Between Rock and a Hard Place: Flood-Induced Mobility, Change in Population Dynamics, and Human Health

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1. Background

India experiences some of the highest rates of internal displacement globally every year. There were a total of 2.5 million disaster-related displacements in 2022, and 96 percent of them were caused by floods. The most impacted state is Assam (IDMC, 2023). Such changes in spatial dynamics as a result of flooding can influence the population size, structure, and composition, which can subsequently increase or decrease social vulnerability (Cutter & Finch, 2008).

Apart from the direct losses, such as the loss due to displacements and destruction of lives and properties, subsequent indirect effects on health and wellbeing are associated with flooding (Walker-Springett et al., 2017). The overflow of two rivers in West Bengal in 1998 caused an outbreak of cholera (WHO, 1998; Sur et al., 2000). There are few similar incidences of such major disease outbreaks; however, literature suggests that floods increase the risks of transmission of infectious diseases (Bandino et al., 2015; Deka et al., 2021). A plethora of health conditions, both physical and psychological, are reported to be associated with floods in studies conducted in India and other parts of the world (Fernandez et al., 2015; Munro et al., 2017).

The link between floods and health is established through a complex combination of agents, host, and environment; the classic ‘epidemiological triad’ that influences physical health and 'secondary’ stressors such as displacement during or after flooding are found to be significantly associated with symptoms of depression, anxiety, and post-traumatic stress disorder (Paranjothy et al., 2011; Foudi et al., 2017; Tong, 2017). The possible mechanisms by which floods affect mental health have been extensively researched. In this paper, we explore the nature of flood-induced mobility in a recurring flood-affected Aie river basin in India and its influence on change of population dynamics in the study setting. We also analyse the consequence of flood-induced mobility on the health of the population. The condition of comorbidity after flood exposure is not adequately addressed in the Indian context. This study makes a humble attempt to fill that gap. Although many of the findings are consistent with the previous research, it is crucial to re-establish the facts found in the other setup.

2. Data and Methodology

Broadly, the sources of data are divided into two categories: 1) Secondary Data Sources: a) Primary Census Abstract, Bongaigaon, 1991 to 2011, and text sources such as Report on the Census of Assam for various years are considered (see Appendix Table 1); 2) Primary Data: An extensive field study was conducted in nine villages of Bongaigaon District from February 2022 to March 2022 to collect qualitative and quantitative data (see Appendix Tables 2a, b, c, and d). Information on health is gathered through self-reported data. Three scales were used to measure anxiety, depression, and PTSD. The PCL-5 scale and two-item anxiety and depression scale were

used. The internal reliability and validity of these scales were tested, the results of which shall be discussed in the full paper. While information on physical health is gathered for all usual residents of the study area, the information on mental health was gathered only for a subset of the population using two excluding criteria (see Appendix Tables 3a).

The cross-sectional study design was used to collect data. No repeat interviews were taken. Households belonging to flooded villages are the 'exposed' and households belonging to the non-flooded villages are the 'control' households. This is a mixed-method study with a core quantitative component (collection of numbers) and a supplementary component that includes qualitative aspects (collection of words) (Greene et al., 1989). To identify the risk and protective factors of diseases, odds ratios adjusted by potential confounders were calculated (see Appendix 3b and 3c for potential confounders)

3. Study Setting

A massive flood catastrophe hit several villages in Bongaigaon District on August 14, 2021. In the six months from August 2021 to February 2022, as part of the research, some of the flooded villages were visited, and numerous locals were spoken to. Although rainfall was normal, reports indicate that flooding was caused by the release of dam water from upstream, which caused a structural failure (embankment torn in multiple places) that allowed floodwater to overflow into nearby villages (Sentinel Digital Desk, 2021). Five of the nearby flood-affected villages and four non-flooded villages were selected at random for study.

[Figure 1 about here]

4. Results

4.1. Nature of flood-induced mobility its consequence on change in population dynamics

Displacement[1] and relocation are common in the flood-affected areas. More than one-fifth of the flood-affected participants (22.68 percent) were displaced temporarily to relief camps, roads, or relatives' houses. In 2021, seventeen households lost their homes to flooding, out of which fifteen households later got four *bigha*[2] of land each from the government and relocated to a different village. They, in addition to losing their properties, also lost their livelihood and lacked access to basic infrastructure such as electricity in their new habitat. Recovery, therefore, is a

[1] Displacement in this context means displacement or evacuation during flooding to relief camps, higher ground such as embankments or roads, and relatives' houses, most of these displaced people return to their homes post-floods. A few of these displaced people who incurred damage to houses or severe losses had to relocate for an extended period (or permanently) even after the floodwater receded, which can be captured in their length of stay at their current residence. It is logical to think that those who stayed less than one year at their current residence have recently relocated due to the 2021 flooding. This is the logic behind using 'displacement' and 'duration of stay at current place of residence' as two separate independent variables.

[2] A local unit of measurement, 7.5 bighas in Assam, is equal to 1 hectare

long-term process. Evidence of long-term mobility at the household level is gathered from the households' duration of their stay at their current place of residence; the median year of stay at the current place of residence is higher in the non-flooded villages (Appendix Figure 1). The association between flood exposure and duration of stay at the current place of residence is found to be significant[3]. Individual migration for employment is going on in parallel with household migration. Floods erode resilience; due to limited opportunities for diversification into other occupations in situ, people migrate for employment. The number of households with at least one person outmigrating[4] is significantly higher in the flood-affected villages[5]. Young, and often less-educated, males going out to earn a livelihood are the general characteristics of our migrants from the area. Other 'push' factors driving outmigration from the area include meagre land holding size. These characteristics point to 'distresses'-driven outmigration intended to supplement household income. Over three-fourths of the migrants (78.13 percent) leaving flood-affected areas send back remittances to their families, and half of them send back every month[6].

Migration in the flood-prone areas of Bongaigaon is not a one-way process. In-migration from eastern Bengal to Assam began "abruptly" in the twentieth century and afterwards increased quickly and has remained a significant force for population change in Bongaigaon (Dyson, 2018; p. 206). By 1911, the commencement of voluntary streams of settlers began. This stream of settlers arriving from Mymensingh is Muhammadans and settled down in lower Assam, including parts of Bongaigaon. Recent changes in the social composition can be understood against the backdrop of a long history of inmigration and the ongoing displacement and relocation induced by recurring floods. Decreasing density and negative growth rates indicate 'depopulation'; this phenomenon is not present in all flooded villages. The migrants appear to be selective, with one of the two religious groups moving out and selling the riverine land at a lower price to the other[7], which alters the area's social composition. Even though the flooded and non-

[3] A chi-square test of independence showed that there is a significant association between flood exposure and duration at the current place of residence, $x^2(2, N=505)=101.93$, $p=.000$

[4] At least one member has out-migrated, irrespective of the timing; the event may be recent or several years ago.

[5] A chi-square test of independence showed that there is a significant association between flood exposure and the number of households with at least one member out-migrating, $x^2(2, N=505)=6.41$, $p<.05$

[6] Among 32 out-migrating households from flood-affected villages, 13 receive remittances every month, 5 receive them every alternate month, and 7 receive them less frequently. Only five households did not receive remittances back. Information on 2 households was not received.

[7] Information gathered during focused group discussion 4. The participants had been residing in their place of residence for a year. They had spent the previous 20 years in relief camps in Hapachora for a payment of three to four thousand rupees per household per year. Later, they bought small pieces of land amounting to one or half a Pura (2.5 Acres) that cost them 1 to 1.2 lakhs per Pura. The previous residents in Hapachora offered them the land for a lower price because it is close to the river. The participants expressed satisfaction with their possession and

flooded settlements are located nearby, there is a discernible difference in their religious composition. We have located a specific 'trapped population' group that are members of economically marginalised religious minorities who lack cultivable land and are engaged in toilsome jobs for sustenance[8].

[Insert Table 1 and 2 about here]

4.2.Flood, displacement, and health

4.2.1. Displacement: a protective factor for dermatological ailments?

Non-displacement during the recent floods increases the odds of dermatological diseases[9] by 3.14 times. The prevalence of dermatological ailments is one of the highest. During floods, floors and walls of houses get wet; disease vector moulds grow on wet floors and walls (Metts, 2008). Marooned in wet and slippery houses may increase the chances of traumatic wounds, cuts, and injuries. When exposed to floodwater contaminated with sewage, animal waste, and organic matter, the injured skin can exacerbate and cause various dermatological diseases (Azuma et al., 2014; Parker et al., 2022). Constructing more functioning and well-operated relief camps can fill this gap.

[Insert Table 3 and Figure 2 about here]

4.2.2. Shorter stay at current place of residence: a risk factor for psychological ailments?

When compared to those who have lived in their current place of residence for more than fifty years, the odds of developing PTSD, anxiety, and depression are two, five, and three times higher in participants who have lived in their current place of residence for one to ten years. The odds of developing anxiety, depression, and comorbidity are five, six, and two times higher in participants who have moved to their current place of residence in less than one year compared to the participants who have lived for more than fifty years, respectively.

[Insert Table 4 about here].

5. Conclusion

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in their decision to invest time in purchasing a piece of land that does not require paying rent (as they did in the past).

[8] Information is gathered during interviews with Key Informant1). Due to inter-community tension in the northern part of Kokrajhar between Bodo and Muslims, the Muslims were chased away. The religious minority people, around 11000 of them, later were brought to the current location in Bongaigaon by then MLA. There is literature on the Bodo and Muslim conflict following the Bodoland Accord of 1993, which occurred in several places, including Borpeta, Bongaigaon, Kokrajhar and Dhubri (Pathak, 2012; p. 20).

[9] A person reporting any one or a combination of these conditions, i.e. skin infection and allergic reaction, Tinea Pedis (fungal infection), and boil in head and body (bacterial infection) during or after August 2021 flooding

The frequent channel change of the tributaries of the River Brahmaputra and release of water from upstream areas intensify the flood and displacement problem. As flood water recedes, people return home only to be displaced by the subsequent waves of flood; some people relocate to a different locality. At the individual level, outmigration for work is significantly higher in the flood-affected villages. The history of inmigration into the area and the recent inmigration from the neighbouring districts due to communal conflict as well as selective outmigration is changing the social composition of the flood-prone areas. Self-reported health data among the flood-affected participants shows that short-term displacement during a flood is a protective factor for dermatological ailments, the disease with one of the highest prevalence rates among flood-prone people. On the other hand, a shorter stay at the current place of residence is a risk factor for mental ailments; relocation to new places increases the odds of developing anxiety, depression, and PTSD after the flood. It further suggests that recovery is a prolonged process and adequate attention is needed to protect the health and well-being of the people even after the flood recedes.

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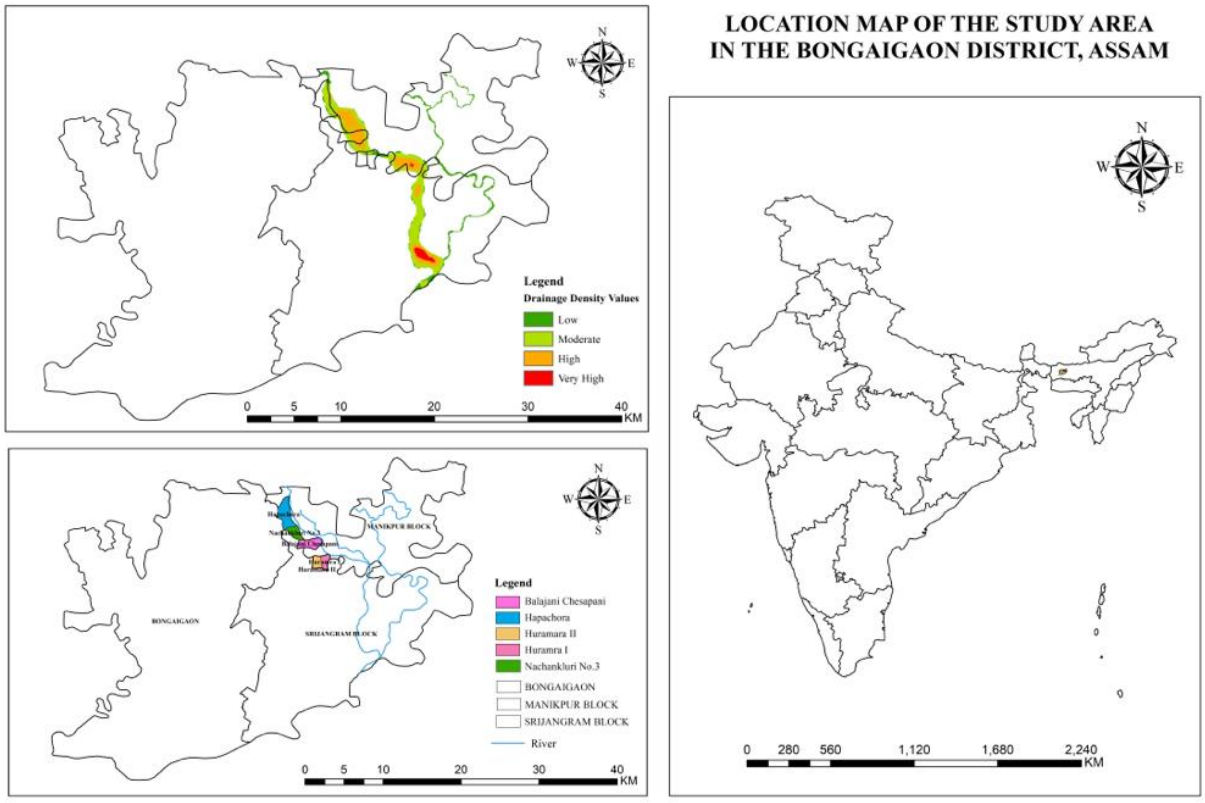

Figure 1: Location of Study area in Bongaigaon district, Assam
Source: Constructed by the researcher

Table 1: Village-Wise Total Population and Decadal Variation of Population, 1991-2011

	Total population			Decadal variation		Sex ratio, 2011	Density of population
Village	1991	2001	2011	2001-1991	2011-2001		
Balajani Checha Pani*	1306	1641	1546	335 (25.65)	-95 (-5.79)	1050.39	498.13
Hura Mara Pt I*	464	482	500	18 (3.88)	18 (3.73)	1040.82	310.95
Hura Mara Pt II*	666	725	639	59 (8.86)	-86 (-11.86)	1015.77	333.30
Nachankuri No.3*	440	833	1637	393 (89.32)	804 (96.52)	1001.22	776.20
Hapachora*	1298	1753	2084	455 (35.05)	331 (18.88)	990.45	1106.98
Thakurani Khora Para	1076	1100	1240	24 (2.23)	140 (12.73)	1046.21	460.88
Donkinamari	1304	1854	2085	550 (42.18)	231 (12.46)	959.59	1044.28
Fouzdar Dewan Para	1400	1468	1430	68 (4.86)	-38 (-2.59)	1106.04	467.7
Kaimari Lohra Para	822	909	986	87 (10.58)	77 (8.47)	983.90	460.88

Source: Primary Census Abstract, 1991, 2001, 2011, India
*Flooded villages

Table 2: Village-wise Religious Composition, 2022

Village	Hindu	Muslim
Balajani Checha Pani*	11 (14.5)	65(85.5)
Hura Mara Pt I*	10 (55.6)	8 (44.4)
Hura Mara Pt II*	47 (100)	0
Nachankuri No.3*	0	58(100)
Hapachora*	10 (17.9)	46 (82.1)
Thakurani Khora Para	83(98.8)	1 (1.2)
Donkinamari	31 (100)	0
Fouzdar Dewan Para	88 (100)	0
Kaimari Lohra Para	47 (100)	0

*flooded villages
Source: Primary survey, February-March 2022

Table 3: Association between Mental Health Outcomes Status of Displacement and Duration of Stay at the Current Place of Residence (Odds Ratio and 95% CI. Adjusted ORs are adjusted for all Potential Confounders)

	aOR (95%)			
Explanatory variables	**Probable PTSD (cases (n)=128, Sample size (N)=450)**	**Probable Anxiety (cases (n)=216, Sample size (N)=450)**	**Probable depression (cases (n)=176, Sample size (N)=450)**	**Probable comorbidity (cases (n)=93, Sample size (N)=450)**
Duration of stay in the current place of residence: More than 50 years	1	1	1	1
Less than 1 year	1.89(0.61-5.9)	4.09(1.17-14.29)*	5.64(1.57-20.22)**	2.56(0.83-7.95)
1 to 10 years	1.96(0.88-4.4)	3.64(1.52-8.69)**	3.42(1.51-7.76)**	1.83(0.77-4.34)
10 to 50 years	1.02(0.56-1.87)	0.7(0.41-1.19)	0.65(0.37-1.12)	0.94(0.48-1.85)
Duration of floodwater at the house premise: less than one week	1	1	1	1
More than one week	1.6(0.96-2.69)	1.69(1.04-2.75)*	1.9(1.15-3.12)*	1.58(0.89-2.81)
Depth of floodwater inside the house : less than 100 cm	1	1	1	1
More than 100 cm	1.68(0.94-3.01)	1.3(0.75-2.26)	1.87(1.07-3.28)*	1.3(0.68-2.47)
Status of displacement: not displaced	1	1	1	1
Displaced	1.12(0.67-1.86)	0.92(0.57-1.48)	0.79(0.48-1.3)	0.86(0.48-1.54)

** Significant at .01 percent; *significant at .05 percent

Source: Calculated by the researcher based on household survey data, February-March 2022

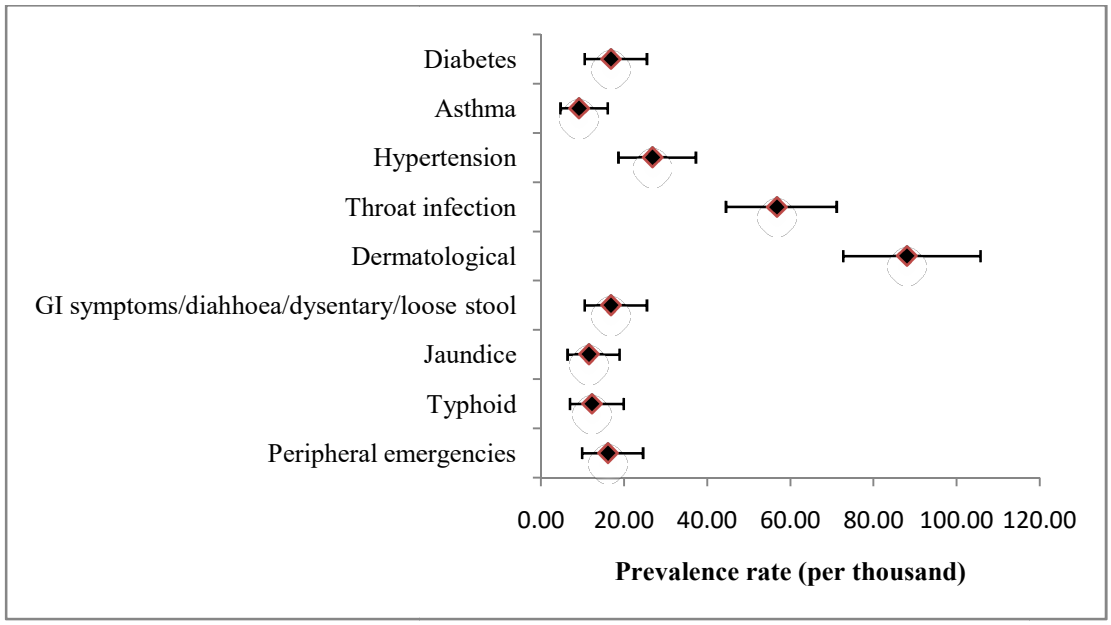

Figure 2: Period Prevalence Rates of Various Diseases from the day of flood till the time of survey

Table 4: Association between Dermatological Ailments and Years of Residence at the Current Place, and Status of Displacement (Adjusted Odds Ratios and 95% CI. Adjusted Odds Ratios are adjusted for all Potential Cofounders)

Explanatory variables	Number of individuals with **Dermatological illness (n)** 112; Sample size (N) 1305)
6. Years of residence: More than 50 years	1
Less than one year	1[10]
1 to 10 years	2.53(1.2-5.34)*
10 to 50 years	1.63(0.96-2.76)*
13. Status of displacement: Displaced[11] (296)	1
Not displaced (1009)	3.14(1.57-6.3)**

** Significant at .01 percent; *significant at .05 percent
Source: Calculated by the researcher based on household survey data, February-March 2022

[10] The number of positive cases in this category is zero
[11] Displacement during floods includes all those individuals who have shifted to relief camps, roads, embankments, or relatives' homes.

Appendix Table 1

1) Secondary Data Sources:

a) Census of India

Primary Census Abstract, Bongaigaon, 1991 to 2011. Data on village-wise population, overall as well as separately for males and females, village-wise population of 0 to 6 years, information on availability of healthcare centre –village wise are obtained.

b) Text sources:

- Driberg, J. J. S. (1883). *Report on the Census of Assam for 1881*. Office of the Superintendent of Government Printers.
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Appendix Table 2:

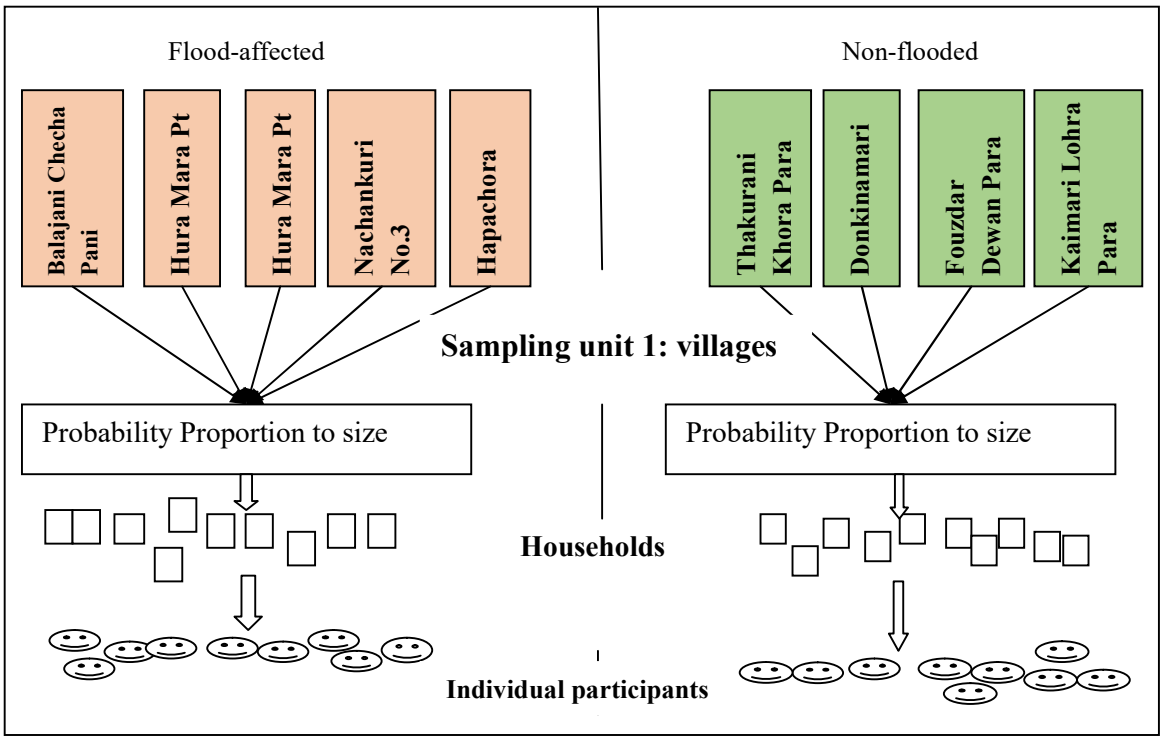


Table 2a: Stage-Wise Study Site Sampling
Source: Prepared by the researcher

Table 2b: Demographic Information of Key Informants

Number	Gender, age	Designation
KII 1	Male, 63 years	Retired school Headmaster
KII 2	Male, 55 years	Person in charge of a relief camp
KII 3	Male, 55 years	President, Kakoijana Panchayat
KII 4	Male, 40 years	Accountant, Sidalsatti MHPC
	Female, 45 years	Auxiliary Nurse and Midwife, Sidalsatti MHPC
KII 5	Male, 50 years	School headmaster
KII 6	Male, 40 years	Doctor, Sidalsatti MHPC
KII 7	Male, 45 years	Multi-Purpose worker, Sidalsatti MHPC
KII 8	Male, 50 years	Persons in charge of relief camp
	Male, 45 years	
KII 9	Female, 40 years	Accredited Social Health Activist Hura Mara II
KII 10	Female, 30 years	Accredited Social Health Activist, Hura Mara I
KII 11	Male, 45 years	Secretary, Village Development Party Nachunkuri No.3
KII 12	Male, 50 years	Panchayat Member, Hura Mara I
KII 13	Female, 40 years	Panchayat Member, Hura Mara II
KII 14	Male, 49 years	School headmaster
KII 15	Female, 33 years	Doctor, Hapachora Health and Wellness Centre

Table 2c: Village-Wise Distribution of FGDs and KII Participants

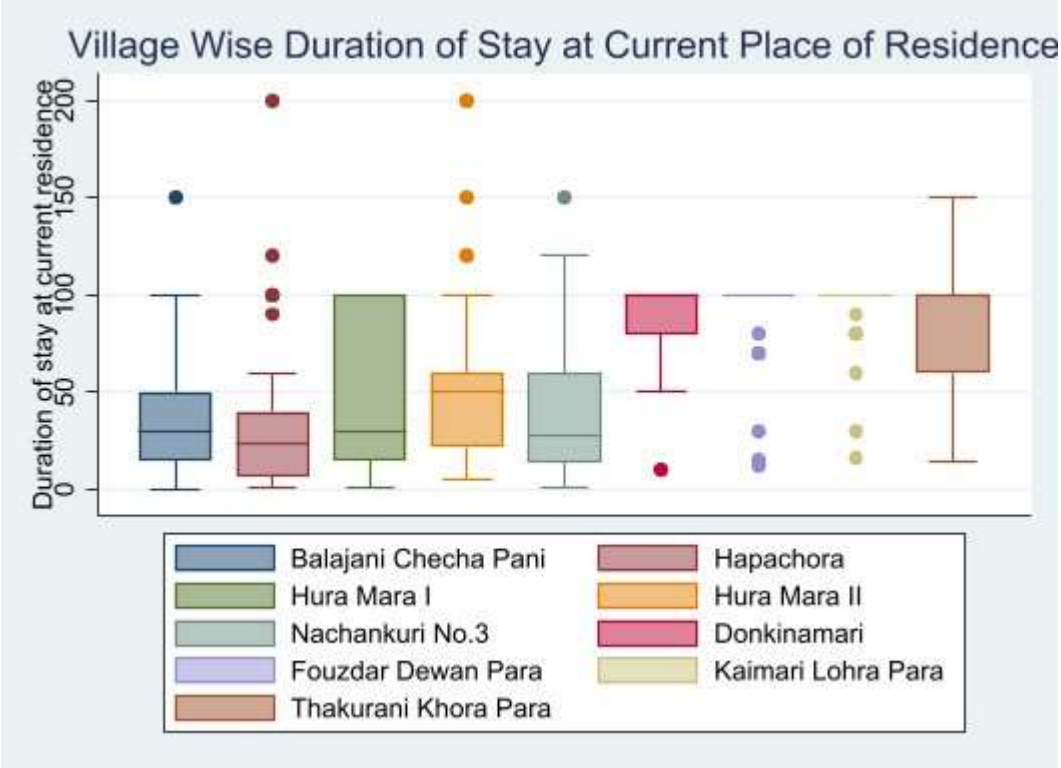
Block Name	Village Name	Focus group discussion (total number of participants)	Number of key informant interviews conducted
Srijangram	Hura Mara II	FGD 1 and 2 (13)	2
Srijangram	Hura Mara I	FGD 3 and 5 (15)	2
Manikpur	Hapachora	FGD 4 (7)	2
Manikpur	Nachankuri No.3	FGD 6 (8)	1
Srijangram	Balajani Checha Pani	FGD 7 and 8 (15)	10 (including healthcare workers and the person in charge of the relief camp)
Total		**8 (58)**	**17**

Table 2d: Village-Wise Sample Size Selected

Block	Village	Number of households as per Census 2011	Number of sample households	Population in sample households		
				Total	Male	Female
Srijangram	Balajani Checha Pani*	319	76	428	213	215
Manikpur	Hapachora	406	56	279	143	136
Srijangram	Hura Mara Pt I	111	18	74	35	39
Srijangram	Hura Mara Pt II	160	47	192	98	94
Manikpur	Nachankuri No.3	306	58	332	173	159
	Total flooded	1302	255	1305	662	643
Manikpur	Donkinamari	410	31	132	75	57
Srijangram	Fouzdar Dewan Para	295	88	345	166	179
Srijangram	Kaimari Lohra Para	221	47	181	94	87
Srijangram	Thakurani Khora Para	295	84	333	171	162
	Total non-flooded	1221	250	991	506	485

Source: Calculated by the researcher based on the cited information

Appendix Figure 1: Duration of stay at the current place of residence, village wise



Duration of stay	FLOOD-AFFECTED VILLAGES					NON-FLOODED VILLAGES			
	Balajani Chechapani	Hapachora	Hura Mara I	Hura Mara II	Nachankuri	Donkinamari	Fauzdar Deewanpara	Koimari Lohrapara	Thakurani Khurapara
< 1 year	1.32	3.57	16.67	0.00	8.62	0.00	0.00	0.00	0.00
1-10 years	9.21	30.36	5.56	4.26	6.90	3.23	0.00	0.00	0.00
11-20 years	34.21	10.71	11.11	14.89	31.03	0.00	2.27	0.00	3.57
> 21 years	55.26	55.36	66.67	80.85	53.45	96.77	97.73	100.00	96.43

Source: Primary Survey, February-March 2022

Appendix Table 3:

Table 3a: Survey Instruments, Level of Data Collection, and Participants of Primary Survey for Quantitative Data by Study Objectives

objective	Instruments used	Level of data collection	Participants	Total number of participants
Investigate the prevalence and risk factors of various diseases	Self-reported health effect checklist	Individual level	All the usual residents of the surveyed households	2296 (1305 flood-affected and 991 non-flooded)
Investigate the prevalence and risk factors of psychological morbidity	1. PHQ-4; 2. PCL-5	Individual level	All the usual residents without any pre-existing mental illness, above the age of 18 years and present at the time of the survey	866 (450 flood-affected and 416 non-flooded)

Source: Prepared by the researcher

Table 3b: Description and Characteristics of Variables Used in the Analysis to Find Out the Risk and Protective Factors of High-Prevalence Diseases

Outcome variables	**Description of the variable**		**Type of variable**
Typhoid	Whether the participant contracted the disease at any time after 14 August 2021 till the time of the survey		
Jaundice			
Dermatological ailments			
Throat infection			
Gastrointestinal diseases			
Explanatory variables			
Parameter	**Indicator**	**Description**	**Type of variable**
Demographic characteristics of the participants	1. Age	Age of the participant	Categorical
	2. Gender	Gender of the participant	Categorical
	3. Marital status	Marital status of the participant	Categorical
Environment	4. Years of residence	Years of stay at the current place of residence	Categorical
Proxies for socioeconomic status	5. Education	Among minors, i.e., those below 18 years of age, the father's education level (if the father is dead, then the mother's education) is	Categorical

		considered, not his or her education level.	
	6. Income quartile	The income quintile of the household the participant belongs to	Categorical
Severity of flooding	7. Depth of flood	Depth of floodwater inside the house	Categorical
	8. Duration	Duration of floodwater in the house premise	Categorical
Environment: Exposure to person-to-person contact	9. Displacement status	Whether the participant was displaced or evacuated during the flood	Categorical dichotomous
Condition of water and sanitation	10. Source of drinking water	Main source of drinking water	Categorical
	11. Type of toilet	Type of toilet used in participants' home	Categorical
Environment: exposure to mould	12. Material of floor	Material used on the floor of participants' home	Categorical
	13. Material of walls	Material used in the walls of participants' home	Categorical

Table 3c: Description and Characteristics of Variables Used in the Analysis to Find Out Risk and Protective Factors of Mental Health Outcomes

Outcome Variables		**Types of Variable**
Probable PTSD		Categorical dichotomous
Probable anxiety		
Probable depression		
Probable PTSD, anxiety and depression		
Explanatory Variables		
Parameters	**Indicators**	**Types of Variable**
Severity of flooding	1)Depth of flood water inside the house; 2) duration of flood water in house premise	Categorical Categorical
Warning and displacement	3)status of flood warning; 4) status of displacement ;	Categorical Categorical
'Loss' stressors arising after flooding	5)crop lost; 6)livestock lost; 7)workdays lost; 8)damage to houses that needed repairing	Categorical dichotomous
Socioeconomic characteristics of household	9) income; 10)duration of stay at the current place of residence	Categorical Categorical
Demographic characteristics of participants	11)age; 12)gender;	Categorical Categorical dichotomous

	13)marital status;	Categorical
	14) education attainment	Categorical
	15) disease prevalence after flood[12];	Categorical dichotomous
	16) presence of chronic illnesses or long-term health conditions[13]	Categorical dichotomous

[12] Prevalence of these health conditions was reported after a flood: fractured hand and leg; drowning; cuts and injury; body pain; weakness; gastrointestinal symptoms (upset stomach, vomiting, nausea); diarrhoea/dysentery/loose stools; jaundice; typhoid; malaria; other skin infection and irritation (not tinea pedis); eye infection.

[13] Chronic and long-term health conditions identified among the participants are- hypertension, asthma, low blood pressure, diabetes, heart condition, paralysis, TB, liver problems, blindness, epilepsy, birth deformity, cancer, chest pain, and nerve problems