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DOI
10.1016/j.envsci.2024.103852

Publication date
2024

Document Version
Final published version

Published in
Environmental Science and Policy

Citation (APA)
Chereni, S., Sliuzas, R. V., Flacke, J., & van Maarseveen, M. (2024). Influence of hazard-related and cognitive factors of households' flood risk perceptions in Kampala, Uganda. *Environmental Science and Policy*, *160*, Article 103852. https://doi.org/10.1016/j.envsci.2024.103852

Environmental Science and Policy 160 (2024) 103852

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

Influence of hazard-related and cognitive factors of households' flood risk perceptions in Kampala, Uganda

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ARTICLE INFO

Keywords:
Flood risk
Perception
Households
Factors

ABSTRACT

Understanding lay people's flood risk perceptions has become an essential component of flood risk management especially with respect to ascertaining possible responses both to risk situations and to government actions. However, different contextual factors determine how they respond, and little has been done in the African urban context to study flood risk perception trends. Using data from 612 household questionnaires, this paper documents the hazard-related and cognitive factors of flood risk perception (measured using perceived likelihood of flood-induced property damage, as the dependent variable) in 3 neighbourhoods of Kampala, Uganda. Correlation and ordinal regression analysis established a positive influence of flood experience on flood risk perception in 2 of the neighbourhoods. In contrast, it has a negative influence in the third neighbourhood, which also goes for existing mitigation measures. However, in the latter, flood-induced property damage and existing mitigation measures showed a positive influence. Additionally, flood-induced financial costs positively influence risk perception in two of the three neighborhoods. These differences are associated with case characteristics, including the widening of drainage channels and socio-economic characteristics, and partially confirm the findings from previous studies. The contextual trends provide insights to improve the application of the Protection Motivation Theory.

1. Introduction

Floods rank high among world disasters, kill thousands of people, and affect several millions yearly (CRED - Catholic University Leuven & UNISDR, 2017). Considering how lay people perceive the likelihood of such damage is an important component of (subjective) risk assessment which should be considered in flood risk management efforts. The urgency to effectively manage flood risk is increasing due to climate change and growing urbanization, resulting in more people being exposed globally (Adelekan and Asiyanbi, 2016a; Lwasa, 2010). This is more evident in the Global South, where urban population growth outpaces planned spatial development, and millions of people end up living in flood-risky informal settlements.

For some time, policymakers viewed flood risk from a realist approach, relying on its objective measurements and overriding lay people's views with those of experts. Consequently, its management was viewed as a pure engineering undertaking. Since the early 1980s, researchers and practitioners alike have learnt that engineering approaches alone are not enough in flood prevention and that residents' private resilience-building efforts are integral (Bubeck et al., 2012; Jasanoff, 1998; Osberghaus, 2015). The value of private mitigation measures springs from a growing understanding of residual risk - that the capacity of public mitigation infrastructure can be exceeded or they can fail, leading to the 'failed-levee effect' (Ludy and Kondolf, 2012a). Therefore the part of flood protection that comes from the people at risk can provide an additional layer of protection to reduce flood-related deaths and property losses in such situations (Barendrecht et al., 2017). Undervaluing vulnerable residents' contribution in flood risk mitigation efforts increases the possibility of mitigation failure or maladaptation (Ardaya et al., 2017; Slovic, 1987). It also amounts to an

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https://doi.org/10.1016/j.envsci.2024.103852
Received 12 November 2023; Received in revised form 18 June 2024; Accepted 25 July 2024
Available online 10 August 2024

opportunity cost, i.e., overlooking a key stakeholder group in resilience building.

However, lay people's risk perceptions are often different from expert judgements, and this often causes them to react unexpectedly (Houston et al., 2019; Jasanoff, 1998; Mitsushita et al., 2022; Rana and Routray, 2016; Rowe and Wright, 2001; Siegrist and Gutscher, 2006; Terpstra, 2011a). For example, they may perceive low flood risk and stop to self-protect when actually risk is increasing. Birchall and Kehler (2023) also established polarized perceptions of human agency on the environment across four Canadian districts. Therefore improved understanding of flood risk perceptions and their influencing factors can help policymakers to anticipate people's behavior, including their potential resilience building efforts (Morss et al., 2016). In seeking more understanding of people's perceptions of risk, it is crucial to also investigate how their risk perceptions and willingness to implement autonomous measures can be affected by the implementation of engineering solutions factoring contextual characteristics (Bempah & Oyhus, 2017; Terpstra, 2011). Accordingly, management of perceptions to better reflect the actual risk situation is paramount in the co-production of flood resilience. In line with this, a comprehensive risk management policy agenda that includes the management of risk perception has been set in many countries (Jasanoff, 1998)

The foregoing points to the need for integrated risk management approaches in order to build resilient communities. In doing so, the factors influencing risk perception must be well understood. While the influence of socio-economic factors on flood risk perception can easily be ascertained, that of hazard-related and cognitive factors is a bit complex because of its sensitivity to psychological and cultural contexts (Lechowska, 2021). We therefore, compare the influencing factors of risk perception in two informal settlements and one affluent neighbourhood in Kampala, Uganda. Within the auspices of the PMT, we modelled the influence of the distance from the drainage, extent of flooding, flood related property damage, flood-related financial loss, flood related health problems, willingness to mitigate, and flood information on households' perceptions about the likelihood of future flood-induced property damage.

2. Theory and past studies

2.1. Theoretical perspectives on risk perception

The understanding of risk perception has been guided by 2 paradigms – the constructivist paradigm and the rationalist paradigm (Birkholz et al., 2014; Lechowska, 2021). The constructivist paradigm provides that risk perception is a contextual issue that is shaped by socio-cultural factors like beliefs, norms, and values. Under this paradigm, three groups of theories stand out – Cultural Theory, Practice Theories, and Network theories. The Rationalist paradigm is based on the understanding that threats can induce a rational cognitive process in an individual, that determines protective behavior. Key theories in its ambit include the Limited Rationality Theory, The Limited Preferences Theory, The Psychometric approach, and the Protection Motivation Theory. Of all these theories, the cultural theory and the Protection Motivation Theory have been widely used, and of late the latter stands out and scholars are working to improve its formulation by incorporating concepts from other theories, and applying it in different contexts (Babcicky and Seebauer, 2019; Oakley et al., 2020), hence the motivation for this study.

2.2. The Protection Motivation Theory (PMT)

PMT originated from the Health Sciences (Rogers, 1975) with some roots in Expectancy-Value Theory. It associates motivation to adopt healthy behaviors with attitudinal change based on cognitive processes intervening fear appeals (Marikyan and Papagiannidis, 2023) PMT was later applied in disaster management (Ejeta et al., 2015) and it provides that individuals decide to self-protect or not to self-protect against disaster risk if they perceive it to be higher than what they can withstand (threat appraisal); if they are able to do something *(self-efficacy)*; and if the available protection choices are deemed effective and affordable *(response efficacy)*. Following Babcicky and Seebauer, (2019), we use part of a modified version of the PMT (Poussin et al., 2014) with hazard-related, cognitive, and socio-economic characteristics as potential drivers of flood risk perception, as the guiding framework for this study - Fig. 1 below.

Guided by the PMT, existing studies have revealed mixed directions of relationships between environmental and socio-psychological variables on the one hand, and flood risk perception on the other (Andráško et al., 2020; Bubeck et al., 2018; Grothmann and Patt, 2005; Kellens et al., 2011; Morss et al., 2016; Patel and Fatti, 2013; Raška, 2015a; Wachinger and Renn, 2010). However, scholars agree more on many of the variables. Although there is such a consensus on many of the variables, the degree of influence established is in many cases are low. Consequently, recent efforts have been directed at specific subcomponents of the PMT to draw detailed insights and improve the theoretical formulation itself (Babcicky and Seebauer, 2019a; Bubeck et al., 2018; Cannon et al., 2020; Seebauer & Babcicky, 2020), while some have documented changes in behaviour related to PMT components (Bubeck et al., 2023). The current study takes a leaf from some of these studies and provides detailed insights on flood hazard-related and cognitive factors of risk perception using cases from a sub-Saharan African urban context. In the modified PMT version, we focus on hazard related and cognitive concepts and their connection to perceived likelihood of flood-induced property damage as a dimension of flood risk perception (Fig. 1 above).

2.3. Flood risk perception

The conceptual boundaries of risk and risk perception are not crispy (Slovic, 1987; Bubeck et al., 2012; O'Neill et al., 2016) and "along with great diversity in conceptual definitions of perceived risk comes great variety in operational or measurement definitions of the concept." (Wolff et al., 2019, pp 2). Some common examples are: equating perceived risk to feelings of anxiety, fear, being nervous or worrying or equating perceived risk to perceived

Probability. Risk differs from hazard in that the latter is a threat to people and their valuables while the former is the degree of the latter (Buchenrieder et al., 2021). Thus, risk is the probability of destructive effects of a hazard.

Flood risk perception therefore, is the subjective judgement of both the probability and severity of impending floods on the one hand, and the perceived capacity to withstand their impact (Bubeck et al., 2012, Lechowska, 2018), and together with affect (fear), they form the 2 measurement levels of threat appraisal in the PMT (Babcicky and Seebauer, 2019). Some broaden the meaning to include perceptions about the causes of risk, especially where anthropogenic factors can easily be associated with flood risk (Vávra et al., 2017; Ziervogel et al., 2016). This direction of research is crucial because residents and government officials need to be on the same page regarding the influence of their actions on flooding and the responsibilities they should share in resilience building (Birchall and Kehler, 2023) However, for the purposes of this study, we focus on subjective judgement of the probability and severity of impending floods.

In line with the foregoing, guided by Slovic's (1987) model of risk and Raaijmakers et al.'s (2008) conceptualisation, Lechowska (2018) identified three elements characterizing flood risk perception in many of past studies - awareness, worry, and preparedness. Although the PMT formulation does not directly include these three components, they are comparable with other variables in its framework following Babcicky and Seebauer's (2019) exposition of the PMT components. For example, awareness i.e., knowledge of a hazard event and/or its trends, can be compared to perceived probability of a flood event in the future. Both

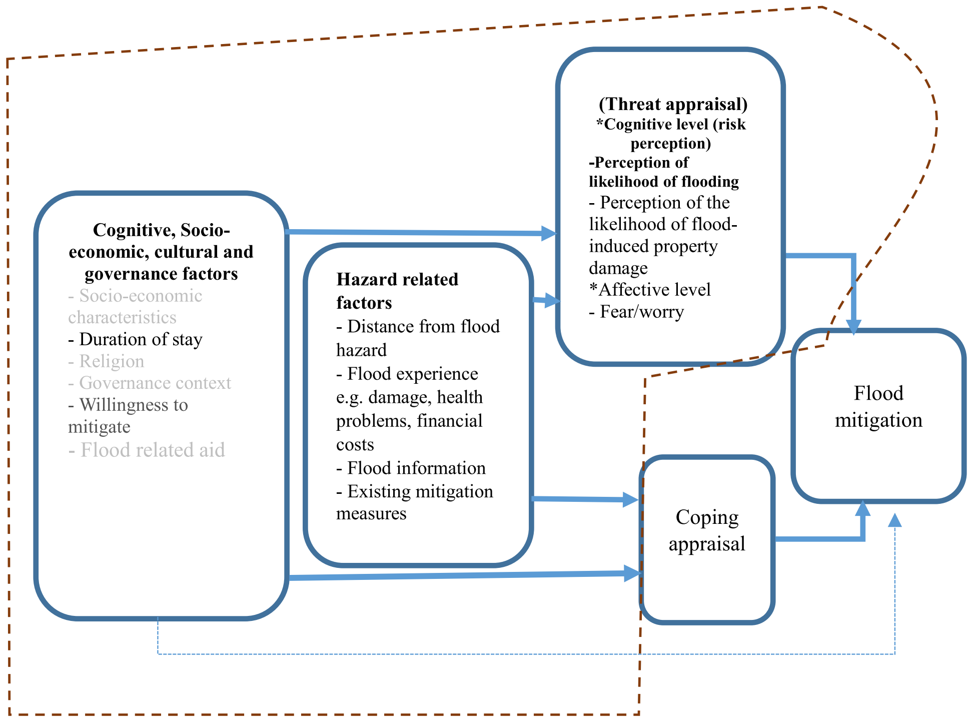

Fig. 1. Extended Protection Motivation Theory: the polygon with brown dashed borders indicates the concepts we focus on in this work. (adapted from Rogers, 1975).

are influenced by direct experience, age, gender, education, income, knowledge, and information dissemination (Botzen et al., 2015; Lechowska, 2018). Worry i.e., negative feelings about uncertain and undesirable events and situations (Rasool et al., 2022; Sjoberg, 1998), is comparable to fear. Studies that measure fear often ask respondents how worried they are about a potential disaster. However, in PMT formulation, fear is seen as an affective variable separate from risk perception – which is seen as cognitive, but both fall under threat appraisal (Babcicky and Seebauer, 2019). Preparedness is related to perceived likelihood of consequences that is usually measured under threat appraisal in the PMT (Bubeck et al., 2018). However, it is also related to the perceived ability to withstand/control the impacts of future flood events factoring existing measures already in place (Raaijmakers et al., 2008; Bubeck et al., 2012). Both are affected by direct experience, gender, and education.

Our conceptualization in the current work is inclined to Babcicky and Seebauer's (2019) conceptualization of risk. We capture risk perception by using perceived likelihood of flood-induced property damage as the dependent variable. This is partly in line with other studies, for example, de Wolf et al. (2024) use four measures of risk perception that include how worried participants "felt about the danger of a flood at their home and indicate their feelings of concern about the consequences of flooding," Pg 1307. Other scholars, for example, Liu et al. (2022) and Zabini et al. (2021) explain it as a composite variable that includes components of expected likelihood of a severe disaster and the perceived vulnerability of the respondent, and they measure it as a composite index. In our conceptualization, for a person to judge the likelihood of flood-induced property damage, they would have implicitly considered the likelihood of flood events in the future and their ability to withstand the potential impacts. We consider damage to property since flood-induced deaths are not many in this area.

2.4. Factors of flood risk perception

Past studies document mixed influences of proximity to a flood hazard, flood experience, flood damage, and flood information, on flood risk perception (see Table 1). However, in many cases, the relationships

Table 1
Summary of literature on risk perception factors.

Factor	Relationship with risk perception	Sources
Cognitive/behavioral		
Flood experience	Positive	(Botzen et al., 2009; Bradford et al., 2012; Grothmann and Reusswig, 2006a; Kellens, Zaalberg, Neutens, et al., 2011; Kreibich et al., 2007; Messner and Meyer, 2006; Raaijmakers et al., 2008b; Siegrist and Gutscher, 2006; Terpstra, 2011a; Wachinger et al., 2013; Kreibich et al., 2007; Miceli et al., 2008; Bubeck et al., 2023; Ullah et al. 2020; Bodoque et al., 2019)
Flood information	Positive	
	Negative	(Thieken et al. 2010; Miceli et al., 2008; Buchenrieder et al., 2021)
Implemented measure	Positive (marginal effect over time)	(Bubeck et al., 2023)
Property damage	Positive	(Cannon et al., 2020)
Willingness to mitigate	Positive	(Bienacki et al., 2009)
Knowledge	Mediating factor	(Kreibich et al., 2007; Miceli et al., 2008; Bienacki et al., 2009; Colten & Sumpter, 2009; Comănescu and Nedelea, 2016; Raaijmakers et al., 2008; Berman & Tyyskä, 2011; Boholm, 2011; Wachinger et al., 2013)
Geographical factors		
Proximity to hazard	Positive	(Lindell & Hwang, 2008; Miceli et al., 2008; O'Neill et al., 2016; Zhang et al., 2010; Ullah et al. 2020)
	Negative	(Colten & Sumpter, 2009; Qasim et al., 2015; Ali et al., 2022)
	None	(Kellens et al., 2011)

between predictor (explanatory) and outcome (dependent) variables are weak (Bubeck et al., 2013; Kellens et al., 2011; Thieken et al., 2010; Zaalberg et al., 2009).

Proximity to a hazard for example, was found to increase perceptions of the likelihood of serious damage or loss near Dublin City, Ireland, and in Khyber Pakhtunkhwa, Pakistan (O'Neill et al., 2016; Ullah et al., 2020). However, in some cases the opposite is true, for example, Ali et al., (2022) observed that people living in the zone closer to the Indus river had less fear compared to those who lived away from the river. The authors attribute this to a sense of safety likely brought about by embarkments on the river; and to the sample selection of those with past flood experience among those who lived away from the river. In the same vein, flood experience, flood-induced losses, past flood damage, and flood-related financial costs have been found to increase the perception of high risk through memories of past undesirable experiences related to a disaster (see Table 1 below), which is linked to fear (Reynaud et al., 2013). However a recent synthesis by Andráško et al. (2024) clarified how experiencing a flood is itself affected by other socio-economic factors and the flood extent. As a result, it can play a mediating role in risk perception models. Table 1 below summarises the findings about the influences of risk perception from past studies.

These differences in flood risk perceptions factors can be associated with contextual factors (Ullah et al., 2020) and their potential implications on the PMT applicability inspired this study. As already alluded to, flood risk perception falls within the flood threat appraisal component of the PMT. However, it is difficult to measure in quantitative terms and scholars have used multiple questions to measure it's various aspects (Houston et al., 2019; Kellens et al., 2013). Consequently, like in some previous studies, we use the perception of the likelihood of flood-induced property damage as its proxy.

2.5. Hypotheses

The following hypotheses therefore guided this study:

H1. . Experiencing a high extent of flood positively correlates with perceptions of high future flood risk

H2. . The shorter the distance from a flood hazard, the higher the perception of future flood risk

H3. . Having already implemented flood damage mitigation measures is associated with perceptions of low future flood-induced property damage.

H4. . Households that experienced flood-related property damage, flood-related financial loss, and flood-related health problems perceive higher likelihood of future flood damage respectively.

H5. . Households that received flood-related information have higher perceptions of future flood-induced property damage.

H6. . Households that are willing to spent on flood damage mitigation perceive high likelihood of future flood-induced property damage.

3. Materials and methods

3.1. The Kampala case

Kampala is the capital city of Uganda and one of Africa's rapidly growing cities (Vermeiren et al., 2012) with 1.9 million inhabitants (Aryampa et al., 2019). Its hilly terrain, coupled with the fast-growing urban footprint increases flash flood risk, especially in the city's many low-lying areas and marshes. Flash floods are therefore, prominent and they cause household property losses, waterborne diseases, and escalate maintenance costs for drainage and road networks (Lwasa, 2010). Although floods mostly affect low-lying areas, their cascading impact on health, transportation, livelihoods, and waste management affect the wider urban economy. As part of its efforts to improve service delivery, the City of Kampala implemented the Kampala Institutional reform and Infrastructural Development Program (KIIDP) in 2009 which resulted in governance rearrangements that in turn saw improvements in revenue collection. These funds, coupled with a World Bank loan resulted in improvements in the implementation of the Kampala Drainage Master Plan. Consequently, some primary drainage channels were widened and/or dredged, including the Nsooba-Lubigi primary drainage channel which passes through Bwaise III.

We purposively chose three neighborhoods within Kampala (Bwaise III, Nateete, and Ntinda) based on flood occurrence (Fig. 2) and socio-economic characteristics. Although all the case areas experience floods, they have different: levels of public adaptation measures; socio-economic characteristics; and geographical characteristics that we expected to generate different insights into the contextual determinants of risk perceptions (Table 2).

Bwaise III informal settlement developed in 1960 on a swamp and now covers about 19 ha. It falls under the Buganda Kingdom and is administered by The Buganda Land Board. The settlement has become the epicentre of informal development in the area. It has 5 administrative zones which are home to approximately 22,000 people (about 4000 households) in total. Most households are involved in informal activities like welding and vending, among other activities (ACTogether Uganda, n.d.). Bwaise III suffers from frequent flash floods for many years. Within the government's efforts to reduce floods, the Nsooba-Lubigi primary drainage that passes through the settlement was widened in 2013–2014. However, dredging it has proved difficult, leading to gradual siltation and recurrent flood risk. The widening of this drainage channel enabled us to establish implications of government flood mitigation measures on flood risk perception by comparing results for Bwaise III to those of Nateete, where such measures have not yet been undertaken.

Nateete is an informal settlement of about 45 ha which also experiences frequent flash floods. Eighty percent of the land is owned by the municipality while the remainder is privately owned. It is inhabited by approximately 45,000 people, constituting about 9000 households. The settlement has about 4000 structures, 25 % of which are residential, 63 % are mixed use, 11 % are business premises and 1 % other. It has several factories that attract a lot of urban migrants seeking jobs in the city (ACTogether, 2014)

Ntinda is an affluent suburb located in Nakawa Division which grew in the 1960s as a residential area for railway company workers (Chrysestom, 2012). It has grown into a suburban business district with industries, shops, wholesale activities (Maganda, 2012) including an affluent neighbourhood that accommodates rich politicians. Some low lying parts of the neighbourhood experience flash floods but not as severe as those in Bwaise III and Nateete.

3.2. Sampling strategies

As already alluded to, we used purposive sampling to select the three neighbourhoods. The cases were chosen because of the above-mentioned characteristics which allowed a comparative analysis of risk perceptions and their contributing factors. To choose housing units and households, we used systematic random sampling. The method entailed overlaying the topographic map of the area with a fishnet in ArcMap 10.1, and picking every house coinciding with a fishnet centroid of 100x100m (Chereni et al., (2020). In cases of multiple households per unit, only one – usually the first or readily available household was selected. In Ntinda and Nateete, we picked every 2nd and 3rd house in a row, respectively.

3.3. Data collection and analysis

3.3.1. Data collection

Using structured questionnaires (154 in Bwaise III, 248 in Nateete, and 210 in Ntinda) administered face to face (appendix 1) in August 2017, we generated data about socio-economic status, flood experience,

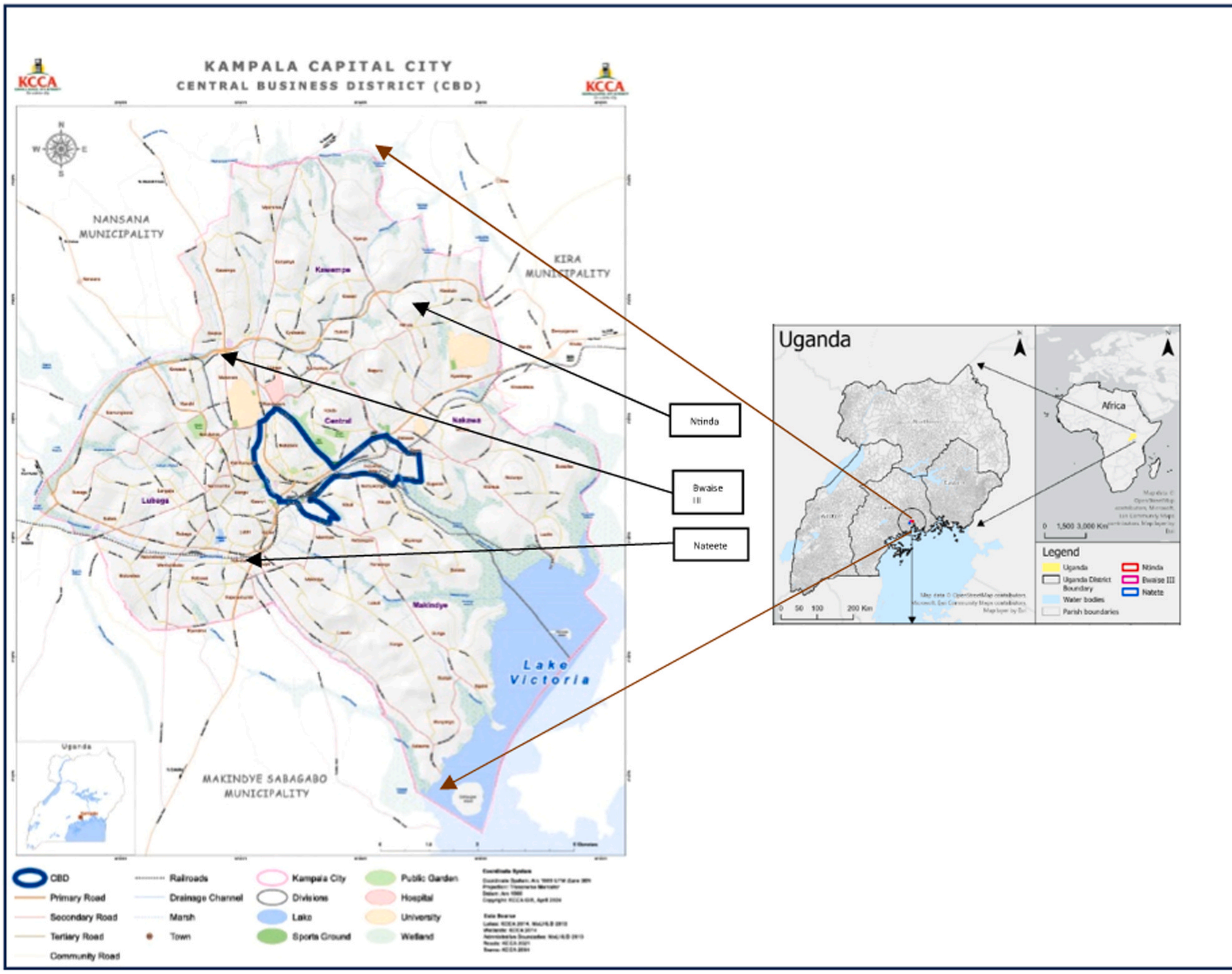

Fig. 2. Location of case study areas in Kampala.

and flood perception. Most questions where either binary or ordinal [four levels were used to avoid 'tempting' the respondents to just choose the average (Moors, 2008)]. The questions were also consistently bipolar to avoid potential negative/positive inclination in responses (Kamoen et al., 2013).

At the beginning of each data collection session, the assistants were randomly assigned to a route on a map where they would pick households for interviewing as explained before. Via a *WhatsApp* group, the Principal Investigator could reassign assistants to specific households depending on their preferred language to avoid inconsistencies that could arise due to language difficulties. During daily briefing and debriefing sessions, refinements to the data collection were made if required (Chereni, Sliuzas, and Flacke, 2020). In so doing, we reduced social desirability bias and loss of meaning which often arises where non-ethnic interviewers are used (Adida et al., 2016). Via transect walks and observations, flood-water marks on walls and the presence of flood mitigation measures were also noted.

3.3.2. Data analysis

We analysed questionnaire data in the Statistical Package for Social Sciences (SPSS) through which we first generated frequency tables and graphs. We also used cross-tabulations to examine the general distribution of the data in the respondent variable and the explanatory variables. Second, we performed correlation analysis (*Spearman's Rho*) among all the variables to identify potential multi-collinearity among explanatory variables and to highlight predictor variables which significantly correlated with the response variable for the subsequent analysis. No signs of potential multi-collinearity were identified (*i.e.,* no set of predictor variables had a correlation factor of 0.8 and above). Third, predictor variables that were significantly correlated with the perceived probability of flood induced property damage were further tested for multi-collinearity. None had a Variance Inflation Factor (VIF) of at least 10, and the Dublin Watson Statistics for all the models were between 1.7 and 2.1, which pointed to acceptable auto-correlation among the predictor variables.

To establish key factors of perceived likelihood of property damage, most of the existing studies used linear regression models despite the fact that a number of the variables are non-linear. In this study, we used Ordinal Logistic Regression (OLR) modelling to exploit its ability to track changes in the measured categories of variables to maximise variation explanatory capacity (Tutz, 2022). The formula for the Ordinal Logistic Regression is expressed:

$$Logit(p(\gamma \leq j)) = \beta_{jo} \quad - \alpha_1 x_1 - \ldots - \alpha_p x_p$$

Where: β_{jo} is the interception at the γ axis; α_1 is the regression coefficient ofx_n; and x_n are the explanatory variables.

Throughout the analysis, missing responses were treated as system-missing data, and cases with no valid answer per variable were removed from the analysis. As the socio-economic status of the population in each case study area is near-homogenous and has wide experience with floods, the removal of cases without valid entries per respective variable was deemed appropriate. This was confirmed by comparing means of socio-economic variables with estimates from

Table 2
Summary characteristics of the cases.

	Cases		
	Bwaise III	Nateete	Ntinda
Characteristics			
Type of neighbourhood	**Slum** (19 ha under The Buganda Kingdom) with MSMEs	**Mixed – planned high density** and **slum** (45 ha 80 % municipal land and 20 % private) with all business sizes)	**Affluent low** density (municipal land close to a big industrial area)
Year of establishment	1960	1900	1960
Population	22,000 (4000 households) (ACTogether Uganda, n.d.)	45,000 (9000 households) (ACTogether, 2014)	35,000 (KCCA, 2011)
Average household size (N)	5	5	3.6
Sample size (n)	154 households	248 households	210 households
Average Household size (own survey)	4.94 (one sample t-test: $p < 0.05$	3.93 (one sample t-test: $p < 0.05$	3.7 (one sample t-test: $p < 0.05$
Flood and damage experience	Many years of flooding and flood damage to property and loss of a few lives	Many years of flooding and flood damage to property and loss of a few lives	Not much flooding – floods in low lying parts. Other areas experience runoff
Widening of primary drainage and desilting of secondary channels	Yes in 2013–2014	No widening of primary channel and less desilting	No widening of primary channel and less desilting of secondary channels

settlement profiles done by ACTogether and Uganda Bureau of Statistics using one-sample t-tests (ACTogether, 2014; ACTogether Uganda, n.d.; Uganda Bureau of Statistics, 2017) as shown in Table 2.

4. Results

4.1. Descriptive statistics of risk perception determinants

Table 3 below shows frequencies of responses across the variable categories. In all the three neighbourhoods, more than 50 % of the respondents received flood-related information with a slightly higher figure in Bwaise III. However in all the neighbourhoods people do not show much initiative to look for the information themselves with over 80 % indicating that they do not look for it. More people are willing or highly willing to implement flood mitigation measures in Nateete (about 60 %) with Bwaise III recording the lowest percentage (about 43 %). Nateete also has the highest percentage of households that had implemented the 2 highest levels if mitigation in 2017 (about 77 %) followed by Bwaise III (about 71 %) with Ntinda trailing at about 42 %. This comes as no surprise, since the neighbourhood also recorded the highest number of respondents who suffered flood-induced property damage (about 60 %) compared to about 14 % for Bwaise III and about 10 % for Ntinda. Consequently, it has te highest number of people who incurred flood-induced financial costs and flood-related diseases (about 64 % and 49 % respectively) compared to Bwaise with about 20 % and 16 % respectively, and Ntinda with about 15 % and 13 % respectively. Nateete also experienced the highest percentage of people who experienced high to extremely high floods (about 28 %) compared to Bwaise III and Ntinda with about 9 % and about 22 % respectively. The neighbourhood also ties with Ntinda for households which earn UGX160 000 per month at 20 % with Bwaise III recording the lowest (about 6 %). In all the three cases, the respondents were largely female (over 60 %). In Nateete, more people lived within 200 m (97 %) from the drainage channel compared to 83 % and 36 % for Bwaise III and Nateete

Table 3
Response frequencies.

	Bwaise III		Nateete		Ntinda	
Variable	***N***	*%*	N	*%*	N	*%*
Received Information about floods?						
Yes	87	*56.5*	128	*51.6*	108	*51.4*
No	61	*39.6*	97	*39.1*	92	*43.8*
Missing	6	*3.9*	23	*9.3*	10	*4.8*
Looked for information about floods?						
Yes	16	*10.4*	36	*14.5*	29	*13.8*
No	132	*85.7*	203	*81.9*	179	*85.2*
Missing	6	*3.9*	3	*3.6*	2	*1*
Willing to implement mitigation measures?						
Not willing	66	*42.9*	64	*25.8*	76	*36.2*
Somewhat willing	13	*8.4*	22	*8.9*	12	*5.7*
Willing	10	*6.5*	23	*9.3*	11	*5.2*
Highly willing	57	*37.0*	128	*51.6*	101	*48.1*
Missing	8	*5.2*	11	*4.4*	10	*4.8*
Level of mitigation by 2017						
Nothing	14	*9.1*	11	*4.4*	36	*17.1*
Communitarian	8	*5.2*	4	*1.6*	8	*3.8*
Non-structural	2	*1.3*	10	*4.0*	1	*.5*
Structural level 1	11	*7.1*	9	*3.6*	30	*14.3*
Structural level 2	36	*23.4*	68	*27.4*	39	*18.6*
Structural Level 3	73	*47.4*	122	*49.2*	49	*23.3*
Missing	10	*6.5*	24	*9.7*	47	*22.4*
What is your perception about the likelihood of your household property getting damaged?						
No	55	*35.7*	38	*15.3*	129	*61.4*
Low	46	*29.9*	39	*15.7*	44	*21.0*
Medium	19	*12.3*	45	*18.1*	6	*2.9*
High	32	*20.8*	124	*50.0*	29	*13.8*
Missing	2	*1.3*	2	*0.8*	2	*1*
Did you incur flood-induced property damage?						
Yes	22	*14.3*	148	*59.7*	21	*10.0*
No	128	*83.1*	96	*38.7*	184	*87.6*
Missing	4	*2.6*	4	*1.6*	5	*2.4*
Did you incur flood-induced financial costs?						
Yes	30	*19.5*	159	*64.1*	32	*15.2*
No	118	*76.6*	84	*33.9*	173	*82.4*
Missing	6	*3.9*	5	*2.0*	5	*2.4*
Did you or a member of your household suffer from flood-related disease?						
Yes	25	*16.2*	122	*49.2*	28	*13.3*
No	124	*80.5*	122	*49.2*	178	*84.8*
Missing	5	*3.6*	4	*1.6*	4	*1.9*
Extent of flooding						
Low	22	*14.3*	58	*23.4*	17	*8.1*
Medium	14	*9.1*	78	*31.5*	17	*8.1*
High	5	*3.2*	60	*24.2*	6	*2.9*
Extremely high	1	*.6*	9	*3.6*	40	*19.0*
Missing	112	*72.7*	43	*17.3*	170	*81*
Income						
0–40 000 UGX	15	*9.7*	73	*29.4*	39	*18.6*
40,001–80,000 UGX	36	*23.4*	25	*10.1*	21	*10.0*
80,001–120,000 UGX	39	*25.3*	13	*5.2*	16	*7.6*
120,001–160,000 UGX	23	*14.9*	16	*6.5*	13	*6.2*
160,001–200,000 UGX	16	*10.4*	15	*6.0*	11	*5.2*
240,001–280,000UGX	1	*.6*	8	*3.2*	10	*4.8*
320,001–360,000 UGX	4	*2.6*	16	*6.5*	13	*6.2*
360,001 UGX and above	5	*3.2*	11	*4.4*	8	*3.8*
Missing	15	*9.7*	18	*17.3*	10	*4.8*
Gender						
Male	38	*24.7*	88	*35.5*	76	*36.2*
Female	115	*74.7*	153	*61.7*	133	*63.3*
Missing	1	*0.6*	7	*2.8*	1	*0.5*
Distance from the channel						
1–50 m	44	*28.6*	120	*48.4*	11	*5.2*
51–100 m	43	*27.9*	70	*28.2*	10	*4.8*
101–150 m	28	*18.2*	41	*16.5*	24	*11.4*

(*continued on next page*)

Table 3 (*continued*)

Variable	Bwaise III N	Bwaise III %	Nateete N	Nateete %	Ntinda N	Ntinda %
151–200 m	12	7.8	10	4.0	31	14.8
201–250 m	14	9.1	3	1.2	30	14.3
251–300 m	7	4.5	2	.8	23	11.0
351–400 m					18	8.6
401–450 m					12	5.7
451–50 m0					12	5.7
501–550 m					9	4.3
551–600 m					5	2.4
601–650 m					10	4.8
651 m and above					9	4.3
351–400 m					6	2.9

respectively.

Nateete has the highest perception of the likelihood of flood-induced property damage among the three cases (Fig. 3 below). Overall, 85 % of residents perceived some likelihood of damage compared to 64 % in Bwaise and 40 % in Ntinda. Moreover, about half of the respondents have a high expectation of flood-induced property damage compared with 20 % in Bwaise III, and 13 % in Ntinda. That residents of Nateete express higher likelihood of flood damage than those of Bwaise III is surprising given that the latter is often referred to as one of Kampala's flooding hotspots, but perhaps the recent drainage improvements in Bwaise have influenced resident perceptions.

4.2. Correlation of perceived factors and likelihood of flood-induced property damage

Generally, associations between predictor variables and perceived likelihood of flood-induced property damage are weak (Table 4).

Key observations are that Bwaise III had the lowest number of significant factors (4) followed by Nateete (5) and Ntinda (7). Flood-induced property damage, health problems, and financial costs are significant in all the three cases. Willingness to spend on mitigation is significant in Bwaise and Ntinda, while extent of flooding is significant in Nateete and Ntinda. Having received flood-related information are significant in Nateete only while monthly rent, distance from the drainage channel, and existing mitigation measures are significant in Ntinda only. Extent of flooding, flood-induced property damage, flood-induced health problems, and flood-induced financial costs have relatively stronger associations with perceptions of future flood-induced property damage.

That in all three cases, flood-induced property damage, health problems, and financial costs show significant negative relationships with the perceived likelihood of property damage is surprising. One would normally expect positive relationships. These unexpected results can be explained by the fact that households that had suffered such losses had often put up some protective measures against future losses. In each settlement, we found some correlation between mitigation actions and the perceived likelihood of flooding. In Bwaise III, households that had experienced health problems had constructed flood barriers with sandbags ($p < 0.05$) while those who suffered financial losses had rebuilt their houses or raised the floor ($p < 0.05$). Households in Nateete had put up flood barriers with sandbags ($p < 0.01$) while those in Ntinda that suffered health-related losses had constructed small dykes for protection ($p < 0.05$). Perhaps one of the most striking features of the other variables with significant correlations is their cross-case variability, for example, flood experience showing opposite correlations comparing Nateete and Ntinda.

4.3. Factors of the likelihood of future flood-induced property damage

The results of the ordinal regression models indicate weaker associations of the levels of individual predictor variables (factors), but a better overall explanation of the variation in the perceived likelihood of property damage compared to many existing studies. Table 5 below shows the model fitting outputs between explanatory variables and the perceived likelihood of property damage in the three case study areas.

The models fit the data ($p < 0.001$) in all three models from the three cases (Table 5 below) – the 'intercept-only model' (without predictors) is not equal to the final model (with predictors). With Chi Square deviance and Pearson goodness of fit tests producing non-significance values ($p > 0.05$), we fail to reject the null hypothesis (that there is no significant difference between the sample parameter and the expected value) and conclude that our models best fit the data. In the test of parallel lines, p values are greater than 0.05 for the three cases, suggesting that the ordered logit coefficients are unequal across the levels of the response categories. The Nagelkerke R Squared values suggest that the models

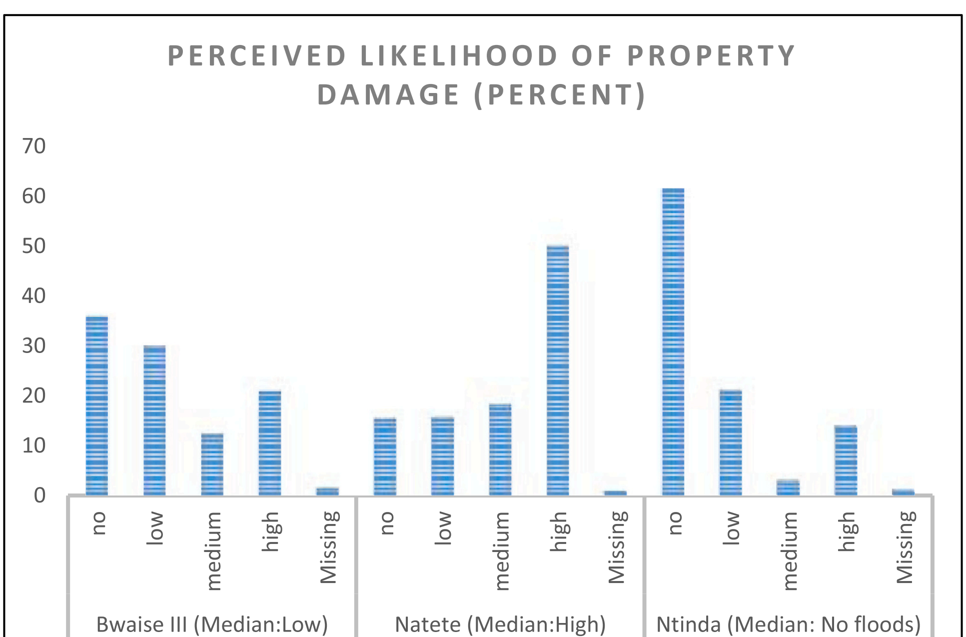

Fig. 3. Perception of the likelihood of property damage.

Table 4
Association between explanatory variables and perceived likelihood of property damage - Spearman's Rho.

	Bwaise III			Nateete			Ntinda		
Predictive variables	**Co-efficients**	**Sig.**	**n**	**Co-efficients**	**Sig.**	**n**	**Co-efficients**	**Sig.**	**n**
Extent of flooding	.046	*.658*	94	.505**	*.000*	205	−.5**	*.000*	*204*
Distance from channel	−.006	*.943*	149	−.009	*.883*	246	−.332**	*.000*	208
Existing mitigation measures	−.014	*.867*	142	−.071	*.293*	222	.219**	*.005*	162
Willingness to spend on mitigation	.249*	*.003*	144	.007	*.914*	237	.257**	*.000*	198
Looked for flood risk information	−.022	*.792*	146	−.063	*.330*	238	−.040	*.567*	206
Received information	.104	*.212*	146	−.169*	*.011*	224	−.030	*.673*	198
Flood-induced property damage	−.348**	*.000*	148	−.509**	*.000*	243	−.367**	*.000*	203
Flood-induced health problems	−.280**	*.001*	147	−.387**	*.000*	243	−.448**	*.000*	204
Flood-induced financial costs	−.375**	*.000*	146	−.534**	*.000*	242	−.540**	*.000*	203

NB: * means $p < 0.05$ and ** means $P < 0.001$

Table 5
Model fitness Information.

	Bwaise III model		Nateete model		Ntinda model	
Important variables	Variation	Significance	Variation	Significance	Variation	Significance
Model-fitting: Intercept only(final)	250 (197)	0.000	404 (317)	0.000	217(143)	0.000
Goodness of fit: Pearson (Deviance)	187 (156)	0.44	325 (276)	0.56	121 (107)	0.934
Nagelkerke R Square	0.37		0.4		0.46	
Test of Parallel lines: Null hypothesis (General model)	197 (172)	0.55	317 (281)	0.487	143 (129)	0.967

explain 37 %, 40 %, and 46 % of the variation in perceived likelihood of property damage in Bwaise, Nateete, and Ntinda, respectively.

Tables 6-8 below show the parameter estimates from the ordinal regression models for the three cases, including the proportional odds for changes in the response variable given the variation in the predictor variables. The proportional odds were calculated for orders which showed significant contributions in explaining the variation in the perception of the likelihood of flood-induced property damage by exponentiating the estimate [ordered log-odds (logit) regression co-efficients] in the third column. The model considers the last order to be the base category from which it begins to calculate whether the effect of changes in the orders are statistically significant from zero in estimating levels of perception of the likelihood of flood-induced property damage.

The general observation from the results is that in Bwaise III, flood experience, flood-induced property damage, willingness to spend on mitigation, and existing mitigation measures showed statistically significant influences on the perception of flood-induced property damage. In Nateete, flood-induced property damage, flood-induced financial costs, and distance from the drainage channel are important, and in Ntinda, flood experience and willingness to mitigate are important.

4.3.1. Influencing factors of perception of flood-induced property damage in Bwaise III

Table 6 below shows the ordinal regression model estimates and proportional odds of changes in the perception of likelihood of flood-induced property damage in response to changes in the levels of

Table 6
Parameter estimates and proportional odds for Bwaise III.

		Parameter Estimates						95 % Confidence Interval	
		Estimate	Std. Error	Wald statistic	df	Sig.	Proportional odds	Lower Bound	Upper Bound
Threshold	Likelihood of Property Damage (no)	−2026	,501	16,359	1	,000		−3008	−1044
	Likelihood of Property Damage (Low)	-,341	,463	,543	1	,461		−1250	,567
	Likelihood of Property Damage (Medium)	,456	,468	,949	1	,330		-,461	1373
Location	No flood Experience	−2337	,844	7675	1	,006	0.1	−3991	-,684
	1 year flood experience	-,783	,577	1844	1	,174		−1914	,347
	2 years flood experience	-,343	,525	,429	1	,513		−1372	,685
	3 years flood experience	0^a	.	.	0	.		.	.
	Suffered flood-induced property damage	1497	,615	5926	1	,015	4.5	,292	2702
	Suffered no flood-induced property damage	0^a	.	.	0	.		.	.
	Received flood information	-,619	,419	2184	1	,139		−1440	,202
	Did not receive flood information	0^a	.	.	0	.		.	.
	Not willing to spend on mitigation	−1080	,403	7185	1	,007	0.3	−1869	-,290
	Somewhat willing to spend on mitigation	−1706	,719	5627	1	,018	0.2	−3115	-,296
	Willing to spend on mitigation	,064	,793	,007	1	,935		−1489	1618
	Highly willing to spend on mitigation	0^a	.	.	0	.		.	.
	No mitigation done	1384	,641	4657	1	,031	4	,127	2640
	Involved in communitarian mitigation	,536	1,06	,256	1	,613		−1542	2615
	Implemented non-structural mitigation	−18,961	,000	.	1	.		−18,961	−18,961
	Implemented structural mitigation 1	−2009	,858	5487	1	,019	0.13	−3691	-,328
	Implemented structural mitigation 2	,423	,424	,998	1	,318		-,407	1254
	Implemented structural mitigation 3	0^a	.	.	0	.		.	.

Link function: Logit.
a. This parameter is set to zero because it is redundant.

Table 7
Parameter estimates and proportional odds for Nateete.

		Parameter Estimates							
		Estimate	Std. Error	Wald statistic	df	Sig.		95 % Confidence Interval	
							Proportional odds	Lower Bound	Upper Bound
Threshold	Likelihood of Property Damage (no)	−17,797	,869	419,6	1	,000		−19,500	−16,094
	Likelihood of Property Damage (Low)	−16,249	,872	347,1	1	,000		−17,958	−14,539
	Likelihood of Property Damage (Medium)	−14,902	,889	280,9	1	,000		−16,644	−13,159
Location	No flood Experience	−1050	,669	2,5	1	,116		−2362	,261
	1 year flood experience	-,401	,660	,37	1	,543		−1695	,892
	2 years flood experience	-,036	,584	,004	1	,950		−1181	1108
	3 years flood experience	0[a]	.	.	0	.		.	.
	Suffered flood-induced property damage	1099	,466	5,6	1	,018	3	,185	2013
	Suffered no flood-induced property damage	0[a]	.	.	0	.		.	.
	Incurred flood-induced financial costs	1681	,483	12,1	1	,001	5.4	,734	2628
	Did not Incur flood-induced financial costs	0[a]	.	.	0	.		.	.
	Received information	,341	,304	1,3	1	,261		-,254	,936
	Did not receive information	0[a]	.	.	0	.		.	.
	No mitigation done	1223	,695	3,1	1	,078		-,139	2585
	Involved in communitarian mitigation	1883	1428	1,7	1	,187		-,916	4682
	Implemented non-structural mitigation	,263	,763	,12	1	,730		−1233	1759
	Implemented structural mitigation 1	1672	,930	3,2	1	,072		-,151	3495
	Implemented structural mitigation 2	,448	,354	1,6	1	,207		-,247	1142
	Implemented structural mitigation 3	0[a]	.	.	0	.		.	.
	0–50 m	−17,350	,812	456,9	1	,000	3	−18,941	−15,759
	51–100 m]	−17,138	,830	426,0	1	,000	4	−18,766	−15,511
	101–150 m	−17,590	,859	419,8	1	,000	2.3	−19,272	−15,907
	151–200 m	−17,403	,000	.	1	.		−17,403	−17,403
	301–350 m	0[a]	.	.	0	.		.	.
	Not willing to spend on mitigation	-,180	,406	,196	1	,658		-,976	,617
	Somewhat willing to spend on mitigation	-,552	,513	1,16	1	,282		−1557	,454
	Willing to spend on mitigation	,862	,544	2,51	1	,113		-,205	1928
	Highly willing to spend on mitigation	0[a]	.	.	0	.		.	.

Link function: Logit.
a. This parameter is set to zero because it is redundant.

Table 8
Parameter estimates and proportional odds for Ntinda.

		Estimates							
		Estimate	Std. Error	Wald statistic	df	Sig.		95 % Confidence Interval	
							Proportional odds	Lower Bound	Upper Bound
Threshold	Likelihood of Property Damage (no)	-,619	,792	,611	1	,435		−2173	,934
	Likelihood of Property Damage (Low)	1774	,808	4821	1	,028		,191	3358
	Likelihood of Property Damage (Medium)	2474	,837	8727	1	,003		,832	4115
Location	No flood Experience	−2093	,751	7771	1	,005	0.12	−3565	-,622
	1 year flood experience	-,861	,801	1156	1	,282		−2431	,709
	2 years flood experience	,636	,737	,746	1	,388		-,808	2080
	3 years flood experience	0[a]	.	.	0	.		.	.
	Not willing to spend on mitigation	,109	,488	,050	1	,824		-,848	1066
	Somewhat willing to spend on mitigation	2140	,731	8566	1	,003	8.5	,707	3574
	Willing to spend on mitigation	1134	,843	1809	1	,179		-,519	2787
	Highly willing to spend on mitigation	0[a]	.	.	0	.		.	.
	No mitigation done	−1385	,736	3542	1	,060		−2828	,057
	Involved in communitarian mitigation	-,664	,837	,629	1	,428		−2305	,977
	Implemented non-structural mitigation	19,038	,000	.	1	.		19,038	19,038
	Implemented structural mitigation 1	-,071	,546	,017	1	,897		−1141	,999
	Implemented structural mitigation 2	-,657	,506	1684	1	,194		−1650	,335
	Implemented structural mitigation 3	0[a]	.	.	0	.		.	.
	[Experienced flood-induced health problems	1066	,727	2150	1	,143		-,359	2490
	Did not experience flood-induced health problems	0[a]	.	.	0	.		.	.
	Incurred flood-induced financial costs	,927	,741	1563	1	,211		-,526	2380
	Did not Incur flood-induced financial costs	0[a]	.	.	0	.		.	.

Link function logit.
a. This parameter is set to zero because it is redundant.

predictor variables for Bwaise III.

The table shows that households that have no ***flood experience*** are 0.1 times less likely to perceive high flood-induced property damage than those who experienced it for one year *($p < 0.05$)*. Households that experienced ***flood-induced property damage*** are almost 4.5 times (proportional odds column) more likely to perceive a high likelihood of future flood-induced property damage than those that did not *($p < 0.05$)*.

Existing mitigation measures also influence the perception of the likelihood of flood-induced property damage. Households that do not have/are not involved in any mitigation measure are 4 times more likely to perceive a higher likelihood of flood damage compared to those who participate in communitarian mitigation *($p < 0.05$)*. Households that have implemented level 1 structural measures are 0.13 times less likely to perceive a high likelihood of flood-induced property damage compared to households that have implemented level 2 structural measures *($p < 0.05$)*.

Willingness to spend on mitigation explains the variation in the perceived likelihood of flood-induced property damage in the lower levels of the variable scale. Households that were somewhat willing to mitigate were 0.2 times more likely to have a higher perceived likelihood of property damage than those that were willing ($p < 0.05$). Those that were not willing to mitigate were 0.3 times more likely to have a higher perceived likelihood of property damage than those that were somewhat willing ($p < 0.05$). Although having suffered from ***flood-related health problems*** was significantly correlated with the perception of the likelihood of flood-induced property damage, it was excluded from the model to reduce noise.

4.3.2. Influencing factors of flood-induced property damage in Nateete

Table 7 above illustrates that distance from the ***drainage channel, flood-induced property damage, and flood-induced financial costs*** are important predictors of perceived likelihood of property damage. In the proportional odds column, one can observe that households which ***experienced*** it were 3 times more likely to perceive higher likelihood of flood-induced property damage than those who had not ($p < 0.05$). Experiencing ***flood-induced financial loss*** was positively related to perception of likelihood of flood-induced property damage. Those who experienced it were 5.4 times more likely to perceive a high likelihood of flood-induced property damage than those who did not ($p < 0.05$). ***Proximity to the drainage channel*** negatively influences perceptions of likelihood of flood-induced property damage. Residents who live between 0 and 50 m, 51–100 m, and 101–150 m away from the drainage channel are 4 times, 3 times and 2.3 times less likely to perceive future flood-induced property damage compared to those who live 51–100 m, 101–150 m, and 151–200 m, respectively.

4.3.3. Influencing factors of perception of flood-induced property damage in Ntinda

Table 8 below illustrates the results introduced at the beginning of this section that in Ntinda, ***flood experience*** and ***willingness to mitigate*** are the key factors of perceived likelihood of flood-induced property damage.

One can observe that households that had no ***flood experience*** were 0.12 times more unlikely to perceive the occurrence of flood-induced property damage in the future compared to those who had experienced it for one year, *($p < 0.05$)*. The lack of significant effect in the higher levels of the variable suggests that an increase in flood experience above the one-year experience does little to nothing to increase perceptions of future flood-induced property damage. Regarding willingness to mitigate, those who are somewhat willing, are 8.5 times more likely to perceive the likelihood of flood-induced property damage than those who are willing *($p < 0.05$)*.

5. Discussion

Our findings have shown that residents of Nateete have the highest perception of the likelihood of flooding on average, followed by Bwaise III, and Ntinda respectively. One would expect Bwaise III to top the list given the history of flooding in the area. However, the widening of the Nsooba-Lubigi primary drainage which passes through the settlement can help to make sense out of the results, especially when one compares it with Nateete with almost similar characteristics, but had not benefited from the widening of the primary drainage which passes through it. This demonstrates how sensitive such communities can be to government actions which can potentially lead to a reduction in self-protective measures.

That we found generally weak associations between individual predictors and perceptions of likelihood of flood-induced property damage comes as no surprise given the trend in the PMT literature on flooding. In our case however, computing these associations in an ordinal regression model improved the predictive power of the variables. Nagelkerke R^2 values as high as 0.37, 0.42, and 0.46 for Bwaise III, Nateete, and Ntinda respectively, are generally high relative to what other scholars found elsewhere (Botzen et al., 2009; Rana et al., 2020). Regarding the factors of risk perception, there are both convergences and divergences between what we found and what other scholars found. We discuss these relationships below, paying attention to contextual differences of the cases.

Flood experience has a positive influence in Bwaise III but a negative one in Ntinda. Extent of flooding was found to be an important predictor for the perceived likelihood of property damage only in Nateete which also had the highest perception of the likelihood of flooding. This difference may be explained by the greater intensity of flooding in Nateete and its terrain physiography. Nateete has a more uneven terrain than Bwaise III and, since its primary drain had not yet been improved, its flooding experiences are more variable than those in Bwaise. However, although the improved primary drainage channel in Bwaise has reduced flooding in some parts, floods also occur due to overflowing secondary and tertiary drains and from rainwater accumulation on land parcels (Chereni, 2016).

The positive relationship we found between risk perception and flood extent of flooding confirms the first hypothesis, and is in line with studies in Belgium, Germany, the Netherlands, Greece, Brazil, and Switzerland (Ardaya et al., 2017; Botzen et al., 2015; Diakakis et al., 2018; Messner and Meyer, 2006; Raaijmakers et al., 2008; Wachinger et al., 2013). As a new finding related to extent of flooding, we further established that flood-induced financial costs are a key factor in Bwaise III, while for Ntinda, flood-induced property damage and willingness to mitigate are additional key factors. Results about the first 2 influences are in line with hypothesis 4 and the third confirms hypothesis 6. Bearing in mind that Bwaise III is an informal settlement with the majority low income earners, the finding on the influence of flood-induced financial costs helps us to understand that, for a threat that is less likely to kill to drive changes in risk perceptions among such communities, it has to be associated with draining their mearger financial resources.

The existence of a non-significant relationship between flood risk information and flood risk perception in our findings disagrees with hypothesis 5 and is different from what obtains in the consulted literature (Botzen et al., 2009; Bradford et al., 2012; Grothmann and Reusswig, 2006a; Kellens, Zaalberg, Neutens, et al., 2011; Kreibich et al., 2007; Messner and Meyer, 2006; Raaijmakers et al., 2008b; Siegrist and Gutscher, 2006; Terpstra, 2011a; Wachinger et al., 2013; Kreibich et al., 2007; Miceli et al., 2008; Bubeck et al., 2023), which established a positive relationship. In our study areas, there was no systematic provision of flood forecast information directly to the households, but only sensitisations through ad hoc fora when big storms are anticipated. At the settlement level, community organizations were trying to cover this gap but their activities were still incidental (Chereni, Sliuzas, Flacke, et al., 2020). Our findings show that the majority of people in Bwaise III and Nateete rely on neighbors and community leaders for flood-related information. One can hypothesize that these sources do not command enough authority to influence households' perception of the likelihood of flood damage.

Our findings on the influence of proximity to a hazard partly confirms and partly dispute hypothesis 2. The negative relationship between flood risk perception and distance from a hazard coincides with Qasim et al. (2015); and Colten and Sumpter (2009) who established negative influences of distance from a hazard on flood risk perception in Pakistan and New Orleans, respectively. However, it differs from those in (Ullah et al., 2020); Miceli, Sotgiu, and Settanni (2008); Zhang, Hwang, and Lindell (2010); and O'Neill et al. (2016), who established positive relationships between these two variables in Italy, Texas, and Europe, respectively, and Kellens, Zaalberg, Neutens, et al.'s 2011 finding in Belgium. Our finding of a negative relationship in Nateete can be explained by the fact that it is largely an informal settlement and those who settle near the drainage have stronger economic motivation (lower rents) which most likely outweighs perception of danger until the risk reaches a very high threshold.

Having implemented or being involved in implementing some flood mitigation measures is associated with low perception of risk in Bwaise III confirming hypothesis 3. On the case level, we established a higher perception of the likelihood of flood-induced property damage in Nateete where there has been little flood prevention and mitigation activity by the government compared to Bwaise, where much had been done. The finding suggests a growing trust in the government intervention in Bwaise, which confirms findings in the literature (Ali et al., 2022; Birkholz et al., 2014; Bubeck et al., 2013; Cutter et al., 2003; Grothmann and Reusswig, 2006b; Kellens, Zaalberg, Vanneuville, et al., 2011; Kousky and Kunreuther, 2009; Ludy and Kondolf, 2012; Raška, 2015b; Terpstra, 2011b; Wachinger et al., 2013). These dynamics are likely to cause a reduction in implementation of self-protective measures and require government authorities to conscientize residents of the need for continued implementation of such measures to provide redundancy.

5.1. Limitations of the study

Our conceptualisation of risk perception and research operationalisation can be viewed both as a strength and as a weakness. It digresses from the common method of building a risk perception index which in itself ensures comprehensiveness but can also pose problems if not constructed carefully (de Wolff et al., 2024). Although we make a contribution to the flood risk management knowledge pool, our study falls short like in most previous studies on behavioural approaches to risk management – what Kuhlicke et al. (2020) termed a knowledge limitation associated with a focus on the individual, which often results in low predictive power of the models.

5.2. Implications of the findings for the improvement of the Protection Motivation Theory

Three findings in Kampala are crucial for potential improvement of the PMT. First, researchers applying the PMT in food risk perception studies, especially in informal settlements in the Global South, should consider ways to quantitatively include place attachment in their models. At the moment the variable has largely been used qualitatively from a Cultural Theory perspective. Furthermore, our findings of lower perceptions of flood risk among residents who had more mitigation measures and those in an area where the local government had widened the primary drainage rekindles the need, as Kuhlicke et al. (2020) note, to consider feedback effects of adaptive measures on threat appraisal. Although Bubeck et al. (2012) found that a few studies which tested that relationship found no to small relationships, it will be good to do this in different contexts. This also links back to other early models of risk perception, for example, Slovic's (1987) model. In other words, as efforts to improve PMT application involves adding socio-economic variables, the effects of preparedness on risk perception or threat appraisal in general, should be seriously considered. In some way of speaking, the PMT should not be seen as a linear process, but as a cyclical process.

That these informal settlements are a default 'subsidy' on the cost of housing means that their perception of risk is affected by the potential benefit of very low housing costs when they choose to settle there. Therefore, by their nature, they are not risk averse and consequently they are likely to underestimate the risk. Second, the influence of the transient nature of informal settlements on risk perception changes should be investigated in panel studies to understand how the perceptions of those who fail to move to better places change. Furthermore, panel studies are crucial in line with the feedback effects discussed above.

6. Conclusions and areas for further research

This study sought to establish the hazard-related and cognitive factors of risk perception in three neighbourhoods of Kampala guided by six hypotheses related to the Protection Motivation Theory. On the backdrop of mixed results and low to moderate explanatory power of variables and models used in the literature, we improved the explanation of variation in risk perception. We conclude that although the extent of flooding is not an important predictor of the perceived likelihood of property damage, considering related factors such as flood-induced damage and flood-induced financial costs, one can conclude that residents in the three areas have some feeling of vulnerability to flooding impacts. However, where the government has taken significant flood mitigation actions, the perception of flood risk drops. This in turn may reduce households' willingness to invest directly in private flood mitigation measures. In terms of policy, and in light of the results of this study, the City Authority should try to make the experiences and costs already suffered by the residents more salient among these residents in order to encourage them to take private preparedness action.

In light of the mixed results with low levels of variance explained in the models, in the literature, and in our study (though with an improvement), further research must explore different research designs that include grounding of research on flood risk perception in different contexts and consider using different research approaches to unravel some context-specific trends that can enrich existing theoretical frameworks including the PMT. Moreover given that our ordinal regression models explained relatively higher variation in likelihood of flood-induced damage compared to what obtains in the literature, we recommend more explorative research to identify other categorical variables that can help explain more variation in flood risk perception. Additional variables/alternative approaches should include/involve considering the role of collective perceptions rather than focusing on the individual.

Declaration of funding

This research was funded by the Faculty of Geo-Information Science and Earth observation of The University of Twente through a Ph.D. fieldwork grant.

Declaration of Competing Interest

We declare that there are no other conflicts of interest related to this work, except that looking for reviewers from our affiliated institutions can result in picking reviewers who are familiar with our work.

Data availability

Data will be made available on request.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.envsci.2024.103852.

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