Chapter VIII: Flood Hazard Management

8.1 Introduction

Disaster management requires multi-disciplinary and pro-active approach. Besides various measures for putting in place institutional and policy framework, disaster prevention, mitigation and preparedness enunciated in this paper and initiatives being taken by the Governments, the community, civil society organizations and media also have a key role to play in achieving the goal of moving together, towards a safer India. The message being put across is that, in order to move towards safer and sustainable development, development projects should be sensitive towards disaster mitigation.

The mission is vulnerability reduction to flood hazards, be it natural or manmade. This is not an easy task to achieve, keeping in view the vast population, and the multiple causative factors to which this region is exposed. However, if we are firm in our conviction and resolve that the society is not prepared to pay the price in terms of casualties and economic losses, the task, though difficult, is achievable (Sarkar S., 2008).

The proposed steps towards vulnerability reduction, putting in place prevention and mitigation measures and preparedness for a rapid and professional response. With a massive awareness generation campaign and building up of capabilities as well as institutionalization of the entire mechanism through a techno legal and techno-financial framework, we are gradually moving in the direction of sustainable development.

The various prevention and mitigation measures are aimed at building up the capabilities of the communities, voluntary organizations and Government functionaries at all levels. Particular stress is being laid on ensuring that these measures are institutionalized considering the vast population and the geographical diversity of the region. This is a major task for the implementing agencies to put in place mitigation measures for vulnerability reduction. The ultimate goal is to make prevention and mitigation a part of normal day-to-day life.

The flood hazard management in sub-Himalayan Jalpaiguri district may be discussed under the headings:

8.2. Short term area specific structural measures

A large variety of methods of engineering and non-engineering nature are under application around the world in mitigating flood disaster. At the global scale, the commonest form of flood mitigation measures includes channelization and detention facilities.

Channelization involves construction of open channels is a commonly used method of reducing the size of a floodplain or floodway. To prevent erosion, channels can be lined with grass, wire-enclosed rock, concrete, riprap or cobblestones placed a few layers deep. Open channels allow water to enter them at almost any point, thus compensating for inadequate tributary collection systems.

Detention facilities such as dams, store flood waters and release them at lower rates, thus reducing or eliminating the need for major downstream flood control facilities, the construction of which would disrupt the developed areas. Perhaps the greatest disadvantage of detention facilities, assuming a structurally sound facility, is the false sense of security that such structures create among the general public as they assume the detention facility has eliminated any flood hazard; that they are consequently totally unprepared for the possibility of a flood that exceeds the design capacity of the facility. An attempt has been made to outline some of the important measures adopted by different agencies to mitigate the impact of flood hazard in sub-Himalayan North Bengal.

Structural measure of flood hazard mitigation involves both engineered and non-engineered structures. These include construction of embankments, dykes, river channel re-shaping and river training etc. (NBFCC, 1965). However, before advocating for any comprehensive plan for hazard mitigation, it is imperative to evaluate the past structural measures adopted for mitigation of flood hazard. The following structural measures are adopted in sub-Himalayan North Bengal.

8.2.1 Embankment, dykes and bed-bars

Construction of marginal embankment along the bank of the river has been generally resorted to for preventing the floods from spilling its natural banks. This has been the easiest and quickest method of saving the land and people from the fury of floods. Though there has

been a controversy about their feasibility, it still remains one of the favourite short term measures which can be implemented at the demand of the public (NBFCC, 1965). It is observed that embankments, dykes, spurs and bed-bars are most commonly used as structural measure adopted in the study area since 1954 devastating flood (figure 8.1). Flood, like many other natural processes have many beneficial effects on the economy and environment. The traditional flood protective measure (embankment) deprived North Bengal to receive beneficial effects at the one end and accelerates the darker side of flood (aggradations, bank failure, avulsion) at the other end (Sarkar, S. 2007; 2008).

The detrimental effect of embankment in controlling flood hazard has been demonstrated globally and it is proved to be counter-productive. The North Bengal Flood Control Commission so far constructed 364 km long embankments in Jalpaiguri district in the name of flood protection. It could protect 494 sq. km area at the cost of another 1400 sq. km area brought under the threat of flood hazard. Following are the major effect of embankment on the fluvial dynamics of sub-Himalayan river:

- Aggradation vis-à-vis rising of riverbed at an alarming rate and in many cases riverbed is now higher than the ground level inducing avulsion.

- Providing false security among the local inhabitants and instrumental for large scale human settlement in the river valley e.g., between embankment and active channel. Responsible for making the North Bengal's river more unpredictable

Keeping in mind the inadequacy of such structural measures in controlling flood menace over a large area and its long term adverse effects on environment, the following suggestions are proposed (a) embankments should only be constructed in strategic and high priority area with proper layout and materials i.e., ACM and (b) the existing embankments should be strengthened and be properly maintained since breaching of such structures often caused catastrophic loss and avulsion.

Though construction of embankment as proposed in the Master Plans of Tista, Jaldhaka and Torsa basins, the same is to be reviewed further. First of all, the longitudinal slope of the river as well as average slope of the terrain required to be analysed to assess the

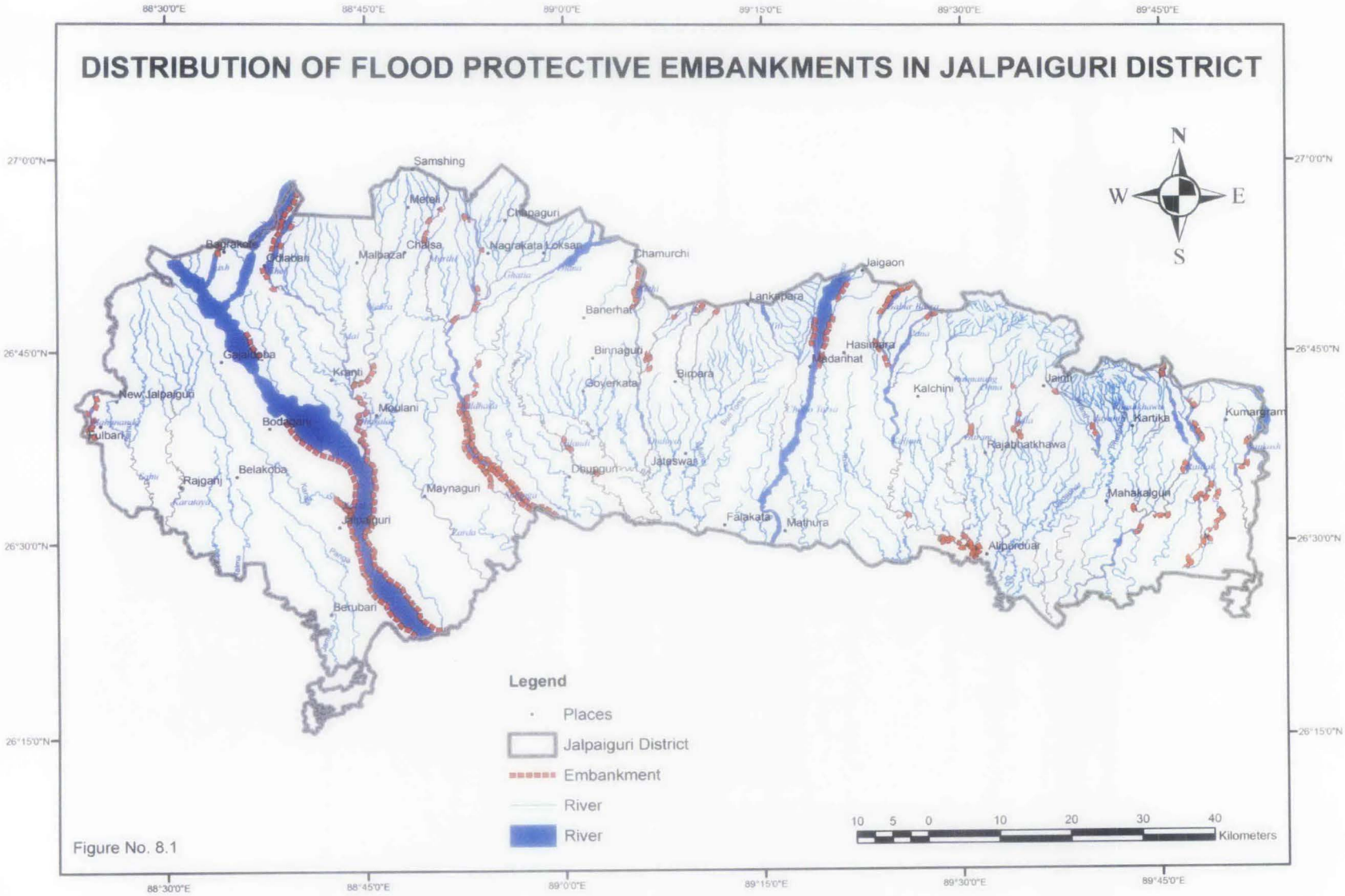

DISTRIBUTION OF FLOOD PROTECTIVE EMBANKMENTS IN JALPAIGURI DISTRICT
88°30'0"E
88°45'0"E
89°0'0"E
89°15'0"E
89°30'0"E
89°45'0"E
27°0'0"N
26°45'0"N
26°30'0"N
26°15'0"N
N
W
E
S
Samshing
Metali
Chapaguri
Chalsa
Nagrakata
Loksan
Malbazar
Chamurchi
Jaigaon
Lankapara
Banerhat
Binnaguri
Birpara
Goyerkata
Hasimara
Madarihat
Kalchini
Jaldapara
Kartika
Kumargram
Rajabhatkhawa
Mahakalguri
Alipurduar
Falakata
Mathura
Jateswar
Dhupguri
Maynaguri
Jalpaiguri
Moulani
Kranti
Gajaldoba
Bodaganj
New Jalpaiguri
Fulbari
Rajgani
Belakoba
Berubari
Legend
Places
Jalpaiguri District
Embankment
River
River
10 5 0 10 20 30 40
Kilometers

Figure No. 8.1

gradation of sediments being carried by the river. As observed from the study the slopes of the rivers further south at International border is flat enough and the suspended sediment of lighter density along with fertile silt content is noticed. Therefore, flooding of surrounding areas has resulted in fertility of the area. Loss of crops during monsoon in such areas is supplemented, by increase in production during non-monsoon period. Embankments should, therefore, be judiciously constructed in this zone to protect densely populated areas against direct thrust of flood (WAPCOS, 2003).

In the piedmont (foothills) region, the rivers carry sand during flood due to steeper slope. Flooding of agricultural land results sand casting, thereby productivity of land is totally lost. Low and permeable embankment may be suitable so that sand to a great extent would be filtered.

Due to increase in population and developmental activities, breaching of embankment causes heavy loss due to damage of property. Hence, to reduce frequency of breaching of embankments, the embankments already constructed should be able to withstand a flood of 100 years return period. For rural areas, however, where only agricultural land is required to be protected, embankments may be designed against a flood discharge of 25 years returns period. It is suggested that major embankments in bank of main rivers like Tista, Jaldhaka, Kaljani, Torsa should be protected against a flood of 100 years return period (WAPCOS, 2003).

Construction of embankments along the rivers of Jalpaiguri district has since been started from the year 1954 and these are being constructed, or proposed to be constructed wherever felt necessary. Maintenance cost of these embankments is exorbitantly high. However, the same is very much warranted to contain the likely damage due to floods.

8.2.2. De-silting of wet land & riverbeds

Low lying areas, spill zones, left out course of rivers/oxbow lakes, *beel* areas and other water bodies act like detention reservoirs which moderate direct flood flow. With gradual construction of embankments, the spill zones have been cut off from the main flow resulting spills over banks. Such water bodies, though not capable for receiving flood from

upper valley through main course, can absorb local run-off to quite an extent. Reclamation of land through drainage schemes was one of the primary objectives in past. Such reclaimed lands suffered from drainage congestion and spreading of habitation in urban areas even in the low lying areas which as posed severe problems as on today.

It is therefore suggested that water bodies, perennial or seasonal, should be kept free from any man made activities. Detailed investigation works need to be carried out for regulation of flow into and out of these water bodies through introduction of technically feasible control devices to enable these to act as storage reservoirs during dry period and detention basins to absorb local surface runoff (WAPCOS, 2003).

Among the other structural measures, widening of existing road and railway bridges and culverts across the rivers should be initiated to ensure free and uninterrupted natural load movement of the rivers. This will also reduce the chance of avulsion and flood to some extent.

Small irrigation channels cut by the villagers or, *Jampoi* often accelerate avulsion. The *Jampoi* shall be brought under the direct supervision of GP as well as I &W department followed by the necessary structural modifications depending their respective vulnerability. River lifting, tube well and rainwater harvesting should be promoted to phase out the *Jampoi*.

8.3. Short term area specific non-structural measures

The structural measures as proposed in the previous section are found insufficient in providing a full protective umbrella against flood menace. The following are the major short term area specific non-structural measures proposed for the said purpose:

- Catchment area protection and improvement through afforestation and scientific land-use and slope management. This is a lag term protective measure which will control sediment production and maintain hydrological cycle. It will also improve the fluvial efficiency, competency and navigability of rivers.

- Early warning system is also considered to be one of the components of flood mitigation.

- People's participation through education and creating awareness among the potential victims also proposed as a mitigating measure for reducing flood damage. During the execution of the present project, a large number of youths from the local schools and volunteers have initiated massive campaign programme regarding the flood safety rules among the local resident, particularly among those who are residing in high risk zones.

8.3.1. Flood plain zoning

Flood plain zoning is an important and useful non-structural measure of flood management becoming more and more popular. Flood plain zoning means segregate the different sections of flood valley of a river into different category of its hazard potential and management needs. It is proposed to identify and map the following three categories of potential flood hazard zone along the river valley based on (i) topographic details, (ii) past occurrences of flood hazard, (iii) frequency and magnitude of floods and (iv) nature of protection measures already adopted.

1. Identification of *prohibitive zone* and listing of families settled in fringe area, land use practice, domestic animals, source of drinking water and other services existed in such zone

2. Identification of *restrictive zone* and listing of families settled in buffer zone, land use practice, domestic animals, source of drinking water and other services existed in such zone.

3. Identification of *warning zone* and listing of families settled, land use practice, domestic animals, source of drinking water and other services existed in such zone.

It is also equally important to make a projection of possible damages under different degree of human intervention/development project in the respective identified zone.

Digitization, geo-referring and development of GIS with attachment of data related to the hazards shall be adhere to and on-line linkage with the stakeholder agencies to facilitate decision maker to take right decision at right time. High resolution satellite image can also be integrated with GIS platform to quick retrieval of ground reality and also to upgrade the existing database. This will further help in preventing of human encroachment in flood valley and construction of flood shelter (Geo-referred) in high priority area at G. P. level (Sarkar, S. 2010).

8.4 Long term measures

It is now well understood that flood as a natural hydro-geomorphic process cannot be controlled neither it should be attempted any more. The term flood management is more frequently be used instead of flood protection across the globe. It is also understood that in the name of so called flood prevention and protection the measures so far taken in the sub-Himalayan Jalpaiguri district in stakeholders interest in fact found counter productive. In fact, such measures instead of serving its original purpose aggravate the basic problem further. The problem of flood hazard in Jalpaiguri district has been complicated further which demands successful implementation of long term measures to sustainable phase out of the problem. Some of the long term measures applicable in the study area have been discussed in the following section.

8.4.1 Watershed management

Deforestation via-a-vis environmental degradation in the watersheds of the sub-Himalayan river indeed plays the decisive role in contemporary increased frequency and magnitude of flood hazard in Jalpaiguri district. Vicious cycle of degradation has already been established in the sub-Himalayan watersheds most probably except Butanese part. Perhaps, the only possibility to reduce the flood hazard in sub-Himalayan Jalpaiguri district lies into the pro-active watershed management in catchment area in Darjeeling-Sikkim-Bhutan. It is thus an intra and international affairs and co-operation among the states and nations. However, some activities may be possible to adopt within our own national territory. Cooperation between India and Bhutan has already been initiated in this regard. Competent authority should take initiative to inform the people living in threshold areas within the watersheds (prohibitive/restrictive zone) categorically about the hard reality of possible

hardship during the different stages of watershed management processes (Sarkar, S., 1991; Sarkar, S. 2007).

The model future course of action for comprehensive watershed management plan in sub-Himalayan watersheds should include (i) identification of *degradation prone area* and plot it on map at gram panchayet level; (ii) *Degradation/Deforestation zoning* of micro-watershed at gram panchayet level on mauza map; (iii) identification of *prohibitive zone* and listing of families settled in fringe area, land use practice, domestic animals, source of drinking water and other services existed in such zone; (iv) identification of *restrictive zone* and listing of families settled in buffer zone, land use practice, domestic animals, source of drinking water and other services existed in such zone; (v) identification of *potential threatened zone* and listing of families settled, land use practice, domestic animals, source of drinking water and other services existed in such zone (Sarkar, 2011).

8.4.1.1 Watershed budgeting

Comprehensive watershed management also require watershed budgeting which includes the total interaction between man and nature. In fact it's a budgeting between the nature's productivity and human society's demand (Starkel, L., Sarkar, S., Soja, R., Prokop, P. 2008). A balance between these two is the key to the success i.e., the sustainable watershed management

Requirements: Peoples' yearly consumption requirements of essential items viz. cereals, fruits, fat, milk, sugar, pulses and nuts, vegetables, meat and egg etc. should be assessed considering their respective consumption on per day capita basis. Similarly, the needs for concentrates (rice brawn, pulse husk and oil cakes), dry fodder, green fodder, grass etc. for the bovine stock of cows, she-buffaloes and cattle should be worked out.

Production: Based on the average yield figures, gross net production of cereals pulses, oilseeds, vegetable etc. is assessed. Similarly, the milk yield, meat, chicken, eggs and cattle feeds, is estimated and the surplus/short falls are worked out.

Action Plan: Watershed concept is evolved for managing the soil moisture regimen. Rainwater is harvested to the maximum possible extent in the upper reaches, stored,

conserved and distributed in an efficient manner for feeding the soil moisture. The moisture in uplands moves downwards and maintains the moisture in lowlands. Rainwater harvesting along with various measures helps in checking the velocity of water and recharging groundwater. In this way, rainwater retention, retarding and recharging increase the resource situation and improve water movement. The improvement in soil moisture increases the biomass production proportionately. An effort is made herein to present some details on preparation of a plan for a possible understanding of the listed disciplines and their interrelationships.

Survey: First step is collection of data on the status of the watershed characteristics. Information could be collected from the local, district, and state government and central government departments and through detailed canvassing in the specific watershed. A proforma indicating the inventory of watershed management plan has been evolved for ready reference, restricting the length in proportion to the Government's decision about the per hectare expenditure for watershed development.

Technical Backdrop: An essential requisite for watershed management is actual assessment of land, soil and ecological regime of the area. The objective is to determine the extent of land damage, erosion condition and rate of soil loss. It helps in classifying the lands suitable for different activities and fixes area-wise measures together with methodologies to be adopted for soil conservation. It gives a detailed picture of soil moisture status, an important prelude in deciding the mode of greening. Overall appreciation of present species and practices vis-a-vis land use forms a basis in choosing the activities and deciding their priorities for implementation.

Watershed Plan: The end product of survey, investigation, data collection, data processing, and reporting of various aspects on different disciplines is formulation of integrated multi-disciplinary annual action plans. It is to be shaped by the competent authority with due consideration to integration, approach, concept and technical backdrop, appropriate technology, socio-economic conditions, and the last but not the least in any way the people's active participation. It is needless to say that emphasis should rest with soil and water conservation in growing greenery with simple and affordable scientific inputs. The plan should include facilities on agro-industrial infrastructures, community participation and supporting data. It is natural to envisage quantitative treatment, as far as possible, as to status,

technical background, plan, programme and projection. The plan should pronounce the estimates, outlays, funds requirement and assign the job responsibilities within a specified time schedule.

8.4.2 Land use control

The purpose of Land-use regulation is to obtain the beneficial use of flood-prone areas with a minimum of flood damage and a minimum expenditure on flood protection. Some of the many adverse implications of human occupancy of flood plains have been repeatedly emphasized, as has the impracticability, in most cases, of abandoning such areas altogether (Sarkar, S. 2007). Land-use regulation aims, therefore, at a policy which combines the abandonment of limited parts of the flood-prone areas with the careful regulations of land-use in the remainder of such areas.

8.4.3 Construction of check dam/reservoir/barrage

Construction of check dams/reservoir/barrage often considered as one of major long term structural measures adopted against flood problem around the world. Thousands of Dams/Reservoirs were so far been constructed across the world under the Multipurpose River Valley Development Projects. Of late, we observed and understood the irreparable damage that caused to the fluvial environment due to such mega-intervention. As a result, the human society becomes aware and gradually favours small check dams to be constructed across sub-watersheds to check soil erosion and ground water recharge.

In sub-Himalayan Jalpaiguri district only one barrage with a length of 921.5 m has been constructed under Tista Barrage Project at Gajoldoba for a design flood discharge of 20,100 cumec. The project is proposed to be executed in three phases. First phase of the project envisaging irrigation potential of 9.23 lakh hectare is divided into three stages. Under stage I, three pick up barrages have been constructed on the rivers Tista, Mahananda and Dauk. Out of five main canals, Tista-Mahananda Link canal (25.75 km) and Mahananda main canal (30.45 km) have been constructed in all respects while the other canals are under various stages of construction. A dam on the river Tista has also been proposed near Gail khola in the district of Darjeeling. However, its location has since been changed and proposed at 800 m upstream of Sevok Coronation Bridge. Apart from supply of irrigation water, it will

generate 600 MW of hydro-power and partially contribute to flood management in entire North Bengal which also work for the Jalpaiguri district.

The Tista barrage constructed at Gajoldoba in the district of Jalpaiguri has an important role in regulating the flow of the river Tista. It has been observed that guided barrage operations have helped to reduce shoal down-stream of barrage and thereby preventing scour to the Apalchand Forest on the left bank of the river Tista. There are provisions for construction of barrages across the river Jaldhaka, Raidak, and Torsa under stage-II of the project to utilise the water resources of these rivers.

In the Torsa basin, 50 check dams have been proposed for flood moderation in its Master Plan. It suggested that the detailed survey and investigation of these schemes may be carried out the detailed report may be prepared to establish techno-economic viability and take up construction depending upon the priority and availability of funds (WAPCOS, 2003). It is felt that these dams would be more effective in the tributaries rather than the main river. Five alternative sites for the construction of a multipurpose reservoirs having flood control/moderation as one of the components have also been suggested in Phuntsholing to Dorokha reach of river Torsa. All above sites lie in Bhutan where the river passes through hilly terrain. Detailed survey and investigation is required to be carried out for establishing the most viable site.

Construction of 50 check dams has been proposed in the Master Plan of river Jaldhaka. However, their locations and other features are yet to identified. Three multi-purpose reservoirs have also been suggested in the Master Plan as given below (WAPCOS, 2003): (i) on the river Diana: Catchment area: 260 sq. km; (ii) on the river Murti: Catchment area: 130 sq. km; (iii) on the river Jaldhaka: Catchment area: 390 sq. km.

In the Mahanda basin, two barrages have been constructed one across the river Mahananda at Phulbari, district Jalpaiguri and the other across the river Dauk in Chopra, district of North Dinajpur.

Setting up *hydro-meteorological stations* covering the whole watershed to monitor: a) rainfall, b) temperature, c) humidity, d) discharge, e) sediment load and other hydrological parameters and f) land use pattern shall be taken/strengthen immediately to develop proto-

type model. This is a must to understand the mechanism of flood generating forces and to evolve a full proof flood forecasting model in sub-Himalayan Jalpaiguri district.

8.5 Flood preparedness and response

In order to respond effectively to foods, Ministry of Home Affairs has initiated National Disaster Risk Management Programme in all the flood-prone States. Assistance is being provided to the States to draw up disaster management plans at the State, District, Block/Taluka and Village levels. Awareness generation campaigns initiated to sensitize all the stakeholders on the need for flood preparedness and mitigation measures. Elected representatives and officials are being trained in flood disaster management under the programme. Bihar, Orissa, West Bengal, Assam and Uttar Pradesh are among the 17 multi-hazard prone States where this programme is being implemented with assistance from UNDP, USAID and European Commission.

8.5.1 Preparedness

Floods which are natural hazard need not become a disaster, if we are prepared to deal with them. Some preparedness measures that we need to carry out at the individual and at the government level are:

8.5.1.1 Pre disaster

Individual Preparedness:

- Know the route of the nearest safe shelter
- First Aid kit should be ready with extra medicines for snake bite and diarrhea
- Tie up all valuables at the top of the roof
- Radio with extra batteries, torch, ropes to be kept ready
- Store dry ration, kerosene, biscuits, baby food for at least for 7 days
- Water proof bags, polythenes to store clothes and valuables
- Be ready with umbrella and bamboo sticks (to protect yourself from snakes)
- Identify a highland/mound for the cattle and have sufficient fodder for them

- As soon as you receive warning tune to the local news in the radio/Television for the latest update
- Don't spread rumors. Get authentic data and then announce it
- Check your emergency kit

If you have to Evacuate

- Pack clothes, essential medicines, valuables, personal papers in a water proof bag
- Inform the Disaster management team member to the place that you are shifting .
- Raise furniture and appliances to a higher place
- Switch off all electrical appliances
- Put sandbags in the toilet bowl and cover all sewage backflow
- Lock your house and take the route suggested
- Don't into water of unknown depth and current

Government Preparedness:

- Update all the resource inventory
- Control room should be functional for 24 hours
- Identify all the shelter places where people could be evacuated
- Activate all the First Aid and the Rescue and Evacuation team
- See to it that there is no blockage in the flow of the river
- Ascertain the availability of dry food, drinking water and medicines
- Ascertain the fodder availability for cattle's
- Mobilise boats, vehicles which will help in evacuation and rescue operation and also in the distribution of relief
- Prior storage of food grains in the vulnerable pockets
- Identify the relief centers
- Inspect, strengthen and repair all the approach roads and culverts
- Provide mobile wireless sets the villages likely to be cut off
- Arrange adequate hand pumps where wells are likely to be inundated
- Liaison with army, Navy, Coast guards and the Railways locally
- Prepare maps of alternate route, resources available

8.5.1.2 During disaster

Individual

- Drink boiled water or put halogen tablets
- Keep food covered. Don't take heavy meals and eat food that is hot
- Use raw tea, rice water, coconut water during diarrhea
- Be careful of snake bites as snake bites are common
- Don't let children stay in empty stomach
- Avoid entering flood water. Stay away from water which is above knec depth

Government

- Carry out rescue and evacuation
- Operation of Control Room and provide warning update
- Provide relief materials
- Mobilizing resources like boat, dry food, temporary shelter
- Ensuring the availability of medicines, drinking water, tankers etc.
- Co-ordination at various levels and agencies
- Mobile health units to be made available
- Damage assessment of life, livestock, crop and livelihood

8.5.1.3 Post disaster

Individual

- Listen to the latest flood bulletin before moving from the shelter place
- Use recommended routes to return back
- Dry all electrical equipment before using it
- Avoid touching any loose wire
- Beware of snake bites
- Clean the house and disinfect the surrounding by using bleaching powder

Government

- Rescue people who are stranded
- Restore roads and power supply
- Provide safe drinking water
- Check outbreak of any epidemics
- Mobile health teams to be mobilized
- Take the help of the NGOs

- Carry out damage assessment
- Ensure that adequate, timely and speedy credit is available to the farmers for purchasing agricultural inputs and cattle.

8.5.2 Flood hazard response

The majority of the deaths and much of the destruction created by floods are largely preventable. A great deal can be done to lessen the impact of a disaster. The stakeholders as well as engineers, planners, politicians and others needs to understand the nature of the hazard and decision and a commitment needs to be made to provide mitigation measures to reduce flood damage. Human response to flood hazard is a complex socio-economic processes and diagrammatically represented in figure 8.2.

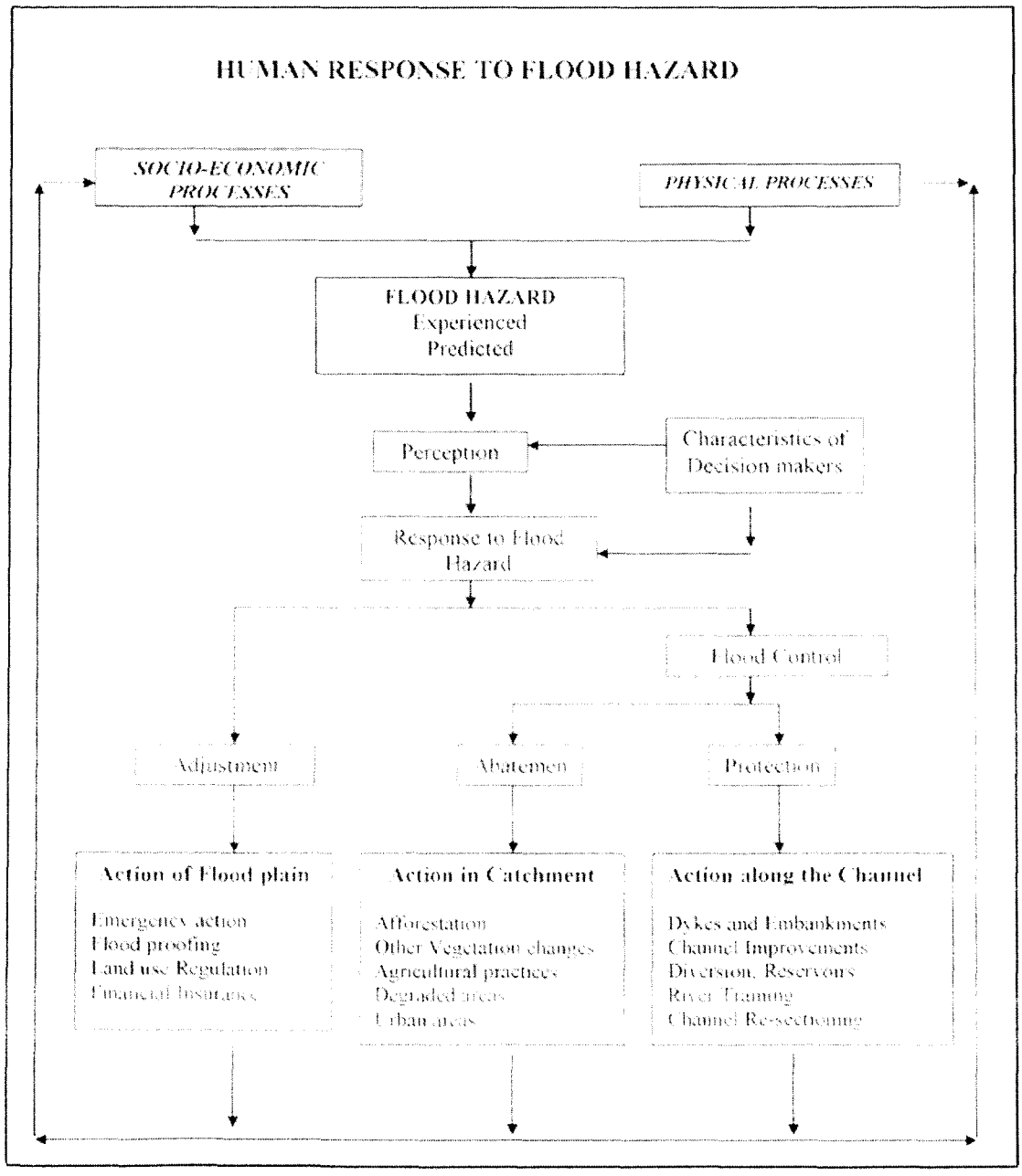
Reduction of harmful effects of a flood requires actions on three fronts: reducing the vulnerability of the physical settlements and structures in which people live; reducing the vulnerability of the economy; and strengthening the social structure of a community so that community coping mechanisms can help absorb the impact of a disaster and promote rapid recovery (Baker, V.R. et. al. 1988; Kale, V. S. (ed.); 1998).

The *first step* in vulnerability reduction for human settlements is to identify the high-risk areas. This is done by relating a natural hazard, such as a flood, to the terrain and to the probability that such an event will occur. This activity is known as risk mapping. Flood risk mapping, for example, would indicate the areas likely to be covered by water during floods of given magnitude.

The *second step* in vulnerability reduction is to identify those communities that are particularly susceptible to damage or destruction. This is done by relating risk to agriculture, pisciculture, and animal husbandry etc. life supporting activities.

The *third step* is the selection of a vulnerability reduction strategy consisting of a comprehensive floodplain management program. The objective of such a program should be the absolute reduction of flood damage potential. This can be accomplished by (a) preventing an increase in flood damage potential resulting from new development in floodplains, and (b)

reducing the flood damage potential in already developed floodplains. Both approaches must be used if the objective of reduced flood damage potential within a community is to be realized.



Based on Sarkar, S, 2008

Figure No. 8.2 Human Response to flood hazard

8.6 Preventive approaches

Preventive floodplain management approaches usually consist of land use controls, such as floodplain regulations and sub-division regulations, which are applied to the 100-year

floodplain. Briefly, the procedure is to define the 100-year water surface elevations, flood outlines and floodway. The floodway is the channel and the portion of the adjacent floodplain required to pass the 100-year flood without significantly increasing the water surface elevation, assuming the remainder of the floodplain is not available to convey flood water.

Once the floodplain and floodway are defined, potential development agencies have the options, which are subject to regulation, of leaving the floodplain in open space, developing the fringe area, or modifying the floodplain or floodway to remove areas from the floodplain. Development that occurs under any of these options will essentially be free from major flood damage up to and including the 100-year flood event (Mukhopadhaya S.C., 2010).

It is important to work with development agencies to make them aware of the flood hazard, the need for addressing the hazard and the options available to them as noted above. Experience has shown that these agencies have recognized the need to address the flood hazards and have exercised the options available to them to build quality developments safe from flooding during the 100-year event. Other preventive approaches include:

1. The acquisition of floodplain land, or at least the development rights to the land, by the overseeing agency. This could take the form of land swaps that provide alternatives to development of the site.
2. Incentives to encourage for future development on safer sites with safer methods.
3. Diversification of agricultural production that include identification and planting of flood-resistant crops or adjustment of planting season, if possible, to avoid coinciding with the flood season; establishment of cash and food reserves.
4. Reforestation, range management and animal grazing controls to increase absorption and reduce rapid runoff.
5. Construction of raised areas or buildings specified as refuge areas if evacuation is impossible.

8.7 Remedial approaches

In developed floodplain areas, where a high flood damage potential already exists, simply applying land use controls to defined floodplains will not have an immediate impact

on the flood damage potential. Additional actions must be implemented if the goal is to reduce a community's flood damage potential. Remedial floodplain management involves the planning, design, construction and maintenance of facilities to reduce the flood damage potential in an already developed floodplain. The remedial options available include construction of flood control works, flood-proofing of existing installations, flood detection and warning systems, acquisition and relocation or demolition of structures, and public awareness programs.

8.7.1 Flood detection, forecasting and warning

Flood detection vis-à-vis forecasting and warning systems can be effective in reducing loss of life and property damage. In flash flood locations the major benefit will be reduction in loss of life. In slow-rising flood situations major savings from reductions in flood damage can be accomplished. Flood forecasting systems can range from inexpensive networks of volunteers, rainfall and stream stage observers and simple rule curves to sophisticated networks of telemetric gauges, AWS and computer models (Mukherjee, M. 2008).

The ability to forecast flooding is limited to the time during which changes in the hydrological conditions necessary for flooding to occur have begun to develop. The formulation of a forecast for flood conditions requires information on current hydrological conditions such as precipitation, river stage, water equivalent of snowpack, temperature, soil conditions over the entire drainage basin, as well as weather reports and forecasts.

In small headwater regions a forecast of crest height and time of occurrence is all the information required to initiate effective adjustments; the relatively rapid rate of rise and fall makes the period of time above flood stage relatively short. In lower reaches of large river systems where rates of rise and fall are slower, it is important to forecast the time when various critical stages of flow will be reached over the rise and fall. Reliability of forecasts for large downstream river systems is generally higher than for headwater systems.

Methods for warning the public should be well thought out, documented, and practiced on an annual basis. Ways to disseminate warnings include radio, television, warning sirens and public address systems. Users of detection and warning systems should be

aware that all members of the public will not respond in the desired manner to warnings. An understanding of how and why people respond to warnings is an essential ingredient in any warning system.

Warning time for peak or over bank conditions can range from a few minutes in cloudburst conditions to a few hours in small headwater drainages to several days in the lower reaches of large river systems. As with forecasting, the time and reliability of the warning increase with distance downstream where adequate knowledge of upstream conditions exists. The data collection network is necessary for collecting the information, the technical expertise required for interpretation, and the communication system needed to present timely information to potential victims, which are the services that many poor and developing nations find difficult to provide. Fortunately, the Flood Meteorological wing of India Meteorological Department is maintaining recording stations, monitoring and disseminating to the concern agencies for sub-Himalaya catchments. Flood warning is disseminated by following means:

- High priority telegram
- Doordarshan
- All India Radio
- Bulletins in the press
- Satellite based disaster warning systems
- Teleprint & Telex
- Telephone and
- Government channel

8.7.2 Human resource development

Human resource development at all levels is critical to institutionalization of flood disaster mitigation strategy. The National Centre for Disaster Management at the national level has been upgraded and designated as the National Institute of Disaster Management. Besides, the other functions assigned to the National Institute of Disaster Management include development of exhaustive National level information base on disaster management policies, prevention, mechanisms, mitigation measures; and providing consultancy to various

States in strengthening their disaster management systems and capacities as well as preparation of disaster management plans and strategies for hazard mitigation and disaster response.

8.7.3 Awareness generation

Recognizing that awareness about vulnerabilities is a sine qua non for inducing a mindset of disaster prevention, mitigation and preparedness, the Government has initiated a nation-wide awareness generation campaign as part of its overall disaster risk management strategy. Apart from the use of print and electronic media, it is proposed to utilize places with high public visibility viz. hospitals, schools, railway stations and bus terminals, airports and post offices, commercial complexes and municipality offices etc. to make people aware of their vulnerabilities and promote creation of a safe living environment. A novel method being tried is the use of government stationery viz. postal letters, bank stationery, railway tickets, airline boarding cards and tickets etc. for disseminating the message of disaster risk reduction. Appropriate public awareness programs should be implemented for the following purposes:

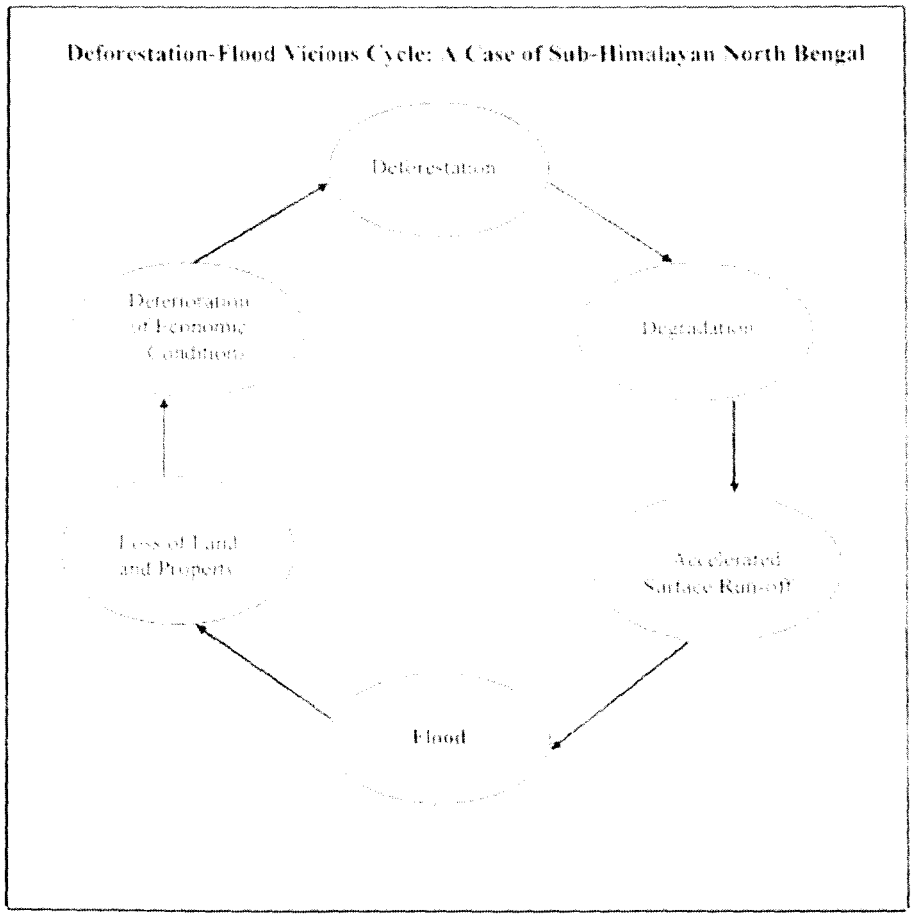
a) to make floodplain occupants and/or owners aware of identified flood hazards;
b) to encourage individuals to take actions such as flood proofing and developing escape plans, to mitigate their flood potential;
c) to make individuals aware of the existence and operation of flood warning plans and
d) to encourage individuals to keep drainage ways clean and to report potential maintenance problems.

8.8 Conclusion

Flood hazard mitigation involves measures to reduce the effects of disaster causing phenomena. All actions to reduce the impact of a disaster that can be taken prior to its occurrence, including preparedness and long term risk reduction measures. It also includes the planning and implementation of measures to reduce the risks or man-made hazards, and the process of planning for effective response to disaster which do occur. Disaster mitigation includes scientific analysis of risk assessment, social, economic, legal and technical processes

in the development of mitigation measures and administration and political processes in application of these measures.

Floods are caused not only by rain but also by human changes to the surface of the earth. Farming, deforestation, and urbanisation increase the runoff from rains; thus storms that previously would have caused no flooding today inundate vast areas. Not only do we contribute to the causes of floods, but reckless building in vulnerable areas, poor watershed management, and failure to control the flooding also help create the disaster condition. For the intensively utilized floodplains of sub-Himalayan North Bengal, the application of these approaches will require considerable political will and co-operation by the stakeholders.



(Based on Sarkar, S, 2008)

Figure 8.3 Deforestation – flood vicious cycle

Deforestation via-a-vis environmental degradation in the watersheds of the sub-Himalayan river indeed plays the decisive role in contemporary increased frequency and magnitude of hazards. Vicious cycle of degradation has already been established in the sub-Himalayan watersheds. Perhaps, the only possibility to save the habitable environment lies

into the pro-active watershed management. It is thus, our imperative duty to inform the people living in threshold areas within the watersheds (prohibitive/restrictive zone) categorically about the hard reality of possible hardship during the different stages of watershed management processes.

Let us tell our people living in threshold areas (prohibitive/restrictive zone) categorically that you are living in an unsafe area and it is not possible to provide you security against possible flood. The land use pattern, house type must be suitable to cope up the possible threat. The traditional art and life style of ***living with flood*** must be adhered to. However, the life both human and animal along with movable property must be protected through the construction of Flood Shelter nearby preferably within the radius of 5 km.

The model future course of action for comprehensive watershed management vis-à-vis flood management plan in sub-Himalayan North Bengal shall include:

1. Identification of *flood prone area* and plot it on Cadastral map (Scale 1:3960) at Gram Panchayet level.
2. Flood plain zoning of the major rivers at Gram Panchayet Level on Mauza map.
3. Projection of possible damages under different degrees of hazard.
4. Identification of sites for Flood Shelter and facilities needed.
5. Digitization, geo-referring and development of GIS with attachment of data related to the hazard. An on-line linkage with the forecasting agencies will help decision maker to take right decision at right time.
6. It will be possible to arrange for emergency evacuation, rescue for human and animal and also for movable commodities.
7. The GIS thus developed will also be of great help in providing efficient relief measures.

Although, the task is enormous, expensive and time consuming, yet the concern departments with the help of Gram Panchayet can initiate such programme. Expert agency can also be engaged. Such approaches although, would not control flood yet it will definitely reduce the loss and sufferings of the victims to a maximum extent. A portion of the money that spend for the construction of traditional flood protection may be kept aside as the emergency fund for the possible victims.

8.9 References

1. Baker, V.R, et. al. 1988: Flood Geomorphology, John Wiley, 503p.

2. Dhar O.N., Nandargi S., 2000: A study of floods in the Brahmaputra basin in India, International Journal of Climatology, 20, 771–78.

3. Kale, V. S. (ed.); 1998: Flood studies in India, Geological Society of India, Memoir 41.

4. Mukherjee, M.K. 2008; Studies on Hydrological models of major Himalayan rivers in North Bengal; Unpublished Ph.D thesis, North Bengal University, pp.217.

5. Mukhopadhaya S.C., 2010; Geo-hazard in the Himalayan North Bengal with particular emphasis on Floods in Geo-hazards in sub-Himalayan North Bengal ed. S. Sarkar, nbu, p.83-87.

6. NBFCC, 1965; Master Plan of Flood Control and Drainage Improvement in the catchment of river Teesta, December, 1965; Govt. of West Bengal.

7. Sanyal, C. C. et. Al. (ed.) 1970; Jalpaiguri District Centenary Souvenir (1869-1968), Jalpaiguri.

8. Sarkar, S., 1991:Environmental degradation in the upper Mahananda basin: A case study of soil erosion and strategies for soil conservation, in Environmental Degradation and Developmental Strategies in India (ed. M. M. Jana et all); Ashis Pub. House, pp. 78-99.

9. Sarkar, S. 2007: Watershed degradation vis-à-vis Environmental Crisis: A Study in Sub-Himalayan West Bengal, Integrated Watershed Management & Eco Restoration in Darjeeling Hills, Deptt. of forest, Govt of west Bengal, p. 18-26, 2007.

10. Sarkar S., 2008: Flood hazard in the Sub-Himalayan North Bengal, India, in S. Singh, L. Starkel, H.J. Syiemlieh (eds.), Environmental Changes and Geomorphic Hazard, 247-262, Bookwell, New Delhi, Shillong.

11. Sarkar, S. 2010; Geo-hazards in sub-Himalayan North Bengal (ed.), University of North Bengal pp.1-188.

12. Starkel, L., Sarkar, S., Soja, R., Prokop, P. 2008; Present-day evolution of the Sikkimese-Bhutanese Himalayan piedmont, Polska Academia Nauk, Prace Geograficzne, 219, Warszawa, p.1-122.

13. WAPCOS, 2003; Master Plan for Flood Management and Erosion Control in North Bengal, Phase-I (Volume I & Volume-II), March-2003, Govt. of West Bengal, Uttarbanga Unnayan Parshad, Office of the Commissioner, Jalpaiguri Division.