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Flood Risk Analysis by Using Geographic Information System at Sarankhola Upazila, Bagherhat

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Abstract:

Bangladesh is one of the most disaster prone country in the world community, especially to flood hazards. Due to the geographical location the South-Western coastal region of Bangladesh is a highly risky zone of flood - a common phenomenon in this area. The flood risk has been assessed against non-spatial data by using the Geographic Information Systems (GIS) tool. The equation R =∫ [(H + V – C) / 3] (Blaikie, 1994) was used to calculate the risk score. According to Rahman, 2004, the variables are measured at a scale from 1 to 4, where the upper value indicates the highest limit of any variable. (Rahaman, 2004). The Southkhali is the most risky Union in the Sarankhola Upazila because of the large water body on three sides.

Key words: Disaster, Community, Flood Hazard, Flood Risk, GIS and Coastal Region.

1. Background of the Study

Nowadays, Earth is facing disastrous phenomena on an unprecedented scale, 1 out of 25 people worldwide being

affected by natural disasters (Guha-Sapir et al. 2004). Natural disasters are of the highest concern of the various types of disaster. Natural disasters include earthquakes, floods, cyclones, droughts, tornadoes, landslides, hurricanes and tsunamis (Melelli and Taramelli 2004; McInnes 2006). According to Guha-Sapir et al. (2004), over the past 30 years, the number of reported natural disasters has increased steadily, from slightly fewer than 100 in 1974 to a little more than 400 in 2003, an almost four-fold increase. South and East Asia, like Bangladesh, India and China, are still in the utmost group with a high quantity of its population having been affected by natural disasters. All of these countries have a high population density, particularly in river catchments. In addition, most of the people's livelihoods are based on agriculture. When floods occur, then the number of affected communities quickly reaches into the hundred thousand and in some cases millions.

Bangladesh is most vulnerable to several natural disasters and every year natural calamities upset people's lives in some part of the country. The geographical setting of Bangladesh makes the country vulnerable to natural disasters. Floodplains occupy 80% of the country. Mean elevations range from less than 1 meter on tidal floodplains, 1 to 3 meters on the main river and estuarine floodplains, and up to 6 meters in the Sylhet basin in the north-east (Rashid 1991). Only in the extreme northwest there are elevations higher than 30 meters above the mean sea level. The northeast and southeast parts of the country are hilly, with some tertiary hills over 1000 meters above mean sea level (Ahmed et al. 1999). The South-West coastal zone of Bangladesh is the most risk prone area to disasters like cyclones and tidal surges. In Sarankhola Upazila under Bagherat District, one of the coastal areas which is characterized by its proximity to sea, and in Sundarbans reserve forest, rivers have been experiencing many natural disasters for a long time. As a result, development activities are

hindering and people are in the grasp of poverty for long years. Floods occur frequently and regularly in the study area.

This study has analyzed the vulnerability of people to flood and assessed the risk of inhabitants of this area by using the Geographic Information Systems (GIS). In order to develop an integrated assessment method, GIS technique is applied to measure vulnerability with respect to spatial factors, which is important for several disasters such as flood, cyclone, and river erosion. Apart from the spatial analysis, GIS is also used to produce various thematic maps (e.g. hazard map, vulnerability map and risk map) derived from the calculation. Along with secondary data retrieved from the national survey (e.g. BBS), a social survey and a PRA study were conducted to determine the devastation intensity of hazards as well as the factors of vulnerability.

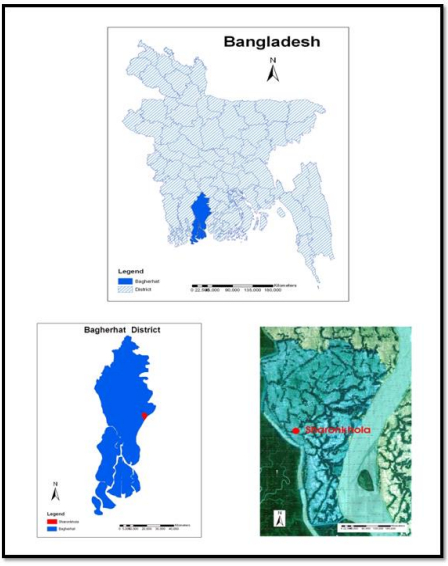


Figure 1: Location of the study area in Bangladesh and Bagherhat district

2. Methodology

The Participatory Disaster Risk Analysis (PDRA) method has

been used in this study. It is not a new method but a modified version of the Disaster Crunch Model of Blaikie and a coordination of some prevailing methods to analyze people's vulnerability and risk. In the PDR analysis it is believed that 'Risk' is an outcome of probable magnitude of any particular hazard and its impact upon any population group or other physical or non-physical features after considering the capacity to reduce the impact of the cumulative total of the hazard and the vulnerability.

Logically it can be described as:

$$\textbf{Risk} = \int \textbf{(hazard + vulnerability – capacity)}$$

For simplifying the mathematics of any 'disaster risk' units of all tree variables (hazard, vulnerability & capacity), these are considered here as the same unit and scores of the variables are made average to get a unique scale of risk perception.

So, mathematically, risk can be described as:

$$\mathbf{R} = \int \mathbf{[(H + V – C) / 3]}$$

(Blaikie, 1994)

Where,
R = Risk
H = Hazard
V = Vulnerability
C = Capacity

Each of the variables are measured at a scale from 1 to 4, where the upper value indicates the highest limit of any variable whether it is 'hazard' or 'vulnerability' or 'capacity' (Rahaman 2004). The value of hazard threat, vulnerability and capacity factors are categorized under high (4), medium (3), moderate (2) and low (1) and assigned their respective score. To evaluate the risk for disaster, each of these variables: hazard, vulnerability and capacity are assessed by fixing some criteria. Furthermore each of these criteria can be assessed separately to make it more logical, especially for any participatory assessment which made people's opinion more analytical and judgmental. The GIS tool has been used against the total score of the risk for

each Union to understand the risk for union basis.

3. Results and Discussions

3.1 Hazard assessment

For assessing hazard in case of flood, the criteria should be:

- Frequency: To assess the score of flood hazard frequency, trend line or time line and seasonal calendar have been taken in to consideration.
- Intensity: The duration of flood and the water level have been considered.
- Magnitude: Magnitude of flood due to high tide and dam collapse.
- Associated disasters: The considered factors are: diseases / pest attacks / others after flood, duration of associated disasters, and causality of associated disasters.

Criteria	**Scale of Scoring (Scale range = 1 to 4)**	**Total score**			
		S.khali	**D.sagar**	**Royenda**	**K.takata**
Frequency	Occurs in every year =4	3.72	3.8	3.81	3.73
	Occurs in two- three years gap =3				
	Occurs in four years gap =2				
	Occurs in five and over five years gap =1				
Intensity	Over 10 feet water height =4	3.49	1.43	2	2.3
	6 to 9 feet water height = 3				
	1 to 5 feet water height=2				
	Little flooding =1				
Magnitude	Loss of human life or property value 40000 and more =4	3.89	1.65	3.5	2.5
	Property value of Tk. Less than 40000 =3				
	Complete destruction of houses or farms=2				
	Minimum destruction=1				
Associated	Starvation or	3.73	2.3	3.4	2.8

disasters	unemployment for a long time =4				
	Disasters and defray of Tk. 5000 and more =3				
	Loss of cattle foods or disasters of low harm =2				
	Loss of reserve food or low defray for associated disaster =1				

Table 1: Hazard assessment of flood in Sarankhola Upazila
(S.khali=Southkhali, D.sagar = Dhansagar, K.takata= Khontakata)

Now,

Calculation of Hazard Scores for Royenda Union = (3.81+2+3.5+3.4)/4 = 3.17
Calculation of Hazard Scores for Dhansagar Union = (3.8+1.43+1.65+2.3)/4=2.23
Calculation of Hazard Scores for Khontakata Union = (3.73+2.3+2.5+2.8)/4 =2.84
Calculation of Hazard Scores for Southkhali Union = (3.72+3.49+3.89+3.73)/4 =3.7

3.2 Vulnerability assessment

These are the criteria for assessing the vulnerability of people against flood:

1. Location of the house (near to river / shelter / killah / in low land)
2. Increase income source
3. House structure
4. Local coping mechanism
5. Relief
6. Awareness
7. Reserve food
8. Repair tool
9. Infrastructure

Criteria	**Scale of Scoring (Scale range = 1 to 4)**	**Total score**			
		S.khali	**D.sagar**	**Royenda**	**K.kata**
Location of the house	Location within walking distance to high place =1	1	2.13	1.06	1.6
	Within 1 km. of high place =2				
	Location within 2 to3 km. =3				
	Location more than 3				

	km. =4				
Insecure income source	Percentage of people lives on daily wage =4	3.8	2.13	3.37	2.8
	Percentage of people lives on monthly wage =3				
	Percentage of people lives on income after certain period =2				
	Percentage of people lives on Govt. service men =1				
House structure	House with pacca structure =1	4	4	4	4
	House with pacca floor and wall =2				
	House with pacca mud-made floor and wood wall =3				
	Katcha house structure =4				
Criteria	Scale of scoring (Scale range =1 to 4)	S.khali	D.sagar	Royenda	K.kata
Local coping mechanism	Practice of effective coping mechanism =1	3	2	2	3
	Presence of coping mechanism but not so effective =2				
	Presence but not Practice =3				
	No presence of coping mechanism =4				
Relief availability	Easy access and sufficient relief =1	2.54	3	2.68	3.1
	Hard access but sufficient relief =2				
	Hard access and non-sufficient relief =3				
	No relief available =4				
Awareness	Most of the people are aware of disasters =1	1	1	1	1
	More than 50% people are aware =2				
	Less than 50% people are aware =3				
	Less than 25% people are aware =4				
Availability of	Sufficient reserve food	4	3.26	3.75	3.8

Reserve food	=1				
	Moderate Sufficient reserve food =2				
	Non- sufficient =3				
	No reserve food =4				
Repair tool	Immediate availability of repair tool in low expense =1	1.6	1.4	1.25	1.1
	Availability in affordable expense =2				
	Availability in moderate expense after long time =3				
	No tool =4				
Infrastructure	Good =1	3.14	2	3.18	2.2
	Moderate =2				
	Satisfactory =3				
	Low =4				

Table 2: Vulnerability assessment of flood in Sarankhola Upazila
(S.khali=Southkhali, D.sagar = Dhansagar, K.kata= Khontakata)

Now,

Calculation of Vulnerability Scores for Royenda Union
= (1.06+3.37+4+2+2.68+1+3.75+1.25+3.18)/9 = 2.47
Calculation of Vulnerability Scores for Dhansagar Union
= (2.13+2.13+4+2+3+1+3.26+1.4+2)/9 = 2.32
Calculation of Vulnerability Scores for Khontakata Union
= (1.6+2.8+4+3+3.1+1+3.8+1.1+2.2)/9 = 2.51
Calculation of Vulnerability Scores for Southkhali Union
= (1+3.8+4+3+2.54+1+4+1.6+3.14)/9 = 2.67

3.3 Capacity Assessment

Capacity assessment criteria against flood:

1. Physical protection system
   - Dam or embankment & Vegetation belt
2. Shelter
   - Killa or high place
   - House of relative or neighbors
3. Communication
   - Road surface type (pucca / Kutcha/ Semipucca)
   - Mode of communication
   - Availability of mobile / telephone etc.

- Accessibility to mobile phone / telephone etc.

4. Management system
   - Disaster warning tools (Radio / Mike)
   - Disaster management committee (active / inactive)
   - Disaster management plan
   - Skilled /unskilled volunteer
   - Availability of standing order
   - NGO (work on disaster)
5. Financial support
   - From relative / rich men / NGO / Mahajan
   - Loan availability
   - Repayment process
6. Medical support
   - Availability of health centre
   - Availability doctor and medicine

Criteria	**Scale of scoring (scale range = 1 to 4)**	**Score for union**			
		R.da	D.sagar	K.kata	S.khali
Physical protection system	Presence of physical protection system =4	2	2	3	2
	Presence but moderate condition =3				
	Presence but condition is unsatisfactory =2				
	No physical protection system =1				
Shelter	Presence of high place/Killa with proper capacity =4	2	2	2	2
	Presence with medium capacity =3				
	Presence with low capacity =2				
	No availability =1				
Communication	Pucca road =4	2	1	2	2
	Semi-pucca road =3				
	Kutcha road =2				
	Kutcha road with bad surface =1				

	Easy availability of energy driven device =4	2	2	2	2
	Moderate availability of energy driven device=3				
	Low availability of energy driven device = 2				
	no availability =1				
	Adequate no. of accessible telephone/mobile=4	2	2	2	2
	Presence of telephone/mobile but hard access=3				
	Presence but limited number and limited access=2				
	No presence = 1				
Management system	Presence of adequate no. of disaster warning tools=4	2	2	2	2
	Limited no. of disaster warning tools and easy access =3				
	Limited no. of disaster warning tools and limited access=2				
	No warning tools=1				
	Properly active disaster management committee =4	2	2	2	2
	Moderate active DMC=3				
	Presence of DMC but inactive=2				
	No DMC =1				
	Availability of adequate skilled volunteer =4	1	1	1	1
	Availability of moderate no. of skilled volunteer =3				
	Presence but not available in time = 2				
	Unskilled volunteer = 1				
	Presence and implementation of local disaster management plan=4	1	1	1	1

	Presence and limited implemented = 3				
	Presence but no implementing DMP= 2				
	No DMP = 1				
Criteria	Scale of scoring (scale range = 1 to 4)	R.da	D.sagar	K.kata	R.da
	Presence and implementation of standing order =4	1	1	1	1
	Presence and limited implemented SO = 3				
	No implementation of SO = 2				
	No SO = 1				
	Local / regional NGOs working on disaster solely = 4	4	3	3	4
	Local / regional NGOs working on other matters but provide support in disaster = 3				
	Support from outsider NGO = 2				
	No support from NGOs = 1				
Financial support	Financial support from relatives/rich/NGO as relief =4	4	4	4	4
	Loan support with easy repayment=3				
	Loan with high interest=2				
	No loan available =1				
Medical support	Presence of clinic/health center/doctor get easy support =4	3	2	2	2
	Presence but provide moderate support =3				
	Very few no. and/or hard to get support =2				
	No medical support =1				

Table 3: Capacity assessment of flood in Sarankhola Upazila

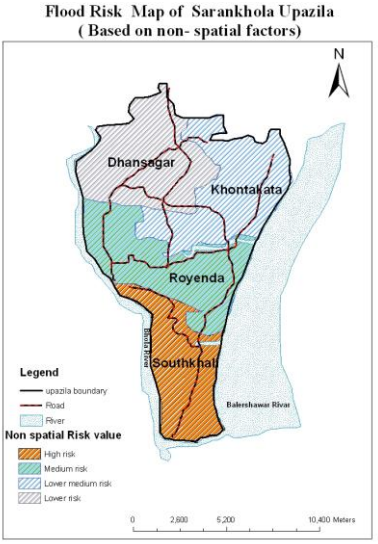
(S.khali=Southkhali, D.sagar = Dhansagar, K.kata= Khontakata, R.da = Royenda)

Now,

Calculation of Capacity Scores for Royenda Union
= (2+2+2+2+2+2+2+1+1+1+4+4+2+)/13 = 2.15
Calculation of Capacity Scores for Dhansagar Union
= (2+2+1+2+2+2+2+1+1+1+3+4+2)/13 = 1.84
Calculation of Capacity Scores for Khontakata Union
= (3+2+2+2+2+2+2+1+1+1+4+4+2)/13 = 2.07
Calculation of Capacity Scores for Southkhali Union
= (2+2+2+2+2+2+2+1+1+1+3+4+2)/13 = 2.07

Name of the union	Hazard(H)score	Vulnerability(V) score	Capacity (C) score	Risk score (H+V-C)/3
Royenda	3.17	2.47	2.15	1.16
Dhansagar	2.23	2.32	1.84	0.90
Khontakata	2.84	2.51	2.07	1.09
Southkhali	3.7	2.67	2.07	1.43

Table 4: Flood risk index of Sarankhola upazila (based on non-spatial factors)



Map 2: Flood risk map of Sharonkhola Upazila based on non-spatial factors

This map is based on the non-spatial data of the Sharonkhola Upazila. The risk score of the Royenda, Dhansagar, Khontakata, Southkhali are 1.16, 0.90, 1.09 and 1.43

respectively. The higher value represents a higher degree of risk with respect to potential and existing flood due to high tide and dam collapse occurrence. From Map 2, it can be easily remarked that the Southkhali Union is the most risky area due to flood. Three sides of the Southkhali are surrounded by the water body: the Bhola River in the Western part, the Balershawar River in the Eastern part, and the Bay of Bengal in the southern part of the Southkhali Union. On the other hand, Dhansagar Union is the safest area because the Bhola River is only in the Western side. The risk of flood in Royenda is the second in position: the Balershawar River is a dangerous river for the high current, being located in the Eastern part of the Royenda Union, while the Bhola River is near the Western part of the Royenda Union. The Khontakata Union is a less risky zone to flood hazard because only its eastern side is enclosed by the Balershawar River, being also situated at a long distance from the Bay of Bengal.

4. Conclusion

Bangladesh is a natural disaster prone country, the coastal belt being the mainly and most severely affected area. Flood is the most common phenomenon in the South-Western region. This research reveals the actual situation of Sarankhola upazila in terms of different disasters being faced over time. The vulnerability of this coastal area varies due to diversified socio-economic settings. The perception of the local people in the study area is that they are not at so severe a risk due to the presence of the Sundarbans, but the Sundarbans itself is at a risk due to change of sweet water flow, and increasing salinity. Moreover, illegal intervention on embankment or "Bheri Bundh (BB)" by shrimp farmers of this area augmented the risk of people to floods, water surge etc.

Therefore, a sustainable approach to disaster management policy and appropriate mitigation plans are

crucial for this area. It is essential to take better disaster mitigation and prepared efforts involving local people. According to them, mainstreaming disaster management activities with mainstreaming of development issues is essential to reduce the disaster damage over time.

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