FLOOD HAZARD ASSESSMENT IN MURSHIDABAD DISTRICT OF WEST BENGAL USING GIS TECHNIQUE

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ABSTRACT

Flood, a disaster is a natural calamity and sometimes maximum human intervention on the river bank leads to flood hazard. Flood is generally occurred due to the combination of hydrological and meteorological conditions over a geographical region. Murshidabad is a flood prone district in West Bengal. A frequent flood is occurred in this district which is devastating in nature causes a tremendous damage in terms of loss of life, property, damage of households, reduction of agricultural land and environment degradation. Because of heavy rain during the month of July to September, flood occurs every year in regular basis in the district. Besides this, the district is in effect of serious erosion caused by relentless and continuous changes of course of rivers Ganga/Padma, Bhagirathi and their distributaries. The present paper intends to study the flood hazard assessments in Murshidabad analyzing the rainfall data, drainage density, geomorphologic features, water level and flood frequency analysis. The thematic maps of these factors are prepared using ArcGIS-10.1and ERDAS-9.1 tools. In this study Weighted Overlay Analysis method is adopted to prepare flood hazard zonation map based on multi-criteria assessments using technology of satellite imagery and GIS. The zonation of flood hazard map is identified as moderate, high and very high vulnerable zone in the district.

Keywords: Flood Hazard Assessment, Weighted Overlay Analysis, GIS technique, Murshidabad District.

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INTRODUCTION:

Flood is a disaster among the most devastating natural hazards in the world. It is most frequent and costly natural disaster in terms of human and economic loss. The devastating effects of floods on lives and property lead to heavy toll on human life than any other natural phenomena. As a result, flood is one of the greatest challenges to weather prediction. Flooding constitutes the most prevalent and costly natural disaster in the world (Kyu-Cheoul Shim et al., 2002). Flood hazard is the chance that a flood event of a certain magnitude will occur in a given area within a given period of time. Flood hazard mapping is a fundamental component for appropriate land use planning in flood prone areas. It creates easily-read, rapidly accessible charts and maps which facilitates the administrators and planners to identify areas of risk and prioritize their mitigation efforts.

Floods are probably the most recurring, widespread, disastrous and frequent natural hazards of the world. India is a country with diverse hypsographic and climatic conditions. More than 60% area in India has affected by flood sand and 22 States are categorized as multi hazards States. India is one of the worst flood affected countries, being second in the world and accounts for one fifth of global death count due to floods. India receives 75% of rains during the monsoon season (June-September). As a result almost all the rivers are flooded during this time resulting in sediment deposition, drainage congestion, invading into the main land. More than 8 million hectares of land in India are annually affected by floods and out of 8 million about 3.6 million hectares area is cropped area. U.P, Bihar, Assam, West Bengal and Orissa are among the high flood prone states in India (Figure-1). According to a Central Water Commission Report, nearly 37 million hectares (nearly 1/8th of India's geographical area) of fertile land are prone to flood at one time or another during the monsoon (Valdiya, 2004).

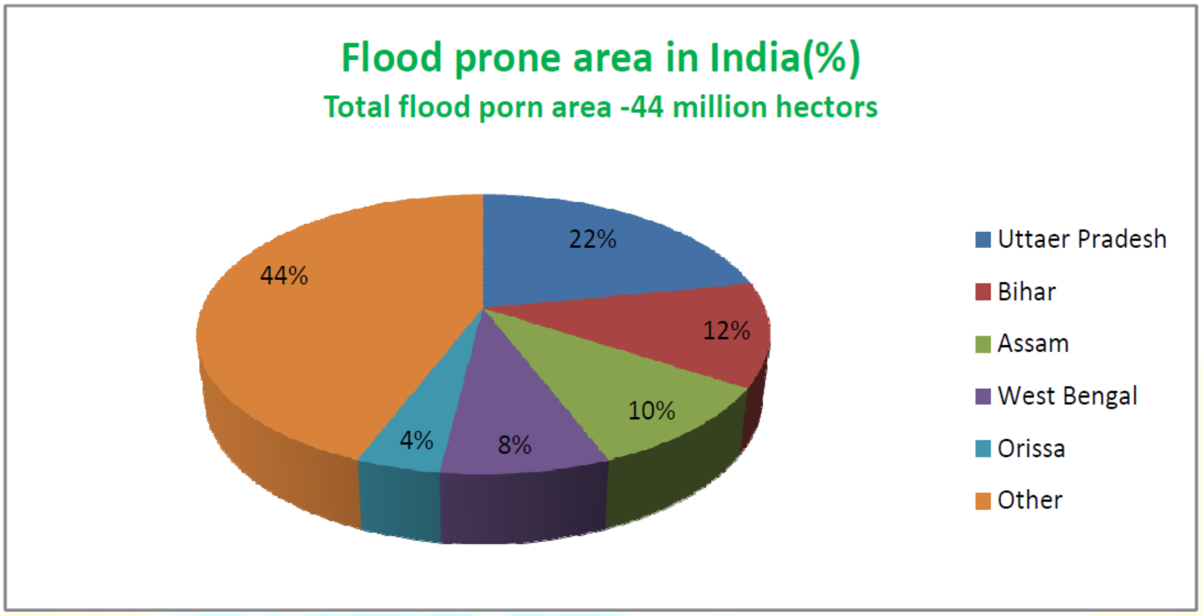
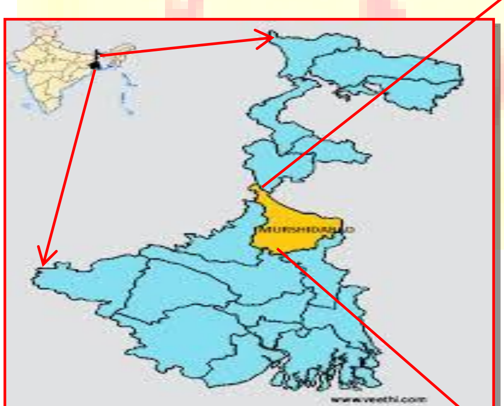


Figure-1: Flood prone area in India

Advancement of Remote Sensing and Geographic Information System are used to greatly facilitate the operation of flood mapping and flood risk assessment (Sanyal et al., 2004). It is evident that GIS plays a great role in natural hazard management because natural hazards are multi-dimensional and the spatial components are inherent (Coppock, 1995). The main advantage of using GIS for flood management is that it not only generates a visualization of flooding but also creates potential to further analyze this product to estimate probable damage due to flood (Hausmann et al., 1998; Clark, 1998). Smith (1997) reviewed the application of remote sensing for detecting river inundation, stage and discharge. The Present study intended to use an efficient methodology to accurately delineate flood vulnerability assessment and flood hazard mapping of Murshidabad district using advance technology of satellite imagery and GIS. Flood Hazards Mapping can be used to eliminate the base coinage for reorganization of facilities and infrastructure, formulation of plans for future expansion and flood management planning for future protection in the district.

STUDY AREA:

Murshidabad district is located in the lower gangetic plain of West Bengal. It is the northern most district of the Presidency Division of West Bengal lying between 23°43'30" North to 24°50'20" North latitudes and 87°49'17" East 88°46' East longitude. Soil of the district is very fertile, covering an area of 5,324 km² and having population of 7103807 (Census 2011). Presently the district has five sub-divisions namely Jangipur, Baharampore, Lalbag and Kandi and Domkal including 26 blocks. The district is drained by the Bhagirathi and Jalangi rivers and their distributaries. The River Bhagirathi passes through the district from north to south divided the district almost into two equal halves. The western part having stiff clay soil, reddish in colour and undulated topography is called "**Rarh**" and simultaneously the eastern part of the Bhagirathi containing alluvial and fertile soil is known as **"Bagri".** The rich fertile clay-loam, loam, loamy-sandy etc. soils provide a vivid scope to explore the cultivation potentialities deserve a healthiest form of primary activity. The district has three agro-climatic zones viz. old alluvial zone, new alluvial zone and lateritic light soil zone. In 2013, the cultivated area was 392.23 (000ha) in Murshidabad which is relatively more than that of other districts in West Bengal. Murshidabad District is characterized by tropical wet and dry climate (Koppen's climate classification). The annual mean temperature is approximately 26.2°C; monthly mean temperatures range from 10°C to 38°C and in normal the average annual rainfall in Murshidabad District is 129.6cm (GoWB, Dist. Stat. Hand Book, 2012)



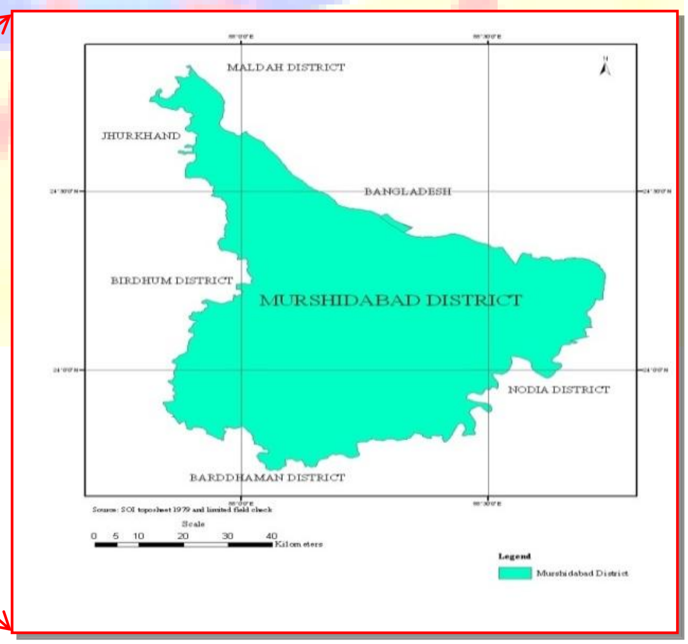


Figure-2: The Map of Study area

Berhampore town is the headquarters of the district. This district plays a significant role in interconnecting both the ends of West Bengal. It borders with Malda district in the North, Jharkhand's Sahebgunj district and Pakur district in the North-West, Birbhum in the West, Bardhaman in the South-West and Nadia district in the due South. Murshidabad district makes international border with Bangladesh in the East. Frequent occurrence of flood is one of the major factors of Murshidabad district to be less developed.

OBJECTIVES:

The present study consents to appraise an assessment of flood hazard mapping in Murshidabad district using advance technology of satellite imagery and GIS. The study deals with following objectives:

1. To study the drainage pattern of the study area.
2. To analyze the various impact assessments of flood hazard in Murshidabad district.
3. To identify the vulnerable areas and to prepare flood zonation map of Murshidabad district.

MATERIALS AND METHODS:

The present research is based on primary as well as secondary data sources. The study includes field survey, map studies and computer based analysis. In primary session, fieldworks were conducted to acquire first hand data required for the research. Most of the essential data for improving mapping accuracies of spatial changes were collected through the fieldwork. Landscape observations, meetings with experts, and structured interviews also were conducted in the district. The socio-economic data were collected from different government department like District Disaster Management Authority (DDMA), Irrigation Department, Agricultural Department, Food and Supplies Department, Population Statistics Department, Animal Resources and Development Department, Metrological Department and P.W.D (Road). In this study the software (ArcGIS 10.1, ERDAS Imagine 9.1), Survey of India (SOI) topographic Map (1979), National Atlas & thematic maps (2002), Satellite imagery- IRS-P6 (Feb. 2007), GPS-Garmin etrex & Garmin vista, Scanner, Printer, camera etc. were used. ERDAS (Leica) and ArcGIS software (ESRI) have been used to generate various thematic layers like morphological map, drainage map, and flood hazard map etc. The GPS and field information have been used for the preparation of final map.

The entire methodology, based on primary and secondary data analysis is attempting to cover the study area for a flood hazard assessment, monitoring and flood hazard mapping using technology of satellite imagery and GIS in Murshidabad district. The present study is carried out using Multi criteria evaluation methods. Important places, Road, Streams, Water body, Soil, and Micro Watershed were digitized using Arc-GIS 10.1 tools. After digitizing and plotting the map using Equal Interval Method, the rank of each factor was given on the basis of its estimated significance in causing of flood. The data layers have been integrated in GIS by Weighted Overlay Analysis using Raster calculator. The detailed methodology is given below (figure-3).

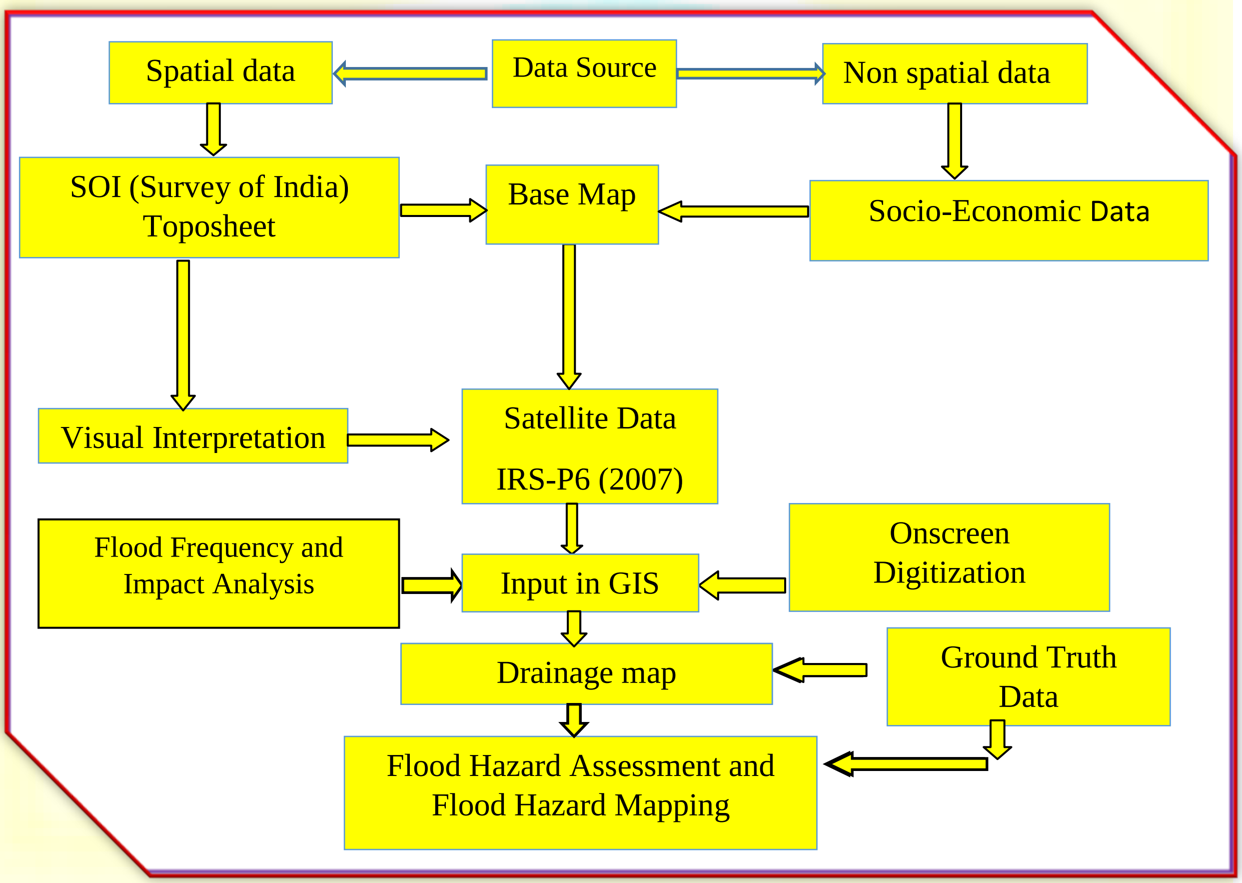


Figure-3: Flow Chart of the Methodology for Flood Hazard Assessment of Murshidabad

RESULT AND DISCUSSION:

GEOMORPHOLOGICAL STUDY:

Geomorphically, the district is drained by the Bhagirathi and Jalangi rivers and their distributaries. The district is divided into two almost equal parts by the Bhagirathi River known as Rarh and Bagri (figure-4). The Bhagirathi, a branch of the Ganga flows southward bifurcated from the Ganga at Dhuliyan municipality of Murshidsabad district. Some floodplains of the rivers joining the Bhagirathi on its west bank are Banshloi, Pagla, Dwaraka, Mayurakshi, and Babla vividly reflected in the district. Thus it contributes to the building of these areas as fertile floodplains by depositing layers of rich alluvium. Agriculturally these lands are so rich and lucrative that the ever-present risk of recurring floods cannot dissuade people from flocking there in ever greater numbers (Mollah, 2012). Every year flood hits this low land area, which results severe damage of agricultural crops in the district. The average elevation of the district is 29-30 meters and western part of the district is higher than the eastern part with hard rock.

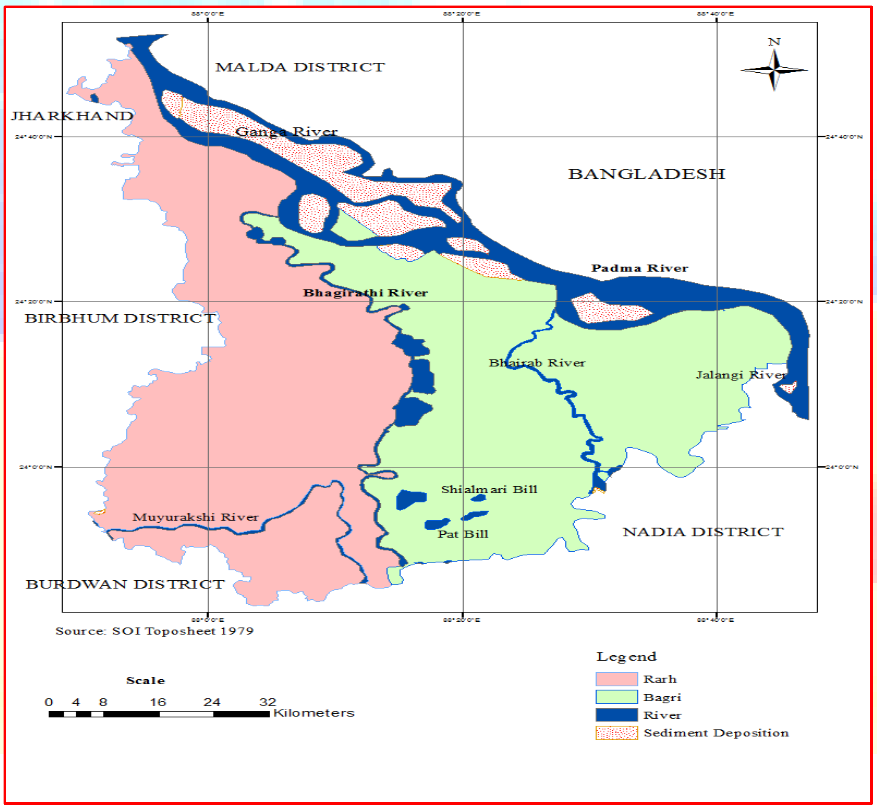
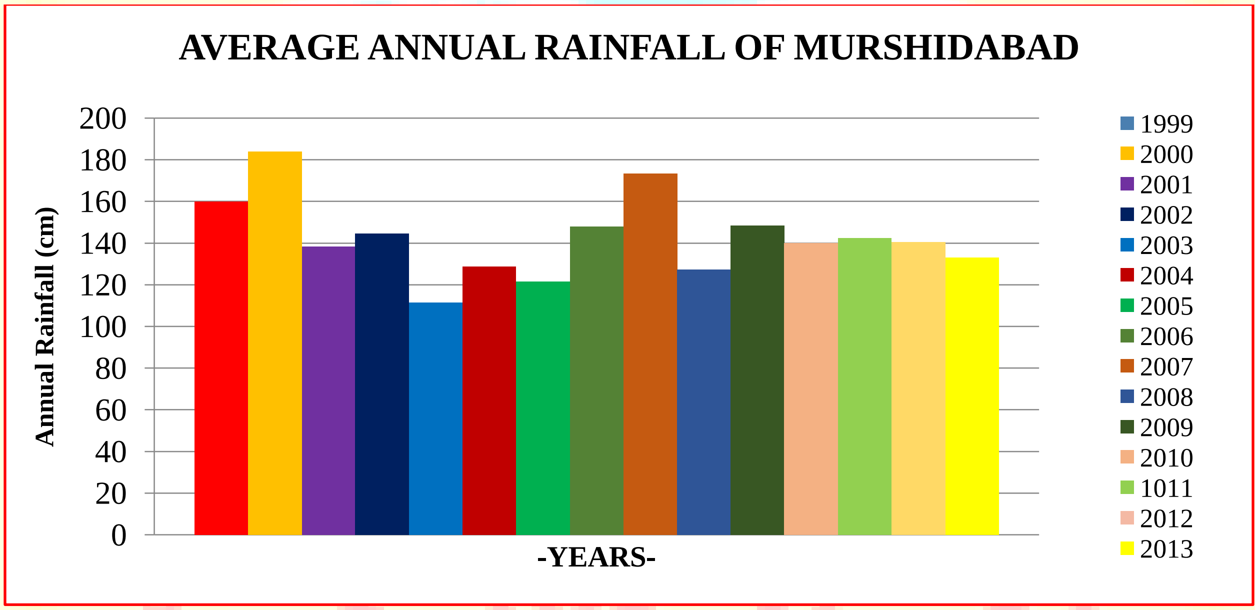


Figure-4: The relief feature of Murshidabad district

RAINFALL DATA ANALYSIS:

Most of rainfall in Murshidabad district has received during the month of July to September by the effect of South-West monsoon. Rains brought by the Bay of Bengal branch of South-West monsoon lash the city between June and September and South-West monsoon supplies the district with most of its annual rainfall of approx 1100 mm (District Contingency plan, 2011). After the analysis of rainfall data it is observed that maximum rainfall is occurred as 184cm and 173cm during 2000 and 2007 respectively which results occurring of flood in 2000 and 2007 but others' year rainfall was moderate such as 160.09cm, 144cm, 147cm, 140cm, 142cm and 140cm during 1999, 2002, 2006, 2009, 2010, 2011 and 2012 (Figure-5) which results moderate flood in the district. Rainfall was 111.48cm in 2003, 128.72cm in 2004, 127.40cm in 2008 and 133cm in 2013. Floods are common during Monsoon causing loss of life, destruction of property, and loss of crops in the district.



Source: Annual Report Book of Murshidabad, various years.

Figure- 5: Average annual rainfall statistic of Murshidabad

RIVER DENSITY ANALYSIS:

Two main rivers in Murshidabad are the Ganga/Padma and the Bhagirathi with the tributary Bhairab forming the main channel. The eastern tract between the Bhagirathi, the Ganga and the Jalangi permeated by several other offshoots of the great river is in no way different from ordinary alluvial plains of Bengal. The whole area lies low and is exposed to annual inundations which sometimes caused to human lives much suffering. The eastern half of the district known as Bagri looked like an isosceles triangle. The Ganga/ Padma and the Bhagirathi form the two approximately equal in shape. The Jalangi forms the entire base in the east of the district. The

Bagri is low-lying and alluvial, with a humid climate and a fertile soil, which is liable to be flooded by the spill of water by the Bhagirathi and other rivers. The western part of the district called Rarh Region is drained by western tributaries of River Bhagirathi.

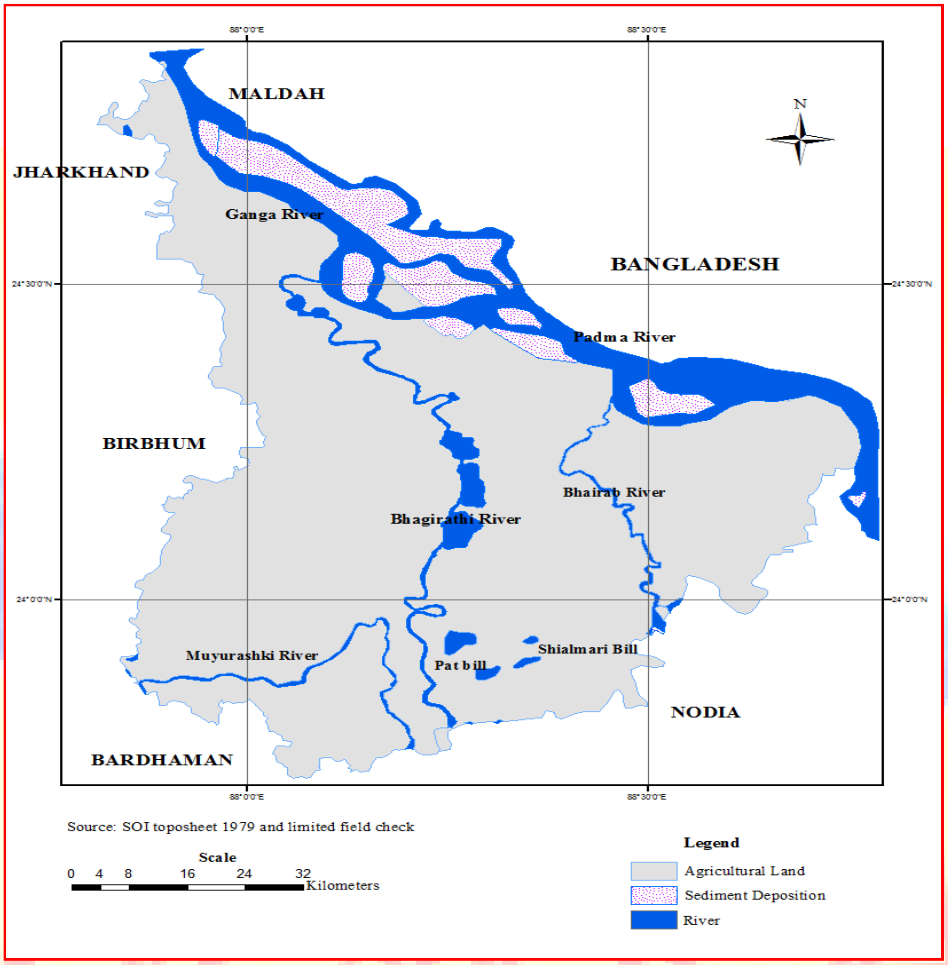


Figure-6: River Pattern in Murshidabad District

The Farakka barrage in the north monitors the flow of water into the river Bhagirathi through the feeder canal. Here the rivers are fed by the discharge from Mayurakshi system through Tilpara, Baidhara and Deucha barrage and ultimately gets emptied into the Bhagirathi through the river Babla. About 1,800 sq. km. of area in the neighborhood of Kandi town lying on the west bank of the river Bhagirathi is flooded by the combined discharges of the rivers Mayurakshi, Dwarka, Brahmani, Gambhira, Kopai and Bakreswar; and of which Mayurakshi is the main contributor (Mollah, 2012). An empirical scientific analysis reveals four major causes contributing to this disaster. These are: (a) Heavy rainfall, (b) Excess water released from the reservoirs of

Massanjore dam and D.V.C., (c) Decay of drainage channels, (d) Human intervention intercepting the hydraulic regime. Due to heavy rainfall in the monsoon months the water level of River Ganga/ Padma rises. Consequently, this causes high flow in the distributaries but these distributaries no longer active rivers and they are in degenerating stage. These rivers are not capable of containing this water from Ganga, finally causes flood in the blocks along the Ganga/Padma.

FLOOD FREQUENCY MAPPING:

Flood frequency analysis is an important factor in determining flood hazard assessment for Murshidabad district of West Bengal. Available data of annual flood reports were collected during 1870–2014 from the District Disaster Management Authority of Murshidabad which is used to produce a map depicting the frequency of flood occurrences in the district. From the archived information, most the blocks of Murshidabad were experienced 36 major flood events during 1870-2014, whereas a number of blocks were highly affected in respect to agricultural and households damages. It gives an optical view of occurrence of flood in the study area. For this a limitation of block administration records is that the entire block is reported as 'inundated' even if, most of the time, only a part is affected (Sanyal et al., 2006).

FLOOD IMPACT ANALYSIS:

For the flood hazard assessment, flood impact analysis is most significant one for the district. The shifting course of river Ganga is causing large scale disaster in terms of flooding and bank failure in Malda and Murshidabad Districts of West Bengal. River bank erosion/failure and flooding in these two districts have become a chronic phenomenon since early '60s and the problem manifested itself to formidable magnitude during the last five decades (Bhaskar et al., 2012). Since the flow of river intercepted at Farakka, the sedimentation on the riverbed has increased (Rudra, 2001). To understand flood hazards and environmental changes, it is imperative that engineers and hydrologists utilize historical and paleo-flood records to improve risk analysis as well as to estimate probable maximum flood on rivers such as these in a highly flood-prone regions of West Bengal (Kron, 2005). About 24 lakh people of Murshidabad now live along the banks of Ganga. To protect this 174 km. stretch, Rs. 1740 crore are estimated. But in the budget the sanctions for this Irrigation Department was a measure of Rs. 396 crore only. Actually every year between July to September 15 lakh cusec water passes through the poor alluvial basin of Murshidabad due to heavy rain which increases bank slumping five times than the dry month. From 1931 to 1977, 26769 hectares land has been eroded. Many villages have been fully submerged. Thousands of people have lost their dwellings (Mollah, 2012). The decade 1980- 1999 is a decade of erosion of this district badly affected Giria, Sekhalipur, Khejustala, Mithipur, Fajilpur, Rajapur, Akheriganj, Parashpur villages. In 2002-2003, 694 families are completely submerged and shifted to other places. 612 families in 2003-2004 were shifted their dwellings, and carry like a curse livelihoods. During the year 2006-2007, 1354 families were shifted due to river bank erosion and consequent flooding in Jalangi block many mouzas were fully washed away. In 2007 severe erosion occurs in Lalgola, Bhagawangola II, Farakka, and Raninagar II blocks. During 2008 Bamnabad of Raninagar II block is affected by erosion and 168 families are shifted and total 1245 families are affected in Lalgola, Bhagwangola I and Bhagwangola II block in the study area.

WATER LEVEL ANALYSIS OF MAJOR RIVERS IN MURSHIDABAD:

There are five major rivers among them Bhagirathi and Ganga/Padma play very important role in the district and other rivers are Kuaya, Padma and Dwaraka. Here based on the height of water level from the different reading stations, rivers were divided into Danger Level River and Stream Danger Level River (GoWB, Flood Preparedness Plan, 2014). The water level of the Ganga River at Farakka reading station was 22.25m (Danger Level) and 22.85m (Stream Danger Level), but at Akhriganj station it was 18.44m (Danger Level) and 19.05m (Stream Danger Level). The Bhagirathi river at Berhampore station was 17.22m (Danger Level) and 17.83m, (Stream Danger Level), the Kuaya river at Tarapur was 22.71m (Danger Level) and 23.05m (Danger Level); and Dwaraka has two reading station at Sankarghat and Rangram, there were 20.40m, 17.36m (Danger Level) and 21.30m,17.46m (Stream Danger Level) respectively (figure-7).

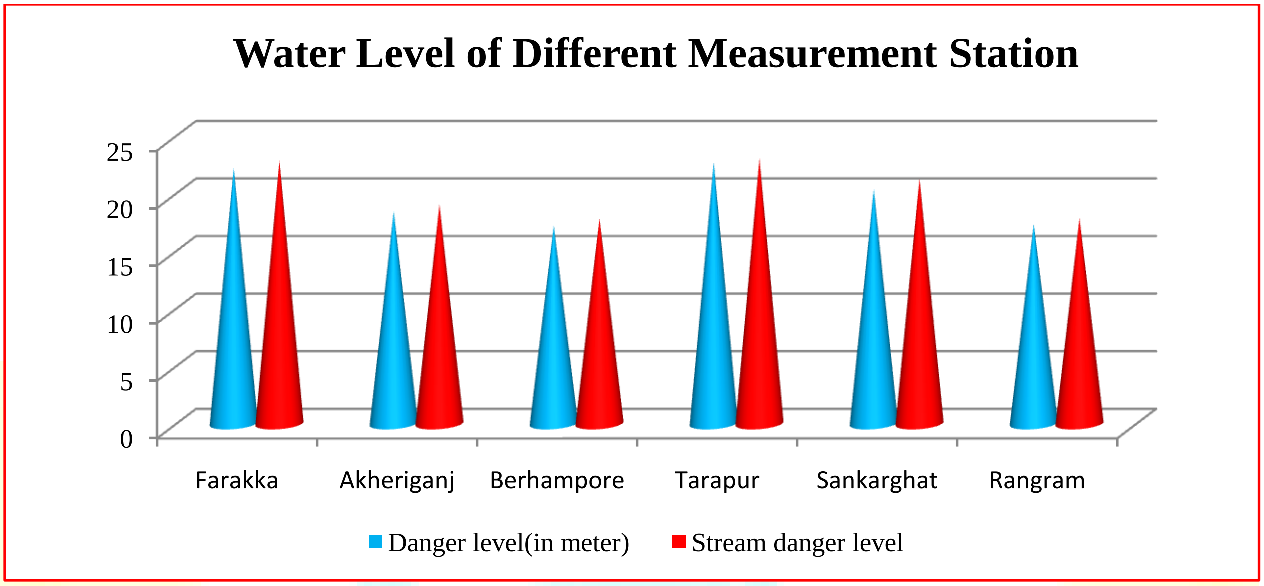


Figure-7: Water level of different measurement station of Murshidabad district.

VARIABLES ANALYSIS FOR FLOOD HAZARD ASSESSMENT:

A flood hazard map integrating hydrological data with socio-economic variables could be used to account for intangible damage (Boyle et al., 1998). The variables considered here include population density (pop-den), road density and access to safe drinking water (Sanyal et al, 2006). Population density of each block is chosen as an indicator of the economic assets under potential flood threat and provides a guide to the commensurate relief measures required. For the rapid evacuation of affected communities during a hazardous flood, a good network of all-weather roads is essential – a factor that has received considerable attention in recent times and been recognized as a core non-structural requirement of flood management (Rashid et al., 2000; Rashid & Haider, 2002). Therefore, the calculation has omitted non-surfaced roads that cannot be relied on during the monsoon season. Any comprehensive flood management strategy includes protecting vulnerable population from intangible damage. In Gangetic West Bengal the outbreak of water-borne; in particular diarrhea disease is a major concern after flood-waters recede (Sur et al., 2000; Kunni et al., 2002). Access to safe drinking water is thus another key element in post-flood hazard management. To quantify this aspect of hazard another variable, termed 'epidemic', was devised to measure the percentage of villages having no access to safe drinking water to the total number of villages in each of the development blocks of Murshidabad district. Taking the model of Joy Sanyal, the present study provides weightage of the flood hazard index with adding some other important variables like morphological feature, flood frequency, annual rainfall, damage intensity and cost estimate model analysis at the time of before flood, during flood and after flood situation in the block level and at village level by the government and non-government organization.

WEIGHTING FOR THE FLOOD HAZARD INDEX MODEL:

The weighting for the Flood Hazard Index Model (FHIM) was applied in eight steps. In order to depict the heterogeneity of different environmental and socio-economic factors like relief features, climate condition like rainfall and temperature, over population, river density contributing to flood hazard, all eight variables were standardized for Flood Hazard Index (Table-1) and knowledge-based weighting was applied to each variable. It represents that a high level of dispersion across different blocks in Murshidabad District. The progressive weighting was adopted on the table-1 based on the evidence of flood hazard reports collected from the different governmental and non-governmental organization of the district and which is indicated that nonlinear manner of the number of flood occurrences during the period 1870-2014. Flood hazard index model has been calculated with the help of Joy Sanyal FHI scheme, and its outcome represents that the flood hazard curve becomes increasingly steeper at the higher values of flood vulnerable in the study area. The eight variables were used as flood prone, population density, cost estimation, food probability, elevation, overflow, evacuation, epidemic for preparation of Flood Hazard Index Model at blocks level. The blocks prone to flood are classified as a high to moderate flood hazard zone.

Table-1: Flood Hazard Index Model for Murshidabad District

The Block Level Study	Hazard Indicators	Hazard Factor	Variable Name	Source
	Number of Food frequency (1870-2014)	Risk of flooding	Flood-prone	DDMA annual flood reports
	Population density (persons qs km)	Economic assets under flood threat	Population - density	Census of India, 2011
	Damage intensity (RS - per head)	Economic losses	Cost estimate	DDMA annual flood reports
	River density analysis	Overflowing	Flood probability	SOI toposheet
	Morphological feature (M)	Submerged area by the flood	Elevation	SOI toposheet

	Annual rainfall (mm)	Risk of flooding	Overflow	IMD Kolkata
	Road density (sq km)	Ease of evacuation and sending relief	Evacuation	District Statistical Handbook (2014)
	Access to safe drinking water (% of villages having no safe source)	Outbreak of a waterborne disease in the post-flood situation	Epidemic	District Statistical Handbook (1914)

FLOOD HAZARD MAPPING:

Different combinations of the weighting factors were used to the data analysis and flood hazard index was modified moderately depending on local conditions. Then the final flood hazard index- zonation map was prepared for the study area. Flood Hazard zonation values are divided into three classes very high, high and moderate (figure-8). The very high flood hazard zone includes sixteen blocks found east to south eastern part of Bhagirathi river namely Raghunathganj –II, Lalgola, Raninagar –I, Raninagar –II, Beldanga –I, Beldanga-II, Berhampore, Hariharpara, Nowda, Samserganj, Khargram and Kandi. The blocks Raghunathganj–I and Sagardighi fall under the high flood zone and other eight blocks Murshidabad, Nabagram, Farakka,Suti-I, Suti-II, Jalangi and Bharatpur –II come under moderate flood zone of the district.

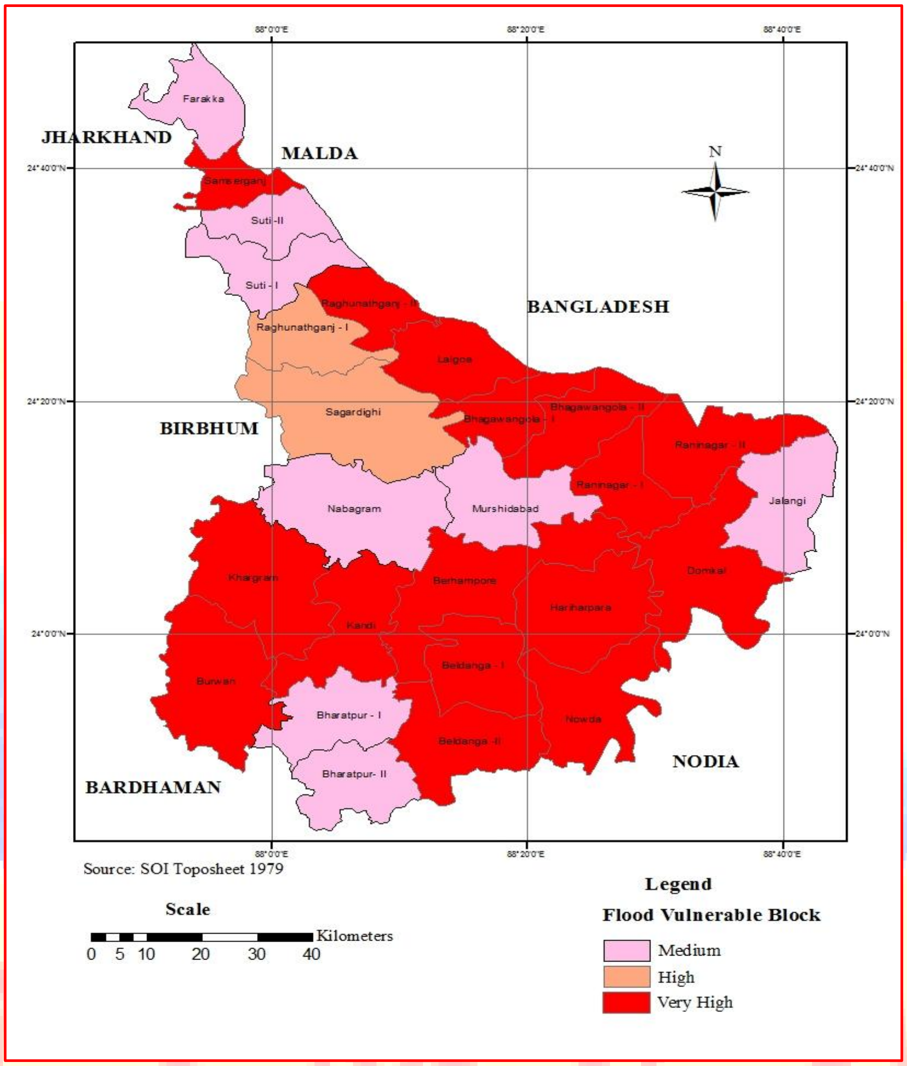


Figure- 8: Flood Hazard Zonation Map of Murshidabad District

CONCLUSION:

Geographically Murshidabad district is located in the lower gangetic plain of West Bengal. The present study provides an assessment of flood hazard in Murshidabad district. Flood has a very detrimental effect on individual; masses of human and animal lives; and environment degradation. Flood as it is a disaster cannot be prevented but their impact on people lives can be reduced by taking some measurable steps to a considerable extent. Long term & short term action plans; hazard and risk mapping; awareness programme; flood preparedness programme; and disaster management scheme are some major extenuatory steps to mitigate flood hazard. The technology of satellite imagery and GIS have been used in this study for mapping flood hazard, modeling and analysis of variety of applications in flood hazard management at block level. Most of the blocks in Murshidabad district highly affected due to annual flood. The district has been divided into three vulnerable zones viz. very high vulnerable zone, high vulnerable zone and moderate vulnerable zone. This result finally suggested that the whole area of the district is flatted low land and moderate to highly flood prone.

Flood frequency of the study area was slightly increase due to climate change and its result brings the study area to heavy rainfall during June to September month by the effect of South-West monsoon and district generally experiences with submergence of low lying land. The flood zonation map and various impact assessments of flood in the present study furnish a planning approach to the comprehensive development of Murshidabad district. Using the flood hazard map, flood prone areas can be identified which will be helpful for planner and decision maker for reorganization of facilities and infrastructure, and formulation of flood management planning for the future protection and sustenance in the district.

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