9th Urban Drainage Modeling Conference
Belgrade
September 2012

Historical Development of Hydroinformatics Tools in Bangladesh

&

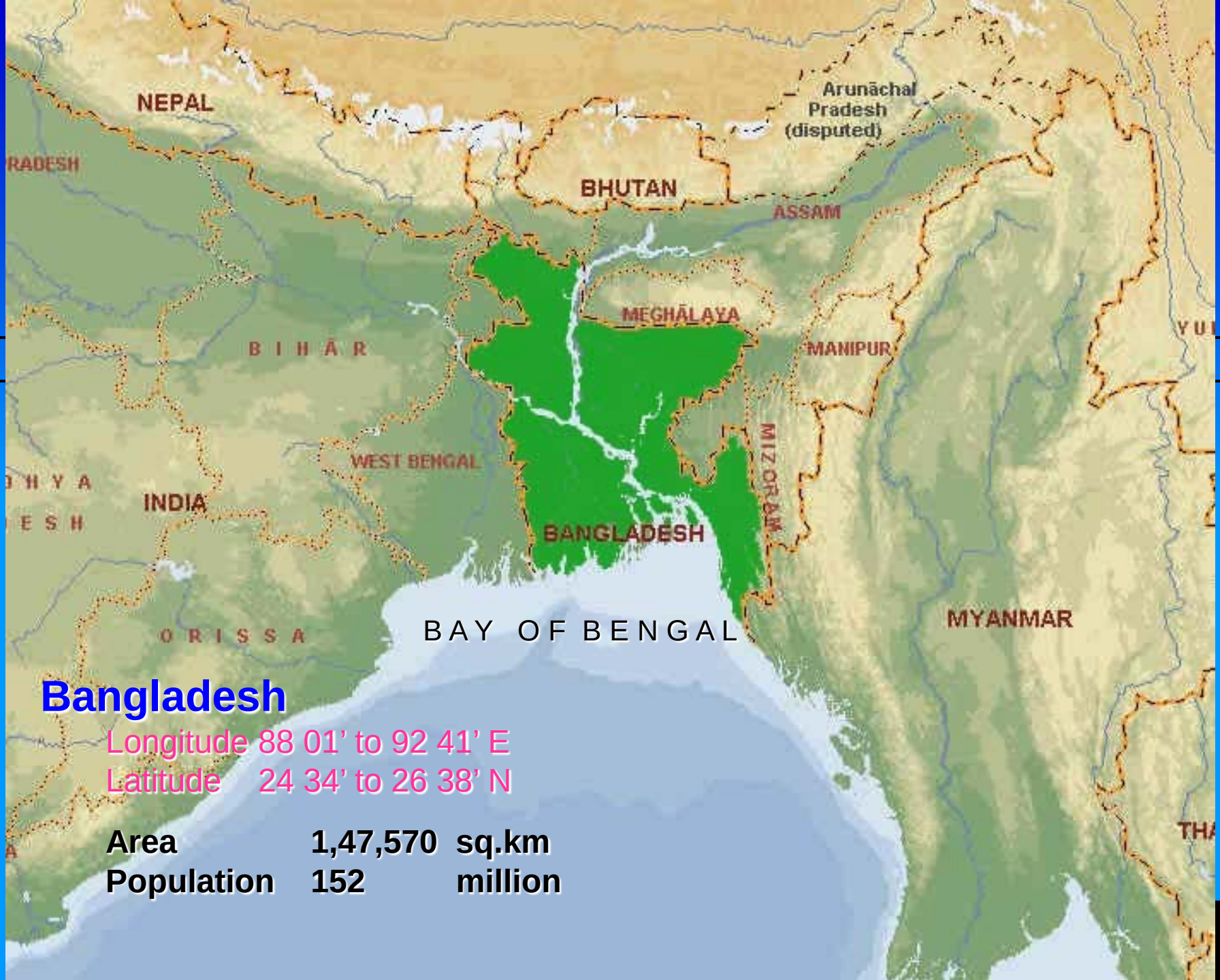
Challenges and state-of-the-art in Urban Drainage Modelling

David Mohammed Khan

INSTITUTE OF WATER MODELLING
I W M
Bangladesh

Outline

- Background on Bangladesh
- History of hydroinformatics
- Urban drainage modeling



Bangladesh

Longitude 88 01’ to 92 41’ E
Latitude 24 34’ to 26 38’ N

Area	**1,47,570**	**sq.km**
Population	**152**	**million**

- **River System :**

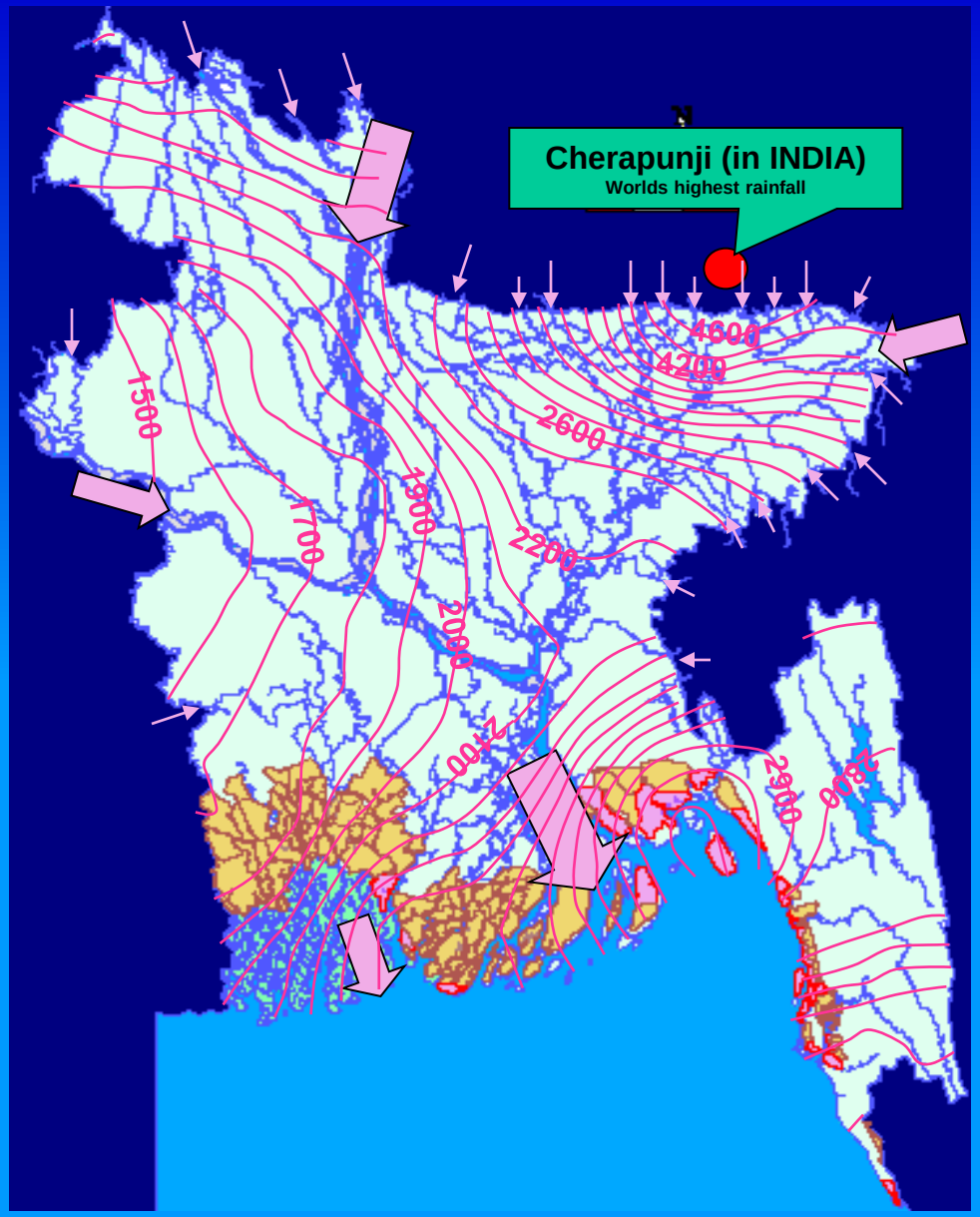
  24,000 km

- **Annual Average Rainfall:**

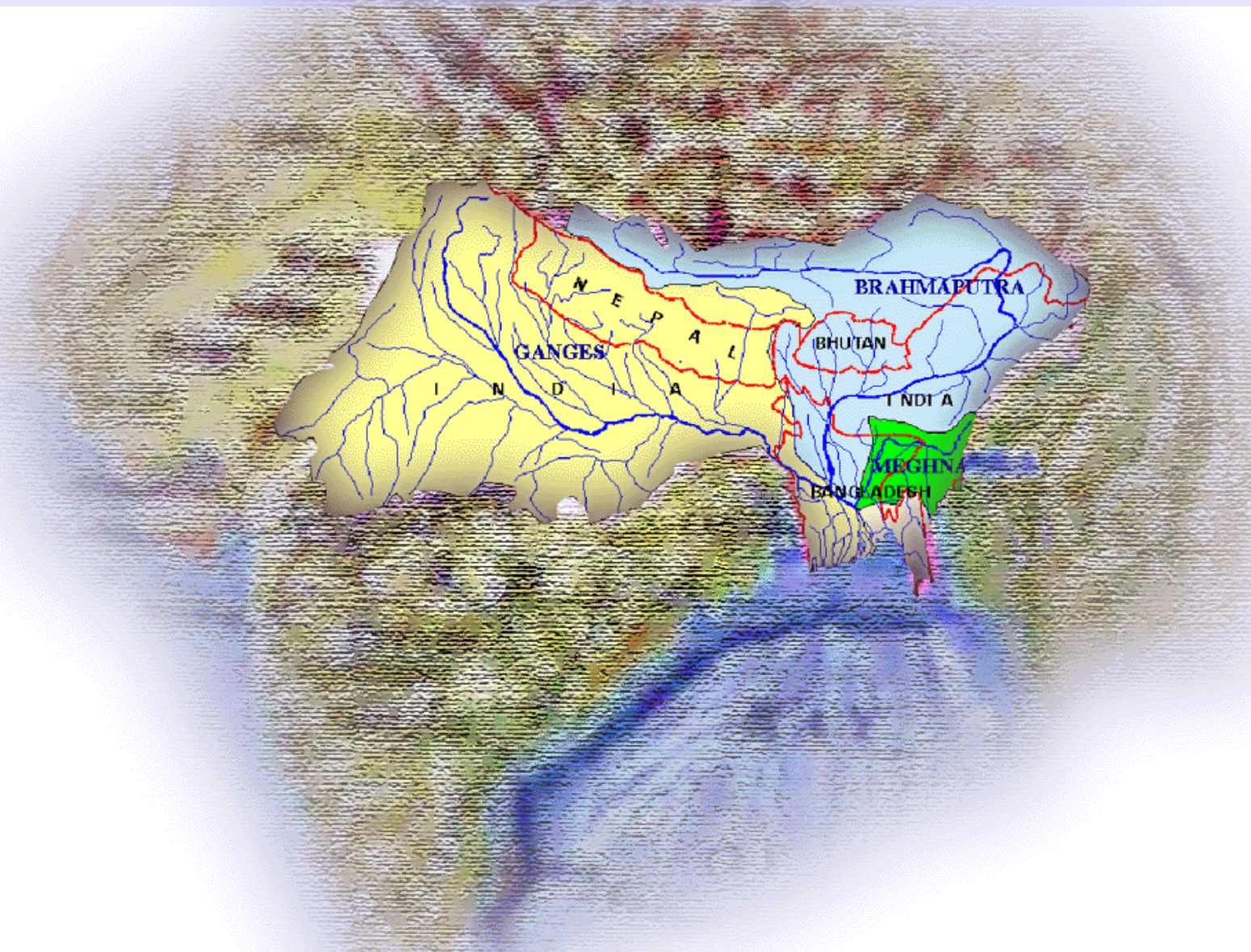
  2300 mm

- **Trans-boundary Flow:**

  57 rivers



- Around 1200 BCM flow passes through the country
- 92% flow originates from catchments in India, Nepal, Bhutan & China
- GBM basins area: 1.72 Mkm^2



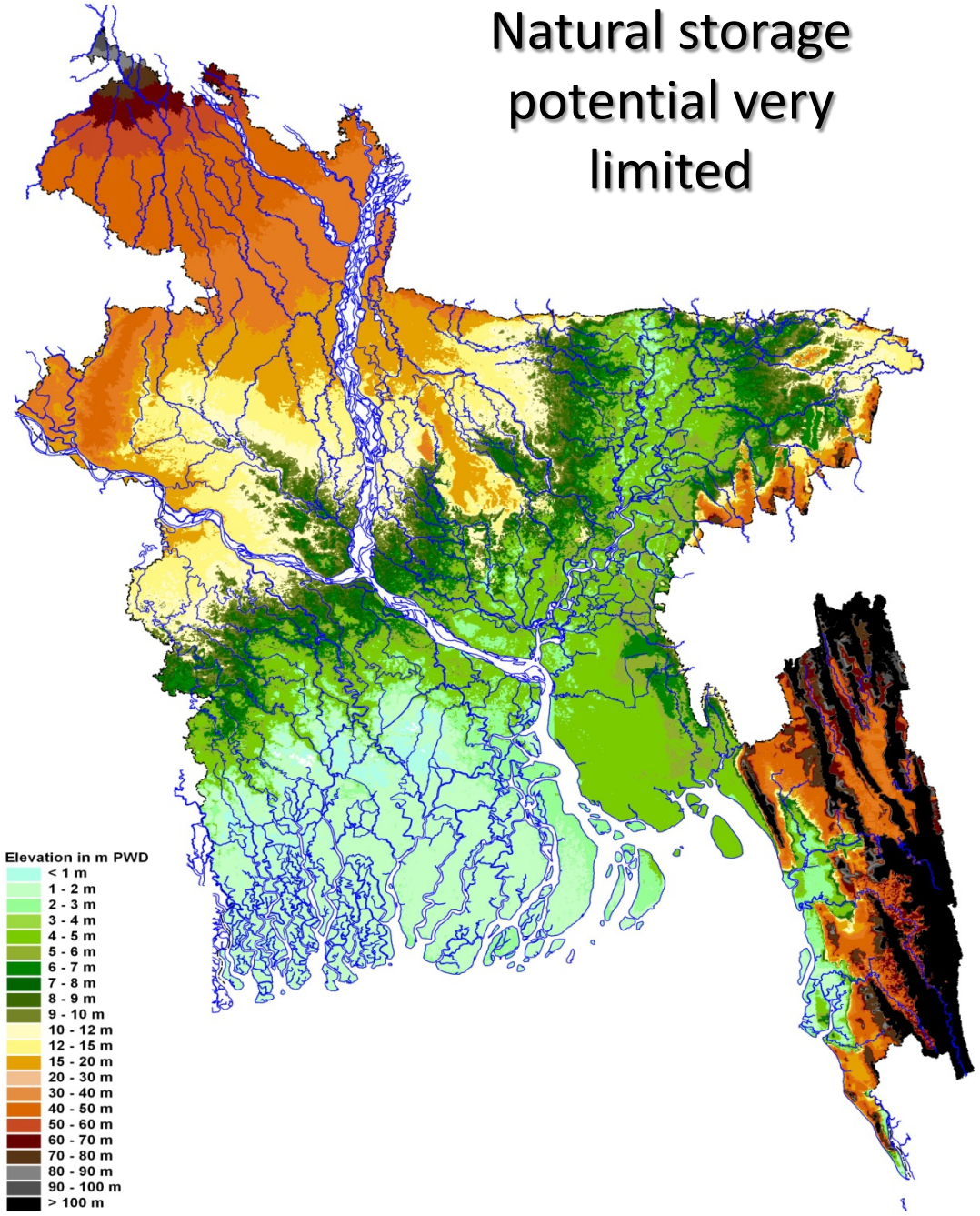
The Ganges, the Brahmaputra & the Meghna Basins

Wide variation of seasonal flow

Basin	Average Dry season (Nov-Apr) flow (appx) (MCM)	Average wet season (Jun-Oct) flow (appx) (MCM)	Average annual flow (appx) (MCM)
Ganges	45,000	320,000	365,000
Brahmaputra	105,000	490,000	340,000
Meghna	24,000	170,000	195,000

approx 12% flow during Nov-Apr and 85% during Jun to Oct

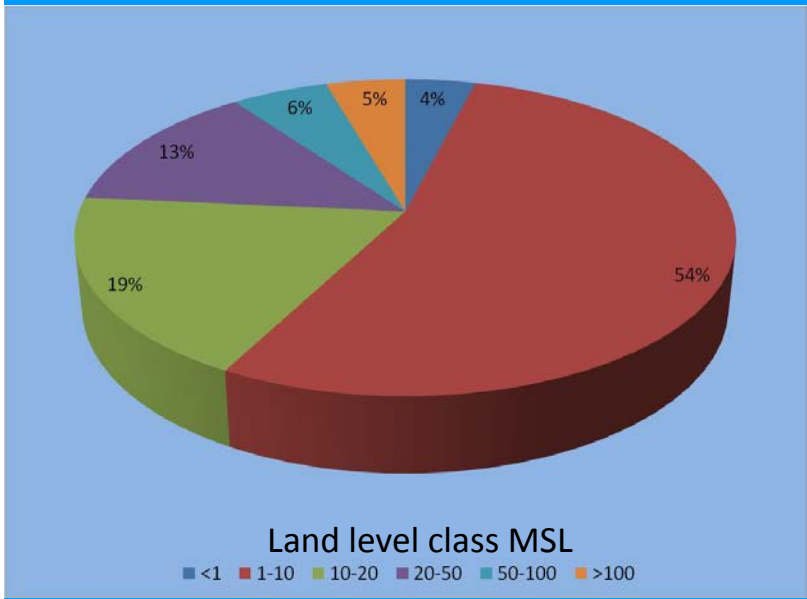
Natural storage potential very limited



Topography of Bangladesh is generally flat

80% area below 20 MSL

5% area above 100 MSL




Too little water


Too much water

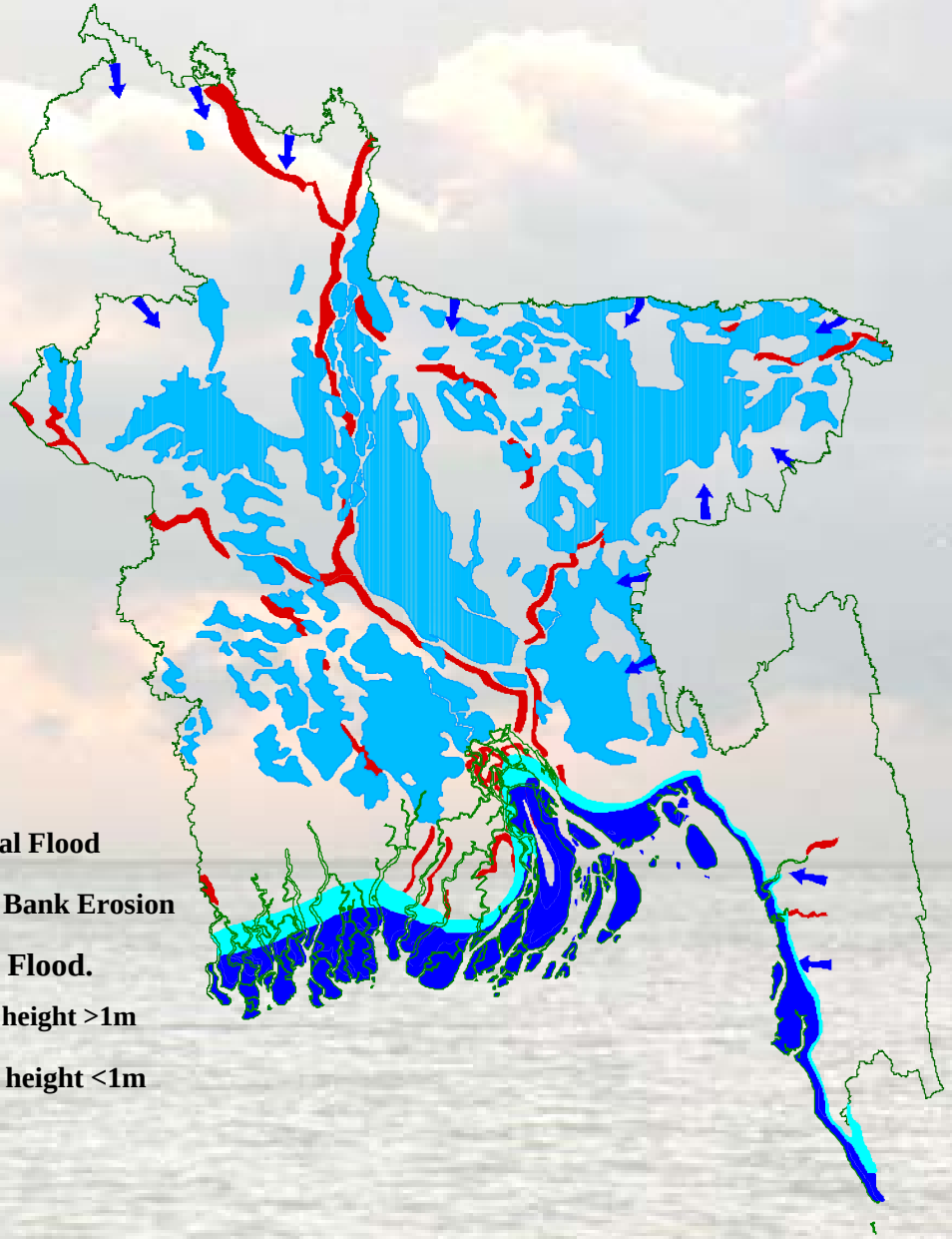

Degrading
environment

- Too much water
  - 22% area inundate by flood in a normal year
  - More than 60% inundated in 1988, 1998 & 2004
- Too little water
  - Bangladesh suffers from water scarcity in dry season;
  - Extensive areas require supplementary irrigation for crops in the monsoon
- Degrading environment
  - Nearly 38 million people in the southwest region of the country under threat
  - Saline water intrusion from the sea
  - Decline in freshwater flow

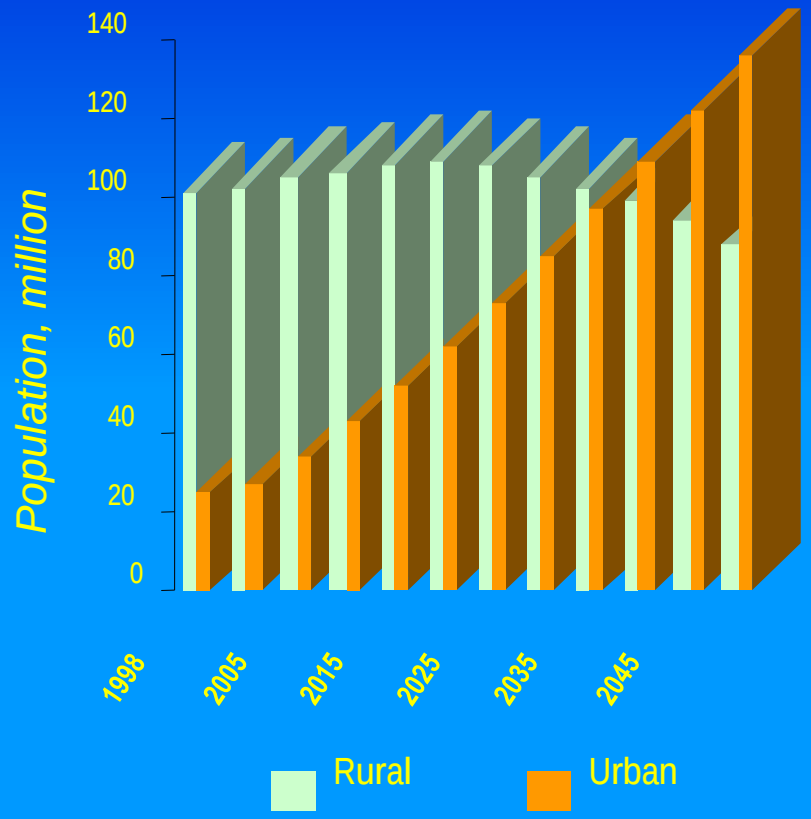
Large flood prone area

River bank erosion a major problem

Susceptible to storm surge

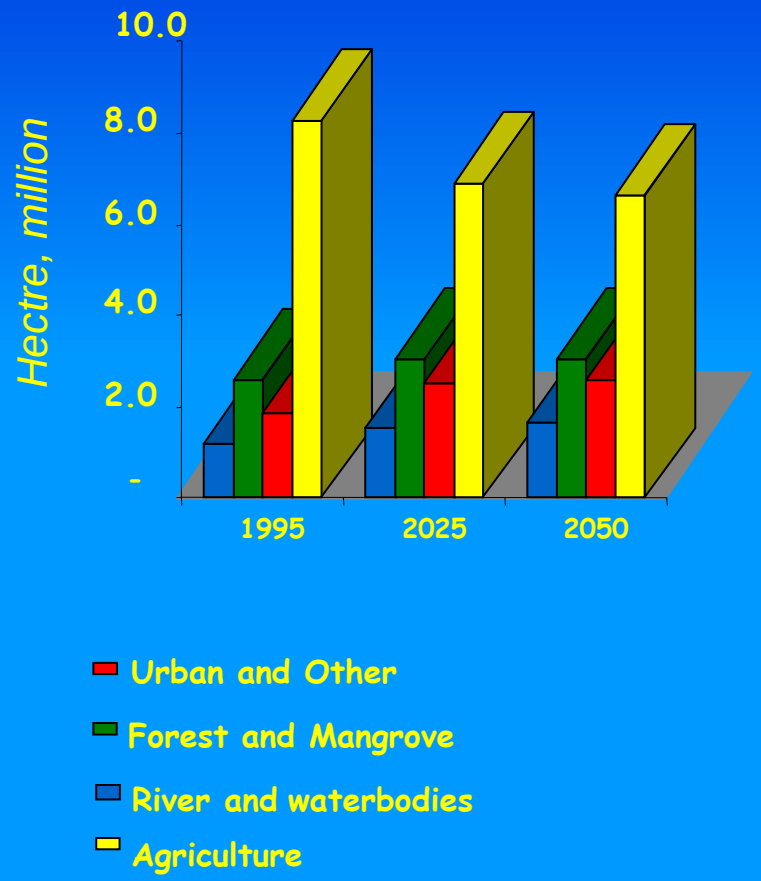


Driving Forces Determining the Future State of Water Resources



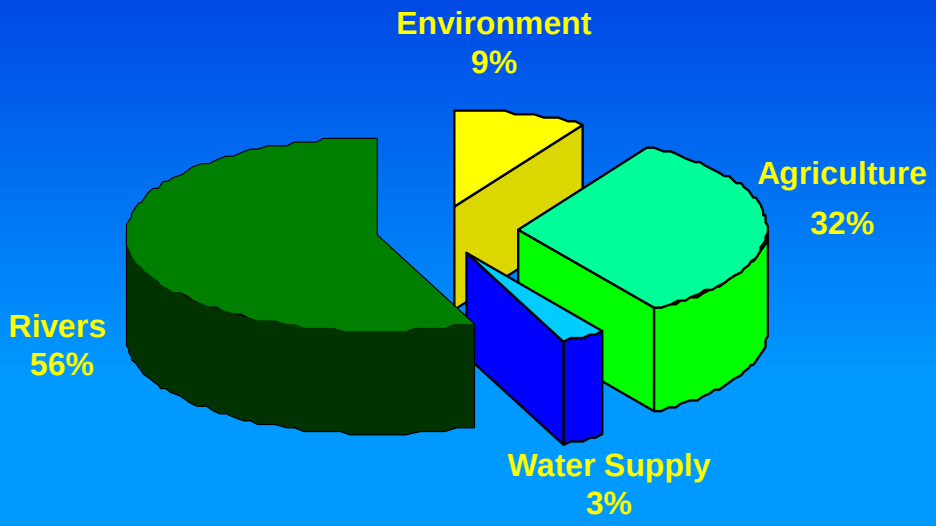
- Total population will increase from 152 million to 181 million by 2025,
- 224 million by 2050.
- Increase of food production will be the main challenge

Driving Forces Determining the Future State of Water Resources



- Urban population will increase to 73 million by 2025
- 136 million by 2050.
- Water supply and sanitation problems will be major issue

Driving Forces Determining the Future State of Water Resources



Water demand in 2025

- The two main sources of water
- Trans-boundary inflows from the Brahmaputra, Ganges and Meghna rivers
- Ground water which is exploitable over 56% of the country,
- Conjunctive use of surface water and groundwater will be required to meet the demand

Climate Change

More Frequent and Intense Rainfall

Increased intensity of urban and river flooding

Warmer climate

Change in vegetation of waters
Altered recharge of aquifer
Increased water demand
Increased drawdown due to m

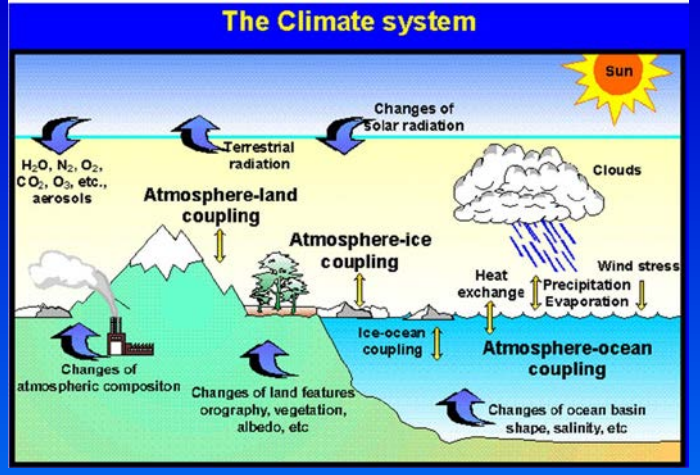
Sea level rise

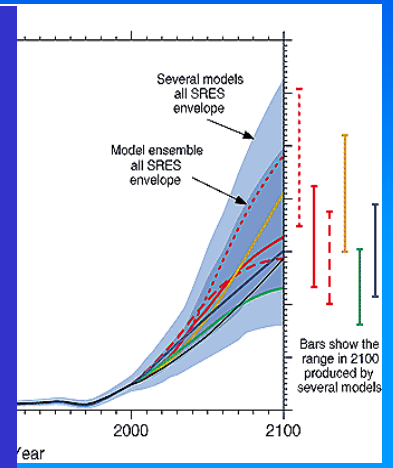
Increased salinity intrusion in s
Drainage constraints in poldere

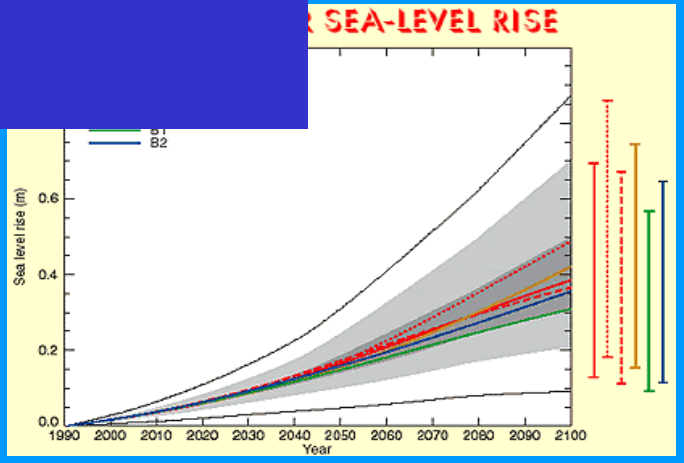
Warmer SS & Sea level rise

Increased intensity and frequen
increase of risk of urban utilities

Bangladesh is one of the most vulnerable countries in the world





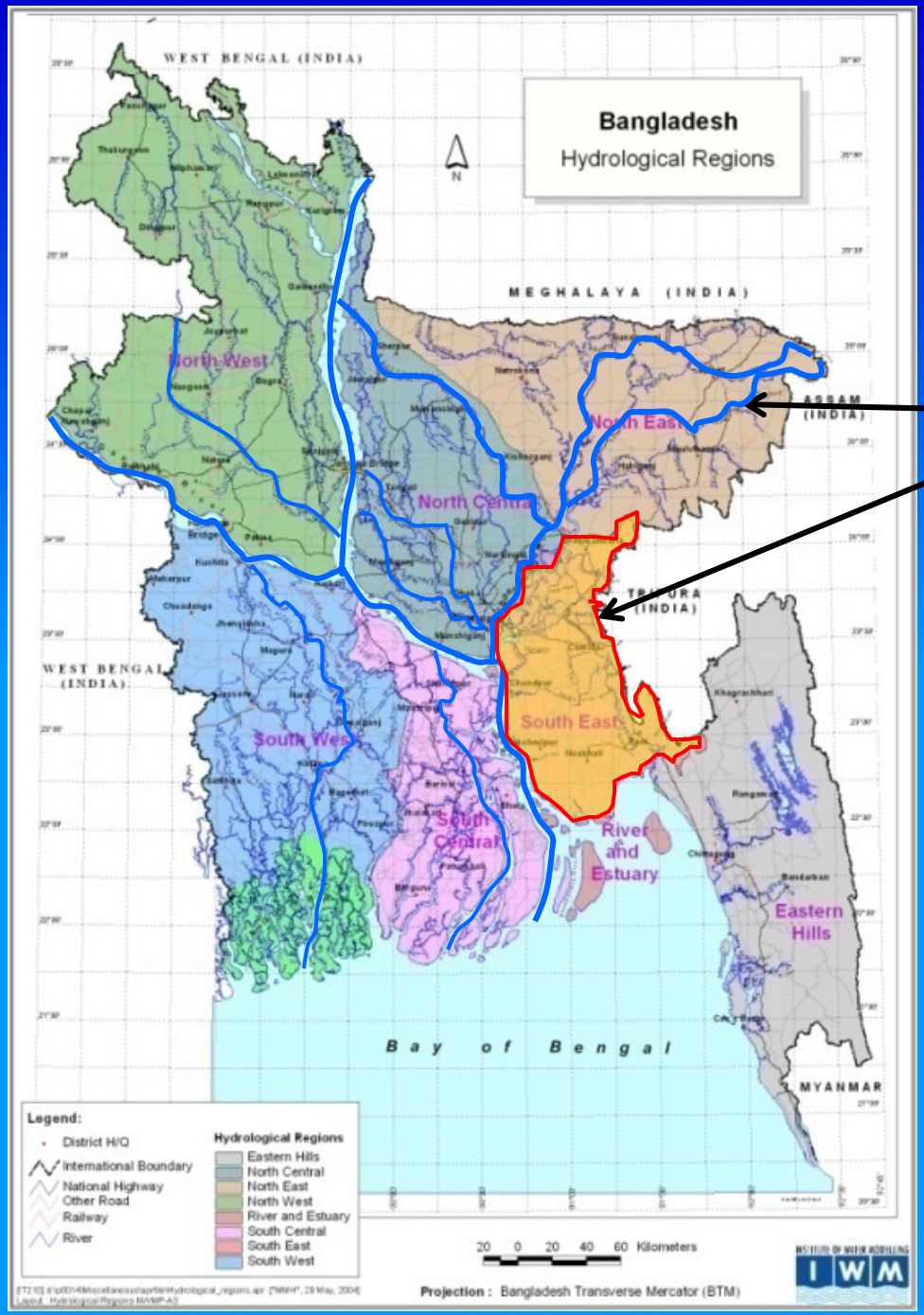


Milestones

- National Water Plan 1, 1986
- Surface Water Simulation Modelling Programme Phase I, 1986-1989
- National Water Plan 2, 1988-1991
- Flood Action Plan, 1989-95
- Surface Water Simulation Modelling Programme Phase II, 1990-1993
- Surface Water Simulation Modelling Programme Phase III, 1994-1996
- Surface Water Modelling Centre Trust, 1996
- National Water Policy, 1998
- National Water Management Plan, 2002
- Institute of Water Modelling (IWM), 2002

Historical development of hydroinformatics tools in Bangladesh

1986 – 1989	1990 – 1993	1994 – 1996	1997 – 2001	2002 – To Date
SWSMP - I	SWSMP - II	SWSMP - III	SWMC TRUST	IWM TRUST
Support to National Water Plan	Support to Flood Action Plan	Commercial Applications, Environment, WR Management, Urban drainage management	Command Area Development Coastal Zone Management Port & Estuary management Groundwater management National Water Mngt Plan Roads & Highways Large River Crossings	Climate change Urban water management Water supply & sanitation Land reclamation
Basic GUI & CLI	**GUI on top of MS DOS**	**Model-GIS interface**	**Animation tools Advanced GUI**	**Neural Networks DSS Process models << >> Impact models GSM & WAP applications**
1D River Model GM and SERM	1D Morphological & Salinity Model	WQ, GW, UD 2D Hydrodynamic Model	Institutionalization – self sustaining, non-profit Trust organization	River basin, WD Modelling Sewerage system modelling, River erosion forecasting, storm surge forecasting modelling, Climate change impact modelling
	All regional Models SWRM, NWRM, NERM, NCRM, EHRM	Flood forecast modelling	2D Hydrodynamic, Morphological & Salinity Model of Bay of Bengal	Regional training, HRD, R&D
			2D Curvilinear Hydrodynamic model of Major Rivers	
			Advanced Survey & Monitoring	

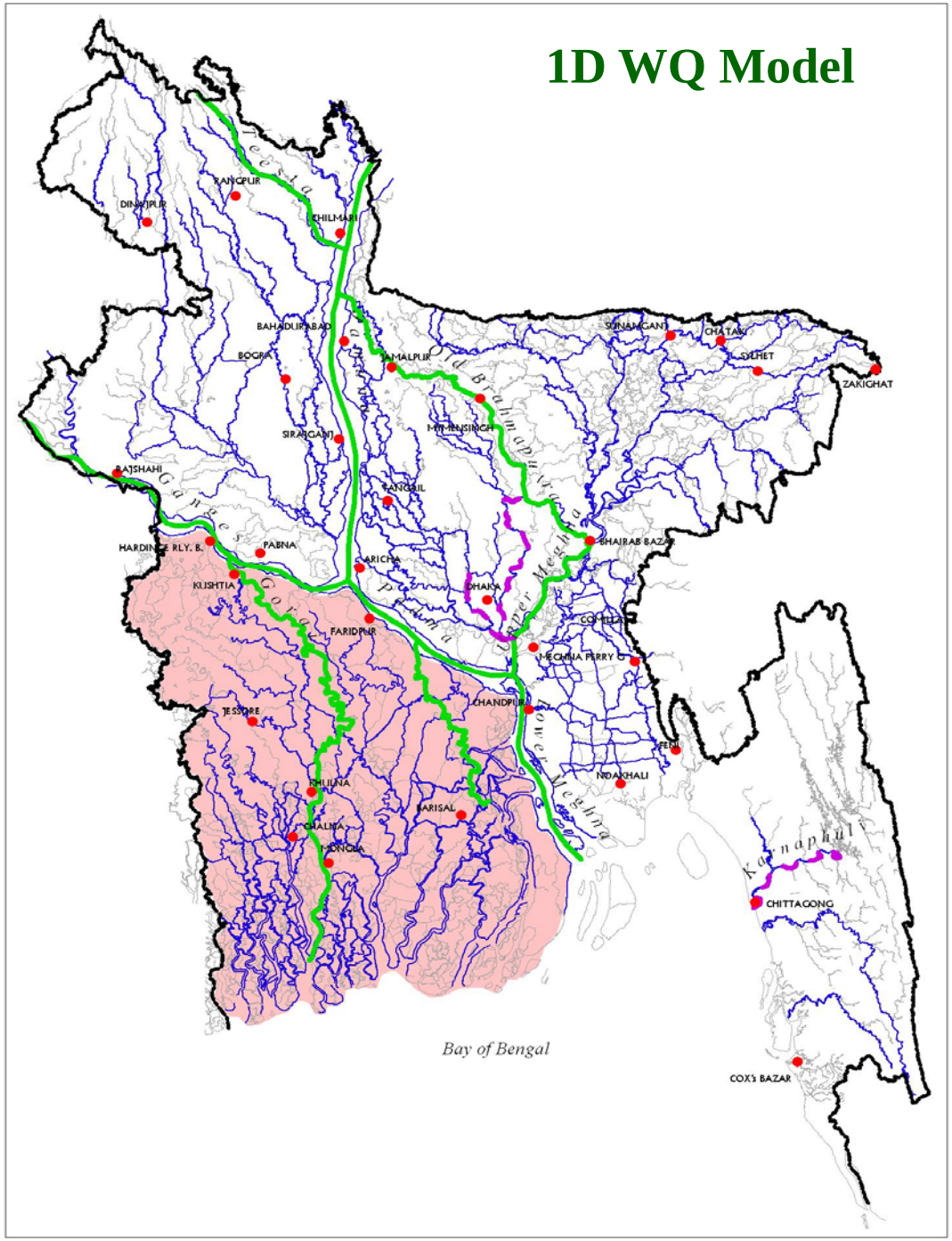


1986-89

General Model of Large Rivers

Detail Southeast Region Model

1-dimensional hydrodynamic modelling

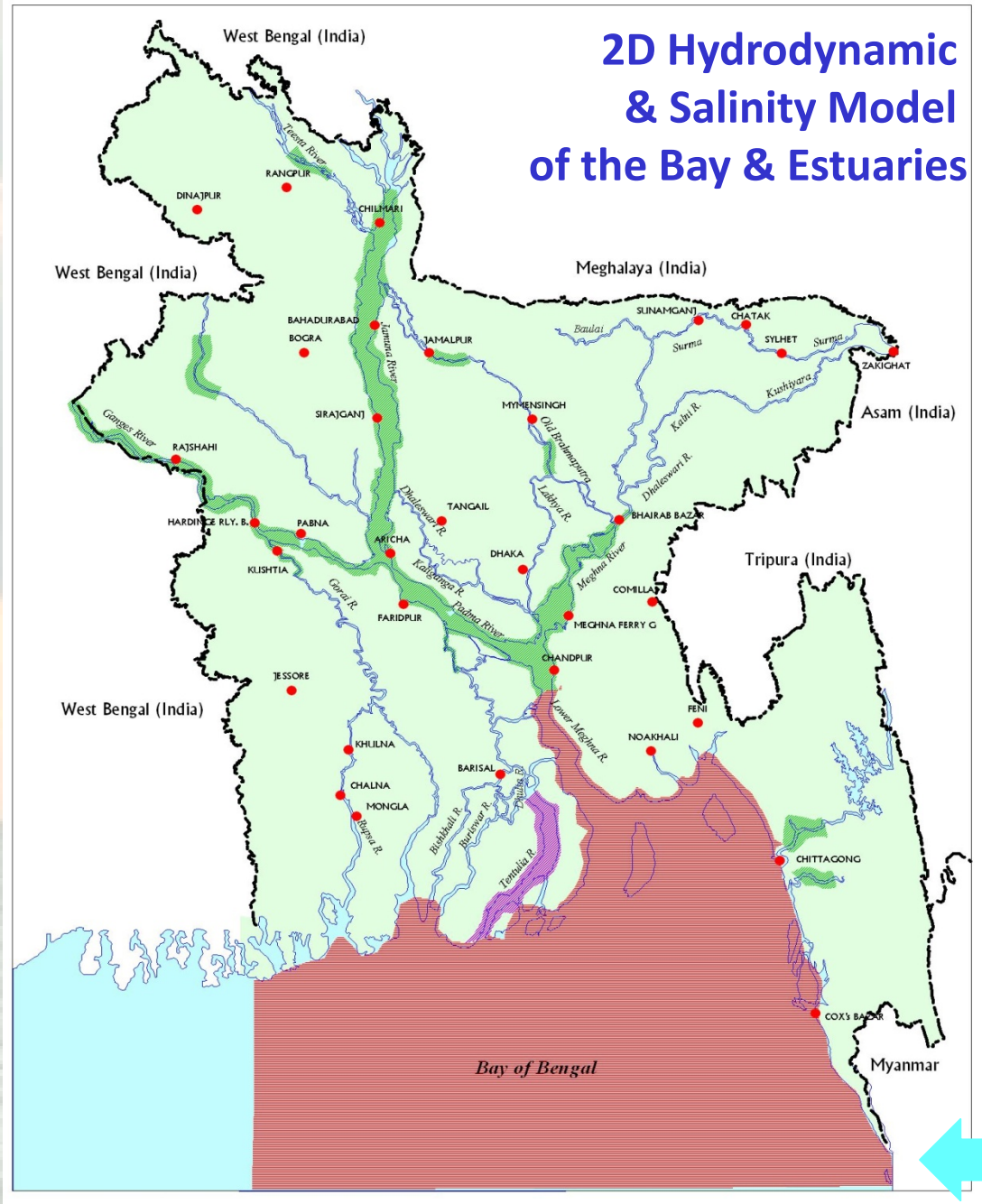


1990-93

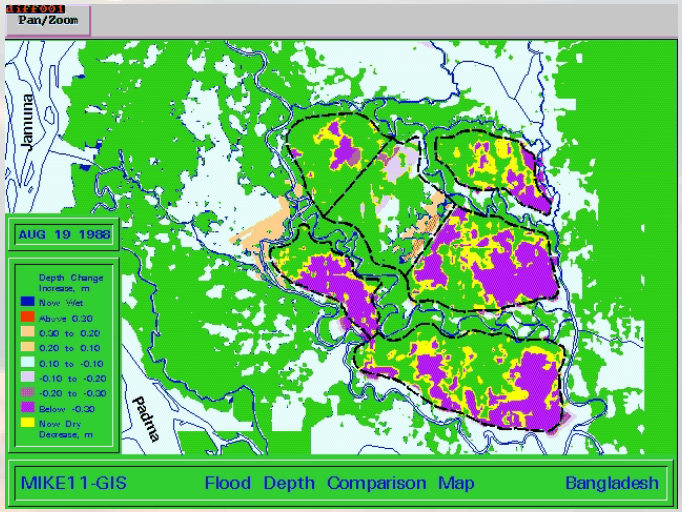
A comprehensive set of models developed over the years

1994-2001

A comprehensive set of models developed over the years



Model – GIS interface

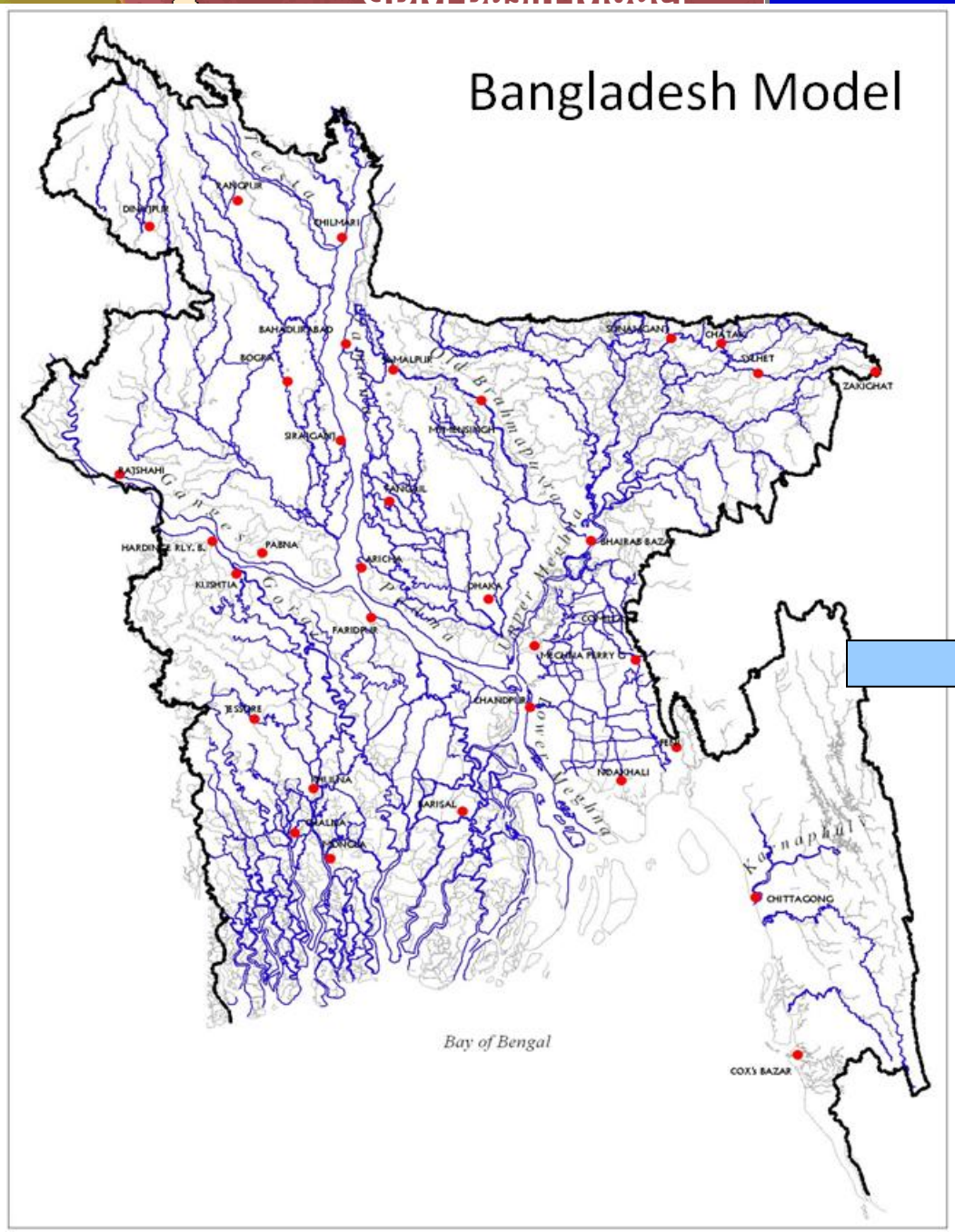


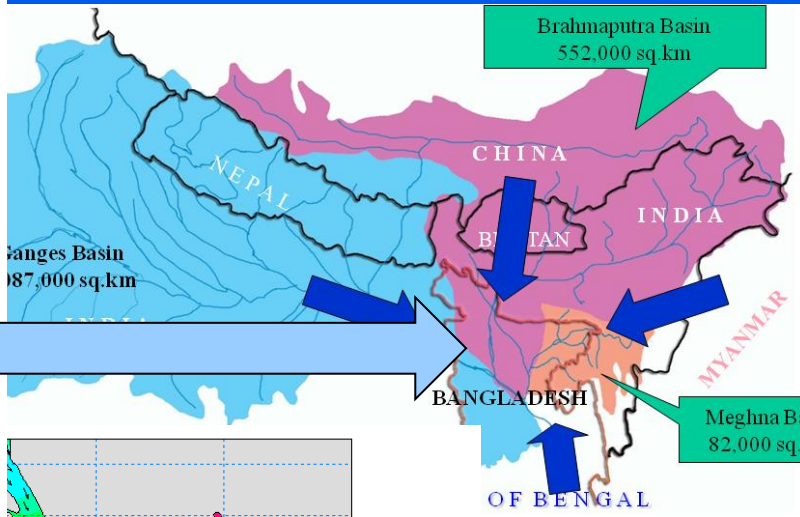
Model Result Animation

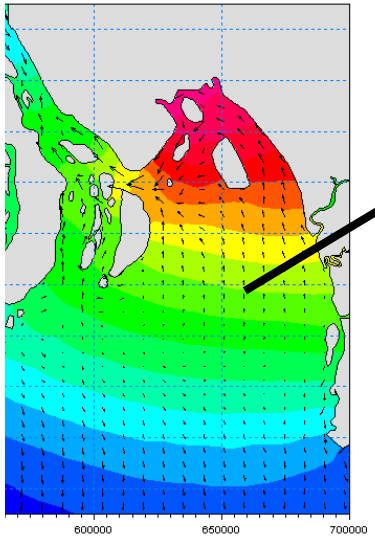
GBM Basin Model

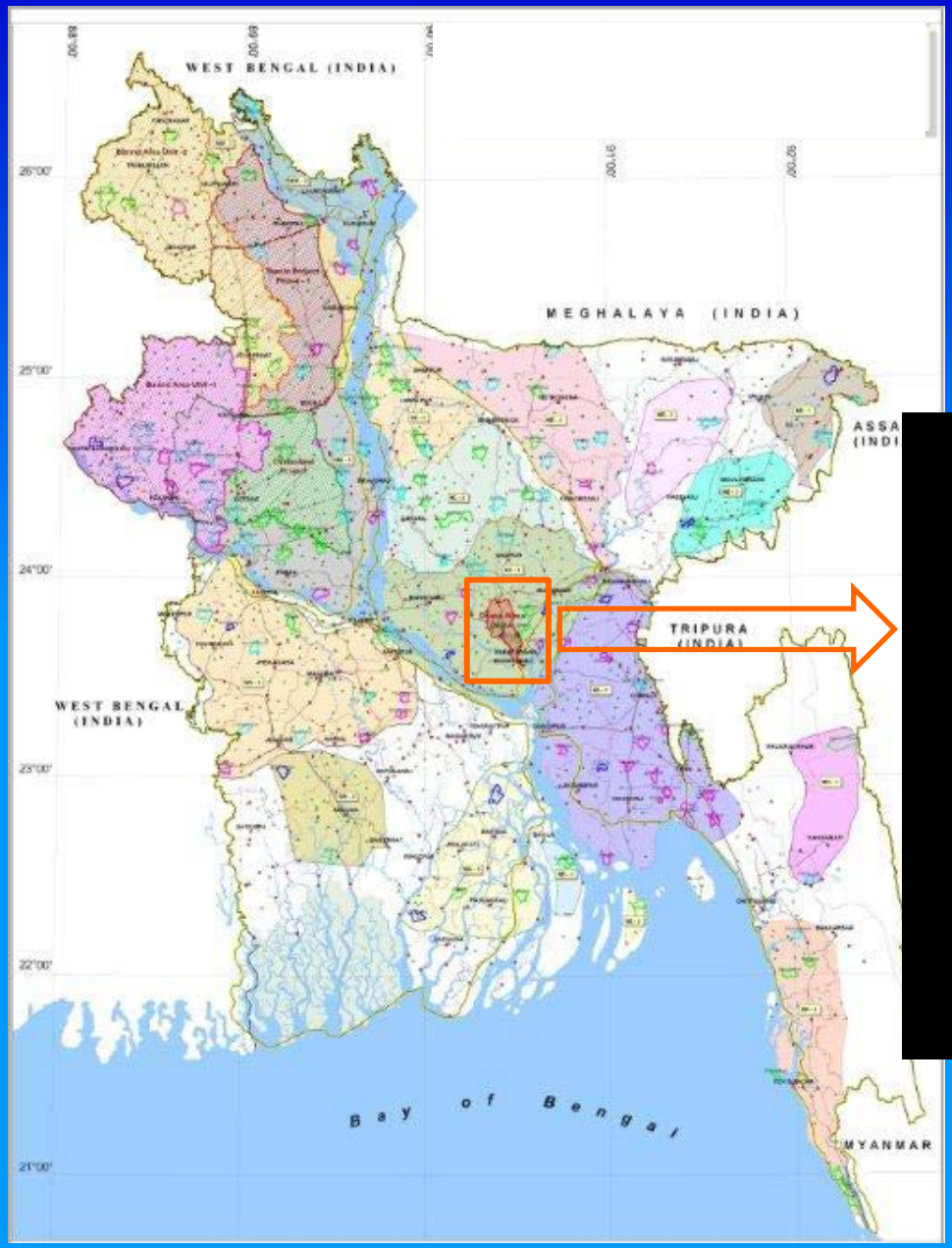
2002-12

Simulation of upstream boundary conditions of Bangladesh model





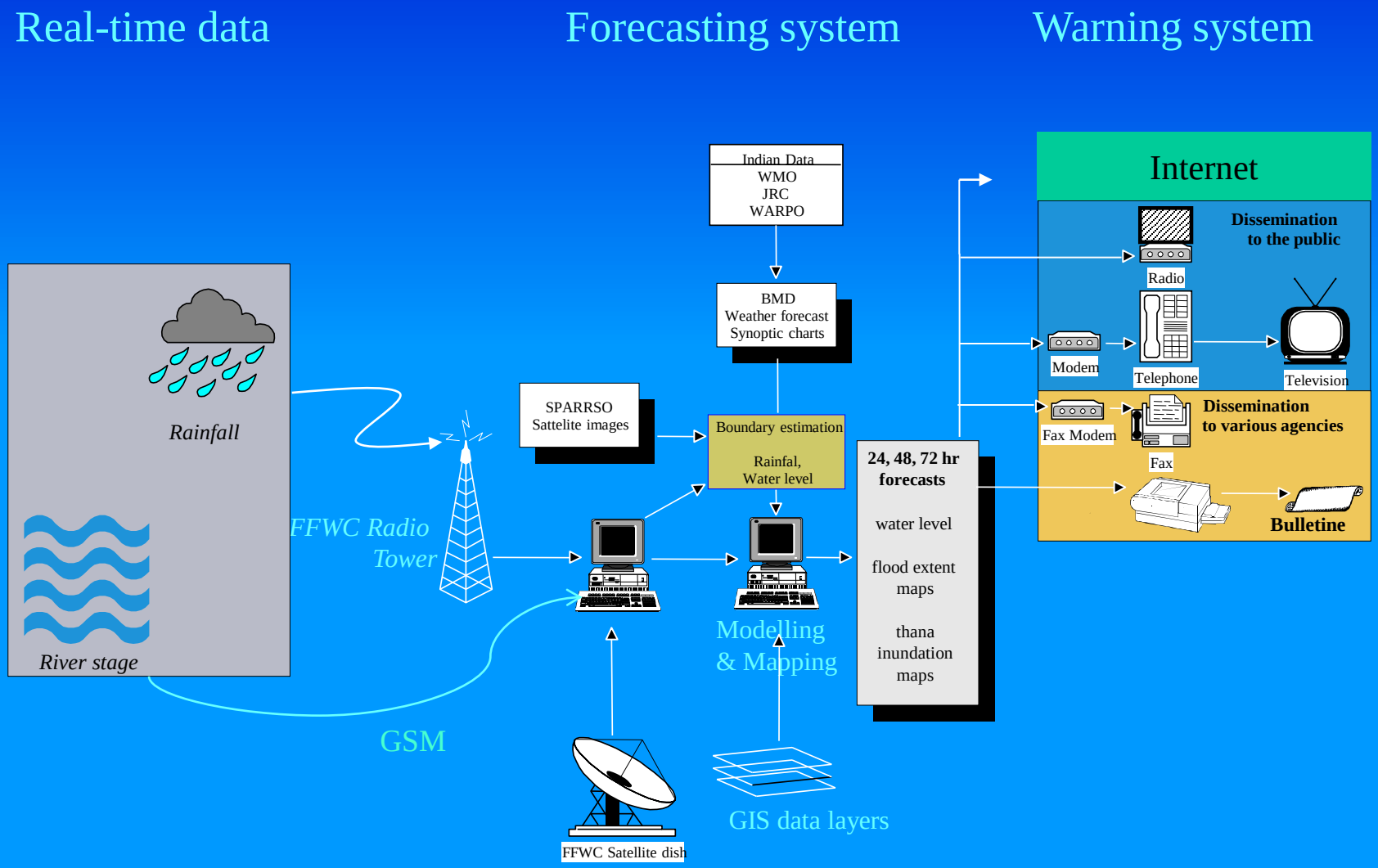




2002-12

Bangladesh Groundwater Model

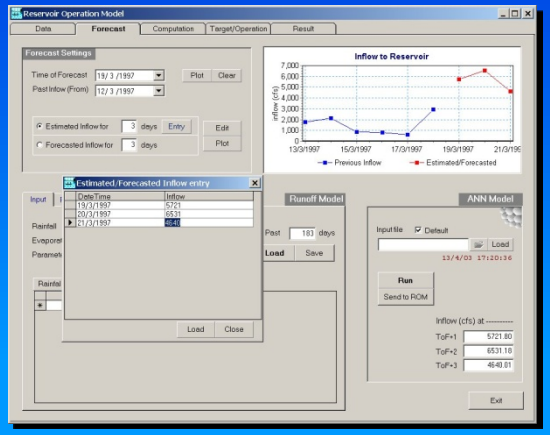
Present Flood Forecasting & Warning System



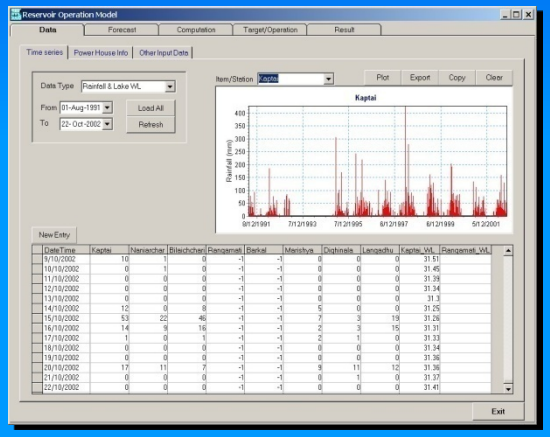
DSS: Technology Integration

Karnafuli Reservoir Operation Model

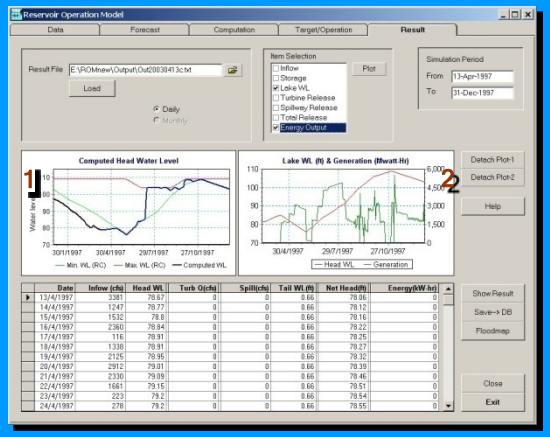
Neural Network Prediction of inflow



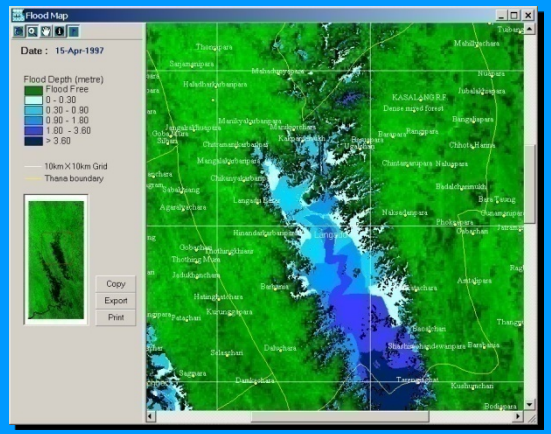
Simulation Engine



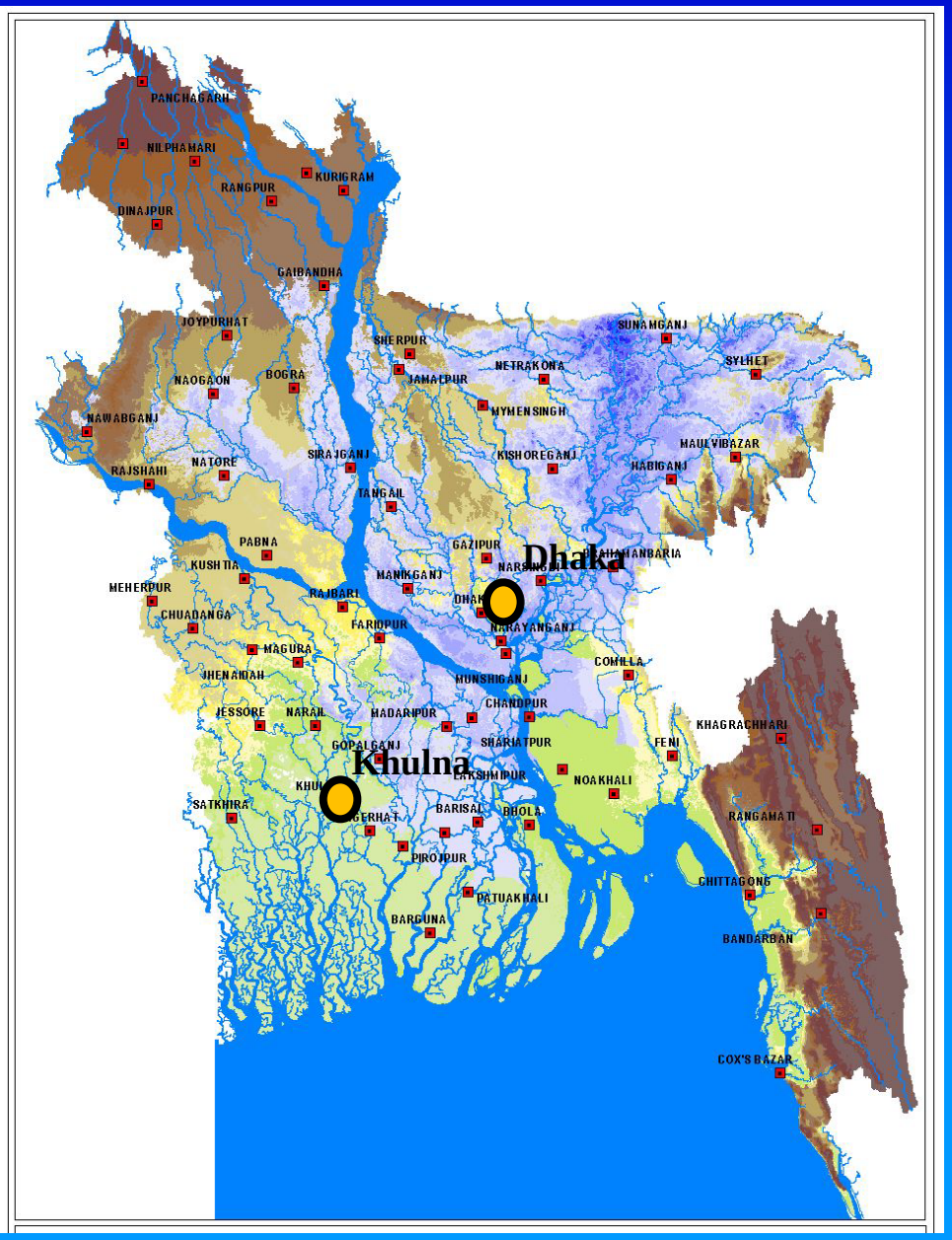
Database



Result presentation tool



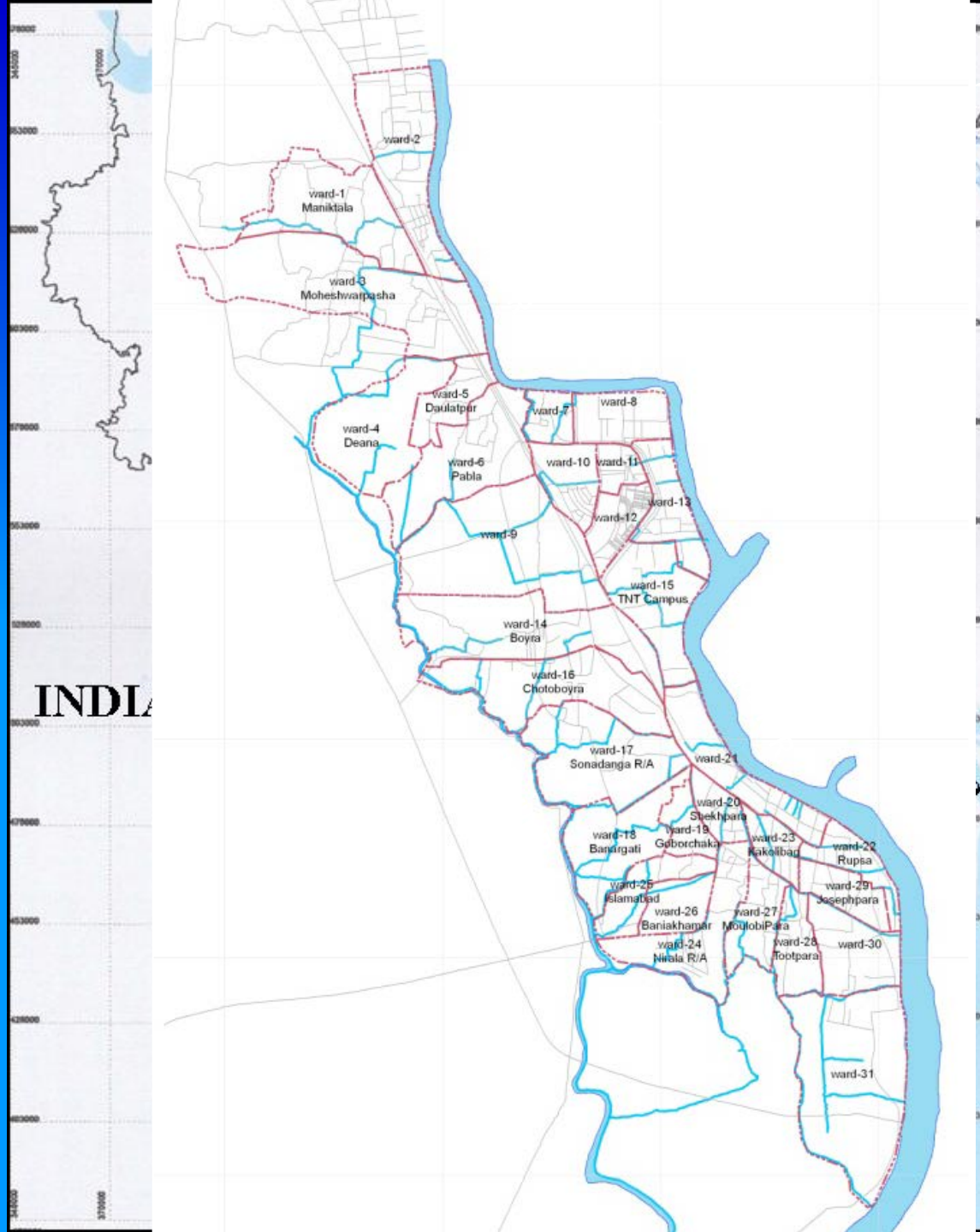
GIS mapping



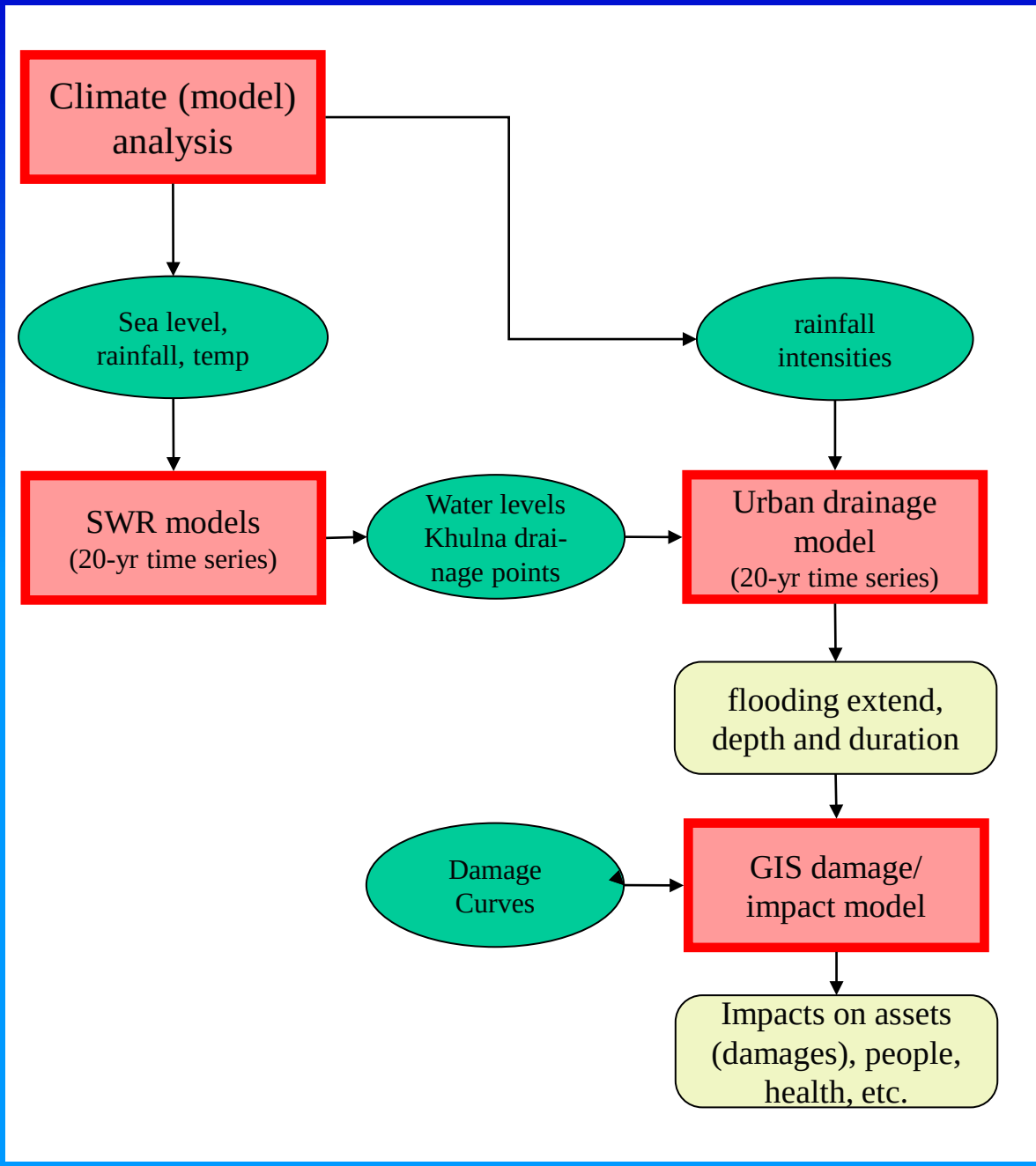
Urban Drainage Modeling

Khulna City

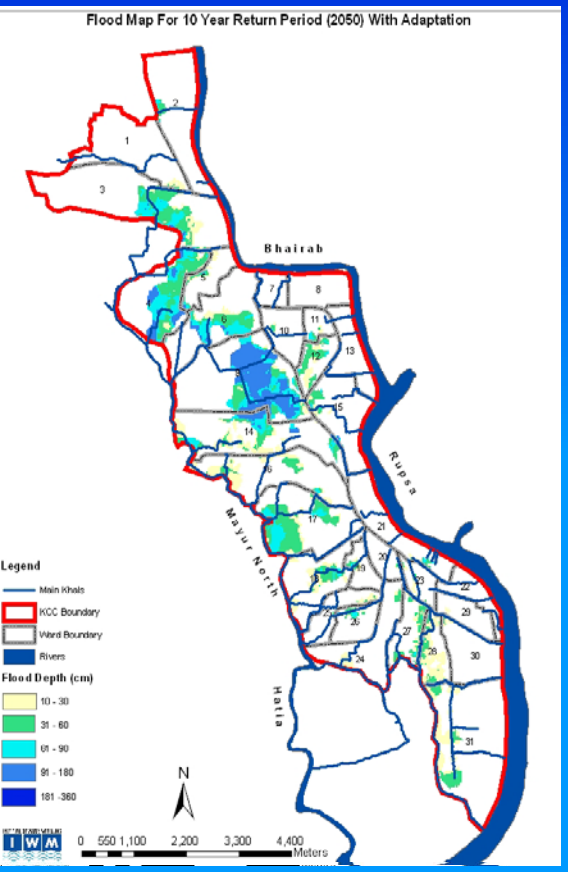
- 3rd largest City
- 45 km^2
- 1.2 million people
- Experiences frequent water logging



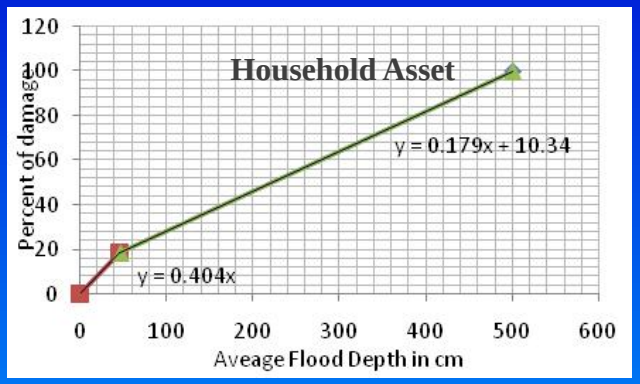
Study Approach and Methodology

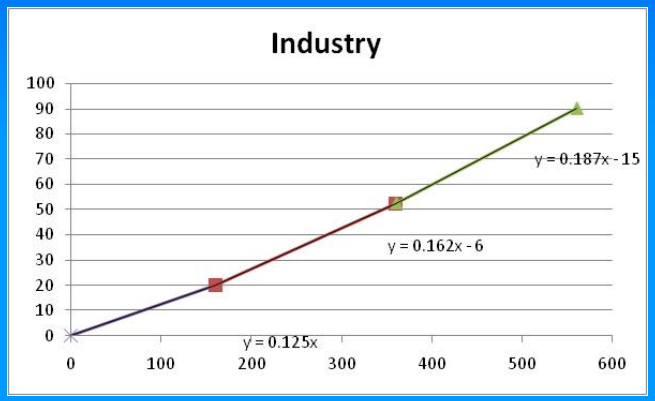


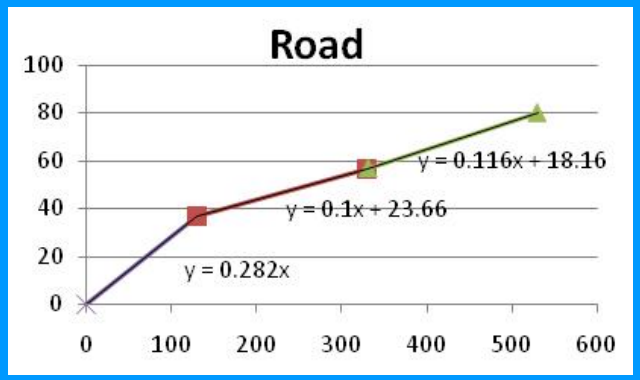
Inundation Map



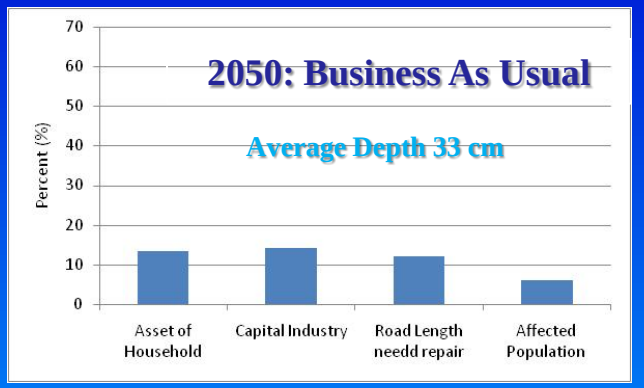
Damage Assessment

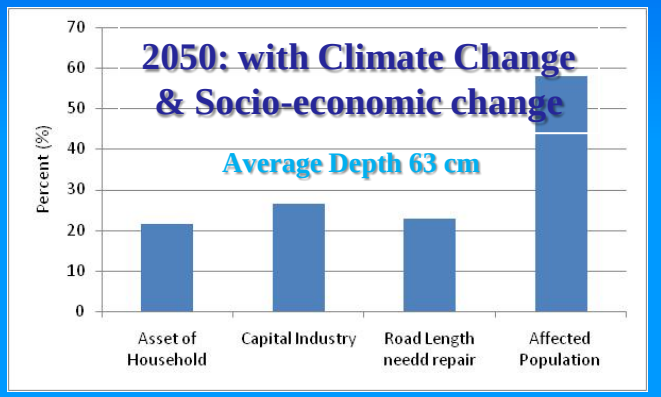


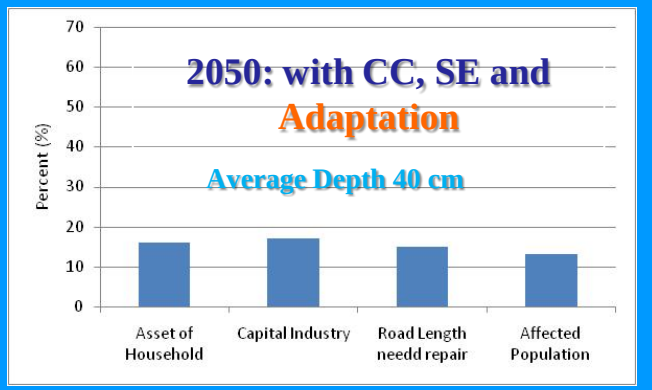




Loss and Benefit



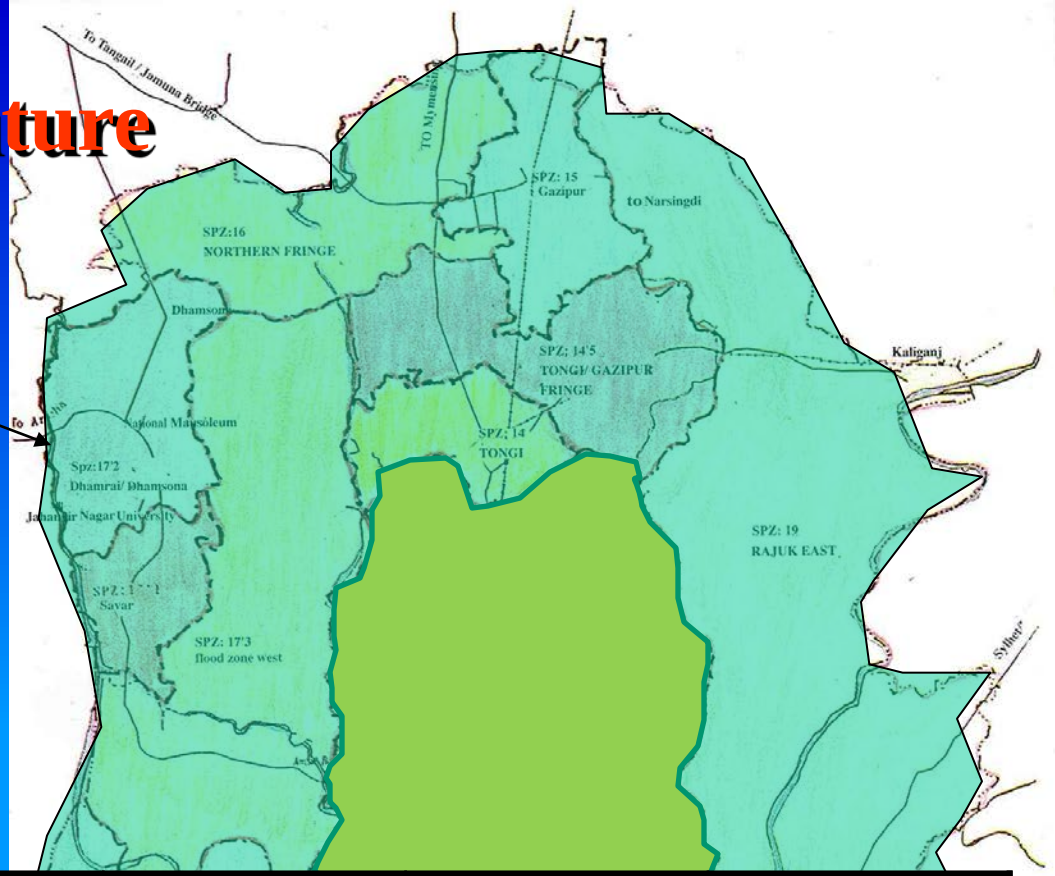




The Present & the Future

City Expansion

2025



Year	1991	2005	2011	2015	2025
Population (mill)	7.3	10.05	12.2	14.9	21.63
Area km^2			350		>1500

Greater Dhaka having an area 350 km²

i. Western Part: 136 km²

ii. Eastern Part: 124 km²

iii. DND Area : 57 km²

iv. Narayanganj: 33 km²

v. Total area: 350 km²

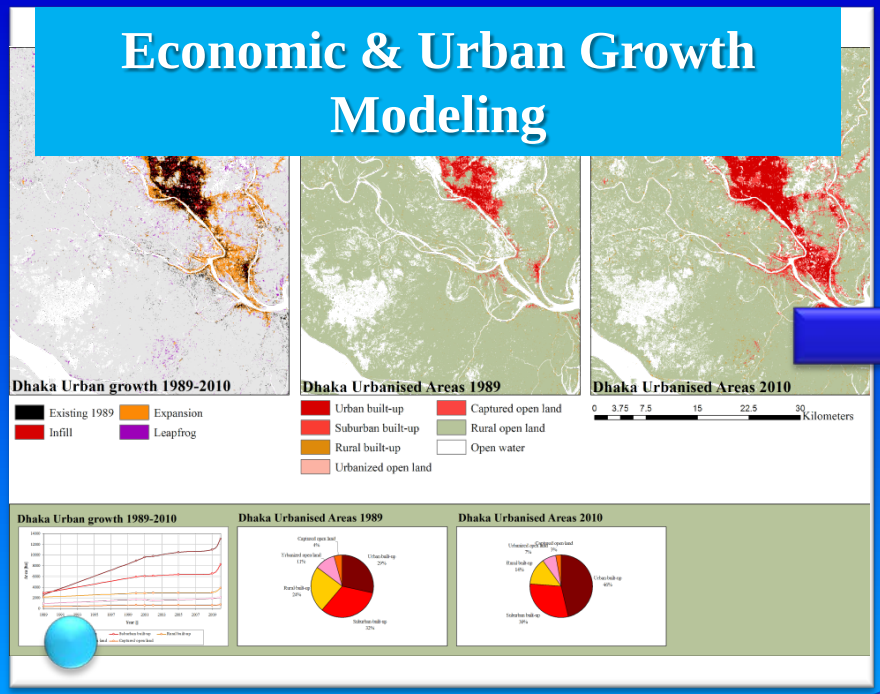
Flood embankment

Flood wall

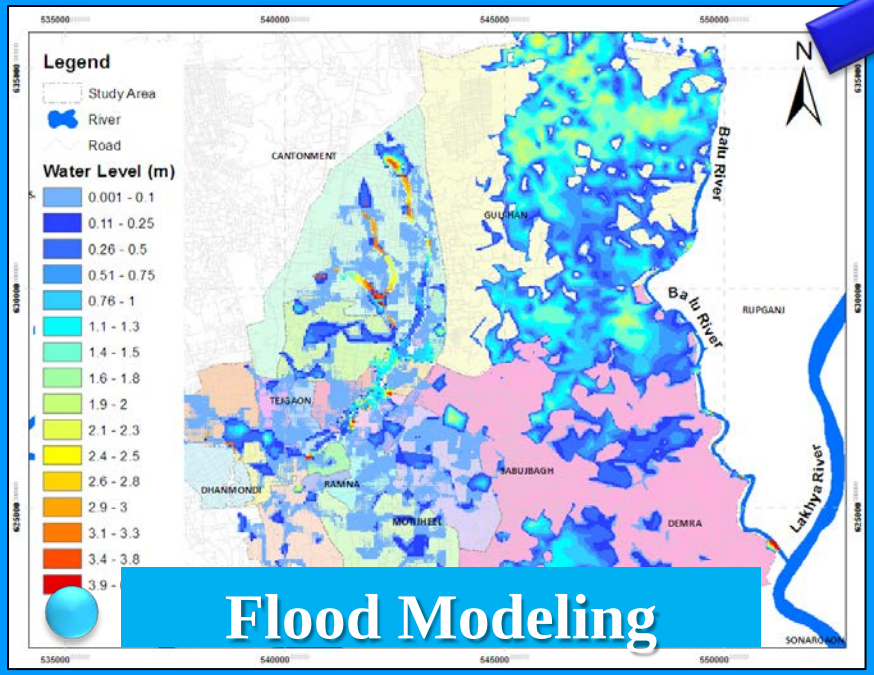
Collaborative Research on Flood Resilience in Urban Areas (CORFU)

- Learn from each other through collaborative research
- Case study cities in Europe and Asia
- 7 Work Packages,
- Funded by European Commission

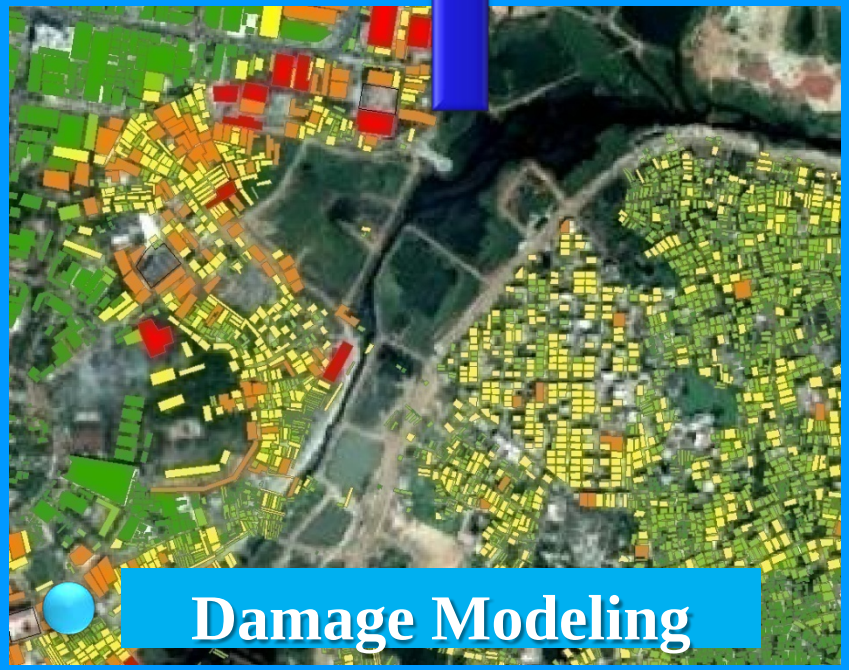
Economic & Urban Growth Modeling



FLOOD MANAGEMENT STRATEGIES



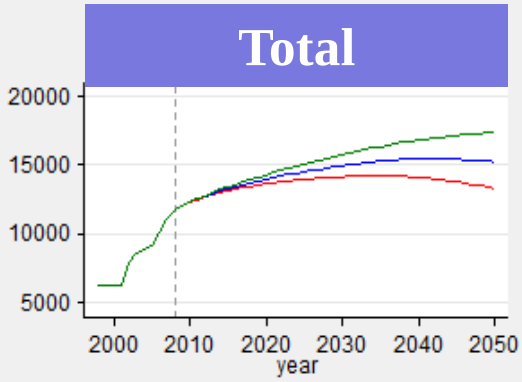
Flood Modeling

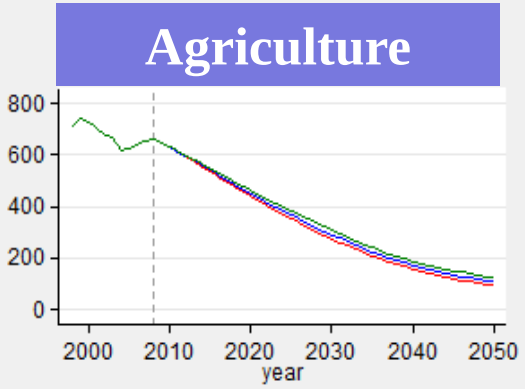


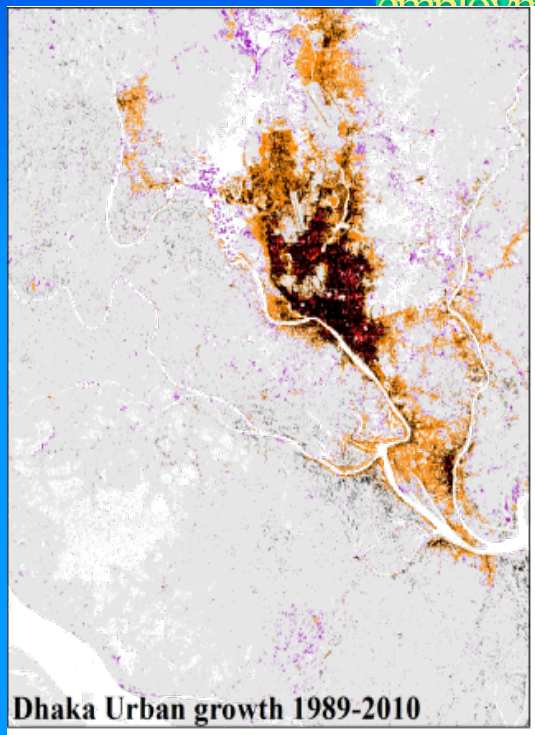
Damage Modeling

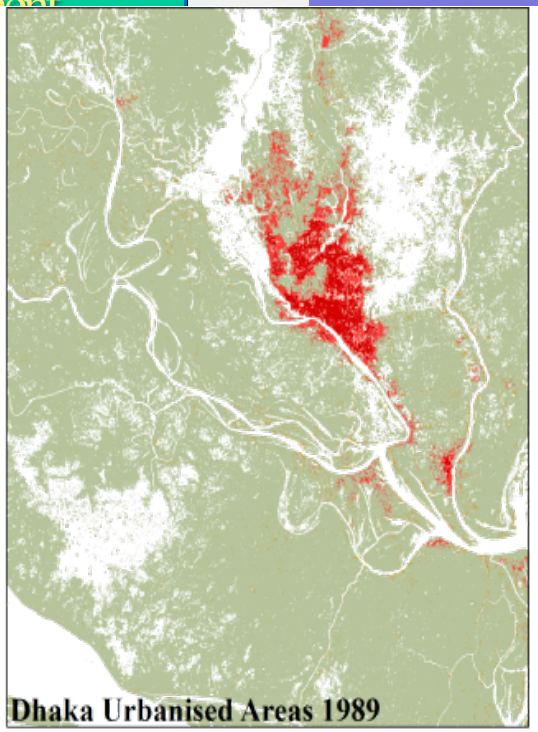
Economic Growth Modeling

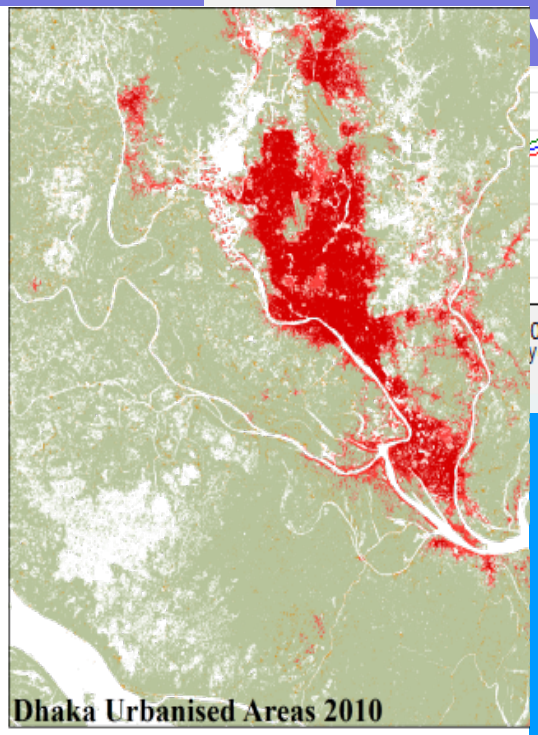
Scenarios for employment



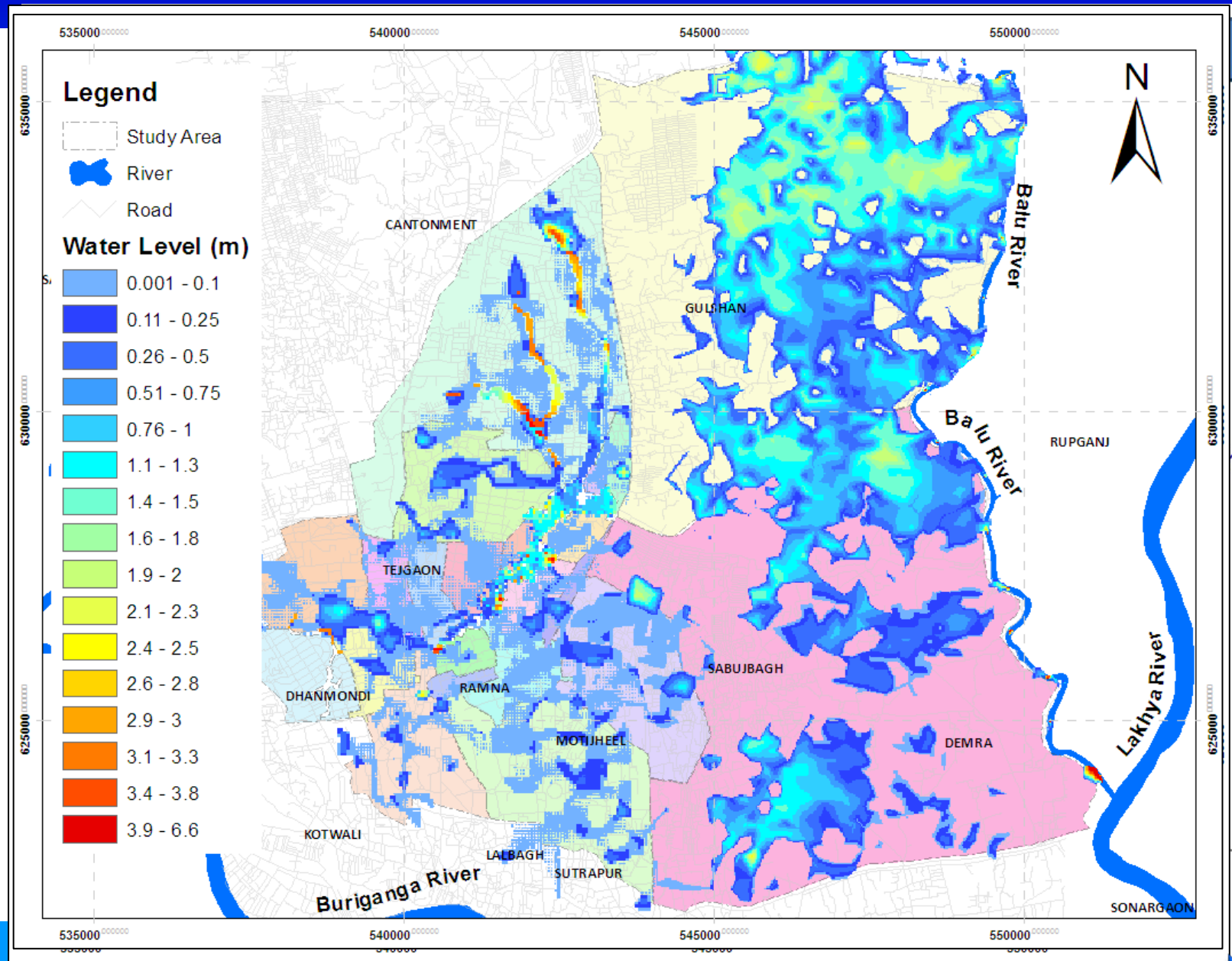




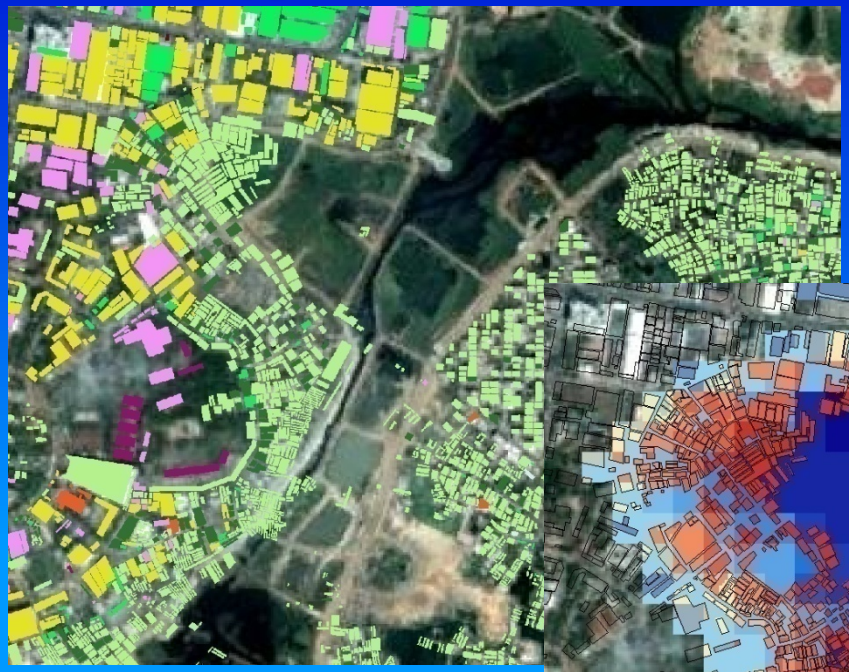




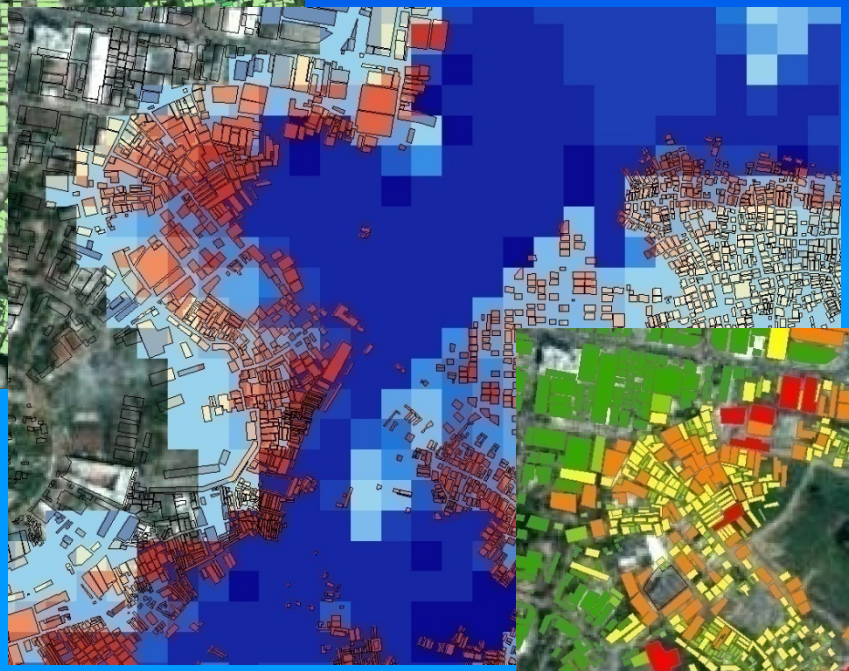
Urban Growth Modeling


Legend
Study Area
River
Road
Water Level (m)
0.001 - 0.1
0.11 - 0.25
0.26 - 0.5
0.51 - 0.75
0.76 - 1
1.1 - 1.3
1.4 - 1.5
1.6 - 1.8
1.9 - 2
2.1 - 2.3
2.4 - 2.5
2.6 - 2.8
2.9 - 3
3.1 - 3.3
3.4 - 3.8
3.9 - 6.6
N
535000
540000
545000
550000
635000
630000
625000
CANTONMENT
GULSHAN
Balu River
RUPGANJ
TEJGAON
SABUJBAGH
DHANMONDI
RAMNA
MOTIJHEEL
DEMRA
Lakhya River
KOTWALI
LALBAGH
SUTRAPUR
Buriganga River
SONARGAON

Land-use map from building types

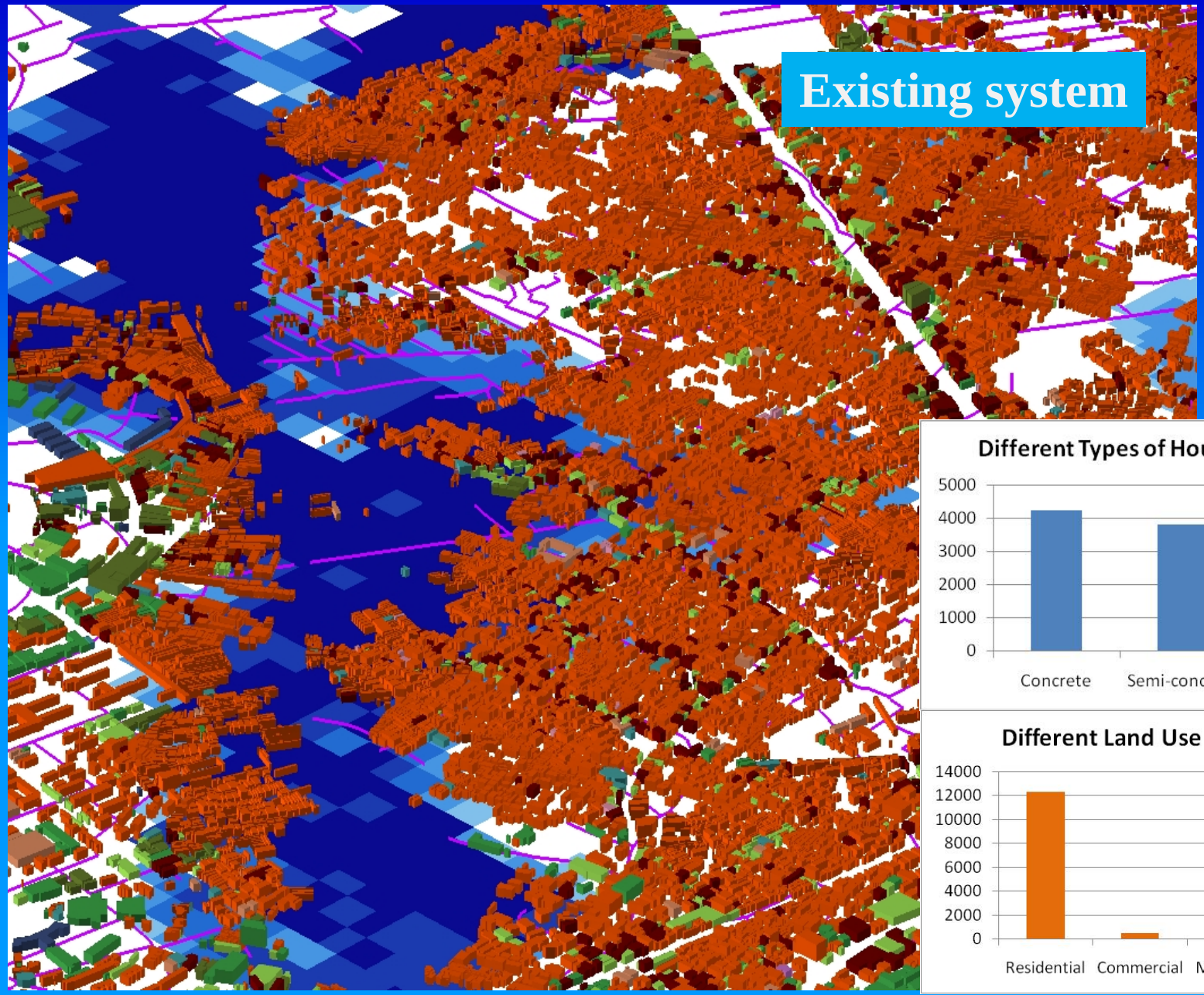


Calculated damage per unit area

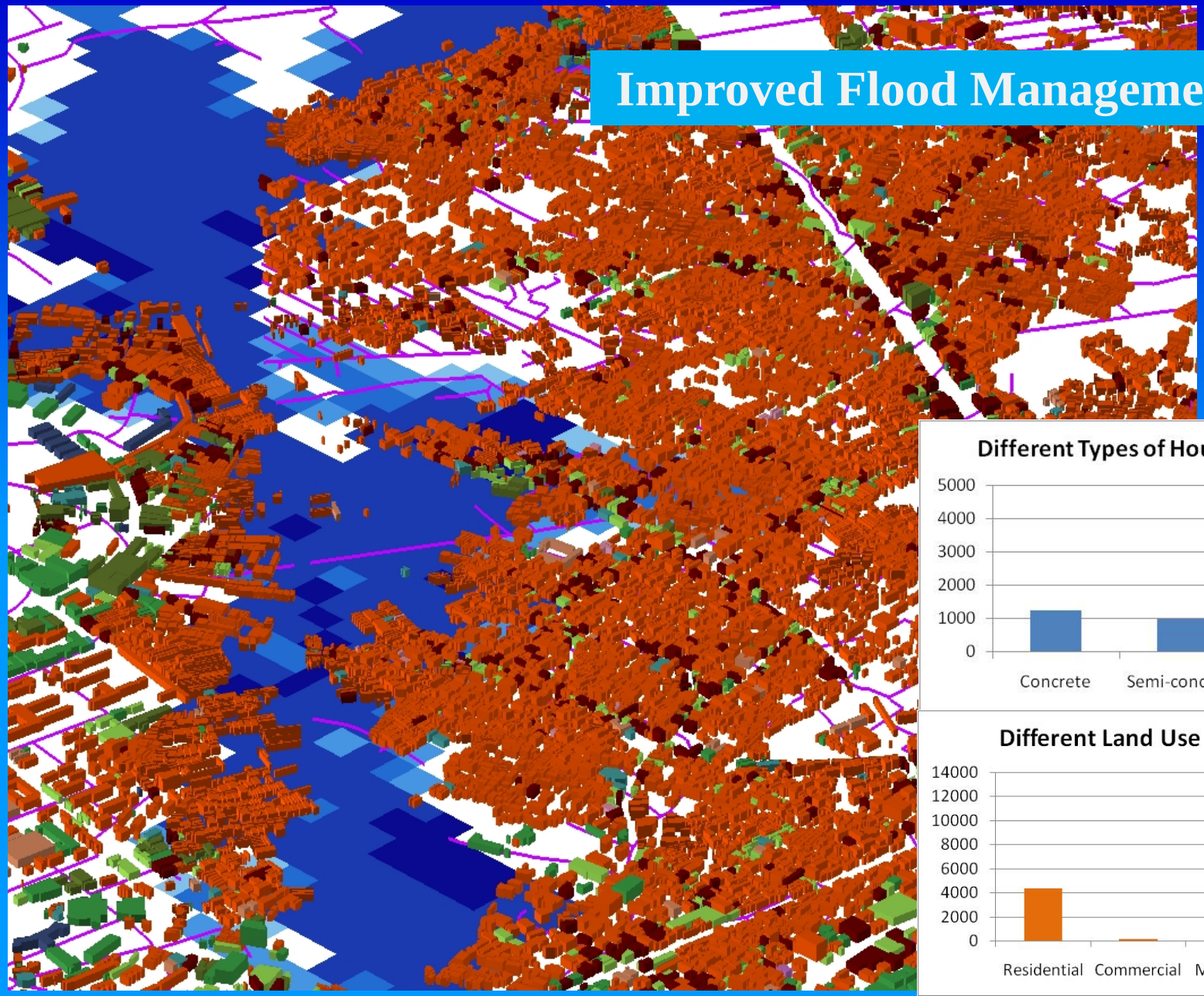


Building damage

Existing system



Improved Flood Management



Challenges

- 2D flooding computation (software and hardware)
- Data availability and quality
  - Monitoring network
  - 2D modeling where high quality data not available
- Integration of different data sets (temporal and spatial scales)
- Feedbacks among models (Urban growth, flooding, response)
- Size of data set

Conclusion

- In Bangladesh IWM has experienced wide application hydroinformatic tools
- It is also working outside Bangladesh in countries like Malaysia, Nepal and Tajikistan
- Urban drainage models has become an essential tool, IWM has developed tools for 148 municipalities of Bangladesh

Thank You