International Journal of Asian Social Science Research; Vol.3, No.5; 2026
E-ISSN: 3006-2179 P-ISSN: 3005-754X
DOI: https://doi.org/10.70267/ijassr.v3n5.6276
Published by: Zeus Press

Household and community level vulnerability to disaster in Bangladesh: An exploratory study on the flash flood 2022 in Sylhet district

Md. Abdus Sattar*

Associate Professor, Open School, Bangladesh Open University, Gazipur-1705

**Corresponding author: Md. Abdus Sattar Email: sattar@bou.ac.bd*

Abstract

This study explored the household and community level vulnerability of flash flood 2022 affected people of Sylhet district in Bangladesh. However, this study was conducted in three unions namely *Barhal, Biroshree, Kajalsar* of Zakiganj upazila of Sylhet district. Both quantitative and qualitative methods were applied to collect data from the field. To achieve the objectives of this study 360 respondents were surveyed from the flash flood 2022 affected area and 3 KIIs were conducted. The results of this study show that the households were rather often considered as low-to-moderate vulnerable to socioeconomic and disaster category (an average of mean value 2.08). Besides, the average of all mean value 1.49 highlights that there was a medium degree of social and structural vulnerability at community level. The Composite Social Vulnerability Index (SVI=1.54) shows that the social vulnerability was medium in the study area. However, the results of this study show that vulnerability to flash flood was multidimensional including socio-demographic factors, exposure to environmental factors, unstable economic conditions and institutional limitations in the study area. The results of this study would help every stakeholders to formulate own policy to lessen the vulnerability of flash flood affected people in Bangladesh.

Keywords

Household, Community, Vulnerability, Flash Flood, Bangladesh

1. Introduction

Bangladesh frequently experiences flooding and the ways in which it is managed are gaining notice on a global scale. This country is more vulnerable to hydrological disasters like floods because of its geographic location in the downstream of India. Although, the flash flood in Sylhet region should not limiting in a hydrological even but also it considered as a challenge due to the multi-dimensional vulnerability, coping strategies and institutional capacities [1]. In June 2022 an extraordinary rainfall in the upstream in India caused a mid-June 2022 flash flood that submerged most of the parts of Sylhet district. About 7 million people are affected and this devastating flash flood reveals serious physical and socioeconomic vulnerability and destroys dwelling places, agriculture and

infrastructure [2]. Because of the geophysical location of this district and heavy rainfall in the upstream creates the flash flood 2022 and it damages household, crops, infrastructure, communication channels and disrupts health system and livelihood options of the entire community and which is reflected an institutional preparedness gaps [3]. Researchers [4, 2] identified the underlying causes of the flash flood of this area is located in the low-lying *Haor* basin where living millions of people with exposure to environmental and socioeconomic vulnerability and this vulnerability exposed to the most disadvantaged group like poor, women, elderly people and people with disabilities. However, the economic vulnerability of the population depends on the over dependence on the unstable livelihood options such as, agriculture and fishing where physical vulnerability prompted due to poor housing and infrastructure, environmental issues and deforested hilly areas. Environmental disasters that negatively affect human health, well-being, livelihood substitutes and the environment of natural resources are more likely to affect the disadvantaged and poor communities. Since all of the sources are flooded under water, flash floods lead to pollute drinking water which spreads cholera, diarrhea and other waterborne diseases. Prohaska & Peters argued that exposure to floods and wildfires make treat to cancer diseases [5]. Similarly, Datar et al. investigated the exposure of natural disaster to chronic diseases for children such as, diarrhea, fever and breathing illness [6]. Moreover, livelihood options and assets are extremely exaggerated and damaged due to environmental disaster like flash flood that reduces the income level of the farmers [7]. Kawasaki et al. identified that people with poverty have tend to live in flood prone area that enhances poverty among them [8]. People are the potential exposure to the impacts of climate change because of flood exposed extra burden to fisherman and they remain endless poverty [9]. Moreover, flash flood induced vulnerability to individual and community depends on various factor such as, poor physical infrastructure [10-13] and structural provisions [14-16]. However, this study focused on assessing the people's vulnerability to flash flood in the context of household and community.

1.1 Research objectives

- to analyze household level vulnerability to flash flood; and
- to analyze community level vulnerability to flash flood.

1.2 Research questions

RQ1: What was the household level vulnerability to flash flood?

RQ2: What was the community level vulnerability to flash flood?

2. Review of literature

2.1 Flash flood in Sylhet region

Some studies conducted by the researchers focusing on flash flood in Sylhet regions. For instance, Akter et al. mapped the spatiotemporal rainfall variability and its relationship to flash flood [17]; Howlader et al. assessed flash flood through GIS-MCDM tool [18]; Islam et al. quantified inundation due to flash flood using satellite earth observations [19]; Shafiq focused on the frequency and impacts of flash flood [20]; Tuli et al. analyzed the impacts of flash flood in Sylhet and Sunamganj using Google Earth [21]; Sium et al. assessed the multilayer impacts of flash flood on land and land cover [22].

2.2 Factors of vulnerability to flash flood

Recent studies on Sylhet have donated to knowledge about the hazard of flash floods but is unequal in relation to the tow objectives of this study [23- 29].

Geospatial and multi-criteria studies offer a comparatively good evidence of physical exposure to vulnerability and it also depends on rainfall, density in drainage system, geomorphology, slope, topographic dampness and land-use [30- 42]. The worth of this figure of work is that it has clear the areas of concentration of flash flood vulnerability but households and community level various socioeconomic and demographic condition induces

flash flood related vulnerability [43-63, 1]. Moreover, the study on hazards is progressively ascribing flash-flood severity to change in using of land, congestion in drainage system and pressures on river flow systems as opposed to rainfall. The literature reviewed above indicates that flash floods are not a naturally occurring event like others but are a process that occurs at a basin scale and whose effects are influenced by the socio economic and demographic characteristics of the population.

2.3 Research gap

The literature reviewed above indicates that most of the prior studies are not directly related to the present study with regard to study area, study population, study objectives and analytical approach. The absence of research work that is specifically related to Sylhet is not only the large gap in literature but also there is a gap of research between different geographical and thematic aspects. Empirical studies conducted in Sylhet region have been conducted at either district level (Sunamganj) or basin level rather than at the district level of Sylhet, with resulting significant gaps in research.

3. Materials and methods

Existing studies on Sylhet and northeastern regions of Bangladesh on flash flood provide a suitable methodological perception to conduct this study. However, this study applied a triangulation of quantitative and qualitative methods for data collection.

3.1 Study area

Three unions namely-*Barhal, Biroshree, Kajalsar* of Zakiganj upazila of Sylhet district were purposively selected as study area due to geographical location, rainfall and river estuaries that make this area vulnerable to flash flood. Among 9 unions, 3 unions were selected which were severely affected by flash flood 2022.

3.2 Participants

For quantitative data 360 flash flood 2022 affected male and female were selected as participants. Considering the age (18-70+ years), gender (male, female and other) and experience of flash flood, the participants of this study were selected from the *Barhal, Biroshree, Kajalsar* unions of Zakiganj upazila of Sylhet district.

3.3 Data collection

For quantitative data randomly selected 360 respondents from the study area were surveyed through a semi-structured questionnaire. The sample population was selected by the help of local leaders, community leaders and community people. Moreover, to strengthen quantitative data 3 KIIs were conducted through a well-organized checklist linked to the objectives of the study.

3.4 Primary and secondary data

The primary data for both quantitative and qualitative methods were collected from direct field study from December 2023 to January 2024 whereas secondary data were collected through a rigorous desk review of related documents during the study period.

3.5 Prepare, analyze and presentation of data

The collected data were sorted manually, analyzed by using SPSS software and presented in table in accordance with research objectives.

4. Results and analysis

4.1 Household level vulnerability

The data shows the multidimensional features that indicates the vulnerability to flash flood in Table 1 and 2. The mean value of total average means 2.08 shows that households were in the low to moderate vulnerability range although it had a number of structural faults. Regarding the issue of family composition data indicate that nuclear family (M=1.10) and male-headed household (M=1.25) were predominant. The average household size (M=3.38) indicates moderate dependence which increases food demand at the post disasters situation. There was recurrent exposure to flash floods and experience of households to expose to flash floods more than once previous past ten years (M=1.79). Although death rates due to previous flash floods were relatively low (M=1.99) but the number of injured people (M=1.78) indicates the middle level of physical vulnerability. The accessibility to early warning systems (M=1.84) was partly covered which indicates the deficiency of communication provision. The housing structures (M=2.47) were mostly semi-*pucca* which supports that the people of the study area had moderate resilience and continue to face the occurrence of structural harm. Receiving treatment from medical center cause delay in emergency situation due to the distance to medical facilities as the access barriers (M=2.61). There was high breakability in economic indicators. The monthly income (M=2.31) was also low-to-moderate and there was low income diversification opportunity (M=1.31). The majority of households had only one earning member (M=1.48) which indicates the limitation of adaptation capacity. The low ability of household savings (M=1.31) and low amount of savings (M=1.15) specify a weak financial cushioning capacity. The level of education of household head (M=2.60) indicates limited diversification of employment opportunity outside the area and occupation of household head (M=2.64) shows that the two biggest sectors were agriculture and informal labor which were highly vulnerable to climate change. Household land ownership (M=1.21) remarks to small scale ownership of land which was prone to be affected by flash floods and induces vulnerability for household. The variables of social capital reflected moderate outside networks such as, having relatives outside of the affected areas (M=1.56) and relatives working or with outside of area (M=1.75). The institutional dependency (M=1.93) was indicated by the households that seek the help of the local authorities. The health vulnerability persisted high due to the presence of chronic illnesses/disabilities (M=4.53) indicates supplementary risks associated with nutrition and rehabilitation.

Table 1: Household level vulnerability (N = 360)

Sl.	Variable	Category	%	Mean	SD
1	Type of family	Single	92.5	1.1056	0.3949
		Nucleus	4.4		
		Extended	3.1		
2	Experiencing injury by family member	Yes	25.0	1.7806	0.4828
		No	71.9		
		Not sure	3.1		
3	Losing family member	Yes	1.7	1.9944	0.1668
		No	97.2		
		Not sure	1.1		
4	Type of house structure	Jhupri	13.6	2.4750	0.8984
		Katcha	39.4		
		Semi-pucca	32.8		
		Pucca	14.2		
5	Receiving any form of warning about flash flood	Yes	16.4	1.8472	0.3900
		No	82.5		
		Not sure	1.1		
6	Size of household	2 members	4.4	3.3833	0.9279
		3 members	6.7		

Sl.	Variable	Category	%	Mean	SD
		4 members	46.1		
		5 members	31.7		
		More than 5 members	11.1		
7	Experiencing flash by household in last 10 years	1 time	40.3	1.7972	0.8008
		2 times	43.6		
		3 times	12.2		
		More than 3 times	3.9		
8	Household head	Husband	83.1	1.2500	0.6098
		Wife	10.0		
		Son	5.8		
		Daughter	1.1		
9	Number of disable and injured member in the family	1	7.8	4.5306	1.2101
		2	4.2		
		3	1.4		
		More than 3	.6		
		None	86.1		
10	Household head's monthly income	Tk. 5000-10000	28.9	2.3111	1.2278
		Tk. 10001-15000	35.6		
		Tk. 15001-20000	20.0		
		Tk. 20001-25000	8.9		
		Tk. 25001-30000	4.4		
		Tk. 30000+	2.2		
11	Distance of medical center	1-2 km	7.2	2.6167	0.6180
		3-4 km	23.9		
		5 km	68.9		
12	Living time in the area	5-10 years	5.0	4.1778	1.1667
		11-15 years	5.8		
		16-20 years	13.1		
		21-25 years	18.6		
		More than 25 years	57.5		
13	Level of education of household head	Primary education	26.1	2.6028	1.4203
		Secondary education	32.5		
		Higher secondary education	13.9		
		Tertiary education	10.0		
		No formal education	17.5		
14	Occupation of household head	Business	13.1	2.6417	1.3065
		Cultivation	53.1		
		Public service	7.8		
		Private service	8.9		
		Service in informal sector	17.2		
15	Number of income sources of the household	1	75.6	1.3111	0.5904
		2	17.8		
		3	6.7		
16	Number of earning member in the family	1	65.3	1.4889	0.7312
		2	20.6		
		3	14.2		
17	Savings of household	Yes	71.9	1.3111	0.5256
		No	25.0		
		Not sure	3.1		
18	Monthly amount of savings	No savings	25.0	1.1556	0.9635

Sl.	Variable	Category	%	Mean	SD
		Tk. 1000-2000	46.7		
		Tk. 3000-5000	18.6		
		Tk. 6000-10000	7.2		
		Tk. 10000+	2.5		
19	Household with land	Yes	83.1	1.2139	0.5077
		No	12.5		
		Not sure	4.4		
20	Having relatives outside the affected area	Yes	46.9	1.5611	0.5552
		No	50.0		
		Not sure	3.1		
21	Having member/relatives with jobs outside the affected area	Yes	29.2	1.7556	0.5291
		No	66.1		
		Not sure	4.7		
22	Meet with local authority for assistance	Yes	15.8	1.9361	0.4994
		No	74.7		
		Not sure	9.4		
23	Having own or rent farming	Yes	56.4	1.5389	0.6748
		No	33.3		
		Not sure	10.3		
			Average	2.08	0.74

An average mean of 2.08 indicates that the households were rather often considered as low-to-moderate vulnerable to socioeconomic and disaster category.

Table 2: Composite vulnerability index by household indicators (N = 360)

Dimension	Variable	Mean	Normalized CVI (0–1)
Exposure	Experiencing flash by household in last 10 years	1.7972	0.22
	Type of house structure	2.4750	0.38
	Receiving any form of warning about flash flood	1.8472	0.24
	Experiencing injury by family member	1.7806	0.21
	Losing family member	1.9944	0.29
Sensitivity	Size of household	3.3833	0.56
	Number of disable and injured member in the family	4.5306	1.00
	Distance of medical center	2.6167	0.42
	Type of family	1.1056	0.00
	Household head	1.2500	0.05
Adaptation	Household head’s monthly income	2.3111	0.36
Capacity	Number of income sources of the household	1.3111	0.06
	Number of earning member in the family	1.4889	0.13
	Savings of household	1.3111	0.06
	Monthly amount of savings	1.1556	0.00
	Household with land	1.2139	0.02
	Having relatives outside the affected area	1.5611	0.12
	Having member/relatives with jobs outside the affected area	1.7556	0.21
	Meet with local authority for assistance	1.9361	0.27
	Having own or rent farming	1.5389	0.11
	Level of education of household head	2.6028	0.44
	Occupation of household head	2.6417	0.45
	Living time in the area	4.1778	0.87

4.2 Community level vulnerability

The calculated average of all mean value 1.49 highlights that there was a medium degree of social and structural vulnerability at the community level. The factors that relate to identity impacts of individual, identity impacts of

individual in community, availability of employment and livelihood, environmental and climate change factors and access to basic services all combine to determine the social status and living conditions of individual in the community. Some of the dimensions, including employment and livelihood opportunities (Mean=1.70) had a comparatively stronger impact which indicates economic limitations and poor job diversification. Characteristics of identity also contributed greatly in the determination of both individual (Mean=1.57) and individual status in the community (Mean=1.55). The problems of environment and climate change had moderate impacts on the social interaction, agriculture and livelihood (Mean=1.31) and the access to basic services such as, healthcare, education and financial institutions were also somewhat limited (Mean=1.33). These results suggest that exposure to the environment and access to institutional services were combined with individual and community identity structures and economic opportunities to induce vulnerability to flash flood in the community. Table 3 and 4 present the results.

The Composite Social Vulnerability Index (SVI mean=1.54) in Table 4 shows that the communities under the study were considered by the moderate degree of social vulnerability. Of the four dimensions, livelihood and employment vulnerability (Mean=1.70) carried the highest level of vulnerability that indicates the social vulnerability in the study area were affected by employment opportunities, occupational diversification and employment and livelihood opportunities for women. Job opportunities were limited and seasonal in the study area which compels members of the community to find employment and livelihood opportunities outside the area results to induce vulnerability. The social identity dimension (Mean=1.65) was also found to be significant, meaning that identity categories like race, ethnicity, religion and marital status had a moderate influence to people regarding their social status in the community indicates that the social stratification and identity-based difference may affect the access to resources and decision making power. Community status dimension (Mean=1.47) indicates the moderately low hitherto significant impacts of identity based factors regarding the status of individuals in the community environment. However, notwithstanding the differences in identity but their impact seems to be less significant than livelihood-related vulnerabilities in the community. Lastly, environmental and service related vulnerability dimension (Mean=1.32) carries the lowest mean score. Nonetheless, difficulties like crop damage due to climatic conditions, livelihood turbulences, displacement of people, lack of accessibility to health care, financial services and shelter were also significant factors to induce vulnerability to flash flood. Widely, the composite index indicates that livelihood uncertainty, employment unpredictability and social stratification were all factors that define the vulnerability profile of households in the study area. These vulnerabilities exacerbate food insecurity and nutritional risks, especially in marginalized households regarding economic condition in flash flood prone areas.

Table 3: Community level vulnerability (N = 360)

Dimension	Indicators	Mean Range	Average Mean Value
Identity Impacts on Individual Status	Race; Ethnic; Religious; Language; Sex; Gender; Social class; Socioeconomic condition; Job status; Marital status; Educational status; Familial/kinship linkage; Age structure.	1.0944 – 2.0861	1.57
Identity Impacts on Community Status	Racial and individual in community; Ethnic and individual in community; Religious and individual in community; Language and individual in community; Sex and individual in community; Gender and individual in community; Social class and individual in community; Socioeconomic condition and individual in community; Job and individual in community; Marital status and individual in community; Educational status and individual in community; Familial/kinship linkage and individual in community; Age structure and individual in community.	1.0944 – 2.0861	1.55
Employment and Livelihood Opportunities	Opportunity of decent work for all in the community; Availability work for all in the community; Opportunity to move for work outside the community; Opportunity	1.4861 – 1.9056	1.70

	for diversified occupation in the community; Opportunity for women to work outside the family; Opportunity for women to work within the community; Opportunity for women to work within the community; Opportunity for work over the year.			
Environmental and Climate Impacts	Disruption of social interaction and climatic issue, Climatic issue and damages of crops, Climatic issue and disruption of livelihood, Climatic issue and displacement of people.	1.1833 1.4333	–	1.31
Access to Basic Services	Access of children to education; Access to health care services; Access to financial services; Access to decent housing; Access to social services; Access to public places.	1.1528 1.5806	–	1.33
Average				1.49

Table 4: Composite Social Vulnerability Index

Dimension	Average Mean	Normalized SVI (0–1)
Social Identity Vulnerability	1.65	0.56
Community Status Vulnerability	1.47	0.37
Livelihood & Employment Vulnerability	1.70	0.51
Environmental & Service Vulnerability	1.32	0.54
Composite Social Vulnerability Index	1.54	0.90

5. Discussion

5.1 Household level vulnerability

The analysis of 360 households of this study shows that range of vulnerability of households was normally low-to-moderate although structural and socioeconomic vulnerabilities existed in the study area. Households were mostly nuclear and male headed with moderate vulnerability that reflects dependence and affected by flash flood in terms of food demand. Repeated exposure to floods, *Katcha* (39.4%) semi-*pucca* (32.8%) house and imperfect reporting of early warning signals were the sings of the lack of physical accessibility. Adaptation capacity was constrained by economic fragility such as, low income (35.6% household earned monthly Tk. 10001-15000), solo earning member (65.3% of the household had one earning member), lack of income diversification opportunity (75.6% of the household had sole earning sources) and low savings (46.7% of the household saved Tk. 1000-2000 per month) which increase level of household vulnerability. Furthermore, household vulnerability was revealed through dependence on cultivation (53.1% of the households depended on cultivation) and service in the informal sector (17.2%) and by not having any relatives outside the affected area (50%). Inadequate access to help from the community was also showed in moderate social networks. Households were vulnerable in terms of exposure, sensitivity and adaptation capacity. However, exposure was moderate due to frequent floods, *Katcha* and semi-*pucca* housing and imperfect early warning signals resulting cumulative risk. The highest sensitivity was due to size of household (46.1% of the household consisted of 4 members), chronic disease (7.8% of the household had 1 disable and injured member), low access to healthcare (68.9% of the household were 5km away from medical center) and decisions were made by male member increase sensitivity as the aftermath of the flood. There was a low adaptation capacity due to low-to-moderate income, dependence on solo sources of income, savings limitation, dependence on cultivation and small landholding limits coping and recovery. External support somewhat accompaniments resilience but cannot counter vulnerabilities completely. This results align with the study of Lee et al., where authors found recurrent flood exposure and increasing risk due to post flood effects [64] and Haque et al. observed that structural characteristics of housing become the source of different loss and disruption [65]. Moreover, Al-Mueed et al. highlighted imperfect early warning signals restrict the people to act in uneven preparedness and exposure continuation [66].

5.2 Community level vulnerability

The results reveal that the community had an average vulnerability in the context of social and structural issue. For example, the lack of diversification in income sources and opportunities in employment and livelihood (Mean=1.70) whereas factors of identity impacts on individual status (Mean=1.57) and identity impacts on community status (Mean=1.55), access to basic services (Mean=1.33) and environment and climate impacts increase community level vulnerability. Vulnerability level reflects condition in the community in the context of disaster affected individuals and communities though community is the main concern in vulnerability literature and its dynamic characteristics is important [67]. However, researchers [68- 71 cited in 67] identified that due to dynamic-systematic interaction as a result of the characteristics of community level vulnerability in community changes.

The Composite Social Vulnerability Index (SVI=1.54) shows that the social vulnerability was medium in the study area. Livelihood and employment insecurity was the most influential factor, caused by a lack of job diversification and seasonal work reduces economic resilience to flash flood. Access to resources and decision-making power was also resulted by social identity factors such as, ethnicity, religion and marital status although the differences in status in the community was minor and it was less than livelihood restraints. Lack of access to services and environmental issues were also some causes of vulnerability. Susan L. Cutter and co-authors introduced the Social Vulnerability Index technique for measuring vulnerability based on multi-level socioeconomic and demographic variables [72]. Tasnuva et al. identified that low-medium, medium, and medium-high to high household level social vulnerability [73].

6. Conclusion

The results of this study show that vulnerability to flash floods was multidimensional which was affected by socio-demographic factors, exposure to environmental factors, unbalanced economic conditions and institutional limitations in the study area. Mid aged respondents, extended family and moderate-to-low levels of education were the largest limitation to adaptation capacity and strengthening dependence. The household resilience was impaired due to the gender based decision making process where the women were excluded in disaster preparedness process. The study also shows that there was large dependence on agriculture and single sources of income which limits the economic diversity and as a result the household was highly exposed to the risk of flash floods. These represent severe vulnerability by being exposed to flash floods more than once every decade and had more than one occurrence of exaggerated household. Recurrent submerges and inundation rates affect livelihoods, damage property and food security that this study revealed. The overall food crises, illness and unemployment were the strongest indicators of sensitivity in flash floods. These realities illustrate that even moderate floods may had severe nutritional and health-related strain in the case of disregarded groups those had limited access to healthcare system and safe drinking water. Although households employ borrowing, selling of valuable assets and depending on relief as coping strategies and most of these were generally reactive and untenable. Household were severely vulnerable due to the lack of structural preparedness, medical preparedness although some the household used to saving money, preservation of seed indicates the middle adaptation capacity. The vast spread of housing damage and self-reconstruction further stressed disaster recovery due to the lack of institutional supports. The results show that crop diversification, sanitation and presence of disaster management committees at the community level indicate some levels of resilience. The Composite Social Vulnerability Index (SVI) shows a moderate vulnerability which was mainly due to livelihood insecurity, inadequate access to basic services and social inequalities.

References

[1] N. Akter, M. Islam, M. Karim, M. Miah, M. Rahman, Impact of flash floods on agri-based livelihoods in Sylhet Haor basin, Annals of Bangladesh Agriculture. 26 (1) (2022) 61–73. https://doi.org/10.3329/aba.v26i1.67019

[2] IFRC, Bangladesh Floods 2022: Final Report (Emergency Appeal MDRBD028) International Federation of Red Cross and Red Crescent Societies. 2023.

[3] GoB, Population and housing census: Community Report: Sylhet Bureau of Statistics, Ministry of Planning. 2025

[4] R. H. Khan. M. S. Islam,F.Zaman, Assessing the spatio-temporal variability in the frequency and magnitude of flash floods and their driving strategies: Evidence from Haor Region of Bangladesh: Assessing the spatio-temporal variability, Journal of the Asiatic Society of Bangladesh, Science. 50(1) (2024) 33-50.

[5] T. R. Prohaska, K. E. Peters, Impact of natural disasters on health outcomes and cancer among older adults, The Gerontologist. 59 (1) (2019) S50-S56. https://doi.org/10.1093/geront/gnz018

[6] A. Datar, J. Liu, S. Linnemayr, C. Stecher, The impact of natural disasters on child health and investments in rural India, Social Science & Medicine. 76 (1) (2013) 83–91. https://doi.org/10.1016/j.socscimed.2012.10.008

[7] S. Guo, S. Liu, L. Peng, H. Wang, The impact of severe natural disasters on the livelihoods of farmers in mountainous areas: A case study of Qingping Township, Mianzhu City, Natural Hazards. 73(3) (2014) 1679-1696. https://doi.org/10.1007/s11069-014-1165-9

[8] A. Kawasaki, G. Kawamura, W. W. Zin, A local level relationship between floods and poverty: A case in Myanmar, International Journal of Disaster Risk Reduction. 42 (2020) https://doi.org/10.1016/j.ijdrr.2019.101348

[9] P. Tran, Nguyen, Tan, Dinh, C. Nguyen, K. L. Hoang, Nguyen, P. Ty, Flood vulnerability-rural poverty nexus: Implications for disaster risk reduction and sustainable rural development in Vietnam, Environment and Ecology Research. 11 (2023) 362-377. https://doi.org/10.13189/eer.2023.110210

[10] S. Pathak, H. K.Panta, T. Bhandari, K. P. Paudel, Flood vulnerability and its influencing factors, Natural Hazards. 104(3) (2020) 2175-2196.

[11] N. L. S. Len, N. Bolong, R. Roslee, F. Tongkul, A. K Mirasa, J. L. Ayog, Flood vulnerability of critical infrastructures-review, Malaysian Journal of Geosciences. 2(1) (2018) 31-34.

[12] A. A. Husaini, An assessment of flood vulnerability on physical development along drainage channels in Minna, Niger State, Nigeria, African Journal of Environmental Science and Technology. 9(1) (2015) 38-46. https://doi.org/10.5897/AJEST2014.1815

[13] A. Peck, S.Karmakar, S. P. Simonovic, Physical, economical, infrastructural and social flood risk-vulnerability analyses in GIS, Department of Civil and Environmental Engineering, The University of Western Ontario, 2007.

[14] G. Kikwasi, E. Mbuya, Vulnerability analysis of building structures to floods: The case of flooding informal settlements in Dar es salaam, Tanzania, International Journal of Building Pathology and Adaptation. 37(5) (2019) 629-656.

[15] H. C. P. Chung, K. Adeyeye, Structural flood damage and the efficacy of property-level flood protection. International, Journal of Building Pathology and Adaptation. 36(5) (2018) 471-499.

[16] D. Mustafa, Structural causes of vulnerability to flood hazard in Pakistan, Economic Geography. 74(3) (1998) 289-305.

[17] N. Akter, M. R. Islam, M. A Karim, M. G Miah, M. M. Rahman, Spatiotemporal rainfall variability and its relationship to flash flood risk in Northeastern Sylhet Haor of Bangladesh, Journal of Water and Climate

Change. 14(11) (2023) 3985-3999.

[18] R. Howlader, M. A Hossain, C. S.Jahan, M. F. Rahaman, M. M. A. Chowdhury, Risk assessment and zonation of flash flood in Sylhet basin, Northeast Bangladesh using GIS-MCDM tool, Safety in Extreme Environments. 6(4) (2024) 305-318.

[19] M. S Islam, J. R. Mitra, M. K. Rahman, Quantifying flash flood inundation and assessing damage using satellite earth observations: The case of 2022 flash flood in Bangladesh, Geomatics, Natural Hazards and Risk. 17(1) (2026) 2614729.

[20] S. I. Shafiq, The Frequency and impact of flooding in the Sylhet division of Bangladesh: An investigation, Paul B McNulty. 11(1) (2023) 13-18.

[21] R. D. Tuli, K. J. Rashid, T. Akter, Impact analysis of the 2022 flood event in Sylhet and Sunamganj using Google Earth Engine, In Modern cartography series. 12 (47-69) (2024) Academic Press.

[22] S. M. Sium, A.Sharabony, K. M. F. Haq, Quantitative multiyear assessment of flood impact on land use and land cover in Sylhet Region, Bangladesh: Insights from sentinel imageries, Earth Interactions. 30 (1) (2026) 1-13.

[23] S. Sarker, I. Jahan, X. Wang, A. Azad, Geospatial approach to assess flash flood vulnerability in a coastal district of Bangladesh: Integrating the multifaceted dimension of vulnerabilities, ISPRS International Journal of Geo-Information. 14(5) (2025) 194.

[24] N. Godara, A. Challana, T. Bansal, A. Bawa, Geospatial techniques for flash flood hazard assessment and management, In Sustainable Development Using Geospatial Techniques. (2024) 241-262.

[25] M. Shawky, Q. K. Hassan, Geospatial modeling based-multi-criteria decision-making for flash flood susceptibility zonation in an arid area, Remote Sensing. 15(10) (2023) 2561.

[26] H. A. Hamid, W. Wenlong, L .Qiaomin, Environmental sensitivity of flash flood hazard using geospatial techniques, Global Journal of Environmental Science and Management. 6(1) (2020) 31-46.

[27] S. Khajehei, A. Ahmadalipour, W. Shao, H. Moradkhani, A place-based assessment of flash flood hazard and vulnerability in the contiguous United States, Scientific Reports 10 (1) (2020) 448.

[28] J. Xiong, J. Li, W. Cheng, N. Wang, L. Guo, A GIS-based support vector machine model for flash flood vulnerability assessment and mapping in China, ISPRS International Journal of Geo-Information. 8 (7) (2019) 297.

[29] S. Abuzied, M. Yuan, S.Ibrahim, M. Kaiser, T. Saleem, Geospatial risk assessment of flash floods in Nuweiba area, Egypt, Journal of Arid Environments. 133 (2016) 54-72.

[30] K. Nagamani, A. K. Mishra, M. S. Meer, J. Das, Understanding flash flooding in the Himalayan Region: A case study, Scientific Reports. 14(1) (2024) 7060.

[31] M. Abdelkareem, A. M. Mansour, Risk assessment and management of vulnerable areas to flash flood hazards in arid regions using remote sensing and GIS-based knowledge-driven techniques, Natural Hazards. 117(3) (2023) 2269-2295.

[32] S. Ahmadi, H. Amjadi, K. Chapi, R. Soodmand Afshar, B.Ebrahimi, Fuzzy flash flood risk and vulnerability assessment for the city of Sanandaj, Kurdistan Province, Iran, Natural Hazards. 115(1) (2023) 237-259.

[33] L. G. Fonseca Alves, C. de Oliveira Galvão, B. L. de Farias Santos, E. Fernandes de Oliveira, D. Andrade de Moraes, Modelling and assessment of sustainable urban drainage systems in dense precarious settlements subject to flash floods, LHB. 108(1) (2022) https://doi.org/10.1080/27678490.2021.2016024

[34] M. Saharia, P. E. Kirstetter, H. Vergara, J. J. Gourley, I. Emmanuel, H. Andrieu, On the impact of rainfall spatial variability, geomorphology, and climatology on flash floods, Water Resources Research. 57(9) (2021) e2020WR029124.

[35] A Alam, B. Ahmed, P. Sammonds, Flash flood susceptibility assessment using the parameters of drainage basin morphometry in SE Bangladesh, Quaternary International. 575 (2021) 295-307.

[36] A. Karkani, N. Evelpidou, M. Tzouxanioti, A. Petropoulos, N. Santangelo, H. Maroukian, L. Lakidi, Flash flood susceptibility evaluation in human-affected areas using geomorphological methods-The case of 9 August 2020, Euboea, Greece. A GIS-based approach. GeoHazards 2(4) (2021) 366-382.

[37] M. Prama, A. Omran, D. Schröder, A. Abouelmagd, Vulnerability assessment of flash floods in Wadi Dahab Basin, Egypt, Environmental Earth Sciences. 79(5) (2020) 114.

[38] Y. Chen, Y. Wang, Y. Zhang, Q. Luan, X. Chen, Flash floods, land-use change, and risk dynamics in mountainous tourist areas: A case study of the Yesanpo Scenic Area, Beijing, China, International Journal of Disaster Risk Reduction. 50 (2020) 101873.

[39] S. Mahmood, A. U. Rahman, Flash flood susceptibility modelling using geomorphometric approach in the Ushairy Basin, eastern Hindu Kush. Journal of Earth System Science. 128(4) (2019) 97.

[40] A. Bannari, A. Ghadeer, A. El-Battay, N. A. Hameed, M. Rouai, Detection of areas associated with flash floods and erosion caused by rainfall storm using topographic attributes, hydrologic indices, and GIS. In Global Changes and Natural Disaster Management: Geo-information Technologies Cham: Springer International Publishing. 2017. pp. 155-174.

[41] M. T. Rahman, A. S. Aldosary, K. M. Nahiduzzaman, I. Reza, Vulnerability of flash flooding in Riyadh, Saudi Arabia, Natural Hazards. 84(3) (2016) 1807-1830.

[42] I. Braud, M. Borga, J. Gourley, M. Hürlimann, M. Zappa, F. Gallart, Flash floods, hydro-geomorphic response and risk management, Journal of Hydrology. 541 (2016) 1-5.

[43] S. Gul, I. Khalil, K. Hidayat, Impact of 2022 flood on girls' education: A case study of District Nowshera, Khyber Pakhtunkhwa, Pakistan, International Journal of Disaster Risk Reduction. 114 (2024) 104988.

[44] A. Clarke, N. Coleman, A. Mostafavi, Analyzing common social and physical features of flash-flood vulnerability hotspots in urban areas. arXiv preprint arXiv:2404.01085. 2024.

[45] R. A Balgah, K. A. Ngwa, G. R. Buchenrieder, J. N. Kimengsi, Impacts of floods on agriculture-dependent livelihoods in Sub-saharan Africa: An assessment from multiple geo-ecological zones, Land. 12(2) (2023) 334.

[46] S. R. Fatema, L. East, S. Islam, K. Usher, Gender-based vulnerabilities for women during natural disasters in Bangladesh, Frontiers in Communication. 8 1180406 (2023) https://doi.org/10.3389/fcomm.2023.1180406

[47] C. E. Haque, M. A. K. Azad, M. U. I. Choudhury, Social learning, innovative adaptation and community resilience to disasters: The case of flash floods in Bangladesh, Disaster Prevention and Management: An International Journal. 31(5) (2022) 601-618.

[48] A. G. Palacio-Aponte, A. J. Ortíz-Rodríguez, S. Sandoval-Solis, Methodological framework for territorial planning of urban areas: Analysis of socio-economic vulnerability and risk associated with flash flood hazards, Applied Geography. 149 (2022).

[49] X. Yang, S. Guo, X. Deng, W. Wang, D. Xu, Study on livelihood vulnerability and adaptation strategies of farmers in areas threatened by different disaster types under climate change, Agriculture. 11(11) 1088 (2021).

[50] A. K. Christian, B. D. Dovie, W. Akpalu, S. N. A. Codjoe, Households' socio-demographic characteristics, perceived and underestimated vulnerability to floods and related risk reduction in Ghana, Urban Climate. 35 100759 (2021).

[51] F. Naz, S. E. Saqib, Gender-based differences in flood vulnerability among men and women in the char farming households of Bangladesh, Natural Hazards. 106(1) (2021) 655-677.

[52] A. Deria, P. Ghannad, Y. C. Lee, Evaluating implications of flood vulnerability factors with respect to income levels for building long-term disaster resilience of low-income communities, International Journal of Disaster Risk Reduction. 48(2). 101608 (2020).

[53] N. T. T. Pham, D. Nong, A. R. Sathyan, M. Garschagen, Vulnerability assessment of households to flash floods and landslides in the poor upland regions of Vietnam, Climate Risk Management. 28:100215 (2020).

[54] J. Abedin, H. Khatun, Impacts of flash flood on livelihood and adaptation strategies of the Haor inhabitants: A study in Tanguar Haor of Sunamganj, Bangladesh, The Dhaka University Journal of Earth and Environmental Sciences. 8(1) (2019) 41-51.

[55] P. D. Speis, E. Andreadakis, M. Diakakis, E. Daidassi, G. Sarigiannis, Psychosocial vulnerability and demographic characteristics in extreme flash floods: The case of Mandra 2017 flood in Greece, International Journal of Disaster Risk Reduction., 41 (2019).

[56] E. Aroca-Jiménez, J. M. Bodoque, J. A. García, A. Díez-Herrero, A quantitative methodology for the assessment of the regional economic vulnerability to flash floods, Journal of Hydrology. 565 (2018) 386-399.

[57] N. Bayraktar, Ü. Dal Yilmaz, Vulnerability of elderly people in disasters: A systematic review, Turkish Journal of Geriatrics/Türk Geriatri Dergisi. 21(3) (2018).

[58] B. Bolin, & L. C. Kurtz, Race, class, ethnicity, and disaster vulnerability. In Handbook of Disaster Research. (2017) 181-203.

[59] K. Karagiorgos, T. Thaler, J. Hübl, F. Maris, S. Fuchs, Multi-vulnerability analysis for flash flood risk management, Natural Hazards. 82(1) (2016) 63-87.

[60] E. Lisa, F. Schipper, Religion and belief systems: Drivers of vulnerability, entry points for resilience building?. In Cultures and Disasters. pp. 145-154. Routledge, 2015.

[61] A. K. Azad, K. M. Hossain, M. Nasreen, Flood-induced vulnerabilities and problems encountered by women in northern Bangladesh, International Journal of Disaster Risk Science. 4 (2013) 190-199.

[62] I. Ruin, J. D. Creutin, S. Anquetin, E. Gruntfest, C. Lutoff, Human vulnerability to flash floods: Addressing physical exposure and behavioural questions, Flood risk management: Research and Practice. (2009) 1005-1012.

[63] M. Siudak, Role of education in reducing flash flood effects. In Gruntfest, E., Handmer, J. (eds) Coping With Flash Floods. NATO Science Series, vol. 77. Springer, Dordrecht. Pp.15-18.

[64] D. Lee, H. Ahmadul, J. Patz, P. Block, Predicting social and health vulnerability to floods in Bangladesh, Natural Hazards and Earth System Sciences. 21(6) (2021) 1807-1823. https://doi.org/10.5194/nhess-21-1807-2021

[65] S. Haque, K. Ikeuchi, B. B. Shrestha, A. Kawasaki, M. Minamide, Relationship between residential house damage and flood characteristics: A case study in the Teesta River basin, Bangladesh, International Journal of Disaster Risk Reduction. 96 (2023). https://doi.org/10.1016/j.ijdrr.2023.103901

[66] M. Al-Mueed, M. R. A. Chawdhery, E. Harera, R. A. Alhazmi, A. M. Mobrad, S. M. Althunayyan, A. M. Al-Wathinani, Potential of community volunteers in flood early warning dissemination: A case study of Bangladesh, International Journal of Environmental Research and Public Health. 18(24) (2021). https://doi.org/10.3390/ijerph182413010

[67] A. Pamungkas, S. A. Bekessy, R. Lane, Vulnerability modelling to improve assessment process on community vulnerability, Procedia-Social and Behavioral Sciences. 135 (2014) 159-166.

[68] S. L. Cutter, C. Finch, Temporal and spatial changes in social vulnerability to natural hazards, Proceeding Natural Academy Science U.S.A. 105(7) (2008) 2301-2306, https://doi.org/10.1073/pnas.0710375105

[69] I. Armas, Social vulnerability and seismic risk perception, case study: The historic centre of the Bucharest Municipality-Romania, Natural Hazards. (2008) 397-410.

[70] G. Bankoff, G. Frerks, D. Hilhorst, Mapping Vulnerability: Disasters, Development and People, First ed., Routledge. 2004. https://doi.org/10.4324/9781849771924

[71] A. M. Odeh, H. T. Battaineh, Causes of construction delay: Traditional contracts, International Journal of Project Management. 20(1) (2002) 67-73.

[72] S.L. Cutter, B.J. Boruff, W.L. Shirley, Social vulnerability to environmental hazards, Social Science Quarterly. 84 (2003) 242-261. https://doi.org/10.1111/1540-6237.8402002

[73] A. Tasnuva, M. R. Hossain, R. Salam, A. R. M. T. Islam, M. M. Patwary, S. M. Ibrahim, Employing social vulnerability index to assess household social vulnerability of natural hazards: An evidence from southwest coastal Bangladesh. Environment, Development and Sustainability. 23(7) (2021) 10223-10245.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

I would like to sincerely thank Bangladesh Open University for providing financial assistance to conduct the study.