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Flash Flood Risk and Resilience Analysis of Tanguar Haor Adjacent Areas

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Abstract

Bangladesh faces various types of natural hazards from its birth due to geographical location and physiographic sitting. Flood is the most common event among them. North-eastern part of Bangladesh faces flash flood almost every year with large scale of damage. Tanguar Haor, a famous ramsar site of Bangladesh located in Sunamganj district. This wetland adjacent areas are the most vulnerable zone in terms of flash flood hazard. About more than 80% people are the direct victim of this hazard. This study tries to assess the risk and resilience status of flash flood using risk and resilience assessment matrix. To accomplish this research both primary and secondary data have used. Through this work the comparative view between risk and resilience status has tried to represent. That shows the actual penetration of the depth of risk reduction policy making to improve the condition and minimize the losses of flash flood in the study area.

***Keywords*:** Flash flood; Vulnerability; Probability; Risk and Resilience.

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1. Introduction

Natural disasters are those events that occurs naturally which are responsible for the damage of life and property. Simply, we can say the unusual behavior of the nature is pointed as natural disaster. Bangladesh faces such type of disaster from her birth. Recently it is recognized as the most vulnerable country in terms of natural hazards [4]. Flood is the most common natural hazard for Bangladesh which occurs in regular basis and Bangladesh ranks two in term of world flood vulnerability index [10]. Flood in Bangladesh are generally divided into four major categories. These are Flash Flood, River Flood, Rain fed flood and Coastal Flood [12]. Flash flood is considered as quick rise and fall of water level. It is simply defined as a rapid onset flood of short duration with a relatively high peak discharge of water level [14]. It is characterized by rapid rise and fall in water levels. Flash flood can occur within a time-period between few minutes to few hours [6]. Tanguar Haor is located at the North-eastern part of the country. Flash Flood is the most critical natural issue for Tanguar Haor and its adjacent areas. The severity of flash flood depends on time and quantity of rainfall in the hill and drain out capacity of main rivers [1]. When heavy rainfall occurs in the hilly regions of India, water quickly moves towards the Tanguar Haor area through Jadukata River and different canals. Not only Jadukata river but also Dhanu and Bauli rivers are responsible for flash flood in this area [2]. People of these areas (Tanguar Haor adjacent) are in great risk due to flash flood. Remoteness, poverty and natural hazards are the major risk factors here. About 87% haor people are poor and primary economic activities are their main way of livelihood. Their main economic activities are agricultural practice and fishing [9]. Flash Flood affects this region any time from March to September [14]. Boro rice, BRRI Dhan 28 and BRRI Dhan 29 are the major food crops cultivated in Tanguar Haor. Some other crops like chili, onion, garlic, potato, bean, coriander are also cultivated here [11]. Among those crops Boro Dhan, BRRI Dhan 28 and BRRI Dhan are harvested in April to May when early flash flood visits. Other crops are damaged mainly due to mid and late flash flood [9]. Besides their housing structure makes them more vulnerable in terms of flash flood. Majority of their settlements are made by clay, bamboo, wood etc. About 87.2% houses are kacha, 6.9% jhupri, 5.2% semi-pacca and remaining only 0.7% pucca [3]. Though their flash flood risk status is extreme, their resilience status is very negligible due to their risk reduction strategy. Government of Bangladesh implies several action plans to reduce the risk factors. Strategies like protection strategies, short term action plan and long-term action plan are the main phase. Protection strategies are the structural management like- embankments, flood shelter, flood proofing etc. Otherwise, some other actions like flood warning, changes of settlement structure, shifting of agriculture etc. All these helps to reduce risk of flash flood proportionately [13]. Haor people are poor and vulnerable. They are mostly deprived, distressed and destitute. Although there was no dearth of prescription from the government and policy makers, haor people always remained excluded from the mainstream [5].

2. Study Area

Tanguar Haor is located in North-eastern part of Bangladesh under Sunamganj district. The area of this unique ecosystem including 46 villages of two upazilas (Dharmapasha and Tahirpur). Tanguar Haor is located between 25°2'16.52"N latitude to 25°11'12.78"N latitude and 91°10'42.29"E longitude to 90°59'14.89"E longitude. It is surrounded by Kalmakanda and Barhatta upazila in the west, Jamalganj and Bishwambarpur in the east, Mohanganj Thana in the south and India in the north. Table 1 and figure 1 represents the Tanguar haor adjacent

area.

Table 1: Study Area at a Glance

Tanguar Haor	Tahirpur Upzila	Dharmapasha Upzila
	Number of Union: 7	Number of Union: 10
	Village: 243	Village: 313
	Total Household: 37931	Total Household: 34871
	Total Population: 215200	Total Population: 182969

(Source: BBS, 2019)

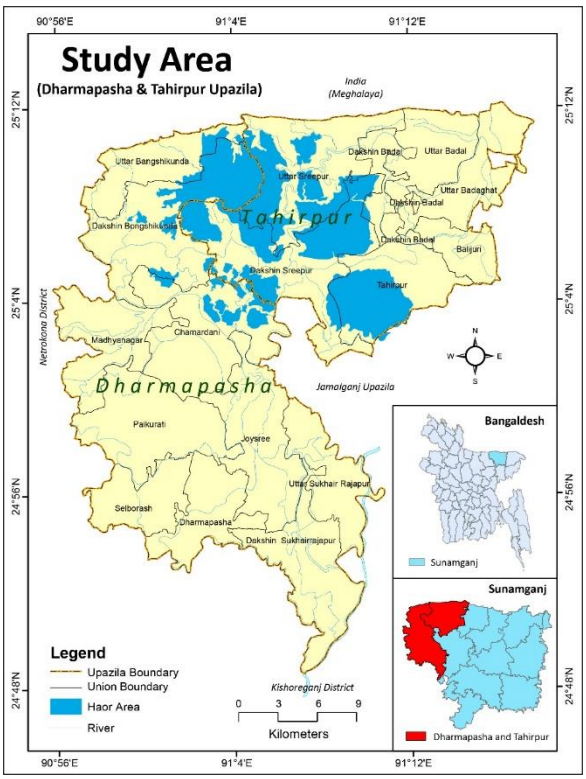

Figure 1: Study Area (Tanguar Haor Adjacent areas)

(Source: Compiled by Author, 2020)

3. Aim and objectives

3.1. Aim

The broad aim of this study is to assess the flash flood risk and resilience status of local people and make comparison among them.

3.2. Objectives

The following objectives are set to complete the present research works.

i. To assess the flash flood risk status of local people in the study area.
ii. To analyze the resilience status; and
iii. To examine comparative analysis between flash flood risk and resilience status.

4. Methodology

To fulfill this research both primary and secondary data have used. To collect the primary data quantitative and qualitative techniques are used. Primary data are collected through Field Observation, FGD (Focused Group Discussion), Questionnaire Survey, Interview. This technique is applied on the local people of the study area to assess the flash flood risk and resilience status using risk assessment matrix and resilience assessment matrix. A risk assessment matrix is a matrix that assess the risk using the hazard probability and vulnerability (Risk = Hazard probability × Vulnerability). Flash flood probability has determined based on the frequency of this event in the study area according to the opinion of local people. Flash flood vulnerability indicators are identified through FGD (Focused Group Discussion) on the basis of the priority of respondent. A resilience assessment matrix is a matrix that assess the resilience status using hazard probability and resilience status (Resilience = Hazard probability × Resilience). Flash flood resilience indicators are marked through FGD (Focused Group Discussion) based on the precedency of the respondent. Here, the more the flash flood probability and the more the vulnerability indicators the more the flash flood risk. And the less the flash flood probability and the more resilience indicators the more the flash flood resilience. To collect this data, we have used simple random sampling method.

Sample size has calculated using the following equation-

$$Sample\ Size = \frac{z^2.P\ (1-P)/e^2}{1 + (z^2.P\frac{(1-P)}{e^2N})}$$

[curioresearch.net, 2020]

Where,

Confidence Level = 80%, Margin of Error =10%

After that this raw data are processed by using MS Excel-2013 and finally with the help of ArcGIS 10.3 risk zoning map of the study area has developed. The Correlation between risk and resilience have identified by using SPSS and the spatial auto correlation between place and risk has marked with the help of ArcGIS 10.3. Secondary data have collected from secondary sources (Journals, Published articles, Government Websites). Flash flood vulnerability of the study has marked using pervious flood record. Overall, ArcGIS 10.3 helps to develop the flash flood vulnerability map of the study area.

4.1. Flash Flood Vulnerability of the Area

Dharmapasha and Tahirpur upazila are most flash flood vulnearable area in Sunamganj District. This area is surrended by jadukata, someswari, kangsa, konai and paikartola river. Most of those rivers are originated form Meghalaya Hill. Every year Meghalaya hilly area receives huge amount of rainfall that reaches in the study area with huge volume of water in a short duration of time. This happen almost every year in the study area. Figure 2 illustrates the Tanguar hoar adjacent affected area.

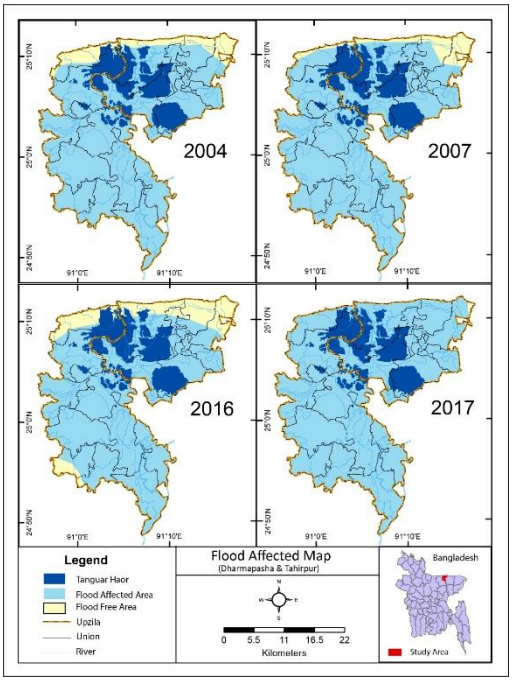

Figure 2: Flood Affected Map

(Source: FFWC, 2004, 2007, 2016 & 2017)

From the previous flood record it is clear that this area affected by flash flood almost every year. The Figure 2 shows flood situation of the study area. In 2007 and 2017 both upazila submerged by flood. And in 2004 and 2016 the area is also submerged by flood except a little portion of Northern part. Not only this four year but also this scenario is common most frequently (March-September).

4.2. Flash flood risk assessment of the study area

Flash flood risk assessment is the mechanism to assess the risk status due to flash flood hazard. Tangoar Haor adjacent areas faces flash flood almost every year. This causes a lot of damages, especially in agriculture sector. Not only the agricultural sector but also their housing, communication, stored food etc. faces damage too. Flash flood event occur frequently in Tanguar Haor. But every people in the study area doesn't face flash flood hazard equally. The people who lives in low lying and haor adjacent areas, they face this hazard more intensively. But the others are not like them. This factor is the probability of flash flood hazard which varies person to person, place to place in the study area. Otherwise damage rate also varies person to person. For that reason, flash flood probability and vulnerability indicators are selected on priority basis.

Flash Flood Risk= Hazard (Flash flood probability) × Vulnerability.

4.3. Flash flood Probability

Flash flood probability is the possibility of the occurrence of flash flood that is not same for all. In the study area the variation seems in the same area based on some factors like flood proof housing, settlement on high land etc. That's why probability of flash flood hazard categorized as five hierarchical stages.

The flash flood probability is the primary mechanism to know the intensity of flash flood probability in the study area. People of Tanguar Haor adjacent faces flash flood in various level that depends on some criteria. Flash flood probability -

i. Every year flash flood occurs severely.
ii. It occurs every year but sometimes it is severe.
iii. It occurs every year but not so severely.
iv. It occurs after every few years (Generally after every 2-3 years).
v. It occurs once every ten years.

(Source- Questionnaire survey, 2020)

4.4. Flash flood vulnerability

Flash flood vulnerability is the possibility of harm due to flash flood. This also varies with area to area, person to person. In the study area variation seems on the basis of several status like- settlement statuses, economic status, dependency on agriculture etc.

Vulnerability indicators are marked as hierarchically on the basis of the opinion of the people of the study area. Vulnerability indicator of flash flood -

i. There is agricultural land in haor and its adjacent low-lying areas.
ii. Livelihood is completely depending on agricultural production & fishing.
iii. Settlements are situated haor adjacent lower elevated areas & height is low.
iv. Homestead are made by mud and other raw materials.
v. Day-wise income (Fisherman, Day labor), lack of Savings & poor flood Adjustment knowledge.

(Source- Questionnaire survey, 2020)

Tanguar Haor exhibits a unique wetland ecosystem. About 40,000 people directly depend on it for their livelihood. It is located at eight unions of Tahirpur and Dharmapasha Upzila under Sunamganj district. Figure 3 shows the Risk Assessment Matrix. Flash flood is the most common hazard for this zone, especially Tanguar Haor adjacent areas (Ten unions of Dharmapasha and seven of Tahirpur upzila) faces this hazard more frequently [7]. So thus, this study focuses on these areas.

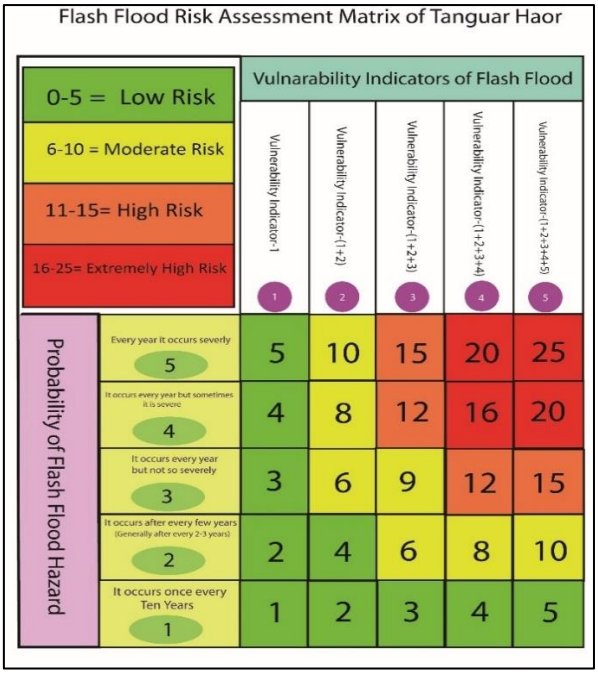

Figure 3: Risk Assessment Matrix

(Source: Modified from Donoghue after 2020)

From the above matrix (Figure 3) individual flash flood risk has assessed seven unions of Tahirpur upzila and ten unions of Dharmapasha upzila. According to the assessment flash flood risk status of Tahirpur upzila is worse more than Dharmapasha Upzila. In Tahirpur upzila, most of the people of Uttar Sreepur and Dakshin Sreepur are in extreme risk in terms of flash flood. About more than 70% people both of these unions are in extreme risk. Moreover,a great portion of Dakshin Badal, Uttar Badal, Badaghat are in high risk zone and about more than 65% people are in this zone. Overall, Tahirpur Sadar and Balijuri faces moderate and low risk due to flash flood (Table-2). About one lack fifty-five thousand people lives in this upzila. Among them more than one lac ten thousand people are in extreme and high risk of flash flood, only 10.53% people are in low risk. Flash flood risk status of Dharmapasha upzila is slightly different from Tahirpur. In this upzila extreme risk of flood is more than 60% which is found in Uttar Bangshikunda and Chamardani. In Dakshin Bongshikunda risk is extreme in level (56.1%) but not as severe like them (Uttar Bangshikunda and Chamardani). Joysree and Madhyanagar holds greater portion of people in high risk zone. Moderate level of flash flood risk is existing in Uttar Sukhair Rajapur, Paikurati, Selborash. About more than 50% people are in this zone. Most of the people of Dharmapasha and Dakshin Sukhair Rajapur are in low risk of flash flood (Table-2). Overall, about one lac eighty thousand people lives in this upzila. Among them more than ninety thousand people are in extreme and high risk of flash flood, only 21.07% are in low risk.

Table 2: Flash Flood Risk Index

Risk Index

	Union	Population	Sample Size	Nature of Risk			
				Extreme	High	Moderate	Low
Tahirpur Upzila	Uttar Sreepur	33,457	42	78.57%	14.28%	7.14%	0%
	Dakshin Sreepur	16,605	40	72.5%	17.5%	7.5%	2.5%
	Daksin Badal	16,827	40	22.5%	62.5%	10%	5%
	Uttar Badal	25,514	41	21.95%	65.85%	9.76%	4.88%
	Badaghat	33,454	42	16.67%	69.05%	9.52%	4.76%
	Tahirpur Sadar	15,300	40	12.5%	22.5%	52.5%	12.5%
	Balijuri	14,031	40	7.5%	15%	30%	47.5%
	Total=	1,55,188	285	33.33%	38.25%	17.89%	10.53%
Dharmapasha Upzila	Uttar Bangshikunda	17,549	41	68.29%	17.07%	9.76%	4.88%
	Chamardani	18,685	41	63.41%	12.2%	14.63%	9.75%
	Daksin Banshikunda	21,967	41	56.1%	21.95%	14.63%	7.32%
	Joysree	17,193	41	12.19%	41.46%	26.83%	19.51%
	Madhyanagar	18,523	41	17.07%	51.23%	17.07%	14.63%
	Uttar Sukhairrajapur	14,512	40	12.5%	22.5%	55%	10%
	Paikurati	22,335	41	4.87%	14.64%	53.66%	26.83%
	Selborash	20,175	41	14.63%	17.07%	53.66%	14.63%
	Daksinsukhair Rajapur	8,019	40	7.5%	20%	27.5%	45%
	Dharmapasha	24,011	41	7.31%	12.2%	21.95%	58.54%
	Total=	1,82,969	408	29.66%	23.04%	29.17%	21.07%

(Source: Field Survey, 2020)

5. Risk zoning

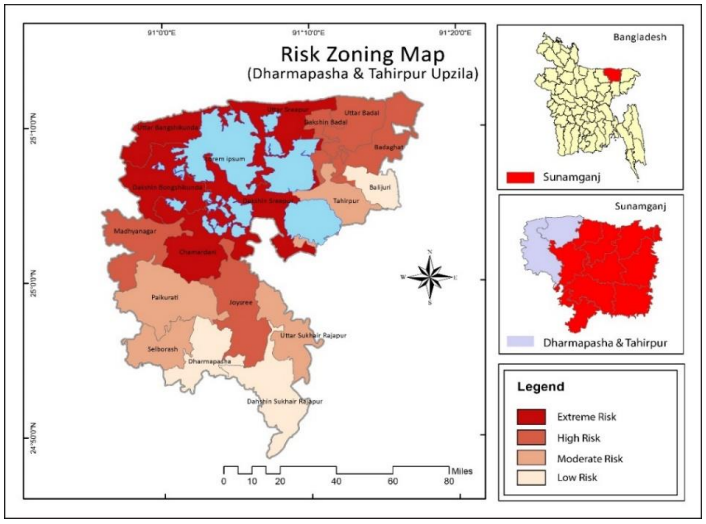

Figure 4: Risk Zoning Map

(Source: Compiled by Author, 2020)

Risk zoning is the mechanism that represent an area by dividing it on the basis of their risk status. Risk zoning usually presented as map. The risk zoning map usually important for disaster planning Figure-4 represents the several risk zone of Tanguar Haor adjacent areas in terms of flash flood. This map clears that the variation of risk status.

6. Flash flood resilience assessment of the study area

Flash flood is the most common natural hazard in Tahirpur and Dharmapasha upzila. People of this areas faces this hazard almost every year. Their settlement, agricultural production, communication system and everything damages intensively. But their resilience status against this hazard is not so strong. Because of their poor economic status and the geographic location also reduce the resilience status. For example- Boro is the main agricultural products for them. They cultivate it in haor areas. And these crops face flash flood most of the time. Resilience is the ability to bounce back from adversity. It is a necessary skill for coping with life's inevitable obstacles and one of the key ingredients to success. Learning to bounce back and to bounce forward. Resilience is about being adaptable. It's about being flexible. It's about recognizing that we've got strengths that perhaps we never knew we had until we have to use them. And like many things in life - the more we practice, the more we learn. The more we find out about resilience and certainly the more we do of it, then the more resilient we become. Flash flood resilience status is the mechanism to assess the flash flood tolerance capability both structural purposes and non-structural purposes. Structural purposes indicate the adaptive capacity of the settlement and other infrastructure against flash flood. And the non-structural indicates everything relevant with livelihood.

Flash flood resilience status = Hazard probability × Resilience indicators

Here,

Hazard probability = The less the hazard probability the more the resilience probability.

Resilience indicator = The more the indicator the respondent has the more the resilience Probability.

6.1. Resilience indicator

Flash flood resilience indicates the tolerance capability in terms of flash flood. This type of capability depends on people's surroundings and economic capability. Overall the geographic condition of an area controls the resilience status.

Resilience indicator of flash flood (Source: Questionnaire survey, 2019)-

i. Settlements are surrounded by flood wall and plants (Hijal and koros forest).
ii. Human settlements are made on the stack of soil and flood tolerate poles in low lying areas.

iii. Agricultural production remains after consumption for store and sell / one or more economic man involved in secondary economic activities in urban areas.

iv. There are savings accounts in Bank/ women involved in micro-credit / Economic Solvency (Family Income more than 5000 per month).

v. Rich in flood preparedness and adjustment knowledge/ Trained volunteer/ Ability to read early warning system.

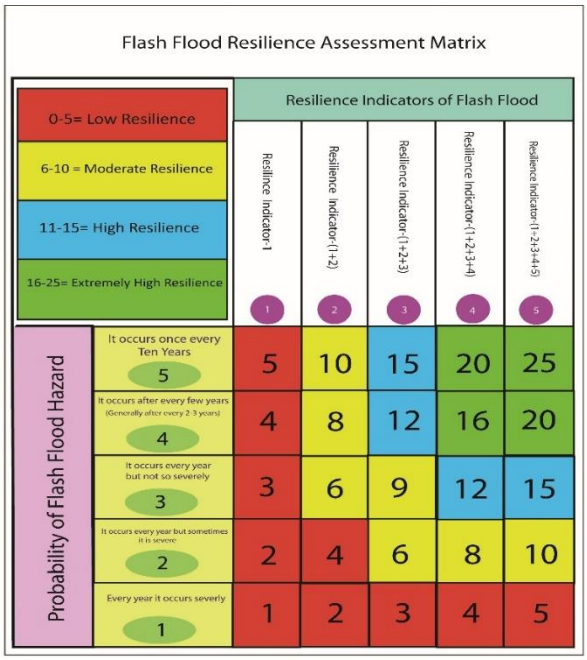

Figure 5: Resilience Assessment Matrix

(Source: Modified from Donoghue after 2020)

Using the resilience assessment matrix (Figure 5) individual resilience status has assessed. According to this assessment, resilience status of Dharmapasha upzila is stronger than Tahirpur Upzila. In Tahirpur upzila more than 55% people have low resilience that makes them more vulnerable in terms of flash flood. Low resilience is intense in Uttar Sreepur and Dakshin Sreepur, it is about more than 70% of their total population. Uttar Badal, Dakshin Badal, Badaghat shows the almost same resilience status. But situation has changed in Tahirpur upzila and Balijuri union. Only 25% people lives with low resilience of flash flood (Table 3). This assessment clears that unions which are in high risk zone, the resilience status of those unions is not as high as they need. Overall resilience status of Tahirpur upzila is not satisfied in terms of flash flood risk status of this upzila. Because in this upzila more than 70% people are in extreme and high risk one the contrary the proportion of extreme and high resilience are only 23.16% (Table 3). This shows a huge gap and that's why they face a great damage due to flash flood almost every year. Otherwise, 37.35% people of Dharmapasha upzila lives in low resilience zone. Uttar Bangshikunda, Chamardani, Dakshin Bangshikunda and Madhyanagar are in this zone but it is not as severe as Uttar Sreepur and Dakshin Sreepur of Tahipur Upzila. In Dharmapasha the proportion of moderate resilience is remarkable. Moderate resilience status is intense in five unions of this upzila. Dharmapasha and

Dakshin Sukhair Rajapur resilience status are quite satisfying (Table 3).

Table 3: Resilience Index

Resilience Index

	Union	Population	Sample Size	Nature of Resilience			
				Extreme	High	Moderate	Low
Tahirpur Upzila	Uttar Sreepur	33,457	42	4.76%	7.14%	16.67%	71.43%
	Dakshin Sreepur	16,605	40	2.5%	10%	12.5%	75%
	Daksin Badal	16,827	40	12.5%	7.5%	17.5%	62.5%
	Uttar Badal	25,514	41	9.76%	7.32%	19.51%	63.41%
	Badaghat	33,454	42	7.4%	9.52%	16.67%	66.67%
	Tahirpur Sadar	15,300	40	15%	27.5%	37.5%	20%
	Balijuri	14,031	40	7.5%	35%	30%	27.5%
	Total=	1,55,188	285	8.42%	14.74%	21.40%	55.44%
Dharmapasha Upzila	Uttar Bangshikunda	17,549	41	7.32%	14.63%	17.07%	60.98%
	Chamardani	18,685	41	9.75%	12.2%	19.51%	58.54%
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	Uttar Sukhairrajapur	14,512	40	12.5%	27.5%	40%	20%
	Paikurati	22,335	41	17.07%	21.96%	41.46%	19.51%
	Selborash	20,175	41	17.16%	24.30%	34.15%	24.39%
	Daksinsukhair Rajapur	8,019	40	20%	22.5%	32.5%	25%
	Dharmapasha	24,011	41	21.95%	29.27%	31.71%	17.07%
	Total=	1,82,969	408	14.46%	20.34%	27.69%	37.35%

(Source: Field Survey, 2020)

7. Spatial Auto Correlation between place and risk

Spatial Auto Correlation follow the first law of Geography given by Tobler. Main theme of this law is "Everything is related to everything else, but near things are more related than distant thing" [8]**.** It tells us how much close objects are in comparison with other close objects. In this study Spatial Auto Correlation represents the connectivity nature of different unions based on their risk value. Figure 6 shows the Moran's I Spatial Auto Correlation.

Here, the z-score of 3.90972095464, that means it is clustered pattern (If the z value is more than +1 then it is clustered). This analysis demonstrates the continuous connectivity of different unions in Dharmapasha and Tahirpur upzila which have extreme risk value.

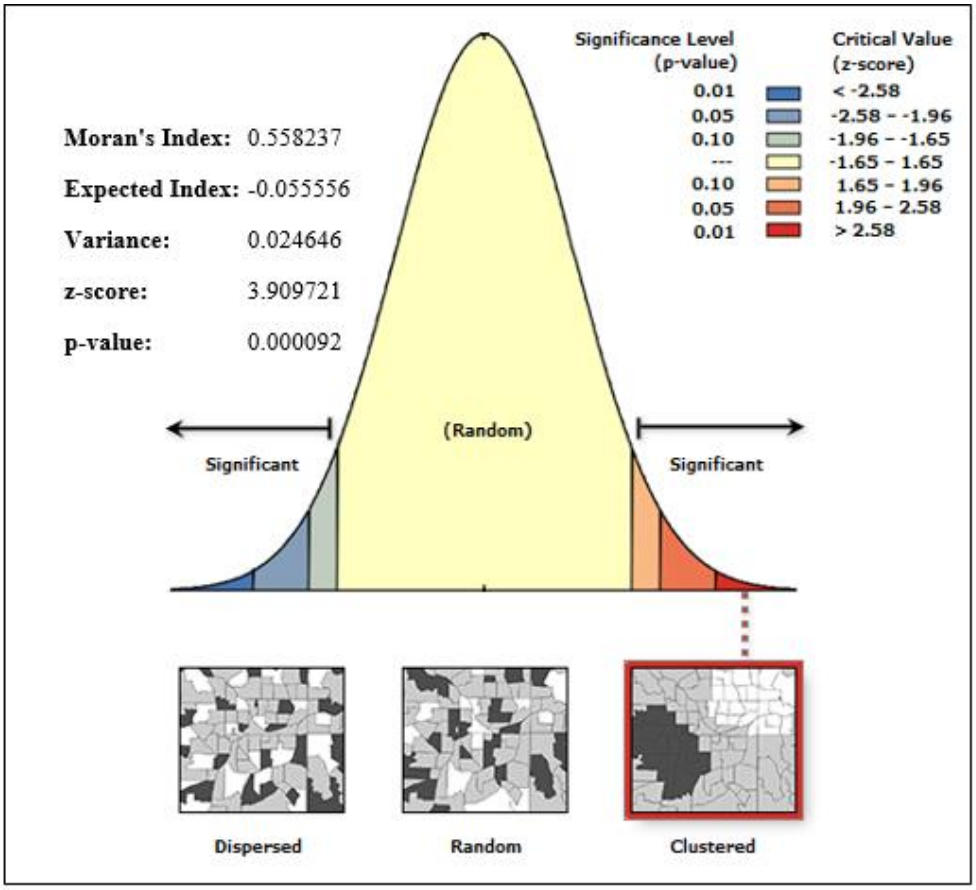

Figure 6: Moran's I Spatial Auto Correlation

(Source: Calculated by Researcher, 2020)

8. Comparative analysis between flash flood risk and resilience status

Risk and resilience are a relevant with one another. If resilience status is strong, this can reduce the harm from hazards. The comparison between risk and resilience status tells us, how much in danger a particular community are? Correlation is the most common mechanism to find out the relationship between two variables. This shows the relation and dependency among the variables. The correlation between risk and resilience status of the unions which are in extreme and high-risk zone has assessed.

Correlations

		Risk	Resilience
Risk	Pearson Correlation	1	-.884**
	Sig. (2-tailed)		.001
	N	10	10
Resilience	Pearson Correlation	-.884**	1
	Sig. (2-tailed)	.001	
	N	10	10

**. Correlation is significant at the 0.01 level (2-tailed).

Here,

Pearson Correlation	= -.814	[Correlation Ranges from -1 to +1]
	= Negative Correlation	[If the value is less than -1 then it is negative Correlation]
		[If the value is less than +1 then it is positive Correlation]
		Significant Level, p = 0.001
		= significant relationship
Degrees of Freedom, r = 5		[Sample size, (n) -2= Degrees of

Figure 7

9. Result

There is a significant negative relationship between risk status and resilience status,

r (5) = -.814, p=.001

This correlation tells us a wide range of risk reduction practice is required to improve the condition of flash flood in the extreme and high-risk zones.

10. Conclusion

Flash flood risk reduction capability of Tanguar Haor adjacent areas mainly depends on Governmental actions. Most of the actions are undertaken by government. Most important task for flash flood risk reduction is structural development and emergency response capability. Emergency response system is well active in Tahirpur and Dharmapasha Upzila. Haor people mainly the aged person accumulated regular and specialist knowledge about the Flash floods through previous observation and practical experience of their surroundings. Local tales and anecdotes related to floods abound and reveal how people live and interpret their landscape over time. Their accounts provide many interpretations of the history and nature of past flash floods. But all these affords are not so helpful to reduce the risk of flash flood. Disaster Risk reduction is a systematic function to identify, assessing and reducing the risk of Disaster. Main aim of Disaster Risk reduction is to reduce socio-economic vulnerabilities in consider with disaster risk as well as facing with the environmental and other hazards that influence them. Government of Bangladesh implies several action plans to reduce the risk factors. Strategies like protection strategies, short term action plan and long-term action plan are the main phase. Protection strategies are the structural management like- embankments, flood shelter, flood proofing etc.

Otherwise, some other actions like flood warning, changes of settlement structure, shifting of agriculture etc. All these helps to reduce risk of flash flood proportionately.

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