

Geographic variability of post-disaster mental health: Case study after the 2017 flood in Bangladesh

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Abstract

Every year Bangladesh faces enormous damages due to flooding. Facing these damages the Government adopts various recovery approaches. However, the psychological dimension of any disaster is generally overlooked in disaster management. Researchers have found that the spatial distribution of post-disaster mental health can help the authorities to apply recovery procedures where they are most needed. For this research, Posttraumatic Stress Checklist (PCL-5), Patient Health Questionnaire (PHQ-9) and Generalized Anxiety Disorder-7 (GAD-7) were used to estimate posttraumatic stress, major depressive disorder and anxiety following three episodes of severe floods in 2017 that affected at least 8 million people. To better understand the spatial pattern of psychological vulnerability and reach a comprehensive scenario of post-disaster mental health, Moran's *I* was applied for spatial autocorrelation and Pearson's correlation and regression analysis for a study of the relationship between the psychological aspects. It was found that psychological vulnerability showed a spatial clustering pattern and that there was a strong positive linear relationship among psychological aspects in the study area. This research might help to adopt disaster management policies that consider the psychological dimension and spatial distribution of various psychological aspects to identify areas characterized by high vulnerability and risk so that they can be reached without delay.

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Introduction

According to the World Health organization (WHO), disasters disrupt normal conditions of existence and generally cause a level of suffering that exceeds the capacity of adjustment of affected communities (WHO, 2002), while the United Nations Office for Disaster Risk Reduction (UNISDR) defines a disaster 'A serious disruption of the functioning of a community or a society involving widespread human, material, or environmental losses and impacts which exceeds the ability of the affected community to cope using only its own resources' (UNISDR, 2009). Indeed, human existence, environment and disaster are all intertwined, and disasters can be referred to as a complex mix of natural hazards and human reaction (Wisner *et al.*, 2004). Disasters such as cyclones, flooding, drought periods, earthquakes *etc.* are often unanticipated and uncertain. Among natural hazards, floods may be the most common as they often take place annually and from the early age of civilization humans have been faced by inundation and destruction of settlements. In the ancient past, disasters were often considered as expressions of the Gods' wrath and the myth of floods is frequent in human mythologies, *e.g.*, in the Christian Bible. However, flooding is a natural phenomenon that cannot be prevented and therefore cause large-scale human distress.

Floods and other disasters have considerable and continuous impacts on both physical and mental health of affected populations as well as on the way of daily life (Freedy and Simpson, 2007; Kim *et al.*, 2008; Niekerk, 2011; Usman *et al.*, 2013; Makwana, 2019; Gaillard *et al.*, 2019; WHO, 2020). Exposed populations that are directly or indirectly affected by strong hazards usually show remarkable distress, while one type of disaster often results in different individual responses. It has been seen that vulnerability and resilience of an individual can significantly influence emotional responses (Gruebner *et al.*, 2015), but these responses to disasters do not always appear immediately sometimes taking months to become established (Mental Health America, 2018). People generally suffer from mild to severe mental health problem in post-disaster periods according to an epidemiological projection by WHO (2019). WHO estimates that 20 to 40% of people involved develop mild psychological symptoms, whereas as many as 30 to 50% may suffer from moderate to severe psychological mental health problems (WHO, 2019). Norris *et al.* (2002) conclude that 22 to 77% people suffer post-traumatic stress, anxiety and depression after major natural disasters. In addition, psychological conditions during and after a hazard can positively influence hazard impacts that sometimes get worse over time (Norris, *et al.*, 2002; McFarlane and Williams, 2012; Makwana, 2019). It is often thought that people with psychiatric disorders and severe mood disorders are more vulnerable and less able than others to cope effectively with disaster related stressors (Jankowski, 2016). However, it is an obvious fact that any people affected by disasters will suffer from long-term trauma, often developing poor mental health conditions afterwards



(Freedy and Simson, 2007; Gruebner *et al.*, 2015; WHO, 2017).

Moreover, people in low- and middle-income countries react mentally more adversely during natural hazards, and the psychological recovery process is slower than in developed countries (Norris *et al.*, 2002). Southeast Asia is particularly vulnerable to natural disasters with examples including first-page news, such as the 2007 Sidr cyclone in Bangladesh, the 2008 Nargis cyclone in Myanmar and the great earthquake of 2015 in Nepal (ADB, 2019; Gonzales, 2019). Besides, flooding is a recurring phenomenon in Bangladesh. Still, the mental trauma and long-term effects of the affected communities during these and other disasters have been overlooked.

Disaster database and statistics of Bangladesh show that the country has witnessed a severe flood event about every 7 years and a catastrophic one with 33 to 50 years interval. Whenever it occurs, people suffer and the government cannot easily deal with the damages caused with respect to agriculture, people's livelihood, environment and infrastructures, such as roads, embankment, buildings, *etc.* along with health conditions (both physical and mental). Flooding affects exposed populations in a significant way and the economic damages caused have medium- to long term-impact on social relationships, individual well-being and physical as well as mental health (Alderman *et al.*, 2015). It is also evident that those in a poor mental state are more vulnerable during disasters and therefore unable to overcome the situation. Moreover, studies of psychological vulnerability are important for the recovery from disastrous situations. Because psychologically strong people as well a community as a whole can be able to build on the community resilience rather than relying on outside support, *e.g.*, in the United Kingdom mental health problems along with other chronic disabilities can cause 80% of the estimated disability in adjusting life after disasters as shown by a study covering the period 2003 to 2008 (Fewtrell and Kay, 2007). The field of hazard and disaster studies mental health has not received interest from researchers until recently. Researchers have started to explore the determinants that are directly responsible for poor mental health conditions including posttraumatic stress disorder (PTSD), major depressive disorder and generalized anxiety disorder in the post disaster period (Ginexi *et al.*, 2000; Agaibi and Wilson, 2005; Kar and Bastia, 2006; Ursano, *et al.*, 2006; Goldmann and Galea, 2014). Till now, researchers have identified and documented various vulnerability factors which impact mental well-being negatively (Rodriguez-Llanes *et al.*, 2013). Such vulnerable factors are high-exposure levels, poor socio-economic conditions, inconsistent demographic structure and frequent traumatic incidents. Moreover, several research results to date show that psychological distress after disasters varies across geographic space (Curtis *et al.*, 2007; DiMaggio *et al.*, 2010; Maghrabi, 2012; Gruebner *et al.*, 2015). Often low levels of psychological distress are centralized in specific geographic areas, and researchers have shown potential use of geospatial analysis to understand the distribution pattern of psychological distress, *e.g.*, the spatial pattern of psychological vulnerability in Gobindaganj Upazila after the 2017 flood.

In this research, we have considered two hypotheses; the null hypothesis that there is no spatial pattern of psychological vulnerability in the study area and the alternative hypothesis that there is a spatial pattern of psychological vulnerability that can be used to direct authority as to where the recovery process should begin, and which geographic areas have the greatest need for post-disaster services. The two objectives were: i) to measure the psychological vulnerability and analyse spatial pattern using spatial statistics; and ii) to investigate the geographical variability of psychological vulnerability in the study area.

Materials and methods

We chose to present a case study since this approach gathers both qualitative and quantitative data producing a more vigorous picture of the consequences due to hazards in the study area considering the space dimension. In addition, case-based research provides in-depth descriptions of a process or phenomenon within a bounded system or settings as pointed out by Weiss (1995) and more recently by Marshall and Rossman (2010).

Study area selection

In 2017, three episodes of severe floods affected large areas of Bangladesh that caused loss of lives and affected the livelihoods of at least 8 million people. The northern part of the country was hit by heavy rains in August, which caused rivers to overflow resulting in severe floods in 31 out of the country's 64 districts (Prothom Alo, 2017; DhakaTribune, 2017; NIRAPAD, 2017). In Gaibandha District, Gobindaganj Upazila is one of those Upazilas that faced massive damage due to the 2017 flood (NDRCC, 2017) (Figure 1). The unions (the smallest rural, administrative units) of Sapmara, Gumaniganj, Gobindaganj Pourashava, Rakhil Baruz, Darbasta, Taluk Kanupur and Nakaihat were the most affected ones in Gobindaganj Upazila. These unions were mostly affected when by the river Karotoya on 20 August 2017 reached 21.41 m above the Public Works Datum (PWD), a measure related to the mean sea level and used to indicate when danger levels are reached. With a danger level for this river declared at 20.15 m PWD (1.08 m above its normal level), this was 1.26 m above the danger level (Davies, 2017). Several ox-bow lakes (a U-shaped water body formed when a meandering part of a river is cut off), channel placements, low-lying areas near the river, damaged embankment and settlements outside of the embankment greatly influenced the damages. For such reason, Gobindaganj Upazilla (Figure 1) was considered for this study.

Sampling

We stratified the sampling procedures into two layers. First, considering the nature of this research, a river of Gobindaganj Upazila was considered as the major geographic variable and based on the location of that river 56 sampling point were determined (Figure 2). Among those points, several were selected within 2-km distance along both sides of the river. For the points across the river, perpendicular lines were drawn through each point along the river and further two sub-points for each base point selected with a 1-km interval. Some places were intentionally avoided to prevent the results from overlapping. Secondly, stratified random samplings were considered to determine the possible points of sample for data collection, Stratified Random sampling, also sometimes called proportional or quota random sampling, involves dividing the population into homogeneous subgroups and then taking a sample random in subgroups (Trochim, 2018). From each point we randomly selected a number of representatives for different stakeholders for a questionnaire survey. In total, 106 males and females were studied.

Study variables and tools

For the study of psychological vulnerability of Gobindaganj Upazila after 2017 flood, both primary data and secondary data were used to conduct this research work. Population data and satellite imageries were the secondary data and those were collected from Bangladesh Bureau of Statistics (BBS) and Google Earth, respectively. To achieve the aim of this research work, the questionnaire

survey and spatial statistical analysis were conducted. In the first phase, the individual's behavioural symptoms (*e.g.*, suicidal tendency, low energy, *etc.*) and physical symptoms (*e.g.*, insomnia, headache, *etc.*) were considered and when collecting the data for PTSD and the depression and anxiety levels from the study area using the following different tools.

Posttraumatic stress checklist for posttraumatic stress disorder

Posttraumatic stress disorder can be measured by the PCL-5, which consists of 20 questions that assesses the symptoms of PTSD developed by Weathers *et al.* in 2013 and used by Blevins *et al.* (2015), the National Center for PTSD (2019) and others). In the

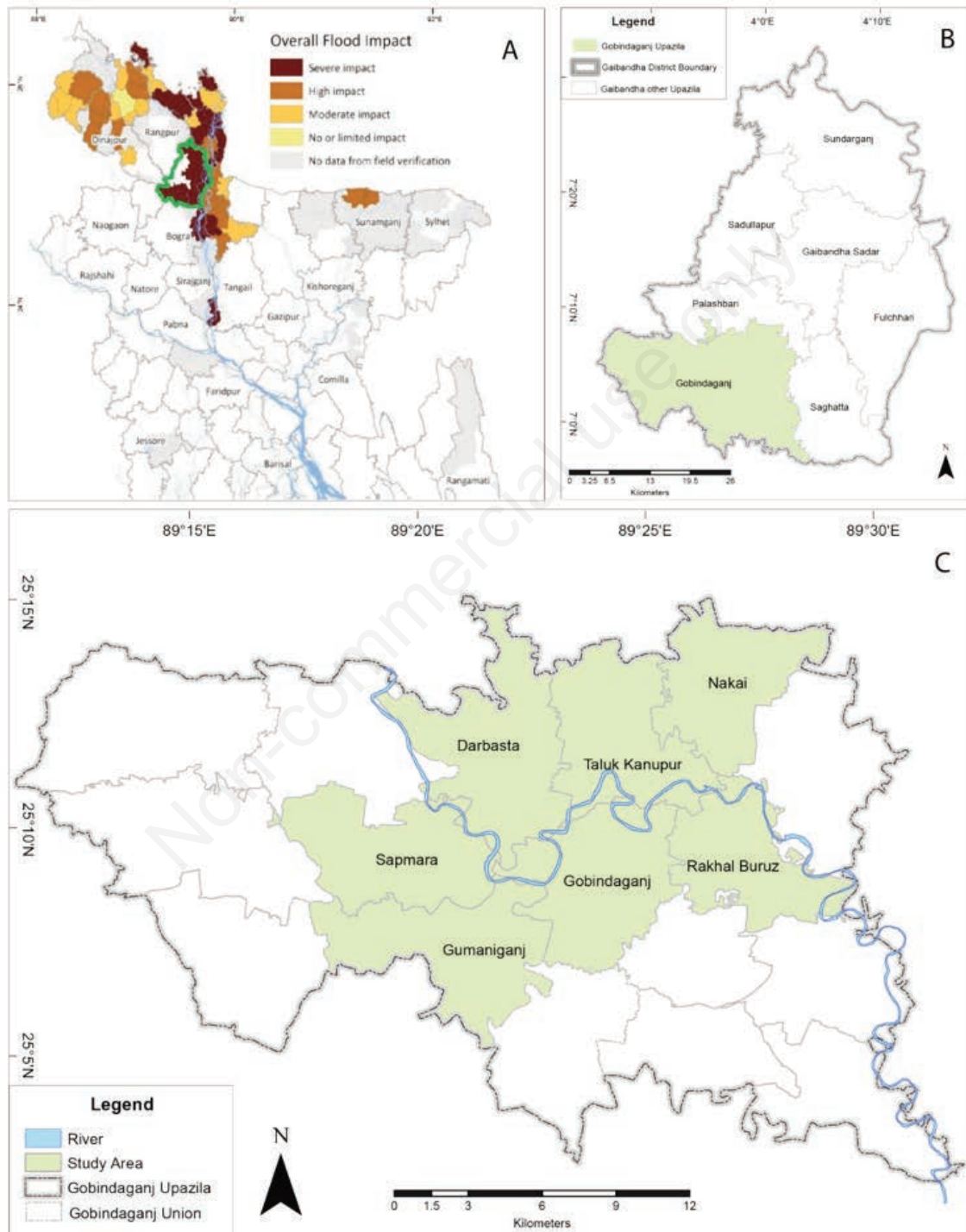


Figure 1. Study area. A) Green area depicts the severely impacted Gaibandha District (source: NDRCC, 2017); B) Gobindaganj Upazila highlighted in the Gaibandha District Map; C) Study area showed in Gobindaganj Upazila Map.

Diagnostic and Statistical Manual of Mental Disorder-4th edition (DSM-4), PCL has three versions: for the military (PCL-M), for civilians (PCL-C) and for specific use (PCL-S). Each of them uses a small degree of different instructions and wording. PCL-5 is most similar to the PCL-S version and often considered the 'golden standard' and reliable tools for screening posttraumatic stress disorder (Blevins, *et al.*, 2015; Osório, *et al.*, 2016; Ibrahim, *et al.*, 2018; Magowan, 2018; American Psychological Association, 2018; Fung, *et al.*, 2019; National Center for PTSD, 2019). It categorizes the posttraumatic stress into four level ranging from 0 to 80.

The generalized anxiety disorder for anxiety disorder

GAD-7 is a seven-item self-report anxiety questionnaire developed by Pfizer Inc. (Williams, 2014). GAD-7 was originally developed as a measure to identify the presence of generalized anxiety disorder. It is considered as helpful and reliable tools for the identification of other common anxiety disorders in clinical practice, such as - panic disorder, social anxiety disorder (Kroenke *et al.*, 2007).

Patient health questionnaire-9 for depression

PHQ-9 is a module of a larger Patient Health Questionnaire, an assessment that patients can complete to screen for mental health conditions developed by Pfizer Inc. It assesses the symptoms of depression identified in DSM-4 by 9 short, general questions and then categorizes the results into five different level of depression. The value of PHQ-9 varies from 0 to 27 and considerably outstanding for diagnose depression (Kroenke, *et al.*, 2001; Rathore, *et al.*, 2014; Rancans, *et al.*, 2018; Maroufizadeh, *et al.*, 2019).

A well-structured questionnaire was developed following PCL-

5, GAD-7 and PHQ-9 along with other general community level questions and used as survey instrument for the data collection. We compiled the answers of the respondents in order to understand how the people reacted as a whole psychologically and estimated their vulnerability level based on the individual scale. The participants were also asked to state their conditions immediately after the flood.

In the second phase, the collected psychological vulnerability data were spatially analysed applying geographical information systems (GIS) with Moran's *I* for spatial autocorrelation. In addition, Pearson correlation coefficient was calculated, and regression analysis carried out using SPSS software. Besides, GIS and remote sensing was used throughout the whole study for georeferencing, digitizing and map production.

Questionnaires

Posttraumatic stress disorder, generalized anxiety disorder and major depressive disorder calculations

Three questionnaires were used as surveying tools with different scale and calculation procedures as described in Table 1. We followed the default calculation procedures for categorize the value according to the scale for further analysis.

Psychological vulnerability

As mentioned previously, posttraumatic stress, anxiety and depression were assessed and measured by PCL-5, GAD-7 and PHQ-9, respectively. These three tools have different scales of measurement, so we converted the measurement scale into a generalized scale to bring all three aspects into one generalized analy-

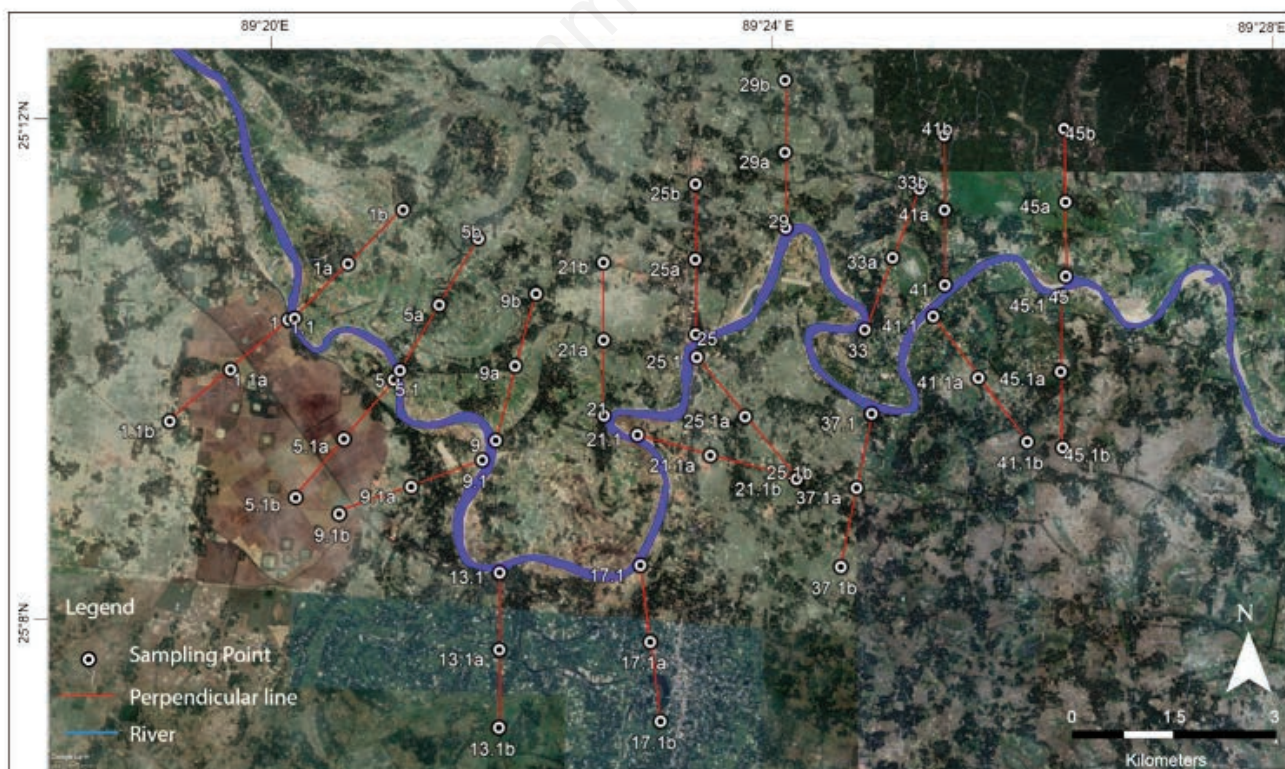


Figure 2. Sampling points.

sis platform to be able to compare the level of their psychological vulnerability. The following formula was used for the conversion of the PTSD, depression and anxiety:

$$V_{PA} = \frac{V_i}{V_H} \tag{1}$$

where V_{PA} represents the psychological aspect considered in this study; V_i the value obtained by an individual for PTSD/anxiety/depression; and V_H the highest value of the scale used in the PCL-5/GAD-7/PHQ-9 calculations.

Statistical analysis

Reflecting the idea of Tobler’s first law of geography (1970) which states that ‘*Everything is related to everything else, but near things are more related than distant things*’, spatial autocorrelation measures the connections and degree of connectedness of close objects compared to other close objects.

Spatial patterns refer to a perceptual composition, position and organization of objects which also consider the space between those objects. Depending on the objects’ arrangement and position, patterns can easily be identified whether it is a cluster linearity, *i.e.* in the X-Y plane, or a spatial pattern with a visible regularity. However, when potential patterns are not easily discerned, spatial statistics is required (Bass, 2015). Spatial autocorrelation is multi-directional and multi-dimensional, making it useful for finding patterns in complicated datasets. While other correlation coefficients measure correlations spanning from perfect to none, Moran’s *I* is slightly different (due to the more complex, spatial calculations) varying from -1 (perfect dispersion) over 0 (no autocorrelation at all, *i.e.* perfect randomness) to +1 which indicates (perfect clustering of similar values, *i.e.* total opposition to dispersion). Using the formula below, Moran’s *I* of spatial autocorrelation can identify whether similar characteristics are clustered or randomly distributed in space (ESRI, 2005):

$$I = \frac{n}{S_o} \frac{\sum_{i=1}^n \sum_{j=1}^n w_{i,j} z_i z_j}{\sum_{i=1}^n z_i^2} \tag{2}$$

where z_i is the deviation of an attribute of feature i from its mean; $w_{i,j}$ the spatial weight difference between features i and j ; n the total number of features; and S_o the aggregate of all the spatial weights.

Regression analysis was conducted in SPSS software in order to observe the relationship pattern among the psychological aspects considered. The following formulas were used for the correlation coefficient:

$$r = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2 \sum(y - \bar{y})^2}} \tag{3}$$

where R represents Pearson’s correlation coefficient; x the mean of the x variables; and y mean of the y variables.

$$y = A + Bx$$

where

$$A = \frac{(\sum y)(\sum x^2) - (\sum x)(\sum xy)}{n(\sum x^2) - (\sum x)^2} \tag{4}$$

$$B = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$$

The regression formula depicts how the dependent variable will change when one or more independent variables change due to factors. In the regression analysis, formula, Y is the dependent variable; X is the independent variable; A is the intercept and B is the slope.

Table 1. Scales used for the questionnaires.

Mental health condition	Measuring tool	Scale		Collected value (mean)
		Score	Category	
Post-traumatic stress disorder (PTSD)	Post-traumatic stress Checklist (PCL-5)	0-20	Mild	Maximum: 62.5 Minimum: 24.5
		20-40	Moderate	
		40-60	Severe	
		60-80	Extreme	
Generalized anxiety disorder (GAD)	Generalized anxiety disorder-7 (GAD-7)	5-9	Mild	Maximum: 17 Minimum: 6
		10-14	Moderate	
		15-21	Severe	
Major depressive disorder (MDD)	Patient health questionnaire (PHQ-9)	0-4	Normal range	Maximum: 18.5 Minimum: 4.5
		5-9	Minimal	
		10-14	Mild	
		15-19	Moderate	
		≥20	Severe	

Results

Spatial distribution of posttraumatic stress disorder

From a general viewpoint of Figure 3, the number of extreme PSTD cases was relatively low (5.7%), and they were found at the adjacent points to the river. Most cases with a moderate PSTD level were found 2 km away from the river and only a few of them (3.8%) around 1 km from the river. However, also some with severe-level PSTD were found between these two categories. Importantly, all cases did not follow this scenario as the topography in some places included ox-bow lakes with very low-lying areas and thus created highly vulnerable conditions resulting in the presence of cases with higher levels of higher-level PSTD unrelated to the distance from the river (see maps 3, 4 and 5). These cases were found in the south-western part of Darbasta Union and they were labeled 'exceptional' as they were due to various local, micro-scale geographic variables.

We also found a difference in the level of post-traumatic stress between males and females. The PTSD score was significantly higher in women; *e.g.*, in the study community, 19.8% of the males and 15.1% of the females showed moderate levels of PTSD, while 28.3% of the males and 31.1% of the females showed severe-level PTSD. Only 1.9% of the males showed extreme-level PTSD, whereas the figure for the females was as high as 3.8%.

Spatial distribution of generalized anxiety disorder

In Figure 4, GAD cases with severe anxiety (24.52%) were found at points adjacent to the river and several exceptional cases in

Darbasta Union and in the western part of Gobindaganj. Moderate-level GAD cases (49.06%) were also found at points adjacent to the river, but 1 km and also 2 km away. As for the PTSD cases, several 'exceptional' cases were found throughout the whole study area. Besides, mild-level GAD cases (26.41%) were found 2 km far away from the river and some 'exceptional' cases were also detected there. As the case for PTSD and MDD, the GAD values also varied between the male and female groups. Females tend to have higher level of anxiety than males; *e.g.*, 17.9% of them showed severe-level GAD, whereas only 8.5% of the males reacted with severe-level anxiety. Whereas 25.5% of the males showed moderate levels of anxiety, only 22.6% of the females did so. With respect to mild anxiety, 9.4% of the females showed these symptoms, while as many as 16.0% of the men reacted this way.

Spatial distribution of major depressive disorder

Figure 5 shows that normal and minimal depression cases were found as far as 2 km from the river. Moderate-level MDD cases were found at adjacent points to the river and a few 'exceptional' cases were seen in the south-western part of Darbasta Union and the western part of Gobindaganj, while mild forms occurred in the area 1 km from the river and also in the southern part of Taluk Kanupur Union. In addition, there were differences in the level of MDD between males and females. The score was significantly higher in women, *e.g.*, moderate MDD cases were found in 12.3% of the males, whereas this affection reached 15.1% in the females. Besides, 22.6% of the males and 24.5% of the females showed mild-level MDD. On the other hand, 13.2% of the males and 10.4% of the females suffered from minimal-level MDD and 1.9% of the males showed normal MDD levels.

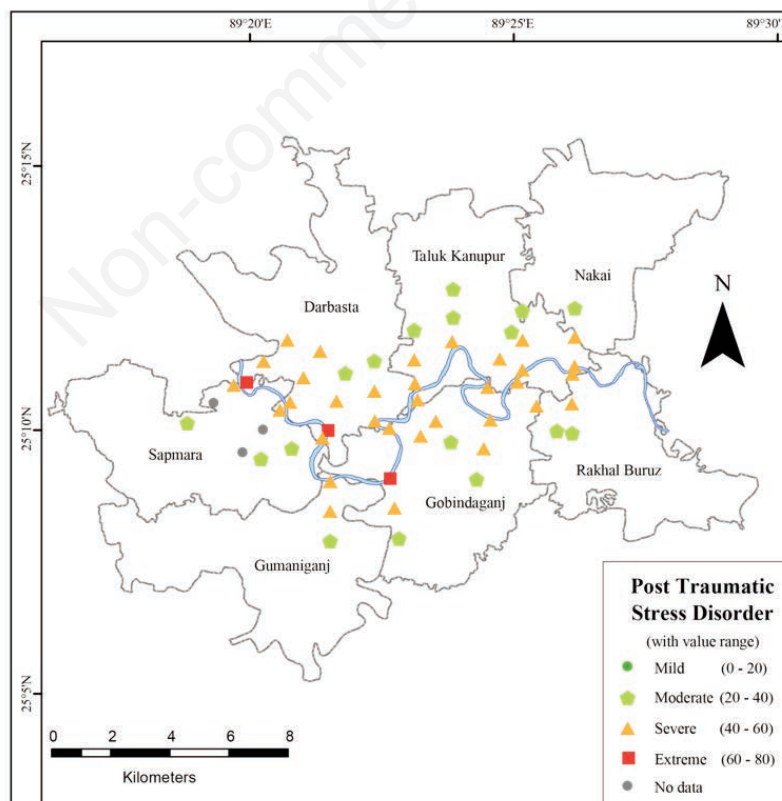


Figure 3. Spatial distribution of post-traumatic stress disorder in the study area.

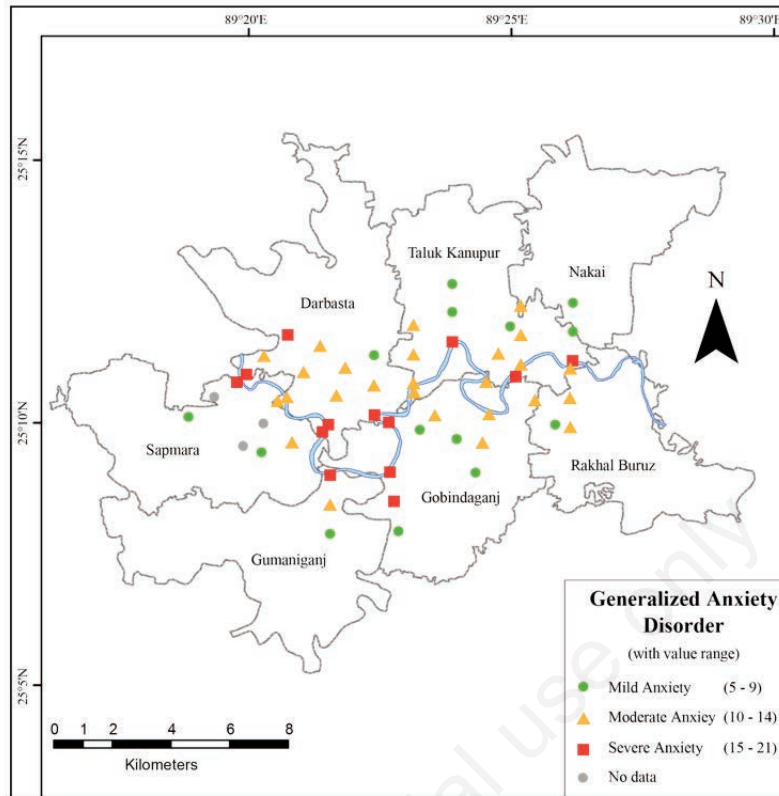


Figure 4. Spatial distribution of generalized anxiety disorder in the study area.

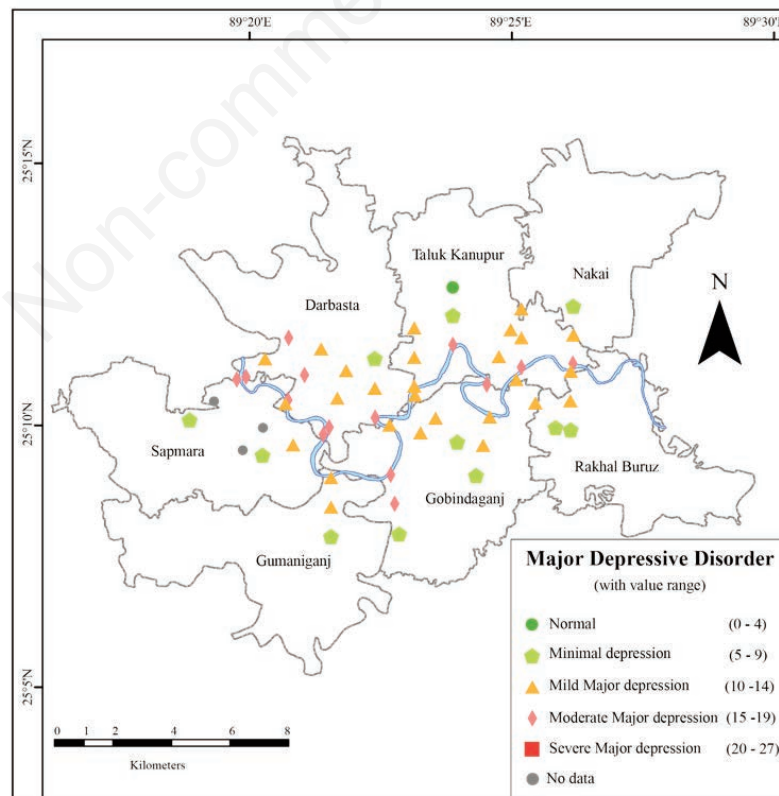


Figure 5. Spatial distribution of major depressive disorder in the study area.

Autocorrelation

Moran's *I* autocorrelation results are presented in Table 2, where it can be seen that the values for PTSD, GAD and MDD were all positive and greater than 0, which indicates perfect clustering of similar values. On the other hand, the positive Z-scores indicate that data were spatially clustered in some way. The P-values, considered as proof against the null hypothesis, were equal and less than 0.0002 which indicate a likelihood of less than 0.02% that the clustered pattern emanating from Moran's *I* and Z-scoring could have been the result of random chance. Thus, the mental health conditions of the community studied were obviously clustered, and we noted that the high values of PTSD, GAD and MDD near the river gradually decreased with increased distance from the river.

Level of the psychological vulnerability in the study area as a whole

As mentioned previously, the PTSD, GAD and MDD data values were normalized by converting them into a joint scale. Based on this approach, Table 3 presents the psychological vulnerability

level of the study community. Since the three aspects of the psychological state (stress, anxiety, depression) can be presented jointly after normalizing the values by converting the values at each sample location, the values of each point of the popular vulnerability level can be mapped and presented graphically (Figure 6). In the map, every point value from first row (the orange line), every point from second row (the blue line) and every point from the third row (the green line) can be visualized. Besides, these values have plotted in triangles. The same procedures were executed to develop the same triangle for both the southern and the northern points. Thus, after plotting the normalized value in triangle anyone

Table 2. Summary of the autocorrelations found in the study area.

Statistic	PTSD	GAD	MDD
Moran's <i>I</i>	0.65	0.66	0.64
Z-score	3.84	3.82	3.71
P-value	≤0.0001	≤0.0001	≤0.0002

PTSD, posttraumatic stress disorder; GAD, generalized anxiety disorder; MDD, major depressive disorder.

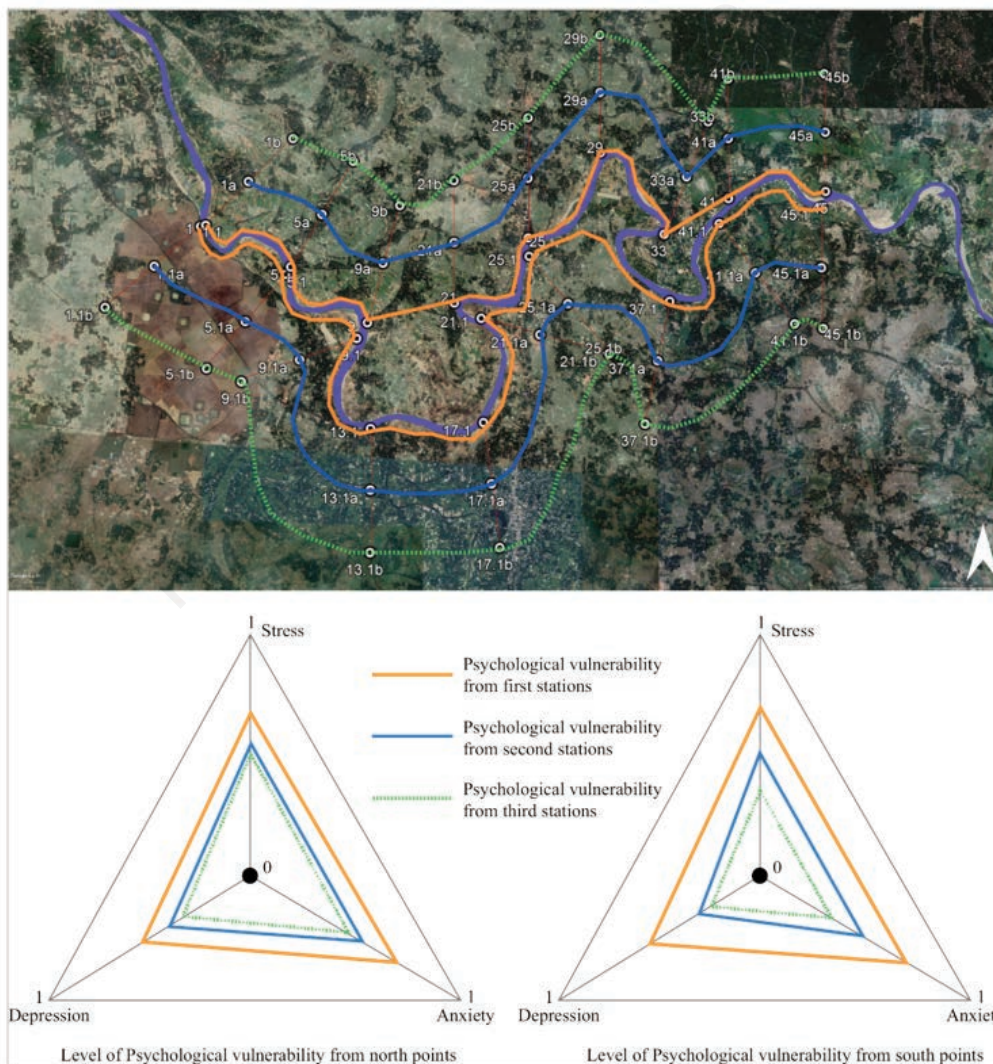


Figure 6. Level of psychological vulnerability of the study area.

can get a holistic understanding of psychological vulnerability of the study community.

These triangles clearly represent the psychological vulnerability level of the community. From the figure it can be seen that the higher level of psychological vulnerability was localized at the adjacent areas of the river and decreased with the distance further away.

The Pearson correlation values are presented in Table 4, showing that the considered three aspects of psychology (post-traumatic stress, anxiety and depression) share a strong positive linear relationship in the studied community. It can be seen that an increase in one aspect of psychology can promote the other two aspects as conveyed by the marked lines.

A simple linear regression was calculated to predict the relationship of three psychological aspects (Table 5). We first calculated the MDD based on the PTSD finding a significant regression

equation ($F(1, 54) = 435.161, <0.000$), with an R^2 of 0.890. This value indicates the proportion of variance in the dependent variable (depression) which can be explained by the independent variables (stress). This is an overall measure of the strength of association and does not reflect the extent to which any particular independent variable is associated with the dependent variable. SE is the standard deviation of the error term and the square root of the mean square.

Discussion

When a natural event or a disaster strikes, the effects on human life and the physical damages caused are spatially delineated. As a result, people suffer from stress, anxiety and depression in the post-disaster period. However, the level of the psychological con-

Table 3. Level of psychological vulnerability of the studied community.

Sample station	Respondent (gender)	Sample (number)	Mean		
			PTSD	GAD	MDD
North - first stations (Points adjacent to the river) (1, 5, 9, 21, 25, 29, 33, 41, 45)	Both	18	0.69	0.72	0.55
	Male	9	0.68	0.67	0.53
	Female	9	0.71	0.78	0.57
North - second stations (Points 1 km from the river) (1a, 5a, 9a, 21a, 25a, 29a, 33a, 41a, 45a)	Both	18	0.56	0.54	0.40
	Male	9	0.53	0.49	0.39
	Female	9	0.58	0.59	0.42
North - third stations (Points 2 km from the river) (1b, 5b, 9b, 21b, 25b, 29b, 33b, 41b, 45b)	Both	18	0.50	0.47	0.35
	Male	9	0.48	0.42	0.33
	Female	9	0.52	0.51	0.37
South - first stations (Points adjacent to the river) (1.1, 5.1, 9.1, 13.1, 17.1, 21.1, 25.1, 37.1, 41.1, 45.1)	Both	20	0.65	0.72	0.48
	Male	10	0.65	0.68	0.47
	Female	10	0.66	0.76	0.49
South - second stations (Points 1 km from the river) (1.1a, 5.1a, 9.1a, 13.1a, 17.1a, 21.1a, 25.1a, 37.1a, 41.1a, 45.1a)	Both	16	0.46	0.45	0.31
	Male	8	0.44	0.42	0.29
	Female	8	0.48	0.48	0.34
South - third stations (Points 2 km from the river) (1.1b, 5.1b, 9.1b, 13.1b, 17.1b, 21.1b, 25.1b, 37.1b, 41.1b, 45.1b)	Both	16	0.34	0.35	0.22
	Male	8	0.33	0.31	0.19
	Female	8	0.36	0.39	0.24

PTSD, posttraumatic stress disorder; GAD, generalized anxiety disorder; MDD, major depressive disorder.

Table 4. Pearson correlation.

Statistic	PTSD	GAD	MDD
PTSD	1	0.943**	0.935**
GAD	0.943**	1	0.950**
MDD	0.935**	0.950**	1

PTSD, posttraumatic stress disorder; GAD, generalized anxiety disorder; MDD, major depressive disorder. **Correlation significant at the 0.01 level.

Table 5. Linear regression analysis of the relationship between the psychological states in the study community.

Variables	MDD				GAD			
	β	95% CI	P-value	SE	β	95% CI	P-value	SE
PTSD	0.935	0.726, 0.893	0.000	0.533	0.943	0.957, 1.161	0.000	0.647

MDD, major depressive disorder (dependent variable); GAD, generalized anxiety disorder (dependent variable); β , coefficient; 95% CI, confidence interval; SE= standard error; PTSD, posttraumatic stress disorder (predictor variable).

ditions instigated is not in the same in every place affected by the disaster as the likelihood of being psychologically injured by a disaster varies with space and time. Thus, people from different places and environmental settings face the same disaster differently. PTSD is the most commonly studied and probably the most frequent and debilitating psychological disorder that occurs after traumatic events and natural disasters (North *et al.*, 1999; Norris *et al.*, 2002). It has been found that the people of the study area showed moderate to extreme stress after the flood. With regard to PTSD, several cases from north-western Darbasta Union seemed to be different than others. We found that the area situated near and in between three ox-bow lakes (Figure 7) was particularly badly affected, with the whole area eventually flooded with the rise in water level. People there developed extreme and severe level of PTSD both near and far away from the river. On the other hand, Sapmara Union which is a part of the Barind Tract (the largest pleistocene terrace of old alluvium in the country) where floods do not touch some parts, people showed only moderate levels of PTSD as damage was indirect and mainly concerned their agricultural land near the river. However, people there were under stress for affected close relatives in other areas touched by the flood, *e.g.*, the channel flowing through Gobindaganj Pourashava, which commonly overflows and therefore caused severe PTSD in the commu-

nity near the river in 2017. Another problem was faced by people from south-eastern Taluk Kanupur and north-western Rakhhal Buruz Unions because of river loops and ox-bow lake problems, which led to severe-level PTSD. Thus, environmental settings of that area significantly influenced the PTSD pattern. In addition, the generalized picture of PTSD in the study area indicated that homogeneous environmental settings might lead a higher level of PTSD near the river, while lower levels of PTSD were found far away from the river, while it can also be said that some heterogeneous geographic settings (presence of ox-bow lakes, river loops, *etc.*) changed the pattern of PTSD.

Another psychological sequela of disasters is general anxiety, which is considered as the sense of dread or fright that something outrageous will happen. It is an emotional response to one or more stimuli that can be internal or external to the person and can be the result of any social situation, both general and space-specific. GAD is mostly less studied in communities affected by disasters, *e.g.*, Norris *et al.* (2002) reported that very limited studies have been conducted on death anxiety, various phobia and panic disorders which are very common in affected communities, and this situation has not changed.

Just like PTSD, severe-level GAD was found near the river, while milder forms of this mental disorder were found far away

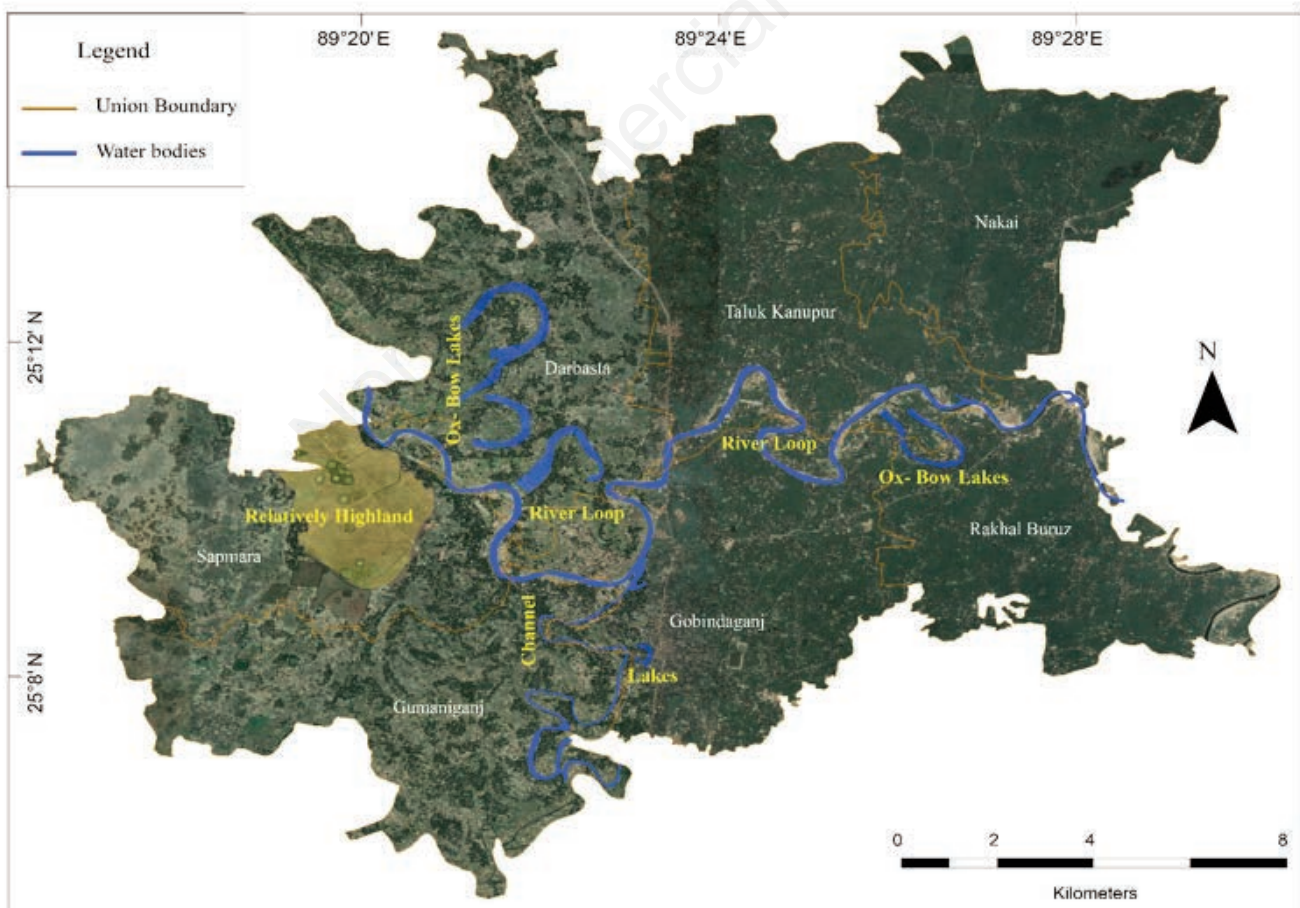


Figure 7. Major geographic variables and their associations in the study area.

from the river. We found that the presence of several geographic variables in the study area as well as PTSD caused varies levels of GAD in the communities. Because of the continuous rise in water level and the position of their settlements relative to the river, the people from south-eastern Taluk Kanupur and north-western Rakhai Buruz developed moderate levels of GAD and people from Darbasta and Gobindaganj severe levels of this disorder.

Depression is the second most commonly studied post-disaster mental health condition (Norris, *et al.*, 2002); however, owing to its large burden in the general population, it may be even more common than PTSD, currently believed to be the most prevalent post-disaster disorder. Clinical depression is a disorder that is sustained over time and affects mood in a general way. The present study community showed normal to moderate major depressions after the 2017 floods, but no severe major depression was noted. In the post-disaster period the study community also faced depressive disorder. Just like PTSD and GAD, the communities near the river showed moderate-level MDD. Darbasta Union and Gobindaganj Community showed moderate-level MDD, while other areas showed mild-level MDD along with the geographic variability along with their internal and external coping mechanism. Damages due to physical settings varied and the external help, recovery procedures, community resilience played vital role in the development of the depressive disorder. It was difficult, sometimes impossible, to find a pattern in a single administrative unit because the impact of hazards does not follow administrative boundaries. However, the understanding of hazard exposure impacts becomes more meaningful when a place is perceived as geographic space. Considering all the geographic variables in the study area, we found a general clustering pattern of psychological vulnerabilities. Generally, higher levels of psychological vulnerability occurred near the river, while a relatively medium level of psychological vulnerability was found 1 km from the river and lower-level psychological vulnerabilities 2 km away (Figure 5). In addition, there was a significant variation in psychological vulnerability between the areas north and south of the river.

Hazards like flood have some geographical extend and factors. Generally, geographical factors like elevation of an area, landforms, soil types, climate and association of other geographical features greatly influence flooding. But the river location, ox-bow lakes, channels, settlements as well as their association are examples leading to vulnerability by flooding causing the community to be mentally vulnerable during and aftermath of such events. Also, these variables play a significant role when attempting to determine the spatial pattern of psychological vulnerability. This kind of vulnerability is high in communities near the river and gradually decreases with distance from it. In Bangladesh, disaster management is generally focused on sustainable development, proper utilizations of resources, mass awareness, *etc.*

In this study the major attention was given to the spatial settings and physical variables of environment and there was a huge scope to consider the social capital, response pattern as well as the community resilience. In future research, community resilience and social capital will be observed to understand this spatial pattern of psychological vulnerability.

Conclusions

This research is based on the interest of the geographic variability of 2017 flood related mental health and psychological vul-

nerability at the individual-level unit of analysis. Recovery processes after hazardous events are longwinded in Bangladesh due to lack of practical knowledge about geographic variability although such knowledge might help to execute recovery initiatives. In addition, mental health is relatively ignored during disaster management initiatives. If there is enough research and focus on the geographic variability of post disaster mental health that might help the disaster management procedure to focus on where help should be given and also indicate future direction of disaster management policy.

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