability among those responsible for protecting others. Inadequacies in information related to flood risk and coping strategies persist, with many residents lacking the knowledge necessary to prepare for and address the potential consequences of flood hazards.

Addressing the identified communication gap through the development of effective risk communication initiatives by the Government, facilitated by the Office of the Prime Minister (OPM), will empower citizens to better cope with and manage flood risks. Leveraging social media can be a valuable tool in this endeavour. Prioritizing preventive and primary healthcare services, property damage compensation, family counselling, and support aligns with the actual risk priorities of the public. The OPM should also enhance awareness of natural hazards and disasters by: (1) improving early warning systems, reaching remote areas, and enhancing system accuracy; (2) formulating and implementing emergency management plans and (3) expanding awareness campaigns on natural hazards and disasters. Government entities at various levels, including Ministries, Departments and Agencies (MDAs) such as the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), Ministry of Water and Environment (MWE) and District Local Government (DLOG), should play a pivotal role in preparing vulnerable communities for anticipated increases in the frequency and intensity of flood hazards.

Deliberate policies focusing on improving household sustenance, enhancing community adaptive coping resources and developing sustainable risk communication management tools are crucial priorities. Coordination among institutions, encompassing governmental, non-governmental organizations and the private sector involved in flood risk management, will enhance the effectiveness of flood risk management throughout all phases—pre-, during, and post-flood events. Future studies should refine vulnerability projections to incorporate the impact of urban changes, economic growth and population dynamics. Additionally, observing how this vulnerability assessment, and others, are received by policy-making agencies and tracking the evolution of this reception over time will provide valuable insights into critical research-policy interfaces in flood risk management.

Finally, utilizing PCA for a detailed and comprehensive social vulnerability assessment nationwide is both feasible and essential. This method aids decision-makers in understanding place-based differential vulnerability and socioeconomic variability at a local level. Such insights can enhance the integration of environmental justice outcomes into all facets of environmental policy and planning, promoting sustainable disaster risk reduction strategies through prioritized programming, project development and informed policy decisions.

6. Future research

Future research is needed to delve into the human aspects highlighted above, such as risk perception and cultural dimensions. Qualitative studies could significantly enhance our understanding of the factors relevant to social vulnerability, as well as how these factors interact and influence each other. Key topics and questions pertaining to social vulnerability can extend beyond areas focused solely on vulnerability, shedding light on issues of justice and power, and elucidating the role of the welfare state in relation to risk management and vulnerability. Potential questions for future research include: Who finds it crucial to identify social vulnerability? Who holds the authority to define vulnerability and determine appropriate actions? What societal values underpin the assessments of vulnerabilities? These questions, which touch on ethical considerations, may span multiple societal domains, such as public health and the evolution of social services, beyond those directly impacting risk management. Consequently, a compelling direction for future research is to explore how broader societal aspects intersect with risk management and social vulnerability.

Authors' contribution

Conceptualization, G.E.; Y.B and A.E.; data curation, G.E.; formal analysis, G.E and Y.B.; funding acquisition, Y.B.; Investigation, G. E.; methodology, G.E.; Y.B and A.E.; software, G.E.; supervision, A.G., Y.B., A.E. and I.K.; writing – original draft, G.E.; writing – review and editing, G.E., I.K., A.G., Y.B. and A.E. All authors contributed to the writing of the manuscript. All authors have read and agreed to the published version of the manuscript.

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Data availability statement

The data that support the findings of this study are available from the corresponding author, [GE], upon reasonable request.

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Appendix A. Household survey questionnaire

A.1. Introduction

The study seeks to assess communities' knowledge and experiences of the impacts of floods on their livelihoods and the coping and adaptation strategies in Manafwa catchment, Eastern Uganda. None of the questions are mandatory and more than one answer can be provided for the same question. While answering, try being as accurate as possible. If a question does not apply to you, please skip it. Information which will be obtained will be used for academic purposes only and will be treated with absolute confidentiality.

Interviewer		Questionnaire Number:
District:	Sub-county:	Village:
Name of Interviewee:		Position in the Household
Date of Interview:		Time of Interview:
GPS coordinates		

1. **Age:** 1) 20–30 2) 31–40 3) 41–50 4) >51 years old
2. **Gender** 1) Male 2) Female
3. **Marital status:** 1) Married 2) Single 3) Divorced 4) Widowed
4. **What is your highest level of education?** 1) None 2) Primary 3) Secondary school 4) Tertiary (Certificate, diploma, degree)
5. **Category of employment:** 1) Employed 2) Not employed
6. **Specify type of employment**.....
7. **What is your monthly household income?** 1) less than USHS 10,000 2) USHS 10,001–100,000 3) USHS 100,001–500,000 4) more than USHS 500,001
8. **Are there children in the household that are under 12 years old?** 1) Yes 2) No
9. **How many are they?**.....
10. **Are there adults in your household that are over 60 years old?** 1) Yes 2) No
11. **How many are they?**.....
12. **Are there people with disabilities in your household?** 1) Yes 2) No
13. **How many people live in your property?**.....
14. Number of males..... and number of females..... In Household
15. **What is the type of your housing?** 1) Permanent (brick under iron roofing) 2) Semi-permanent house (mud and wattle under iron roof) wattle 3) Temporary (Brick under grass thatched) 4) Semi temporary (mud and wattle and grass thatched)
16. What type of hazards do you define as most frequent for your village; what type of hazards have you personally experienced? Specify hazard and when they occurred.....
17. **My property is located in a** 1) *high-risk* 2) *medium-risk* 3) *low-risk* flood zone 4) I do not know the flood risks for my property
18. **How far do you think your property is from Manafwa River?** 1) less than 5 metres 2) 6–5 metres 3) 16–30 metres 4) 31–100 metres 5) 101–500 metres 6) 501 metres–1 kilometre 7) more than 1 kilometre

19. How much do you think the Manafwa River needs to rise above high tide to cause flood damage to your property? 1) less than 2 metres 2) 2.1–4 metres 3) 4.1–6 metres 4) 6.1–8 metres 5) 8.1–10 metres 6) 10.1–12 metres 7) 12.1–14 metres 8) more than 14.1 metres

20. I have lived in this property for——(years)

21. In regard to the house you live in, do you know if it has been flooded before?

1)Yes 2) No

22. When?

23. Do you have any knowledge of past Floods in the area? 1)Yes 2) No

24. Do you remember when the events happened?

25. What do you think were the causes of floods? (Tick all that apply)

- a. Prolonged precipitation
- b. Deforestation
- c. Poor farming methods
- d. Infrastructure development
- e. Others(specify).....

26. In your lifetime, are any of the following statements true about your experience with floods?

- A. A property of mine has been damaged in a flood in the last 1) 0–5years 2) 6–20years 3) 21–50years 4) more than 51years 5) never
- B. I or an immediate family member have been *physically injured* or *psychologically/emotionally affected* by a flood: 1) TRUE 2) FALSE
- C. I have experienced disruption to *my job* that prevented me from working or my *daily activities*: 1) TRUE 2) FALSE
- D. A friend, relative, neighbour, or co-worker I know personally has been injured in a flood: 1) TRUE 2) FALSE
- E. A house of a friend, relative, neighbour, or co-worker I know personally has been damaged in a flood: 1) TRUE 2) FALSE

27. To what extent are major floods a worry to you? Not a worry at all 1 2 3 4 5 An extreme worry

28. How likely do you think a major flood will happen in the future in the village where you currently reside? Extremely unlikely 1 2 3 4 5 Extremely likely

29. How often do you think a major flood will happen on average in the village where you currently reside? 1) never 2) once every 5 years 3) once every 20 years 4) once every 50 years 5) once every 100 hundred years 6) Other: every years

30. What is your estimate of your financial loss to a major flood damaging your property?

1. less than USHS100,000 2) USHS100,001–500,000 3) USHS500,001–1,000,000 4) More than USHS 1,000,000

31. If you decide not to take any effort that reduces flood damage, to what extent do you think your property is protected against a major flood? Not protected at all 1 2 3 4 5 Completely protected

32. If you decide not to take any effort that reduces flood damage, to what extent do you accept the risk of your property being damaged by a major flood? *Not accept the risk at all* 1 2 3 4 5 *Completely accept the risk*

33. To what extent do you agree with the following statements? I am not sure about taking any effort that reduces flood damage to my property myself because...

Not agree at all 1 2 3 4 5 Completely agree

- A. I have coped well with major flood events without taking any effort that reduces flood damage, so I will cope well with another one without taking any effort beforehand.....
- B. Major floods are too powerful, so there is nothing I can do to reduce damage to my property.....
- C. Major floods are natural events that cannot be accurately controlled or predicted, so I must learn how to quickly adapt to potential damages to my property.....

34. To what extent do you agree with the following statements? I am not sure about taking any effort that reduces flood damage to my property myself because...

Not agree at all 1 2 3 4 5 Completely agree

- A. The benefits of living in this property, as it is, are higher than the costs resulting from flood damage.....
- B. My religious beliefs protect me and my property.....
- C. I am emotionally attached to my property, land, or community, so I will take all the risks to continue living here.....
- D. My in- and out-house mobility will be affected if I take some efforts such as house raising.....

35. Who are the most vulnerable to floods in the area? 1) Children 2) men 3) women 4) elderly people 5) poor people 6) PWD 7) widows 8) married 9) single

36. What are the underlying causes of vulnerability to floods in the area? 1) Residing in flood prone area 2) poverty 3) Illiteracy 4) Age 5) Gender 6) ignorance about hazards 7) lack of alternative livelihood(s)

37. What are the impacts of floods in your area? 1) destruction of houses 2) injuries to people 3) loss of crops and livestock 4) destruction of farmland 5) destruction of infrastructure 6) death of people 7) diseases like cholera and malaria

38. To what extent do you agree with the following flood preparedness statements?

Not agree at all 1 2 3 4 5 Completely agree

- A. I am *psychologically/emotionally* prepared to cope with a flood event of any magnitude
- B. I am *financially* prepared to cope with a flood event of any magnitude

39. To what extent do you think it is... *Not at all 1 2 3 4 5 Completely*

- A. The government's responsibility to reduce flood damage to your property.....
- B. Your responsibility to reduce flood damage to your property.....
- C. NGOs responsibility to reduce flood damage to your property.....

40. What form of assistance have you ever received from Government after a flood event?

- 1) Food 2) Medical care 3) Tents 4) Relocation of settlements 5) Financial Aid 6) Nothing

41. What form of assistance have you ever received from NGOs after a flood event?

- 1) Food 2) Medical care 3) Tents 4) Relocation of settlements 5) Financial Aid 6) Nothing

42. To what extent do you agree with the following statements about land use planning? I support the creation of open areas that can naturally be inundated (floodplains) along the Manafwa River because... Not agree at all 1 2 3 4 5 completely agree

- A. Farming, recreation, and forests are better usage for floodplains.....
- B. Engineering structures such as dams allow development but these structures also increase the impacts of major floods if high volumes of water are quickly released.....
- C. These open areas work as 'buffer zones' that effectively reduce flood damage to my property.....

43. After experiencing flood damage, to what extent do you expect financial assistance from... Not expect at all 1 2 3 4 5 Greatly expect

- A. The government.....
- B. The community.....
- C. An NGO.....
- D. Relatives.....

44. To what extent do you agree with the following statements? I may take efforts to reduce flood damage to my property... Not agree at all 1 2 3 4 5 Completely agree

- A. To protect my property value.....
- B. To protect myself and my family.....
- C. To reduce my flood damage expenses.....

45. To what extent would you like to relocate (move out) from the location you currently reside? Do not like at all 1 2 3 4 5 Extremely like**46. Which of the following measures have you taken to reduce flood damage to your property?**

1. Installed flood barriers
2. Relocated to safer ground
3. Avoided cultivation on marginal land/steep slopes
4. Planting of trees
5. Terracing
6. None of them
7. Other measures I took.....

47. How many Neighbours do you know that have taken the following protection measures to reduce flood damage to their property? 1) 0 2) 1-2 3) 3-4 4) 5-10 5) more than 11 Neighbours

- A. Relocation.....
- B. Property improvements.....
- C. House raising.....
- D. 'Doing Nothing'.....
- E. Afforestation

48. To what extent do you believe the protection measures taken by Neighbours to reduce flood damage to their property are 'effective'? *Not effective at all* 1 2 3 4 5 *Completely effective*
- A. Relocation
 - B. Property Improvements.....
 - C. House Raising.....
 - D. 'Doing Nothing'.....
 - E. Afforestation
49. To what extent do you think that protection measures taken by Neighbours influence your decisions to take the following protection measures to reduce flood damage to your property? *Not influence at all* 1 2 3 4 5 *Completely influence*
- A. Relocation
 - B. Property Improvements.....
 - C. House Raising.....
 - D. 'Doing Nothing'.....
 - E. Afforestation.....
50. **How do you access weather forecast information?** 1=TV 2=radio 3= broadcasting systems 4= newspaper 5= internet 6= local authorities 7= neighbours 8= phone relatives
51. **Frequency of accessing weather forecast information** 1= every day 2= every week 3=1or 2 times a month 4= never
52. **Do you access the forecasting information about floods?** 2=No, 1=If yes,
53. **Whom do you get this flood forecasting information from?** 1=TV 2=radio 3 = broadcasting systems 4 = newspaper 5 = internet 6 = local authorities 7= neighbours 8= phone relatives.

Appendix B. Focus group checklist

1. Would you say that you are familiar with the condition of where you live? How would you characterize or describe the condition of these areas?
2. Have these areas been changing in recent years? Could you explain? Is the quality or condition of the area where you live important to you? Why or why not?
3. What are the major livelihood activities of your household?
4. Have you been affected by natural hazards? Could you mention the hazards in order of frequency?
5. How have you been affected by natural hazards?
6. Which hazards could affect the village in the future?
7. Have you taken steps to prepare for disasters/reduce risk?
8. When you hear the term 'flooding', what comes to mind? What does this term mean to you?
9. What are the causes of flooding in your area?
10. Does flooding affect you personally in any way? Please explain.
11. Are areas near your home affected by flooding? Could you explain?
12. What do you see as the most important risks associated with flooding in your area?
13. What in your view are the underlying causes of vulnerability to flooding in the district/community? Elaborate. Who are the most vulnerable?
14. How best can you handle the effects of flooding?
15. Do you have any coping or adaptation strategy towards flooding?
16. Do you receive any assistance in case of flooding? Who provides this assistance? What kind of assistance do you receive?
17. Do you receive any form of information about climate and disasters? Who provides this information? How often is this information provided?

18. Do you think your community has the necessary information and/or resources to be ready for flooding?
19. If not, what additional information and/or resources do you feel your community needs?
20. Who has the primary responsibility in reducing flood risk?
21. What are the main coping strategies if any, that people of the district/community employ during floods?
22. What are the options that might mitigate flood hazards in both short and long term in the district/community?
23. Have you taken steps to prepare for flood disasters/reduce flood risk? Mention the steps taken
24. Is there anything you can do to be more prepared in case a flood occurs?
25. Are you aware of any government programs to protect communities from flooding? If yes, could you explain them?
26. Do you think that the condition of your area might be affected by some of these protection efforts? Could you describe any of these effects?
27. Would you support government programs that protect communities from flooding, even if these programs were damaging to your livelihood activities?
28. Do you think it is possible for a government program to protect communities from flooding while also protecting their livelihood activities? Could you give some examples of how such programs might be able to do that? What kinds of programs would you support most? Why?
29. Would you favor programs that would limit development or other uses of private land in return for greater protection of the area? Why or why not?
30. Are there any other stakeholders that provide assistance in case of flooding? What kind of assistance do they provide?
31. How important do you believe is the involvement of your community in responding to flooding, with the assistance of other stakeholders?
32. What methods of warning your community, of the risk of a flood, would you suggest to be appropriate and/or effective?
33. What more do you think your community, as a group of individuals, could do, to minimize the impact of flooding incidents on you and others within your community?

Appendix C. Key informant interview guide

Core questions for key informant interviews

1.
 - a) Describe the nature of your agency's/community's involvement in floodplain and flood management, including any mandate or guidelines that dictate your involvement.
 - b) Also, staff hours and funds allocated to these issues if you have this information [targets values and areas of responsibility].
 - c) Describe how your agency works with local communities (with whom? frequency of meetings? barriers?)
2.
 - a) What is the process for making and influencing mitigation decisions from your point of view?
 - b) Who is involved? [targets actual decision-making processes]
3.
 - a) What is your perception of how vulnerable Basin communities are to flood?
 - b) What variables do you think most influence the level of vulnerability? [perception of vulnerability]
4.
 - a) Can you describe what you believe would be the ideal process for making mitigation decisions?
 - b) Do you plan to include other stakeholders/community residents?
 - c) And if so, how? [reflects values, perception of community capacities, and attitudes towards public participation in decision-making]
5.
 - a) What do you believe are the biggest barriers to sustainable floodplain management, and why?
 - b) How would you address these barriers? [reveals informants' perceptions of how to improve decision-making process and increase sustainability]
6. What means/mechanism does your agency/community use in determining whether a plan of action to reduce vulnerability should be supported, e.g. cost/benefit? [basis for the judgments; manifest values]
7.
 - a) What do you believe are the chief priorities of the communities affected by your flood (floodplain) management decisions?
 - b) How have you come to understand local values [communication of values]?
8. What types of ethical judgments, if any, have you felt required to make in addressing flood management issues in the Basin? [explicit exploration of values]

Core questions for key informant interviews

Additional questions (added post document analysis)

9. a) If you were to anticipate future changes to how mitigation is done in the Basin and particularly the role of communities/ residents in influencing mitigation actions relevant at a local level, what changes might those be?
b) Has your agency (or your role) experienced changes, and if so, what types?
c) What do you believe has been the cause (or at the source) of any changes?

Prompts:

e.g., expectations?

e.g., values?

e.g., litigation?

e.g., other?

e.g., education?
