EWCE 461

River Engineering and Flood Management

3 Credit Hour

Md. Atikuzzaman

Lecturer

Department of EWCE

Sec-B: Flood Management- 1.0 Credit

Syllabus of Sec-A: 2.0 Credit

- Behavior of alluvial rivers
- River channel pattern and fluvial processes
- Aggradations and degradation
- Local scours
- River training and bank protection works
- Navigation and dredging of sediment movement in river channels
- Bed form and flow regimes
- Case studies

Syllabus of Sec-B: 1.0 Credit

- Flood and its causes
- Flood process in urban and rural area
- Flood management measures: structural and non-structural measures such as dams, reservoirs
- Diversion channels and floodways
- Improvement of channel capacity by dredging
- Land management, Flood proofing, Flood zoning, Flood hazard mapping
- Flood forecasting and warning, Flood damage assessment

Course Outcome (CO)

CO1	Be able to explain the relationships of river planforms with the river Morphological parameters
CO2	Be proficient in calculating and estimating sediment distribution and sediment load of a river
CO3	Be able to apply different engineering perceptions to estimating the scour depth.
CO4	Be familiar with different bank protection and river training work and understand the dredging and navigation processes
CO5	Apply knowledge of flood processes and management strategies to analyze and assess flood risk.

Reference Books

- Any book on Flood Management and Mitigation
- **Water Resources Engineering by R. K. Linsley, J. B. Franzini, D. L. Freyberg and G. Techobanojlous**
- Fluvial Processes in River Engineering (1992) by H. H. Chang
- **Flood Control and Drainage Engineering, Fourth Edition, S.N. Ghosh**
- Urban Flood Management; by Chris Zevenbergen (Author), Adrian Cashman (Author), Niki Evelpidou (Author), Erik Pasche (Author), Stephen Garvin (Author), Richard Ashley (Author)
- Flood Risk: Planning, Design and Management of Flood Defence Infrastructure, By: Paul Sayers
- Vulnerability and Adaptation to Climate Change in Bangladesh: Processes, Assessment and Effects by MD Aboul Fazal Younus

Lecture 9

Flood Hazard Mapping

Flood Risks

- Mertz et al. (2007) defines risk as “the probability that floods of a given intensity and a given loss will occur in a certain area within a specified time period’, implying that risk results from the interaction of hazard and vulnerability.

Flood Risk Analysis

- Risk: expected number of lives lost, persons injured, damage to property, and disruption to economic activities. Depends on:

- Hazard: Probability of an occurrence of flood

- Elements at Risk: Population, buildings, live-stocks, structures, economic activities

- Vulnerability: Degree of loss to a given elements or set of elements; expresses a scale from 0 (no damage) to 1 (total loss)

Flood Risk Analysis

- ***Methodology:***
  - *Assessment of Hazard, (H)*
  - *Assessment of Probable damage from a Hazard, (D = E*V)*
    - *E=Elements at Risk*
    - *V=Vulnerability*
  - *Determination of Risk (R = H*D)*

Assessment of Flood Hazard

- ***Flood hazard*** *is defined as "the exceedance probability of potentially damaging flood situations in a given area and within a specified period of time" (Mertz et al., 2007; ITC, 2004).*

Assessment of Flood Hazard

- Areas subject to flooding, flood inundation depth, magnitude of flooding, duration of flooding, frequency of occurance
- Can be estimated based on model simulation, or
- Can be estimated based on historical inundation data.

Assessment of Flood Hazard

- Hazard assessment results in the preparation of different hazard maps
  - Based on area of inundation
  - Based on different intensity
  - Based on different frequency of occurrence
- Usually flood hazard maps should be prepared for floods of 2.33, 10, 20, 50 and 100 year return periods.

Factors Influencing Flood Hazard

- The **area of inundation** in combination with land use data, reveals which elements at risk would be affected in case of a certain flood event.

- **Inundation depth** the water depth has been identified by different studies as the flood characteristics which has the biggest influence on flood damage.

Factors Influencing Flood Hazard

- The **duration of inundation** is often of importance since the degree of damage is often related to it. This applies to structural safety, the effect of interruption in communications, industrial activity and public services, and agriculture. In many cases, failure of river embankments is also influenced by the duration of the flood water level.

Factors Influencing Flood Hazard

- Another important criterion for flood intensity is the **flow velocity**. It becomes important particularly in mountainous areas or flash flood areas where flow velocities are high, which can lead to dramatic damages to buildings, infrastructures, standing crops.

Factors Influencing Flood Hazard

- The **rate of rise** of flood may also have an influence on flood damages. A high rise rate will reduce the time for warning and evacuation and therefore could increase damages or movable assets. It may therefore influence planning permission for floodplain occupation and its zoning. The consideration of rate of water rise necessitates, similar to flow velocity, a larger effort.

Factors Influencing Flood Hazard

- The **time of occurrence** of flooding is usually important when calculating damages to agriculture. Damages would be quite high if flooding occurs just before the harvest of the respective crops, while they could be relatively low in the case of flooding in early stages such that damages can be recovered by re- plantation of crops.

Assessment of Flood Damage

- Depends on Elements at risk and Vulnerability
- Elements at risk: Population, buildings, live-stocks, crops, structures, economy and so on..
- Vulnerability: means degree of loss (0 to 1)
  - Difficult to estimate or determine
  - Can be estimated through post-disaster survey

Exposure and Susceptibility

- Exposure analysis answers the question “Who or what will be affected by floods?” Exposure can be quantified by the number or the value of elements which are at risk. In a flood prone area, the exposure may be quantified by the total assets (buildings, transportation facilities, agriculture) within the design 100-year inundation area.

- The analysis of susceptibility will then answer the question “How will the elements will be affected damaged?” Susceptibility is usually described by relative damage functions (e.g. depth-damage curves).

Assessment of Flood Vulnerability

- ISDR (2004), which defines vulnerability as '**the set of conditions and processes resulting from physical, social, economic and environmental factors, which increase the susceptibility of a community to the impact of hazards**'.

- ITC (2004) defined vulnerability as '**the degree of loss resulting from the occurrence of a phenomenon**'.

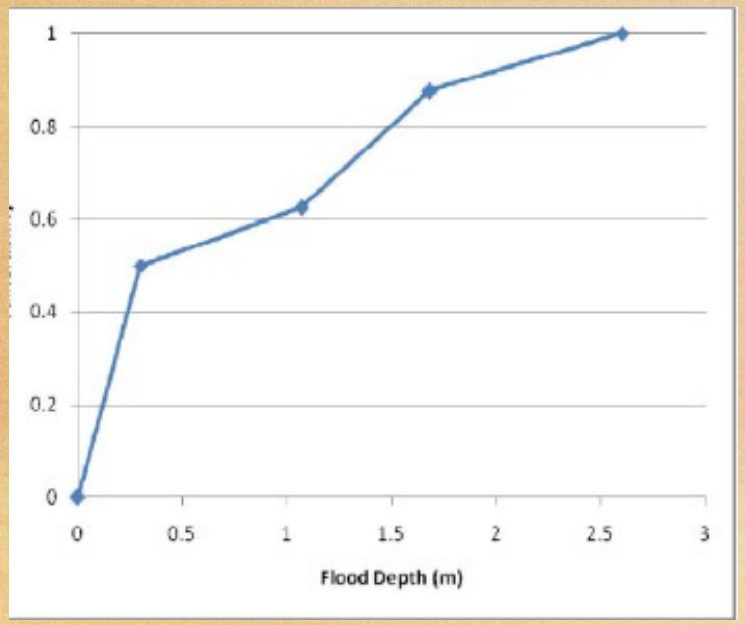
Flood Vulnerability

- Jones and Boer (2003) defined vulnerability as '**the amount of potential damage caused to a system by a particular-related event or hazard**'.

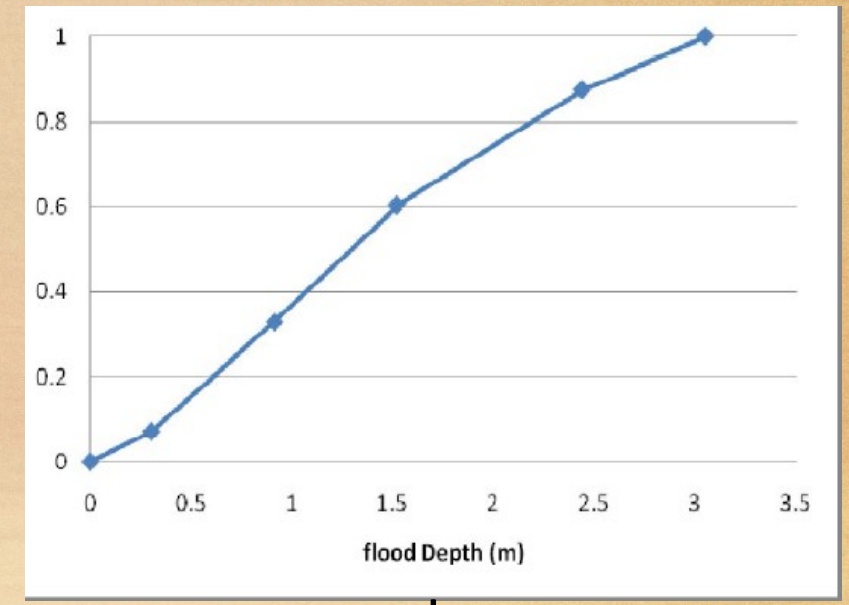
- Mertz et al. (2007) conceptualized vulnerability as two elements, **exposure** (level of being damage potential) and loss (**susceptibility**).

Assessment of Flood Damage

- $D = E_1V_1 + E_2V_2 + \ldots\ldots E_nV_n$
- Where, D = Damage, E = Element at Risk, V = vulnerability.
- Can generate Stage vs Damage curve



agriculture



settlement

Flood Risk Estimation

- R = HD
- Where, R= risk from a given flood with in given period of time at given site;
- H = probability of occurance of this flood which is inversly proportional to the return period; and
- D = potential damage from a given flood at a given site

Flood Risk Estimation

- For example, if D = 10 milion taka for a 20 year return flood, therefore
- R = 1/20*1000000 = 500,000 taka/year
- For a representative evaluation, risks from all possible magnitudes of flood should be calculated and then weighed by their respective probabilities.

Flood Risk Estimation

- In that case an average annual disaster risk from floods of various magnitudes can be determined theoretically as a weighted sum of all the possible disaster risks with in a given long period time (usually 100 years).
- $R = \sum H_n D_n$
- For example, with in 100 year period, use 10, 20, 50, and 100 year floods
- $R_m = 0.1D_{10} + 0.05D_{20} + 0.02D_{50} + .01D_{100}$

Application of Flood Risk Analysis

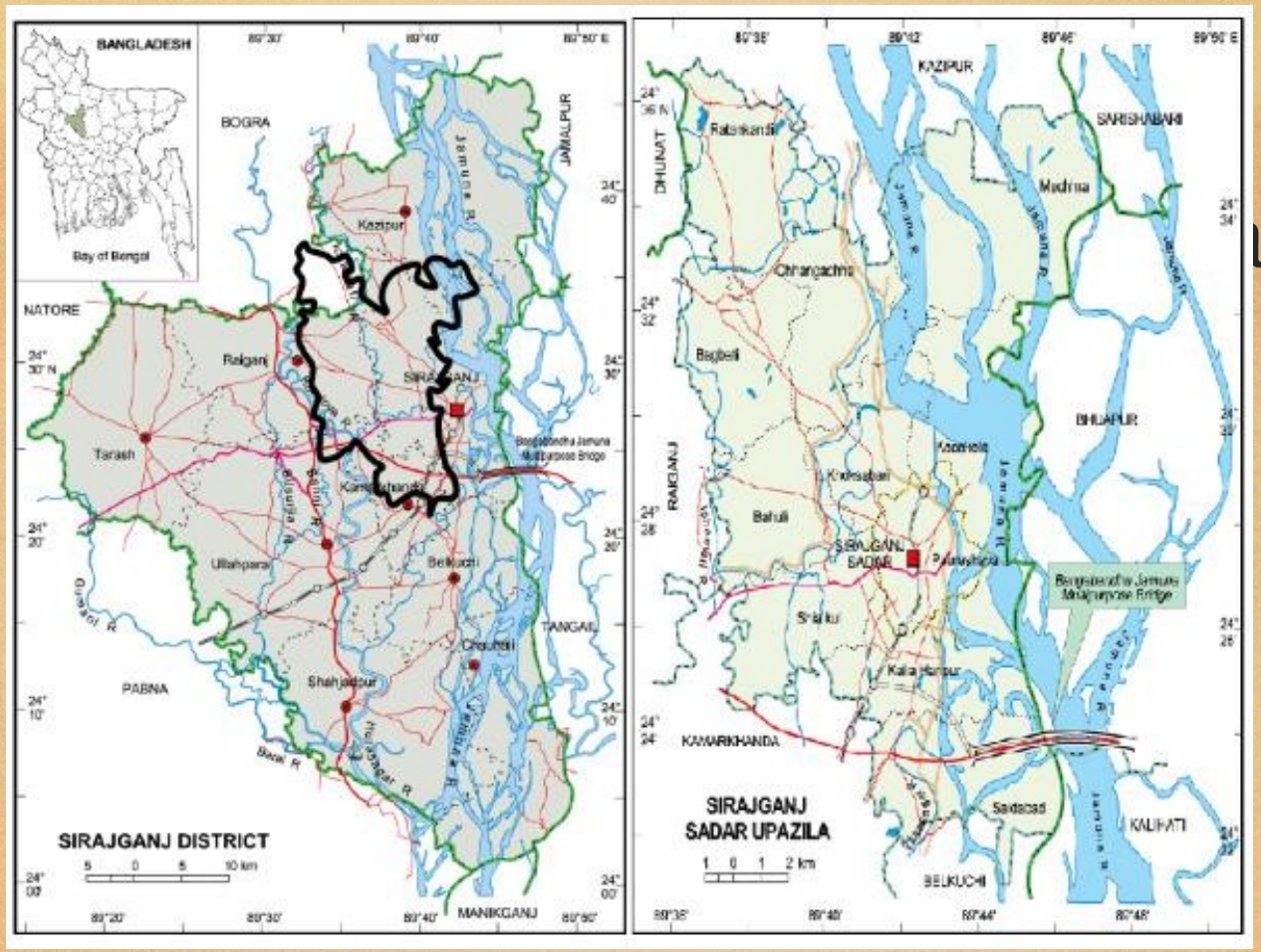
- Decision making of flood mitigation measures
- Planning in land-use control
- Planning in urban development
- Flood insurance

Case Study: 1

Damage Assessment for flooding in Sirajganj District

References

Mozammel et al. (2011) Development of Flood Hazard and Risk Maps with Effect of Climate Change Scenario (http://www.buet.ac.bd/iwfm/ climate/report/Component_1.pdf)


BANGLADESH
Bay of Bengal
BOGRA
JAMALPUR
NATORE
Raiganj
SIRAJGANJ
Tarash
Kazipur
Ullahpara
Belkuchi
Chauhali
TANGAIL
PABNA
Shahjadpur
SIRAJGANJ DISTRICT
MANIKGANJ
KAZIPUR
SARISHABARI
DHUNAT
Ratikandi
Madina
Chhanchina
Bajbeli
BHUAPUR
RAIGANJ
Kamalsbari
Baluti
SIRAJGANJ SADAR
Shalku
Kalaikandi
KAMARKHANDA
Sadarsad
KALIHATI
BELKUCHI
SIRAJGANJ SADAR UPAZILA

Study Area

Sirajganj Sadar Upazila

- Sirajganj Sadar Upazila with an area of 325.77 sq km is bounded by Kazipur Upazila on the north, Kamarkhanda and Belkuchi Upazilas on the south, Kalihati and Bhuapur Upazilas on the east, Kamarkhanda, Raiganj and Dhunat Upazilas on the west.
- The area falls in a major Agro Ecological Zones (AEZ), which is the Active Brahmaputra-Jamuna Floodplain (AEZ-8). Siraganj is located in north-western zone of Bangladesh which has less rainfall. The annual rainfall is 1610 mm.
- In the north, June has a mean rainfall exceeding 500 mm whereas in the south no month has a mean rainfall exceeding 300 mm. However, the main river, the Brahmaputra brings the largest transboundary inflow from upstream catchment area.

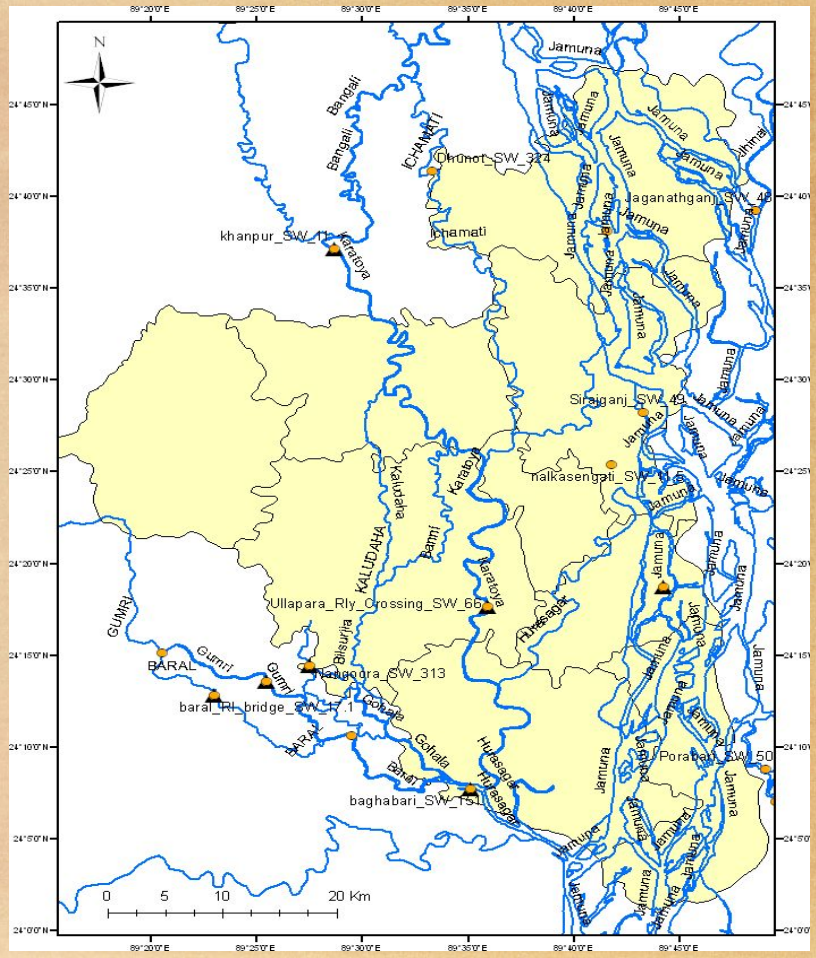
Sirajganj Sadar Upazila

- Major important rivers in and around Sirajganj are Brahmaputra-Jamuna, Bangali, Jamuneswari, Karatoa, and Hurasagar. Sirajganj is considered as the most disaster prone area to river flood and bank erosion.
- Widespread flooding, shifting river channels, constantly eroding cultivated land and settlement and displacement of people are the main problems in this area.
- Land use status of Sirajganj Sadar Upazila shows that the total cultivable land is 23872.93 hectares and fallow land is 772.16 hectares.
- About 21.44% of the land is single cropped, 47.54% double cropped and 31.02% triple cropped. Main crops include paddy, jute, wheat, mustard seed, sugarcane, onion, garlic, potato, sweet potato, chilli and ground nut.

Water level and Discharge gage stations of BWDB

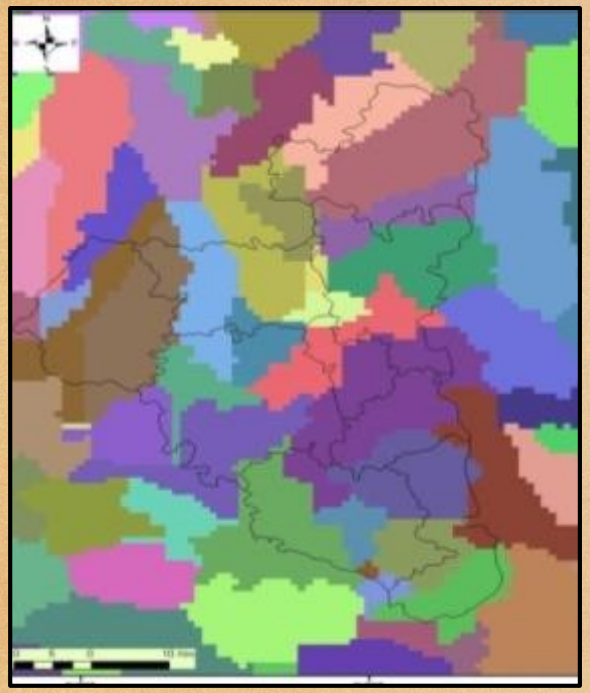
River	Station	Station Name
Bangali	SW11.5	Nalkasengati
Brahmaputra-Jamuna	SW49	Sirajganj
Brahmaputra-Jamuna	SW49A	Kazipur
Deonai/Charalkata/ Jamuneswari/Karatoa	SW66	Ullapara Railway Crossing
Karatoa/Atrai/Gur Gumani/Hurasagar	SW151	Baghabari
Nangoora	SW313	Nangoora
Old Bengali	SW324	Dhunot

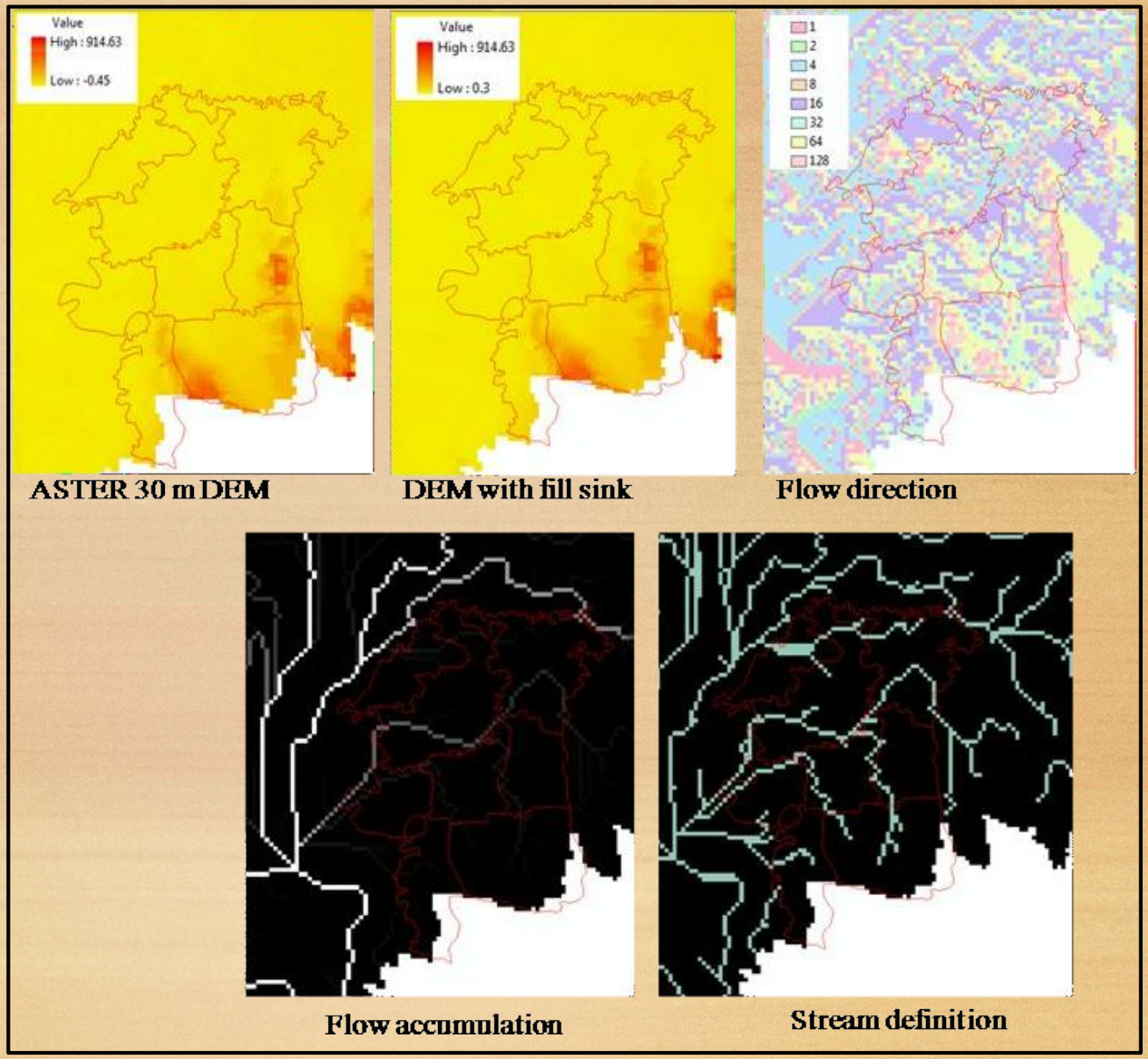
River network, including locations of water level and discharge gage stations



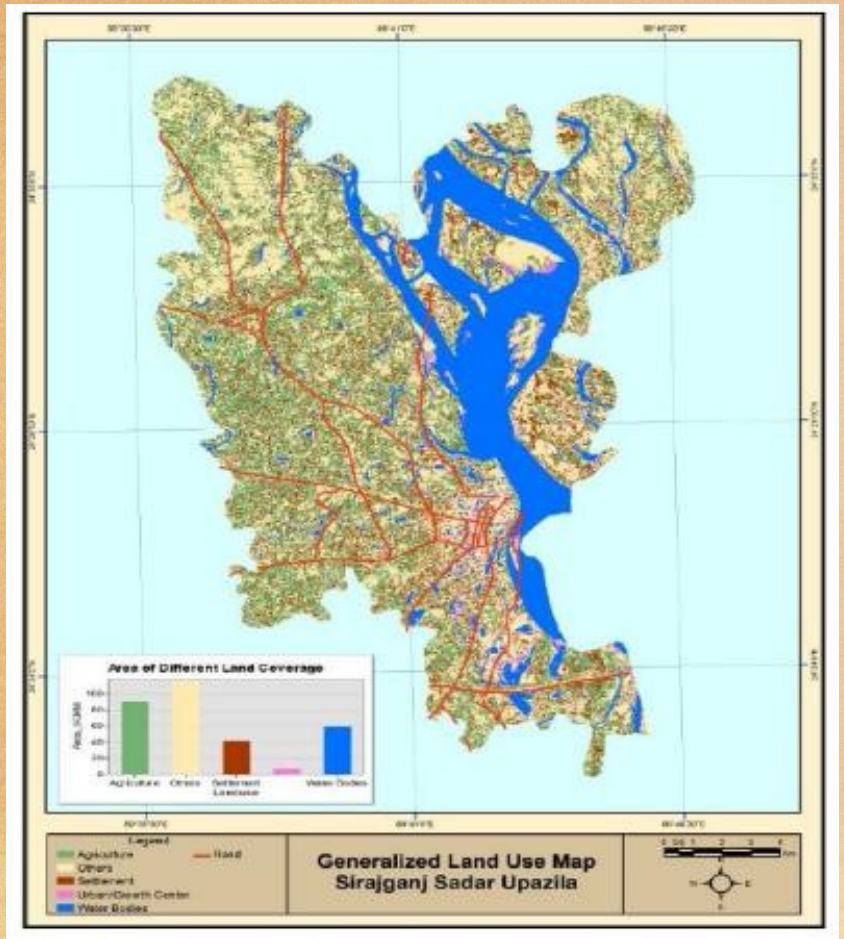
Watershed Delineation using GIS Tools

Watershed

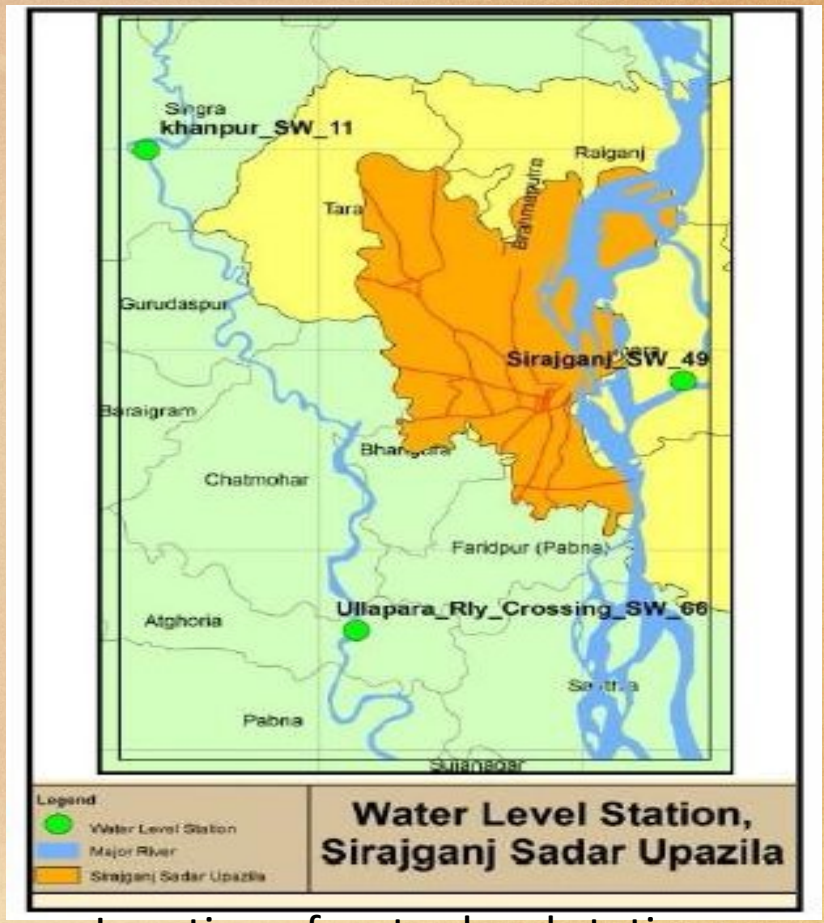




Landuse and hydrographic map of Sirajganj Sadar



Landuse map of Sirajganj sadar

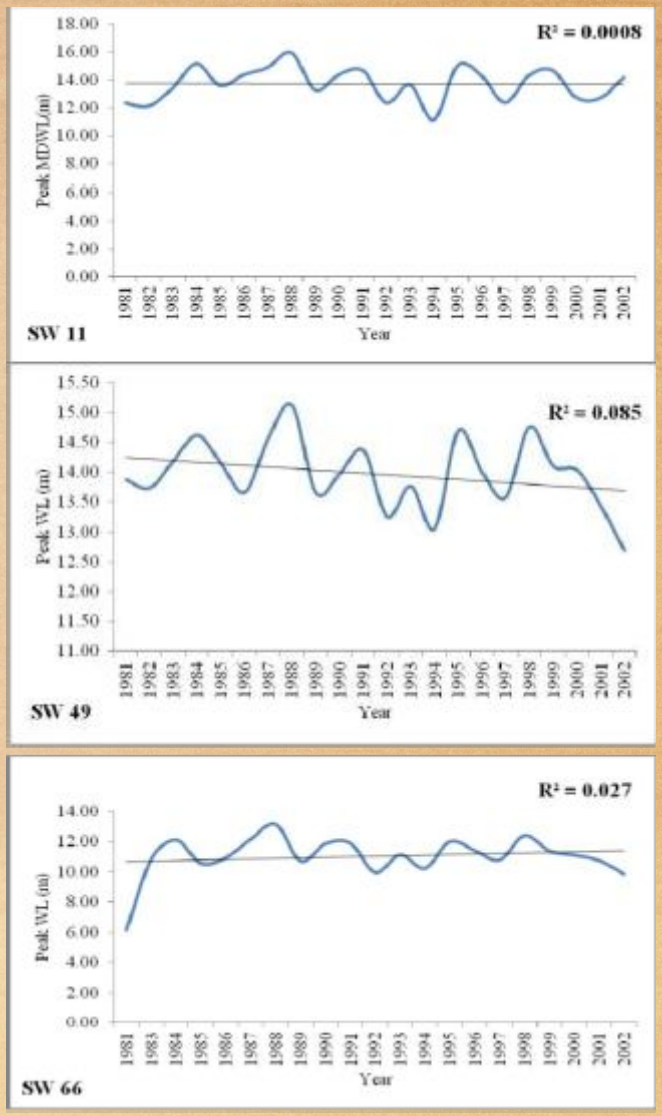


Location of water level stations

Flood Frequency Analysis

- The regression test for linear trend has been carried out for the annual water level series from 1981 to 2002 at Khanpur SW 11 station of Bangali river, Sirajganj SW 49 station of Brahmaputra - Jamuna river and Ulapara Rail crossing SW 66 of Deonai river.

- The graphical trend line of peak water level for all three stations have been drawn in Figure.



Frequency analysis on Brahmaputra River

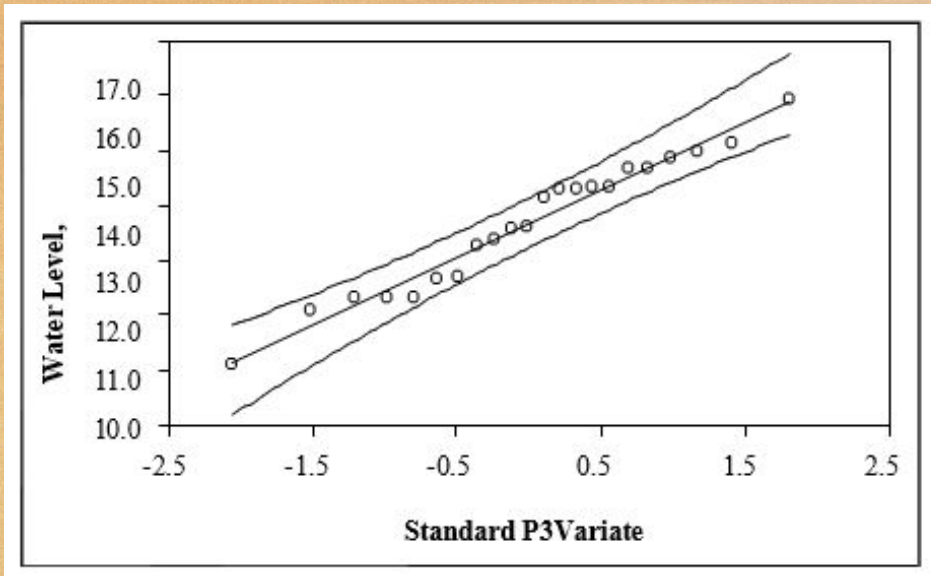
- Then trend free hydrologic data have been used to determine designed flood levels for several return periods (2.33yr, 05yr, 10yr, 20yr, 50yr and 100yr floods) through flood frequency analysis.

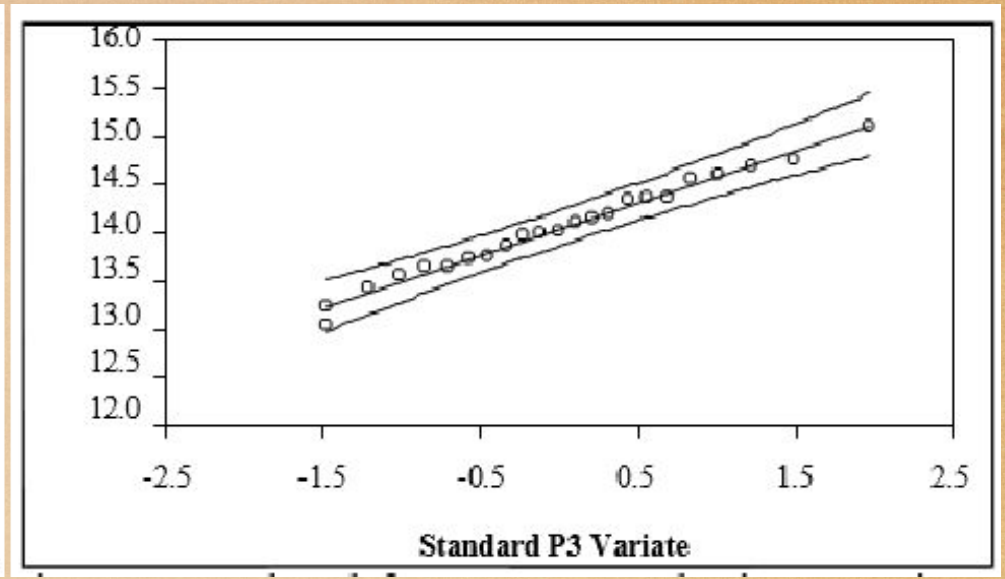
- For selecting best fitted distribution, goodness-of-fit test has been conducted. In the goodness-of-fit test, Probability Plot Correlation Coefficient (PPCC) had been applied.

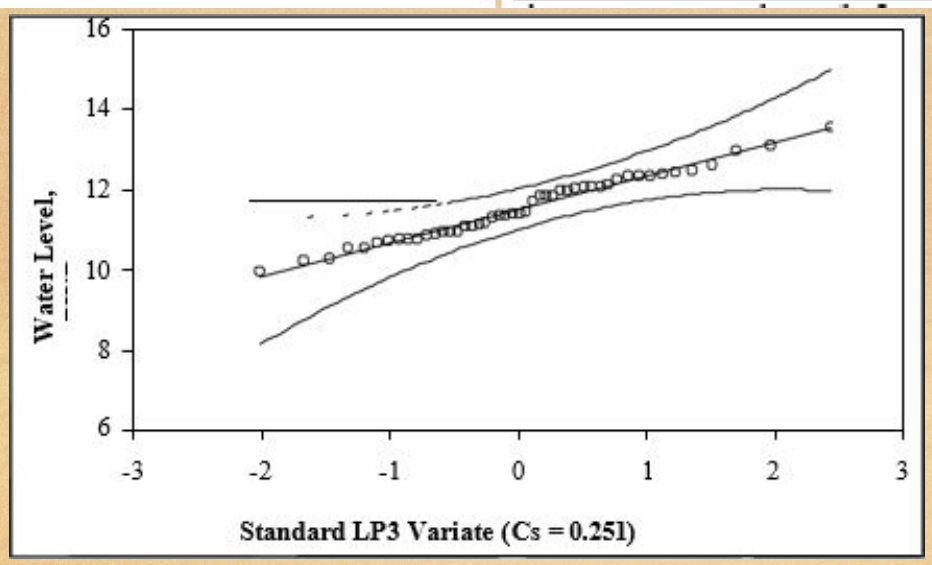
Goodness-of-fit test for selecting most appropriate distribution, SW11

PDF	Return Period						PPCC	Rank
	2.33	5	10	20	50	100		
LN2	13.99	14.89	15.53	16.08	16.37	17.16	0.97801	4
LN3	13.99	14.72	15.18	15.53	15.71	16.14	0.98581	2
P3	13.96	14.72	15.20	15.59	15.79	16.28	0.98593	1
LP3	14.08	14.91	15.44	15.87	16.08	16.62	0.98550	3
EV1	13.69	14.56	15.27	15.96	16.35	17.50	0.94884	5

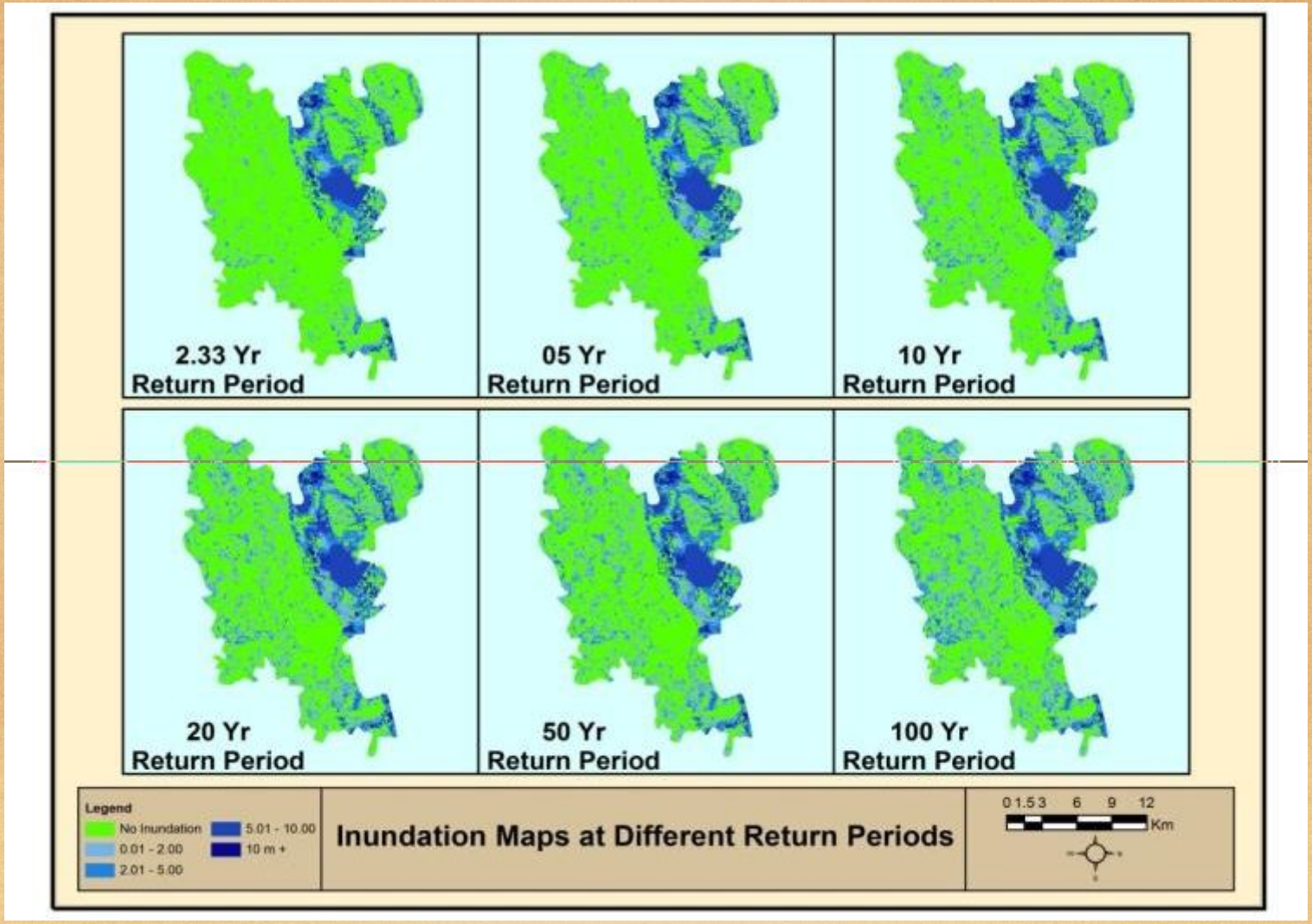
Flood Frequency Analysis



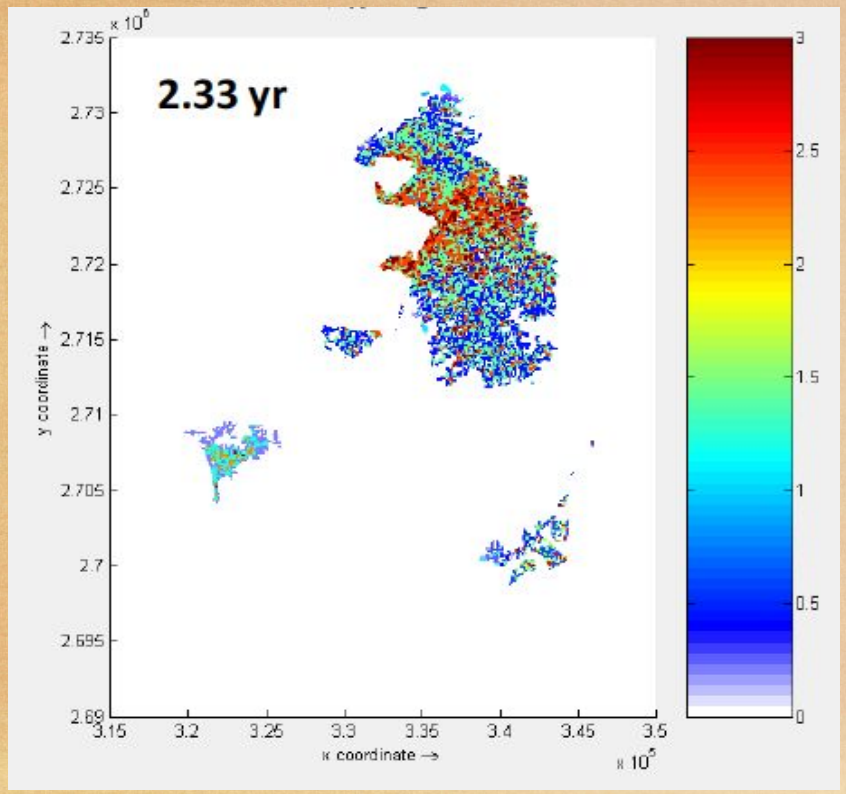


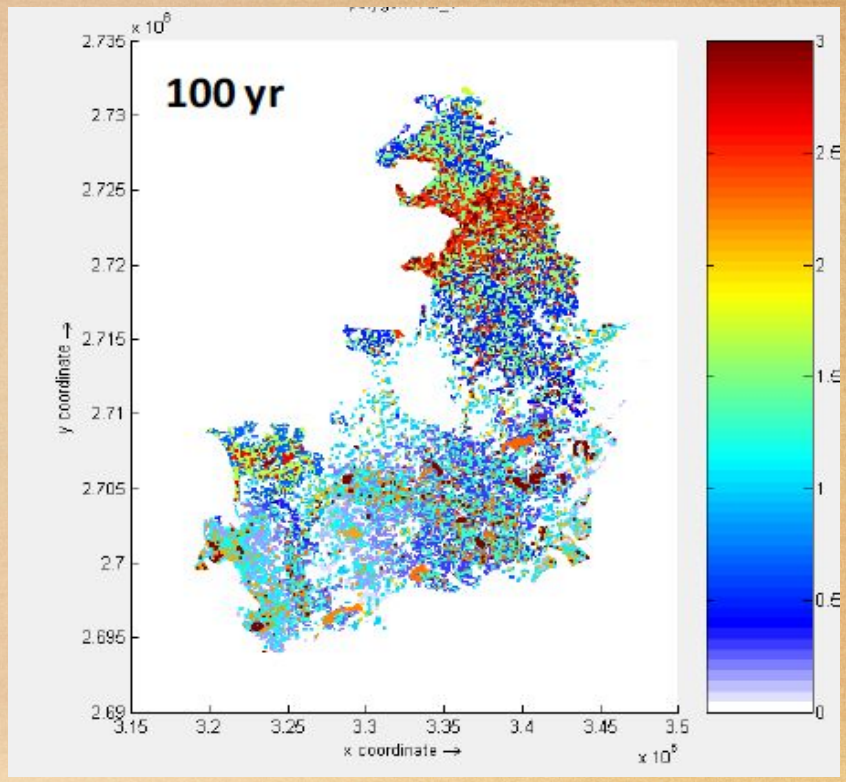


Inundation map at different return period



Inundation map at different return period





Loss/Vulnerability Function

- A stage-damage curve normally relates to a specific class of buildings or crops and presents information on the relationship of flood damage to depth of flooding (or stage).

- For example, crop stage-damage curve has been developed through several field survey are conducted to gathering of crop damage data from actual flood event such as 1988, 1998, 2004 and 2007 the major flood in Sirajganj with respect to flood depth in agriculture land.

Settlement Vulnerability

- Valuation surveys are conducted for the settlement vulnerability assessment.

  Settlement has been classified in four type such as (BB) brick floor-Brick Wall, (BC) Brick floor-CI Sheet wall, (MC) Mud floor CI Sheet wall, (MM) Mud floor Mud(wall).

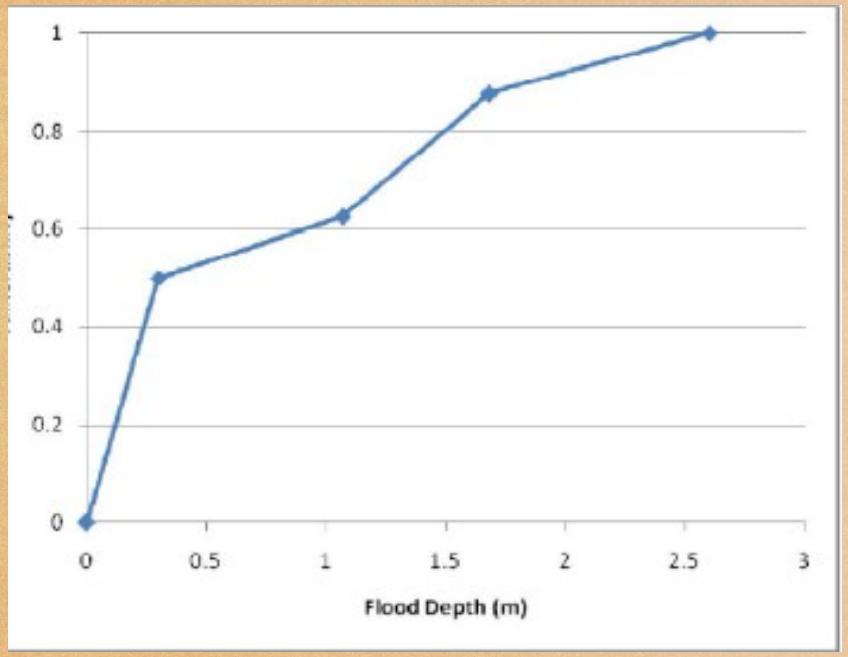
Settlement Vulnerability

- For the selected properties the surveyor quantifies the damage of all items due to flood and their current value based on type, quality and degree of wear. The survey included information on the height above the floor of each item or the heights can be taken as standard from house to house. The information for all samples of each element class is then averaged and stage-damage curves constructed. In the crop stage-damage curve and settlement stage- damage curve vulnerability has been scale 0 to 1.

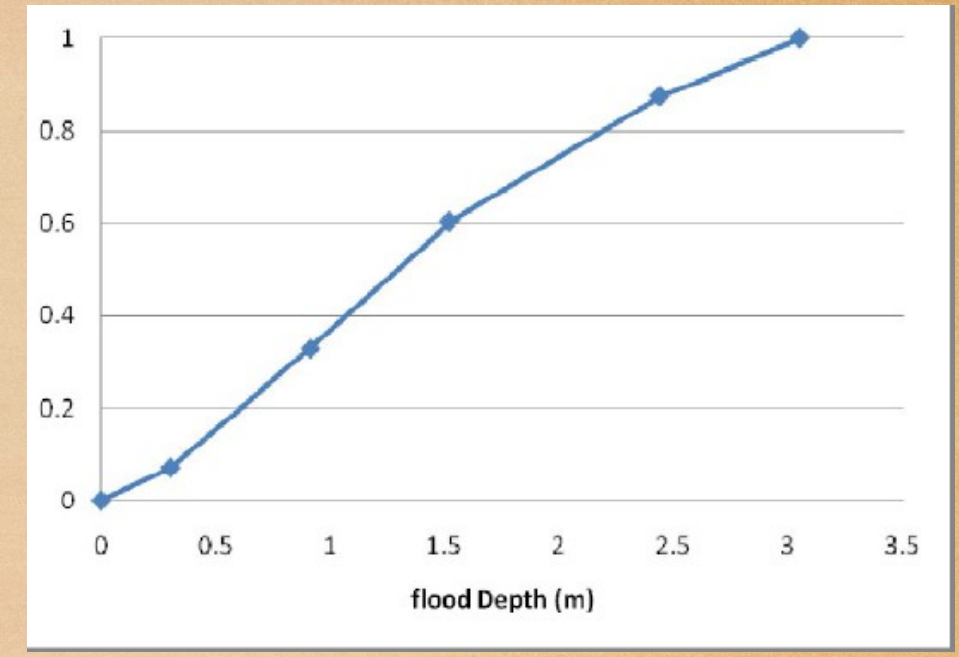
Settlement Vulnerability

- Zero (0) indicates there is no damage, 0.5 vulnerability indicates 50 percent damage and 1.0 vulnerability indicate 100 percent damage of crops and settlements

Normalized Depth-Damage Curve



agriculture



settlement

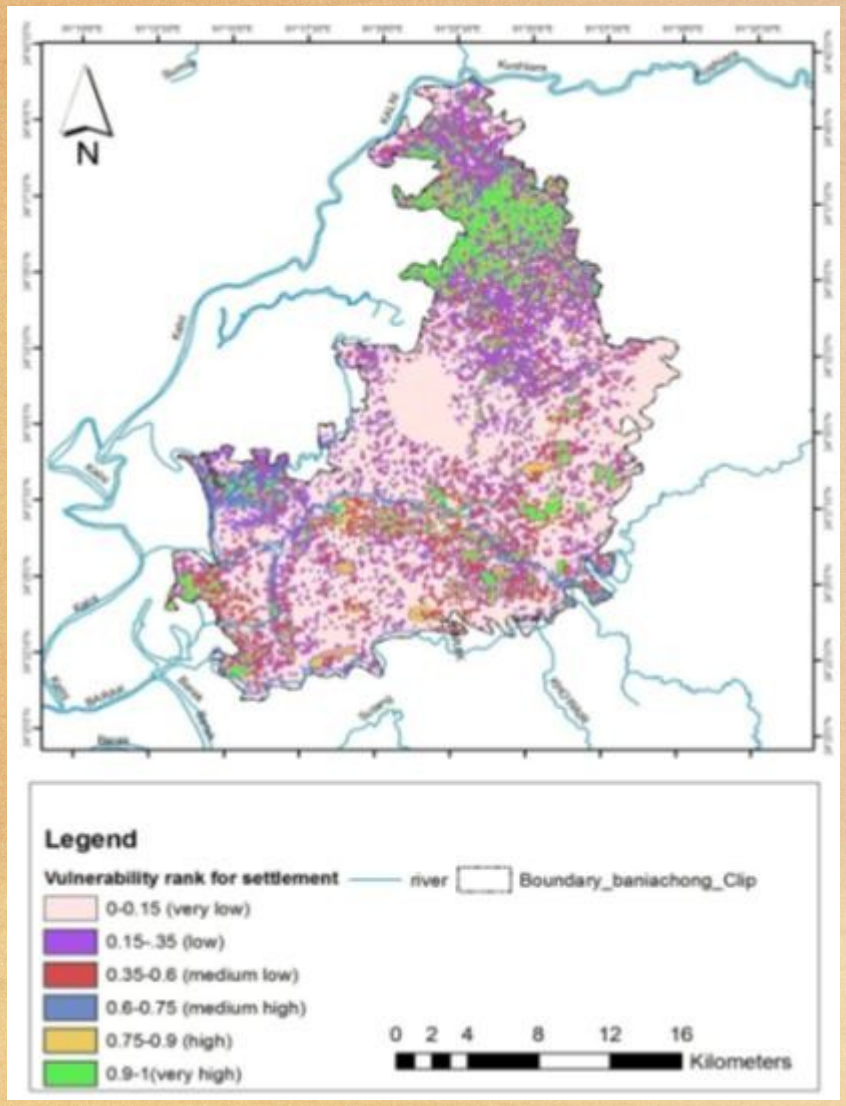
Crop Vulnerability Classification

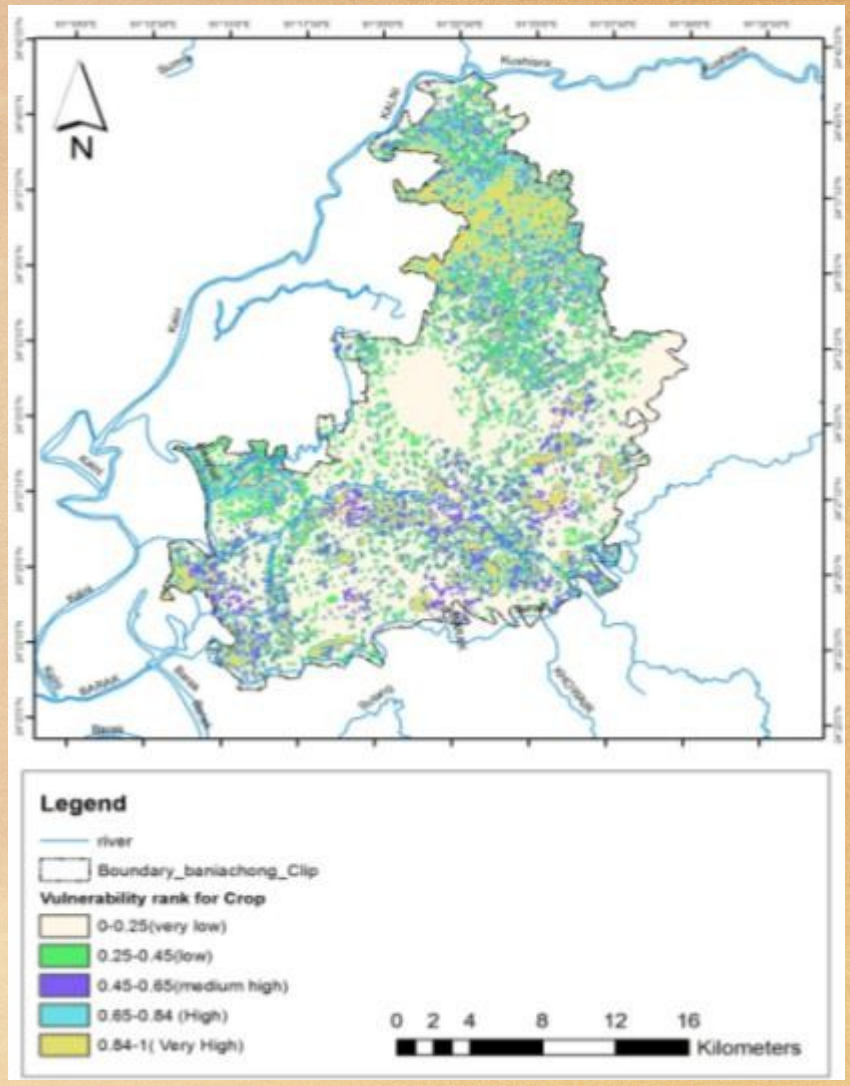
Return Period	Classification	Flood Depth Range(m)	Vulnerability
100yr, 20yr & 2.33yr	Very Low vulnerable	0 – 0.5	**0.50**
	Low vulnerable	0.5 – 1.0	**0.60**
	Moderate vulnerable	1.0 – 1.5	**0.70**
	High Vulnerable	1.5 – 2.25	**0.90**
	Very high vulnerable	2.25-2.75	**1.00**

Settlement Vulnerability Classification

Return Period	Classification	Flood Depth Range(m)	Vulnerability
100yr, 20yr & 2.33yr	Very Low vulnerable	0 - .10	0.10
	Low vulnerable	.10 – 1.0	0.30
	Moderate vulnerable	1.0 – 1.5	0.60
	High Vulnerable	1.5 – 2.0	0.70
	Very high vulnerable	2 – 3.0	1.00

Vulnerability Maps





Case Study: 2

Damage Assessment for flooding in Southwest Zone

References

Tingsanchali, T and Karim, M. F., 2005, Flood Hazard and Risk Analysis in the Southwest Region of Bangladesh, Hydrological Processes, Vol. 19, pp. 2055- 2069

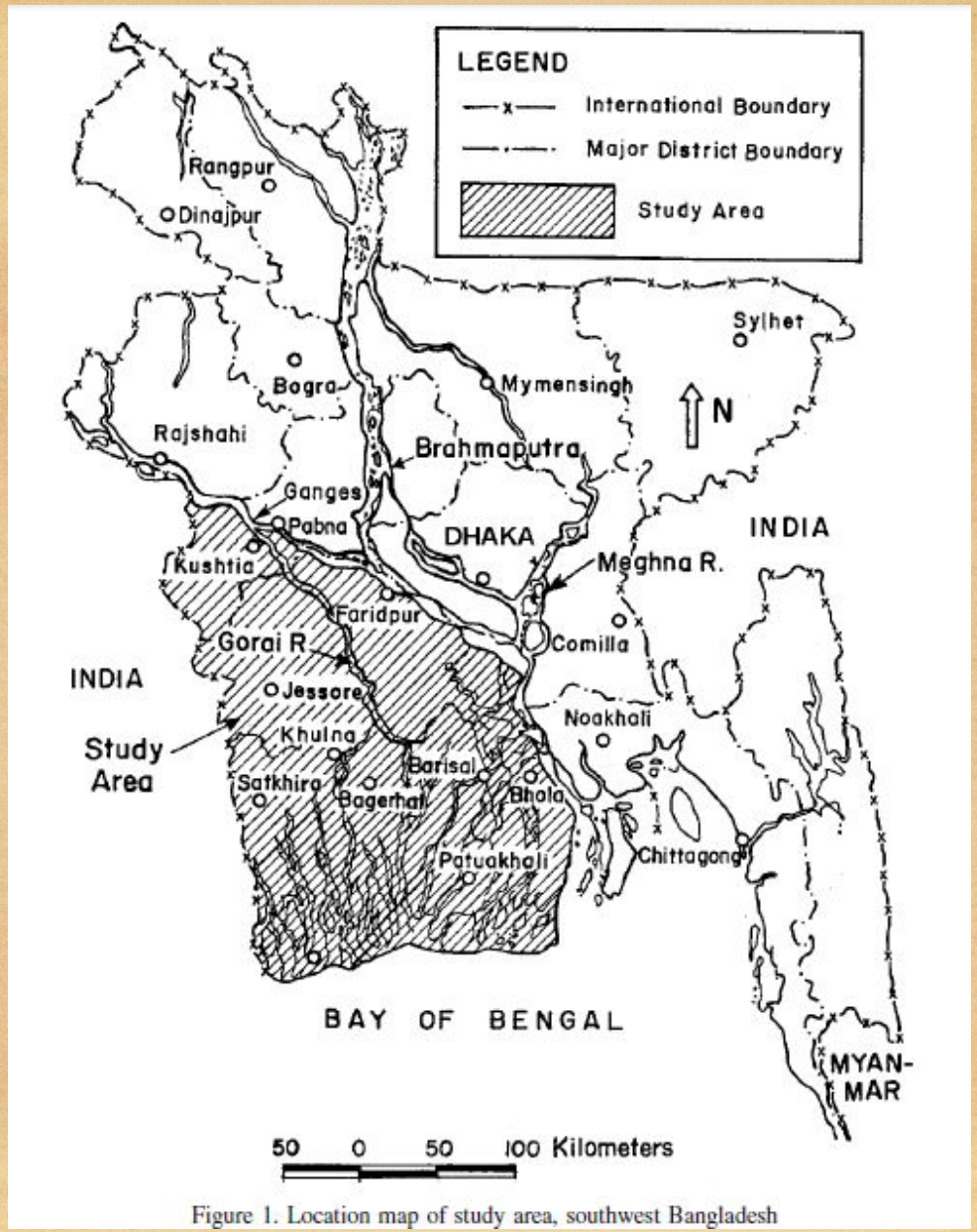


Figure 1. Location map of study area, southwest Bangladesh

Study Area

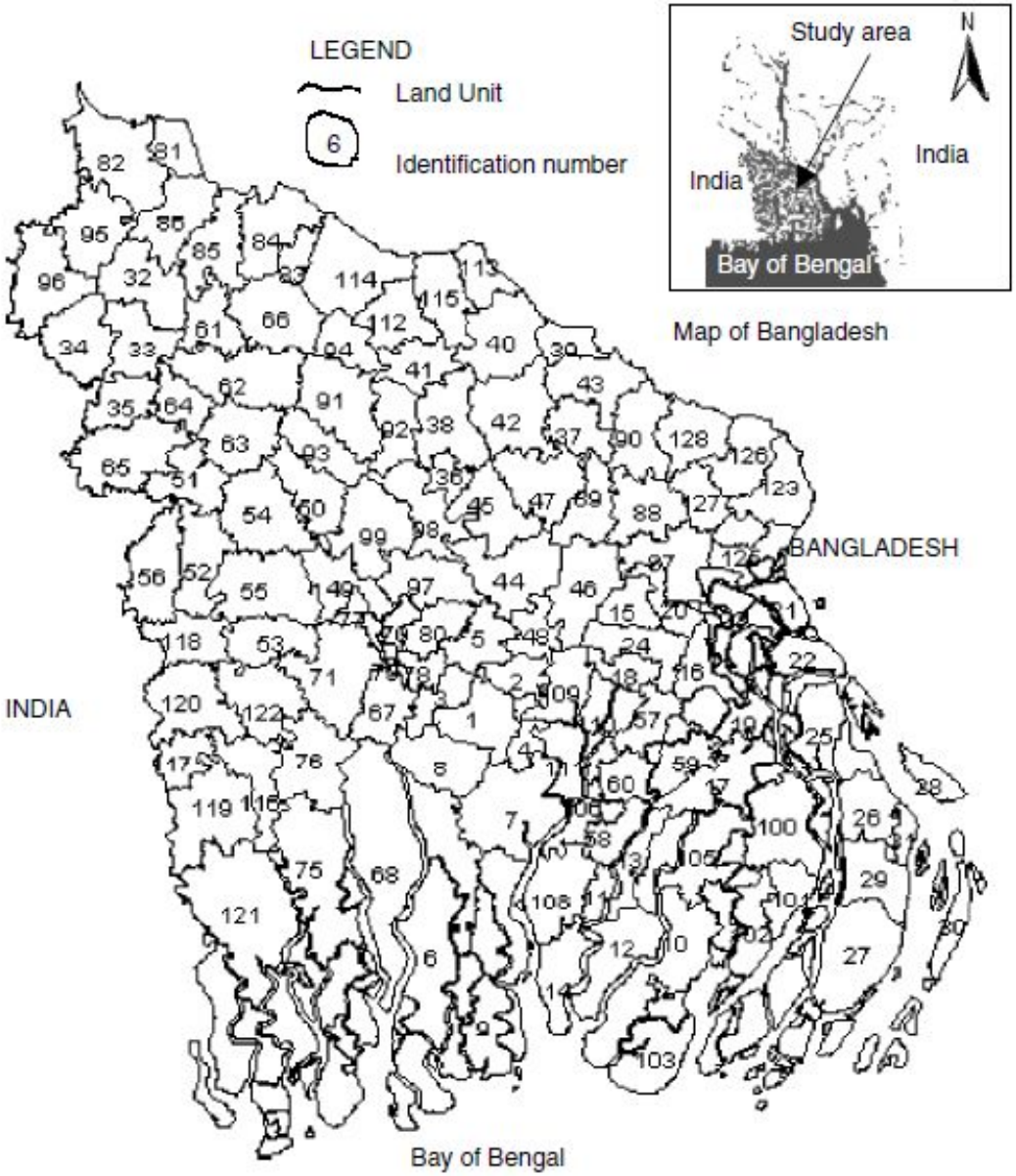


Figure 2. Study area and identification numbers of land units

Study Area

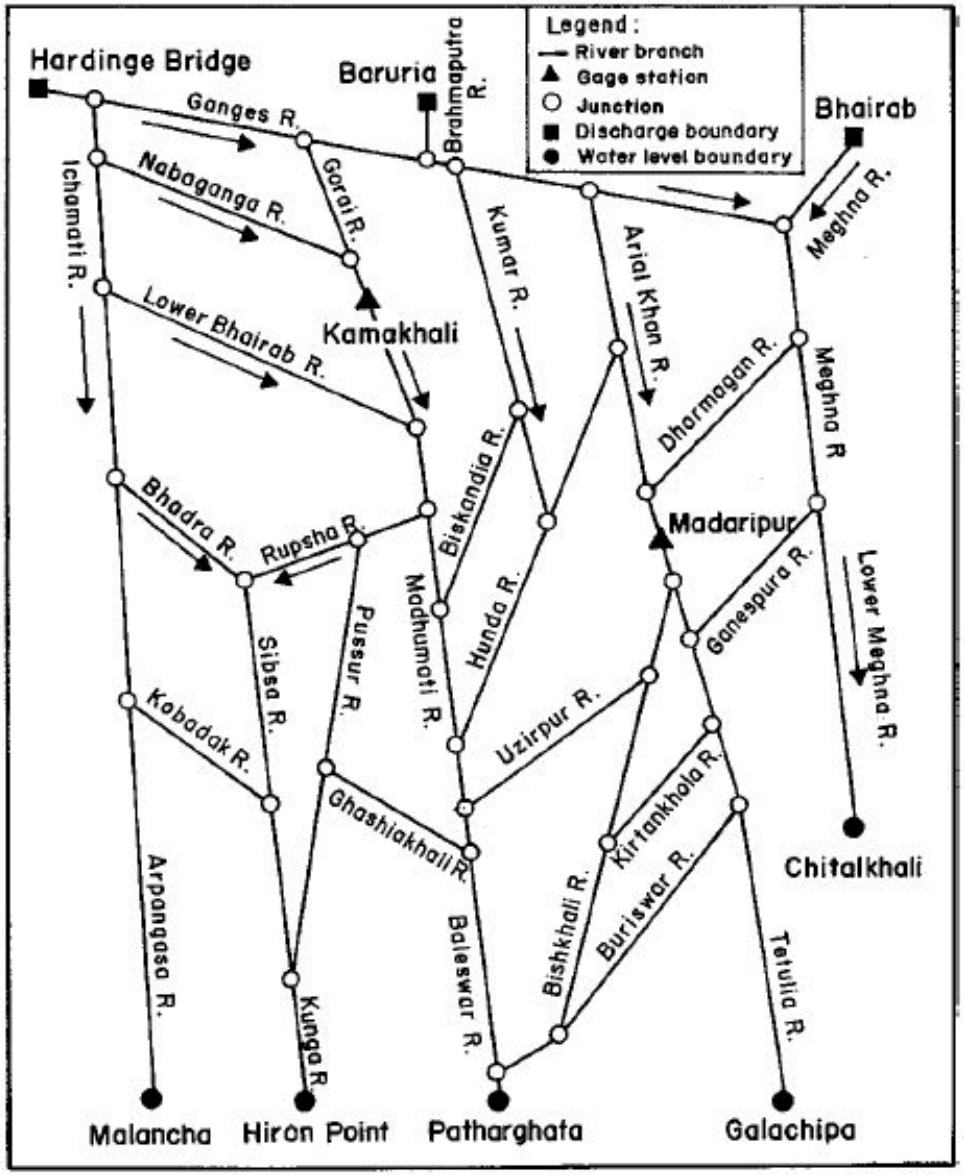
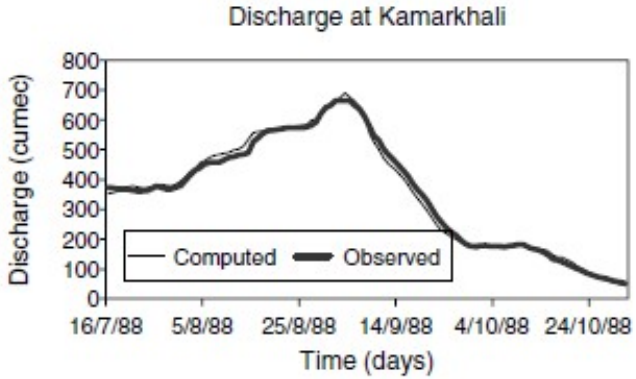
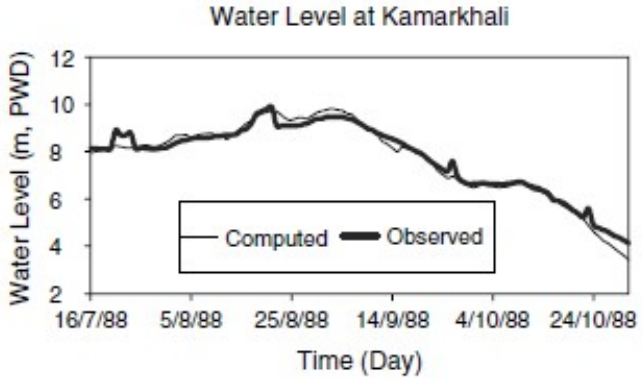


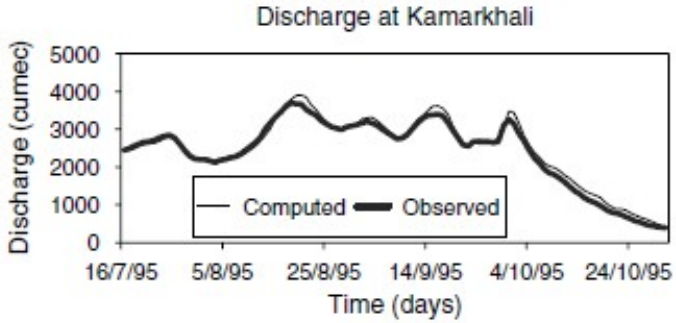
Figure 3. Major rivers and river junctions with boundary and gauging stations

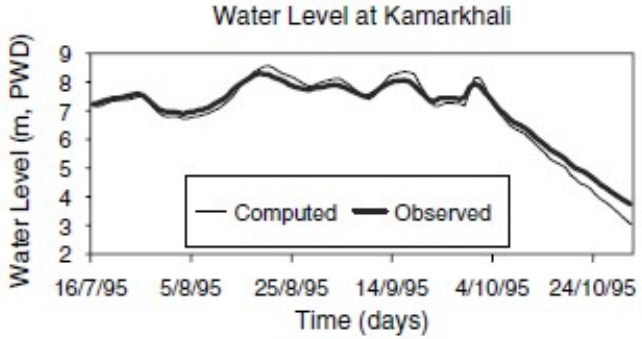
River Network



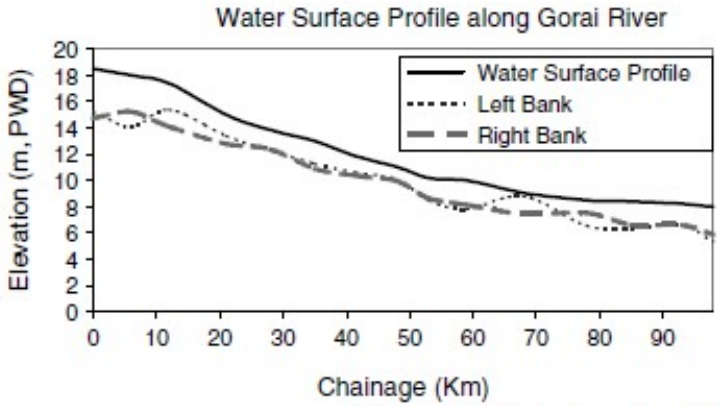


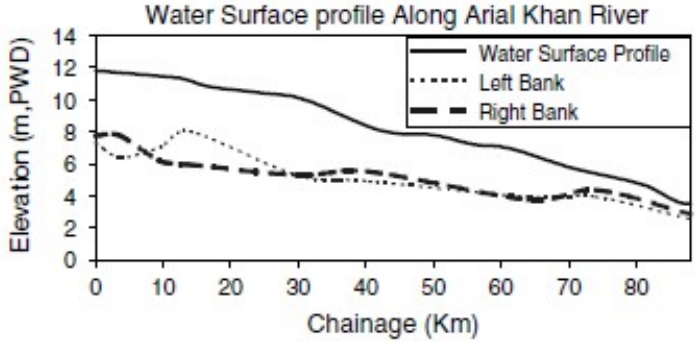
(a) Model calibration





(b) Model verification





(c) Computed envelope of maximum water surface profiles for 100-year flood

Calibration and Validation

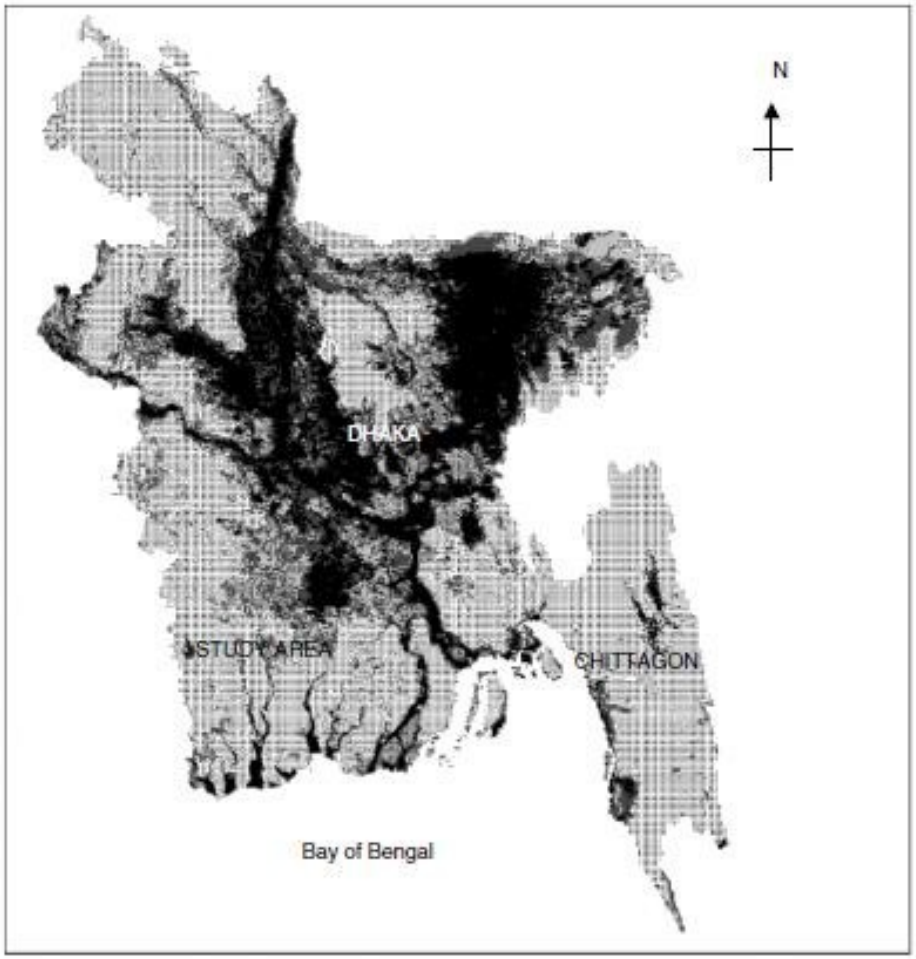


Figure 5. Satellite-based flooding duration map for 1988 flood (based on Islam and Sado, 2000)

Inundation map

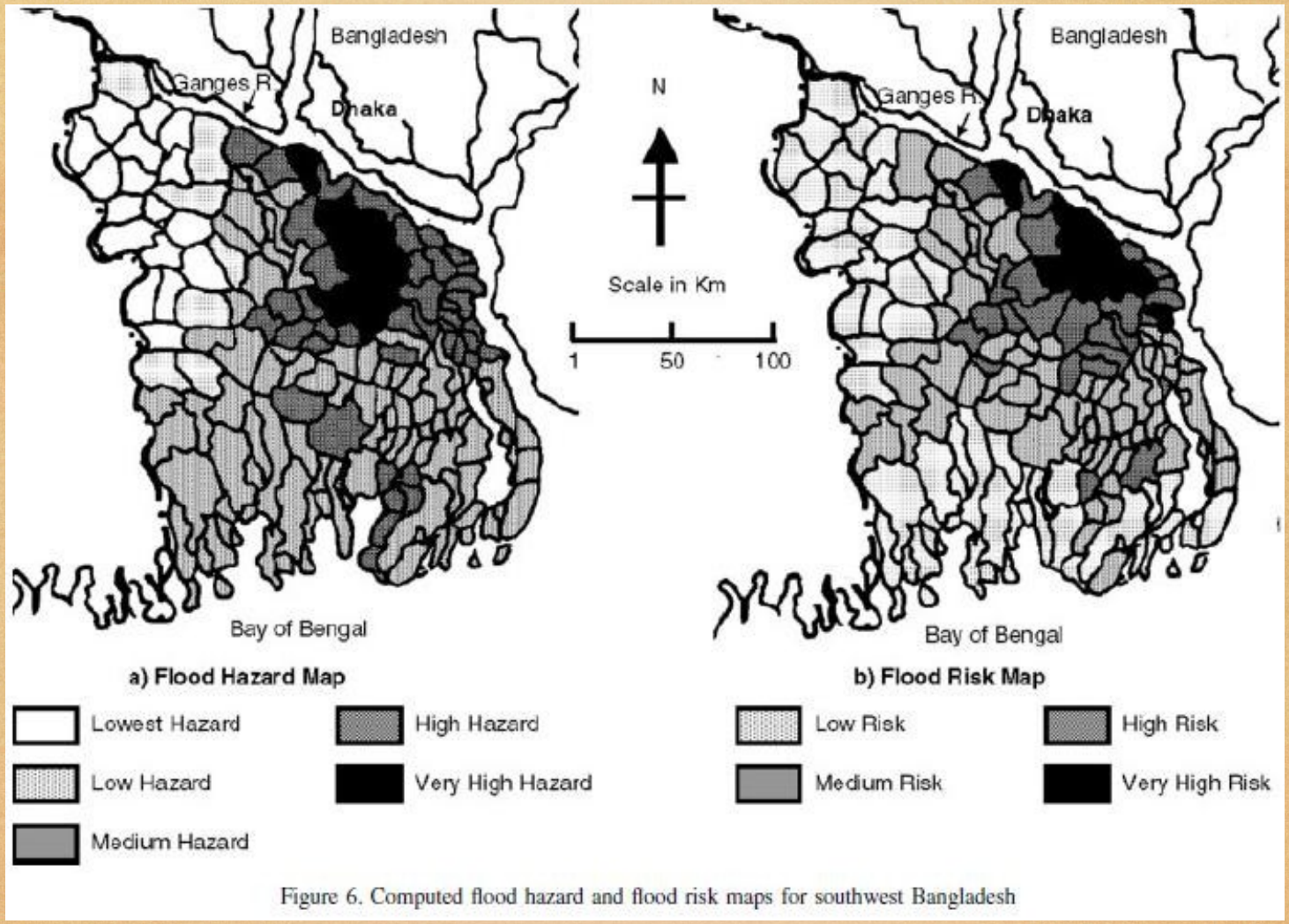


Figure 6. Computed flood hazard and flood risk maps for southwest Bangladesh

Hazard Map and Risk Map