WEB BASED WATER RESOURCE INFORMATION SYSTEM USING SWAT MODEL

Presented by

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VISION

Optimum and sustainable utilization of water resources by different line departments with active involvement of stakeholders for efficient and effective management of flood, drought and drinking water.

MISSION

- **To develop a comprehensive website for hydro-meteorological data and water resource information system (WRIS)**
- **To develop a flood management information system (FMIS) for Bihar state**
- **To develop a drought management information system (DMIS) for Bihar state**

INTRODUCTION

- The available river waters would fall short of demand in near future due to increase in the demand for water for domestic, industrial and municipal uses as a result of the development of civilization and the growth of cities.
- The struggle to obtain adequate supplies of water for both large and small communities has continued to the present times.
- India supports 1/6th of the world population with about 1/15th of the world's land and only 1/250th the world water resources.
- India would have to lay serious consideration for fast emerging crisis in water related areas and adopt proper strategies to ensure integrated water resources management including floods and droughts.

INTRODUCTION

- The erratic behaviour of Indian monsoon causes almost each year droughts and floods to occur simultaneously, sometimes even within the same state.
- The impact of floods is stronger today than ever because of rapid increase in population and resulting industrial and agricultural development and increasing occupation in the flood plains.
- The flood damage continues to show an increasing trend despite the introduction of substantial structural (embankments) and non–structural flood control measures during past several decades in the country.
- It is a big challenge in India to properly moderate floods and droughts together.

IMPORTANT FLOOD EVENTS

- Event-1 -The man-made embankments of river Kosi failed and Flooded north Bihar, India during 18 August 2008 434 Dead bodies were found until 27 November 2008
- Event-2-In June 2013, a multi-day cloudburst centered on the North Indian state of Uttarakhand caused devastating floods and landslides in the country's worst natural disaster since the 200 4 tsunami more than 5,700 people were "presumed dead. Destruction of bridges and roads left about 100,000 pilgrims and tourists trapped in the valleys
- Event-3In September 2014, Heavy Rainfall centered on the North Indian state of Jammu and Kashmir caused devastating floods and landslides in the country's worst natural disaster since the 1944 Kashmir Flood Disaster. More than 700 people were "presumed dead. Destruction of bridges and roads left about more than 100,000 pilgrims and tourists trapped in the valleys

Challenge for Water Resource Engineers and Scientists

- Today, with modern equipments and radars we should be able to develop a web based water information system for predicting floods (expected inundation) and droughts much earlier and stop human disasters.

- Remote sensing, GIS and mathematical modeling can be used for developing comprehensive flood management information system and drought management information system.

- SWAT scientists can do this job

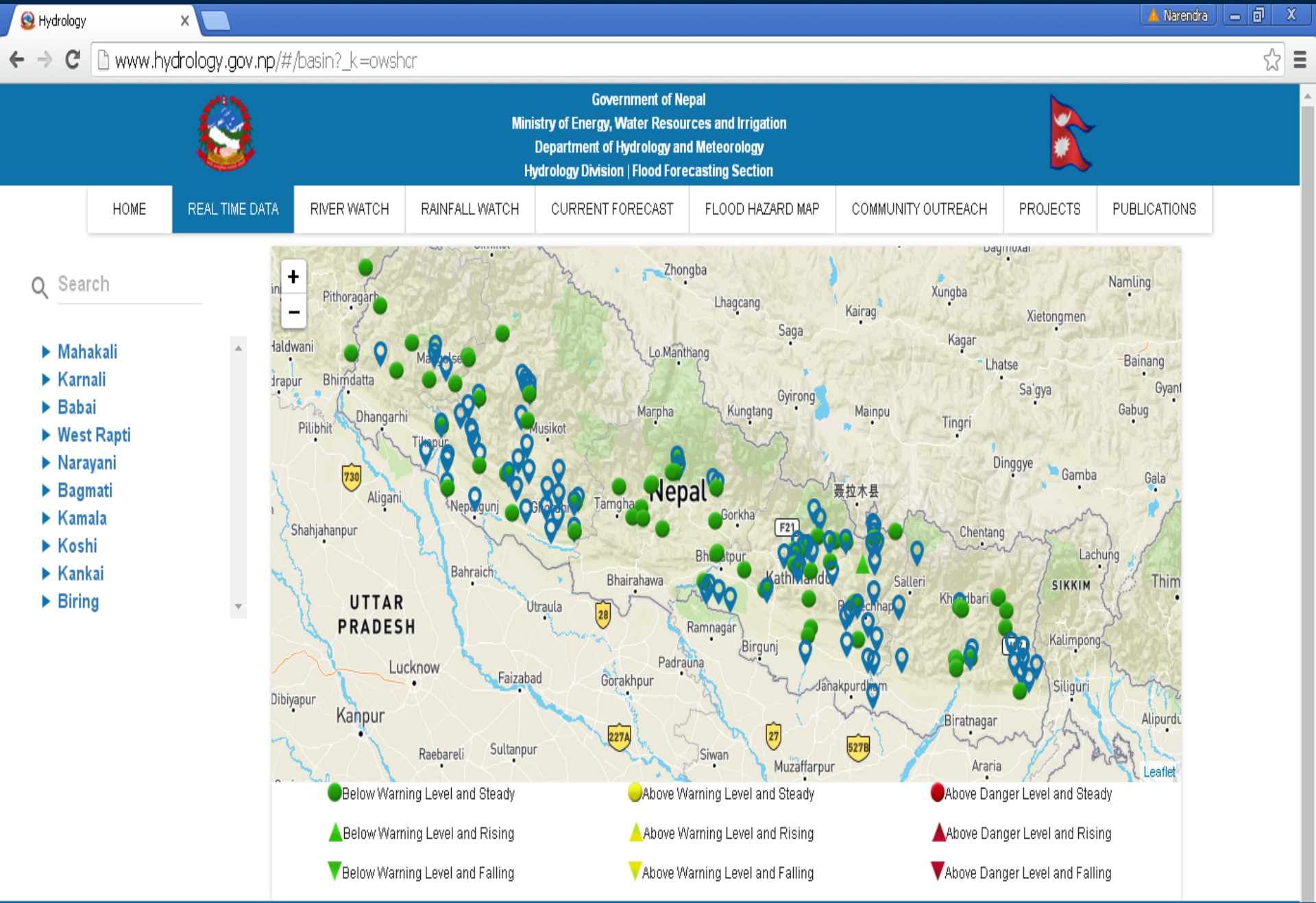
Objectives of the present study

- To develop a web based flood management information system for Bagmati river basin,Bihar, India
- Using Remote sensing, GIS and mathematical modeling for real time flood forecasting and inundation mapping
- Downloading hydro-meteorological data for mathematical modeling from following websites:
- www.imdaws.com/ViewAwsData.aspx,
- www.hydrology.gov.np/new/bull3/index.php/hydrology/Station
- www.fmis.bih.nic.in/Daily_FloodBulletin.html.

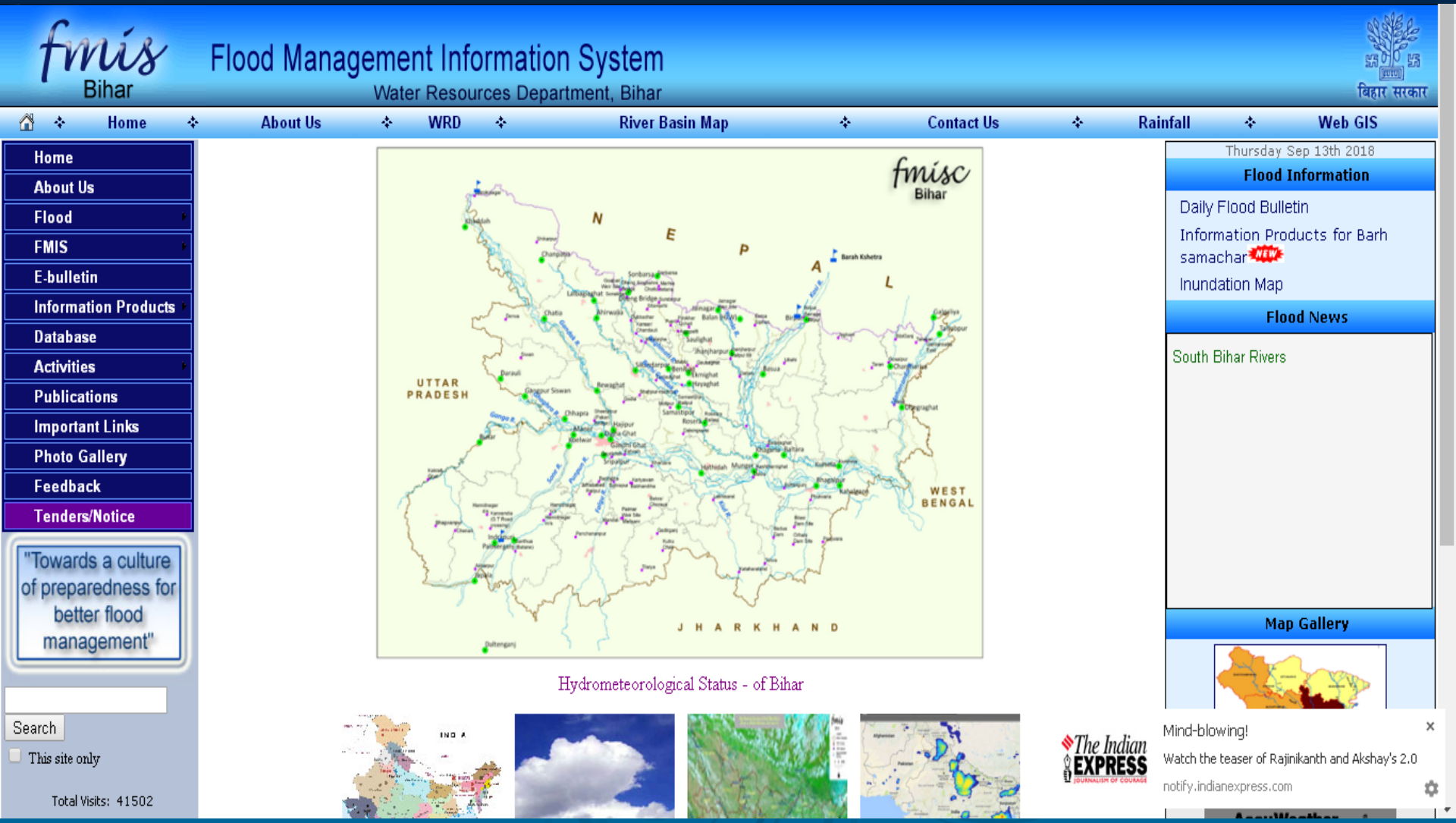
WEBSITES FOR HYDRO-METEOROLOGICAL DATA OF STUDY AREA

www.imdaws.com/ViewAwsData.aspx,

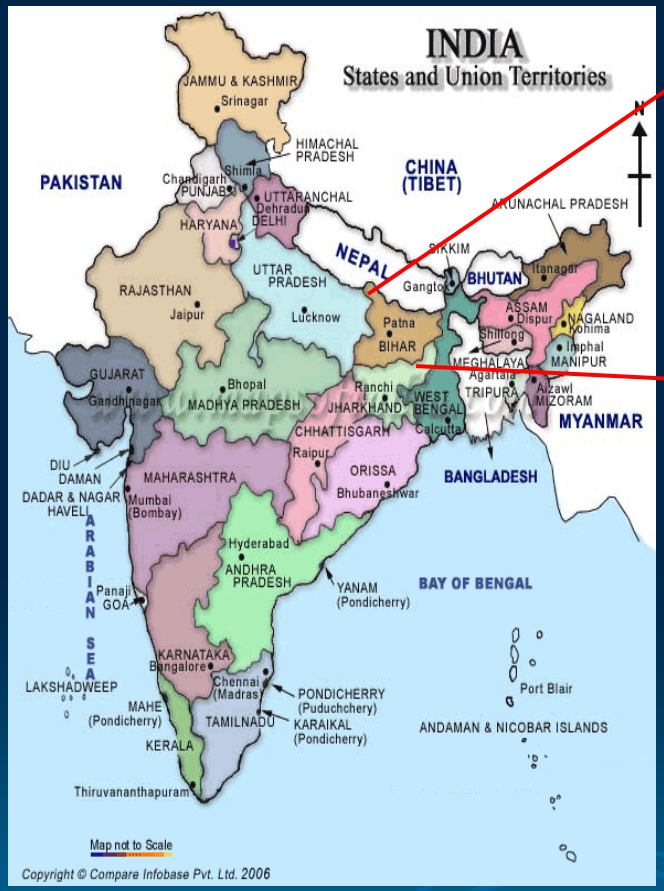
www.hydrology.gov.np/new/bull3/index.php/hydrology/Station

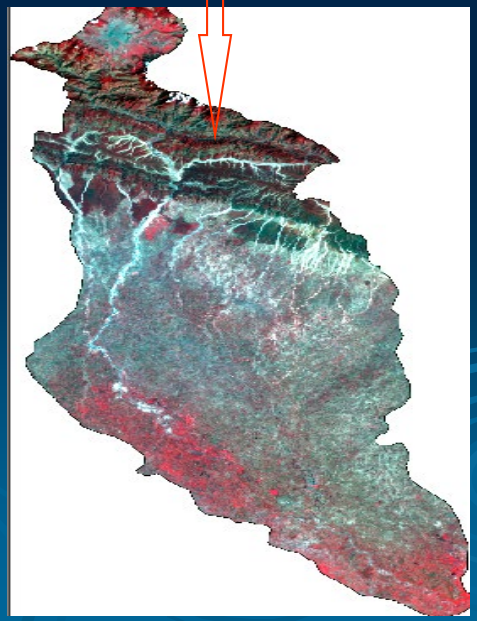


www.fmis.bih.nic.in/Daily_FloodBulletin.html. Real time data can be downloaded during flood season



Study Area – Bagmati river Basin of Bihar, India

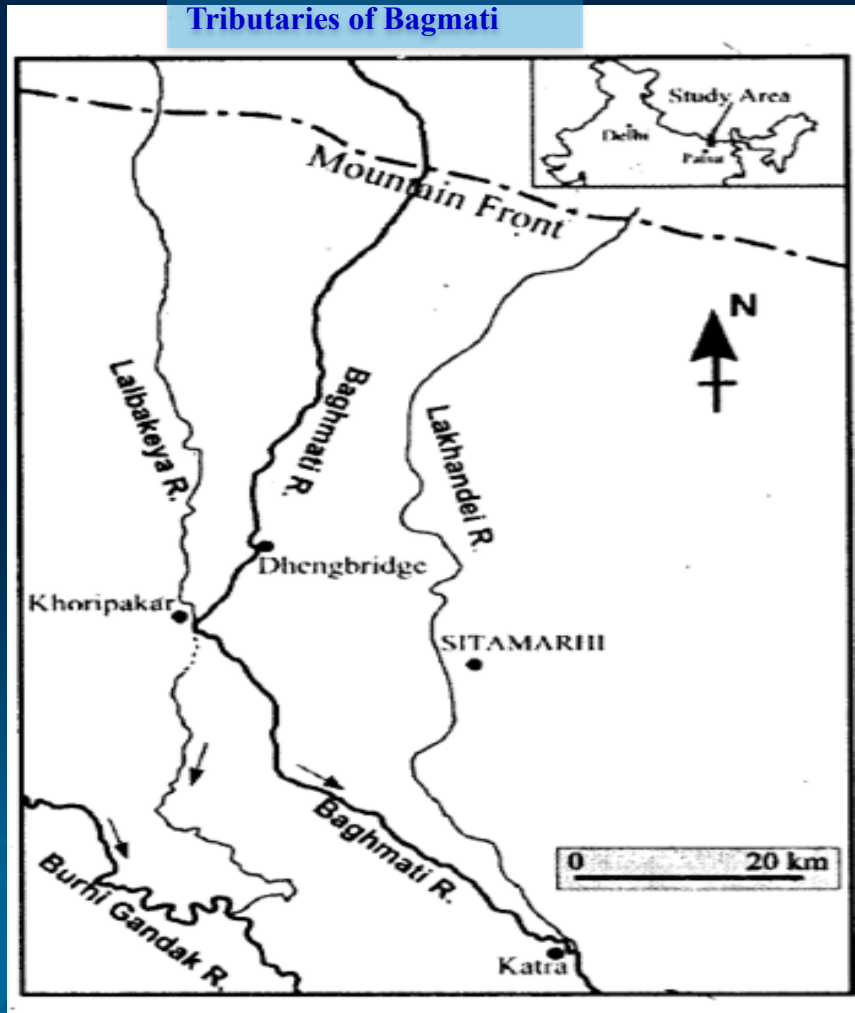




Description of Study Area

Bagmati river basin is geographically located at 25°15' to 27°11'E and 85°15' to 86°20'N in Bihar, India.

Tributaries of Bagmati



Salient features of the Bagmati Catchment

❖The river has Himalayan origin and considerable portion of its catchments lie in the glacial region in Nepal. It is, therefore, snow-fed and perennial in flow. Every year intensively flooded damaging agriculture.Population in Bihar: 5.530Millions, Population density: 1551 persons per Sq Km

❖Tributaries: Lalbakeya (R), Lakhandei (L)

❖ Drainage Area in Bihar: 6500 Sq Km, Cropped Area in Bihar: 5362 Sq Km ;Total length of main river in Bihar: 394 Km ;Elevation range 22 - 2913 m

❖ Annual precipitaion of 1255 mm ((80%) within mid June – mid October);Mean annual flows: 2184.4 MCM.

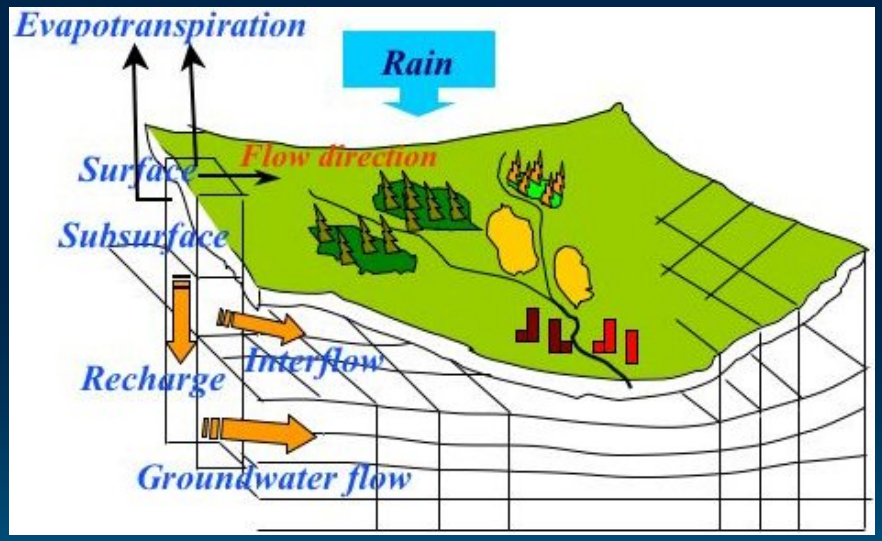
❖Landuse:Net area under cultivation (67%), miscellaneous trees and groves (4.21%), fallow(16%),

❖Soil: The terraces in the Terai comprise of clay, sand and gravels. The hills at the flanks comprise conglomerates and thick beds of sand, rock and shoals.

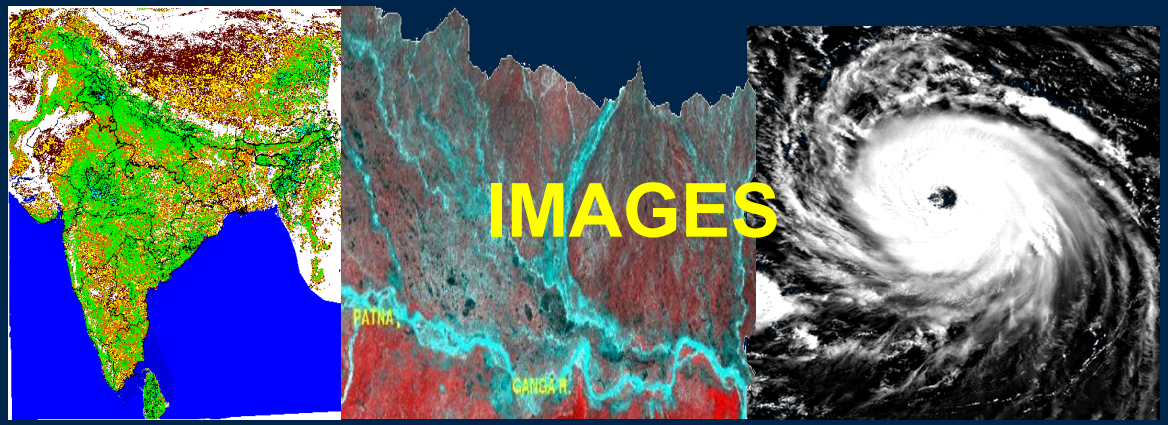
Hydrological Modelling of Baghmati River Basin by SWAT Model

SWAT Model – A Physically Based Model

Equations of mass, energy and momentum are used to describe the movement of water over the land surface and through the unsaturated and saturated zones.

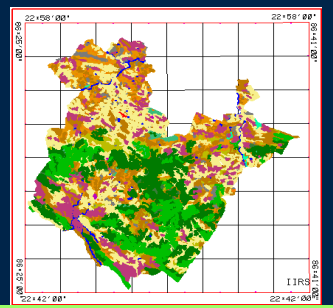


FROM IMAGES TO INFORMATION…



ANALYSIS

MAPS

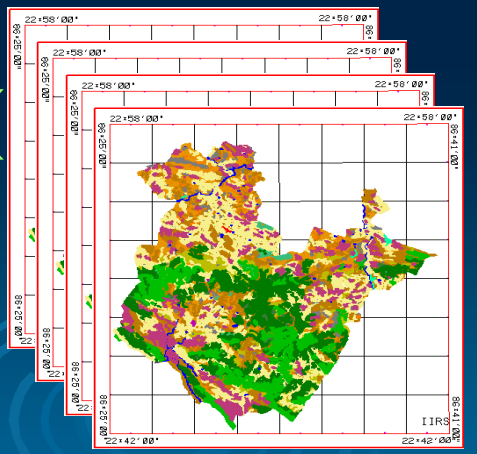


~ 1:12500 THEMATIC

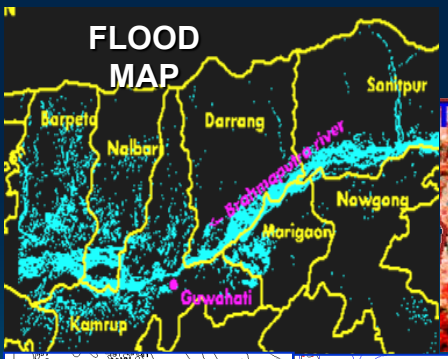
TABLES/ REPORTS

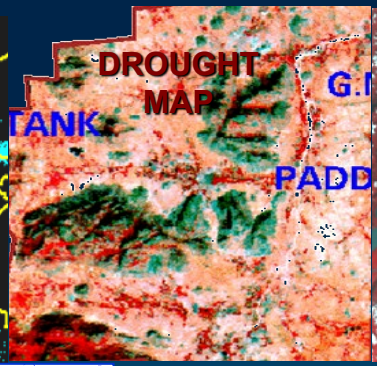
GIS

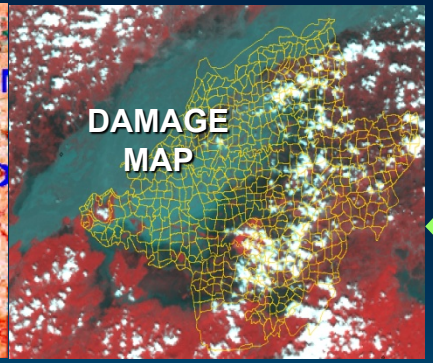
MULTI-LAYER

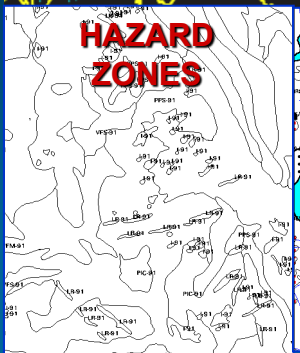


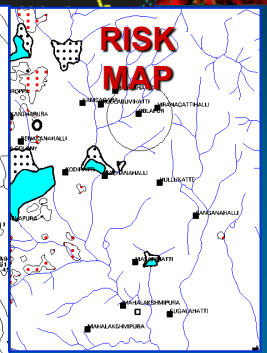
DISASTER MANAGEMENT APPLICATIONS:











……TO DECISION AND ACTION

METHODOLOGY USED IN PRESENT STUDY

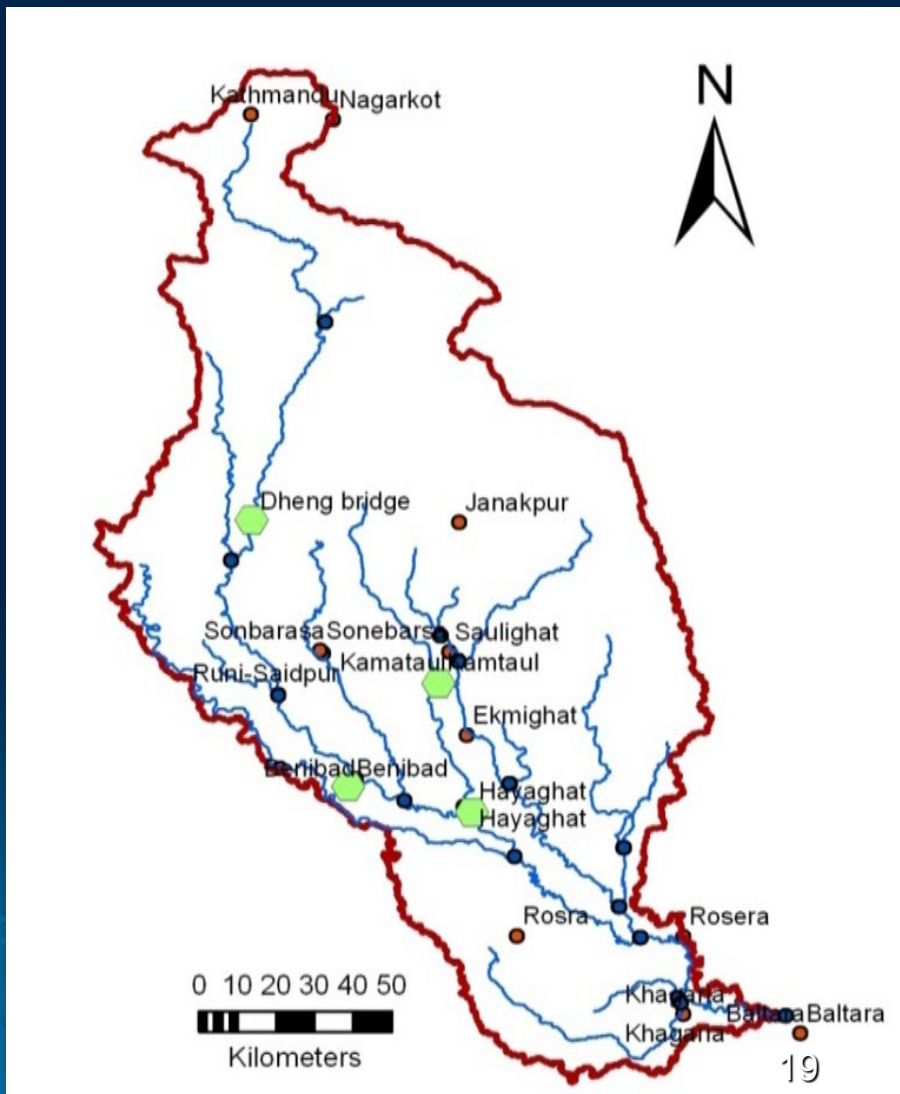
1. Watershed delineation using SRTM DEM
2. Formation of HRUS
3. Writing input tables
4. Runoff generation using Green Ampt Method
5. Using modified SWAT model for real time flood forecasting application

Results and Discussions

Model Set up for Study Area - Bagmati river basin

- (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
- (6) Rainfall data-
  IMD Data,
  Aphrodite Gridded rainfall data,
  real time rainfall data
  downloaded from websites

Gauge Stations and Stream Networks



Watershed Delineation Steps

SRTM DEM

Mosaic or Masking if required

Burning with help of known watershed and river network

Fill Sinks

Direction

Flow Accumulation

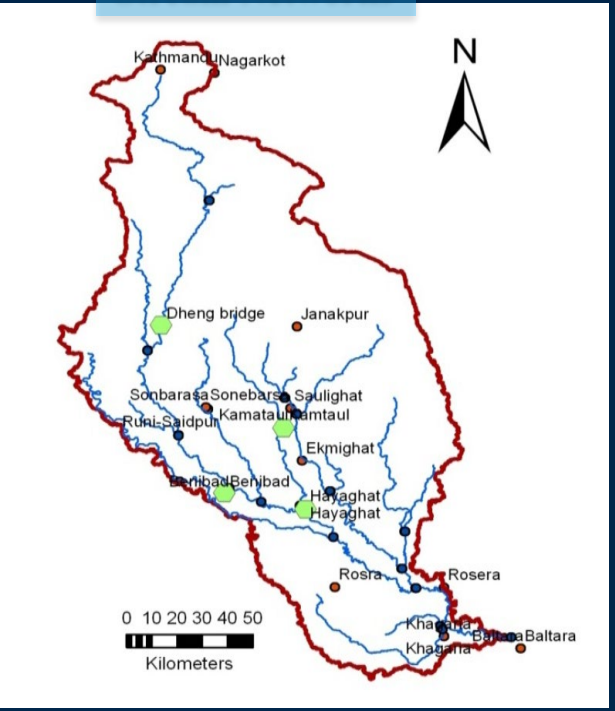
Network Extraction

Drainage Network Ordering

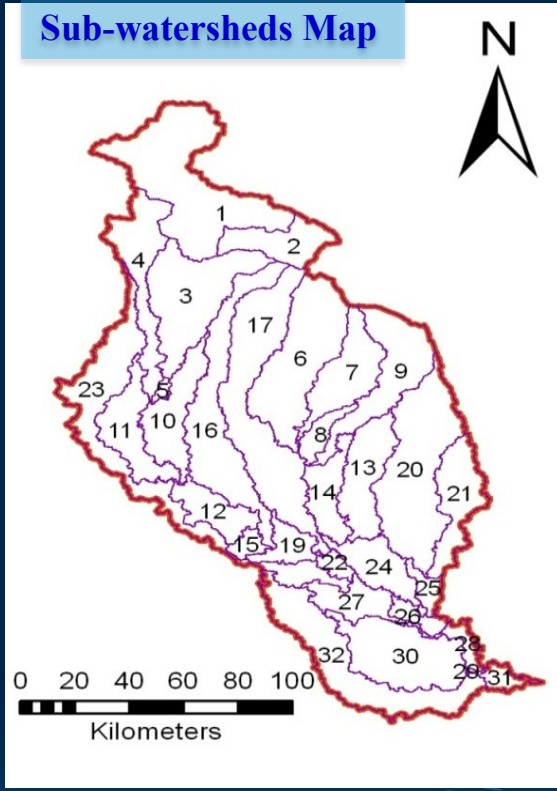
Catchment Extraction

Final Basin Boundary and Drainage map

Stream Networks



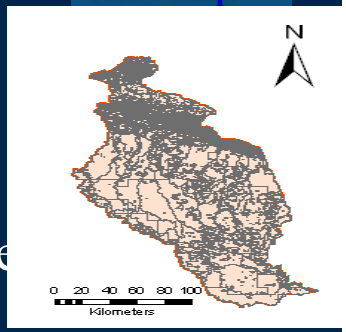
Sub-watersheds Map

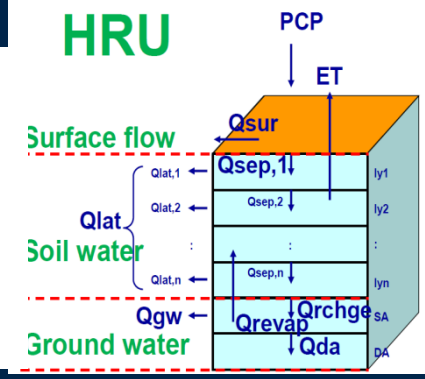


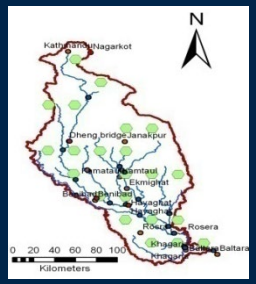
Model Set up (In put Maps)

- Study area: Bagmati river basin, Bihar, India
- Watershed area: 1532353 ha. = 14384 km^2
- Total number of sub-watershed: 32 (threshold leve 30000 ha)
- Number of HRU formation: 206
- MULTIPLE HRUs LandUse/Soil/Slope OPTION :THRESHOLDS : 5 / 5 / 5 [%]
- Number of calibration points: 1 (Hayaghat)

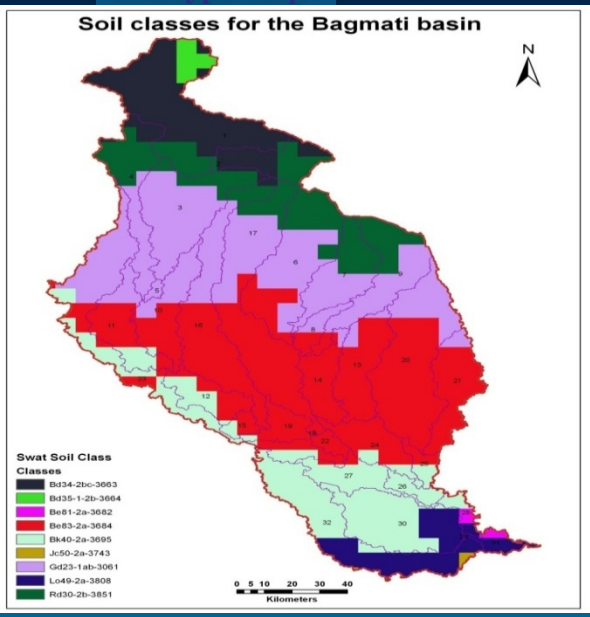
HRU Map



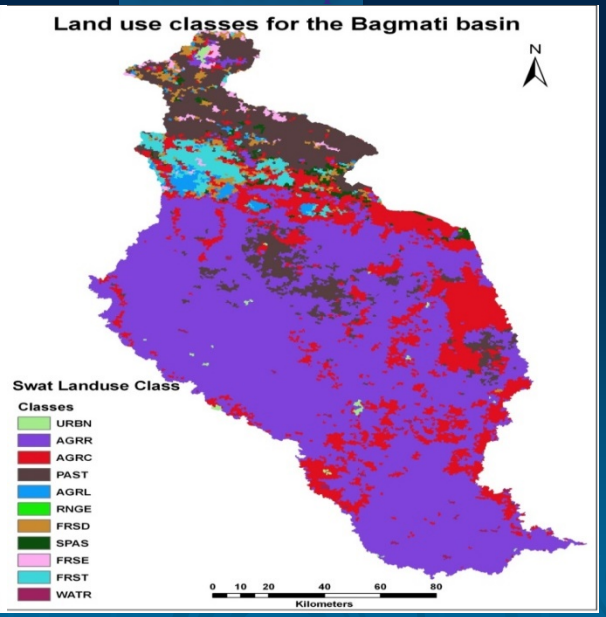




Soil type Map



Land Use Map



DEM

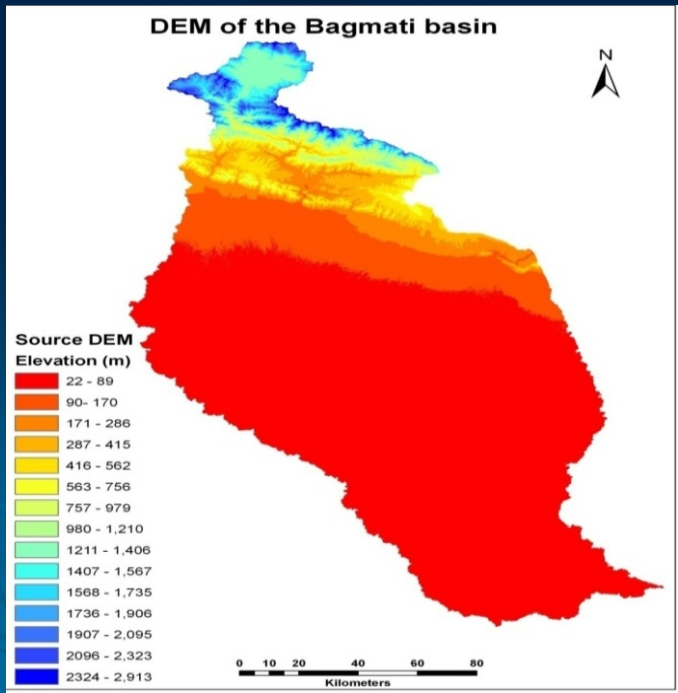


Table 6.4 Details of landuse

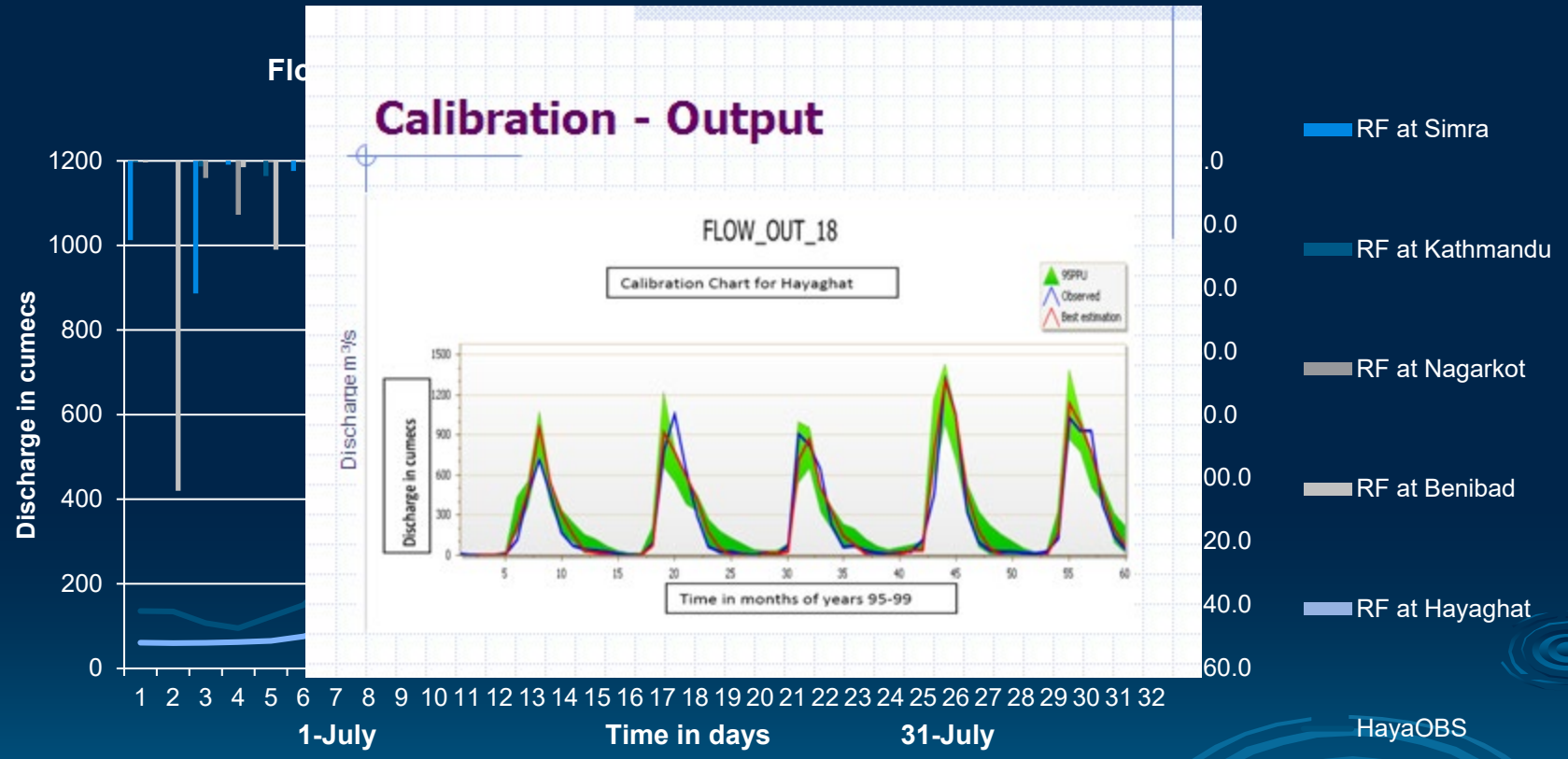
NAME	GLB_LU	LANDUSE
URBN	URMD	Urban
AGRR	CRDY	Agricultural Land-Row Crop
AGRC	CRIR	Pasture
PAST	CRGR	Pasture
AGRL	CRWO	Agricultural Land-Generic
RNGE	GRAS	Range-Grasses
FRSD	SHRB	Forest-Deciduous
SPAS	SAVA	Summer Pasture
FRSE	FOEB	Forest-Evergreen
FRST	FOMI	Forest-Mixed
WATR	ICES	Ice/Water

Table-6.2 Soil properties

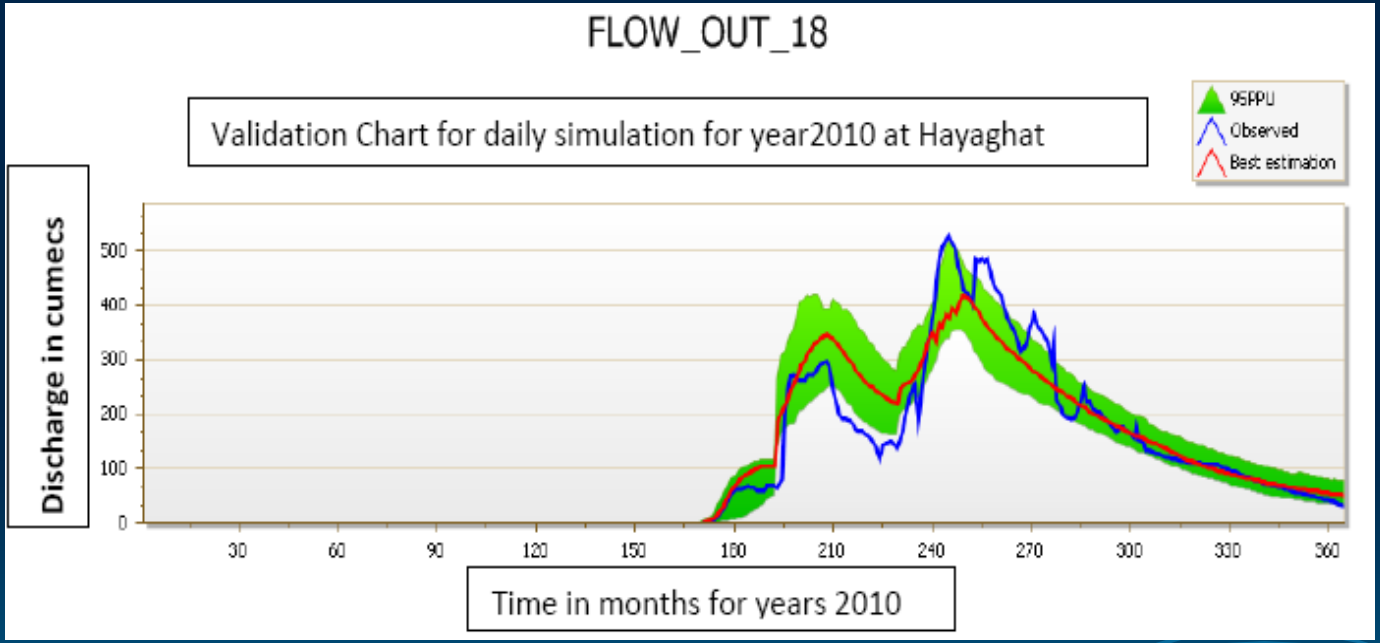
Soil Details

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

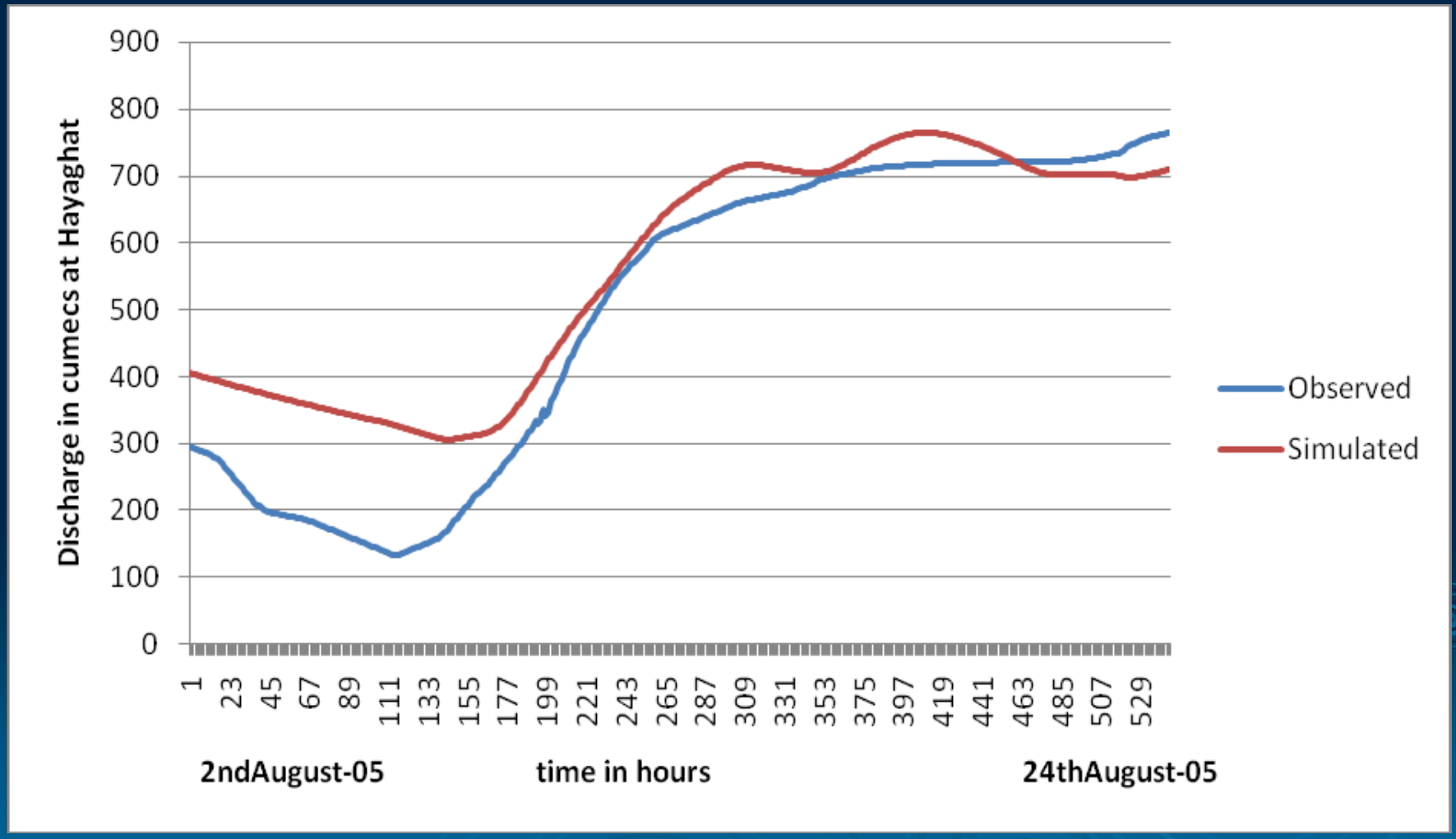
Flow Hydrograph Daily Simulation



Valdation for daily flow 2010



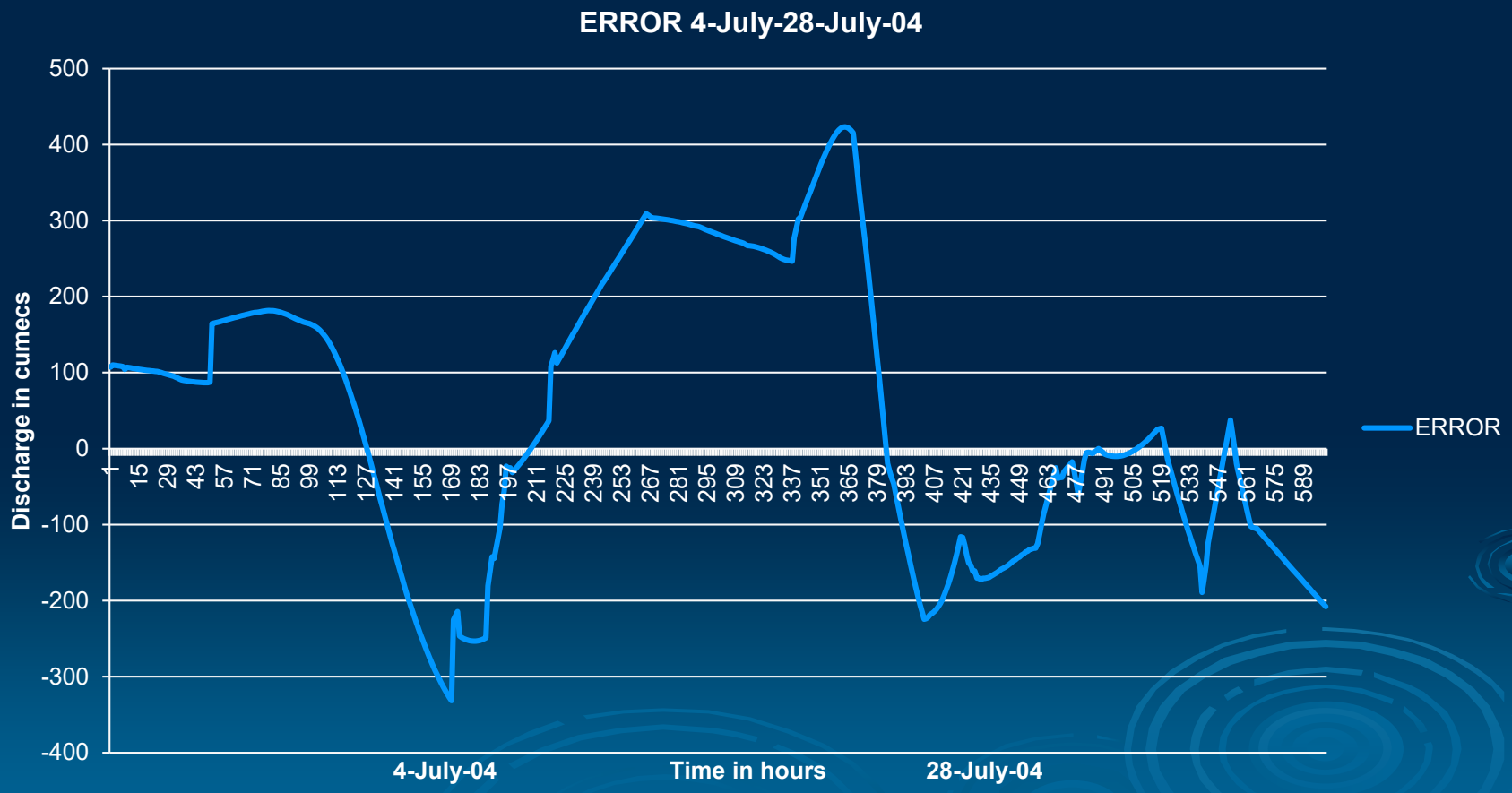
Validation Graph



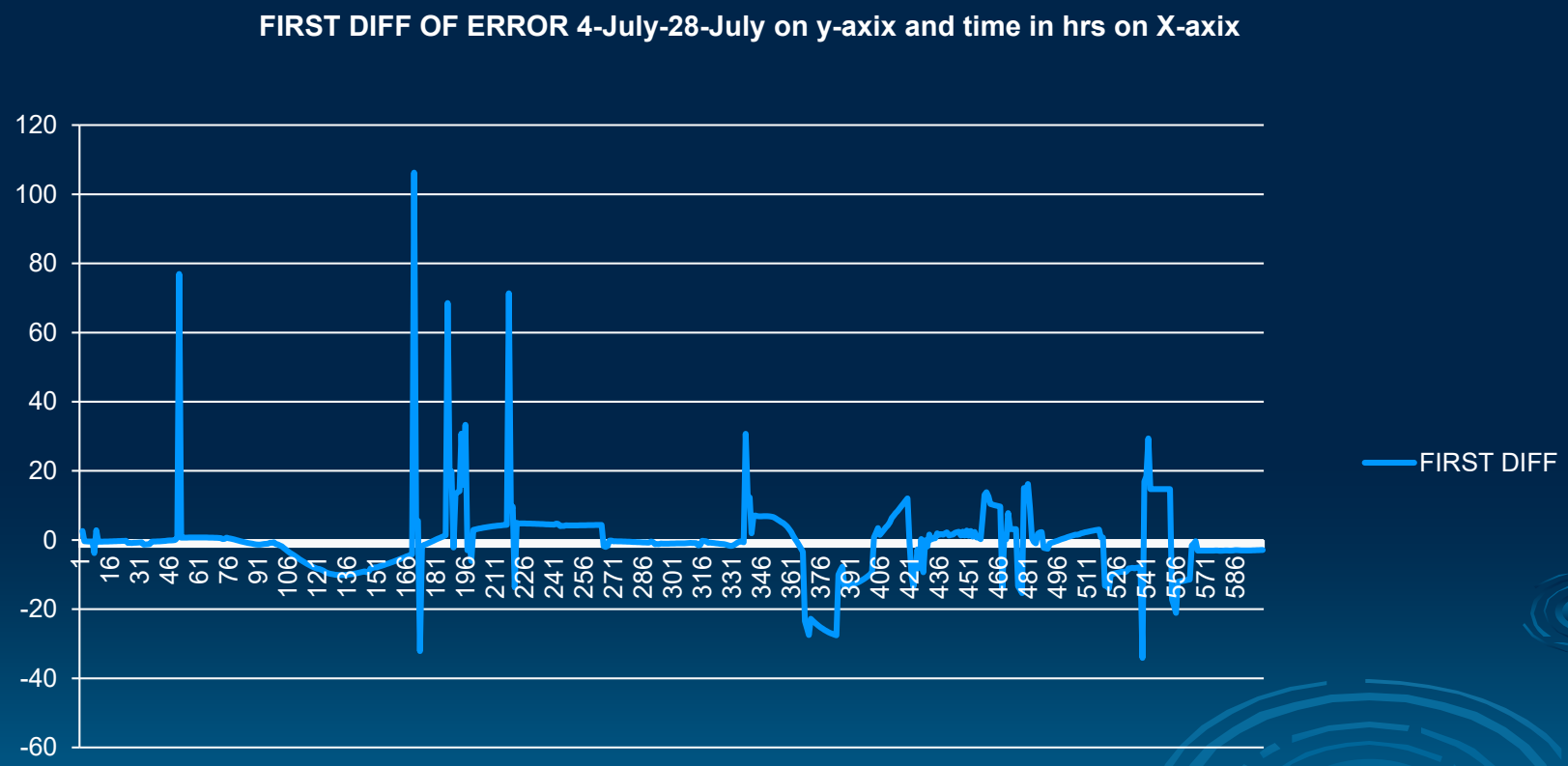
ERROR ANALYSIS

- Time series analysis of errors in hourly simulations/forecasts has been performed. An ARIMA model developed for forecasting error has been deployed for correcting simulated/forecasted hourly flows. Integration of simulation capability of SWAT model and error forecasting capability by time series analysis has been done for solving the problem of real-time flood forecasting

Error 2004 Simulation



Error 2004 hourly simulation



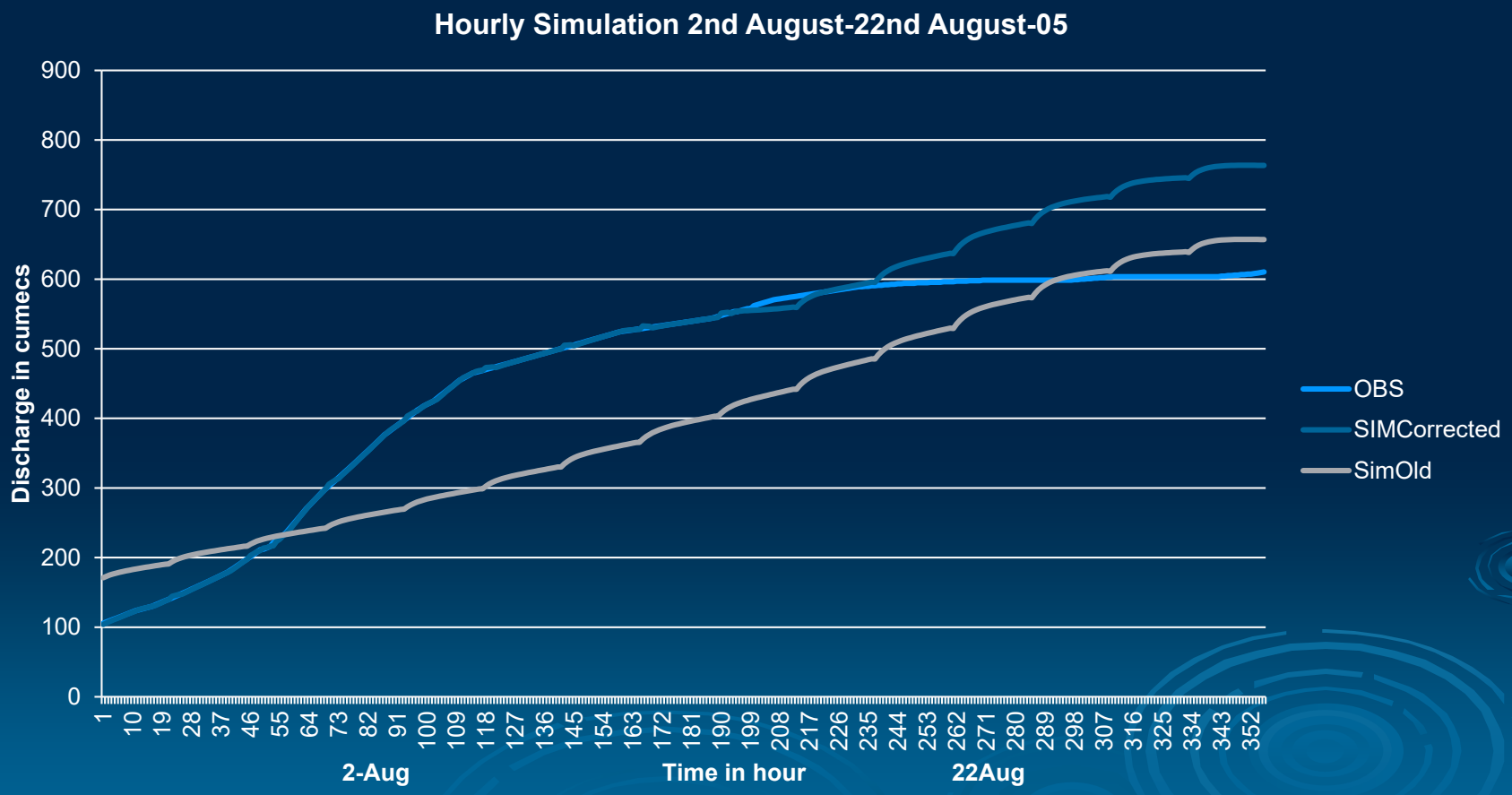
Error Analysis for hourly Simulation of 2005 Flood Events

ARIMA Model Parameters for error analysis for hourly simulation of year 2005

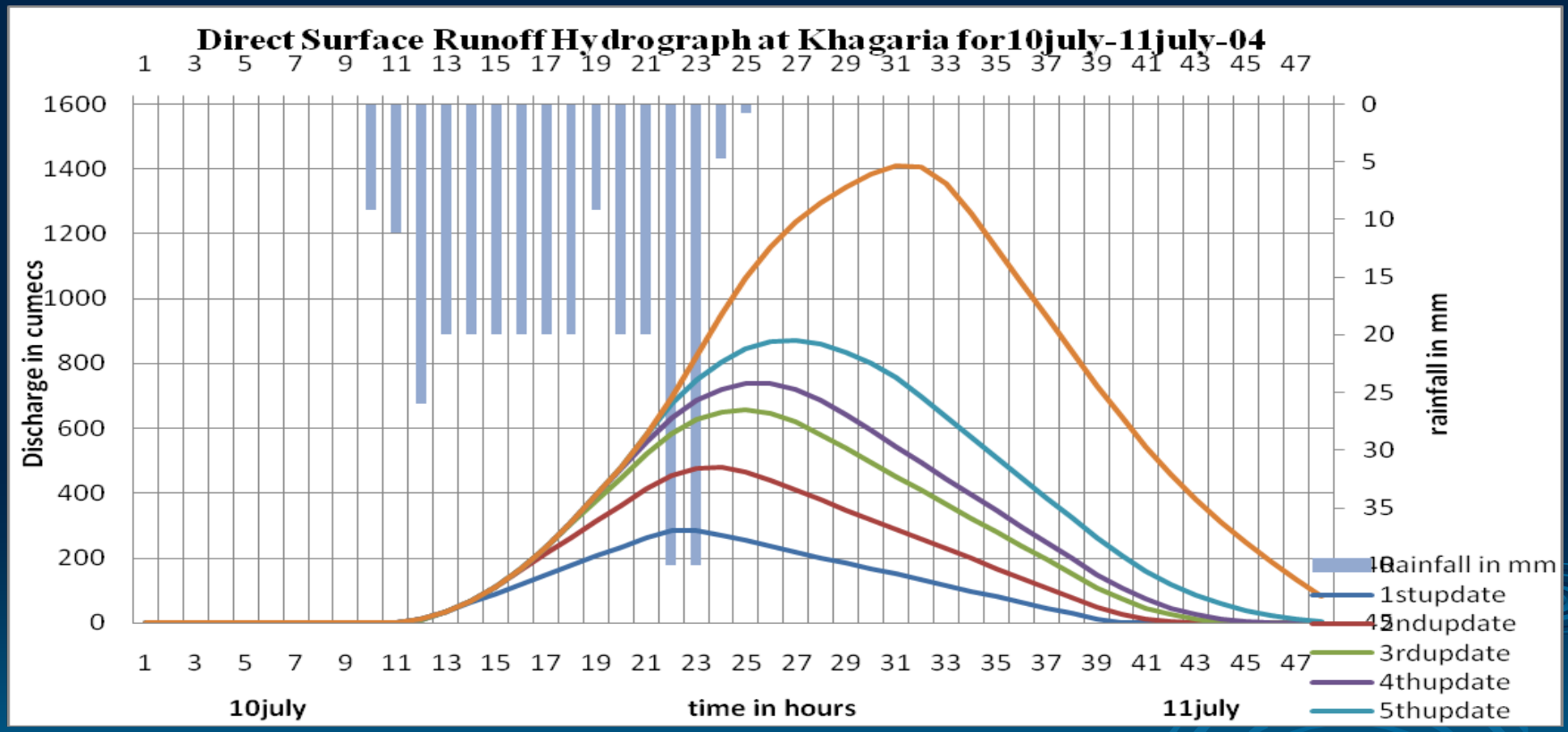
ARIMA Parameters

- B1(LAG1)= 0.6056
- B2(LAG2)= 0.1792
- B3(LAG3)=0.0988

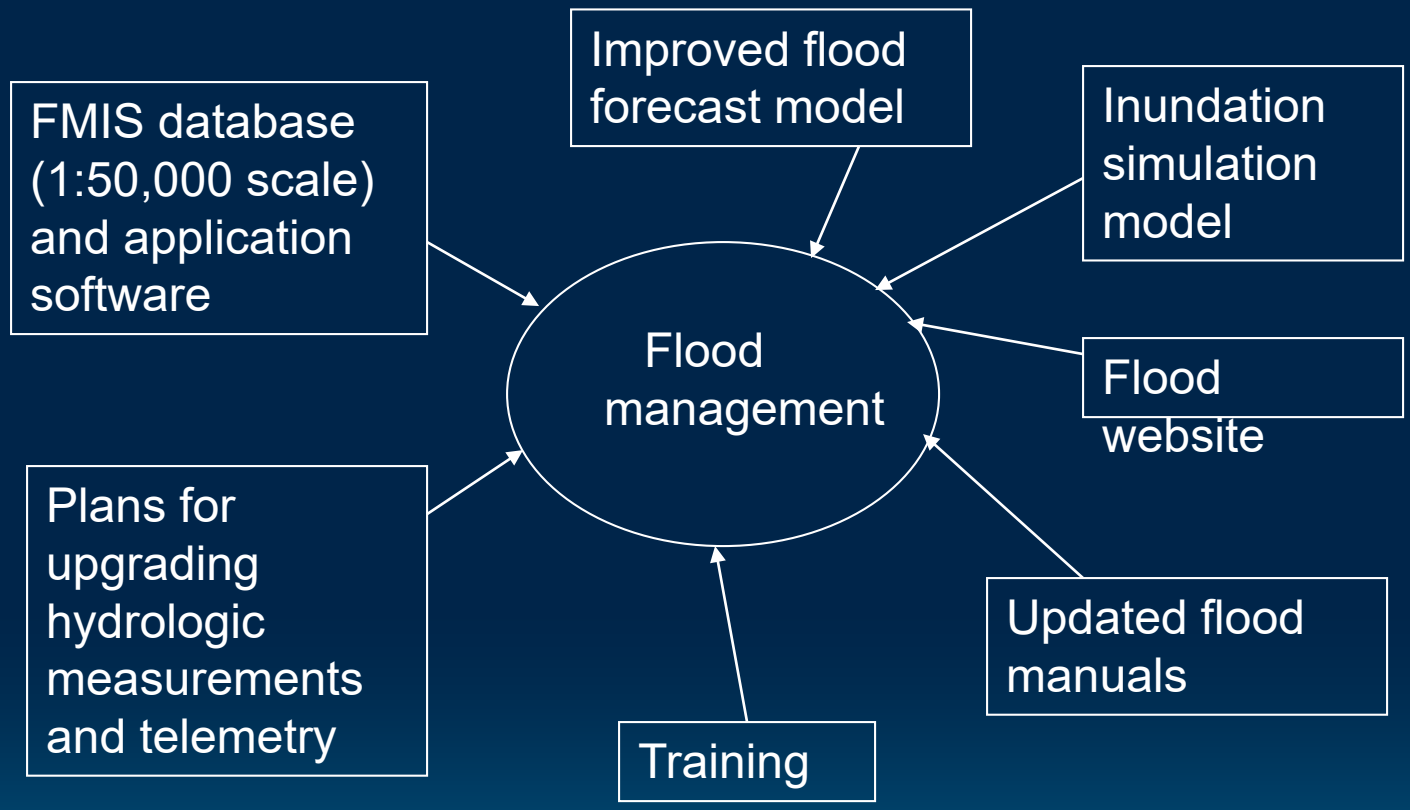
Effect of error correction



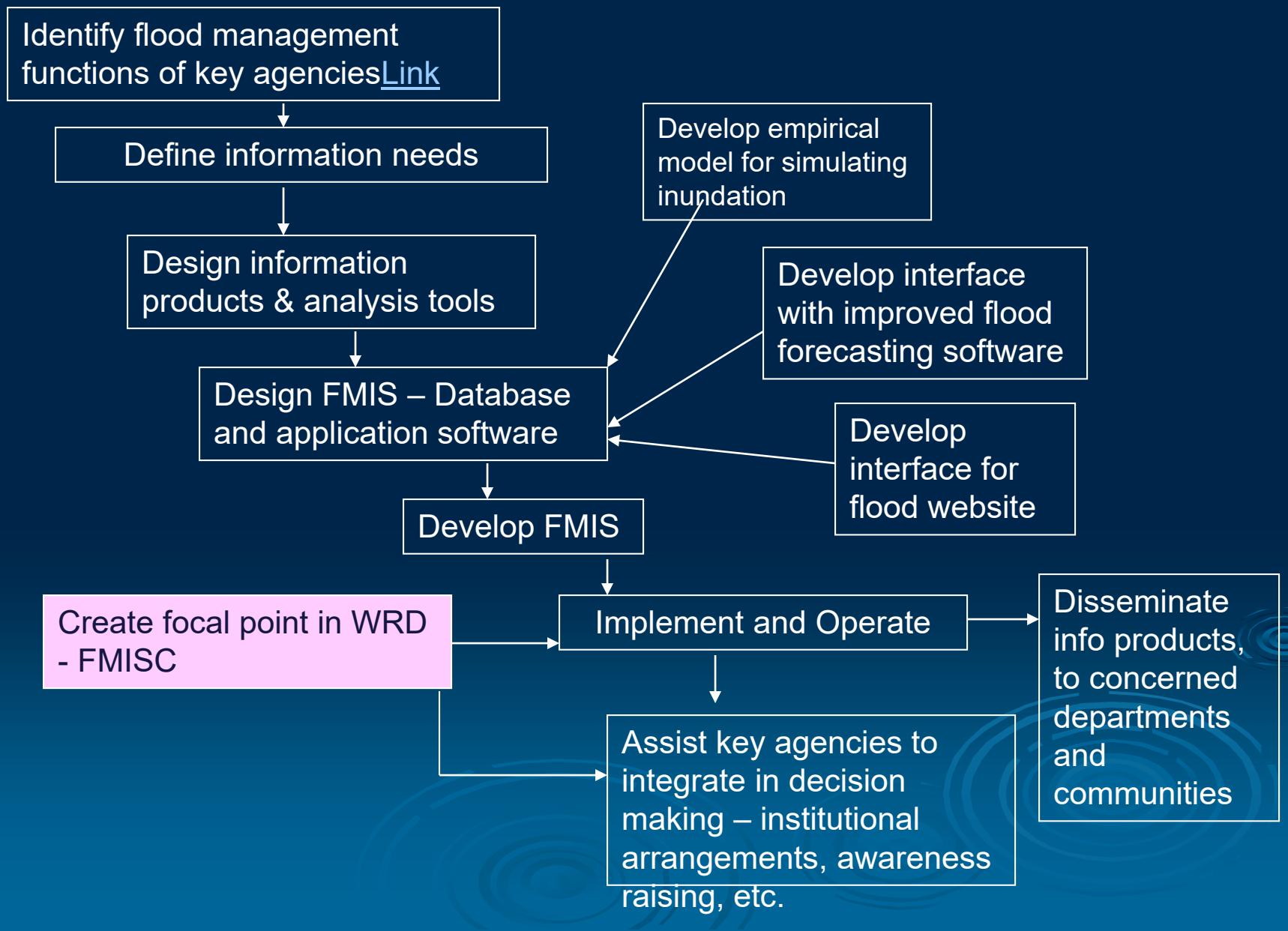
Real time flood forecasting graph generated by SWAT model



Flood Management Information System (FMIS)
FIRST STAGE



FMIS DEVELOPMENT STRATEGY



Information products to be developed

Hydrologic status map	Current water level, trend and forecast	Improved preparedness
Flood inundation maps	Customized for each state agency	Emergency management action
Simulated flood inundation impact	Possible inundation extent, and impact	Early warning for preparedness
Post-flood river configuration & alert	Locate affected and vulnerable sites	Strengthening/ planning flood management works
Seasonal flood summary	Summarize flood frequency, duration, and impact area	Build database on flood hazard for mitigation and management
Flood hazard zoning	Zoning for hazard, risk and vulnerability	Planning mitigation and long term measures
Need based analysis outputs	Thematic and area specific spatial analysis	Specific management needs and action

PREDICTING FLOOD INUNDATION

The comprehensive approach to forecasting flood inundation may involve the use of a suite of models including reliable medium range rainfall forecasting in the upstream catchment area in Nepal and in north Bihar; rainfall-runoff modeling to convert rainfall forecast into runoff forecast; hydraulic routing to downstream areas in north Bihar; Digital Elevation Modeling (DEM) of flood prone areas; modeling flood inundation from over-bank flow, embankment breach, and drainage impedance, and modeling duration and depth of flood inundation.

A simpler approach is to correlate u/s rainfall to flood inundation.

FLOOD WEBSITE

- Review international and national flood sites
- Design website based on best features, including interface with FMIS, and linkage with national and international data sources (eg. Satellite based rainfall estimate and forecast)
- Develop and implement website using a professional agency
- Train FMISC staff in website maintenance

STRATEGY FOR UPDATING FLOOD MANUAL

Review the existing flood manual, for possible updation using FMIS outputs.

eg. Incorporate annual river configuration map and table, showing vulnerable embankment reaches and degree of hazard, for improved preparedness

SUMMARY AND CONCLUSIONS

- Flood management information system has been developed using GIS and Remote Sensing database.

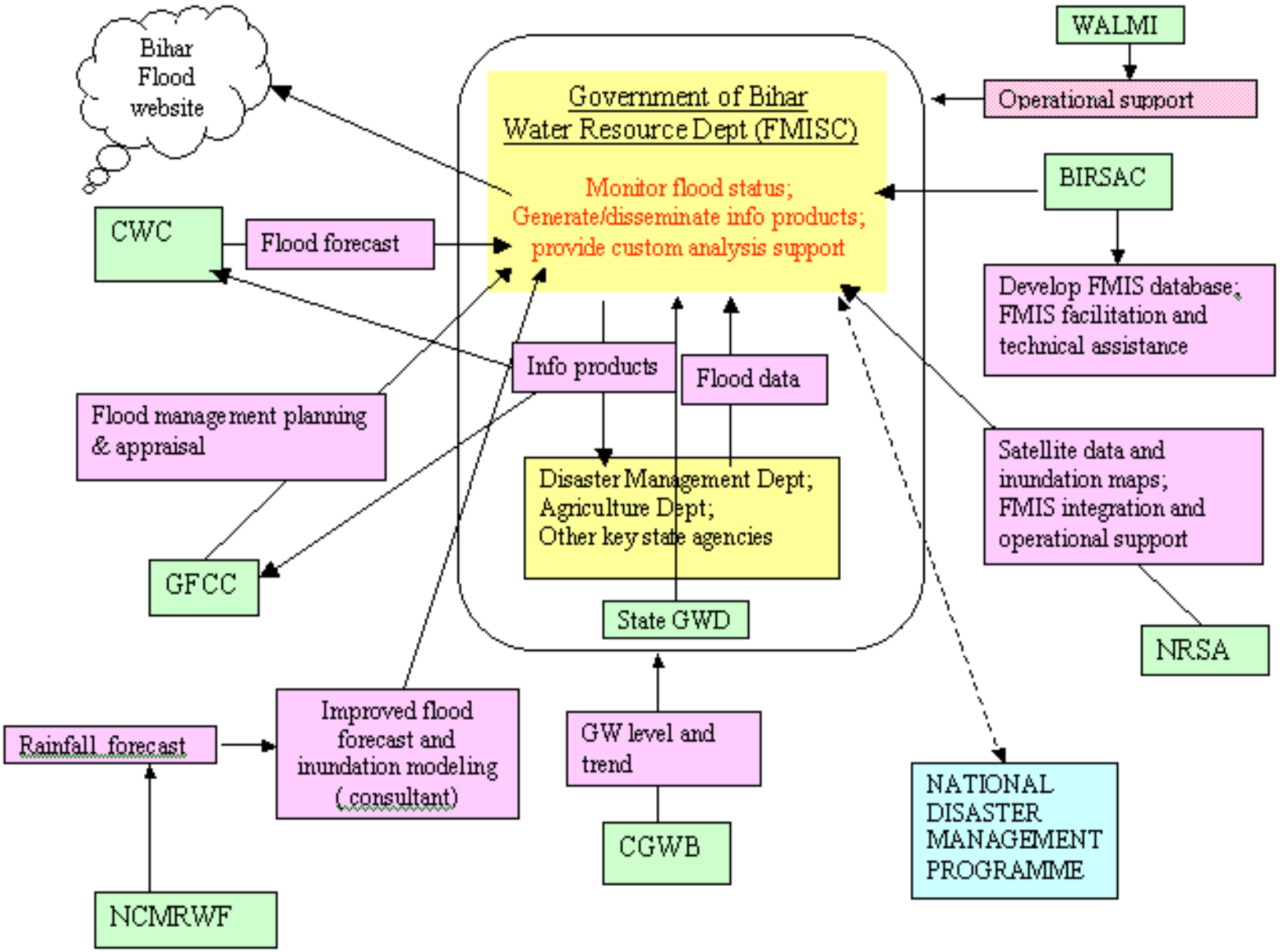
- Compressive website for hydrometeorological data for study area has been developed.

- Artificial intelligence and machine learning along with smart hardware will make it possible to create a comprehensive water resource information system using SWAT model and GIS data base.

- SWAT model has 350 subroutines written in Fortran. Initially it was developed for long term continuous run. But it has been modified for flood forecasting i.e event modeling

- Drought management information system can be developed using SWAT model and GIS database.

Proposed Institutional framework for FMIS



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