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VULNERABILITY OF FLOOD PRONE COMMUNITIES IN THE LOWER REACHES OF SHILAI RIVER- GHATAL BLOCK, PASCHIM MEDINIPUR DISTRICT, WEST BENGAL, INDIA

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ABSTRACT

Climate change, an alteration in the state of the climate can be identified by changes in the mean state and/or the variability of its properties and it persists for an extended period of time. Climate change occurs may be due to natural internal processes or external forces. Specifically, local outcomes of climate change are uncertain in the form of frequency, intensity, spatial extent or duration of weather. Climate extremes like heavy precipitation events increase vulnerability and will ultimately lead to increased stress on human and natural systems and a propensity for serious adverse effects in many places around the world. The main topic of concern in this research paper is the changes in extremes of atmospheric weather and climate variables (e.g., temperature and precipitation), large-scale phenomena that are related to these extremes (viz. change in monsoon character) and collateral effects on the physical environment (e.g. floods etc) and human susceptibility. The study area is the Ghatal block located at the lower reaches of Shilai River catchment and administratively is located within Ghatal subdivision of Paschim Medinipur district of the state of West Bengal. As Ghatal block falls within the Micro-watershed of Shilai River, therefore from the hydrologic point of view, the effect of overland flow rather than the effect of the channel flow is a dominating factor as the channel storage capacity of small watersheds is limited. Moreover a small watershed is very sensitive to high intensity rainfalls of short durations and to land use-changes. The area is very much prone to flood and sediment damage also. The river banks are high and the river itself is narrow here. In winter, waterfalls very low and is further reduced towards its end by being taken –off for irrigating the spring crops. But in Monsoon the river becomes extremely vulnerable and therefore flooding a huge areal extent. This flooding, through the passage of time is subjected to get affected by climatic variations and they inundate all the low lying areas within the block for a longer period of time during monsoon, which affects the agricultural practices and even to human livelihood pattern. The study will focus on the socio-economic conditions of the local people and ways and methods adopted by them to cope with this vulnerability and their adaptability. It will also focus on the developmental plans taken up by the government and proposal of preparing a framework on flood risk-management plans to combat such increasingly adverse environmental conditions.

INTRODUCTION

Climate-related disaster risk is most adequately depicted, measured, and monitored at the local or micro level (families, communities, individual buildings or production units, etc.) where the actual interaction of hazard and vulnerability are worked out in situ. At the same time, it is accepted that disaster risk construction processes are not limited to specifically local or micro processes but, rather, to diverse environmental, economic, social, and ideological influences whose sources are to be found at scales from the international through to the national, sub-national and local, each potentially in constant flux. Disaster entails social, economic, or environmental impacts that severely disrupt the normal functioning of affected communities. Extreme weather and climate events will lead to disaster if:

1) Communities are exposed to those events; and
2) Exposure to potentially damaging extreme events is

accompanied by a high level of vulnerability (a predisposition for loss and damage). On the other hand, disasters are also triggered by events that are not extreme in a statistical sense.

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High exposure and vulnerability levels will transform even some small-scale events into disasters for some affected communities. Recurrent small- or medium-scale events affecting the same communities may lead to serious erosion of its development base and livelihood options, thus increasing vulnerability. The timing (when they occur during the day, month, or year) and sequence (similar events in succession or different events contemporaneously) of such events is often critical to their human impact. The relative importance of the underlying physical and social determinants of disaster risk varies with the scale of the event and the levels of exposure and vulnerability. The potential negative consequences of extreme events can be moderated in important ways (but rarely eliminated completely) by implementing corrective disaster risk management strategies that are reactive, adaptive, and anticipatory, and by sustainable development. The Inter-Governmental Panel on Climate Change (IPCC) 2007, has defined, "Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity." Therefore, vulnerability assessment is the process of identifying, quantifying, and prioritizing (or ranking) the vulnerabilities in a system. Vulnerability from the perspective of disaster management means assessing the threats from potential hazards to the population and to infrastructure. It may be conducted in the political, social, economic or environmental fields.

Study Area

The study area is the Ghatal Block located in the lower reaches of Shilai River catchment and administratively is located within Ghatal subdivision of Paschim Medinipur district of the state of West Bengal. Ghatal block is the severely flood affected area which lies between 22 35' 5" to 22 47' 37" North latitude and 87 36' 22"East to 87 49' 8" East longitude. The study area is situated in lower catchment of the Shilai River, which has originated from Chotanagpur plateau. The study area has tropical monsoon climate, mean annual rainfall ranges between 250 to 300 mm, which is concentrated in the months of June – September and the mean annual temperature is 26° c. The soil properties and hydrologic condition are quite suitable for agricultural cultivation. The geographical area of Ghatal block is 229.91 sq km and has 12 Panchayat, 156 Moujas and 54591 Households (2011).

Objective

- The main objective of the study is to do the socio-economic vulnerability assessment in some selected villages
- The adaptability measurements and coping strategies of the local people to the regular flood hazards
- In-depth analysis of the developmental and risk-management plans to combat such increasingly adverse climatic and environmental conditions

MATERIALS AND METHODS

Multiple databases, including both primary and secondary are required for this research work. The primary data has been obtained based on questionnaire survey, which is concentrated on frequency and duration of flooding, climatic experience of people in last 100-150 years, problems faced by local people during flooding, effect on their livelihood pattern during floods, availability of government aid, healthcare and transport facilities during flooding etc. The secondary data along with their sources are the Toposheets from Survey of India, available Satellite images in soft copy format from Geography Department, University of Burdwan; Climatic data (temperature, rainfall) from District Statistical Handbook of Paschim Medinipur. Other data from District Collectorate Office etc. Beside these, numerous books, journals and reports are followed for basic understanding. Various methods are adopted for proper analysis and interpretation of the study area. Based on available multi-seasonal satellite images and ground observation, the changing river course, flood affected areas, landuse-landcover patterns are identified and drainage map, flood affected mouza maps are prepared for Ghatal block. From the climate data, the rainfall and temperature graphs are prepared from 2005 to 2008 as the years of most variable climate in last decade are identified in between this period. Beside these, the problems of flood hazards are identified, socio-economic impacts of flood hazard on local people are analysed along with their coping strategies.

RESULTS AND DISCUSSION

Climate of the Study Area

The study area has a tropical monsoon climate, hot summer and well distributed normal rainfall. The year divided into four seasons, the winter season starts about middle of December and continuous till the end of February and summer which extend up to May. The South West monsoon season continuous up to the end of September, October and the first half of November is the post monsoon. The study area have highly effected in monsoon season by flood.

Temperature

Temperature rapidly rises about from early March. May is the hottest month with a mean daily temperature 31.7° c. The mean annual temperature is about 28. 92°C. The temperature rapidly decreases appreciably in January when the mean temperature is about 19.7°C January is the coldest month of the year.

Rainfall

The average annual rainfall 250 to 300 mm. Rainfall decreases in the cold weather months of November and December. Considerable amount of monsoon rainfall occurs in association with the movement of Cyclonic depression from the Bay of Bengal. It rains heavily from June to September (Fig. 1)

Floods are a common feature in Ghatal Block which is clear from Table No 1. In this study area there are 12 Panchayats, 156 Moujas and two municipalities. The historical flood events show that 10 Panchayat and 63 Moujas highly flood affected. The flood affected Moujas are shown in the Fig 2.

Livelihood Pattern of The Local People In The Study Area

Ghatal block is a severe flood prone area. Past records depicts that in every year, flood affects the major portion of the area in monsoon time (June to September). Due to flooding in the

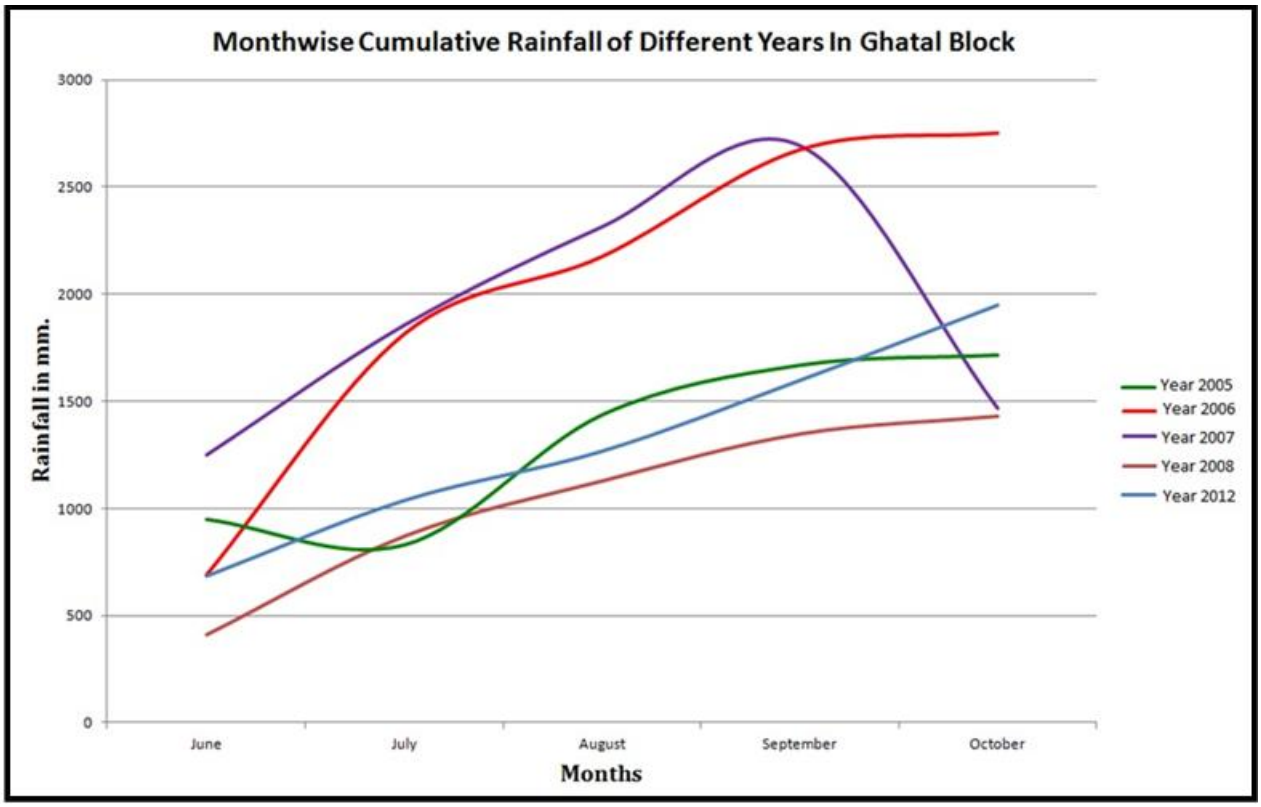

Fig. 1. Monthwise Cumulative Rainfall of Different Years In Ghatal Block

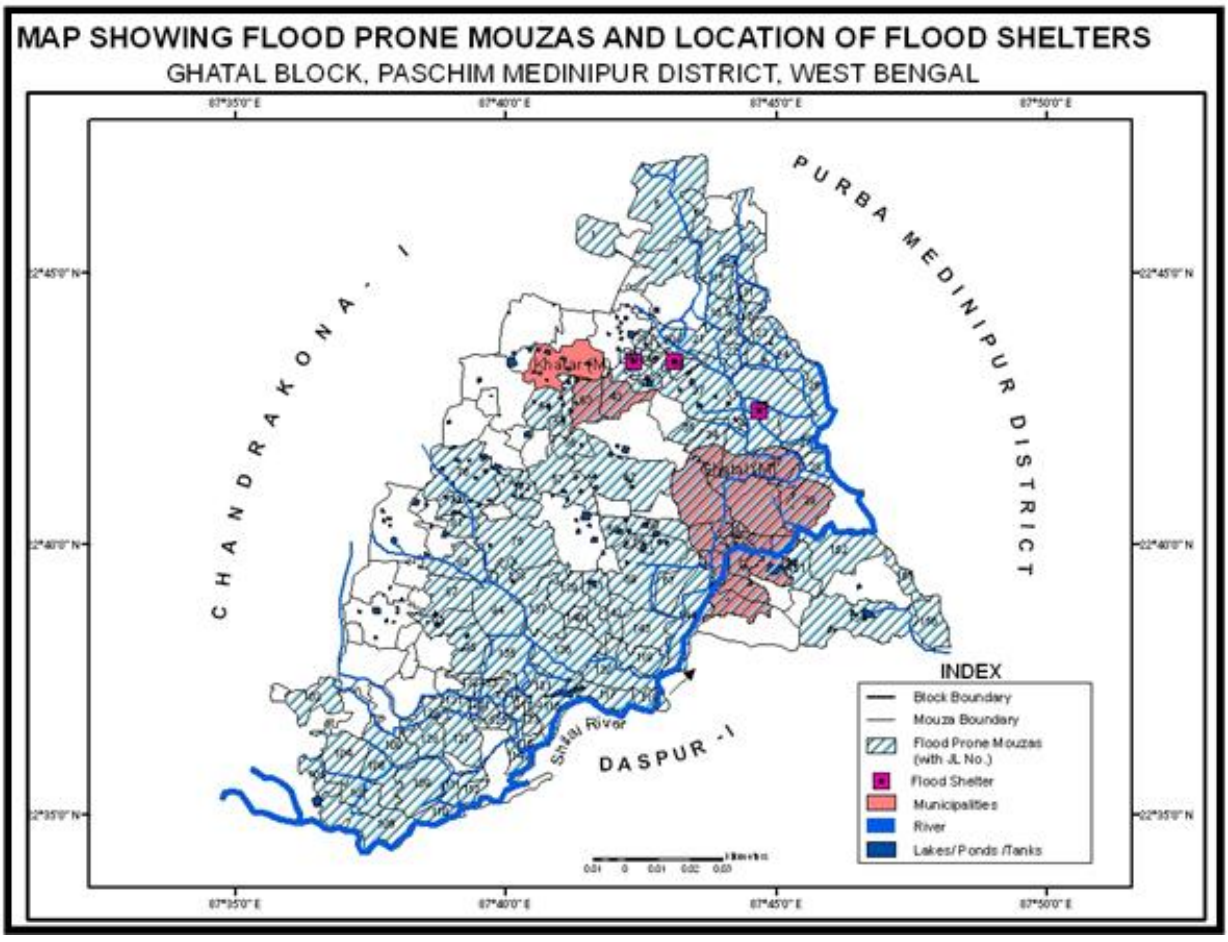

Fig. 2. Map Showing Flood Prone Mouzas And Location Of Flood Shelters, Ghatal Block, Paschim Medinipur District, West Bengal

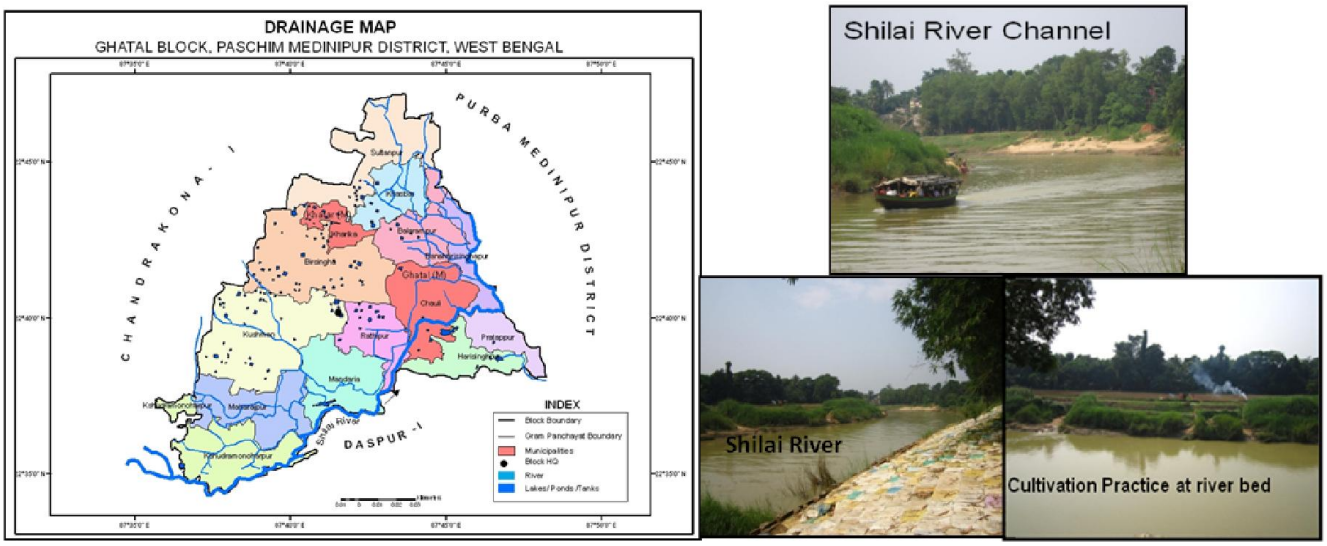

Fig. 3. Drainage Map, Ghatal Block, Paschim Medinipur District, West Bengal

Table 1. Occurrence of the Flood Events

Year	Month Of Monsoon Time	Cumulative Rainfall Of Month In (Mm)	Water Level Of Silabati River (M.) Gadghat Guage Station	Remarks	Charcterics Of Flood On The Basis Of River Gauge Height
2012	JUNE JULY AUGUST SEPTEMBER OCTOBER	409.5 868.9 1126.9 1346 1428.7	4.13	MODERATE FLOOD OCCURRENCE	1.1m-3m= Low Flood Occurrence 3.1m -6 m= Moderate Flood Occurrence 6.1m-9m= High Flood occurrence 9.1m-12m = Very High Flood Occurrence
2008	JUNE JULY AUGUST SEPTEMBER OCTOBER	1251.40 1857.10 2315.70 2694.00 1469.06	8.50	HIGH FLOOD OCCURRENCE	
2007	JUNE JULY AUGUST SEPTEMBER OCTOBER	691.40 1815.90 2177.00 2675.60 2753.20	10.21	VERY HIGH FLOOD OCCURRENCE	
2006	JUNE JULY AUGUST SEPTEMBER OCTOBER	947.00 827.80 1435.40 1667.20 1714.50	8.00	HIGH FLOOD OCCURRENCE	
2005	JUNE	684.60	8.17	HIGH FLOOD OCCURRENCE	

Source: *Irrigation and Waterways Department, Ghatal*

Table 2. Location and Distance of Surveyed Households from Shilai River Bank

Total Households surveyed	Left bank respondents (Flood prone area)	Right bank respondents (Less Flood prone area)	≤ 500m from river bank	501 m to 2 km from river bank	> 2 km from river bank
100	81	19	54	23	23

lower catchment of Shilai river, water over spilling in the study area and the other causes of flooding are narrow river channel, over sedimentation of channel, higher intensity of runoff, heavy rainfall and very low elevation of flood inundated area. To identify the extent of flood exposure to local people, 100 households are surveyed in Ghatal Block, along both sides of Shilai River, ranging about 100mt from the river bank to beyond 2km reach. Among them 54 percent people are living within 500m from the Shilai river, 23 percent are found within 500m to 2km from the river channel and the rest of 23 percent respondents are found beyond 2km from the river reach (Table 2). A more or less similar hazardous scenario is being found all over, only with differential intensity.

Frequency and Duration of Flooding

Among all the respondents, according to the 65 percent people have reported that they face flood once in every year (Table 3). They are mostly beyond 500m reach from river channel and about 80ft above of river bed. To them flood is a regular event during monsoon, therefore they have to dodge Kharif cropping during monsoon rather are more dependent on Rabi crops. It is only 14 percent, who faces flood twice in a year and 12 percent experience floods more than twice in a year. These people are actually within 500m of range of the river even sometimes within 100 to 200 m ranges are also found. Only 9 percent people do not face flood regularly as they are farthest from the river channel. However, whether the flood is frequent

or rare, the flooding period also varies widely. According to the local resident, 32percent people faces flood for 1 month or slightly less, 35percent people experience 8-15 days flood inundation, 28percent has the suffering of less than 7 days (Table 4). But conspicuously the people nearest to the river faces more than 1 month of flooding which accounts for only 5percent people. There is a great variability of rainfall pattern in recent years which has its influence on the extremity of flooding in Ghatal block.

Table 3. Frequency of Monsoon flooding

Total Households surveyed	Not Regularly	Once in a year	Twice in a Year	More than twice
100	9	65	14	12

Table 4. Duration of Monsoon Flooding

Total Households surveyed	≤7 days	8- 15 Days	16 -30Days	> 1 month
100	28	35	32	5

Agricultural Activities

Occupancy of Land: The case study has been thoroughly prepared by household survey throughout Ghatal blocks. People have varying amount of availability of farmland. While 30percent people are not at all dependent on the cultivation the rest 70percent are directly or indirectly involved with this agricultural practice. Among them 30percent having near about 1 acres (more than 2.5 bighas) of land each, 19 percent having 1 bigha to 2.5 bigha of farmland and 21percent having less than 1 bigha of farmland.

Type of Farmland: Moreover, a conspicuous feature of these farmlands are that all these lands are double cropland but due to regular flooding, only 73percent people can afford this double cropping while only 27percent people has to depend on single season cropping, mostly on vegetables in winter months (Table 5). Some people also cultivate boro paddy in their fields.

Table 5. Characteristics of Farmland in Ghatal Block

Households depend on Single Cropping	Households depend on Double Cropping	Area of Single cropping (in percent)	Area of double cropping (in percent)
19 (27percent)	51 (73percent)	24 percent	76 percent

Source of Seeds: As the region is very much vulnerable to flood hazard, therefore the landowners and cultivators have to take special caution regarding storage of seeds. It is found that majority of them about 56 percent people generally buy the seeds from open market and store it, while 27percent has their own storage from the farmland (Table 6). Only 17percent people have to depend on both the open market and their own storage.

Table 6. Source of seeds

Total Households having land	Own Storage	Open Market	Both own storage and Open market
70	19 (27percent)	39 (56percent)	12 (17percent)

Availability of Irrigation Water: Due to the flooding in monsoon people has to depend majority on rabi and zayed cultivation, they have to arrange for irrigation water. There are number of irrigation practices like 47percent cultivators are dependent on River Lift irrigation, 24percent from Mini shallow tubewell and 3percent from pumping from pond and rest of them uses a combination of deep, shallow tubewell or canal and river lift irrigation etc (Table 7). It is found that the agriculture in Ghatal block during non-monsoon period is totally dependent on irrigational practice which is a success even under the threat of flood as a regular event.

Table 7. Source of Irrigation Water

Total Households Having Irrigational Facilities	River Lift Irrigation	Mini shallow Tube well	Pumping from Pond	Canal & Mini Shallow tube well	Deep and Mini shallow Tube well	River lift irrigation and mini shallow tube well	Pond and mini shallow tube well	River lift irrigation, Canal and mini shallow tube well
70	33 (47percent)	17 (24percent)	2 (3percent)	2 (3percent)	10 (14percent)	2 (3percent)	2 (3percent)	2 (3percent)

Domestic Animals and Their Usage

Out of total surveyed people 51percent of them have their own domestic animals. All of them have cows, 5percent have both cows and goats while another 5percent have cows and ducks. It is being found that 90percent people domestically use their animal while 10percent has a motive to sell those as per requirement (Table 8). However it is found that during flood, animals are shifted to higher lands and if they are felt ill, the owners avail doctors for their treatment. The case of death of animals during floods have also taken place but to a very little extent.

Table 8. Types of Domestic Animal and Their Usage

People having Domestic Animals	People have Cow	People have Cow and Goat	People have Cow and Duck	People have domestic usage	People has selling purpose
51	45 (90percent)	3 (5percent)	3 (5percent)	46 (90percent)	5 (10percent)

Source of Drinking Water

As the region is vulnerable to flood, therefore people have to assure the access of safe drinking water during flooding also. Most of the population is served by municipal tap water in Ghatal town; about 30percent town people are dependent on this (Table 9). In other parts of the block, 18percent people have the access of tubewell, 12percent have sub-mersible pump etc. The rest of the people use ponds, river water, combination of tubewell-tapwater etc for domestic purposes. During monsoon, people dependent on ponds, rivers has to cross a long path even to other villages also to get access of tubewell water.

Table 9. Source of Drinking water During Flood

Tapwater	Tubewell	River and Tap water	Tubewell and Tap water	Tubewell and pond	Sub mersible pump
30percent	18percent	7percent	21percent	12percent	12percent

Demographic Pattern

The people are found in both left and right bank of the Shilai River, however the left bank people are more flood prone

compared to the right bank residents. The area has a very high density of population about 883 persons/ sqkm area. Majority of people are residing from a very early period in this region. About 65percent people are the permanent residents who are living with their family for last 100 years or more, about 19percent people residing here for about 50-100years, about 14percent people are staying there only for 20-50 years and only 2percent people are the local resident for less than 20 years (Table 10). Therefore a huge section of the population has experienced the climate change and the resultant recurring floods over a longer passage of time. Moreover the age structure has a proportional shape with high working age population and low child and old age population. Though for a detailed study the aged persons are surveyed mostly, but the region shows a balance in age sex structure. (Table 11). In case of gender profile the region shows backwardness, as the sex ratio is only 852, which is much less than the national standard, even to district standard. With such a demographic profile the local community faces the regular flood occurrence from very early stages and has tried to cope up with their vulnerable conditions.

Table 10. How long Surveyed families are residing

<20 years	20-50years	50-100 years	>100 years
2percent	14percent	19percent	65percent

Table 11. The Age and Sex Structure of the people among the Surveyed Household

<25 years	25-50 years	>50 years	Male	Female	Children below 12 years of age (male +Female)
6 percent	40 percent	54 percent	54 percent	46 percent	20 percent

Vulnerability Assessment of Flooding In Ghatal Block

According to the local people, the vulnerability of the flood in local areas has aggravated the situation especially due to slow but continuous change-over of the climatic variables for past a few years. In addition, various other dimensions have identified by the local people as well as district planners as the causes of local flood. These are:

- Heavy precipitation and release of reservoir water increases the intensity of floods.
- The continuous sedimentation on the river bed reduces the depth of the channel flow.
- Shifting of the river –course increases the vulnerability of flood hazard.
- Bank erosion causes is another important factor of flooding.
- Moreover flows above risk level create the possibility of devastating flood as a whole.

Due to the flooding, farmers generally avoid monsoon season (kharif crop) cultivation as the farmlands are inundated for long. But they have found out a good resultant effect of this flood on their farmland. About 30percent of them agreed that such flood causes sedimentation increase in their land which in next cropping season helps them to increase the productivity of their land (Table 12). About 47percent people are in the consent of about crop loss as well as sedimentation increase. Only 13percent depicts that there is a regular yearly productivity reduction and only 10percent agrees to have their fields being damaged by this flood occurrence. Therefore the farmlands, though they are multi-cropping lands, are generally being used for single cropping or sometimes double cropping except monsoon.

Table 12. Peoples' Perception Regarding the Effects of Flood on Farmland

Sedimentation Increase	Crop loss and sedimentation Increase	Field damage and Crop loss	Reduction of Yearly production
30percent	47percent	10percent	13percent

Effect on fish-cultivation

Among the surveyed people, only 56percent having the ponds for fish cultivation. Due to flooding they are bound to adopt a number of measures to protect their fishes. About 50percent people are compelled to catch the fishes before monsoon as there is the possibility of loss of fishes as well as loss on productivity (Table 13). Even 8percent has the say that sometimes they are unable to save their fishes and has to face the fish death in this period. Only 42percent people accept the idea of cleanliness of water during flooding and rapid inflow of fishes from others pond or even from canals etc.

Table 13. Peoples' Perception Regarding The Effects on Fish Cultivation

People Having Ponds	Compelled to catch fishes before monsoon	Loss of fishes & fish death	Cleanliness of water and inflow of fishes from over-spilling of pond
56percent	50percent	8percent	42percent

Effect on Houses

During the flooding period the local residents face a lot of problems in terms of housing condition. As most of the houses in rural sides are kutchha, therefore these houses are most intensely affected by the flood. Beside this, the Pakka houses are also get damaged due to long inundation period. Therefore the people have to bear the burden of reconstruction and renovation almost regularly. If the flood situation reaches to the extreme vulnerable then only people shifts from their home to some other areas. However only 16percent people generally shifts to some other places due to extreme flooding.

Effects on drinking water availability

The people residing in the very proximity of Shilai river, generally face more problems in accessing drinking water during flooding. 23percent people in the Ghatal municipality depends on municipal tap water all round the year, but about 54percent people depends on local tubewell, which during flooding get inundated (Table 14) .

Table 14. Peoples' Perception Regarding Drinking Water Availability During Flood

Municipal Tap water Availability	Nearly /Distant Tube well (Sometimes Unhygienic)	No Problems Faced because of having own tap or tube well
23percent	54percent	23percent

Therefore the people have to move to distant areas to access other tubewells even in unhygienic means. Only 23percent people, mostly in the town areas confirm that they do not face any problem in accessing drinking water even through flood days.

Effects on Sanitation

Although 95percent people has the access of home latrines considering rural and town areas, it is only 53percent people who can access those during flood times, the rest 42percent has to move to far distant places as all latrines outside their house are inundated during floods (Table 15). Moreover the pakka drainage facilities are only visible in the town areas, though the houses near the river channel faces the prolong inundation due to flooding.

Table 15. Peoples' Perception Regarding Effects on Sanitation During Flood

Use of home Latrine	Move to Community Latrine at distance	Open Latrine
53percent	42percent	5percent

Effects on Health

The prolonged occurrence of flood causes severe health problems to local residents. The most common form of illness due to flooding is Diarrhoea. Beside this, Cholera, food poison, other water borne disease and even snake bite is very common in the flood affected localities. About 42percent people are prone to diarrhea and cholera during flooding, moreover in earlier days due to unavailability of doctors people even died (Table 16).

Table 16. People Face Health Problems During Flood

Diarrhoea and Cholera	Diarrhoea, Cholera and Snake Bite	Diarrhoea, Cholera and Food Poison	Diarrhoea, Cholera and Other Water Bourne Disease
40percent	42percent	9percent	9percent

Availability of Healthcare Facilities during Flooding

As the transport facilities are totally hampered during flooding therefore it is very difficult to get access of medical treatment in times of flood hazard. More or less 58percent people access municipal hospital, whereas 19percent people whose economic condition is a little better access nursing home. It is only 21percent people who do not consult with any doctors rather prefer to have medicines consulting with shop-owner or quack doctors. It is only a few about 2percent who relies completely on local quacks for remedial of disease at that period (Table 17).

Table 17. Availability of Healthcare Facilities To People During Flood

Municipal Hospital	Nursing Home	Medicine Shop & treatment from experienced seller	Local Quacks
58percent	19percent	21percent	2percent

Effects on Accessing Electricity

About 87percent people including rural and urban areas of Ghatal block access electricity. But the intensity of power cut during floods is more or less same. About 55percent people face the continuous power cut even for 7-8 days during inundation and use lanterns, only 27percent people use chargeable electronic lanterns when flood intensity is less (Table 18). Only 5percent people do not face any sort of power cut problems as they reside in much farthest and higher lands from the river bed.

Table 18. People Face Electricity Problems During Flood

No Power Cut During Regular Flood	Power Cut During Regular Water logging and Usage of lantern	Power Cut During Regular Water logging and Usage of Emergency	No Electricity Line
5percent	55percent	27percent	13percent

Effects on Transport and Communication

When the flood condition is very dire in nature, then nothing is available whether public or private transport. People have to move quite a distance either for maintaining their regular livelihoods or for their job or education purpose (Table 19). Every house in Ghatal block owns Dingi or Donga (Small boats) to communicate to some other places during flood situation (Table 20). Therefore, the use of those boats, forcible changes of route, use of vans, rickshaws, damage to roads are very common during flood time. Actually bus transport totally stops during flood times. As the region comes out from inundation, it takes some time to get back to normal condition.

Table 19. Distance To Be Covered Regularly By Local People For Education/Occupation

<500m From house	500-2km From house	>2km From House
21percent	51percent	28percent

Table 20. People Access Transport Facilities During Flood

Use of Own Boats	Use of Local Government Boats	Use of neighbour's Boat half the way and Access of Bus/Van For The rest Path
74percent	16percent	10percent

RECOMMENDATIONS FOR COMBATING FLOOD HAZARD

Adaptation to Climate Change

Adaptation in human systems is defined here as the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, it is defined as the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate. In Ghatal block, there is the possibility of flood protection, some *suggestions* can be provided for future development. This are summed up below.

Flood Routing: It is the technique in hydrology to compute the effect of storage on the shape and movement of the flood wave. It is used in establishing height of a flood peak in downstream location in short term flood forecasting, estimating the protection that would result from construction of a reservoir, determining required levee height for flood protection, determining the adequacy of the spillways, predicting the behavior of the river after a change in channel conditions. It may be divided of two basic types:

Reservoir Routing & Channel Routing, The former analyses the effect of reservoir storage on the flood hydrograph while the latter analyses the effect of storage of a specified channel reach on the flood hydrograph.

Flood Design*:* Reservoir, levees, Channel improvements etc are some of the flood control measures. For an economic and efficient design of these measures floods are to be estimated with reasonable accuracy. Design of culverts, road, rail bridges, drainage works and irrigation diversion works also need a reliable estimate of the flood at the site concerned. A design flood is the flood discharge adopted for the design of a structure after careful consideration of economic and hydrologic factors. As the magnitude of the design flood increases, the capital cost of the structure also increases, but probability of annual damages will decrease. In general, the methods used in the estimation of the design flood can be grouped as:

Envelop curves, empirical flood formula, rational method, unit hydrograph application, frequency analysis etc.

Channel Improvement*:* Channel improvement is done by deepening, widening straightening lining and cleaning out of vegetation and debris from the river channel these change in the river channel increase the flood conveyance capacity of the river. Channel improvement is supplemented by bank stabilization by constructing ripraps, dykes or super and planting deep root trees on embankment.

Dredging of Sediment From River Bed: The Shilai river has a long history of its development, but since its development to its flow, huge accumulation of sediments are found in the channel bed, specially in the lower reaches. To increase the water carrying capacity of the river, even in the monsoon, the river should be dredged in regular basis.

Construction of Permanent Embankment: As the agricultural fields of Ghatal block are very fertile, therefore local people are willing to protect the land from regular flood. Various embankments are found in both left and right bank of the river, but they are of little value as those are temporary in nature. Therefore, permanent embankments, embankment cum road (preferably metalled) are required to control the over-spilling of flood water and consequent damages in roads and in farmland.

River Course Modulation: In a meandering river, meander loops impede drainage and retard disposal of flood water. Whenever, the river meanders becomes extremely sharp, they can be straightened by artificially cutting individual or a series of bends. As there are some sharp bends in Shilai River within Ghatal block, therefore for reducing the intensity of flood such measures should be adapted.

Canal Development from River To Field For Irrigation: This is another important measure for flood water diversion. Through the construction of canals the flood water can be diverted to the field in the form of irrigation water. This would reduce the intensity of flood and also may reduce the occurrence of unavailability of irrigation water.

Housing Act for Riverbank Dwellers: This is another structural measure to be followed by local people. According to the housing act, people should construct their houses at a distance from river bank. This reduces the possibility of house damage, loss of houses, reconstruction, and rehabilitation problem during and after flood occurrence.

Conclusion

Flood in Shilai River is a regular and recurrent phenomenon. It has occurred in the past and will continue to occur in future as well. It is neither possible to totally stop floods nor to completely eliminate flood damages. However, it is possible to minimize the severity of the impact and damage potential. River friendly and multi-pronged measures that are based on scientific understanding of the causes and effects of floods and that recognize the geomorphic importance and environmental value of floods are likely to be more effective, than the existing 'hard' engineering measures of flood control.

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