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Flood Risk Reduction of Rupnarayana River, towards Disaster Management – A Case Study at Bandar of Ghatal Block in Gangetic Delta

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Abstract

The paper discussed the present state of flood at a junction point between two rivers at Bandar of Ghatal block in Gangetic delta and proposed a technological solution to reduced vulnerability of flood. While annual floods have the potential to wreak havoc on unprepared communities, spoil crops and endanger food security, they also play a vital role in agriculture. Flood Management and Mitigation is designed to minimize negative flood-related impacts while preserving the benefits. Flood mitigation involves the managing and control of flood water movement, such as redirecting flood run-off through the use of floodwalls and flood gates, rather than trying to prevent floods altogether. It also involves the management of people, through measures such as evacuation and dry/wet proofing properties for example. The prevention and mitigation of flooding can be studied on a number of levels: individual properties, small communities and whole area or towns or cities. The costs of protection rise as more people and property are protected. The most effective way of reducing the risk to people and property is through the production of flood risk maps. Most countries in the developed world will have produced maps which show areas prone to flooding events of known return periods. By identified areas of known flood risk, the most sustainable way of reducing risk is to prevent further development in those known flood risk areas. It is important for at-risk communities to develop a comprehensive Floodplain Management plan. Those communities that participate in the National Flood Insurance Program must agree to regulate development in the most flood prone areas. Communities should assign a floodplain administrator to oversee the management of the floodplain development permit process. Reduction of erosion hazard we can use by MZWA (Mapping and zoning of watershed area), RZB (Restricted Zone of Build up), various soft engineering techniques and other necessary methods without any negative impacts of natural resources.

Keywords: Flood; Bank erosion; Catchment shape; Sediment; GIS; Model

Introduction

Decision makers worldwide face a difficult challenge in developing an effective response to the threat of water-induced disasters. After prayers to the rain gods, answered in excess in parts of our country, now the focus has shifted to floods. Many states in our country are flood prone due to heavy rain or otherwise. The flood causes loss to human life and wide spread damage to property. Unimaginable damage to agriculture takes place affecting the States planning and upset the financial budgeting there by slowing down the whole economy of the country. People not affected by the flood tend to ignore the event thinking that it does not affect them so why bother? Flood is not unique to India. Floods come in different parts of the world. Floods are the biggest cause of loss of life every year throughout globe. Majority of countries do not document or map floods methodically. Flood affects many areas of national economy. Following are some of the areas needing attention from government bodies [1].

- Agricultural Damage
- Commercial and Industrial Damage
- Residential Properties Damage
- Transportation Damage
- Man and Livestock Damage
- Flat Land

Background of the Study Area

River Silabati and Dwarakeswar meet at Bandar, and the combined flow is named as Rupnarayan, which joins river Hoogly at Geonkhali covering a distance of 78 km. The study area extends between 22039'30''N & 87046'12''E and 22039'30''N & 87047'15''E to 22040'50''N & 87046'12''E and 22040'50''N & 87047'15''E at Bandar, Paschim Medinipur, West Bengal, India. The catchment area of both the tributaries has typical tropical monsoonal type of climate with an average rainfall of 1320 mm to 1630 mm. Annual temperature ranges from 11°C to 45°C. The angle of junction of river Silabati and Dwarakeswar with respect to river Rupnarayan are 230 and 360 respectively. The gradient of Dwarakeswar (0039'52.56") is more than Silabati (0011'55.03") and Rupnarayan (009'25.16"). The average elevation of the junction is 12 m. from mean sea level. The junction area is characterized by a sequence of pools and riffles. Semi-diurnal tide is active here and tidal impulse penetrates a little beyond Bandar. Tidal bore of lower magnitude is an important phenomenon at that junction (Figure 1).

Objectives

- To find out the main causes of flood and it's effect on the eco-geo- environmental condition.
- To generate and apply eco-friendly technological solutions and

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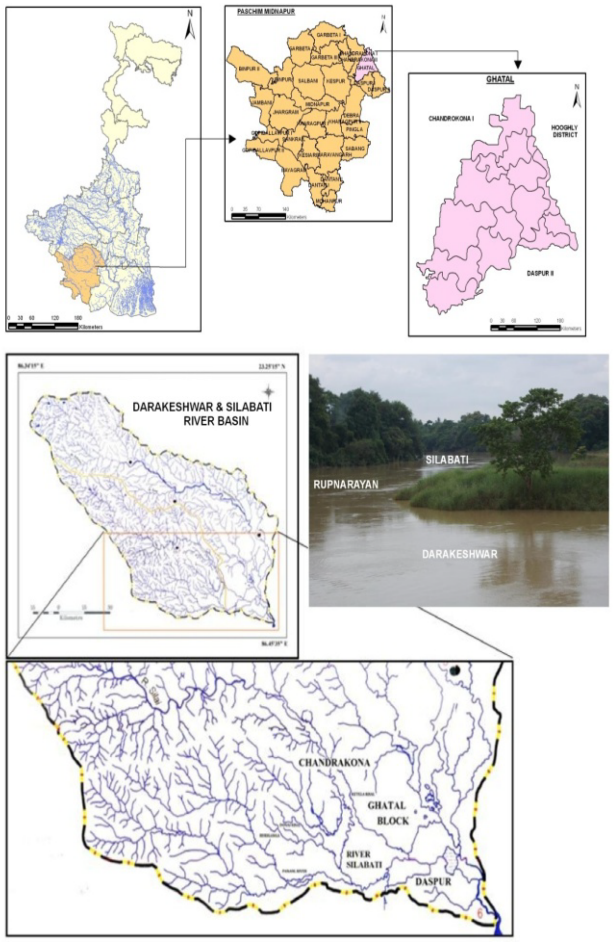

Figure 1: Map of Study Area.

arrangements supported by local technical knowledge and materials for flood risk reduction.

Materials and Methods

When at one end of a tidal river section the water level changes, the water level at the other end of the section will also change after some delay. The delay is determined by the length of the river section and by velocity the initial change propagates through the river. For the major part this propagation velocity depends on the average depth of the river section.

C= (g.h) (+)/(-) V

Where,

c=propagation velocity

g=acceleration of the gravity

h=average depth

v=velocity of the flow

(+)=when c and v are in same direction

(-)=when the direction of the v differs from that of c

The propagation velocity (c) is much higher than the current (v). In a river section with average depth 10m, propagation velocity is about 10 m/sec. and with an average depth of 5m, it is about 7 m/sec, assuming the value of 'V' close to zero. The water level at the confluences of the major rivers with the sea is constantly changing due to tides. These changes propagate O not only along their own courses but also along the many bifurcations, creeks etc., changing with varying time-length water levels at both ends of each river of creek section, initiation a pattern of flows in the various water ways.

Several past studies had presented discrimination between the straight, meandering, and braided streams on the basis of discharge and channel slope. Lane [2] suggested the following criterion for the occurrence of braiding.

$S>0.004\ (Q_{m})^{-0.25}$ (1)

Where, $Q_{m=}$mean annual discharge; and S=channel slope.

Using bank full discharge Q_b, Leopold and Wolman in 1957 [3,4] proposed the relationship for braiding to occur, which also predicts braids at higher slopes and discharges:

$S>0.013\ Q_b^{-0.44}$ (2)

Where, $Q_{b=}$bank full discharge.

Antropovskiy (1972) developed the following criterion for the occurrence of braiding

$S>1.4Q_b^{-1}$ (3)

Leopold and Wolman also indicated that braided and meandering streams can be separated by the relationship:

$S=0.06\ Q^{0.44}$ (4)

Where, S=channel; and Q=water discharge.

However, these indicators have been criticized by Schumm and Khan [5] as none of these recognizes the importance of sediment transport. These results imply a higher power expenditure rate in braided streams, a conclusion reinforced by Schumm and Khan's [6] flume experiments. However, none of these investigators recognizes the control of channel pattern by sedimentology. Since, bed material transport and bar formation are necessary in both meander and braid development processes, the threshold between the patterns should relate to bed load. Henderson [7] re-analyzed Leopold and Wolman's data to derive an expression including d_{50}, median grain size (mm):

$S>0.002\ d_{50}^{1.15}\ Q_b^{-0.46}$ (5)

Where, d_{50}=median grain size

According to equation (5), a higher threshold slope is necessary for braiding in coarse bed materials. Bank material resistance affects rate of channel migration and should also influence the threshold, although its effect may be difficult to quantify and also be non-linear since greater stream power is required to erode clays and cobbles than sands.

Parker's stability analysis [8] indirectly illustrates the effects of bank material resistance by defining the meander - braid threshold as:

$S/F_{r=}D/B$ (6)

Where, D=mean depth of the flow; B=width of the stream, and Fr=Froude number.

However, depth, width and Froude number may be expressed in terms of discharge and bank silt-clay percentage, as suggested by Schumm (Richards, 1982). Meandering occurs when $S/Fr \leq D/B$, braiding occurs when S/Fr ≥ D/B, and transition occurs in between S/Fr ~ D/B.

Ferguson (1981) suggested for braiding to occur, which predicts steeper threshold slopes for braiding in channels with resistant silty banks.

$S>0.0028\ (Q_b)^{-0.34}\ B_c^{0.90}$ (7) Where, B_c = percentage of silty clay content in the bank material (Figure 2).

Results and Discussion

Floods vary in degree of severity in terms of areas extent or magnitude and in depth. They are, thus, classified as minor or major flooding. In a *minor flooding*, inundation may or may not be due to overbanking. When there is no bank overflow, flooding is simply due to the accumulation of excessive surface run-off in low lying flat areas. Floodwaters are usually confined to the flood plain of the river along the channel, on random low-lying areas and depressions in the terrain. Floodwater is usually shallow and there may not be a perceptible flow.

During a *major flood*, flooding is caused by the overflowing of rivers and lakes; by serious breaks in dikes, levees, dams and other protective structures; by uncontrollable releases of impounded water in reservoirs and by the accumulation of excessive runoff. Floodwaters cover a wide contiguous area and spread rapidly to adjoining areas of relatively lower elevation. Flooding is relatively deep in most parts of the stricken areas. There is a highly perceptible current as the flood spreads to other areas.

While floods take some time, usually from 12 to 24 hours or even longer, to develop after the occurrence of intense rainfall, there is a particular type which develops after no more than six hours and, frequently, after an even less time. These are what are known as *flash floods*.

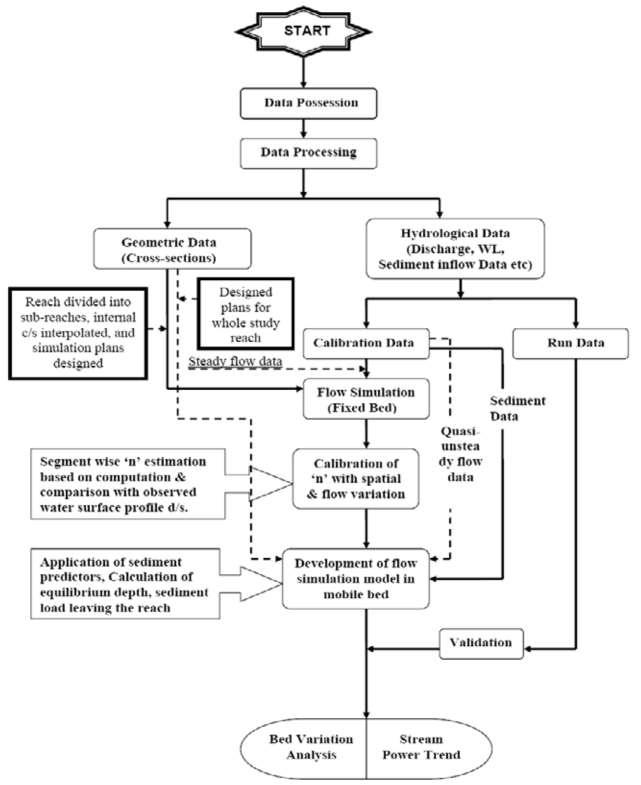

Figure 2: Flow Chart of Methodology.

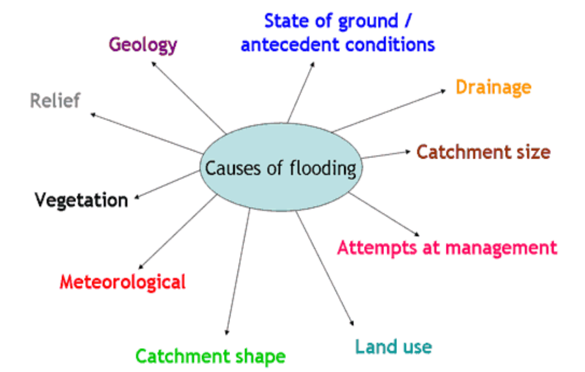

Figure 3: Causes of flood of the Study Area.

Month	Rainfall in mm.		
	2013	2012	2011
January	0	0	0
February	35.6	36.6	37.7
March	128.7	122.7	132.6
April	54	64	56
May	182.2	158.7	147.3
June	333.6	340.6	339.1
July	1092.7	1127	1198
August	356	355	361
September	442.5	338.6	498.6
October	52.8	78.7	69
November	31.6	35	38
December	0	0	10.2

Table 1: Month wise rainfall chart (Silabati development authority).

Causes of flood in the study area (Figure 3)

Main causes of the flood at Bandar of ghatal block are -

Meteorological: High rain fall in monsoon season is main causes for flood at Bandar area of Ghatal block.

Month wise rainfall chart (Silabati development authority) (Table 1 and Figure 4).

Catchment size: Badar is a junction point of dwarakeswar and silai river and the combined flow is named as Rupnarayan. So in a monsoon season two rivers carry on huge amount water and when meet the junction point of Bandar, water is overflow. Because catchment size of river is not enough here (Figure 5).

Catchment shape: The actual width of the river Silabati and Dwarakeswar is 50 m., but it is 80 m for Rupnarayan. The expected width of Rupnarayan is 66.66 m [9]. The increase volume of water due to tidal effect is one important cause for the extra width of Rupnarayan River at junction. This sudden widening causes flow separation leading to increased sedimentation.

Effects of flood

Flooding can be very dangerous – only 15 cms of fast-flowing water are needed to knock you off your feet! Floodwater can seriously disrupt public and personal transport by cutting off roads and railway lines,

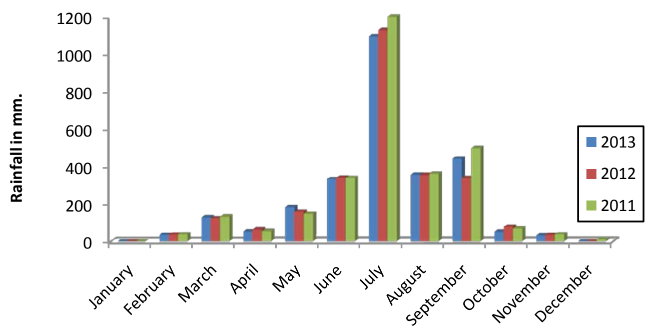

Figure 4: Month wise rainfall in various year of the Study Area.

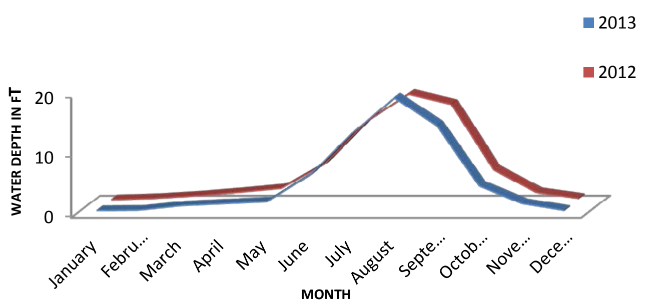

Figure 5: Depth of water in river at Bandar.

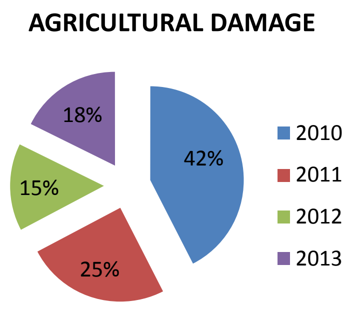

Figure 6: Agricultural loss.

as well as communication links when telephone lines are damaged. Floods disrupt normal drainage systems in cities, and sewage spills are common, which represents a serious health hazard, along with standing water and wet materials in the home. Bacteria mould and viruses, cause disease, trigger allergic reactions, and continue to damage materials long after a flood. Floods can distribute large amounts of water and suspended sediment over vast areas, restocking valuable soil nutrients to agricultural lands. In contrast, soil can be eroded by large amounts of fast flowing water, ruining crops, destroying agricultural land/ buildings and drowning farm animals.

Agricultural loss: Agricultural land is the vital resource for the people living in study area specially those who live in land, total agricultural production of that particular land and labour force engaged in that occupation. The poor had less amount of land to support their family. Almost 62 percent of the total population lives on agriculture (Figure 6).

Loss of households: Last few years some residential house is partly or completely damaged by flood and an erosion of the selected area (Table 2 and Figure 7).

Loss of road: Last four years every year 1.5 to 2.5 km average road is destroyed by flood of the selected area (Table 3 and Figure 8).

River bank erosion: River bank erosion put enormous stress to the people who reside along with riverbanks as they lost their homestead, agricultural lands and overall agricultural production (Figure 9).

Damage of population: Unfortunately many family or person is affected by flood or shifted of the selected area in last decade (Table 4 and Figure 10).

Flood risk reduction management

Flood control refers to all methods used to reduce or prevent the detrimental effects of flood waters. Some of the common techniques used for flood control are installation of rock berms, rock rip-raps, sandbags, maintaining normal slopes with vegetation or application of soil cements on steeper slopes and construction or expansion of drainage channels. Other methods include levees, dikes, dams, and retention or detention basins. There are two types of measures to mitigate the flood damage: structural mitigation measures and non–structural mitigation measures.

YEAR	Full damage	Part Damage
2010	8	18
2011	3	7
2012	0	5
2013	1	9

Source: B.D.O and field survey

Table 2: Number of households.

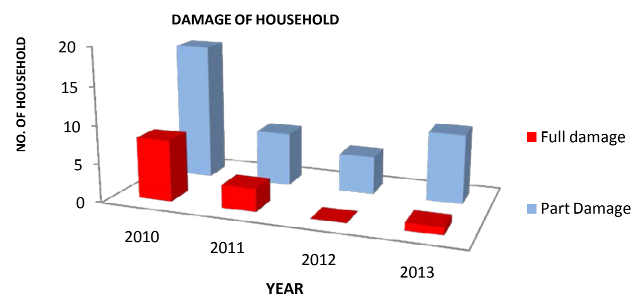

Figure 7: Damage of household (No. of Household).

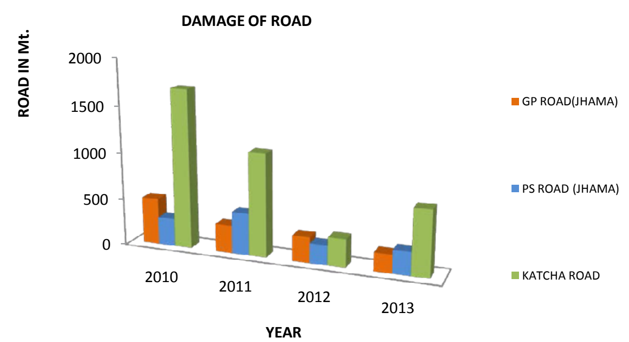

Figure 8: Damage of Road (in Meter).

Year	G.PROAD (JHAMA)	P.S ROAD (JHAMA)	KATCHA ROAD(mt)
2010	500	300	1700
2011	300	450	1100
2012	275	212	300
2013	200	250	700

Source: B.D.O and field survey

Table 3: Damage of road in mt.

Figure 9: An image of river bank erosion.

Year	Shifted Population	Affected Population
2000	325	2082
2001	275	1565
2002	272	1365
2003	155	1090
2004	300	750
2005	172	542
2006	135	460
2007	0	45
2008	85	350
2009	132	572
2010	62	350
2011	55	275
2012	42	180
2013	22	150

Source: B.D.O and field survey

Table 4: No. of population.

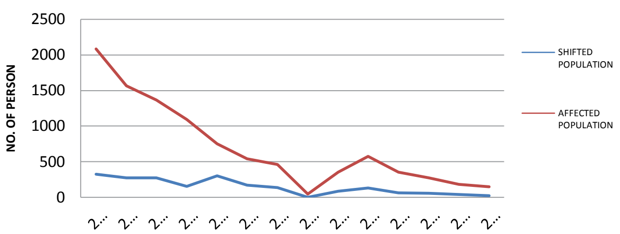

Figure 10: Affected and shifted population during flood in various year.

Structural mitigation measures:

- Reduction of flood peak by storage reservoirs

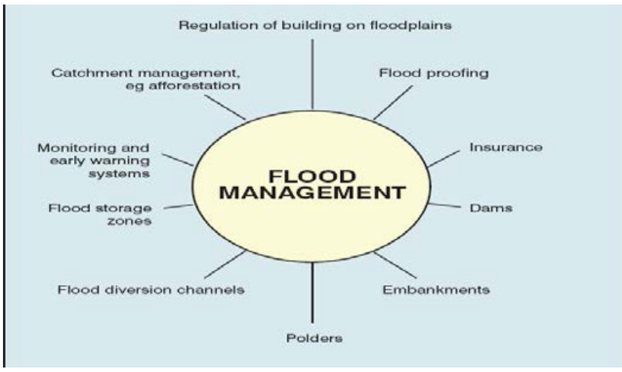

Figure 11: Flow chart of flood management.

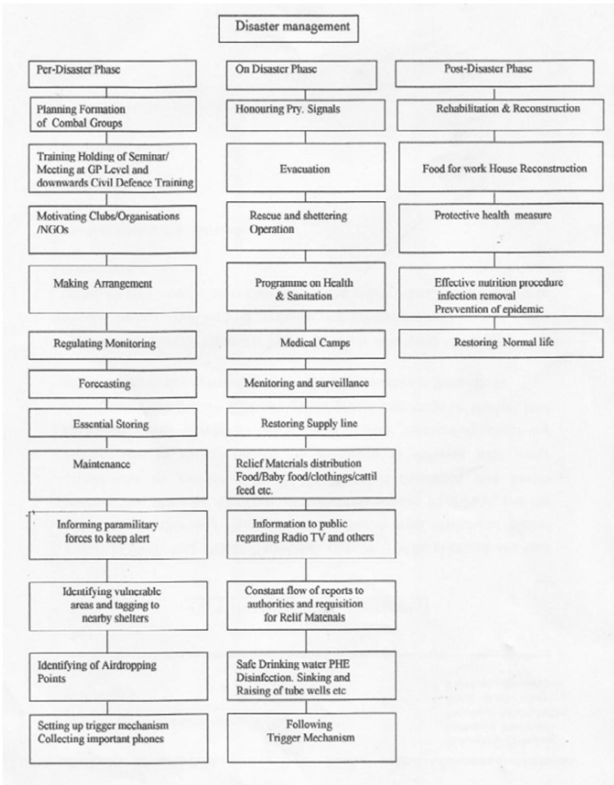

Figure 12: Flowchart of Managerial action for Flood Reduction Process of Dwarakeswar-Silabati-Rupnarayan river.

- Storage reservoirs and detention basin
- Confining river flood by embankments
- Flood wall
- Channel improvement works
- Cut – off
- Diversion of flood water: floodway
- Construction of higher earthen platform in low – lying flood prone area
- Sluices

- Ring bund

Non-structural mitigation measures (Figure 11):

- Drainage linkage system (DLS)
- Prepared RZB (Restricted Zone of Buildup)
- Prepared MZBA (Mapping and Zoning of Basin Area)
- Connection of rivers with source
- Flood forecasting or warning
- Flood proofing
- Weather modification
- Mathematical modeling
- Flood insurance (Figure 12)

Conclusion

Irrigation and Waterways Department (I & WD) Govt. of West Bengal has already taken up distillation works in some major reaches of the river. However, the progress is not up to the mark and there is no comprehensive project to solve the problem. Finally I thing long term sustainable development is ideal development for any type disaster management including flood.

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