Integrated Flood Management in Bagmati river basin of Bihar, India Using Modern Technology

Presented by

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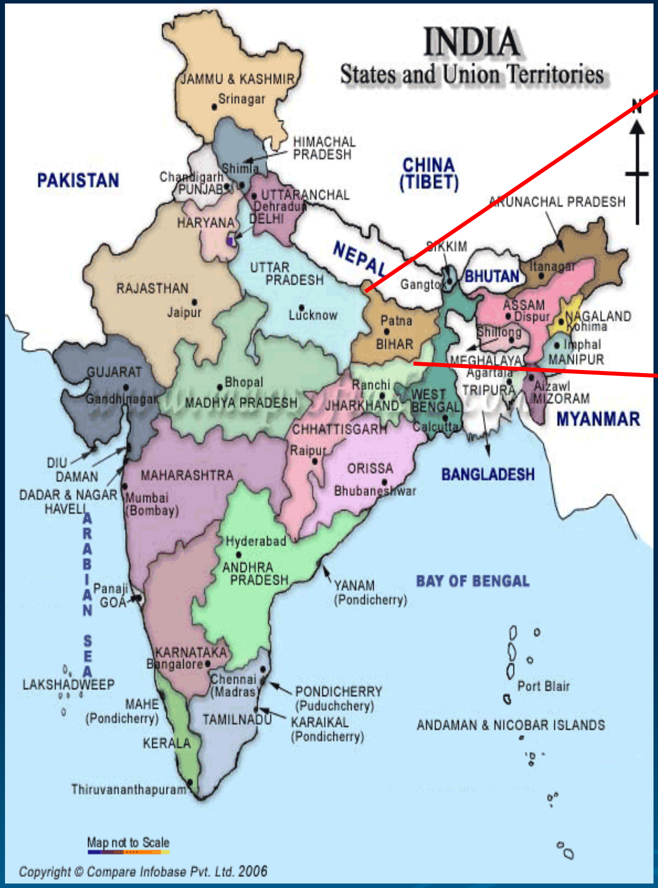
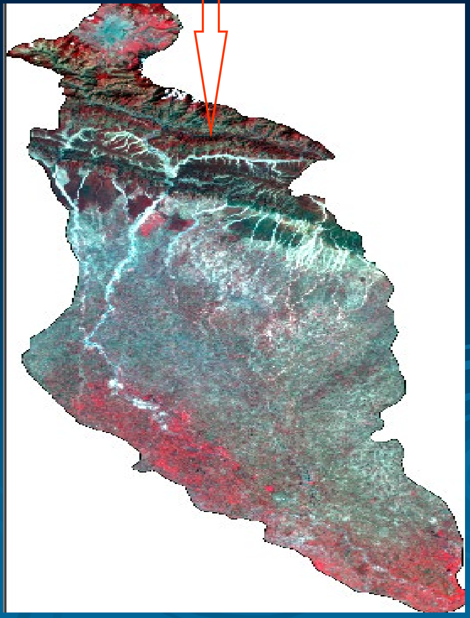
STUDY AREA – BAGMATI RIVER, BIHAR,INDIA





Introduction

- Floods are most recurring natural disasters.
- More than 520 million people are affected by flood per year in the world. It gives result in estimates up to annual deaths of 25,000.
- In India average annual deaths due to flood about 1800 and total losses about 2700 crores (ref. CWC report).
- Main causes of damage are:
  1) Unpreparedness
  2) Failure to give warnings
  3) Lack of accurate information about expected flood inundation areas and
  4) Time lag in mobilization of resources

Average annual loss due to Floods in India

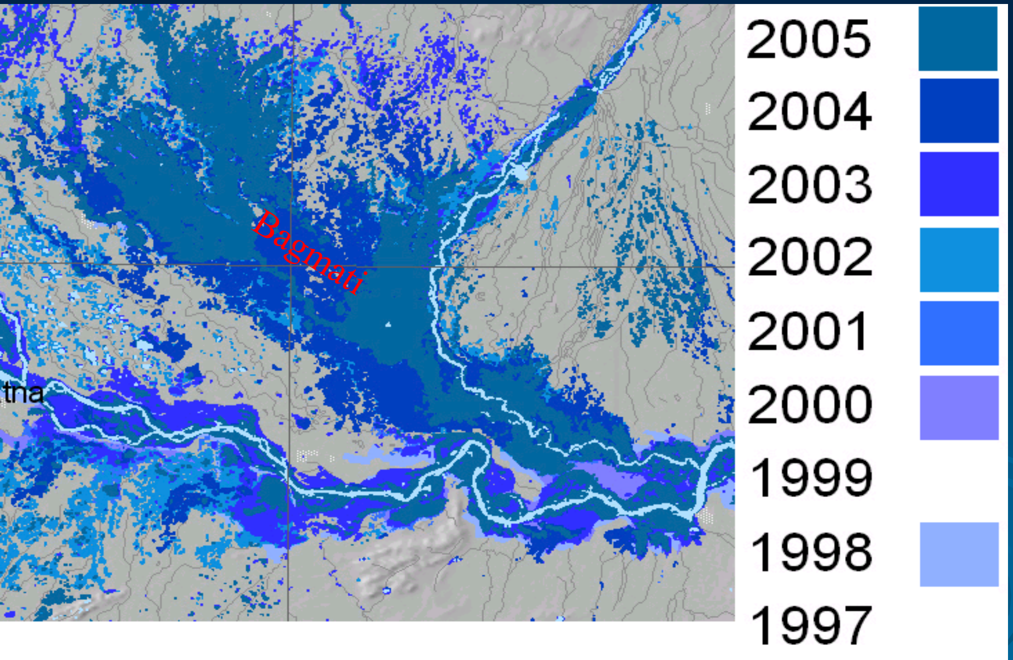
S. No.	Items	Loss
1.	Area affected	7.35 million hectare
2.	Population affected	40.967 million
3.	Human lives lost	1793 number
4.	Cattle lost	85599 number
5.	Houses damaged	1452904 number
6.	Houses damaged	370.607crore
7.	Crop area damaged	3.72 million hectare
8.	Crop damaged	1095.132crore
9.	PublicUtilities damaged	1186.456crore
10.	Total losses	2706.243crore

Introduction contd.

❖ Bihar is India's most flood-prone state.

❖From 1999 to 2005 the flood damages reached **US$531** millions in North Bihar only.

❖2007 floods will be remembered for high degree of rainfall which was even more than year 2004 flood. About 700 persons died. Public property damage was worth 1700 crores.



- ❖ Present practice of Flood Management by WRD GoB – Anti-erosion works (recommended by TAC and SAC) after flood.
- ❖ **Real time flood forecasting and expected inundation mapping** can provide cost-effective mitigation to water managers

THE GROUND REALITY

SAFETY ON THE EMBANKMENTS

MAKESHIFT SHELTER

EMBANKMENT BREACHES

ROAD CUM EMBANKMENT BREACH

STRANDED POPULATION


STRANDED

STRANDED

EMERGENCY RELIEF- AIRDROPPING

DISRUPTED COMMUNICATION


OVERTOPPED ROAD
13 14:32

FLOOD HAZARD TYPOLOGY

- TYPOLOGY I: FLASH FLOODS – FLOODS FROM NEPAL RAINFALL, LEAD TIME IS SHORT 8 HOURS, RECESSION IS FAST, NO IMPACT ON AGRICULTURE
- TYPOLOGY II: RIVER FLOODS – LEAD TIME 24 HOURS, RECESSION IS 1 WEEK OR MORE,
- TYPOLOGY III: DRAINAGE CONGESTION IN RIVER CONFLUENCE- LEAD TIME > 24 HOURS, LASTING INUNDATION, NO KHARIF SEASON AGRICULTURE
- TYPOLOGY IV: PERMANENT WATER LOGGING - SHRINKAGE IN AREA ONLY IN FEB, LOCAL RAINFALL, MICRO-RELIEF ASPECTS
- TYPOLOGY V: FLOOD MANAGEMENT IN URBAN AREAS
- TYPOLOGYVI: FLOOD MANAGEMENT IN IRRIGATION COMMANDS

FLOOD HAZARD TYPOLOGY IN STUDY AREA

TYPOLOGYVII:FLOOD MANAGEMENT IN HIGHLY VULNERABLE REACHES OF RIVER EMBANKMENTS

TYPOLOGYVIII:FLOOD MANAGEMENT IN AREAS WHERE THERE IS HIGH POPULATION LOCATED VERY NEAR TO RIVER

TYPOLOGYIX:FLOOD PRONE AREAS HAVING WATER LOGGING WITH HIGH DEPTH FOR LONG PERIOD OF TIME

TYPOLOGYX: FLOOD PRONE AREAS HAVING DRAINAGE CONGESTION FOR SMALL PERIOD OF TIME

TYPOLOGYXI:HAZARD CAUSED BY HIGH PEAK AND LOW VOLUME

TYPOLOGYXI:HAZARD CAUSED BY HIGH VOLUME AND LOW PEAK

TYPOLOGYXII:HAZARD CAUSED BY HIGH PEAK AND HIGH VOLUME

Traditional Flood Management

- Addresses only negative aspects of flooding
- Focuses on reducing flooding and reducing the susceptibility to flood damage
- Provides adhoc reactions and are carried out in isolation
- Expresses the risk of flooding simply as the exceedence probability of a flood of a given magnitude on a particular stretch of river
- In limited studies flood inundation modeling for various return periods has been attempted.

present practice of flood management

- Before monsoon period anti-erosion works and during the monsoon flood fighting works are done at vulnerable sites. A joint committee, after seeing the river regime after the flood, and erosion, suggests vulnerable sites and propose for anti-erosion schemes.
- On the basis of the committee's report, field Executive Engineers measure the damages and frame schemes as per relevant design and prepare estimate. They put it before Technical Advisory committee (TAC). After recommendation by TAC the schemes are sent to Scheme Review Committee (SRC) and with concurrence of Principal Secretary, the agenda are sent to State Flood Control Board.
- The State Flood Control Board is headed by State Chief Minister. Agenda gets approved and fund is made available.

Integrated Flood Management

Paradigm shift

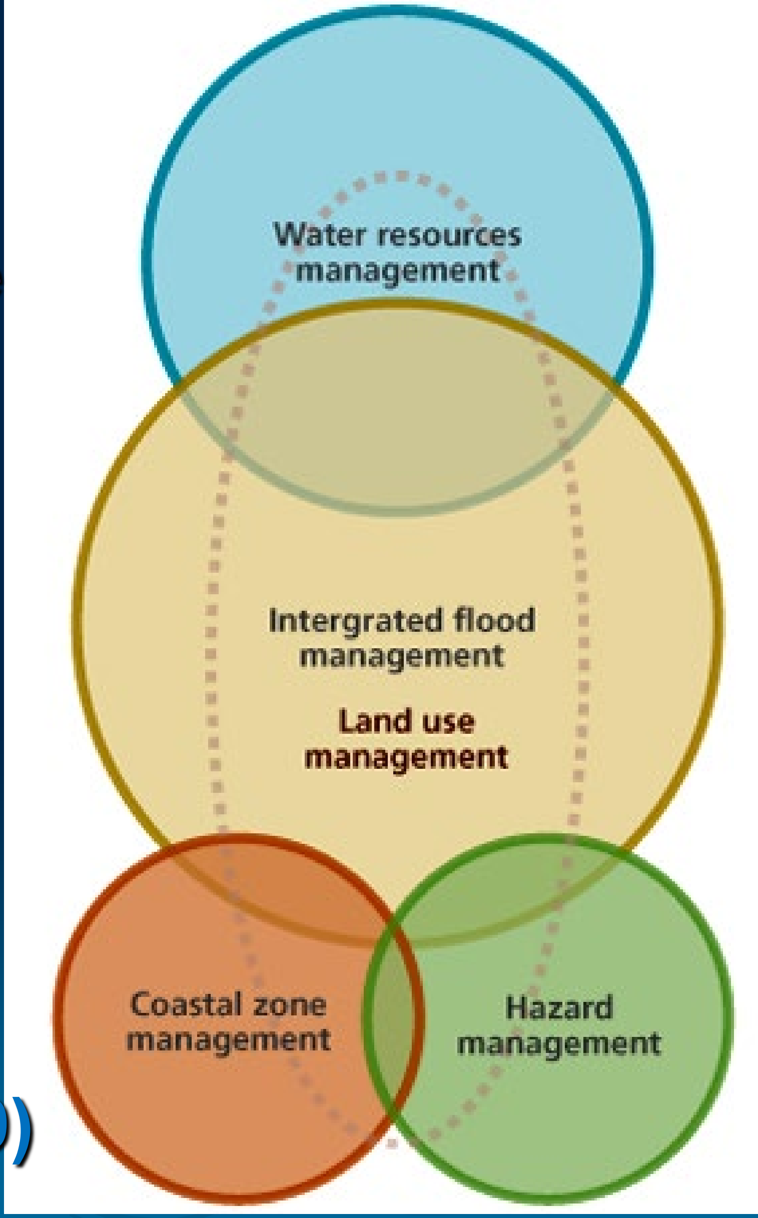
Absolute protection from floods is a myth.

We should aim at maximizing net benefits from the use of flood plains, rather than trying to fully control floods.

Integrated Flood Management

- Improves functioning of the river basin as a whole
  - Recognizing that floods have beneficial impacts and can never be fully controlled.
- Integrates land and water resources development in a river basin.
- Maximizes the efficient use of floodplains and minimizes loss of life.

(WMO No. 1047, 2009)



Integrated Flood Management

Elements of IFM

- Manage the Water Cycle as a Whole
- Integrate Land and Water Management
- Manage Risk and Uncertainty
- Adopt a Best-Mix of Strategies- Structural and non-structural
- Ensure a Participatory Approach
- Adopt Integrated Hazard Management Approaches

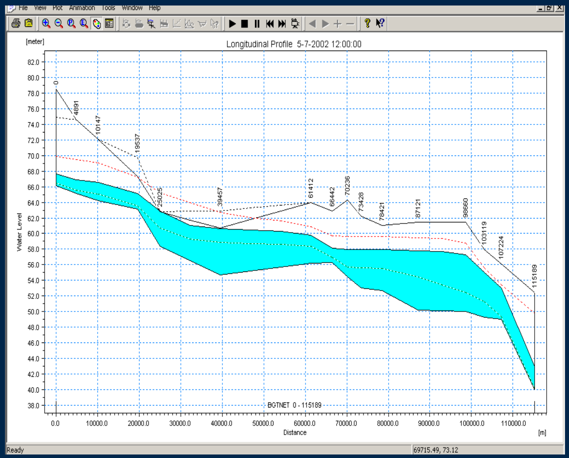
Integrated Flood Management

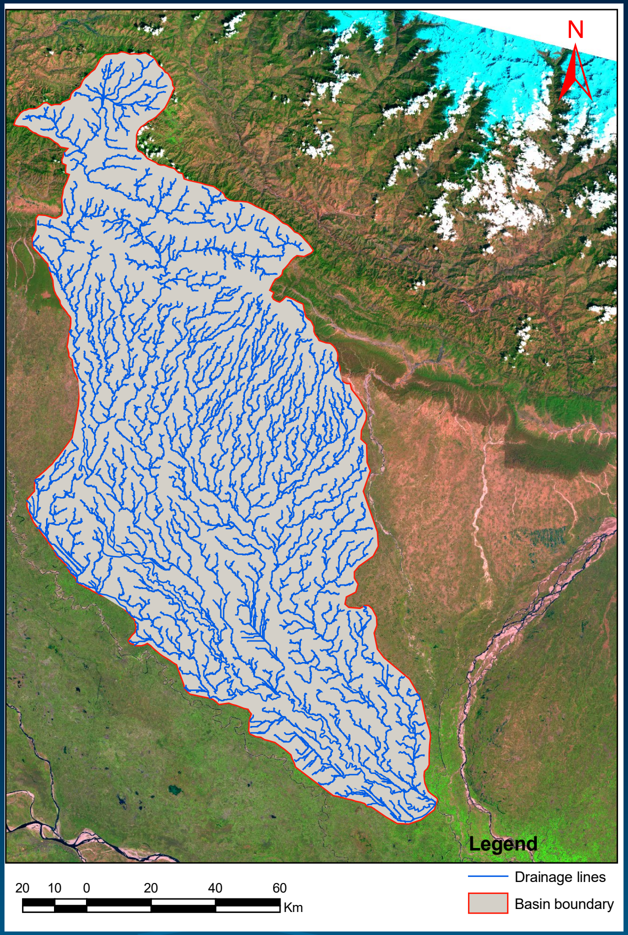
Basin Planning

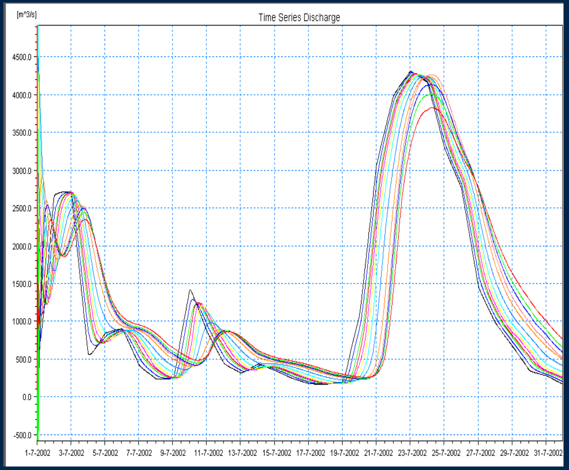
Flood Proofing and Building Codes

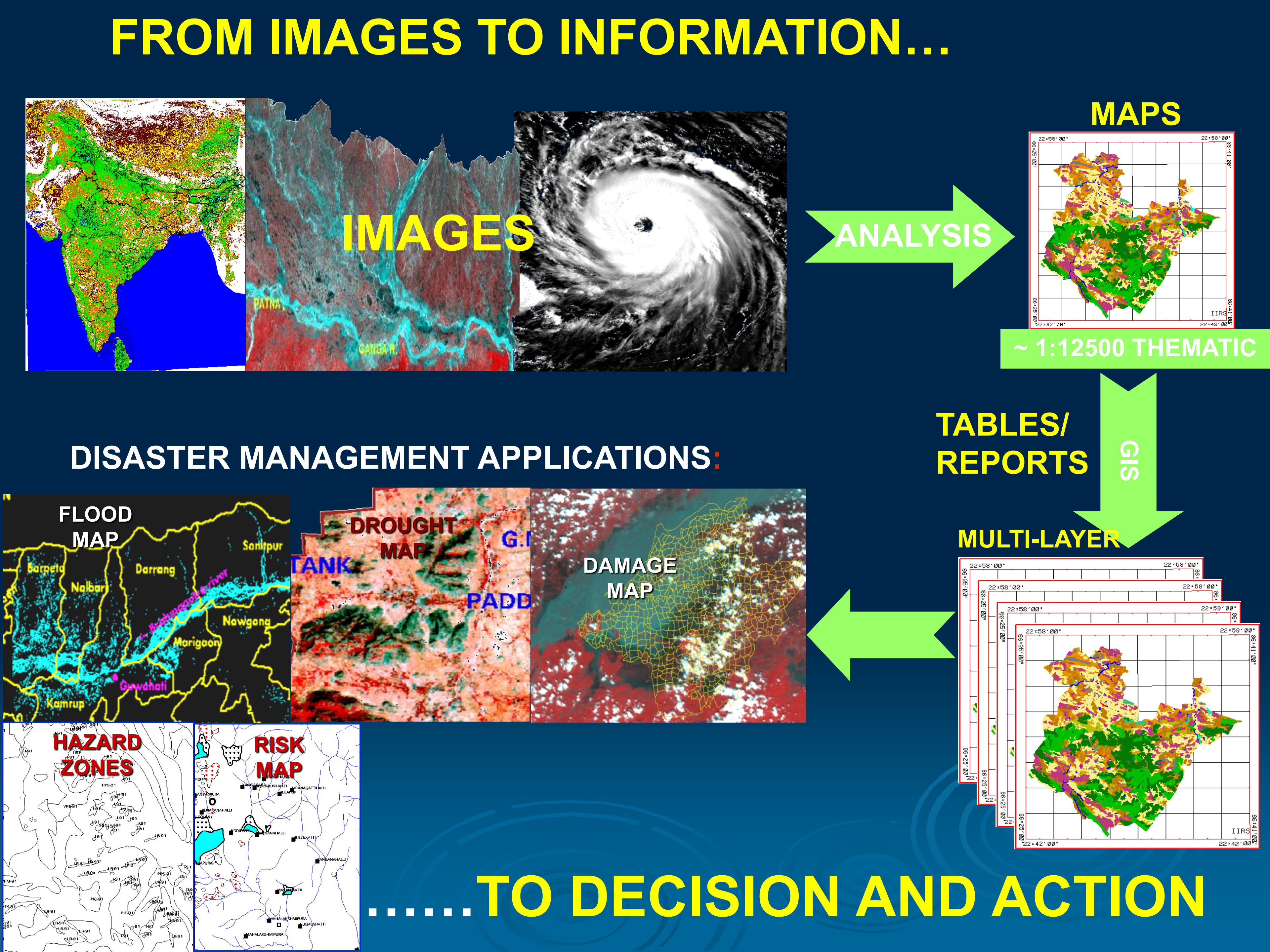
Flood Hazard Mapping

Use of New Technologies & Softwares in Flood sector








FROM IMAGES TO INFORMATION…
IMAGES
PATNA
GANGA R.
ANALYSIS
MAPS
~ 1:12500 THEMATIC
TABLES/
REPORTS
GIS
MULTI-LAYER
DISASTER MANAGEMENT APPLICATIONS:
FLOOD MAP
Barpeta
Nalbari
Darrang
Sonitpur
Brahmaputra river
Nowgong
Marigaon
Guwahati
Kamrup
DROUGHT MAP
TANK
PADD
DAMAGE MAP
HAZARD ZONES
RISK MAP
……TO DECISION AND ACTION

FLOOD MANAGEMENT INFORMATION SYSTEM

DATABASE DESIGN

Database
Attribute
Information
Historical
Database

MONITORING/ MAPPING

Ground-based/
Satellite based

MODELING

Statistical
/physical

NETWORKING

Multi-Point

INTERFACES

Agency-Agency

CHALLENGING TASKS

- Modifying SWAT model for real time flood forecasting of river basins using web based data,

- Mapping expected inundation, and flood zonation by integrating SWAT outputs into HEC GeoRAS and HEC-RAS models

IMPORTANT COMPONENTS

1. Rainfall Runoff Model

2. Runoff Routing Model.

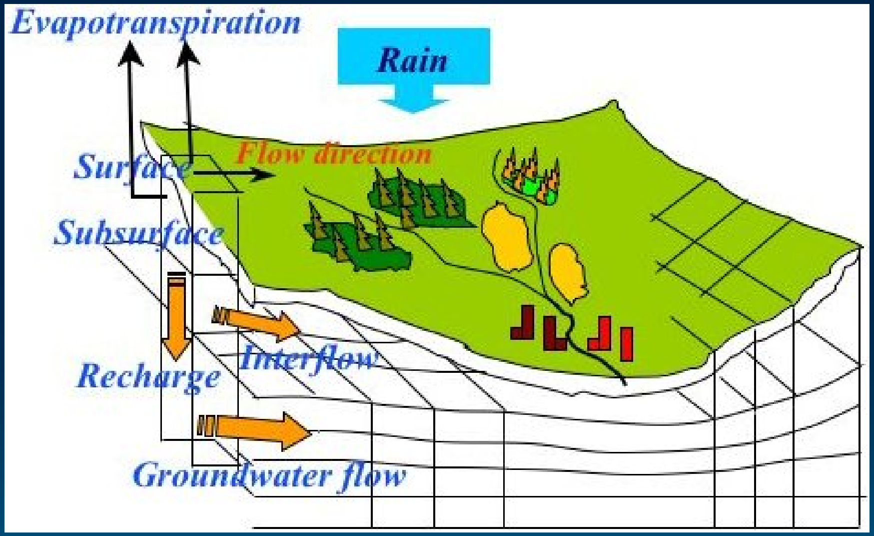
3. Error Analysis and Updating Technique

4. Hydrodynamic model for channel routing (HEC-RAS)

5. Generating TIN and delineating flood plain

SWAT Model – A Physically Based Model

To use the equations of mass, energy and momentum to describe the movement of water over the land surface and through the unsaturated and saturated zones.



Model Set up for study area

Data sets used

- (1) DEM – SRTM (90 m resolution)
- (2) Landuse – Global USGS (2 M)
- (3) Soil – FAO Global soil (5 M)
- (4) Rain gauges /Temperature gauges – IMD
- (5)Stream Gauges – CWC

Digital Elevation Model – SRTM (90m resolution)

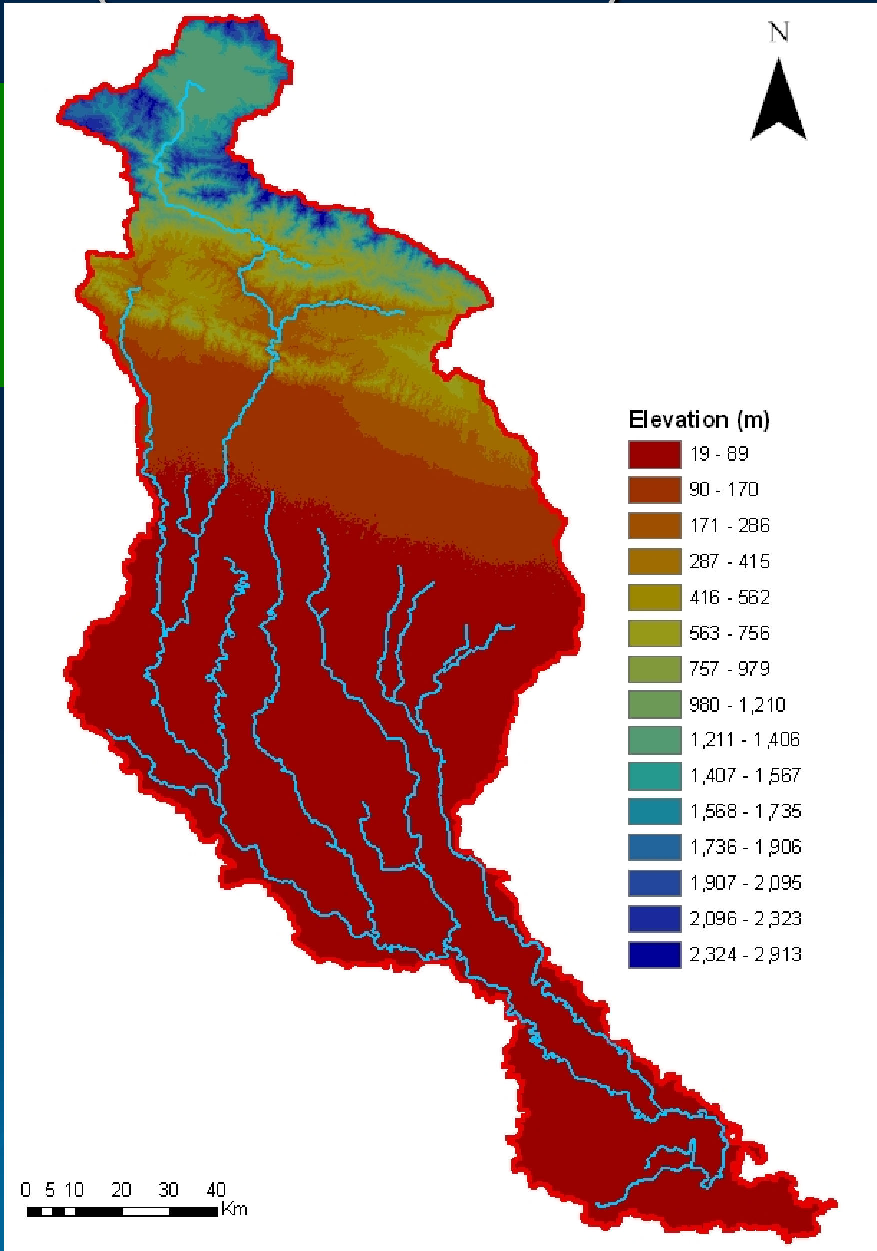
Summary (m)

Min. Elevation: 10

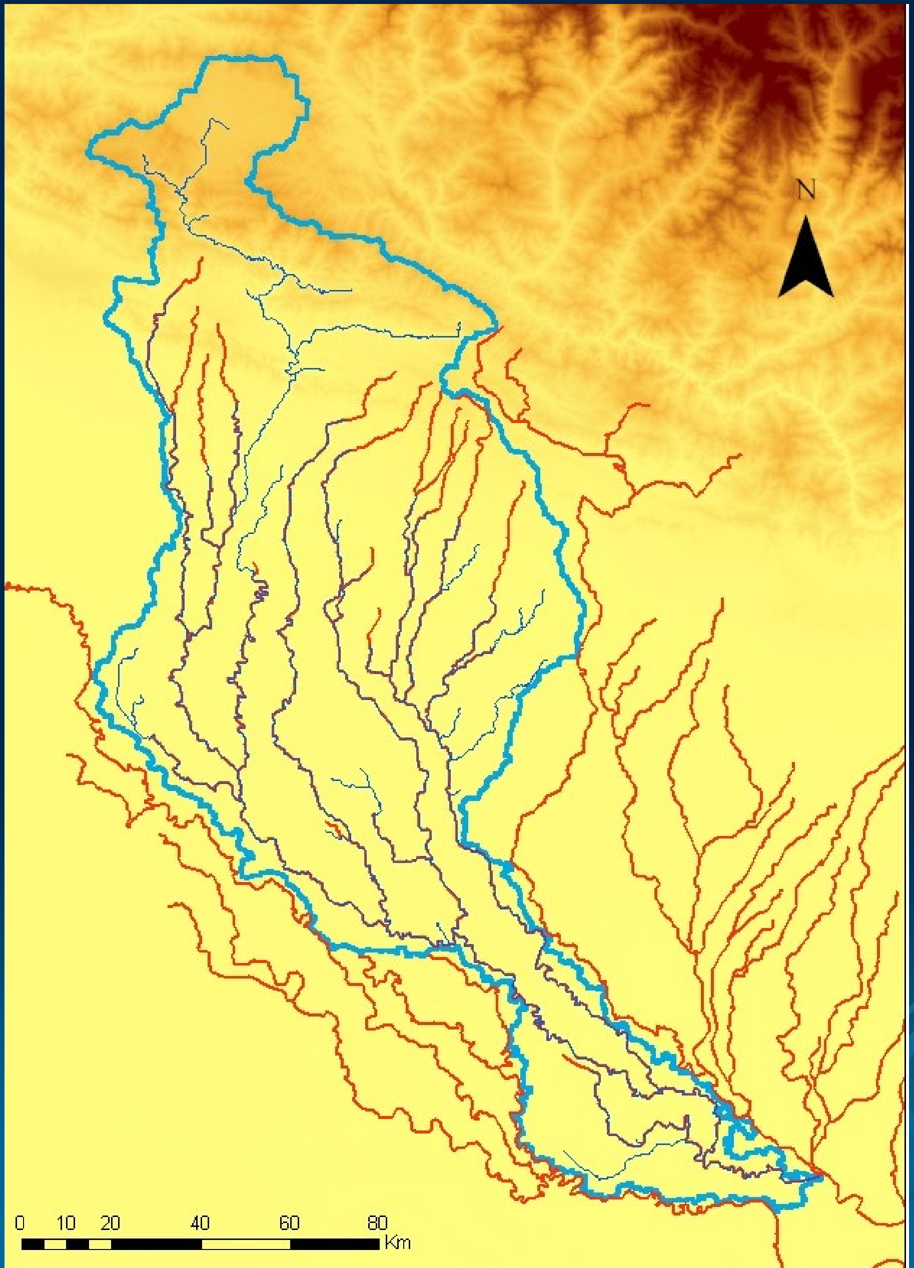
Max. Elevation: 2913

Mean. Elevation: 103

Std. Deviation: 318

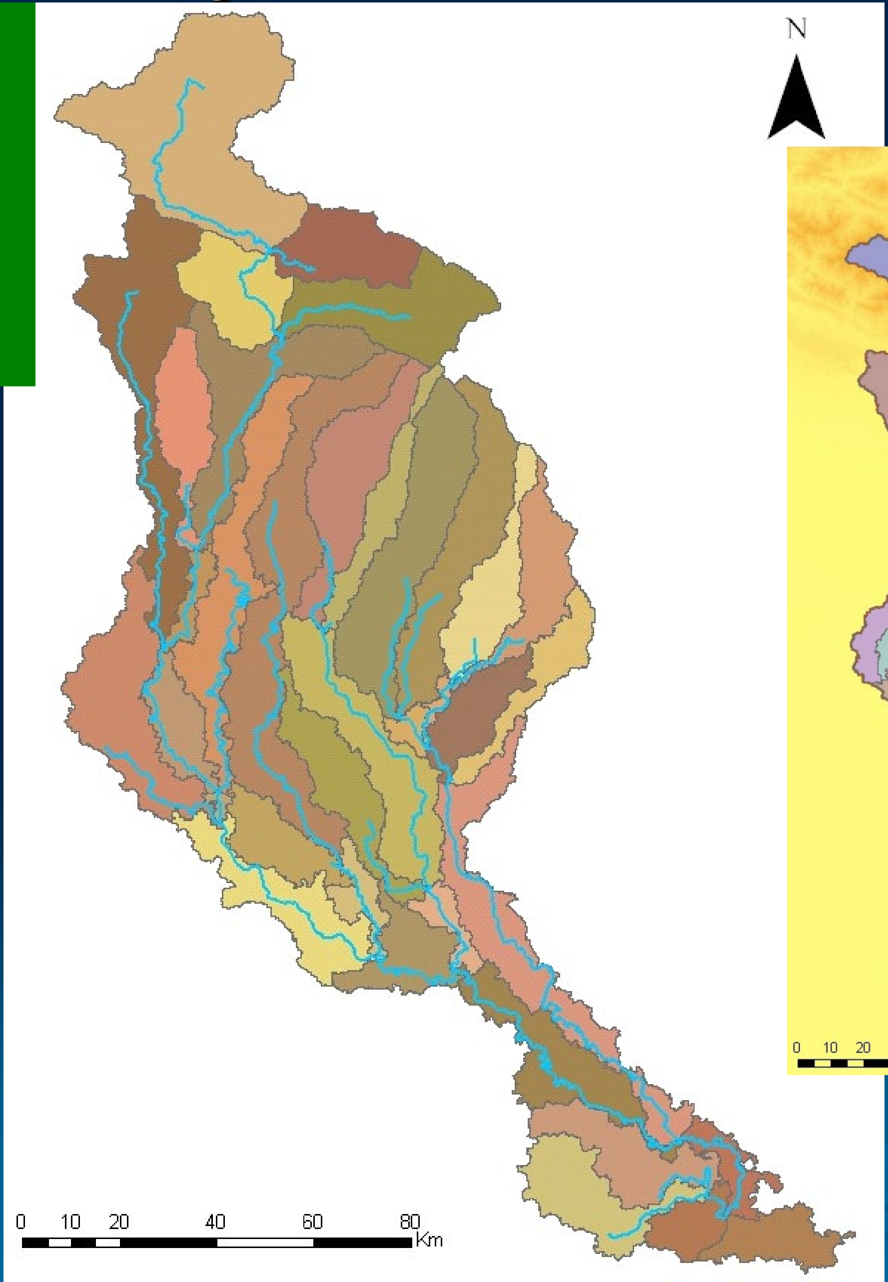


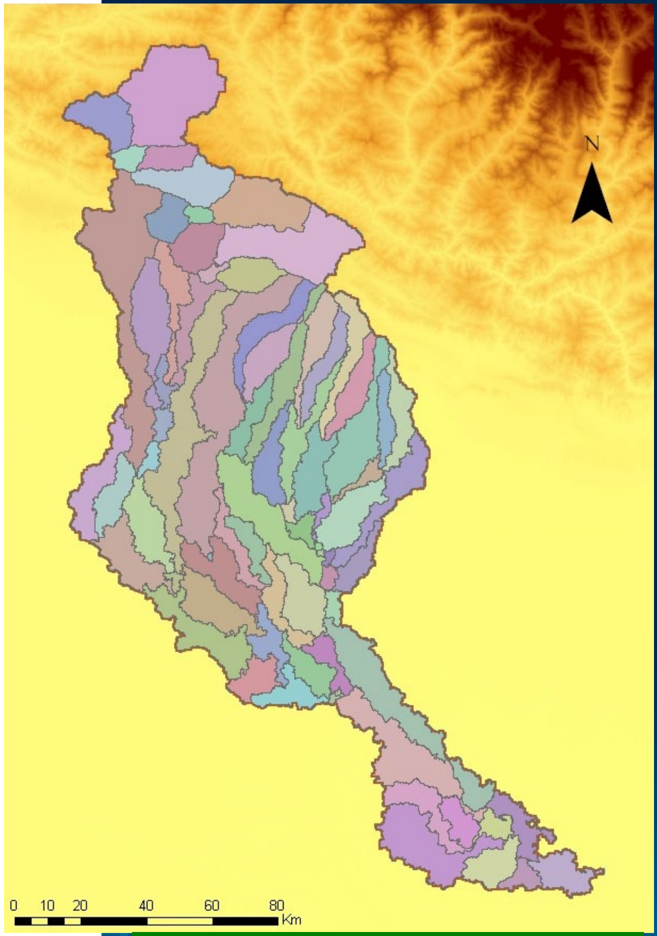
Drainage Network



Automatically Delineated Sub-basins

Summary
Threshold: 25000 ha
No of Sub basins: 37
Area: 1532353 ha
India: 6500 sq km
Nepal: 7884 sq km





Summary
Threshold: 10000 ha
No of Sub basins: 77

Land use - Global

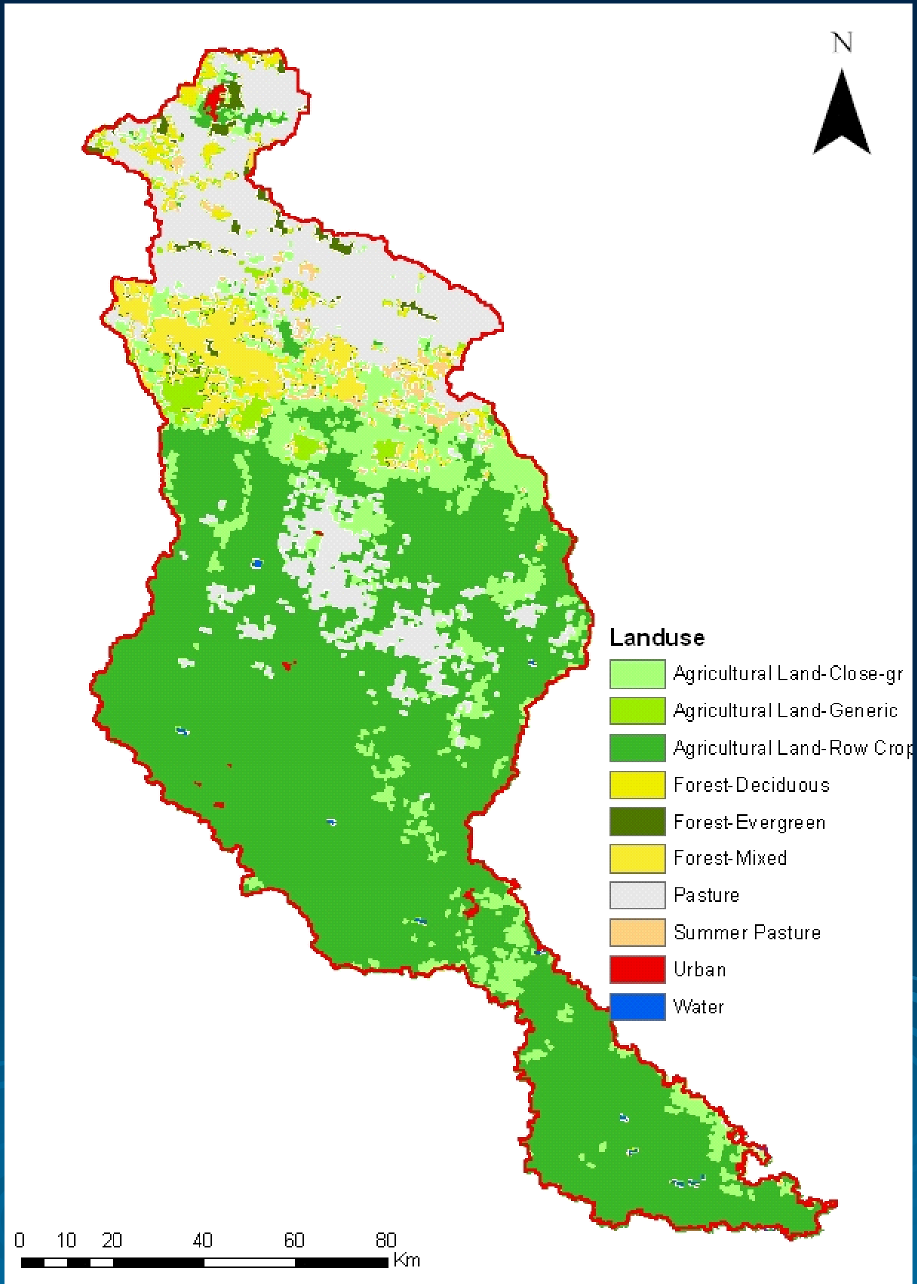
Land Use	% Watershed Area
Agricultural Land-Row Crop	60.24
Pasture	17.79
Agricultural Land-Close-gr	11.45
Forest-Mixed	3.9
Forest-Deciduous	2.3
Agricultural Land-Generic	1.54
Summer Pasture	1.21
Forest-Evergreen	1.06
Urban	0.3
Water	0.2

<u>Summary</u>

Agriculture : 73 %

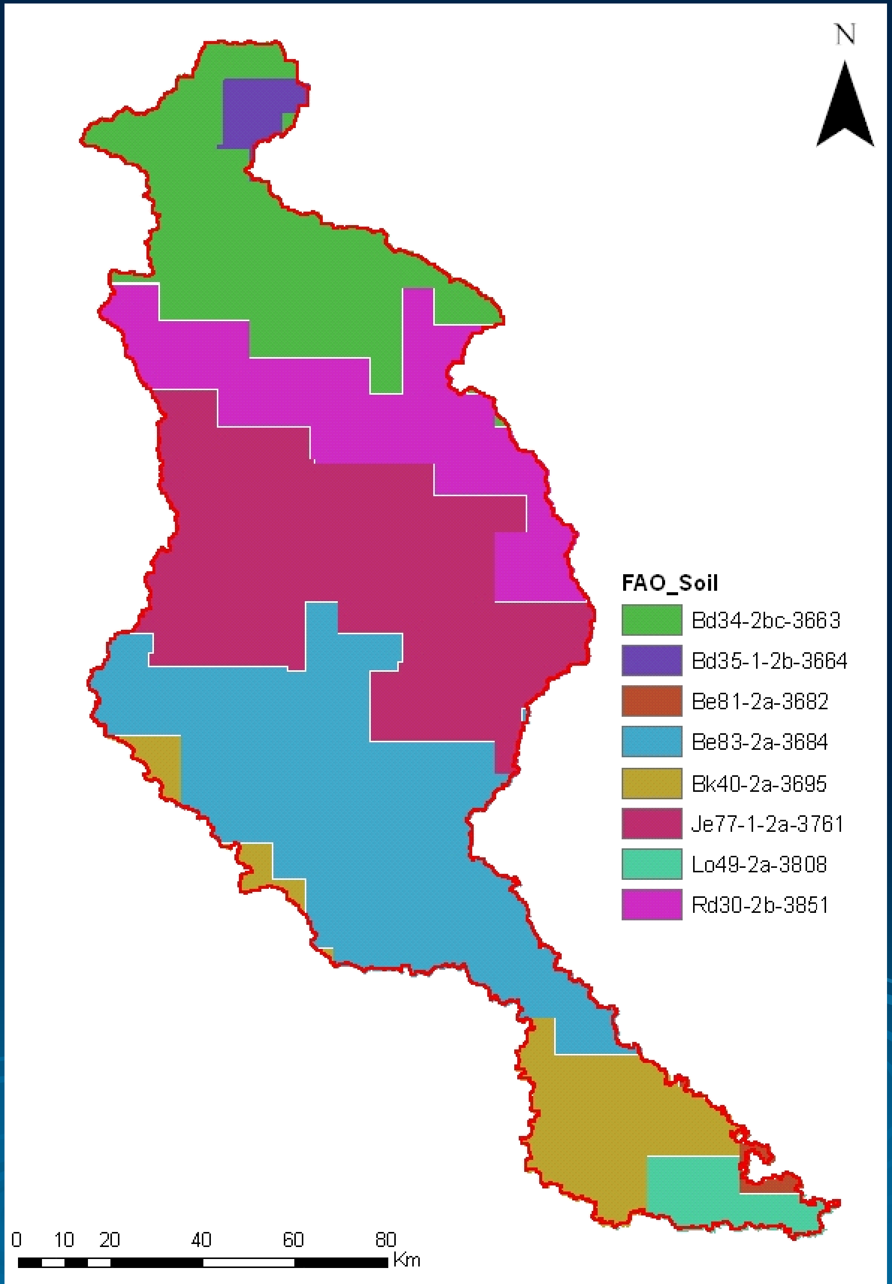
Forest : 7 %

Grassland : 18 %

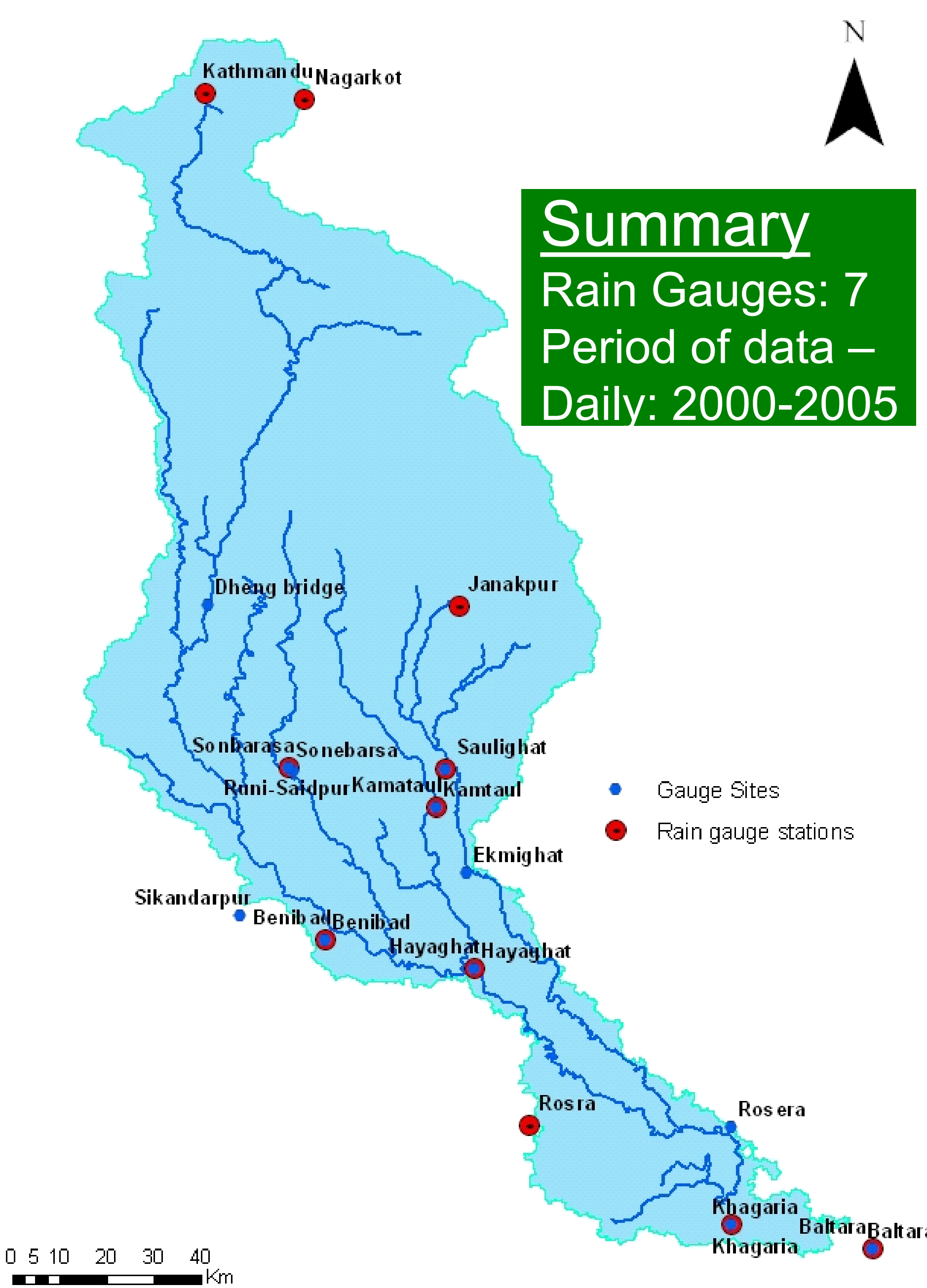


Soil – FAO Global

Soil Taxonomy - Main	Percentage Area
Be83-2a-3684	28
Je77-1-2a-3761	28
Bd34-2bc-3663	17
Rd30-2b-3851	14
Bk40-2a-3695	9
Lo49-2a-3808	3
Bd35-1-2b-3664	1



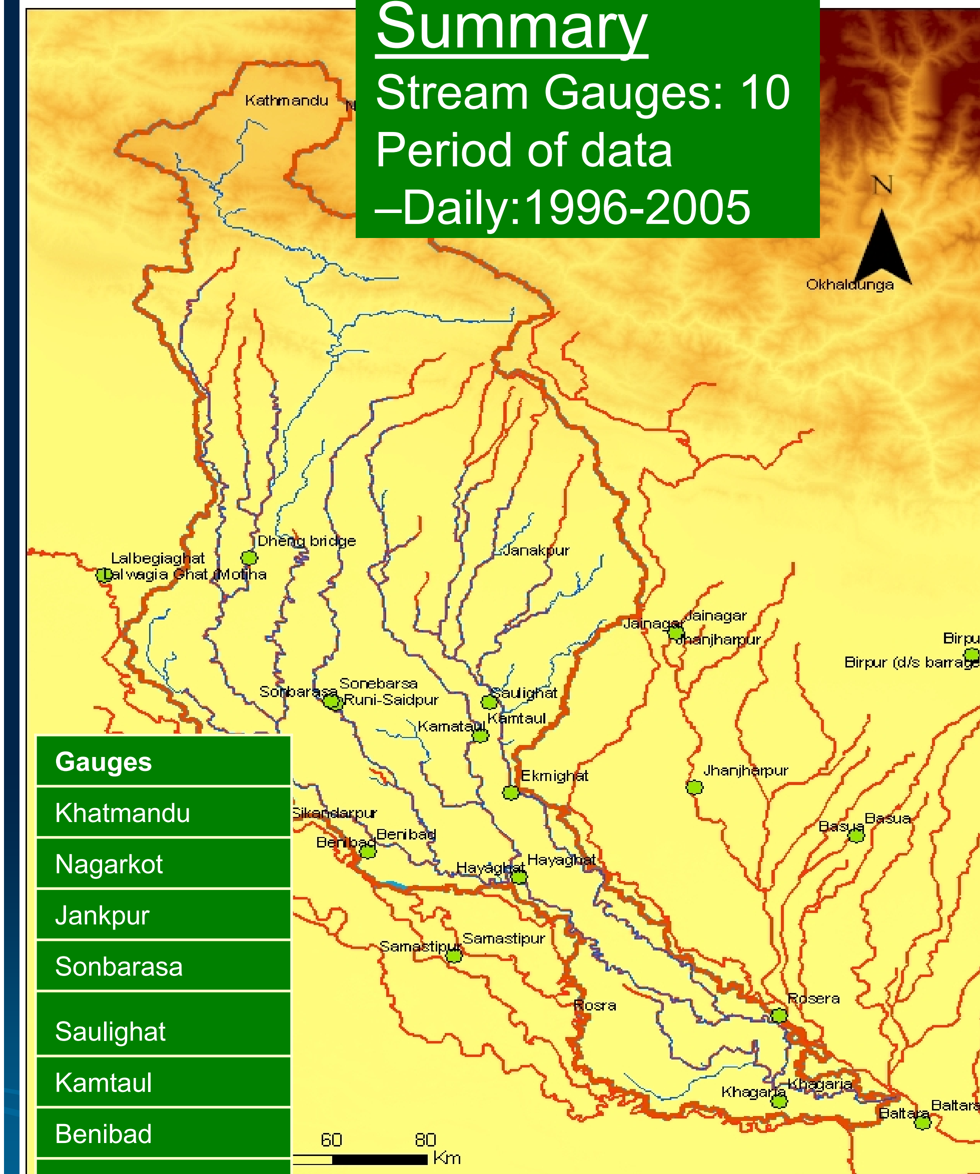
Weather Stations



Summary

Rain Gauges: 7

Period of data – Daily: 2000-2005



Summary

Stream Gauges: 10

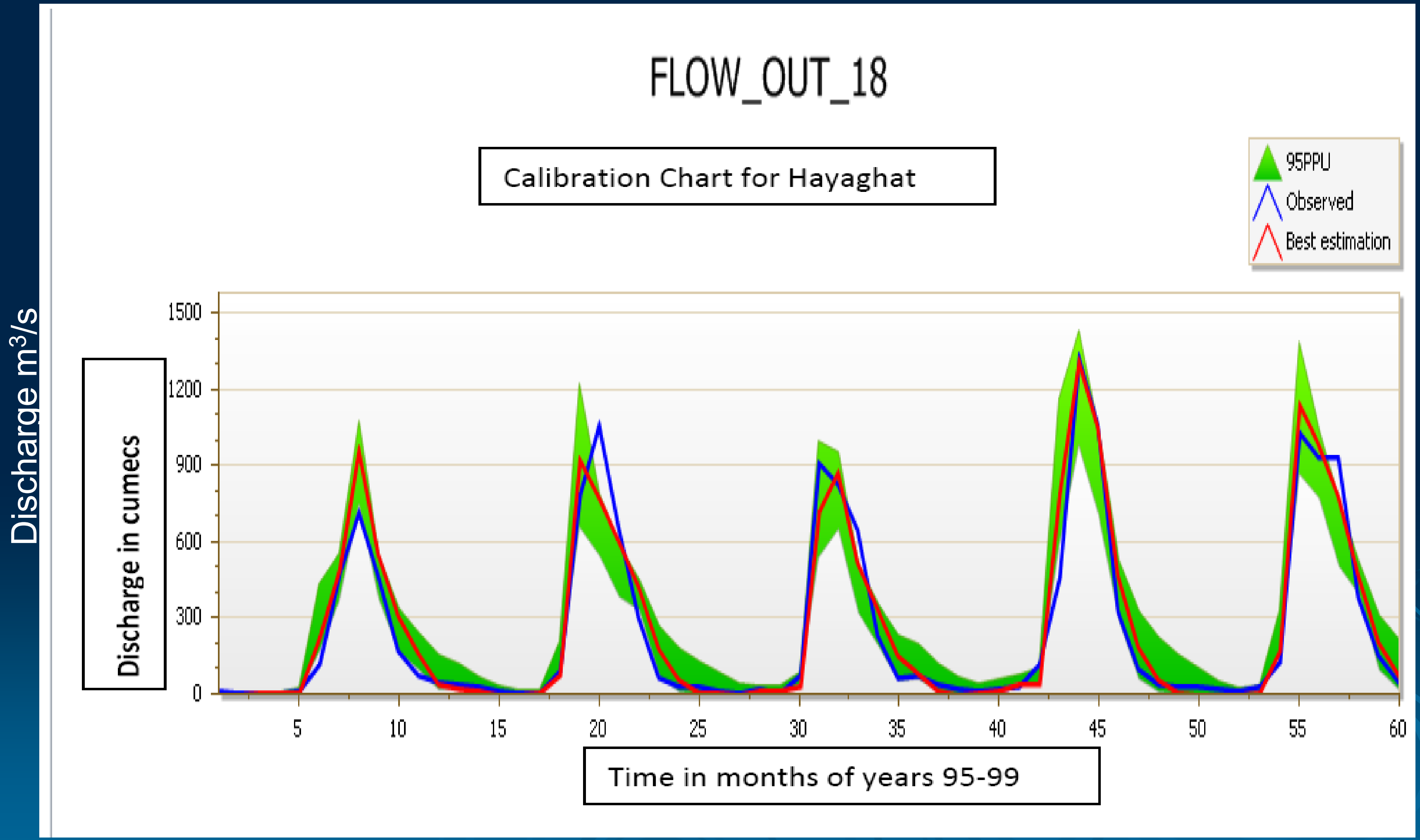
Period of data –Daily:1996-2005

Gauges
Khatmandu
Nagarkot
Jankpur
Sonbarasa
Saulighat
Kamtaul
Benibad
Hayaghat
Khagaria
Runi Saidpur

Soil Details

SEQN	SNAM	NLAYERS	HYDGRP	TEXTURE	SOL_AWC1	SOL_K1	CLAY1	SILT1	SAND1
3663	3663	2	C	LOAM	0.117	35.65	24	35	42
3664	3664	2	C	LOAM	0.157	28.52	17	36	47
3682	3682	2	D	LOAM	0.175	7.77	24	36	40
3684	3684	2	C	LOAM	0.175	13.92	22	38	41
3695	3695	2	C	LOAM	0.175	14.96	20	40	40
3743	3743	2	D	LOAM	0	6.48	18	44	38
3761	3761	2	C	LOAM	0.175	24.73	20	34	46
3808	3808	2	D	LOAM	0.175	6.17	21	35	44
3851	3851	2	D	CLAY_LOAM	0.137	7.17	27	35	37

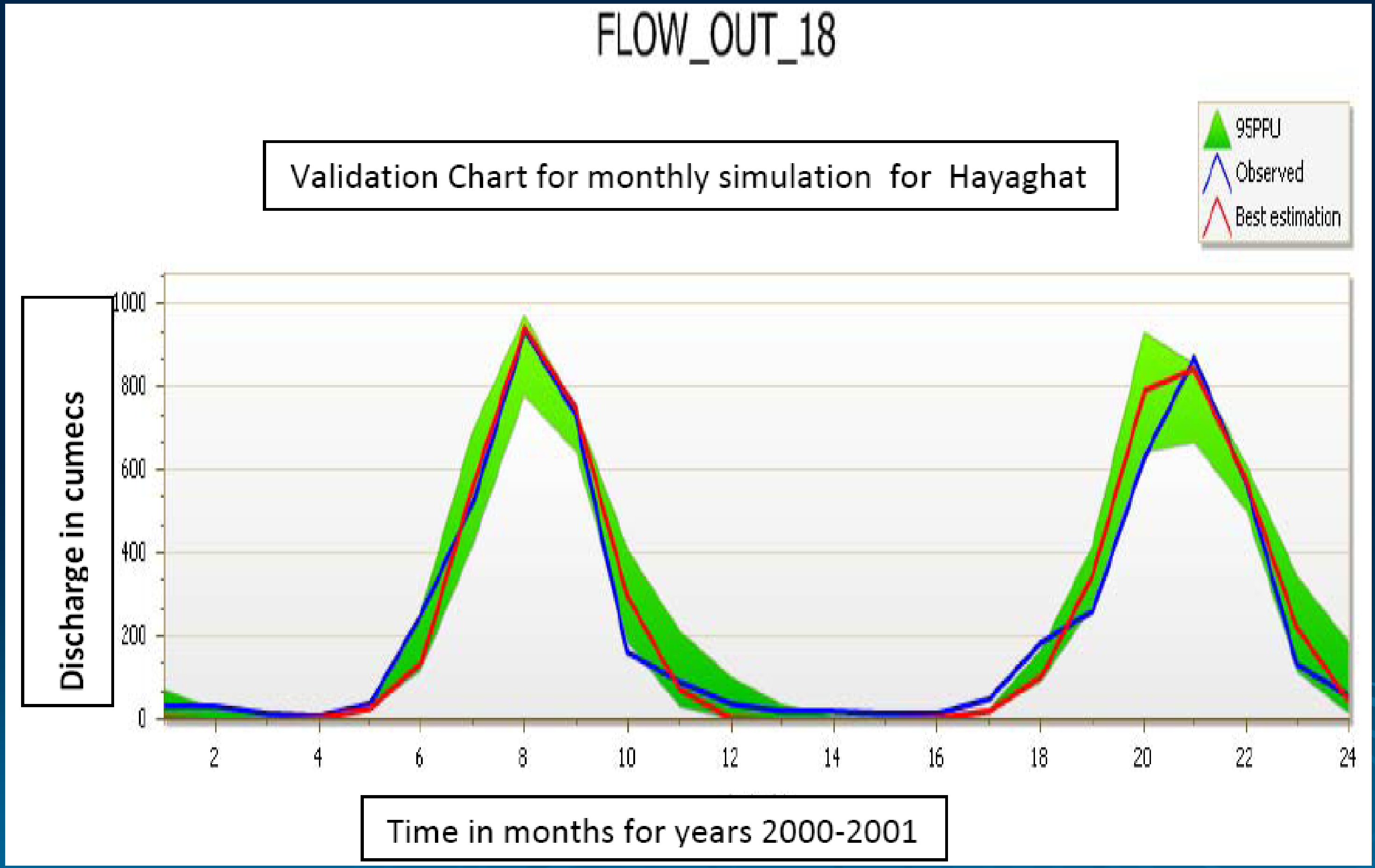
Calibration - Output



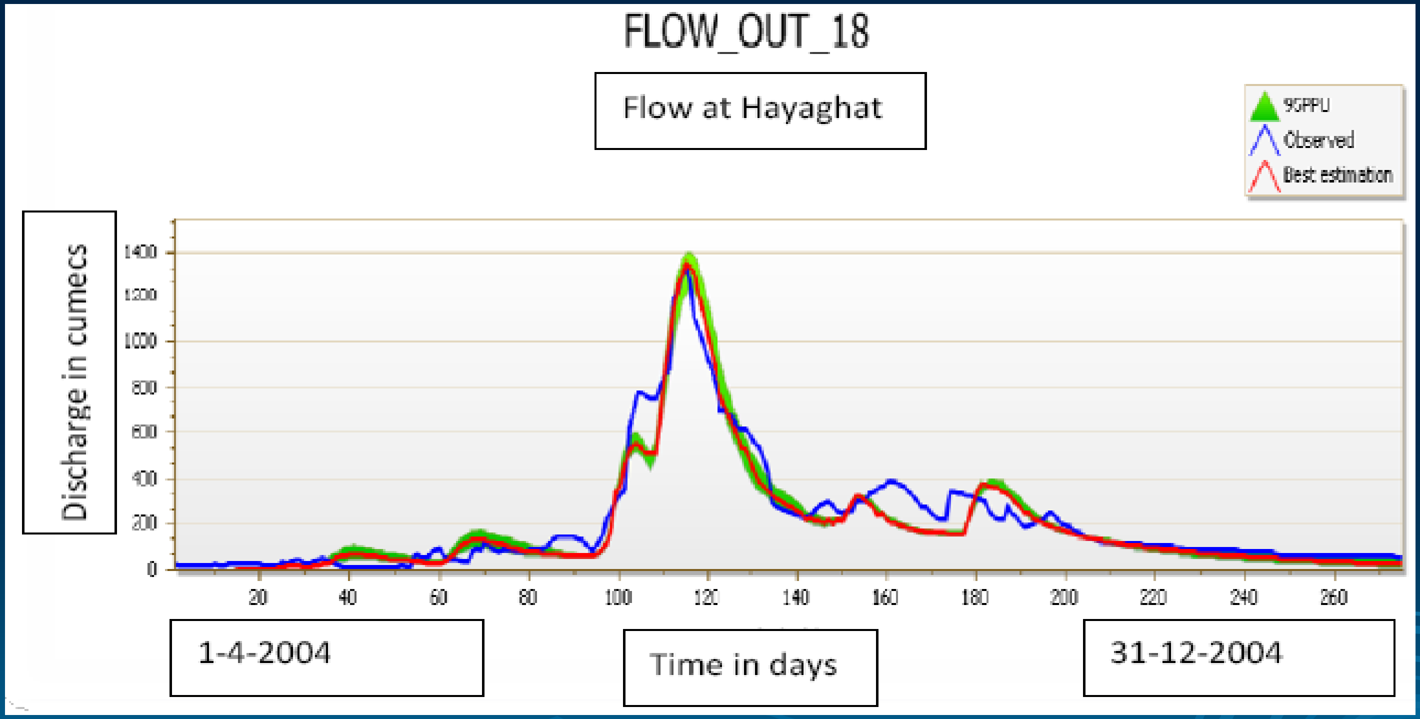
Calibration Results

- Seventeen parameters were selected for sensitivity analysis, calibration, validation and uncertainty analysis to be carried out by SWAT-CUP4 using SUFI algorithm. On the basis of global sensitivity analysis it can be concluded that most sensitive parameter is CN2.mgt followed by GW_DELAY, CH_N2.rte, ESCO.hru, HRU_SLP.hru, GWQMN.gw, GW_REVAP.gw and SURLAG.bsn.
- P-factor and r-factor for calibration were found to be 0.74 and is 0.44 respectively, which are very much within the range recommended for a perfect model. Seventy four percent observed and simulated values lie in 95PPU.
- P-factor and r-factor for validation period are 0.63 and 0.36 respectively which are satisfactory. Nash-Sutcliffe coefficient for calibration period for Hayaghat gauge station was found to be 0.95 which indicates best performance of the model. Nash-Sutcliffe coefficients for validation of the model for daily simulation for years 2004 and 2010 were found to be 0.93 and 0.91 respectively.
- $R^2 = 0.96$

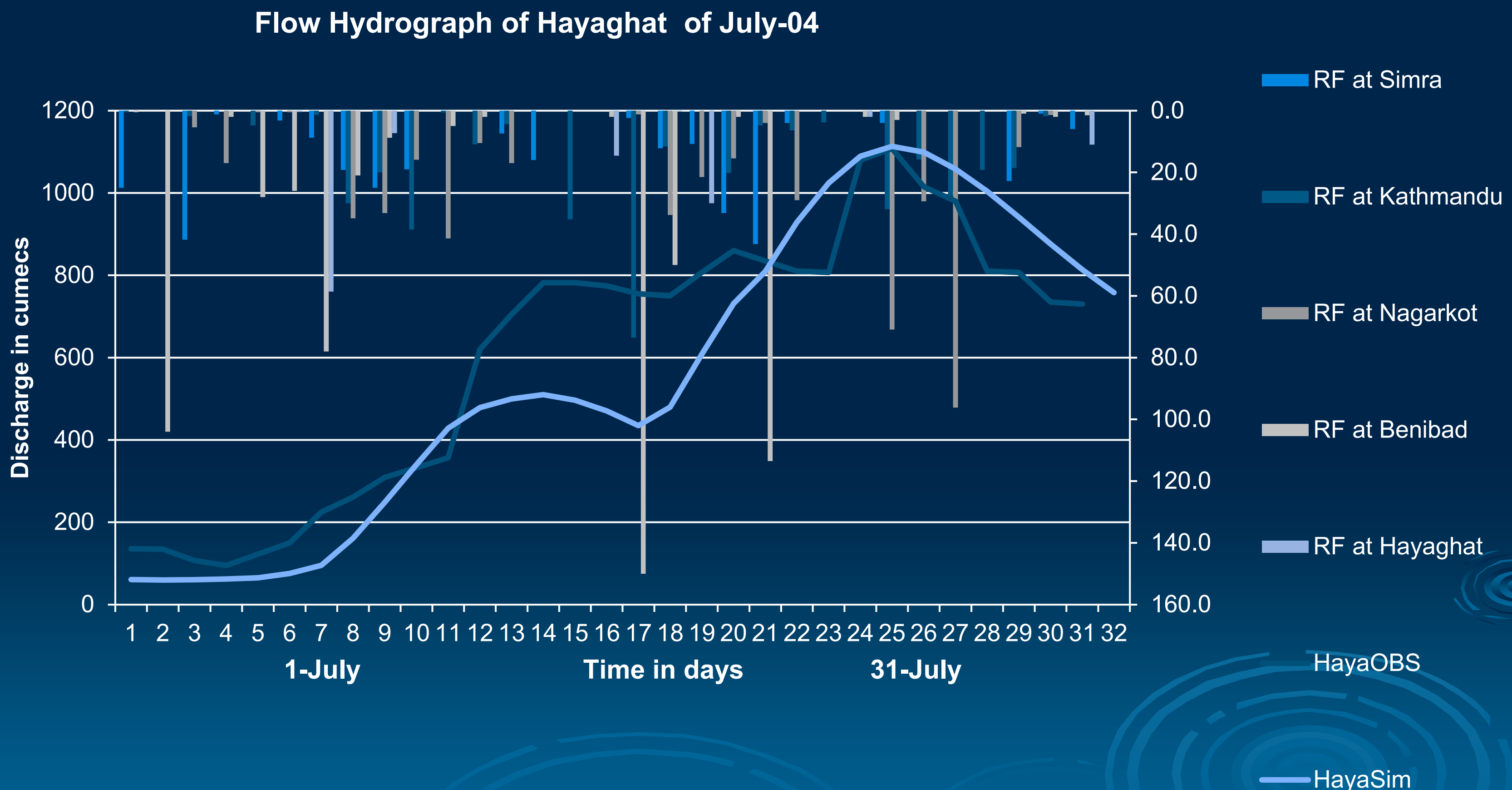
Validation for monthly flow



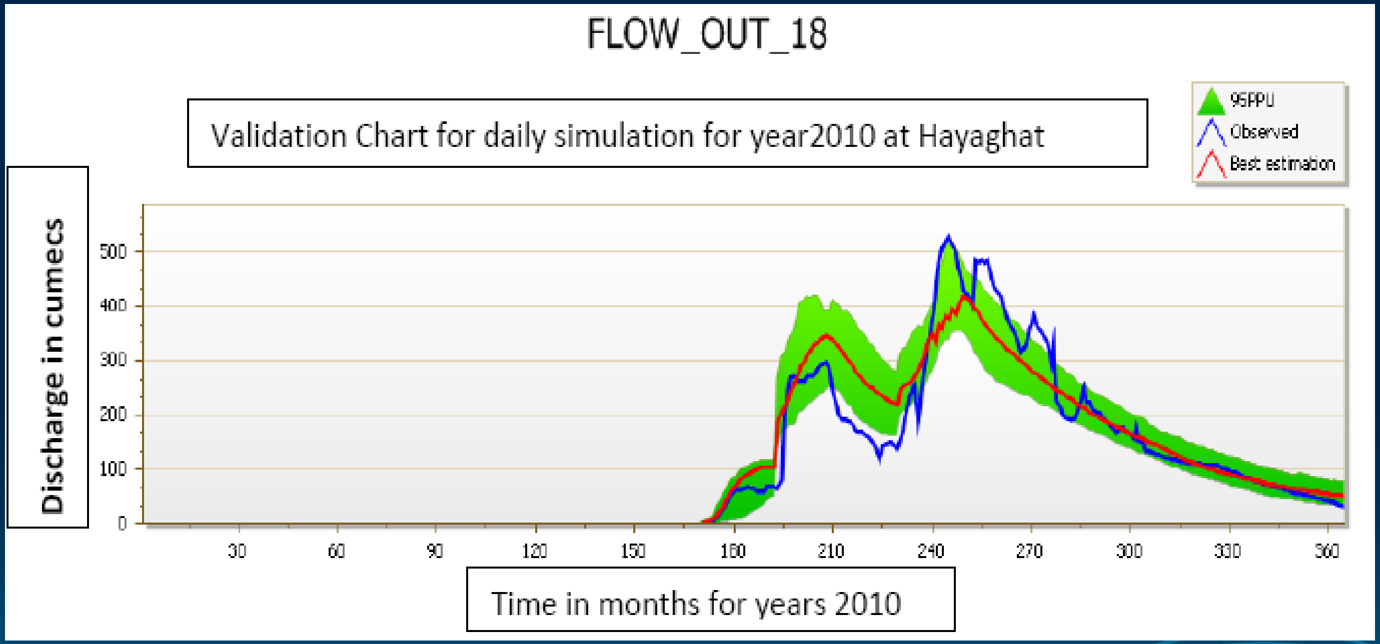
Daily Flow Valdation



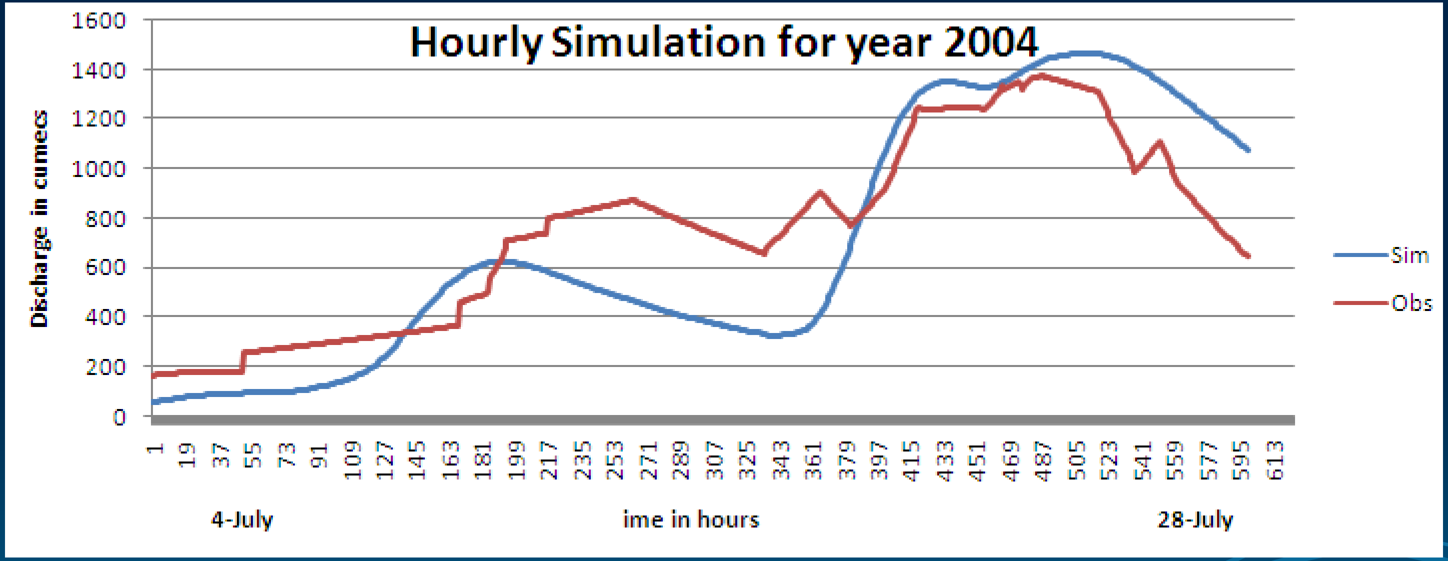
Flow Hydrograph Daily Simulation



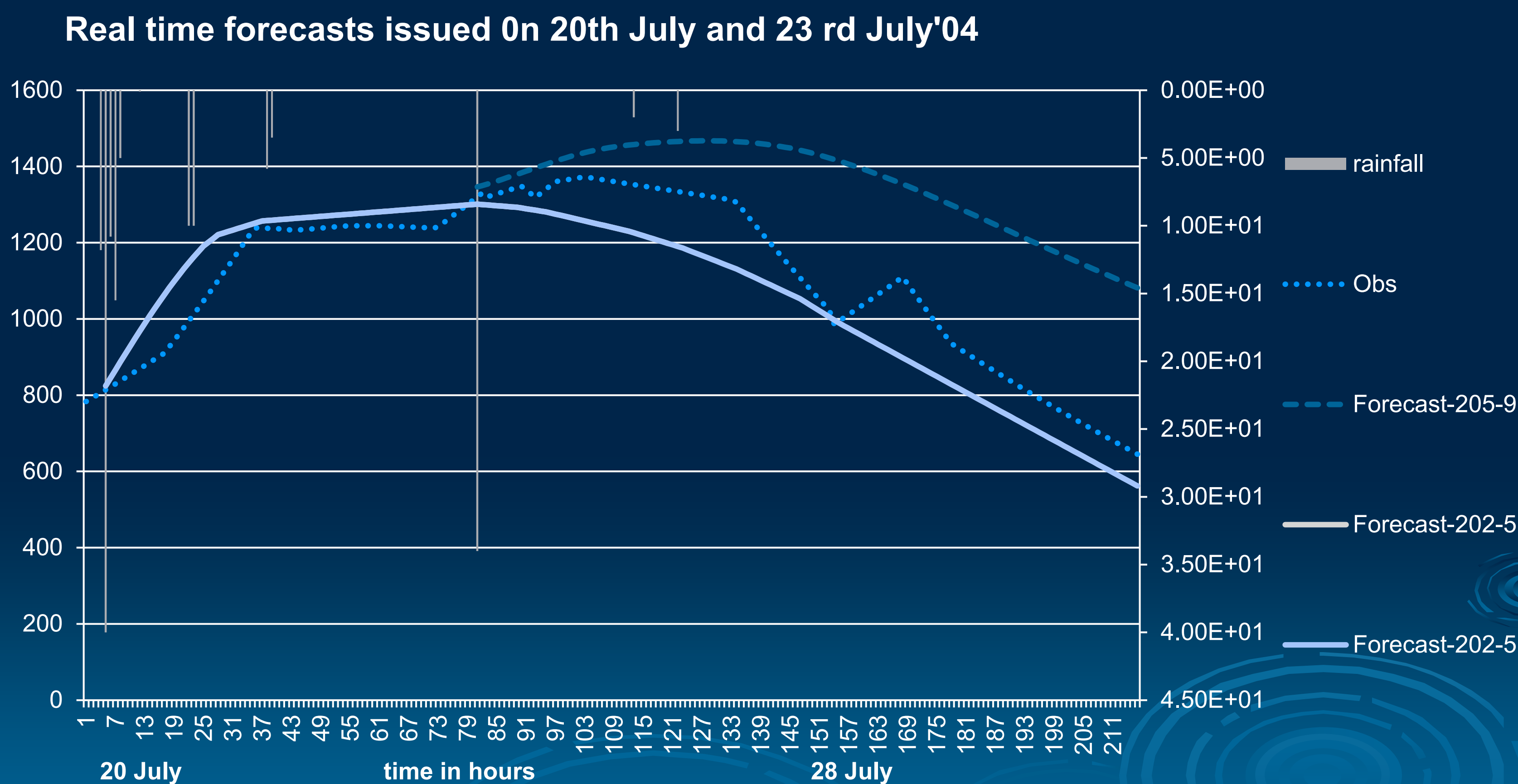
Valdation for daily flow 2010



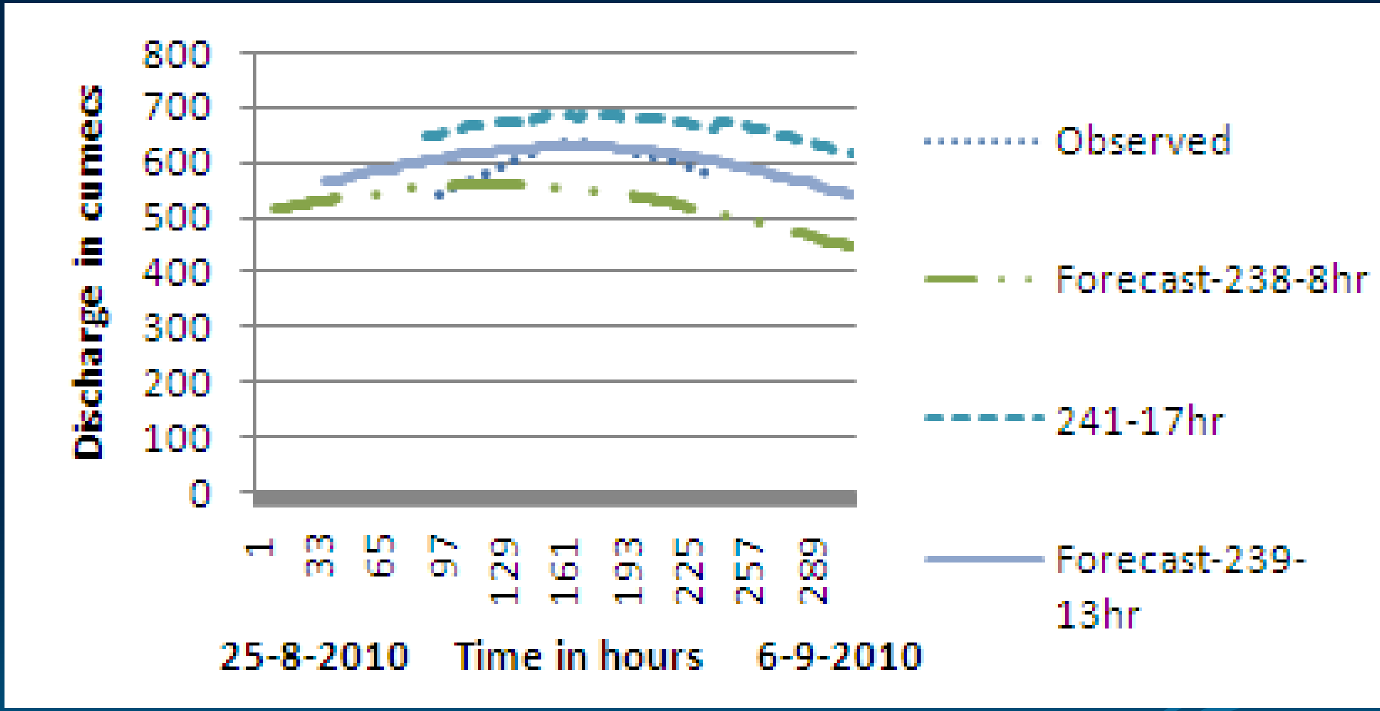
Validation for hourly flow NE = 0.72



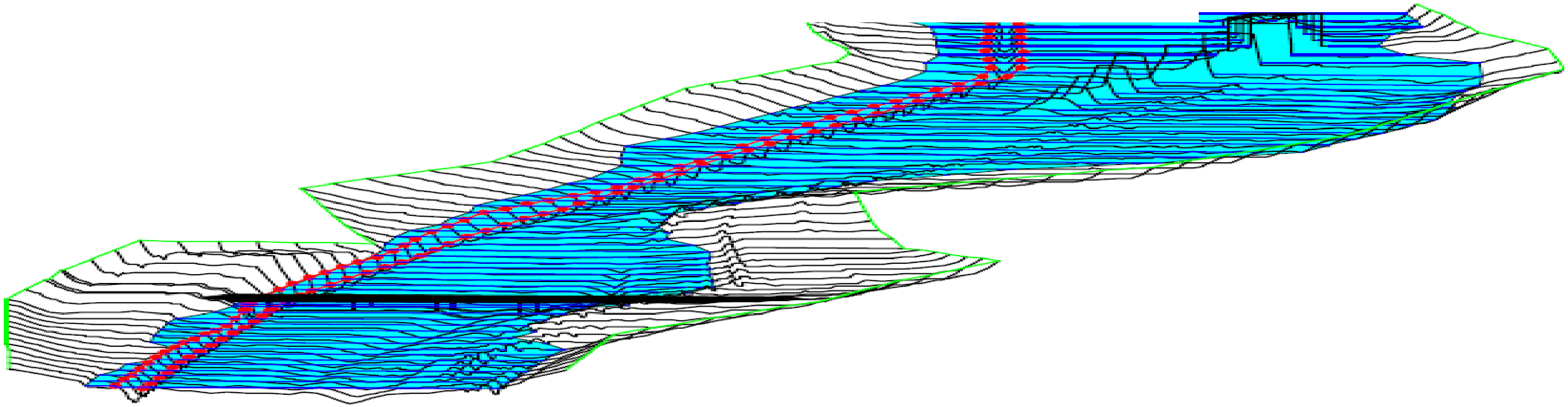
Real time forecasting graphs for 2004 Flood Event



Real time forecast for 2010 Flood event



HEC-RAS
River Analysis System



Inundation mapping using HEC-RAS and SWAT Model

Reach lengths, bank lengths in between cross-sections, cross sections etc. are derived from SRTM DEM

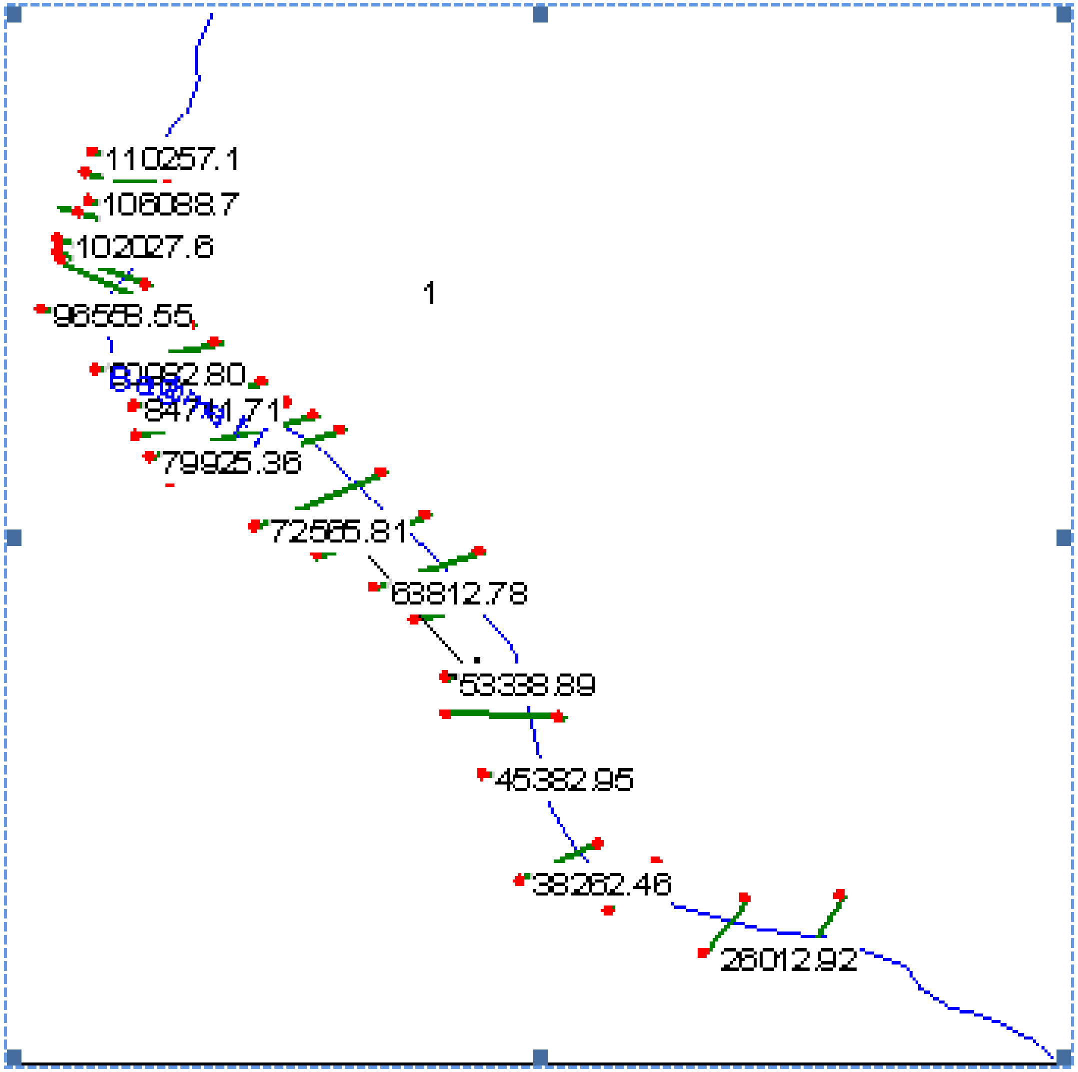


Figure 7.1 Cross section positions of Bagmati Reach between Dheng Bridge an Hayaghat Without bank lines

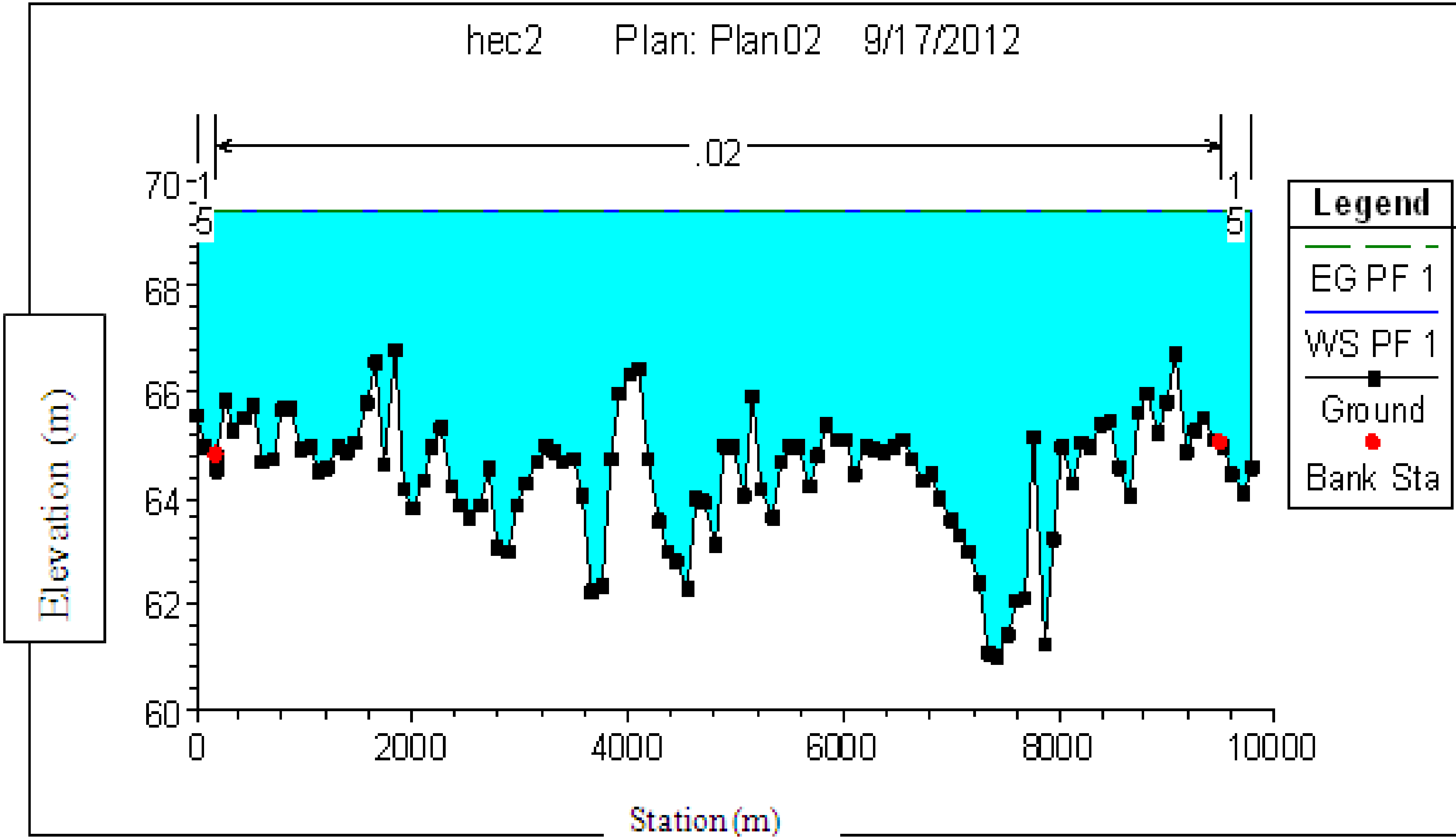
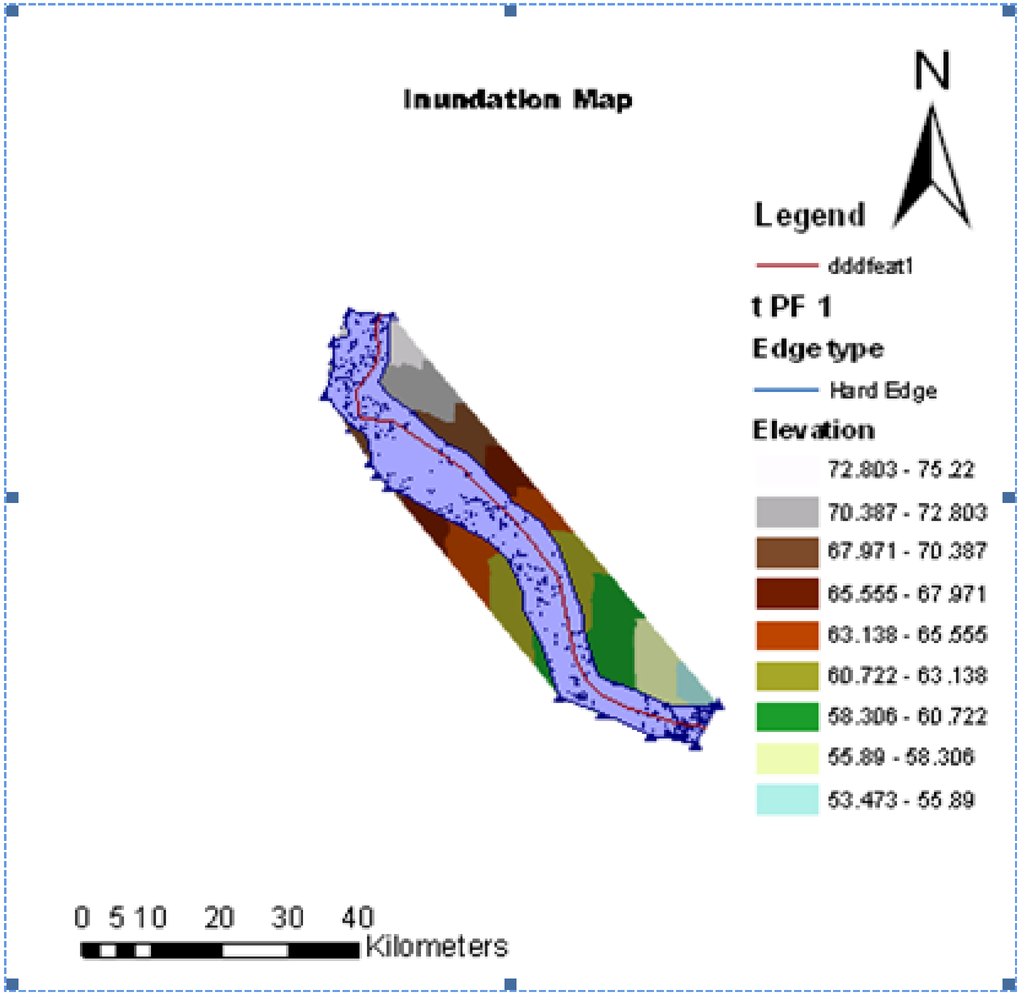


Figure 7.7 Typical cross sections of Bagmati river at 20km downstream of Dheng bridge

FLOOD INUNDATION MAPPING



CONCLUSIONS

Non-structural aspects combined with structural measures will give a better flood management policy for integrated flood management planning.

Modified SWAT model combined with HEC-RAS hydraulic model can be used as an efficient tool for real-time flood forecasting, inundation mapping and flood hazard zoning.

Suggested Components of Integrated Flood Management for future

- **Natural resources management (including water resources for domestic, agriculture, fishery, and industry**
- **Land use management (agriculture, industry, dwelling, urban development, etc)**
- **Environmental management (conservation and modification)**
- **Risk management policies, and**
- **Social development issues (living conditions, level of poverty, equity and fairness principles)**

Questions to be answered for framing Flood Management Policy

- **What role do the flood plains play in the economy of the country/region?**
- **What issues in National development vision/policy have relevance to the condition of floods or flooding and its management?**
- **How flood management can contribute to the national development?**

Questions to be answered for framing Flood Management Policy

- **How flood risks can be appropriately factored in national development planning?**
- **How national development vision/policy should be aligned to the existing and future flood risks?**
- **How flood risks are shared between federal, state, and local governments on one hand and the individual on the other?**
- **What role do the different institutions play in flood management?**

END

Thank You