Climate Change Policy Paper I

Climate Change Adaptation in Flood Plain of West Bengal

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Introduction

Barring barely 1% of its area in mountainous north and 6% in the western plateau fringe, West Bengal is primarily composed of a flat alluvial plain, a large portion of it being a part of the Gangetic delta. This vast flood plain, stretching from the foot hills of Himalayas in the north down to the deltaic stretch, has great physiographic variability with an intense network of 22 river basins.

The vast alluvial plains of the State spread from Jalpaiguri and Siliguri in the north to the Sundarban creeks and the Kanthi littoral in the south. Broad physiographic divisions of this flood plain are the following:

1. The Northern Plains *(Terai Teesta Flood Plain)*

The northern districts have their turbulent rivers, which in rainy season are fast and furious and bring down heavy quantities of boulder, sand and silt which they deposit as quickly as they wash them away. The proper alluvial plain of North Bengal is found between 66m and 27m contour. The northern Flood plain can be subdivided into the following:

a. Piedmont Plains

This narrow width region is washed by 5 major rivers namely Raidak, Torsa, Tista, Jaldhaka and Mahananda with their numerous tributaries. Due to sudden fall in gradient, the rivers channels flare out and deposit the transported materials in the form of fans at the foothills.

b. Dilluvial Plains

Next to this Piedmont plain, Dilluvial Plains is formed by materials eroded from the Piedmont Fans as well as from the Mountains, this zone is inherently flood prone. The river channels are yet to establish themselves as meander loops and are often cut off when the magnitude of floods become exceptionally large.

c. Northern Riverine plains :
South of the Dilluvial Plains extends the true riverine plains. This zone is divisible into two parts according to the disposition of the paleo-deltaic formations. In the east, within the southern parts of Jalpaiguri and Kochbehar, as the Teesta had changed its course eastward, it cause flooding and deposition of fresh alluvial materials with high sand content. In the western part, restructuring of the delta has not happened since the Mahananda and the Mechi have not changed their course. The entire zone is extensively cultivated for rice and jute.

d. Barhind Upland : (Part of Bindhyan Old Flood Plain as per Agro-climatic Classification)
This zone, formed of older ferralitic soils, covers a small area in the eastern part of Malda and South Dinajpur, known as Barind. The meander belt of Ganga, which extends for about 10 kms from both the bank lines is covered with most recently deposited silt.

e. Tal Lowlands (Part of Bindhyan Old Flood Plain as per Agro-climatic Classification):
Practically the whole of the South Dinajpur and the western part of Malda district covered by this zone that remains water logged for a considerable part of the year due to run off from Mahananda. During the monsoon season, these water bodies expand in size. Depending mainly on the monsoon rains, the Tal lowland is used for cultivation of rice in the depressions and jute on the relatively higher ground.

2. South Bengal Plains (Gangetic Flood Plain)

a.South Western plains:
Known popularly as Rarh Bengal (Sanskrit word *roor* meaning rough and uneven) this region lies to the west of Bhagirathi and is a combination of ridge or hill, dome shaped residual mounds and extensive fluvial plains. In this region, the rivers like Mayurakshi, Brahmani, Dwarka, Ajoy, Damodar, Bakreswar Kopai, Silai and Kansai have curved wide valleys.

b. The South-Eastern plain
The area lying between Bhagirathi-Hugli in the west, Ganga-Padma in the north, Indo-Bangladesh border in the east and Bay of Bengal in the south is popularly known as deltaic West Bengal.

Demography

As is apparent from the table below, nearly half of the State's population inhabit the flood plains vast majority of which is employed in the agricultural sector. Gangetic flood plain, including the South Eastern and South Western flood plains mentioned above, has the highest density of population followed by Terai Teesta flood plain and the Old Vindhyan flood plains.

Flood Plains	Blocks	Area Sq.km	2001 Population	Density per sq km	2001 Cultivators
Terai-Tista flood plains	34	11337.98	7110651	627	792139
Old Vindyans flood plain	99	21294.82	17709310	832	1669995
Gangetic flood plain excluding deltaic region	92	15766.46	24257581	1539	1270420
Total	225	48399.26	4090,77542		3732554

Table 1. Demography of the Flood plain regions of West Bengal *(Modified after Census,2001)*

For the state of West Bengal the maximum temperatures have risen by 1ºC[1]. Average temperatures in Eastern India have risen by about 0.6 ºC over the last hundred years, in contrast to the average rise of about 1ºC for the Indian sub-continent as a whole.

Rainfall for West Bengal as a whole has registered an increase. But this increase is not uniformly distributed. In the monsoon months, the trend is towards decrease in rainfall in the months of June, a relatively mild increase in the months of July and August and a relatively greater increase in the month of September. Outside the monsoon season, the winter months have registered a significant decrease in precipitation, while the pre-monsoon and post-monsoon seasons have registered a non-significant decrease and increase respectively. Much of these increases currently appear quite small; the September increase is about 2.8%.

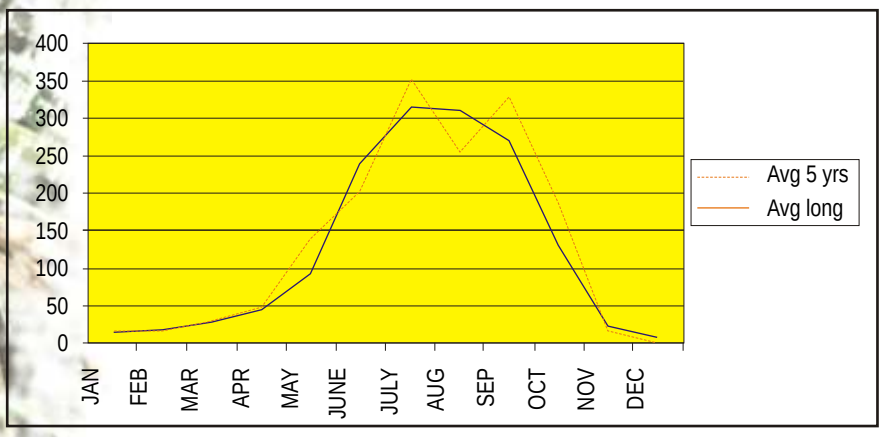

Figure 2. Last 5 years' average Precipitation in Gangetic Flood Plain compared with long term trend.

Floods and Flood Proneness

One of the foremost issues in the climate change impacts on West Bengal is that of floods. The state appears highly vulnerable to the effects of high flows and impairment of the natural drainage mechanism of its rivers due to climatic

1. This data is from Dash et. al., Some evidence of climate change in twentieth-century India, Climatic Change, Vol. 85, p. 299, 2007.

changes and extreme weather events inside and outside the State boundary.

West Bengal is one of the most flood-prone states in India with 37,660 sq. km flood prone area spread over 111 Community Development Blocks. More than 43% of its total geographical area at risk which is significantly higher than the all-India average of 12.17%.

Several of the particular features that lead to floods in both the Northern and Southern part of Bengal are likely to be exacerbated by the effects of global warming. The bulk of the flow in the Northern part is from the snowmelt fed rivers in the Ganga-Brahmaputra basin. The flow in these rivers abruptly decelerates on reaching the plains leading to heavy siltation and consequent rise of the river bed. In the short and medium term rising temperatures are likely to lead to greater flow from snowmelt due to higher summer temperatures while in the long-term flows could actually diminish with eventual glacier retreat. Sudden surges in volumes can occur due to both extreme rainfall events that are likely in this region where total rainfall is set to increase. Sudden surges can also arise from the floods due to glacial lake outbursts which can cause substantial damage downstream. Such flows may also occur due to the collapse of lakes created by landslides and slope failures.

Between 1960 and 2000 the State has had only five flood-free years, when less than five hundred square kilometres were inundated (Table 2).

Flood affected area (in sq. km)	Years during which the flood occurred	Total No. of years
Below 500	1985, 89, 92, 94 & 97	5
Between 500 2000	1962, 63, 64, 65, 66, 72, 75 & 96	8
2000 5000	1960, 61, 67, 69, 70, 74, 76, 80, 81 & 82	10
5000 10000	1973, 77, 93, 95 & 98	5
10000 15000	1968, 79, 83, 90 & 99	5
15000 20000	1971, 86, 87 & 88	4
Above 20000	1978, 84, 91 & 2000	4

Table 2. Flood years between 1960 2000.

The following table illustrates incidence of flood post year 2000.

YEAR	Description of damage and casualities of affected areas
2001	Rains caused flooding in Kolkata and 68 adjoining municipalities affecting 18 million residents. UNICEF reported 1,886,976 houses, 2,375,636 hectares of cropland, 8,187 primary schools, 1,345 health facilities, 3,240 kilometers of highways and district roads, and over 450 kilometers of railway either damaged or destroyed.
2002	Flooding in Jalpaiguri, Cooch Behar and Jalpaiguri in north Bengal due to monsoonal rains. Flash floods swamped ten villages, causing 15 deaths and 11,000 displacements, 9,00,000 pepole were affected,14 crore value of property damaged
2003	Monsoonal rains caused floods affecting the regions of Darjeeling, Jalpaiguri, Malda and Murshidabad. In just two districts, e.g. Malda and Murshidabad as many as 85 villages of 25 GP's of 6 Blocks were affected.
2004	Heavy monsoonal rains affected several districts. Almost 1.7 million people were affected by the flood. One hundred and eighty thousand people were affected.
2005	About 3000 coastal villages were inundated and 60,000 huts and many roads washed away. The East and West Midnapore districts were the worst hit. There is also serious flooding in north and south Parganas, Howrah and Hoogly. In East Midnapore alone 2,500 villages were submerged followed by around 2,000 villages in West Midnapore
2006	16 out of 19 districts in the state were flooded. Most seriously affected district were Murshidabad, Nadia, Burdwan, Birbhum, Howrah and Hoogly. Over 8.3 million people were affected and near half a million houses were damaged.
2007	The hazard affected Kolkata and several other districts. Eighty-three deaths were reported, and millions of people were marooned in 3000 villages in coastal areas of the state. Three districts of West Bengal severely affected by floods with West Midnapore being the worst hit. On another incident, heavy rain from tropical depression in the Bay of Bengal caused flooding leading to 51 deaths, and affecting 3.2 million people.
2008	2.7 million people affected. In East Midnapore and West Midnapore district

Table 3. Incidence of flood after year 2000.

The floods in the Northern part are generally early in the season and tend to be intense and of short duration. The floods in the Southern part of the state are later in the season. The flood pattern in the Southern part is likely to be altered by both increased rainfall in the river basin areas and the slow rise of sea-levels. The outflow of these rivers being dependent on tidal conditions the effects of sea-level rise on the tides is a critical parameter in assessing the potential for floods in the southern part. As is by now well-understood, areas such as the Sunderbans which are in the deltaic region of the Ganga-Padma river system would be particularly vulnerable to flooding and the attendant consequences.

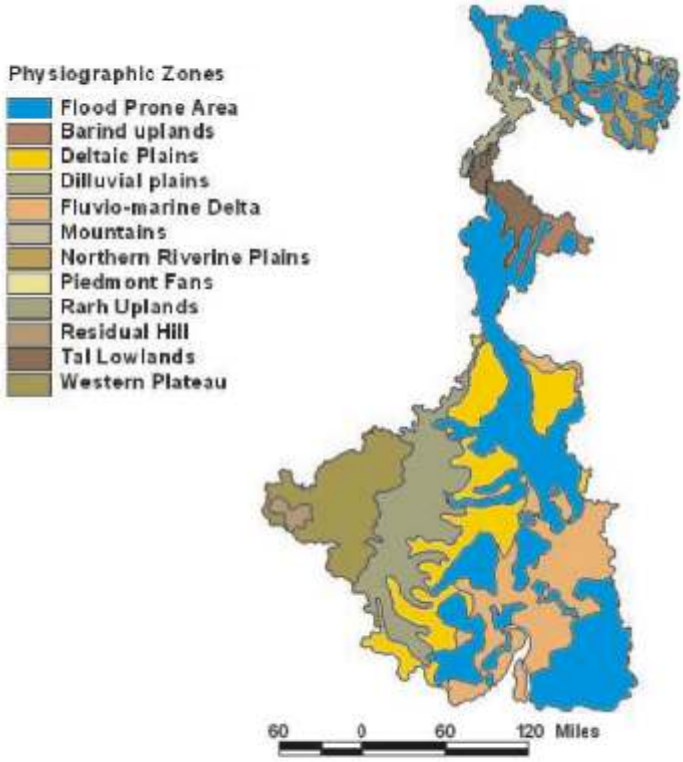

Figure 4. Flood prone areas of West Bengal overlayed on the Physiographic zones.

Apart from floods, the erosion of river banks is also a particular cause for concern. Hot spots in this regard include the left bank of the Ganga upstream from the Farakka Barrage, and in other parts of the Ganga-Padma and Bhagirathi-Hooghly river systems. Several towns on the banks are threatened with annihilation in future if bank erosion continues unchecked.

Vulnerability of Agriculture

As shown earlier, agriculture remains the primary occupation of the vast majority of the population in the flood plains.

Kharif crop in general is at risk in the flood plain regions. This has serious implications for food security for a vast rural population under conditions of climate change.

Aman rice (Monsoon Paddy), one of the major crops in the State, is particularly vulnerable to flooding. The map below shows that majority of the A*man* rice growing areas lies in the flood plain regions of the state. The same areas incidentally also have the largest concentration of cultivators.

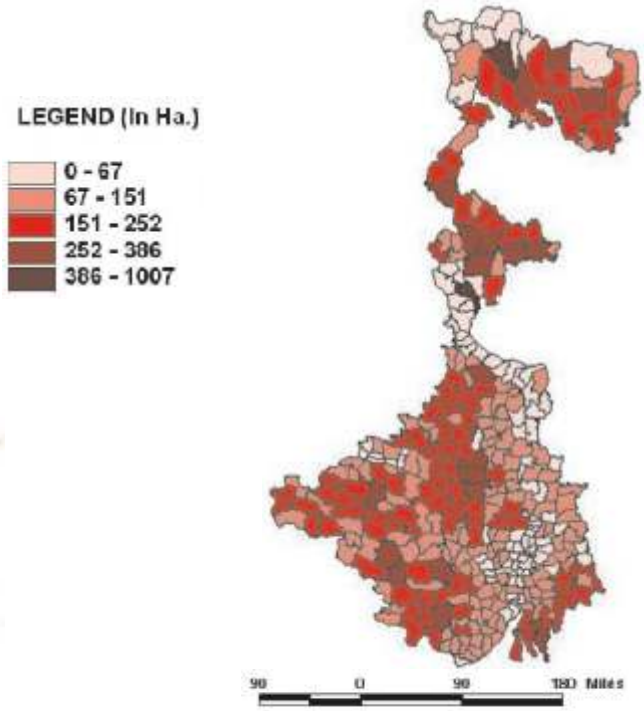

Figure 5. Area under Aman Rice.

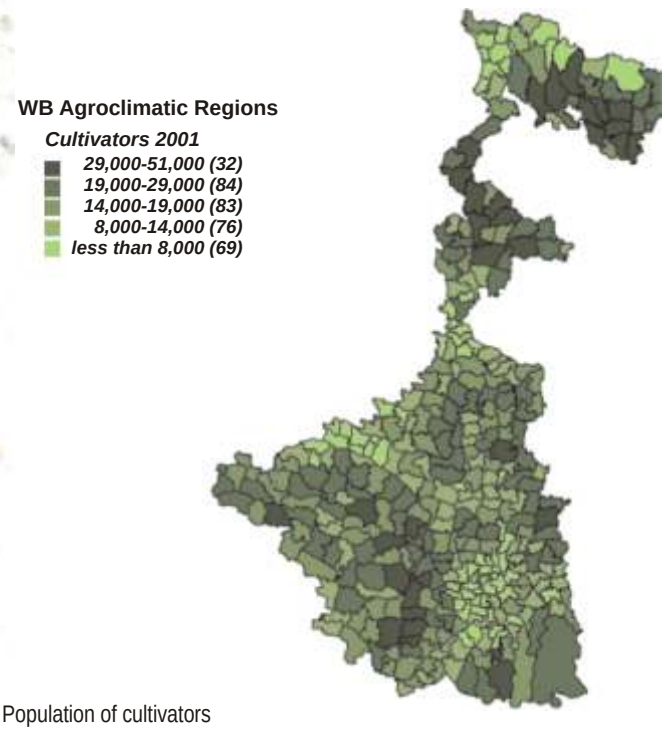

Figure 6. Population of cultivators

Most studies that have considered the impact of climate change on crop performances indicate that *Rabi* (winter) crops would suffer most from temperature increases. Wheat and potato are two major winter crops for West Bengal.

Potato is a major cash crop in West Bengal, and contributes almost 30% of the country's production. Most of this production has been restricted to a few districts although the area under potato in other districts is also on the rise. The following maps (Fig. 6 & 7) show that three districts, namely Hooghly, parts of Bardhaman and East Medinipur in the South Eastern flood plain have the largest area under potato cultivation in the state. Jalpaiguri district in the Terai-Teesta zone also has some potato cultivation. Similar considerations are true for the winter wheat crop too. Wheat, not a traditional crop in West Bengal, had picked up over last three decades. It is cultivated across 3,63,200 ha, mostly in Murshidabad, Malda, Nadia, Uttar Dinajpur, Jalpaiguri, Kochbihar and West Midnapore districts.

Apart from the vulnerability of these crops to rising winter minimum temperature, areas under these crops also lie in the flood prone areas and are hence vulnerable to flooding also.

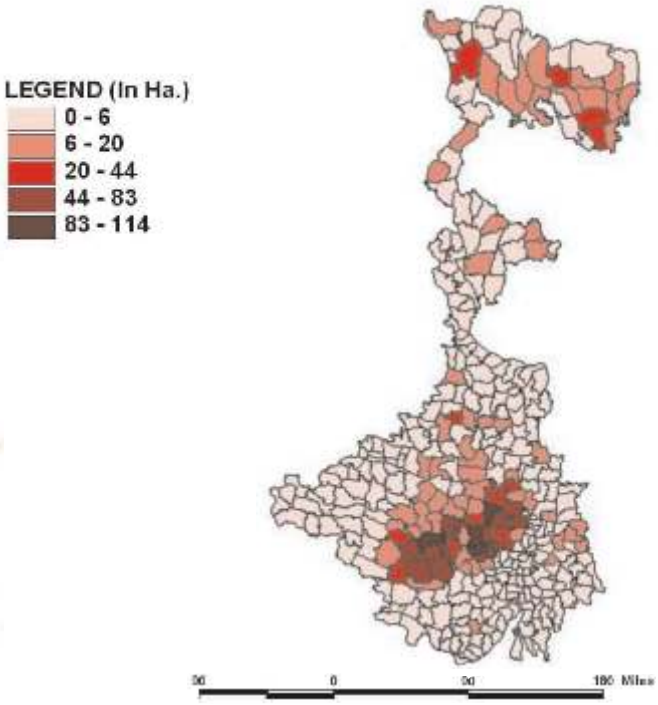

Figure 7. Areas under Potato Crops.

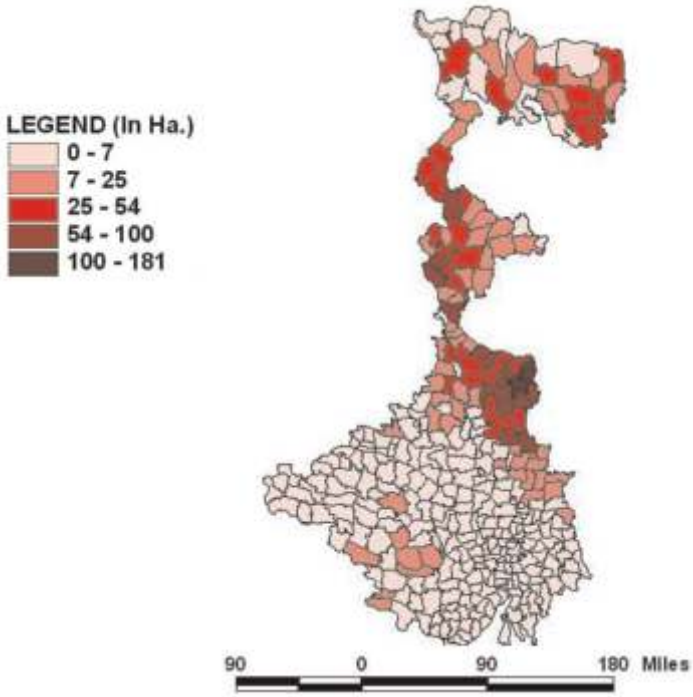

Figure 8. Area under Wheat

Irrigation is a necessary part of reducing vulnerability not in the kharif season but in the rabi season. The decreasing trend of winter rainfall contributes to increasing vulnerability in the absence of expansion of irrigation.

Fisheries and Climate Vulnerability

West Bengal also has a special status in the production of fish seeds for inland fisheries. 75 per cent of the total demand for fish seeds for inland fisheries in India is met by West Bengal alone. Climate change impacts on fisheries are therefore an important area of study both from the regional and the national perspective. Breeding in hatcheries were based on techniques centered on the maturity period occuring until recently in the months of June-August. However it has been observed that the maturity and spawning now occur as early as March in the fish hatcheries of West Bengal and Orissa. The study attributes this to the rise in temperature between 0.37-0.67 ºC in this region and changing patterns of precipitation. Currently the level of production shows that the fisheries industry appears to have adapted to this impact without any significant negative implications for fish production. However the increasing heat stress likely in the peak summer months may undo the adaptation that has occurred so far.

Housing

A significant source of vulnerability is the presence of a large stock of low-quality housing that is particularly prone to damage under conditions of increasing precipitation (and extreme rainfall events) or floods.

The growth in number of permanent houses (with both permanent roofs and walls) has been slow particularly in the rural areas of West Bengal. Between 1990 and 2000 the percentage of households with permanent houses increased from 17.69% in 1990 to 24.86% in 2000.

The growth of semi-permanent (with either permanent roof or wall) housing has been relatively better though still far from being satisfactory. Semi-permanent housing has grown in rural areas from 24.66% to 37.26% in the year 2000.

These figures indicate the need to urgently step up the growth of permanent housing now or in the near future as part of climate change adaptation, keeping in mind that more perceptible climate change effects may be due within a time

span of two to three decades. Of course it may be added that the provision of permanent housing must be considered of the minimum requirements of reaching adequate levels of equitable development.

Drinking Water

Drinking water availability is of a major concern in the wake of climate change. Availability of safe drinking water is a critical issue in post flood scenario as well. West Bengal is a State that has moved over the years from the status of a water-surplus state to one that is increasingly water stressed in leaner months, though access to safe drinking water is higher than the all-India average. However drinking water availability is both temporally and spatially uneven. Per capita water availability has been steadily decreasing as shown in the table below.

Year	Population	Per capita water
1951	2.63	2574
1961	3.49	1940
1971	4.43	1528
1981	5.46	1240
1991	6.80	996
2001	8.02	844
2011	9.40	720

Table 3. Availability of Drinking Water facility.

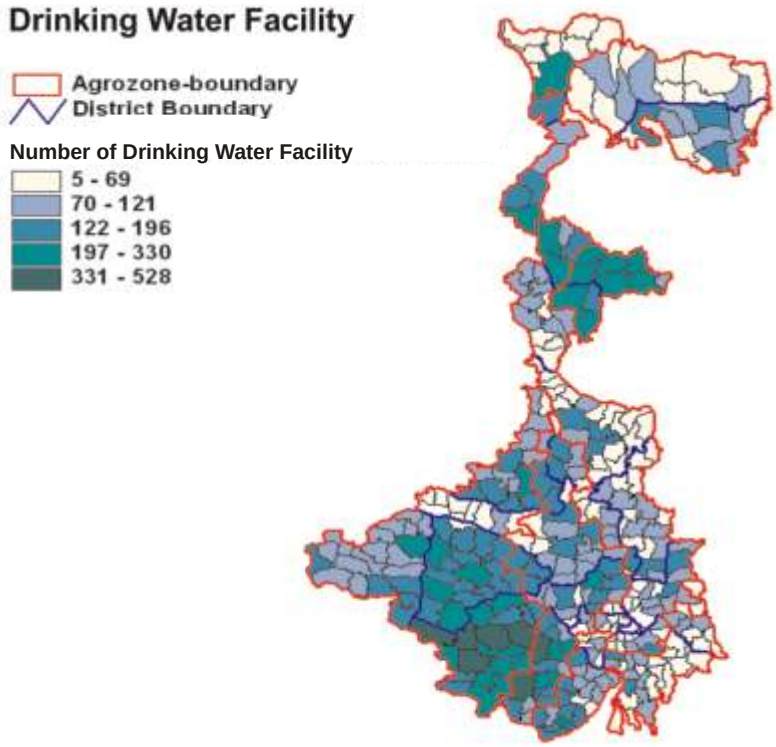

Figure 9. Spatial variability of Drinking water facility.

Public Health

The following figure would illustrate the uneven distribution of public health facilities across various flood prone districts.

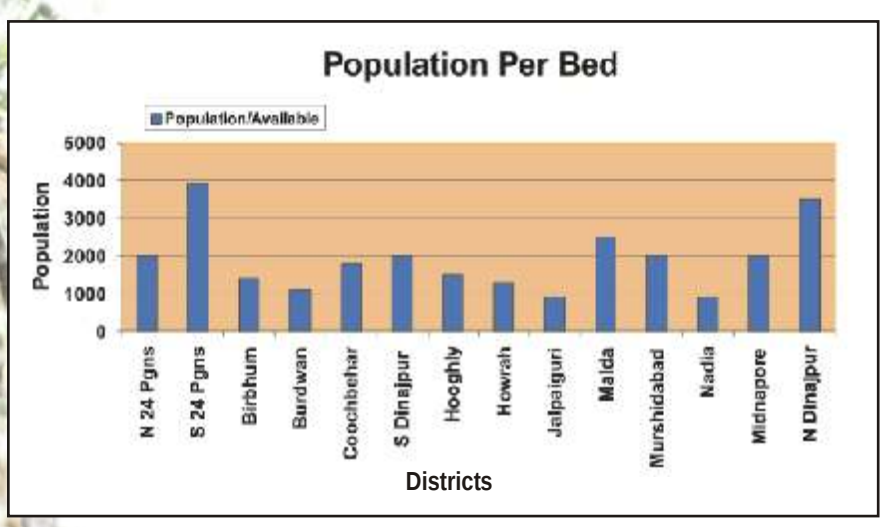

Figure 10. Population catered by a bed in a health facility across flood plain districts.

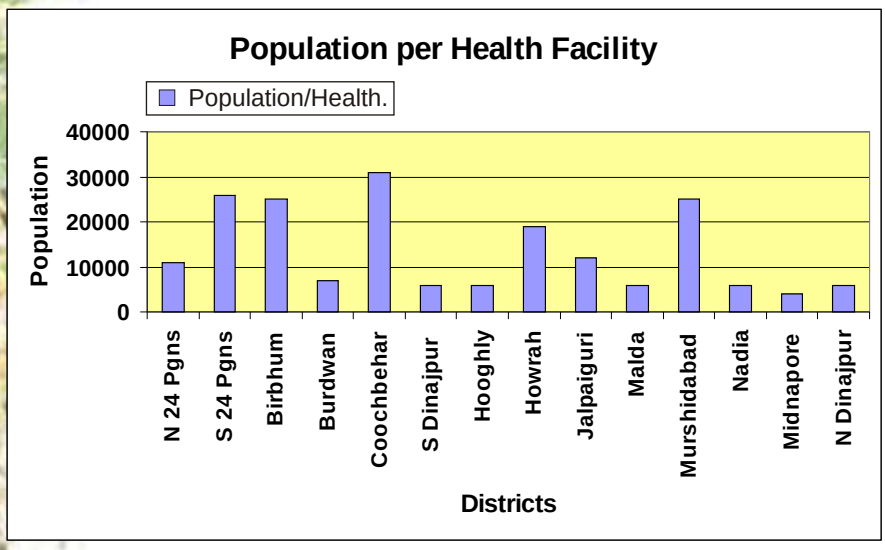

Figure 11. Population catered by a health facility across flood plain districts.

As is apparent from the figures above, pressure on either a health facility or an available hospital bed is high in a number of districts.

Flood preparedness and management

- Any interception across moribund channels in the flood prone areas requires to be removed and selective dredging needs be done to resuscitate them. The wetlands are natural reservoirs of water and all precautionary measures are to be adopted for conservation of such wetlands.
- Dissemination of data and access of vulnerable populations to disaster information system at the Panchayat Samity level. Early warning mechanism does exist in the sate but serious gaps often exist between the information source and the vulnerable population.
- The State has a Disaster Manual, and is one of the very few States in the country that has it. But it is essentially meant for administrative operations. Family level and community level preparedness are still to be achieved. Family level preparedness means the measures by which, the family stocks food, fuel and fodder, prepares shelter *(Machhan)*, fabricates a portable *chulla*, raises community tubewells for drinking water, uses bleaching powder and alum to make clean drinking water and many others depending on local need. Awareness building through suitable application of mass media is required.

- Community's preparedness refers to creation of community volunteer task forces (on warning, search and rescue, water-sanitation, shelter management, carcass disposal etc.) training them on their job as well as pre-positioning of stocks (ORS, medicine, dry food) and boats to carry the affected in case it is necessary. Further a mock drill is conducted every year to remind people of Dos and Don'ts. Excellent field level examples are already available on community preparedness in several districts.
- Convergence of rural development schemes, particularly NREGA in post flood situation has to be achieved. Local civil society organizations may be identified who can facilitate such convergence process.

Agriculture & Fisheries

- A key issue in the State of West Bengal, particularly in the flood plain region, is the question of reducing dependence on agriculture (especially rain-fed agriculture) without endangering food security.

- At the next level, farmers who cultivate the same crop in more than one season would be vulnerable relative to those who grew a more diversified set of crops. The long-standing argument that a diversified cropping pattern makes for more sustainable agriculture, appears to have a renewed relevance in the context of climate change.
- There is urgent need of agronomic adaptations in relation to rain fall distributional changes as well as flood for *Aman* rice cultivation. Suitable introduction of indigenous

varieties that are inherently adapted to changing climatic conditions and water logged situations has to achieved on an urgent basis.

- Adaptive measures are immediately required for winter crops, particularly- potato and wheat. Diversified cropping system at the farm level appears to be answer to tackle the climate vagaries related crop uncertainties.
- Integration of different subsystems like livestock, poultry, fishery, seasonal crop, perennial trees etc in the production system will reduce disaster risk, increase resilience and reduce dependency on a single livelihood. This can be done through reshaping land to drain out logged water and initiating fisheries there. Doing trellis and chicken shed over the pond, introducing biodigester to manage farm waste etc.
- As per the available information, inland aquaculture has been able to adapt to unchanged rainfall distribution pattern. Riverine fisheries may be significantly impacted by changes in flow patterns, flooding, etc. Flooding is critical to river species breeding in the months of June to August. Decreased precipitation in the middle region of the Ganges appears to have led to failure in breeding and a consequent decline in the availability of fish spawn. This has led to an overall decline of the major carps in the

Ganges. This may have implications for river fish catches in Bengal. Alternative or supplementary employment generation seems to be the answer for the vulnerable fishing population.

Housing and Disaster shelter

As discussed above, majority of rural houses in West Bengal are still *Kuchha* or semipermanent. Although there is no scope of any dramatic intervention in this sector, scenario can be improved through effective and transparent implementation of existing rural housing schemes.

Construction of disaster shelter has to be taken up in the flood prone areas in particular for which there is still a sizeable gap.

Public Health & Drinking water

As discussed above public health delivery system is certainly not even across districts. More critical issue however is the quality of health management in a disaster scenario. Disaster medicine has emerged as a key discipline by itself. The medical and para-medical community need to be sensitized and equipped with current disaster medicine knowledge.

Provision of safe drinking water is another critical area that needs immediate intervention. Mass awareness program on simple technologies like SODIS (solar water disinfection) taken up for water purification in the flood affected areas at the household level. Rain water harvesting and purification seems an answer too.

Regional Policy Action Platform on Climate Change (RPAPCC)

Climate change can be viewed as one of the most critical environmental problems to confront us as it is most immediately and inextricably linked to wellbeing, development and economic growth. Thus the solutions to it cannot be left to the confines of the environment but needs to seek clarity and consolidate its response relating the agendas and interests of the multiple constituencies.

Recognising the need for a coordinated proactive response to climate change, WWF-India has developed the concept of "Talking Solutions", which is a process that builds a consolidated understanding, informing a strategic response from among the various key constituencies. As a part of this initiative, a Regional Policy Action Platform on Climate Change (RPAPCC) was formed in the state of West Bengal, India.

Papers in this series are:

1. Climate change adaptation in flood plain of West Bengal
2. Climate change adaptation in coastal region of West Bengal
3. Climate change adaptation in arid region of West Bengal

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