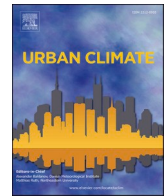




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Urban Climate

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

Households' socio-demographic characteristics, perceived and underestimated vulnerability to floods and related risk reduction in Ghana

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ARTICLE INFO

Keywords:

Floods
Vulnerability
Estimation
Perception
Household
Urban communities

ABSTRACT

There is a current upsurge of climate-related disasters globally with urban centres emerging as hotspots for climate risks such as floods, underlain by population growth and urbanization challenges. Yet, the literature on urban floods suggests limited estimates of “perceived vulnerability”, the latter increasingly gaining acceptance in climate change and disaster knowledge communities. Subsequently in this article, the effects of socio-demographic characteristics of households in underestimating their perceived vulnerability to flooding in Ghana is analysed, for informed flood disaster risk reduction. The findings show female headed households and those with college education as relatively more likely to underestimate their vulnerability to floods, compared to male headed households and those with no education, respectively. The age of male household heads determined their underestimation of floods yet the relationship was non-linear. Additionally, the perceived vulnerability of a household to floods and ability to estimate its status depends on the sex of household head, to potentially influence decision-making and choice of adaptation. In conclusion, differences in the effects of households' background characteristics on perceived vulnerability and capacity to estimate the outcome suggest context specific measures or social interventions in addressing attitudes towards floods disaster risk, and subsequently in formulating disaster risk reduction strategies and policy interventions.

1. Introduction

The Intergovernmental Panel on Climate Change (IPCC), has stated that urban climate change risks are on the increase (Field et al., 2014). Currently, more than half of the world's population are in cities and urban settlements, respectively (United Nations, 2018). This in no doubt increases the concentration of risk from climate change in urban landscapes, communities and subsequently, the households. The heightened pace of urbanization further provides favourable conditions for impacts of climate change to be felt more, especially in cities (Hallegatte et al., 2013; IPCC, 2014; Maheshwari et al., 2020; Ruth and Baklanov, 2012). Although the resources of urban areas as centres of development provides opportunity for resilience building, disaster risk reduction strategies have mostly failed

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<https://doi.org/10.1016/j.uclim.2020.100759>

Received 25 June 2020; Received in revised form 5 December 2020; Accepted 7 December 2020

Available online 26 December 2020

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to match development because of data paucity within the urban local governance system. The United Nations estimates that the 54.5% of people who lived in urban areas in 2016 will increase by over 9.0% by the year 2030, with the majority occupying low-elevation coastal areas (United Nations, 2016). Coastal urban communities are experiencing double exposures of increased occupancy of space and accelerated sea-level rise accompanied by elevated tidal inundation, accelerated erosion, rising water tables, and increase in storms and frequency of cyclones as a result of climate change (Balica et al., 2012; Douben, 2006; Dovie, 2017). Population influx into coastal urban communities will continue globally. Yet in sub-Saharan Africa, development and increased demand for services including shelter, solid waste management, drainage networks and associated infrastructure often do not commensurate with population growth (Dovie, 2015), and the resultant disruptive spatial planning are compounding floods in communities. Subsequently, the effects of climate change are felt most in urban areas because of the underlying pre-disposing conditions, aggravated further by lack of preparedness on the part of urban managers, politicians and the citizenry. Consequently, there is urgency for greater evidence-based awareness of climate change impacts (de Oliveira et al., 2020) and responses to urban floods, that reduce vulnerability, disasters and subsequently increase the resilience of communities and populations (Kelman, 2015). Although it is critical for flood risk managers to engage with the extant science to inform decisions, the scholarship on how differences in socio-demographic characteristics influences perceived vulnerability and risk of floods is inconsistent. This is particularly so, because, there is ample literature that shows that cognitive, affective, social and cultural factors all influence and interact in complex ways to reflect in household's perception of risk or how vulnerable they think there are to a climatic hazard (van der Linden, 2017). This notwithstanding, the understanding of social perception of change and its impacts is crucial as it does not only play a key role in socio-political context but influences the decisions of policymakers significantly (Antronico et al., 2020; Sullivan and White, 2019).

Unique characteristics of communities and households influence their perceived risk or vulnerability to hazards (Codjoe and Dovie, 2019). Generally, households, and population groups possess varying disaster preparedness strategies due to observed differences in their sociodemographic profiles (Kohn et al., 2012). For example, a study conducted in Hong Kong urban city found that the age, level of formal education and the religiosity of respondents were significant predictors of perceived susceptibility to disasters (Chan et al., 2016). Overall, the correct knowledge with respect to the causes, impact and solution to climate changes and its consequences increases with age. That notwithstanding there are misconceptions of both the causes and solutions to climatic hazards across all age groups (Lee et al., 2020). Gender has also been found to be significantly associated with risk perception in hazardous events (Brody et al., 2008). Other studies also revealed the lack of consistency or significant relationship between demographic factors such as education, age and income on climate risk perception (Brody et al., 2008; Milfont, 2012; Stevenson et al., 2014).

Thus, the interpretations of vulnerability are contextual and depend largely on disciplines, the affected and end-users. Whereas physical scientists will conceptualise the vulnerability of a place in terms of specific process and associated impact on the built environment (Closset et al., 2018; Papathoma-Köhle et al., 2011), social scientists define it within the limits of social protection to determine people's ability to cope with stressors (Blaikie et al., 2014). Succinctly, it is the interaction between the social attributes of communities/households and their biophysical environment that truly reveals how vulnerable people are to a hazard (Aksha et al., 2019).

Vulnerability to floods can be considered as the extent to which systems (community, households and/or individuals) across varying spaces are susceptible to flood due to exposure, a perturbation (sensitivity) in conjunction with their ability (adaptive capacity) to cope, and defining the capacity to be resilient, to cope, recover or adapt (Balica et al., 2012). "Perceived vulnerability" on the other hand is a public health concept and often used synonymously with perceived susceptibility, perceived likelihood, and perceived probability, used increasingly in other disciplines and recently for climate risk studies (Adzawla et al., 2020; Macusi et al., 2020). The underlining understanding of its use reveals an individual's belief about the possibility/ likelihood of a threat/problem occurring. According to the Health Belief Model, the greater one's perception of his/her vulnerability to a health problem, the more likely one will engage in any form of precautionary behaviour (Maiman and Becker, 1977). Thus, extending the boundaries of health to mean total general wellbeing rather than diseases only, enables the perceived vulnerability concept to be engaged in this study. The perceived vulnerability to floods from social lenses of populations mediate individual and collective realities of experiences and equally influence coping and adaptation options (van der Linden, 2015; Shakeela and Becken, 2013). The understanding of the factors influencing the perception of vulnerability with respect to flooding would contribute meaningfully to the development of effective strategies of communicating expected outcomes to affected populace (Lechowska, 2018).

As characteristic of many countries globally, over 50% of the Ghanaian population live in urban centers (Ghana Statistical Service, 2013), where the search for low-cost living including shelter by the vast majority of immigrants ends up in low-lying areas not suitable for human habitation because they are mostly prone to floods (Chiang, 2018). Whereas whole communities are exposed to floods, its impacts are expressed more at the household level hence the importance attached to tracking household perception in complementing that of a community. This is because of the differences in socio-demographic characteristics of households which do reflect in the varying effects of structural and non-structural measures to respond to floods (Twerefou et al., 2019). The above notwithstanding, there is a representational paucity on microlevel analyses (at the household level) of vulnerability within the sub-Saharan African context. Therefore, the perceived vulnerability of individuals and that of households is critical as it serves as a key factor in understanding and choosing adaptation strategies (Codjoe and Afuduo, 2015; Owusu et al., 2018). This notwithstanding, households would likely underestimate their vulnerability because it is mostly not quantified and interpreted as part of regular means of living. Underestimation of household vulnerability to flood is of particular interest in this study as opposed to several other studies because the failure to fully capture it undermines adaptive capacities in flood disaster risk reduction strategies and ultimately result in maladaptation. Like many countries, the Sendai DRR framework is yet to be fully operationalised in Ghana to take full advantage of the benefits it brings to development, and the poor understanding of urban flood dynamics make findings of this article timely and potentially imparting in applying science.

An important step to reducing losses and facilitating a culture of resilience building is to assess the extent to which communities and/or households are vulnerable to disasters such as floods (Cutter and Finch, 2008; Montz and Tobin, 2011). Consequently, it is also imperative to understand how households or individuals in urban areas perceive their vulnerability as this would likely reflect the social context in which floods are interpreted and adaptation measures taken (Kellens et al., 2011; Lechowska, 2018). Whereas many studies focus on standard estimation of vulnerabilities, it is important that the element of underestimation be accounted for because it will help strengthen our knowledge of perceived vulnerability of otherwise neglected but important dynamics. This divergence from established protocols for measuring perception is important as perception studies on urban climate and environmental issues has gained increased popularity in research (e.g. de Oliveira et al., 2020). Thus, this paper is aimed at analysing how households' perceived vulnerability to floods compare with computed flood vulnerability (using an index) and how the characteristics of households would likely influence underestimation of vulnerability in flood prone Accra Metropolitan Area in Ghana (Fig. 1).

2. Methodology

2.1. Study site description

Accra is located in the Accra Metropolitan Area of Ghana and as the national capital, it is the trade and commercial hub of Ghana's economy with large peri-urban areas fusing into Accra and occupying an approximate area of 114 km² with a total population of approximately 2 million (AMA, 2020). This region lies in the coastal savannah agroecological zone which has a bi-modal rainfall pattern with annual mean precipitation ranging from 790 mm on the coast to about 1270 mm in the extreme north. Since the inception of the city's expansion in the 1930s, Accra has faced flooding challenges owing to a myriad of causes. Besides the increase in erratic rainfalls in this region, factors contributing to floods in Accra include the low-lying nature of the land, massive population growth increasing the built physical structures preventing infiltration by impervious surfaces, poor and inadequate drainage system and poor waste management (Arnold and Gibbons, 1996; Asumadu-Sarkodie et al., 2015). The impact of floods in these places have been costly in terms of human mortality, properties and displacement (Asumadu-Sarkodie et al., 2015).

The study was conducted in two coastal communities in Accra, namely James Town and Agbogbloshie. The people in James Town are predominantly indigenous Ga, compared to Agbogbloshie which is a multi-ethnic migrant community set in a major market area. These neighbourhoods were chosen for two main reasons, (1) impact of climate change and variability on the coastline and effects on livelihoods (Codjoe et al., 2014) and (2) the locations characterised by rapid population growth with poor social amenities leading to severe social, economic and physical challenges, exacerbating the impact of climate change. Households in Agbogbloshie live

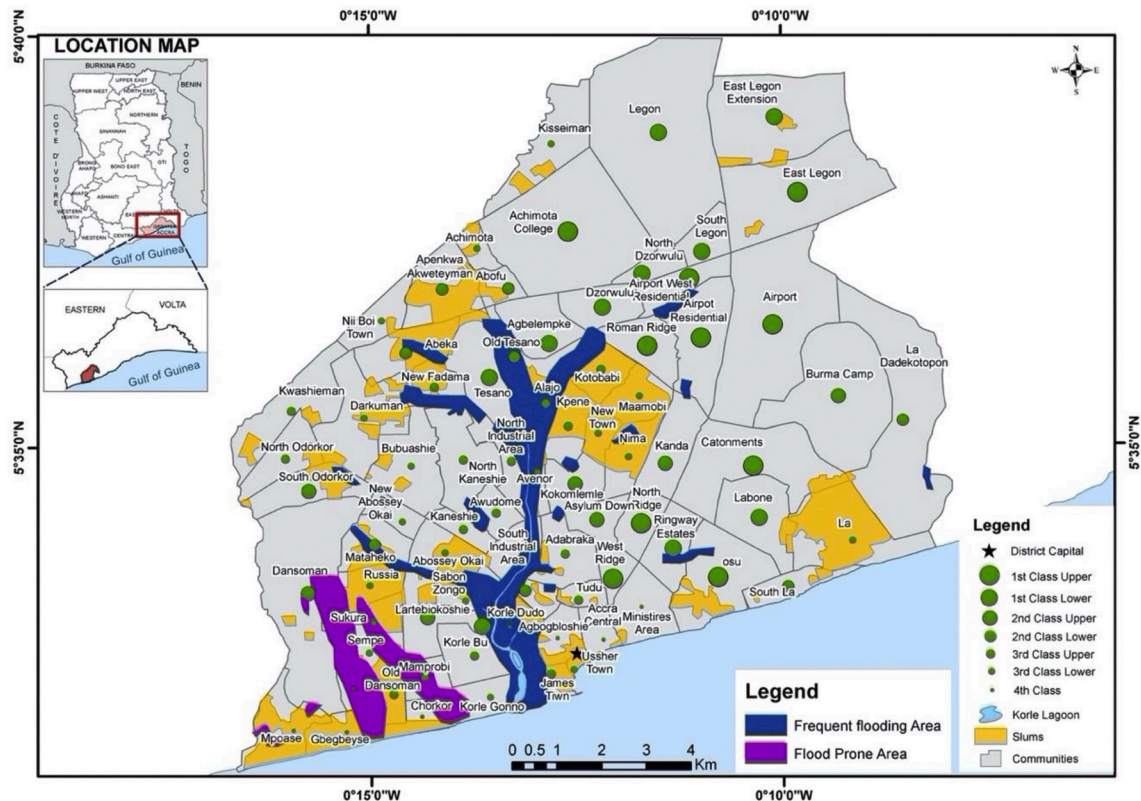


Fig. 1. Map of Accra showing the flood prone areas, slums and the socioeconomic status of locations.

primarily in kiosks and makeshift wooden houses with other occupying uncompleted buildings. Majority of the household structures in Agbogbloshie are without in-built basic amenities such as pipe-borne water, sanitation (bathrooms and toilet), and electricity (Codjoe et al., 2014).

2.2. Study design and sampling

This was a population-based cross-sectional study carried out in 2013, embedded in a larger project i.e. Climate Change Adaptation Research Training for Capacity (CCARTCD) Project conducted by the Regional Institute for Population Studies (RIPS), University of Ghana. This larger study, among other objectives sought to improve understanding of the impacts of climate change on health and food security among households in resource-poor coastal urban communities in Accra, Ghana. The current analysis presented in this paper is part of larger thesis “Household Vulnerability and Adaptation Options in Resource-Poor Communities in Accra, Ghana” (Christian, 2016).

Based on demarcated enumeration areas used for Ghana’s 2010 census data collection, the sampling frame involved a total of 13 enumeration areas systematically selected (8 in location 1 (James Town), 5 in location 2 (Agbogbloshie). Overall, 92 households in location 1 and 178 households in location 2 consented and were interviewed. Thus, a total of 270 households that were interviewed reflected a responds rate of approximately 90%. After a pre-test, and correction of field questionnaires, train field research assistants administered two set of questionnaires were administered, one at the household level (actual household or de facto heads) and the other at the individual level (household members who were eligible, i.e., 15–49 years old for females and 15–59 years old for males). A household is considered as a person or group of persons (i.e. related or not) usually living together in the same dwelling unit, who share same living arrangement and acknowledges one adult male or female as their head (ICF, 2020). The term household head defined as the person recognized by other household members as their head and usually lives with the rest of the household members (Beaman and Dillon, 2012). All eligible study respondents who signed or thumb-printed an informed consent form were interviewed. Interviews were conducted predominantly in Ga (which is the native language of the two communities) and Twi (another widely spoken local language) and occasionally in English.

Questions asked in the study survey included sociodemographic characteristics of individual and households and their experience with flash floods. Ethical approval for this study was granted by the Noguchi Memorial Institute for Medical Research - Institutional Review Board of the University of Ghana.

Table 1
Vulnerability Indictors for flooding in resource-poor coastal communities.

Major components	Minor components	Indicator	Survey questions	Sample reference	Effect on vulnerability
Adaptive capacity	Socio-demographic profile	Age	Age of Household (H) head	(Lechowska, 2018)	+
		Sex of HH head	Sex of H head: Female Head	(Steege et al., 2013)	+
		Education	Education level of H Head	(Muttarak and Lutz, 2014)	–
		Building material	Building materials of walls: Brick /cement	(Alam et al., 2015)	–
	Welfare /Being	Household want parameter	(Frijters and Van Praag, 1998)	+	
	Livelihood strategies	Employment status	Number of H members not employed H Head’s employment status	(Islam, 2018)	+
Sensitivity	Social Network	Social capital	H with no social linkage or support from friend and/or relatives	(Babcicky and Seebauer, 2017) (Adger, 2003)	+
			H cannot rely on receiving support		+
			Health	Access to health provision	The time one takes to the nearest hospital/ health
	Water and Sanitation	Diarrheal incidence	Reported cases over the past month members	(Ding et al., 2013)	+
			Malaria prone index	H with no windows covered with mosquito-proof screens/net	(Larsen et al., 2014)
		Water safety	H with no indoor pipe or improved water source	(Fedoroff et al., 2010)	+
			Water assess Sanitation	H without daily supply of water H without an improved toilet facility	(Smiley and Hambati, 2019)
	Food	Food security	HH did not have enough food to eat in a day or more over the past month	(Akukwe et al., 2020; Cutter, 2017)	+
Average number of full meals taken by H members				–	
Exposure	Climate variability	Flooding	H impacted by flood	(Abu et al., 2013)	+
			The degree to which H is affected by flooding		+

Source: Compiled by the Authors.

A positive (+) sign means an increase in a unit of the variable/indicator increases the vulnerability of a household to flood and a negative (–) sign means an increase in a unit of the variable/indicator decreases household or community vulnerability. Due to variations in the units for the various indicators of vulnerability, it was necessary for each measure to be standardized.

2.3. Computing a vulnerability index and its implication

Generally, there are concerns associated with the selection of indicators to compute a vulnerability index, yet considered fairly robust in nature and highly replicable (de Loyola Hummell et al., 2016). The utility of having a flood vulnerability index has been realised in many other contexts and across varied spatial scales (Guillard-Gonçalves et al., 2015; Siagian et al., 2014) but scarcely used at the household level. The contextualisation of a flood vulnerability index at the household level will contribute to our understanding of the variation between households regarding their vulnerability to flooding within resource-poor urban settings.

Based on the Intergovernmental Panel on Climate Change (IPCC) definition of vulnerability, we construct a household Livelihood Vulnerability Index (LVI) to floods as a function of their exposure, sensitivity and adaptive capacity (IPCC, 2007). This is intended to estimate the differential impact of flood on households in the study communities. This approach uses multiple indicators to assess household adaptive capacity, exposure and sensitivity. Taking a cue from Hahn et al. (2009) and a review of literature over a period close to two-decades, major components of the LVI identified were household Socio-Demographic Profile, Livelihood Strategies, Social Networks, Health, Food, Water, and Natural Disasters and Climate Variability. Indicators or proxies making up for the various major components of the LVI were grouped under household adaptive capacity, sensitivity and exposure (Table 1) Adaptive capacity: This is the characteristics of a household that modulates its ability to adapt. Following the theoretical underpinnings of several studies, the adaptive capacity is considered as a function of households' socio-demographic profile, livelihood strategies and social networks (Duy Can et al., 2013; Opiyo et al., 2014; Thanh Thi Pham et al., 2020). These are household characteristics that either strengthen or weaken their ability to self-protect and recover from floods.

2.3.1. Computation of household vulnerability index (LVI)

The steps used to compute a LVI are as follows:

Step 1: Given that the selected indicators have different units of measurement, first, there was the need to standardize the units. Standardisation of units was done based on the same principle employed for the development of the Human Development Index (Cooke et al., 2007).

$$index_{s,h} = \frac{S_h - S_{min}}{S_{max} - S_{min}} \quad (1)$$

where s_h represents original sub-components (i.e. indicators) for a household h , and s_{min} and s_{max} are the minimum and maximum values for that indicator for the households, respectively.

Step 2: The standardized values for the indicators are then averaged using Eq. (2) below to generate a value for the major components (i.e. Socio-Demographic Profile, Livelihood Strategies, Social Networks, Health, Food, Water, and Variability).

$$M_h = \frac{\sum_{i=1}^n index_{s,i}}{n} \quad (2)$$

where M_h represents one of the seven major components for a household h , $index_{s,i}$ is the sub-components, indexed by i . This makes up each major component. n represents the number of sub-components in each major component.

Step 3: An average of the value for the seven major components (using Eq. 3) is then computed as the household LVI.

$$LVI_h = \frac{\sum_{i=1}^7 w_{mi} M_{hi}}{\sum_{i=1}^7 w_{mi}} \quad (3)$$

LVI_h represents household Livelihood Vulnerability Index and W_{Mi} the weighted average of the seven major components. Based on score generated LVI values were categorized into quartiles; low (1 = 0.211 -to 0.291), medium (2 = 0.292 to 0.367), high (3 = 0.041 -to 0.210) and very high (4 = 0.368 -to 0.623).

2.3.2. Perceived vulnerability

Households' Perceived vulnerability (HPV) was determined by asking household how they perceived their own household vulnerability to excessive rainfall and flood in their communities. Below are the responses given by household and allocated scores: Household not vulnerable / with low vulnerability (score = 1), household somewhat vulnerable / medium vulnerability (score = 2), household is vulnerable / high vulnerability (score = 3), and Household is very vulnerable (score = 4).

2.3.3. Comparing perceived vulnerability with computed vulnerability

The perceived vulnerability of households to flooding is compared to the computed household vulnerability index to determine whether a household underestimates their vulnerability to floods or otherwise. Taking the computed LVI (1 = Low, 2 = Medium, 3 = High, 4 = Very High) as the reference, the difference between the HPV (1 = Low, 2 = Medium, 3 = High, 4 = Very High) and LVI (i.e. LVI - HPV) was computed as used to categories households that: (CE) rightly estimates their vulnerability, (OE) Overestimates their vulnerability and (UE) Underestimates their vulnerability (Table 2).

2.3.4. Empirical model

The choice of the LVI as our reference or "standard" in determining households that underestimate their vulnerability is based on

the fact that an individual's perceived vulnerability to climatic hazard such as floods is (1) limited to their interests, observations information and available technology all of which are very subjective, (2) perceived vulnerability or risk would likely omit critical biophysical, sociodemographic and economic characteristic of the individuals in question and that of the place he/she lives, and (3) perceived vulnerability is influenced by past experience of floods, which may be misleading when considering present and future harms by the climatic (De Bruin and Wong-Parodi, 2014) and finally (4) the uncertainty of climatic hazards in recent times increasingly makes communities and individuals unable to perceive accurately upcoming hazards or their consequences (Rakib et al., 2017a). Thus, individual's and community's response dealing with flooding and disaster management are approached very differently by different people. A computed vulnerability index by experts on the other hand, makes a deliberate attempt to utilize scientific information with respect to flood hazards and risk ensuring to maximize effective flood protection (Messner and Meyer, 2007).

2.3.4.1. Estimation technique. Logit regression is estimated to investigate possible determinants of household heads underestimating their household vulnerability to floods.

The household underestimating flood vulnerability (UV_h) equation, is equivalent to the equation below, is specified as:

$$UV_h = f_x(\text{Household head's Edu, MS, Employ, Mar, Age, Age}^2)$$

The dependent variable is binary (UV_h); takes the value 1 if the household head underestimates household vulnerability to floods and 0 if otherwise. The explanatory variables were formal education (*Edu*), migration status (*MS*) employment status (*Employ*), marital status (*Mar*) and age (*Age*) of the household head. The addition of the age squared (Age^2) to the equation permits the modelling of the effect of the differing ages, rather than assuming the effect to be linear for all ages. All explanatory variables except for the age of the household head were entered as binary variables. Although targeting female-headed households with the aim of reducing poverty remains admittedly female-headed households are likely to face or have faced some elements of gender discrimination relating to earnings, rights, and economic opportunities. This assertion is corroborated by the comparison of some key demographic indicators in the study area by the sex of the household head. For example, in this study population a greater proportion of male household heads were engaged in an income generating activity compared to their female counterparts (84.6% vs 71.9%; $P \geq 0.001$), also a greater proportion of male heads had at least secondary education compared to female heads (77.2% vs. 53.7%; $P \geq 0.001$). Thus, considering the significant gender differences and interest in gendered vulnerability, we explored the different predictors of underestimating vulnerability to flooding in male headed households and female headed household separately.

3. Results

3.1. Overall households characteristics and estimates of vulnerability

Less than half (43.6%) of the households were headed by females (Table 3). A significantly greater proportion of female headed households underestimated their vulnerability compared to their male counterparts ($P < 0.001$).

Approximately 70% of the respondents had at least secondary school education (College Level). More respondents with at least secondary school (college level) education did not underestimate their vulnerability compared to the other levels of education that underestimated their vulnerability to floods (75.7% vs. 58.3% respectively; $p < 0.05$). In addition, a greater proportion of household heads that were not employed underestimated their household vulnerability compared to the employed (89.3% vs. 67.6 respectively; $p < 0.001$). The mean age of household heads was higher for those who underestimate their vulnerability compared to those who did not underestimate their vulnerability ($P < 0.001$).

3.2. Household predictors of underestimation of vulnerability

Table 4 shows the regression result of the predictors of underestimation of household vulnerability to floods. The Table shows

Table 2
Categorisation of households underestimating their vulnerability Levels.

LVI ^a	HPV ^b				Difference in vulnerability estimates (LVI-HPV)				
		Low	Medium	High	Very high				
	X	a	B	C	d	X-a	X-b	X-c	X-d
Low	1	1	2	3	4	0	-1	-2	-3
Medium	2	1	2	3	4	1	0	-1	-2
High	3	1	2	3	4	2	1	0	-1
Very High	4	1	2	3	4	3	2	1	0

Estimated vulnerability (EV = LVI-HPV e.g. X-a).

OE {-1, -2, -3} implies overestimation of perceived vulnerability.

UE {1, 2, and 3} implies an underestimation of vulnerability.

CE {0} implies correctly estimates vulnerability.

^a Computed vulnerability score.

^b Household perceived vulnerability score.

Table 3
Sociodemographic characteristics of respondents by estimation of household vulnerability^a.

Household (H) characteristics	Total		Estimation of vulnerability		<i>p</i> -value	
			Underestimation	Not-underestimating ²		
Household head						
Female head	43.6	(92)	59.3	(64)	27.2 (28)	<0.001
Formal education						
No education	16.1	(34)	20.4	(22)	11.6 (12)	0.027
Primary education	17.1	(36)	21.3	(23)	12.6 (13)	
Secondary and above	66.8	(141)	58.3	(63)	75.7 (78)	
Migration status of head						
Non-Migrant	35.1	(74)	36.1	(39)	34.0 (35)	0.746
Migrant	64.9	(137)	63.9	(69)	66.0 (68)	
Employment status						
Not Employed	21.8	(46)	32.4	(35)	10.7 (11)	<0.001
Employed	78.2	(165)	67.6	(73)	89.3 (92)	
Religion						
Christianity	75.4	(159)	75.9	(82)	74.8 (77)	0.348
Islam	15.6	(33)	17.6	(19)	13.6 (14)	
Other	9.0	(19)	6.5	(7)	11.6 (12)	
Marital status						
Not married	50.7	(107)	55.6	(60)	45.6 (47)	0.149
Married /living together	49.3	(104)	44.4	(48)	54.4 (56)	
Age of household head (yrs.)	44.6 ± 16.3		48.7 ± 18.9		41.6 ± 11.3	<0.001

^a values represent percentage (number) and mean ± standard deviation ²Households that either correctly ranked their vulnerability to flooding equal to their computed vulnerability and households that ranked themselves to more vulnerable than their computed vulnerability.

results of three different models (1) All households (2) Females headed households only (3) Male headed households only.

In the overall (Model 1- Both male and female headed households), Significantly, female headed households were more likely to underestimate their vulnerability to floods compared to their male counterparts. A quadratic relationship (signifying a U-shaped relationship) was found between the age of household head and underestimation of vulnerability. Employment status, migration status and marriage status of the household head did not influence their underestimating of vulnerability to floods in the overall model.

Female headed household only (Model 2): The results show that among female household heads, those married were more likely to underestimate their vulnerability compared to their unmarried counterparts. Also employed female household heads were shown to be significantly less likely to underestimate their vulnerability. Compared to non-migrants, migrants' female heads were more likely to underestimate their vulnerability to floods.

Male headed household only (Model 3): Migrants male household heads were less likely to underestimate their vulnerability

Table 4
Logit regression of determinants of household underestimating their vulnerability.

Explanatory variables	All households		Female Headed Households		Male headed households		
	Coef.	SE	Coef.	SE	Coef.	SE	
Sex of household head							
Female head (=1, 0 otherwise)	1.324	0.375	***				
Marital Status							
Married /living together (=1, 0 otherwise).	0.404	0.349	1.434	0.715	**	0.512 0.505	
Employment status of household head							
Head employed (=1, 0 otherwise)	-0.771	0.445	-1.799	0.817	**	-0.427 0.678	
Migration Status							
Migrant	8.81 × 10 ⁻⁵	0.344	1.819	0.689	**	-1.063 0.482	**
Age of household head							
Age in years (AG)	-0.263	0.001	**	-0.117 0.116		-0.451 0.136	***
AG ²	0.003	0.001	***	-0.002 0.001		0.005 0.001	***
Formal education of household head							
No education: Ref							
Primary education (=1, 0 otherwise)	0.832	0.620	0.932	0.867		2.302 1.075	**
≥Secondary education (=1, 0 otherwise)	0.194	0.517	1.450	0.763		0.195 0.920	
Religion							
Traditional/Spiritualist/No religion: Ref							
Christians	0.545	0.611	0.864	1.099		0.671 0.739	
Moslems	1.200	0.689	*	3.415	**	1.039 0.844	
Pseudo R ²	0.192			0.247		0.213	
Prob > chi2	>0.001			0.001		0.0001	
Number of observations	211			92		119	

Asterisks indicate significant levels: ** implies significant at 5%; *** implies significant at 1%.

compared to non-migrants. While the age of the household head was not a significant predictor of underestimating vulnerability among female household heads, it showed to be a significant predictor of underestimating vulnerability with a U-shape relationship among male household heads. Considering the coefficients of the age variable and the square of age, a turning point of 45 years was calculated. This implies that with increasing age, male heads were less likely to underestimate their household vulnerability to floods until after 45 years. After the age of 45, male household heads were more likely to underestimate their vulnerability. Male household heads with primary education were more likely to underestimate their vulnerability compared to those with no formal education.

4. Discussion

The major goal of this study was to analyze the determinants of households' underestimation of their vulnerability to floods, using the concept of "perceived vulnerability", which is emerging in climate risk studies beyond the public health that it is known for. The study showed that the gender, age, formal education and religious affiliation of the household head determines whether or not the vulnerability of a particular household to floods will be underestimated. From the standpoint of flood risk perception, Wachinger et al. (2013) posited four main factors that influence risk perception that in turn affect how households perceived their vulnerability during natural hazards. These are "Personal, Risk, Contextual and Informational" factors. This current study directly buttresses the influence of some of the personal factors – e.g., age, religion, gender- in modulating risk perception and vulnerability suggested by Wachinger et al. (2013). For example, compared to households headed by males, female headed households in this study underestimate their vulnerabilities to floods. These are, however, not in synchrony with often reported disproportionate exposure to social and household vices such as violence, lack of shelter and lack of adequate drinking water and food that women face during flooding (Rakib et al., 2017b). Gender is a social variable that interacts with other socio-economic and demographic factors to influence individual's capacity to adapt and reduce the effects of climate change (Ahmed et al., 2016; Below et al., 2012). Thus, in order to decipher reasons for gender difference observed in a complex phenomenon such as vulnerability to floods, one needs to consider the differential sensitivity and adaptive capacity of individuals and households to the climatic risk. Specific traits such as limited access to protective social networks or other coping strategies of female-headed households were identified as reasons for their vulnerability during floods (Flatø et al., 2017). In this study, the proportion of female household heads reporting that they can rely on support from relatives and friends was significantly more than the proportion of males relying on support from relatives and friends. Consequently, the female heads underestimated their vulnerability based on an increased possibility of receiving help during floods, leading them to slowly respond to floods.

Given that some personal characteristics such as level of formal education identified in the study affect the source and level of information (informational factors), this study concurs to potential effect of informational factors. The level of education of a household head was important in determining whether vulnerability was underestimated or not. Earlier studies have shown education to be a key social and economic factor in reducing vulnerability to natural disasters (Evariste et al., 2018; Striessnig et al., 2013). A minimum of college education, particularly among female headed households would enhance coping strategies in the aftermath of a natural disaster. This observation is underlain by the greater flexibility and less flood-sensitive income generating activities pursued by educated female household heads compared to their counterparts who are less competitive in education (Muttarak and Lutz, 2014). Lower education affects women's ability to diversify their livelihoods and/or increase their resilience to climatic shocks such as floods. The relatively lowly educated women turn to engage in petty trading and other livelihoods in their communities impacted by the floods (Owusu, 2017). An increase in the quality of female education enhances their "green skills" that increases both their resilience and adaptive capacity, and prepares them to participate in some jobs that are traditionally dominated by males (Kwauk and Braga, 2017). The combined effects of age and gender of a household head also played a crucial role in underestimating vulnerability to floods. Male headed households were less likely to underestimate their vulnerability to floods until they reach the age of 45, then begin to be more likely to underestimate their vulnerability. Thus, older ages (beyond 45 years) was associated with underestimating of vulnerability. Similarly studies conducted in the United States reveal that older adults are often poorly prepared for disasters because they paid less attention to an emergency, adequate information on preparedness, and therefore unable to sufficiently backup supply of water, food, or medicine (Al-Rousan et al., 2014). Similarly, their longer – term experiences of disasters were more likely to be confused with their normal living conditions than for an emerging threat. However, to have an experience or more experience with a climatic hazard, such as floods, is often subject to the attention that one gives to what is happening to his/her environment (Iturriza et al., 2020).

The socio-demographic literature on disasters emphasise the role of religion (Haq and Ahmed, 2017), perceived among some as acts of God, thus leads to fatalistic attitudes towards disaster risk reduction (Ayebe-Karlsson, 2020; Chester and Duncan, 2012; Muttarak, 2017). Thus, place attachment apart from economics and cultural factors have seen religion playing key roles in defining how populations manage their exposures hence will likely determine how they estimate vulnerabilities (Chester and Duncan, 2012). A contextual factor identified to influence the perceived risk and in turn whether or not households underestimate their vulnerability or not in this study was their migration status. Being male or female migrant household head had different effect on how vulnerability to flood was estimated. Hence, the differential effect of migrant's gender and their estimation of vulnerability need to be explored more qualitatively.

When discussing flood-risks adaptation within the Protection Motivation Theory (PMT), households' assessment of threats to natural disasters by their perceived probability or perceived consequence of the occurrence combined with their ability to cope and/or avert being harmed (Schwarzer, 2014; Twerefou et al., 2019). Consequently, there is the need for studies to further address some nuances identified in scholarship on perceived vulnerability require qualitative inquiries into the context within which sociodemographic characteristics influence households' perceived probability of flood occurrence which underlies the underestimating of vulnerability to the natural hazard.

This study is not without limitations, and that, being a cross-sectional study limits its ability to determine causality. A longitudinal study would have shown the effect of changes observed in the covariates on household estimation over time. Although vulnerability indicators were chosen or selected through a thorough review of literature, under-representing the complexities associated with a very broad concept of vulnerability is expected. Also, with regards to computing the vulnerability index, assigning no weights to the selected although very convenient potentially cancels the differential effect of indicators if any.

5. Conclusion

This study offers information on direct correlates of households' underestimation of vulnerability to floods, contributing to current understanding of vulnerability to climate change, driven by floods in an urban city towards informed flood disaster risk reduction. The study suggests that understanding the contextual factors and processes that direct or shape how households and communities engage with the issue of flooding has increasingly become important in adaptation planning and resilience building of cities (Norgaard, 2011). Thus the study is timely in responding to the knowledge gap identified by the Intergovernmental Panel on Climate Change (IPCC) on how to inspire global research on the cities-climate change nexus. This includes two significant back to back events in 2018 both in Canada on the urban climate (i) the first Cities and Climate Science Conference in Edmonton, and (ii) ICLEI Local Government World Congress on Climate Change and Urbanization. Therefore, the heightened interests in urban centres which also have the resources to respond to the impacts of climate change would require strong and new forms of evidence-based information to support urban climate action, which this paper provides. Generally, however, differing household's perception of their vulnerability to floods from the rationale of public authorities and civil and structural engineering contractors in their designing of solutions. Households' perceived vulnerability are fuelled by unique characteristics of the household and the communities they live in, hence the interventions that factor how households perceive their vulnerability to floods will gain more acceptance. Whilst perceived vulnerability to floods will guide flood disaster risk reduction plans that support adaptation and resilience building, it will also help to improve households' literacy on how floods impact their livelihoods and associated assets, rather than thinking that living with it for longer periods is normal. The observed gender differences in the correlates of underestimation of vulnerability buttresses the need for gender-sensitive approaches when designing adaptation measures to reduce flood disasters. Studies on urban floods hardly undertake sensitivity analyses when assessing vulnerability and are unable to state whether or not vulnerability to floods is being underestimated due to the perception of households / communities. Whilst vulnerability indices have been the major pathway to estimate vulnerability, quantifying perceived responses of households which at times translate into underestimation is seen to be highly valuable for decision-making. In conclusion, this paper contributes to providing platform for adopting methods known for particular sectors / disciplines such as health to be drawn into urban climate studies at the interface of science – policy – practice.

Declaration of Competing Interest

The authors have no known competing financial interests, personal or social relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The author would like to acknowledge the support of International Development Research Centre (IDRC), Canada through the Climate Change Adaptation Research Training for Capacity (CCARTCD) Project conducted at the Regional Institute for Population Studies (RIPS), which led to the generation of data for this paper. The lead author is also grateful to IDRC for providing funding for his Ph.D. studies.

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