बिहार सरकार

Expert Consultation Workshop
on
“Improving Flood Risk Management in Bihar”

Organised by
Bihar Aapda Punarwas Evam Punarnirman Society and
Water Resources Departmant, Bihar
in Collaboration with
The World Bank

Venue : Patna

18-19 February 2016


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Editorial Notes

The summary of presentations were either prepared by the presenters and edited, or prepared by Editor and reviewed by respective authors. All other material has been prepared by the Editor. The question and answer at the end of each presentation, Co-Chairs' remarks, and Panel and open discussions have been developed based on the audio recording of the whole proceedings.

ACKNOWLEDGEMENT

The support received from Bihar Aapda Punarwas Evam Punarnirman Society and Water Resources Department, Bihar and the World Bank is gratefully acknowledged. The presence and guidance received from the Honorable Minister for Water Resources Department, Honorable Minister, Energy and Commercial Taxes, Principal Secretary, WRD, and Principal Secretary BAPEPS provided the right directions. The insight received from Joint Secretaries, WRD and BAPEPS were valuable. The staff of Flood Management Improvement Support Centre (FMISC) worked tirelessly to plan, organize and conduct the workshop. Ms. Arti Sinha, Deputy Director, FMISC anchored the workshop programme and ensured timely progression in the two days of the workshop. Thanks are due to Dr. S.Thiruvengadachari, Flood Management Consultant, who provided technical guidance all through the planning to conduct to preparation of Workshop Report. Mr. Deepak Singh, Task Team Leader of Bihar Kosi Flood Recovery Project and Dr. Satya Priya leading the South Asia Water Initiative Trust Fund project in Bihar represented World Bank, and provided needed guidance. The intense interest shown by the participant’s right through the sessions needs to be acknowledged.

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Subject **Page No.**

ACRONYMS

AIBP	Accelerated Irrigation Benefits Program
ANN	Artificial Neural Network
AWS	Automatic Weather Stations
BA	Bagmati-Adhwara
BAPEPS	Bihar Aapda Punarwas Evam Punarnirman Society
BBMB	Bhakra Beas Management Board
BKFRP	Bihar Kosi Flood Recovery Project
CAVI	Control and Visulization Interface
CDR	Call Data Records
CEGIS	Center for Environmental and Geographic Information Services
CFS	Climate Forecast System
CPCB	Central Pollution Control Board
CWC	Central Water Commission
CWMS	Corps Water Management System
CWPRS	Central Water and Power Research Station
DEM	Digital Elevation Model
4DVAR	Four Dimensional Variational Data Assimilation
EAMS	Embankment Asset Management System
ECMWF	European Centre for Medium Range Weather Forecasting
FIA	Flood Impact Analysis
FFWC	Flood Forecasting and Warning Centre
FLEWS	Flood Early Warning System
FMISC	Flood Management Improvement Support Centre
GEFS	Global Ensemble Forecast System
GFS	Global Precipitation System
GLDAS	Global Land Data Assimilation System
GPLESC	Gram Panchayat Level Embankment Surveillance Committees
GR	Ganga Rejuvenation
GTS	Global Telecommunication Stations
HEC-RTS	Hydrologic Engineering Centre's Real Time Simulation
HMS	Hydrologic Modeling System
IAs	Implementing Agencies
ICIMOD	International Centre for Integrated Mountain Development
IMD	India Meteorological Department
IMERG	Integrated Multi Satellite Retrievals for GPM
LGBO	Lower Ganga Basin Organisation
MFP	Meteorological Forecast Processor
MoWR	Ministry of Water Resources
MSP	Mobile Service Provider
NCAR	National Center for Atmospheric research
NCEP	National Centers for Environmental Prediction
NDMI	Normalized Difference Moisture Index
NDVI	Normalized Difference Vegetation Index
NIH	National Institute of Hydrology

NHP	National Hydrology Project
NRSC	National Remote Sensing Centre
PDF	Probability Density Function
RAS	River Analysis System
RD	River Development
RIMES	Regional Integrated Multi-Hazard Early Warning System
SAWI	South Asia Water Initiative
SWE	Snow Water Equivalent
TA	Technical Assistance
TF	Trust Fund
TRMM	Tropical Rainfall Measurement Mission
VIC	Variable Infiltration Capacity
WHYCOS	World Hydrological Observing System
WRD	Water Resources Department
WRF	Weather Research and Forecasting
WRIS	Water Resources Information Systems
WRMS	Water Resources Monitoring System
WMO	World Meteorological Observation

Executive Summary

The Expert Consultation Workshop was organized[1] during February 18-19, 2016 in Patna, Bihar State to review the activities under the World Bank assisted Bihar Kosi Flood Recovery Project (BKFRP) as well as to look at two downstream projects into which BKFRP would transition. The workshop was designed with participation by key decision makers in Water Resources Department, representatives from other flood-prone states, Central government agencies, and academia. The workshop helped share knowledge on the BKFRP activities and invited expert consultation to help strengthen flood risk management in the State. A special session on Flood Forecasting and Early Warning was organized as part of the workshop by South Asia Water Initiative (SAWI) Trust Fund, which is launching a Technical Assistance project to improve flood to strengthen flood modeling capacity in Bihar State.

The Inaugural session was addressed by Sri Bijendra Prasad Yadav, Honorable Minister, Energy and Commercial Taxes Department, and past Minister of Water Resources Department; Sri Rajiv Ranjan Singh, Honorable Minister, Water Resources Department; Mr. Arun Kumar Singh, Principal Secretary, WRD; and Dr. Deepak Prasad, Principal Secretary, Planning and Development Department cum Management Director, . Er. Indu Bhushan Kumar, Chief Engineer, P&M Water Resources Department welcomed the dignitaries, experts and participants and introduced the theme of the workshop. Mr. Gajanan Mishra, Joint Secretary, WRD, Bihar described the long history of Kosi river management. Dr. Satya Priya of World Bank highlighted the several ongoing and upcoming events in Bihar with the assistance of World Bank

The four technical sessions covered: I. Flood Forecasting and Early Warning, II. River and Sediment Management, III. Knowledge Management and IV. Upcoming Projects. Each session had multiple presentations, questions and answers at the end of each presentation, and Panel Discussion at the end of first technical session and at the end of second day technical sessions. The Concluding Session included wrap-up of Workshop proceedings, Way Forward and Vote of Thanks.

This report covers the proceedings of the Expert Consultation Workshop. The report, in addition to sections on the Inaugural Session and the Concluding Session, has separate sections covering each Technical Session, providing the summary of presentation and the issues discussed after the presentation. The major take-aways are also presented at the end of each section. The panel discussion at the end of Technical Session I and open discussion at the end of Technical Session IV are covered in the respective sections.

[1] Organized by Bihar Aapda Punarwas Evam Punarnirman Society (BAPEPS) and Water Resources Department, Bihar in collaboration with the World Bank

Technical Session I: Flood Forecasting and Early Warning

This session included eight invited presentations and a Panel Discussion at the end. The presentations covered research to operational models in other flood-prone regions and provided insights to various modeling approaches and outcomes. Invited experts from India and abroad provided access to best practices in select areas. The panel discussion at the end covered model validation in data-sparse areas, crowd-sourcing to collect needed inundation data, issues relating to procuring data from Central Water Commission, and model performance assessment against event-based thresholds.

An important recommendation from the workshop is the use of non-proprietary and license-free flood forecasting and inundation mapping software for cost-effective and rapid scaling up of models to river basins in Bihar and elsewhere. It is also essential to organize up-front the critical data needed for modeling- historical rainfall and river flow data, river cross-sections, and flood plain DEM, while operational run of model would require assured access to timely meteorological and hydrological data. Arrangements need to be in place for upgrading the model input data including hydrologic and hydraulic data and model setup. Longer lead time would require short-to-medium range ensemble meteorological forecast and real-time data from upstream gauge sites. Ensemble rainfall forecasts and satellite based rainfall estimates are increasingly used in lieu of single source values to improve reliability. Synergy with flood models and outputs being developed/ operated by national and regional agencies in upstream trans-boundary basins would improve forecasts downstream basins in India. Effective early warning can be facilitated by the use of Call Data Records, to send flood alerts to likely affected communities and to track people movement in the area for targeted emergency flood management. Sustainable flood management program would call for development of a cadre of flood modelers with assured career path and incentives, continued skill upgrading, and institutional support.

Technical Session II: River and Sediment Management

The session included four presentations. The analysis of river morphological changes in Kosi system shall be extended to other basins in Bihar, to predict annual changes in embankment vulnerability, embayment between spurs, and the identification of active channel for effective and timely strengthening of flood protection works. The satellite based model shall be complemented by the 1D & 2D Hydrodynamic and 1D Sediment Transport Models set up under the Master Plan consultancy. The Master Plan for River and Sediment management would provide the framework for taking up short-term and long term activities within the integrated river management action program. The Embankment Asset Management System supports rational management of these expensive assets and prolongs operational services and useful life. This should be extended to other basins in Bihar. Community participation for embankment surveillance shall be promoted and expended to other river basins, to pride a sense of ownership and involvement by the likely -affected communities.

Technical Session III: Knowledge Management

The session included two presentations. Structured knowledge base such as the Ganga Flood Risk Atlas and multi-theme GIS data sets of Bihar State effectively support the entire life-cycle of flood risk management, from planning to preparedness to flood relief, rehabilitation and reconstruction. The knowledge bases obviously need to be kept updated with new and better information through the years, and intensified in multiple levels for varying applications. Linkage with other national and State level databases shall be encouraged.

Technical Session IV: Upcoming Projects

The session included two presentations on downstream projects. Similar activities in these projects would need to be formulated taking note of the observations, insights and recommendations arising from this workshop. Standard templates are needed for cost-effective and rapid customizing of flood forecasting and early warning system, Real Time Data Acquisition System, Embankment Asset Management System and community participation, river morphological prediction, and Centre of Excellence in Modeling in basins in Bihar and other States.

Concluding Session

The wrap-up briefly described the proceedings of the inaugural session and four technical sessions covering 16 presentations by invited experts, while the Way Forward identified the key expert consultations and recommendations for way forward.

I. Introduction

1.1 Bihar is India's most flood-prone state, with 76 percent of the total population living under a recurring threat of floods. The state recorded the highest number of floods in India during the last 30 years. On August 18, 2008, the Kosi eastern embankment breached at 11 km upstream of the Kosi barrage in Nepal. The floods had a devastating impact on people and their livelihood. More than 500 people lost their lives, valuable agricultural land was damaged due to silting, and standing crops were destroyed. Massive damage occurred to housing and infrastructure including rural roads, culverts and bridges, especially in the five most affected districts of Supaul, Saharsa, Madhepura, Araria and Purnea. The World Bank assisted Bihar Kosi Flood Recovery Project (BKFRP) was designed to provide timely and focused support to Bihar's reconstruction efforts in the short term while further developing a comprehensive program of support for the state in the longer term. A critical component in the project focuses on strengthening the overall flood forecasting and flood and erosion management capacity in Bihar by enhancing the knowledge, understanding, and capacity for flood and sediment management. This will be achieved by implementing both structural and non-structural measures, mainly focusing on the Kosi River Basin, but with several activities benefiting flood management in the state as a whole. There are three sub-components: (i) knowledge management and capacity building; (ii) flood forecasting and early warning systems; and (iii) structural investments.

1.2 A series of activities to strengthen flood management and flood and erosion management capacity in the State have been conducted such as developing a comprehensive Embankment Asset Management System (EAMS) for Kosi basin, developing a Master Plan for flood and sediment management in the basin, Kosi river behavioral analysis and Community Participation in Embankment Surveillance in Kosi Basin. The Expert Consultation Workshop was organized[2] to review these activities as well as to look at two downstream projects into which BKFRP would transition. The workshop helped share knowledge on the BKFRP activities and invited expert consultation to help strengthen flood risk management in the State

1.3 An Inception Workshop and special session on Flood Forecasting and Early Warning was organized as part of the workshop by South Asia Water Initiative (SAWI) Trust Fund (TF), which is launching a Technical Assistance (TA) project to improve flood to strengthen flood modeling capacity in Bihar State. The workshop was designed for two full days with participation by key decision makers in Water Resources Department, representatives from other flood-prone states, Central government agencies, and academia. Invited experts from India and abroad provided access to best practices in select areas. The workshop organizers prepared a list of issues for focused panel discussion at the end of Technical Session.

[2] Organized by Bihar Aapda Punarwas Evam Punarnirman Society (BAPEPS) and Water Resources Department, Bihar in collaboration with the World Bank

1.4 This report covers the proceedings of the Expert Consultation Workshop. The report, in addition to covering Inaugural and Concluding Sessions, has separate sections covering each Technical Session, providing the summary of presentation and the issues discussed after the presentation. The major observations and insights are also presented at the end of each section. The panel discussion at the end of Technical Session I and open discussion at the end of Technical Session IV are covered at the end of respective sections.

II. Inaugural Session

2.1 The workshop was initiated by the welcome address and introduction to the theme of workshop by Er. Indu Bhushan Kumar, Chief Engineer, P&M Water Resources Department. He explained the origin of river Kosi and described various works being undertaken under ongoing Bihar Kosi Flood Recovery Project and proposed Bihar Kosi Basin Development Project. The great achievement by Bihar engineers of Kosi Breach closure in 2008 within a record time of three months was recalled.

2.2 Mr. Arun Kumar Singh, Principal Secretary, WRD highlighted the different work being undertaken in the field of flood risk management. He applauded the efforts under World Bank assistance whereby the issues of flood risk management have been addressed properly in recent times. He suggested that the knowledge base creation and various systems may be replicated in other river basins also. He stressed on the need of data sharing in the Nepal region and apprised the gathering with different upcoming events in this field. He conveyed that WRD is trying for advancement in irrigation sector also employing new technology as in other advanced countries.

2.3 Dr. Deepak Prasad, Principal Secretary, Planning and Development Department cum Project Director BAPEPS, hailed the World Bank assistance which has now begun to show good impacts of works in the field of Housing, Bridges, Roads, etc. under Bihar Kosi Flood Recovery project.

2.4 Mr. Gajanan Mishra, Joint Secretary, WRD, Bihar also addressed the gathering, describing the long history of Kosi river management.

2.5 Sri Bijendra Prasad Yadav, Honorable Minister, Energy and Commercial Taxes Department, and past Minister of Water Resources Department, in his special remarks highlighted the ground problems of Kosi basin and said that nature, character and behavior of river Kosi and other Himalayan rivers should be studied. He suggested work is needed at micro level with the help of latest technology. He stressed the need for the Centre of Excellence in Bihar in order to solve water management issues and requested the Centre to organize a wider international conference on this matter.

2.6 In inaugural address, Sri Rajiv Ranjan Singh, Honorable Minister, Water Resources Department, said that the topic of the subject is a challenge in the context of Bihar, where better water management is required to address both flood and drought problems. He stressed the need for developing a Flood early warning system, SCADA system and study of nature and behavior of rivers. He also emphasized the need of establishment of Centre of Excellence in Bihar which is underway in BKFRP/BKBDP.

2.7 Dr. Satya Priya of World Bank highlighted the several ongoing and upcoming events in Bihar with the assistance of World Bank and assured of all help from the World Bank side.

III. Technical Session I: Flood Forecasting and Early Warning

Co-Chairs: **Mr. Gorakh Takur, Member, Ganga Flood Control Commission**
Dr. Vivekanad Singh, Head, Civil Engineering Department,
National Institute of Technology, Patna

Session Summary

3.1 The session was initiated with an overview of activities proposed under the SAWI TF Technical Assistance. Subsequent six presentations covered research-to-operational models in major flood-prone regions and provided exposure to various modeling approaches and outcomes. The last presentation addressed various challenges to flood forecast modeling in north Bihar river basins, and opportunities for innovation. The speakers were introduced by the Chair, and the Co-Chair summarized the presentations. The list of Chair, co-chair, and invited experts and their presentations is in Table 1. The presentations are summarized in the next chapter.

Presentation 1. South Asia Water Initiative (SAWI) Project- Strengthening Flood Modeling Capacity in Bihar by Dr. Satya Priya, World Bank

3.2 Dr. Satya Priya presented a brief overview of the recently initiated SAWI TF funded Technical Assistance on Strengthening Flood modeling Capacity in Bihar. The SAWI project would help transition this activity from the Flood Management Improvement Support II project into the downstream projects of Kosi Basin Development Project (KBDP) and the proposed National Hydrology Project (NHP). The activities are focused in the flood-prone Bagmati-Adhwara (BA) basin, and supplement the current Gauge-to-Gauge correlation model of Central Water Commission (CWC) providing flood forecasts at selected downstream sites, once or more times a day, and up to 24 hours in advance. Under FMIS II a flood forecast model based on proprietary software (NAM/MIKE11) has been developed to provide forecast at to 3 days lead time all along the river length, and likely inundation maps. The model however is not fully operational, performance needs to be improved, interfaces need to be more user-friendly, and inundation mapping to be more automated. A major activity in the SAWI project is the upgrading of the existing model for better performance and operational use, integrating satellite based ensemble rainfall estimates and ensemble deterministic and probabilistic rainfall forecasts, and possibly extending the model up to Bagmati's confluence with Kosi river subject to collection of stage-discharge data from temporary network to be implemented. A parallel activity is to develop a similar model but using a public domain and license-free software to support subsequent cost-effective upgrading and scaling up to other river basins. The third activity to support the two models is to develop an automated meteorological framework customized for BA and Kosi basins, to downscale the ensemble rainfall estimates and forecasts for basins of this size. Use of Call Data Records (CDR) is proposed to assist sending the flood alerts to mobile users in the likely affected area, as well as monitor their movement for targeted emergency flood management.

Capacity building in Water Resources Department is planned through training, workshops, and Expert visits. Dr. Satya Priya re-iterated the importance of this workshop, to review flood modeling activities in other flood-prone regions for knowledge sharing on innovative practices and expert consultation.

3.3 In response to a query from the audience Dr. Satya Priya suggested that extension of model downstream of Hayaghat would depend on implementation of planned temporary stage-discharge sites and data collection in the forthcoming flood season. He proposed operationalizing the improved existing model, and continuing upgrades, based on operational experience in the 2016 flood season and further upgrade when the meteorological framework is developed for the BA basin. A question was raised that different river domains with different models may be needed since some reaches are embanked and some only on one side. It was clarified that a suite of models of different types (including statistical models for the basin area close to confluence with Ganga River which has sheet flooding from drainage congestion) may be needed to handle different flow domains.

Presentation 2: Enhancing Hydrological Forecast using Weather Forecast Ensemble Prediction System by Dr. Dilip Kumar Gautam, RIMES

3.4 Dr. Dilip Kumar Gautam gave a brief overview of Regional Integrated Multi-hazard Early warning System for Africa and Asia (RIMES) in Thailand. RIMES, an inter-governmental regional organization supported by UNESCAP, provides support to National Meteorological and Hydrological Services to develop forecasting systems within the WMO framework. The application of extended range forecasts (10 days deterministic forecast, 15 days probabilistic forecast, and monthly and seasonal forecast) were highlighted. The presentation focused on the medium range ensemble weather forecast and seasonal forecast products of European Centre for Medium Range Weather Forecasting (ECMWF), with application in Bangladesh as a case study. Both these forecast systems use coupled atmospheric-wave-ocean models and are under laid by the six physical laws. The characteristics of the ECMWF weather forecasts in regard to data assimilation frequency, spatial resolution, number of ensemble members, area coverage, forecast range and frequency and whether coupled with ocean model were reviewed. The European Centre for Medium Range Weather Forecasting (ECMWF) Ensemble Prediction System (EPS) consists of 51 ensemble forecasts at 15 minutes temporal resolution, 60 vertical layers, two different numerical representations for horizontal resolution, and the 'four dimensional variational data assimilation (4DVAR)' technique for generating initial condition. The ensemble forecast accounts for initial uncertainties, and provides a range of future scenarios consistent with present knowledge of the initial state and model capability. It provides a complete description of weather prediction in terms of a Probability Density Function (PDF). The ECMWF forecasts are then down-scaled and bias corrected using the quantile-to-quantile mapping method. The weather forecast is then used in two different (lumped and distributed) Rainfall Runoff models. The two adjusted model outputs are then combined into one 'multi-model' probabilistic discharge forecast product. Dr. Gautam presented a case study where RIMES assisted Flood Forecasting and Warning Centre (FFWC) in Bangladesh to produce 10 days probabilistic flood forecast and long range (1 to 3 months) seasonal flow outlook. He concluded that different ranges of hydrological forecasts could be generated using ensemble prediction system that could be useful in different flood management function.

3.5 Dr. Gautam responded to the question on flood forecast accuracy that the accuracy increased closer to the event. As the lead time increases, the accuracy decreases. Long range forecast alerts the flood management agencies and the communities of a probable impending event for closer watch and enables appropriate ground preparedness. It would be good to evaluate historic forecast performance in Bangladesh to provide greater confidence in the hydrological forecast system. Dr. Gautam also suggested that forecast performance should be evaluated for exceedance of event thresholds (crossing warning or danger levels or high flood level) rather than absolute accuracy in cms of stage or cusecs of discharge. He clarified that ensemble forecasts have different ensemble members in forecasts of different weather forecast centres. For example ECMWERF has a 51 member ensemble while other centres may have different ensemble members. The ensemble forecasts are generated by perturbing the initial conditions. The ensemble rainfall forecast generates as many members of ensemble hydrological forecasts.

Presentation 3: GIS based operational flood forecasting for early warning in North East India by Dr. Diganta Barman, NESAC

3.6 Dr. Diganta Barman of North East Space Applications Centre (NESAC) described the Flood Early Warning System (FLEWS) system developed in north East India. The system development was triggered by the heavy floods in 2008, initially focused on Lakhimpur district in Assam State, and currently covers actionable flood alerts with 12 to 36 hours lead-time at revenue circle level in all flood-prone districts of Assam. The flood modeling approach combines numerical weather prediction, distributed hydrologic and hydraulic model, and synoptic weather monitoring supported by in-situ gauge monitoring. The meteorological component includes daily weather forecast from WRF numerical weather prediction in NER domain; real time satellite images and products from IMD, ISRO Kalpana 1, and others; and synoptic weather conditions analysis and Advisory from IMD, Automatic Weather Stations (AWS) and others. The hydrological component includes distributed and quasi-distributed and lumped models based on the public domain HEC- HMS software using WRF forecasts providing stream flow forecast for river discharge and threshold exceedance and adjusting based on current flood stage from State and Central gauge network and synoptic weather analysis. The early warning component consists of SMS, emails and web-publishing for flood events. Dr. Barman mentioned the under construction/proposed weather radar network at four locations for now-casting of flood events. Piloting of MIKE FLOOD coupled with 1D-2D models in flood simulation in Guwahati urban area was highlighted. The forecast run starts at 0900 hrs and the flood alert is issued by 1530 hrs the same day. The flood alerts are continuously validated based on inputs from multiple sources. The presentation also covered an innovative approach to flood hazard delineation, based on elevation, proximity to river confluence, proximity to breach, Normalized Difference Vegetation Index (NDVI) and Normalized difference Moisture Index (NDMI). This approach is suggested as a viable approach to flood plain hazard zoning in the absence of close contour Digital Elevation Model (DEM) data sets.

3.7 In response to a question Dr. Barman clarified that the forecast system performed well in more than 60 percent occasions (based on ground inundation reports), with partial rate of success (with reports of river level rise beyond warning level but no inundation) in 30 percent more cases. Improvements in performance would come from close-contour DEM, robust hydrological network, and dynamic data sharing between central and state agencies. To a question on early warning in Nalbari district from a tributary originating in Bhutan Dr. Barman clarified that the flood forecasting is supported by communication on reservoir releases from Bhutan, and the warning is provided with a lead time of 8 hours against the time of concentration of 14 hours. He also clarified that the conceptual physical based model provides forecast all along the river compared to forecast by CWC at specific forecast sites. To a question on data issues in the trans boundary Brahmaputra basin it was clarified that DEM from Cartosat 1 stereo pair is generated for Bhutan and Tibet, global data sets including satellite based rainfall estimates are used for basin area outside Indian border, and real-time data from AWS installed from Arunachal Pradesh onwards in the Indian basin area. He pointed out that CWC sites while scientifically located mostly provide stage information and not discharge data.

Presentation 4: Real Time Decision Support System of River Sutlej and Beas by Mr. Anil Vyas, Bhakra Beas Management Board

3.8 Mr. Anil Vyas of Bhakra Beas Management Board (BBMB) provided an overview of BBMB and its functions. Under the World Bank assisted Hydrology Project II modeling of stream flow forecasting in Sutlej and Beas rivers, focusing on inflow into the Bhakra and Pong reservoirs as well as downstream flooding. The model development was supported by upgrading the existing hydro-meteorological network of automatic rainfall and snow gauge stations. The reservoir simulation is performed with Hydrologic Engineering Centre's Real Time Simulation (HEC-RTS) program, HEC-RTS is a public domain version of CWMS/CAVI programs developed by HEC for its use. The U.S. Army Corps of Engineers Corps Water Management System (CWMS) is a comprehensive data acquisition and hydrologic modeling system for short-term decision support of water control operations in real time. It encompasses data collection, validation and transformation, data storage, visualization, real time model simulation for decision-making support, and data dissemination. Control and Visualization Interface (CAVI) is a client application. The BBMB implementation can be run from PC with different modeling components such as MFP (Meteorological Forecast Processor), HMS (Hydrologic Modeling System), RAS (River Analysis System), RES-SIM (Reservoir Simulation), and FIA (Flood Impact Analysis) with HEC-Gridutil (to provide viewing, processing, and analysis capabilities for gridded data sets stored in HEC-DSS format) and HEC-DSS (HEC Data Storage System) on a single platform. The weather inputs include i) 15 days quantitative and ensemble and temperature forecast from ECMWRF at 0.25 deg resolution updated every 24 hours by National Center for Atmospheric Research (NCAR) in USA; ii) Quantitative precipitation and temperature forecast for 10 days updated every 6 hours from NOAA's Global Precipitation System (GFS), iii) Short term precipitation and temperature forecast for next three days from India Meteorological Department (IMD), iv) near real-time precipitation data at 0.25 degree for every three hours from TRMM, v) hourly real-time precipitation and temperature data from IMD and BBMB gauge sites, and vi) real-time precipitation data at 0.1 deg resolution and half-hour interval. Other model inputs include snow cover imageries from MODIS and other satellite data products from Global Land Data Assimilation System (GLDAS), remote sensed Snow Water Equivalent (SWE) grid and BBMB observed reservoir inflow/outflow and reservoir level measurements. The inflow into the Bhakra and Pong reservoirs has been calibrated for real-time reservoir management.

3.9 The complex reservoir simulation model developed in Sutlej and Beas rivers with multiple meteorological data and basin parameters and the integrated set of HEC suite of models was appreciated by the participants. Mr. Vyas clarified that the first model was NAM//MIKE based and the present model development using HEC suite of models and tools started in 2010. The validation would continue with sustained model improvement based on operational forecast experience. Mr. Vyas clarified that the basic framework of model can be prepared for any basin within three months with the help of HEC tools. The Real Time DSS has to be run after new data is updated in the data-base. All the remote sensed data used by model are open source and available for whole earth surface and can be downloaded through ftp server and formatted into HEC DSS file formats. This is important in trans-boundary basins such as satluj where 2/3 basin area lies outside India and snow-melt runoff is the major contribution to the total runoff (Bhakra has 50 % runoff through snow-melt). This model can be coupled with other open source models like MODSIM DSS for water distribution, HEC- SSP (for statistical analysis) and HEC-RPT and other HEC tools. Mr. Vyas mentioned that 10 to 15 days training would equip the engineers to start developing the model. Mr. Vyas answered another question that the met forecast at 0.25 deg resolution is down-scaled to 10km grid and used. The use of Thiessen polygon method instead of isohyetal method for assigning gauge weights in the hilly catchments was questioned. Use of 2D models for downstream flooding was mentioned.

Presentation 5: Real Time Monitoring and Forecasting of Floods in India by Dr. Vimal Mishra, IIT Gandhinagar, Gujarat

3.10 Dr. Vimal Mishra of Indian Institute of Technology, Gandhinagar underlined the impact of climate change in increasing the frequency of extreme rainfall events, and consequent increase in economic losses. The challenges to real-time flood monitoring include lack of real-time data, bias and uncertainty in satellite based data sets and hydrological models, poor stream flow measurements, human impact on basin response, uncertainty in initial conditions, and reliability of weather forecast. He mentioned the widespread use of Variable Infiltration Capacity (VIC) model to solve energy and water balance over grid cells. The real-time flood monitoring and forecast system uses ground measurements of weather and soil moisture parameters, regional scale rainfall, temperature and soil moisture data from satellites, and 7-day forecasts from the Global Ensemble Forecast System (GEFS) providing 21 ensemble members and forecast from the Climate Forecast System (CFS) of National Centers for Environmental Prediction (NCEP). He recommended the use of Integrated Multi-satellite Retrievals for GPM (IMERG) Global Precipitation Mission, as outperforming Tropical Rainfall Measurement Mission (TRMM) data. Dr. Mishra presented case studies of stream flow monitoring at country and basin scales. The basin scale studies covered Mahanadi and Ghaghra basins. Use of Bhuvan data for generating river cross-sections was mentioned. Initial results on flood modeling in Bagmati and Budhi Gandak basins in Bihar State was presented. He concluded that satellite based rainfall estimates from GPM, higher density of ground measurements of rainfall and stream flow, use of RADAR for basins of short response time, and high resolution weather forecasts are needed to improve real-time flood monitoring and forecasting.

3.11 Though the model is currently at national level and large basin level, application to smaller basins in Bihar would require down-scaling of satellite rainfall estimates, weather forecasts of high resolution, shorter interval and high update rates, and basin parameters such as soil moisture, and validation. Dense network of rain and river gauges and RADARs would be critical in smaller basins or basins with short response times. The cause for increasing frequency of floods in Ghaghra basin after 2008 was questioned. Dr. Mishra mentioned this has to be looked in the background of increasing heavy rainfall episodes or rapidly changing basin characteristics. Some studies have shown evidence of increasing flood causing rainfall events and intensity, but this needs to be further investigated. To another question Dr. Mishra clarified that the inundation mapping was based on available satellite data including from Bhuvan platform.

Presentations 6: Cell Phone Data Analysis for Flood Risk Management by Dr. Apichon Witayangkurn, University of Tokyo, Japan

3.12 Dr. Apichon Witayangkurn of the University of Tokyo made a presentation on the use of Call Data Records (CDR) data for extracting information on people distribution and movement to manage flood risk better. This innovative approach leverages the very high density of cell phones as human sensors to send targeted flood alerts as well as target rescue relief, and rehabilitation. This is needed to supplement Census information which is conducted every few years due to high survey cost and it does not track people behavior/movement in between census years and during the flood event. He proposed the use of CDR for developing a location-based flood warning system as well as to track people distribution and movement during flood to support emergency flood management. Understanding people movement and their behavior can make a better preparation and support flood and other initiative also. This can answer the question like how many people got effect from the flood, where they go. The location of cell phone is either through embedding GPS position in the transmission data stream, or using cell tower data. The latter though could be +/- 100 m is recommended as no additional software is needed in the cell phone, and even basic cell phones can be tracked by the Mobile Service Provider (MSP). The CDR covers data on time and location of voice/messaging/data communication of each handset collected for billing purposes. This is however limited to only those times when the cell phone communicates to the MSP. The handset migration can be tracked and gaps filled through cell tower migration. The population at any time in flood impacted areas is estimated by applying a scaling factor to convert subscriber population registered in that area or those that are communicating with the MSP. Dr. Apichon mentioned the limitations of CDR- not all movements are recorded, represents only a part of total cell phone population in that area, the data is anonymized, and data volume is very large requiring special ‘big data’ analysis system. The operational use of CDR data will involve analysis at MPS office to generate anonymized CDR data which can then be processed by the flood forecasting centre and warnings sent. Dr. Apichon presented case studies of CDR analysis in Japan, Bangladesh, and in other locations. The Bangladesh study indicated that such data can be indispensable to tracking people distribution and movement during flood and will support evacuation planning. Other examples included tracking communication in a business area in Thailand, tracking footfall for marketing campaigns and opening new stores in UK, understanding mobility patterns in Colombo, mapping malaria in Kenya, emergency evacuation monitoring in Japan, and origin-destination tracking in Istanbul. Dr. Apichon then discussed the modus operandi of obtaining CDR data through government-to government agreement or private agreement with the MSP. He suggested that anonymization and randomization of CDR can be done at the MSP office, while further processing of such data for sending flood alerts would be by the flood forecasting agency at the most benefit to the host country.

3.13 The innovative approach of using CDR data for understanding people distribution and movement was well received. It was suggested that a better protocol would be to agree with MSP for sending the flood alert issued by the forecasting agency, who will then analyze CDR data and broadcasts the alert to mobile users in the likely affected area. The MSP can also provide anonymized (or demographic data if privacy restrictions do not apply) data for emergency flood relief and rehabilitation. Capacity building and knowledge transferred shall be conducted to related partners allowing them to operate the system by themselves.

Presentation 7: Development of a Regional Flood Outlook: Opportunities for Cooperation by Dr. Mandira Shrestha, ICIMOD, Nepal

3.14 Dr. Mandira Shrestha of International Centre for Integrated Mountain Development (ICIMOD) provided an overview of the organization, its mission and regional action framework. ICIMOD is an inter-Governmental knowledge sharing, learning and enabling centre with eight member countries in the Hindukush Himalayas (HKH). A review of disasters in 2015 indicated that almost half the disasters globally occur in the Asia-Pacific region. The Himalayan region has on the average 60 disaster events each year during the 30 years since 1985. One-third of these disasters are floods. She reviewed the key issues in the Regional Flood Information System coordinated by ICIMOD. These included recognition of the diversity in technical, scientific and institutional capacity across the region; opportunities for sharing knowledge and experiences; application of state-of-art tools and technologies timely and reliable early warning in a regional framework; strengthening early warning system by integrating risk data; and sharing/exchange of real time hydrologic network data across national boundaries. The World Meteorological Observation (WMO) World Hydrological Observing System (WHYCOS) framework promotes basic observation activities in the member countries, and free exchange of designated hydro-meteorological data. The HKH WHYCOS has upgraded 38 hydromet stations set up in Nepal, Bangladesh, Pakistan and Bhutan with data transmission through CDMA/GSM and satellite telemetry and shared among partner countries; provides access to Global Telecommunication Stations (GTS) of WMO; and additional stations contributed by partners. Dr. Shrestha provided an overview of the Regional Flood Information System has been piloted in the Ganges-Brahmaputra basin since 2014. The regional flood outlook at 21 nodes and with 3 days lead time utilizes freely available data and weather forecasts. The outlook is produced through a conceptual rainfall-runoff model and 1D hydrodynamic flood routing along the river system. The modeling approach uses a range of dynamic observed and multi-satellite based meteorological and hydrological data and static basin data. The current focus is on major rivers in Nepal. Proprietary NAM/MIKE11 models have been used, with real-time hydrometric data, satellite precipitation from TRMM, and quantitative precipitation and temperature forecast from GFS at 25 km grid. The flood forecast has been evaluated in major rivers of Nepal, and shows need for improvement at higher discharge range. Flood outlook and inundation mapping from Chatara to Kursela in Kosi basin has been initiated using 1D and 2D coupled models. The inundation from the Kusaha breach in Kosi left afflux embankment in August 2008 was simulated and compared with satellite based inundation map. Dr. Shreshta described the challenges to be access to topographic data for river cross-sections and flood plain, revision/definition of Alert and Danger levels at model nodes and improved model operation. She emphasized the need to integrate risk information, develop appropriate institutional mechanisms for dissemination, strengthen monitoring network, and build capacity through enhanced cooperation and partnership.

3.15 To a question on how ICIMOD can help data sharing with Nepal, Dr. Shrestha suggested that a formal mechanism should be set in place and ICIMOD could support. Mr. Sahu, Chief Engineer, CWC mentioned that under the Master Plan for Flood Forecasting Government of India has assisted Government of Nepal to upgrade select sites in in Nepal to increase the lead time for CWC flood forecasts in Bihar. He also mentioned that though the data is collected every hour data reaches CWC only at 0700 hrs every day. This means valuable lead time is lost between the time of flood peak and the time by when CWC is provided this data. She requested the Water Resources Department, Bihar to evaluate and use the outputs from the stand-alone flood forecasting system in Kosi basin by Department of Hydrology and Meteorology, Nepal in the 2016 flood season. Dr. Shrestha clarified that ICIMOD assists the member countries to develop the flood forecast system and it is the country that issues the forecast. The Regional Flood outlooks are issued at 0900 hrs and two-to-three time a day in the monsoon season depending on the weather situation, and published in the web, and in critical cases sent directly to the hydromet agencies.

Presentation 8. Flood Modeling in North Bihar: Challenges and Opportunities by Dr. S. Thiruvengadachari, Flood Management Consultant

3.16 Dr. S. Thiruvengadachari, Flood Management Consultant, highlighted the challenges and opportunities in flood modeling in North Bihar river basins. Currently the Central Water Commission provided forecast of flood stage (after the warning level is crossed) at select downstream sites, once or more times a day, based on gauge-to-gauge correlation with the base station. The lead times in North Bihar rivers is 8 to 24 hours. The forecast performance is assessed higher than 95 percent based on whether the forecast stage is within +/- 15 cms and the discharge is within +/_10 percent of observed values. The limitations are i) forecast only at a few sites and not all along the river, ii) the lead-time is restricted to the travel time between the base and forecasting stations, and iii) likely inundation is not mapped. Conceptual physical based models are proposed now to address these limitations. A critical challenge to modeling is in-adequate ground measured data (rainfall, water level/discharge, rainfall forecasts, rating curves, river cross-sections, reservoir releases and outflows, etc.) and poor data quality and accessibility. Opportunities include strengthening the RTDAS network, implementing comprehensive data validation protocols, and data assimilation from ground including RADAR and satellites and numerical weather prediction models. The trans-boundary nature of most Bihar basins pose problems of data availability and access outside India, requiring use of global data sets on basin characteristics and meteorological inputs. The complex basin geomorphology, in-distinct basin boundaries with flow between river systems, varying flow conditions in un-embanked reaches and partial embankment either on one or both sides in other reaches, and multiple inundation scenarios with varying causes pose challenges. An approach of coupling different types of models including statistical, Artificial Neural Network (ANN) and conceptual physical based ID and 2Dbmodels, lumped to distributed, may be needed. In complex basins the modeling approach would adopt a systematic, hierarchical and iterative model development, starting from simple to complex, with increasing complexity addressed by improved model understanding and data availability and quality. Use of ensemble rainfall forecasts, and multiple hydrologic/hydraulic/hydrodynamic models, would lead to ensemble hydrological forecasts for better probabilistic risk assessment. Mapping inundation scenarios continues to be a challenge in the absence of good quality Digital Elevation Model (DEM) and historic data for validation. The validation of inundation extent against satellite derived inundation maps need to take note of the over-estimation in the latter due to the coarse resolution of the satellite data. Where is the ground data on inundation depth, duration and time of incidence? Crowd-sourcing in the flood plain would provide the historic data for validation. Good inundation mapping would require 2D hydrodynamic models with attendant data requirement. Validation remains a weak point in both research and operational models. Standard protocols consistent with the goals of the operational flood forecasting system are needed. Capacity constraints need to be addressed. This calls for a creating a cadre of flood modelers with assured career path and incentives, continuous skill upgrading, sponsored research in academia to complement institutional activities, and developing capacity for downstream use of flood forecasts and early warning.

3.17 There was general support that an assured career path and incentives are essential to attract qualified engineers to this soft activity and to retain them.

Closing Remarks by Co-Chairs

3.18 Dr. Vivekanand Singh congratulated all the eight speakers on the excellent presentations. He reiterated the need for input data availability and quality, selection of appropriate model, calibration and validation and early warning at lead times appropriate for field preparedness. He appreciated the vigorous audience interaction. Mr. Takur congratulated WRD, GoB for identifying the need and taking up studies to develop flood modeling capacity. He clarified that there is no specific flood forecast mandate to any agency, as the need provides the mandate to agencies to come up with appropriate systems. While CWC has been providing the flood forecasts, obviously there is need to improve the forecast lead time, locations and early warning at community level. The State and central agencies need to work together and complement each other in fulfilling flood forecast needs.

Panel Discussion

3.19 The panel discussion was moderated by Dr. Satya Priya, and other members were Dr. S. Thiruvengadachari, Flood Management Consultant: Mr. S.K. Sahu, Chief Engineer, LGBO, CWC; and Mr. A.K. Sen, Director, IMD. A set of issues were prepared to guide panel discussions. Mr. Sahu commented that the gauge-to-gauge correlation model while providing good forecasts at selected downstream sites could be complemented by conceptual and physical based models to increase the lead time and provide inundation information. MR. Sen pointed out that numerical weather forecasting coupled with hydrological forecasting system has increased the lead time. He said translation of quantitative rainfall forecasts need to be coupled with basin models to translate into inundation and impact on society. Dr. Thiruvengadachari pointed out that data supply from CWC for model development is facing many issues- some data are confidential all the time and some during lean flow periods, some previously unclassified data such as sediment load and cross-section data at CWC sites has become confidential, data supply is delayed, sharing of real-time data from CWC sites, etc. Mr. Sahu clarified that the new Classified Data Screening Committee has members from other ministries also, who may have other national considerations in clearing data supply and not. All data requesting agencies including GoI agencies undergo the screening process. He pointed out that in critical cases data supply has been cleared, and future cases. Academic institutions are in general provided data appropriate to the research work planned and cost-free. Differential rates are charged for data supply to different classes of users. Anomalous situation where government agencies are being charged commercial rates just because a consultant is analyzing the data was mentioned. Dr. Satya Priya referred to the new data sharing policies being drafted which may ease data sharing. The National Hydrology Project (NHP) which is a centrally sponsored scheme also is proposing data sharing protocols and policies. Dr. Saroj Kumar Varma suggested that master basin planning proposed in NHP would require agreement between states to share data. Ms. Arti Sinha pointed out that river stage/discharge data is nor shared by Nepal. Dr. Sahu pointed out that given the published station elevation the water depth can be translated to stage. Dr. Nagan Prasad pointed out that an appropriate modeling strategy commensurate with basin complexity need to be developed, coupling of Rainfall Runoff models of Nepal basin area to predict the response at entry point (Dheng Bridge) into Bihar with downstream models in Bihar is needed. He also pointed out the need for a coordinated program for model development, considering the large number of institutions developing models of different types and performance levels. Mr. Sahu responded that CWC can take up forecasting at Dheng Bridge and at other sites if there is a request from the State government. Dr. Gautam pointed out that Kosi and West Rapti basins have been taken up for piloting 3 days flood forecasting system by Department of Hydrology and Meteorology, Nepal to be completed within three years. Once developed these forecasts can become the upstream boundary conditions for downstream forecasting in India. He also pointed out that rea time data is being published in the DHM website, and later on would publish more than 100 hydrological sites and 200 meteorological sites are being implemented with real-tie telemetry under the World Bank assisted Climate resilience project. Historic data can also be purchased at nominal rates. Derivation of rating curve is being delayed, impacting converting river stage to discharge. Dr. Gautam appreciated the use of open source modeling software and mentioned that RIMES is using license-free Delft-FEWS operational forecasting platform. Community warnings and feedback on inundation (using gauges set up in the communities) is facilitated by customized mobile applications. Dr. Barman pointed out that the India WRIS platform publishes basin data at 1:10,000 scale which would be useful in monitoring. Mr. Sahu mentioned the need to revise the danger and warning levels at forecast stations which have been fixed in consultation with the district administration. Post-embankment situation these need to be reviewed and revised. Dr. Satya Priya concluded that there cannot be one single approach, but with better understanding of the basin processes and improved and timely availability of good quality data flood forecasting in Bihar is moving in the right direction. He wished Government of Bihar all success in their endeavor.

Observations and Insights

3.20 Observations and insights from the session include:

a) Public-domain and license-free modeling software are effectively used to develop operational flood forecasting applications in basins of varying size and complexity, in place of proprietary software. This will help scaling-up to multiple river basins rapidly and cost-effectively. There is also a vibrant user community for knowledge sharing and development support.
b) There seems to be a range of open source models (mostly HEC suite of models) available, with tools to customize user-friendly interfaces for data input and output and visualization.
c) Most modeling work were completed in relatively short gestation times. Even the more complex HEC suite of models in Sutlej and Beas basins was developed in three year's time.
d) Most models made innovative use of currently available satellite rainfall estimates (mainly Tropical Rainfall Measuring Mission (TRMM) and Global Precipitation Measurement (GPM) data after bias-correction and down-scaling, and weather forecasts from Weather Research and Forecasting ((WRF) model. Use of ensemble rainfall estimates and ensemble rainfall forecasts and ensemble hydrologic forecasts is relatively new and yet to be widely used. The forecast system in north east India used synoptic weather analysis to adjust forecasts closer to the event.
e) Medium range deterministic (up to 10 days) and probabilistic forecasts (up to 15 days) integrated with flood forecasting model extend the lead time for effective ground response. Different ranges of hydrological forecasts could be generated using an ensemble system. Forecast accuracy decreases with lead time and improves closer to the event.
f) Adequate network density of precipitation (rainfall and snowfall) and river gauging stations is critical to calibrate and bias-correct satellite based estimations and forecasts.
g) Assimilating ground measured rainfall and ensemble satellite rainfall estimates is recommended to improve model performance.

h) Satellite based basin parameters such as land cover-use, elevation, soil moisture, snow cover, etc. would help improve performance of operational stream flow models.
i) Model performance assessment is better done for event based threshold exceedance - such as exceeding threshold for defined events- for example, crossing warning and danger level, inundation extent (within the panchayat), depth (>60 cm, >100m), arrival time (<1 day, <3 days, and > 3 days) and duration (<5 days, <10 days, >10 days).
j) The flood forecast modeling team should include qualified meteorologists to understand, calibrate, validate, downscale, interpret and integrate weather forecasts in the hydrological forecasting system.
k) It would be good to link regional flood forecast modeling system and forecasts/outlooks from ICIMOD to cross-support with data collected under WMO HYCOS[3] framework and integrate upstream forecasts in trans-boundary basins in north Bihar.
l) Community warning can be supported by use of Call Data Records (CDR) at the Mobile Service Provider servers, to locate and broadcast flood alerts to mobile receivers in the likely affected areas. CDR data would also be helpful in monitoring people movement post-event in the flood affected areas for targeted emergency flood management. Necessary institutional arrangements taking note of privacy limitations would need to be agreed.
m) The procurement of historic data from Central Water Commission (CWC) has become more complex, with delays and more data such as river cross-sections at CWC site (needed for developing rating curve) and sediment data becoming confidential. The cost of data has also substantially risen, for consultancies even if organized by State or central government agencies. CWC should also arrange timely sharing of rainfall and stage data received from Nepal under bi-lateral agreements. It is expected that the new Data Sharing Policy proposed under the National Hydrology Project would facilitate better data sharing by CWC.
n) Flood modeling in north Bihar river basins is challenged by its unique characteristics but also provides opportunities to innovate. The complex basin geomorphology, partially embanked -either on one side or both sides- river system and multiple causes of flooding call for a suite of different models (statistical, conceptual and physical based, lumped to distribute) rather than a single model. The recommended modeling approach would start from simple model to complex model, with increasing complexity to suit available data and improved understanding of basin response. The trans-boundary basins mean poor data access in areas outside India, and would need to be supported by global and regional data sets on basin conditions as well as satellite rainfall estimates and ensemble rainfall forecasts. Data assimilation from multiple sources (satellite, RTDAS, RADAR) would provide more dependable input data for the models. Scaling up to other basins would require use of public domain and license-free modeling software rather than proprietary software. Most inundation scenarios can be supported by

[3] World Meteorological Organization (WMO) Hydrological Cycle Observing System (HYCOS) providing access to 38 meteorological stations upgraded in Bangladesh, Bhutan, Nepal and Pakistan and more than 300 Global Telecommunications Stations of WMO

satellite based Digital Elevation Model (DEM) of up to 1 m contour interval, with LIDAR based DEM covering only the very flat flood plains. Validation particularly in regard to inundation mapping suffers from non-availability of historic data on inundation depth, duration and time of inundation. Community-sourcing of such information would help fill the void. Assessment of model performance is another challenge. A standardized model validation protocol need to be established. Operational flood forecasting models take time to mature, and thus require long-term institutional commitment. This would include defining a program and setting goals for different time horizons (0-5, 5-10, 10-15 years), developing a cadre of flood modelers including meteorologists, organizing continuous skill upgrading programs, implementing an assured career path and incentives, and sponsored research in academic institutions.

IV. Technical Session II: River and Sediment Management

Co-Chairs: Dr. Santosh Kumar. Retd. Professor, NIT, Patna
Dr. Mandira Shrestha, ICIMOD

Session Summary

4.1 This session covered four presentations, covering river morphological analysis and annual prediction, preparation of master plan for flood and sediment management, Embankment Asset Management System and community participation in embankment surveillance, all in the Kosi basin. All these pioneering activities have been conducted under the Bihar Kosi Flood Recovery Project assisted by the World Bank.

Presentation 9. Modelling River Morphological Trends by Mr. Sudipta Kumar Hore, Centre for Environment and GIS (CEGIS), Bangladesh

4.2 The Center for Environmental and Geographic Information Services (CEGIS), Bangladesh has a decade-long experience in using remote sensing technology in studying river morphology and bank erosion processes. CEGIS has developed a method/model by which they use satellite images in predicting morphological changes and river bank erosion of the major rivers, such as the Brahmaputra-Jamuna, the Ganges, the Padma and the Lower Meghna. The method/model is also one of the reliable and cost effective approaches for predicting morphological changes on annual basis for bank erosion management. The main objective of the Kosi morphological study is to understand the river morphology and the long term erosion process of the Kosi River, and to develop a methodology for predicting future morphological changes in the rivers of the Kosi river basin. The satellite image-based river behavioral study would cover the rivers of the Kosi River basin, namely, the Kosi, the Bhutahi Balan, the Kamla and the Bagmati. All these rivers enter Bihar from Nepal. The processes of shifting of the main channels from one bank to other are in the scale of years to decade. On the other hand, the processes of channel development and abandonment are very frequent in the scale of month to year. These two processes of different time-scales are highly relevant for characterizing the behavior of the Kosi River. The analysis used hydrologic data of 2001 to 2013, post-monsoon low-flow satellite imagery of 2001 to 2014, river cross-sectional data, and sediment data among others. Time-series satellite images have been used to understand the geo-morphological and planform characteristics of the Kosi River, the Kamla-Balan and the Bhutahi-Balan rivers. The Kosi River has been divided into five reaches based on the man-made control points as well as the braiding and meandering planform characteristics of the Kosi River. The model is used to predict on annual basis the vulnerable reaches, embayment between spurs which may cause scour at the tip of spurs and identification of active channel. While the model is empirical and simple to set-up, but need to be frequently updated for dynamic braided rivers.

4.3 Dr. Barman wanted to know whether braiding Index has been used in the model, and suggested to verify the model performance. Mr. Hore explained that braiding index is not currently used. The model based on data up to 2009 was used to predict changes in 2010 to validate model performance.

Presentation 10 : Preparation of Master Plan for Flood & Sediment Management in Kosi River Basin by Mr. Bibhas Kumar, URS Scott Wilson India Private Limited; Dr. Flemming Jakobsen, DHI (India) Water & Environmental Pvt. Ltd.; and Mr. S C Sinha , Project Director, URS

4.4 The introduction was provided by Mr. Bibhas Kumar, modelling part was presented by Dr. Flemming Jakobsen, and the suggested measures for two management units were presented by Mr. S.C. Sinha.

4.5 The objective is to prepare a master plan which is environmentally friendly, socially acceptable and techno-economically viable. The real challenge is the integration of social equity, economic efficiency and environmental quality solutions. Kosi is a trans-boundary basin lying in China, Nepal and India. The management issues are: 1)excessive generation of sediment in upper catchments in Nepal, 2)Heavy siltation at u/s of Kosi Barrage, 2) shifting of course due to aggradation, degradation, braiding and meandering characteristics of the Kosi River, 3)erosion leading to breaches of Kosi Embankments, 4)Inundation due to annual flooding of 395 villages located between the two embankments, 5)Flooding (450 sq. km) and drainage congestion of the area east of the Eastern Embankment, and 6)Water logging and drainage congestion in the command of eastern Kosi canal.

4.6 Dr. Jakobsen’s presentation covered the modelling activities which were carried out to support the preparation of the Master Plan. He explained how 1D & 2D Hydrodynamic and 1D Sediment Transport Models for Kosi reach from Chatra to Kursela (273km) were set up using MIKE 11 and MIKE 21 C. Sediment yield from upper catchments, sediment flows at Chatra, Birpur, Kosi Mahasetu, Balwaha Bridge and Dhamara Ghat were presented. The predicted bed profile and its effect on availability of freeboard, using 1D HD-ST Model, after 5 year, 10 year & 15 years of simulation were also presented. Distribution of velocity and water depth, using the results of Meso-scale 2D HD Model, over the entire reach of Kosi from Chatra to Kursela was shown. Velocity distribution with spurs in Micro-scale 2D HD Model was presented.

4.7 Mr. Sinha explained the seven management units which were decided to facilitate the preparation of the Master Plan. These Management Units are, 1) The catchment area upstream of Chatra (Outside India) in Kosi river system, 2) Barrage and appurtenant works, 3) The Kosi River Course (From Chatra to Kursela), 4) Embankments, 5) Area between embankments (between Barrage & Koparia), 6) Area east of the eastern embankment and 7) Area west of western embankment suffering from drainage problem. He analyzed the problems and probable solutions for Management Unit No. 1 and Management Unit No. 5. The main problem for Management Unit No. 1: Upper Catchment is the generation of high amount of silt load for Kosi. The recommended solutions were Catchment Treatment and Construction of Kosi High Dam and other storage dams on the tributaries of Kosi. The main problem for Management Unit No. 5 is that almost 1 million people are living on the riverine islands of Kosi between the embankments. These people get totally de-linked from all facilities. The recommended solutions for this units were, 1) Parallel Embankment using Geo-Tubes in conjunction with dredging, 2) Living with the Floods – like flood proofing, flood resistant buildings etc., and 3) Administrative Reorganization – like at least one block headquarter should be in this area.

4.8 Dr. Diganta Barman cited the successful application of porcupines to arrest bank protection in Assam, resulting in silt deposition offering further protection. Mr. Bhibas Kumar mentioned that porcupines are in use for more than 65 years in the basin and have proved effective.

Presentation 11. Embankment Asset Management System in Kosi Basin
by Mr. Rajesh Kumar, CGM, LEA Associates South Asia Pvt. Ltd.

4.9 The Embankment Asset Management System has been developed on a GIS platform with functional modules for operation & maintenance of embankment and related assets through the life-cycle. The development included: i) Collecting all asset data of Kosi Basin through GPS survey and prepare an asset map, geographic referencing all assets through nearly 650km length of embankment and more than 700 locations of spurs & other assets, converting to Shapefile through GIS Software, and Overlay Google, Arc-GIS Base Map & Satellite Images, ii) Identifying all Information / Data Required to archive for Kosi Basin like Engineering Information, Basin Information. Flood Store Information and Documents Information, and iii) Use of K-EAMS in Asset Management of Kosi Basin during Life Cycle of Assets like Designing New or Strengthening Existing Structure, Construction for Implementation of Standard Operating Procedure (SOP), Risk Assessment, Preventive or Corrective Measures / Emergency Response, and Operation and Maintenance (O & M) / Reconstruction. The outputs include: spatial maps of embankment and their assets in Kosi Basin; Functional Module for Inspection, Operation & Maintenance, and generation of various reports & alerts during operation & maintenance; Android Based Application for Inspection of Various Embankment and their Assets; SMS & Web Based Portal for Community Participation during Embankment Surveillance; platform to store all important information for the reference in future; direct access to authorized users for use of embankment database from any location with updating facility; and portal for high level management officer to monitor the operation of embankment and their assets with alerts from their PC / Laptop. The system has been demonstrated to WRD engineers and training camps conducted. It is hoped that the system would be fully operational shortly.

4.10 Dr. Mandira Srestha enquired how and who can access this information system? It was clarified that the EAMS is hosted in a web portal, and authorized users would be able to access this system from a remote location if needed.

Presentation 12. Community Participation in Embankment Surveillance in Kosi Basin by Mr. Rashid Wakil, JPS Associates (P) Ltd.

4.11 Community participation for embankment surveillance is being promoted under the Embankment Asset Management System developed in Kosi basin. Community participation will supplement the departmental capacity which has diminished due to staff constraints, and also provide a sense of ownership amongst the communities adjacent to the embankment. The approach, protocols and mechanisms for community participation in embankment surveillance have been developed and Piloted in select Communities in the Basin. The desired mode of community participation, arrived through consensus, was through formation and strengthening of Gram Panchayat Level Embankment Surveillance Committees (GPLESC) and building capacity to patrol and identify any threat to the embankment. Fifteen GPLESCs have been formed, and the goal is to form fifty more along the embankment. The GPLESC has to be formed according to specified protocols and approved by the Department. The protocols describe the Committee formation and capacity building. Training manuals (both in Hindi and English) have been developed for formation and strengthening of the committees and piloted in about 30 villages and GPLESCs. An Action Plan for community participation across the entire stretch of Kosi and Kamla River basins has been developed. As per the plan WRD needs to conduct one pre-season workshop in each Division during May and one during September of every year, concurrent with the visit of Technical Advisory Committee so that issues of community can be accounted in the annual and long-term action plan for strengthening of flood protection works. The process of information flow has been developed during flood and normal times for effective reporting on embankment safety related issues, namely visual observation of river flow close to embankment, damage to river training works and embankment structures, wave action damaging the river-side slope of the embankment, Seepage of water through embankment, rat holes, and rapidly rising river water level. The information exchange would be from the community to WRD field offices, , FMISC and vice versa through integration into the community report module of EAMS.

4.12 Dr. Thiruvengadachari inquired whether WRD has been sensitized for community participation, and whether community participation has been incorporated in the Standard Operating Procedure for embankment management. Mr. Wakil pointed out that the community participation mode was discussed in Workshops involving both community and WRD field and state level officials and that there was consensus on the proposed modality. He mentioned that community participation in embankment surveillance has been welcomed, particularly in the context of reduced staff in the field offices. The Junior Engineer and PRI members will be part of the Embankment Surveillance Committee. He proposed a funding mechanism to support community participation. As regarding the query on frivolous information being sent by people, it was clarified that a data bank of responsible community members is integrated into the EAMS and therefore the information will be sent and registered only by those people trained for the purpose thereby making it useful to the information. Dr. Mandira Shrestha suggested that engineers from Nepal should also be involved in adopting community participation for surveillance of embankments upstream of barrage. Mr. Wakil confirmed that though the proposed community mechanism covered only the Indian basin area, Nepal engineers had participated in the field training camps.

Closing Remarks by Co-Chairs

4.13 Dr. Mandira Shrestha recorded her appreciation of the four technical presentations, which covered techniques, plans, systems and community participation which she hoped will improve flood risk management. Dr. Santosh Kumar congratulated all the four presenters and concluded that these initiatives shall be sustained and upgraded for better flood risk management in the State.

Observations and Insights

4.14 The analysis of river morphological changes in Kosi system shall be extended to other basins in Bihar, to predict annual changes in embankment vulnerability, embayment between spurs, and the identification of active channel for effective timely strengthening of flood protection works. The satellite based model shall be complemented by the 1D & 2D Hydrodynamic and 1D Sediment Transport Models set up under the Master Plan consultancy. The Master Plan for River and Sediment management would provide the framework for taking up short-term and long term activities within the integrated river management action program. The Embankment Asset Management System supports rational management of these expensive assets and prolongs operational services and useful life. This should be extended to other basins in Bihar. Community participation for embankment surveillance shall be promoted and expended to other river basins, to pride a sense of ownership and involvement by the likely -affected communities.

V. Technical Session 3: Knowledge management

Co-Chairs: Mr. S.K. Sinha, Former Engineer-in-Chief, WRD
Mr. S.N. Tiwari, Retd. Director, GFCC

Session Summary

5.1 The session covered knowledge bases created in the Ganga basin on flood hazard, exposure, vulnerability and risk to support flood risk management, and GIS databases for the whole Bihar State to support flood management through the life-cycle. The former is based on analysis of historic data and models, while the latter is sourced from satellite imagery of different resolution, existing topographic, geographic and census maps and statistics, and outputs from analysis.

Presentation 13. Ganga Basin Flood Risk Atlas by Dr. Satya Priya, World Bank

5.2 The Ganga Flood Risk Atlas was developed by Word Bank to help understand and evaluate areas at risk considering hazard, exposure and vulnerability in the Ganges basin spread across Nepal (15 %, India (80%), China (4 %) and Bangladesh (1%). This will help guide priority flood mitigation program. Key activities included: i) Development of exposure (assets at risk) database for various asset classes such as buildings, infrastructure, demography, and agriculture, ii) Development of one-dimensional steady flow probabilistic flood hazard model for 2, 5, 10, 25, 50, and 100-year return periods using hydrological and hydraulic modeling for the entire Ganges Basin up to its confluence with the Brahmaputra River in Bangladesh, iii) Development of vulnerability curves (damage functions) for each of the exposure (asset) classes, and iv) Estimation of direct losses at sub district/district levels. The Atlas can be accessed at http://www.gangesfloodriskatlas.com/. Dr. Satya Priya demonstrated examples of population affected, economic losses, and characteristics of Kosi basin, flood risk assessment of the basin in terms of population affected and economic losses at different return periods of floods.

5.3 The Atlas indicates that Bihar and Uttar Pradesh states in India and areas of Bangladesh lying in the basin are highly vulnerable to the floods. At sub-basin level, the Lower Ganges is the most severely affected sub-basin. It is recommended to further strengthen the hydrological model by using rainfall gauge or high resolution rainfall data and by taking more number of actual flow gauge stations in calibration and validation. Also, in order to estimate the probable damage to other vulnerable exposures, other remaining assets (bridge, pipelines, livestock, electric lines, other crops, etc.) at risk should also be included in exposure data. The social vulnerability of various ethnic groups and adaptive capacity of people in the flood prone areas of the three countries should also be surveyed and made part of a separate study. The study can be replicated for other basins and sub-basin of the region. Improvements in the data availability, employing process oriented hydro-agrological models, considering detailed aspects of socio economic vulnerability and adaptive capability of various community groups in the study area can further enhance the usefulness of such studies. The sector specific impact of hydro meteorological disasters on the economy of the countries can also be analyzed. He pointed out that the process of Central Water Commission taking over the web based tools for Ganga flood risk assessment is under progress so that the Atlas would become a national resource.

5.4 The question of reclassifying flood risk areas which are now protected by embankments would need to be addressed by the risk of embankment failure. To another question, Dr. Satya Priya clarified that the Atlas is based on available flood data and simple models, and special hazards specific to any area such as cloudbursts in Uttarakhand resulting in floods, or floods from embankment breach in Kosi basin, would need to be addressed separately and integrated into the atlas, which should be continuously updated and upgraded. He explained that while the risk data is at block level in India, it is at district level in Nepal and Bangladesh, mainly the result of limited exposure data available. The Atlas provides the framework. He mentioned that the Central Water Commission is associated with the preparation and use of flood risk atlas, and other agencies like Ganga Flood Control Commission may be associated for updating the atlas as well as promote use. Dr. Satya Priya clarified that indirect or intangible losses are currently not accounted for in the Atlas but may be built-in later. He also clarified that the return periods associated with the risk are based on historical records. It was questioned how to asses risks associated with recent disasters have taken place at smaller discharges compared to the design values, as for example in Kusaha breach or in other rivers.

Presentation 14. GIS Data Base of Bihar by Mr. Sanjay Mathur, FMISC

5.5 Mr. Sanjay Mathur, GIS Specialist, FMISC traced the history of GIS database development and the road map for upgrading the database. His presentation covered what has been developed, how it is being used in day to day functioning of WRD and what is being planned for the future to cater to growing needs. Currently the spatial database covers the whole State, and consists of more than 13 thematic layers with appropriate tabular data. High to very high resolution satellite data including microwave sensor imagery have been used to generate layers on infrastructure, drainage, settlements and communication network. The database is constantly updated with sequential satellite imagery as needed. Departmental data is used to enrich the database. Crowd-sourced data is used as appropriate, as for example in updating dynamic changes in local context. Community reports on embankment condition and river flow are prime examples. In trans-boundary basins available data from public resources are used to cover the whole basin. He suggested popularizing GIS up to field level using freeware GIS software to generate interest and support for this technology. He called for a more liberal data distribution and exchange policy and hoped falling cost of data collection including close-contour topographic data would help migrate to 3D GIS.

5.6 Mr. Mathur clarified that the embankment breaches are mapped using all available data including RISAT satellite's 1m resolution microwave data for mapping floods even during the cloud covered periods. This was effectively demonstrated in the 2008 Kusha breach, when the breach status was continuously monitored, and basic data provided for planning cut-off channels to redirect flow away from the breach, helping closure action. To another question on mapping the gap between irrigation potential created and utilized, Mr. Sanjay replied that while the maps of all irrigation commands have been archived, analysis of irrigation gap is not done as the focus is on flood management. Data also needs to be collected on irrigation statistics at canal division/sub-division level to support analysis. To another question on crowd-sourcing for data collection, Mr. Mathur clarified that such techniques are planned for example in EAMS where embankment and river related data is reported by the communities who have been trained and archived.

Closing Remarks by Co-Chair

5.7 The Co-Chair congratulated the two speakers and suggested that such knowledge bases help plan and prioritize flood management interventions. He recommended greater use of the knowledge by WRD and academia.

Observations and Insights

5.8 Structured knowledge base such as the Ganga Flood Risk Atlas and multi-theme GIS data sets of Bihar State effectively support the entire life-cycle of flood risk management, from planning to preparedness to flood relief, rehabilitation and reconstruction. The knowledge bases obviously need to be kept updated with new and better information through the years, and expanded in multiple levels for varying applications. Linkage with other national and State level databases shall be encouraged.

VI. Technical Session IV: Downstream Projects

Co-Chairs: Mr. S.K. Sahu, Chief Engineer, Central Water Commission
Mr. S.C. Sinha, Retd. Chief Engineer, WRD

Session Summary

6.1 The session covered the downstream projects of Kosi Basin Development Project and National Hydrology Project. The former is focused in Kosi river basin and inherits and expands from the previous Bihar Kosi Flood Recovery Project while the Bihar component of the latter transitions activities like flood forecast modeling and inundation mapping and early warning from the previous Flood Management Improvement Support System.

Presentation 15. Bihar Kosi Basin Development Project by Mr. Anil Kumar, Deputy Director, FMISC

6.2 Mr. Anil Kumar, Deputy Director, FMISC explained the components of the Bihar Kosi Basin Development Project (BKBDP). This project aims to enhance resilience to floods and increase agricultural productivity and competitiveness, augmenting connectivity, and improve contingent emergency response in the Kosi basin. Improving flood risk management provides for strengthening flood control infrastructure, and building institutional capacity. The former includes protection and restoration of spurs and embankment in select reaches. Institutional capacity building includes establishment of a Centre of Excellence for Water Resources Research and Development in WRD and establishing a real-time data acquisition system in Bagmati-Adhwara and Kosi basins. Mr. Anil Kumar traced the achievements in the previous project- Bihar Kosi Flood Recovery Project- in both structural and non-structural activities. The structural improvements included restoration and black-topping of select embankment reaches, restoration of select Dhars, and protection and restoration of select spurs along Eastern Kosi embankment downstream of barrage. Non-structural improvements include development of Embankment Asset Management System and community participation in surveillance, river behavioral analysis to predict changes a year ahead, Master Plan for Flood and Sediment Management, and preparation of Detailed Project Report for establishment of Centre of Excellence.

6.3 Mr. Sahu, CWC pointed out that IIT, Delhi has been tasked by Central Water Commission to conduct the river morphological study of Kosi system to be completed by June 2016, and recommended that FMISC should consult the study which may be useful. Dr. Mandira Shrestha suggested that the various information systems like the EAMS, GIS datasets, and flood forecasting system should be inter-linked to provide a composite system which should be accessible by users. Mr. Anil Kumar agreed and suggested that data access would be possible based on appropriate authorization.

Presentation 16. National Hydrology Project by Dr. Saroj Kumar Verma, Deputy Director, FMISC

6.4 Dr. Saroj Kumar Verma described the National Hydrology Project (NHP) being implemented all over India by Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India with active assistance of World Bank. The presentation covered both National and State proposals. The NHP is being implemented by 47 Implementing Agencies (IAs) including eight Central Agencies, 37 State level agencies and UTs (including surface and ground water components) and two River Basin Organizations. The Central Agencies are : Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR, RD &GR)); Central Water Commission (CWC), Central Ground Water Board (CGWB), National Institute of Hydrology (NIH), Central Pollution Control Board (CPCB), Survey of India (SoI), National Remote Sensing Centre (NRSC) and Central Water and Power Research Station (CWPRS). Water Resources Department (WRD), Bihar is the Implementing Agency for Surface Water Components in Bihar. Minor WRD, Bihar is IA for Ground Water Components. The Development Objective of the project is to Modernize nation-wide the data, information and knowledge support for water resources management, planning and operation in India. The Project components are : A. Modernizing Water Resources Monitoring system (WRMS), B. Modernizing Water Resources Information Systems (WRIS) : Develop and support centralized database management system, water resource data sets, including remotely sensed information; and facilitate state-WRIS; C. Water Resources Management Tools and Applications (WRMTA) including DSS in selected river basins for flood forecasting and reservoir operations, water resources (SW and GW) planning and management, etc.; and D. Modernizing Institutions and Capacity Building through establishing and supporting water resources data centers, trainings, centers of excellence. Expected Benefits from the project are : Standardized countrywide water resources database and country under one water resources information framework; centers of excellence to provide modern water resources knowledge services and partnerships; capacity for addressing critical water challenges in the country; Improved output/outcome focus due to performance-based financing for a broad range of organizations; Modernizing learning and knowledge exchange; and Improved access to information in the public-domain. Dr. Verma also described the Vision and Expectations from National Hydrology Project in the context of Bihar. He also explained the funding and fund flow arrangement to apprise WRD personnel in particular. He explained what activities have been proposed for surface water components in Bihar under NHP and the implementing arrangement within the department and also, the status as on date of the project in Bihar.

6.5 Mr. Tiwari, FMISC wanted to know the scope of digitization of canal command area and area actually receiving irrigation, and suggested development of Canal Asset Management System, similar to EAMS. Dr. Saroj Verma clarified that the village maps will be digitized indicating which field are receiving canal water. Mr. S.K. Sinha enquired whether canal automation and SCADA system are proposed. Dr. Saroj Verma responded that this is not included, but reservoir measurements are included in RTDAS under BKBDP. It was also recommended that canal modernization shall precede canal automation. Water Knowledge Centre is currently proposed in Patna, and perhaps later in river basin headquarters. This will follow similar Centres set-up in other states which were earlier in HP I and II.

Closing Remarks by Co-Chair

6.6 Mr. Sahu appreciated the two informative presentations on the two downstream projects. He hoped that with these slew of projects water resources management in Bihar State.

Observations and Insights

6.7 Similar activities in upcoming projects would need to be formulated taking note of the insights and recommendations arising from this workshop. Development of standard development templates for flood forecasting and early warning system, Real Time Data Acquisition System, Embankment Asset Management System and community participation, river morphological prediction, and Centre of Excellence for Modeling for cost-effective and rapid customizing in basins in Bihar and other States.

Open Discussion on Sessions 2, 3 and 4

6.8 Mr. Sahu, Chief Engineer, CWC suggested that any demand for funds by the State after disasters shall take note of fund disbursement protocols and norms of the Calamity Relief Fund. While advance may be requested from the State component of the fund, disbursement from the central component will have to follow policy set for recommendation by the central team and allocation of relief funds. Mr. S.K. Sinha, Retd. Engineer-in-Chief of WRD suggested that the right bank main and branch canals of the Kosi irrigation command (at least those just after the Eastern Embankment) be strengthened as ‘flood embankment’ under the BKBDP, as the canal embankment had minimized flooding from the 2008 breach floods from spreading eastwards. Mr. Sahu mentioned that the Extension, Renovation and Restoration of Eastern Kosi command has been posed for assistance under the Central scheme of Accelerated Irrigation Benefits Program (AIBP), but was not sure strengthening canal embankment as flood embankment is included. Mr. Tiwari, Retd. Superintending Engineer, GFCC suggested institutional reorganization to bring the entire Kosi embankments under one Chief Engineer instead of three Chief Engineers (of Birpur, Samastipur and Bagalpur) currently having jurisdiction. Similarly for Bagmati-Adhwara system. This would improve operational efficiency. He suggested that the Kosi High Level Committee should visit at least once, in addition to the pre-monsoon visit, during the flood season to have better appreciation of flood management issues. Mr. Tiwari suggested re-examination of hydraulic gradient analysis for embankment safety, considering the river aggradation and consequent higher elevation from the country-side flood plain. He recommended scientific design of bank protection works based on data collection and a dynamic database. River cross-section surveys shall include investigation of bed material also to support design of flood protection works. Mr. Gorak Takur of GFCC supported the development of such database to support design of bank protection works.

VII. Workshop Summary

Mr. Nagan Prasad, Joint Director, FMISC

7.1 A two days' workshop on "Improving Flood Risk Management in Bihar" was jointly organized by Water Resources Department, Govt. of Bihar and Bihar Aapda Punarvas Evam Punarnirman Society (BAPEPS) in collaboration with World Bank at Hotel Maurya, Patna. The workshop aimed to review activities under the World Bank assisted Bihar Kosi Flood Recovery Project (BKFRP) and share knowledge and invite expert consultation. A special session on Flood Forecasting and Early Warning is being organized as part of the workshop by South Asia Water Initiative (SAWI) Trust Fund.

7.2 Er. Indu Bhushan Kumar, Chief Engineer, P&M Water Resources Department welcomed the participants and introduced the workshop theme. Er. Kumar explained the origin of river Kosi and described various works being undertaken under ongoing Bihar Kosi Flood Recovery Project and proposed Bihar Kosi Basin Development Project. He recalled the great achievement by Bihar engineers of Kosi Breach closure in 2008 within a record time of three months.

7.3 Mr. Arun Kumar Singh, Principal Secretary, WRD highlighted the different work being undertaken in the field of flood risk management. He applauded the efforts under World Bank assistance whereby the issues of flood risk management have been addressed properly in recent times. He opined that knowledge and soft components may be replicated in other river basins also. He stressed on the need of data sharing in the Nepal region and apprised the gathering with different upcoming events in this field. He conveyed that WRD is trying for advancement in irrigation sector also employing new technology as in other advanced countries.

7.4 Dr. Deepak Prasad, Principal Secretary, Planning and Development Department cum Management Director, hailed the World Bank assistance which has now begun to show good impacts of works in the field of Housing, Bridges, Roads, etc. under Bihar Kosi Flood Recovery project.

7.5 Mr. Gajanan Mishra, Joint Secretary, WRD, Bihar also addressed the gathering, describing the long history of Kosi river management.

7.6 Sri Bijendra Prasad Yadav, Honorable Minister, Energy and Commercial Taxes Department, and past Minister of Water Resources Department, in his special remarks highlighted the ground problems of Kosi basin and said that nature, character and behavior of river Kosi and other Himalayan rivers should be studied. He suggested that work at micro level is needed with the help of latest technology. He stressed the need for the Centre of Excellence in Bihar in order to solve water management issues and requested the Centre to organize a wider international conference on this matter.

7.7 In inaugural address, Sri Rajiv Ranjan Singh, Honorable Minister, Water Resources Department, said that the topic of the subject is a challenge in the context of Bihar, where better water management is required to address both flood and drought problems. He stressed the need for developing a Flood early warning system, SCADA system and study of nature and behavior of rivers. He also emphasized the need of establishment of Centre of Excellence in Bihar which is underway in BKFRP/BKBDP.

7.8 Dr. Satya Priya of World Bank highlighted the several ongoing and upcoming events in Bihar with the assistance of World Bank and assured of all help from the World Bank side.

7.9 In this workshop four technical sessions were conducted, which covered 16 presentations. Key decision makers in Water Resources Department, representatives from other flood-prone states, Central government agencies, and academia participated in the workshop. On the first day, under the aegis of SAWI trust fund a special technical session on the subject matter of “Flood Forecasting and Early Warning” was organized to improve the flood risk management capacity in Bihar. In this session, experts from India, World Bank and other countries presented their experience and recommendations. The speakers included Dr. Satya Priya, World Bank; Sri Dilip Kumar Gautam, RIMES, Thailand; Dr. Diganta Burman, NESAC, Assam; Mr. Anil Vyas, Bhakra Beas Management Board; Dr. Apichon Witayangkurn, University of Tokyo; Dr. Mandira Shrestha, ICIMOD, Nepal; Dr. Vimal Mishra, IIT Gandhinagar; and Dr. S.Thiurvengadachari, Flood Management Consultant. On the second day, three technical sessions were completed. The session on “River and Sediment Management” was followed by sessions on “Knowledge Management” and “Upcoming Projects” of FMISC, WRD. Mr. Nagan Prasad expressed hope that the valuable suggestions, ideas, experiences and techniques shared by experts during the workshop will improve flood risk management in Bihar.

VIII. Way Forward

Dr. S. Thiruvengadachari, Flood Management Consultant

8.1 A strong recommendation from the workshop is the use of non-proprietary and license-free flood forecasting and inundation mapping software for cost-effective and rapid scaling up of models to river basins in Bihar and elsewhere. It is also essential to organize up-front the critical data needed for modeling- historical rainfall and river flow data, river cross-sections, and flood plain DEM, while operational run of model would require assured access to timely meteorological and hydrological data. Arrangement needs to be in place for upgrading the model input data including hydrologic and hydraulic data and model setup. Longer lead time would require short-to-medium range ensemble meteorological forecast and real-time data from upstream gauge sites. Ensemble rainfall forecasts and satellite based rainfall estimates are increasingly used in lieu of single source values to improve reliability. Synergy with flood models and outputs being developed/operated by national and regional agencies in upstream trans-boundary basins would improve forecasts downstream basins in India. Effective early warning can be facilitated by the use of Call Data Records, to send flood alerts to likely affected communities and to track people movement in the area for targeted emergency flood management. Sustainable flood management program would call for development of a cadre of flood modelers with assured career path and incentives, continued skill upgrading, and institutional support.

8.2 The analysis of river morphological changes in Kosi system shall be extended to other basins in Bihar, to predict annual changes in embankment vulnerability, embayment between spurs, and the identification of active channel for effective timely strengthening of flood protection works. The satellite based model shall be complemented by the 1D & 2D Hydrodynamic and 1D Sediment Transport Models set up under the Master Plan consultancy. The Master Plan for River and Sediment management would provide the framework for taking up short-term and long term activities within the integrated river management action program. The Embankment Asset Management System supports rational management of these expensive assets and prolongs operational services and useful life. This should be extended to other basins in Bihar. Community participation for embankment surveillance shall be promoted and expended to other river basins, to pride a sense of ownership and involvement by the likely -affected communities.

8.3 Structured knowledge base such as the Ganga Flood Risk Atlas and multi-theme GIS data sets of Bihar State effectively support the entire life-cycle of flood risk management, from prioritizing, planning to preparedness to flood relief, rehabilitation and reconstruction. The knowledge bases obviously need to be kept updated with new and better information through the years, and expanded in multiple levels for varying applications. Linkage with other national and State level databases shall be encouraged.

8.4 Similar activities in upcoming projects would need to be formulated taking note of the insights and recommendations arising from this workshop. Development of a standard development template for flood forecasting and early warning system, Real Time Data Acquisition System, Embankment Asset Management System and community participation, river morphological prediction, and Centre of Excellence for Modeling for cost-effective and rapid customizing in basins in Bihar and other States.

Appendix A: Workshop Agenda

Improving Flood Risk Management in Bihar
Expert Consultation Workshop

Bihar Aapda Punarwas Evam Punarnirman Society and Water Resources Department, Bihar in collaboration with the World Bank

Venue: Hotel Maurya, Patna
Date: February 18-19, 2016

DAY ONE- 18 February 2016

Time		Session Names	
09:30	10:00	Registration	
Inauguration			
10:00	10:15	Welcome address and Introduction to the theme of workshop	Er. Indu Bhushan Kumar, Chief Engineer, Planning and Monitoring, WRD, Bihar
10:15	10:20	Presentation of bouquet to Hon'ble Ministers, Principal Secretaries & other Dignitaries	
10:20	10:25	Lighting of the Lamp by Hon'ble Ministers & dignitaries	
10:25	10:35	Address by Dr. Deepak Prasad, Principal Secretary, Planning & Development/Project Director, BAPEPS	
10:35	10:45	Address by Sri Arun Kr. Singh, Principal Secretary, WRD	
10:45	10:55	Managing Kosi _ Past Experience	Mr.Gajanan Mishra, Joint Secretary, WRD, Bihar
10:55	11:10	Special Address by Sri Bijendra Prasad. Yadav, Hon'ble Minister, Energy & Commercial Taxes, Govt. of Bihar	
11:10	11:25	Inaugural Address by Sri Rajiv Ranjan Singh, Hon'ble Minister, WRD & Planning and Development, Govt. of Bihar	
11:25	11:40	Workshop Expectations	Dr. Satya Priya, World Bank
11:40	11:45	Vote of Thanks	Mr. Narendra Pd. Mandal, I.A.S., Addl. Project Director, BAPEPS
11:45	12:00	**Tea**	
TECHNICAL SESSION I : Flood Forecasting and Early Warning			
12:00	12:30	South Asia Water Initiative (SAWI) Project- Strengthening Flood Modelling Capacity in Bihar	Dr. Satya Priya, World Bank
12:30	13:00	Enhancing Hydrological Forecast using Weather Forecast Ensemble Prediction System	Dr. Dilip Kumar Gautam, RIMES, Bangkok
13:00	13:30	GIS based operational flood forecasting for early warning in North East India	Dr. Diganta Barman, Project Manager, NER-DRR, NESAC
13:30	14:30	**Lunch**	

TECHNICAL SESSION- I (Continued)			
14:30	15:00	Real Time Decision Support System for River Satluj and Beas	Mr. Anil Vyas, BBMB
1500	1530	Real Time Streamflow Monitoring and Simulation for River basins	Dr. Vimal Mishra, IIT, Gandhinagar
15:00	15:30	Application of cell phone data record for flood warning and monitoring system	Dr. Apichon Witayangkurn, University of Tokyo
15:30	16:00	Flood forecasting in Nepal river basins	Dr. Mandira Shrestha, ICIMOD
16:00	16:15	Flood forecasting in north Bihar-Challenges and opportunities	Dr. S.Thiruvengadachari, Consultant
16:15	17:00	Panel Discussion	Dr. Satya Priya, World Bank, Dr. S. T. Chari, Consultant, Mr. S. K. Sahu, CE, LGBO, CWC Mr. A.K. Sen, Director, IMD

DAY TWO- 19 February 2016

Technical Session II: River and Sediment Management			
09:30	10:00	Modelling River Morphological Trends	Mr. Sudipta Kumar Hore, Centre for Environment and GIS (CEGIS), Bangladesh
10:00	10:30	Master Plan for Flood and Sediment Management	Mr. Bibash Kumar, URS Scott Wilson Dr. Fleming Jacobsen, MD, DHI India
10:30	11:00	Embankment Asset Management System in Kosi Basin	Mr. Rajesh Kumar, CGM, LEA Associates South Asia Pvt. Ltd.
11:00	11:30	Community Participation in Embankment Surveillance in Kosi Basin	Mr. Rashid Wakil, JPS Associates (P) Ltd.
11:30	12:00	Tea	
TECHNICAL SESSION III: Knowledge Management			
12:00	12:30	Ganga Basin Risk Atlas	Dr. Satya Priya, World Bank
12:30	13:00	GIS Database of Bihar	Mr. Sanjay Kumar, GIS Specialist, FMISC
13:00	14:00	Lunch	
Technical Session IV : Upcoming Projects			
14:00	14:15	Kosi Basin Development Project	Mr. Anil Kumar, Deputy Director, FMISC
14:15	14:30	National Hydrology Project	Dr. Saroj Kumar Verma, Deputy Director, FMISC
14:30	15:30	Open Discussion	
CONCLUDING SESSION			
15:30	16:00	Wrap up of Workshop, Way Forward and Vote of Thanks	Er. Nagan Prasad, Joint Director, FMISC

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Registration of Invitee

Expert Consultation Workshop

on

" Improving Flood Risk Management in Bihar"

Bihar Aapda Punarwas Evam Punarnirman Society and Water Resources Department, Bihar in collaboration with the World Bank

Venue: Hotel Maurya, Patna **Date: February 18 - 19, 2016**

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56	G. P. Jaiswal	Retd. TA-RCD	9431841834	
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58	Ankit Kashyap	MSW, PU	9801369190	
59	Abhishek Kumar.	MSW, P.U.	9709602040	
60	Ram Pukar Ranjan	ENC. WRD. Bihar.	9470888563	
61	Nagan Prasad	JD, FMISL	9431046344	
62	Dr. S. T. Chari	WORD BANK	9290965378	
63	Dr. Saroj Kr. Verma	FMISC, WRD	9835477903	

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72	Ravi Prakash	AD, FMISC, WRD.	7260949445	Ravi 18/02/16.
73	Manish Kumar	AD, FMISC	9473387532	MK 18/02/2016
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Expert Consultation Workshop

on

"Improving Flood Risk Management in Bihar"

Bihar Aapda Punarwas Evam Punarnirman Society and Water Resources Department, Bihar in collaboration with the World Bank

Venue: Hotel Maurya, Patna **Date: February 18 - 19, 2016**

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SAWI SOUTH ASIA WATER INITIATIVE

STRENGTHENEING FLOOD MODELING CAPACITY IN WATER RESOURCES DEPARTMENT, BIHAR

18 February 2016

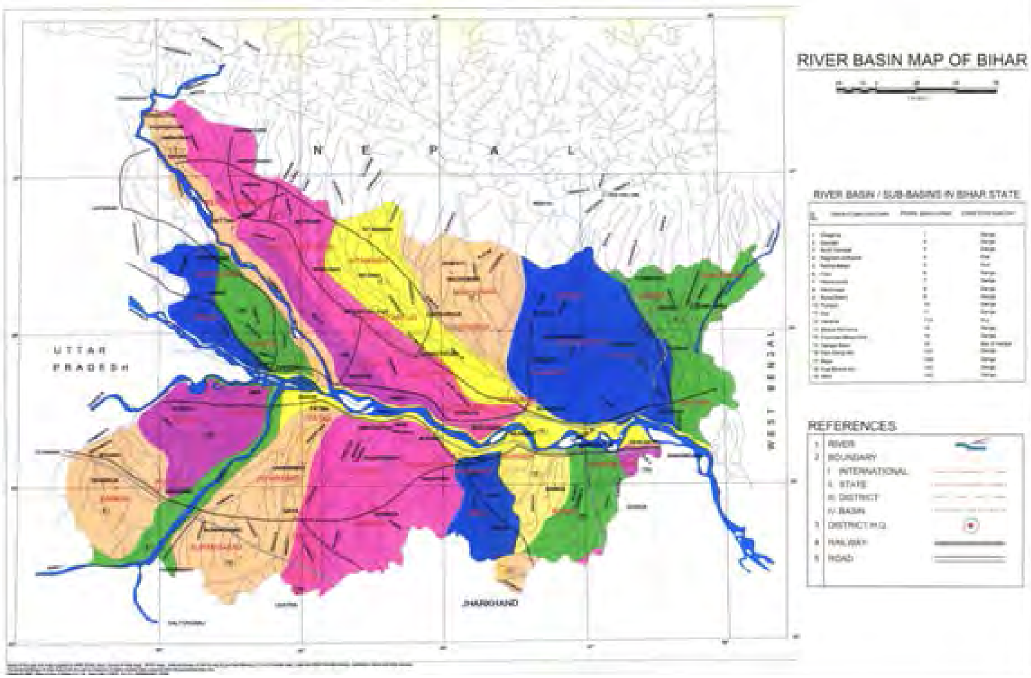
Patna

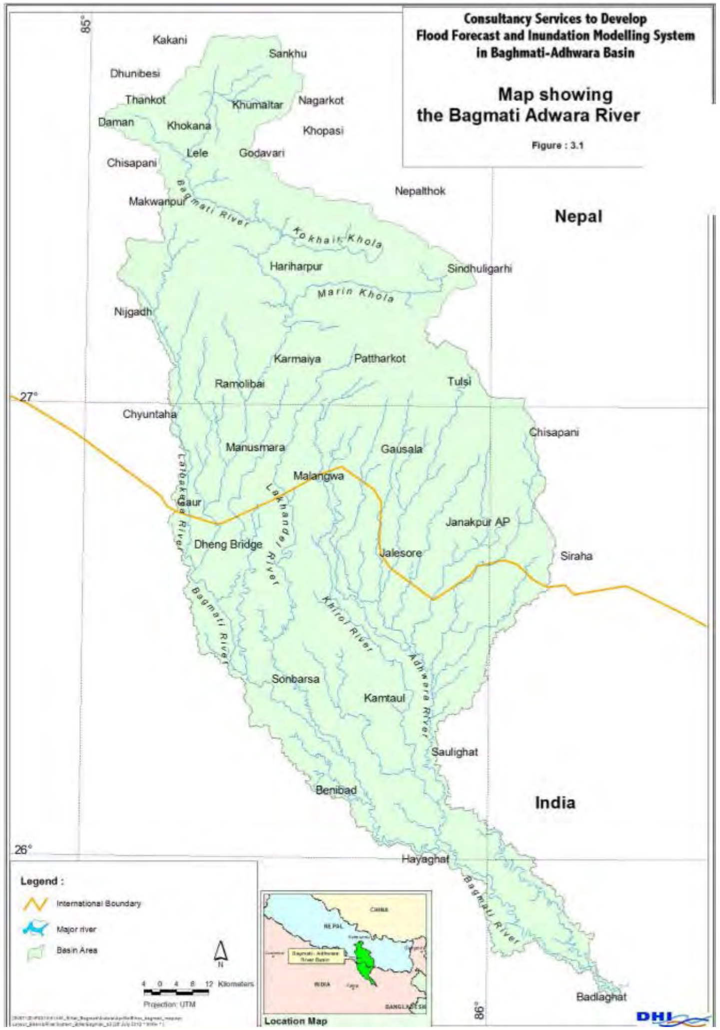
Objective

- Strengthen WRD (FMISC) Institutional Capacity
  - **Coverage:** Baghmati-Adhwara Basin in Bihar
  - Modelling: Tools and models in operational flood forecast
  - Inundation modelling
  - Community outreach for flood warning and risk management

- Expected Outcome
  - Transition from FMIS2 to operational flood forecast system
  - into Kosi Basin Development Project followed by
  - National Hydrology Project

Baghmati-Adhwara Basin





Current Status

- Operational model in BA basin up to Hayaghat using proprietary modelling software
- Needs improved performance, Possible extension to cover downstream of Hayaghat
- Scaling up to other basins may need open source models
- Absence of real time high frequency rainfall data and stage/discharge data
- Community outreach planned but not implemented
- Capacity building for sustained operation and upgrading

Proposed Work under SAWI

- **Bridge funding: to improve the quality of flood forecasts; improve technical capacity of Water Resources Department, through -**
  - **Improved existing model and possibly extend downstream up to confluence with Kosi river**

- **Develop and implement alternate flood model with public domain and license-free software**
  - **for scaling up to other basins in the state, and to assist cost-effective upgrading**

- **Improve data gaps between meteorological and hydrological services by**
  - **implementing automated meteorological framework customized for BA basin and Kosi basin, for ensembles of satellite based rainfall estimates and short-to-medium range rainfall forecasts**

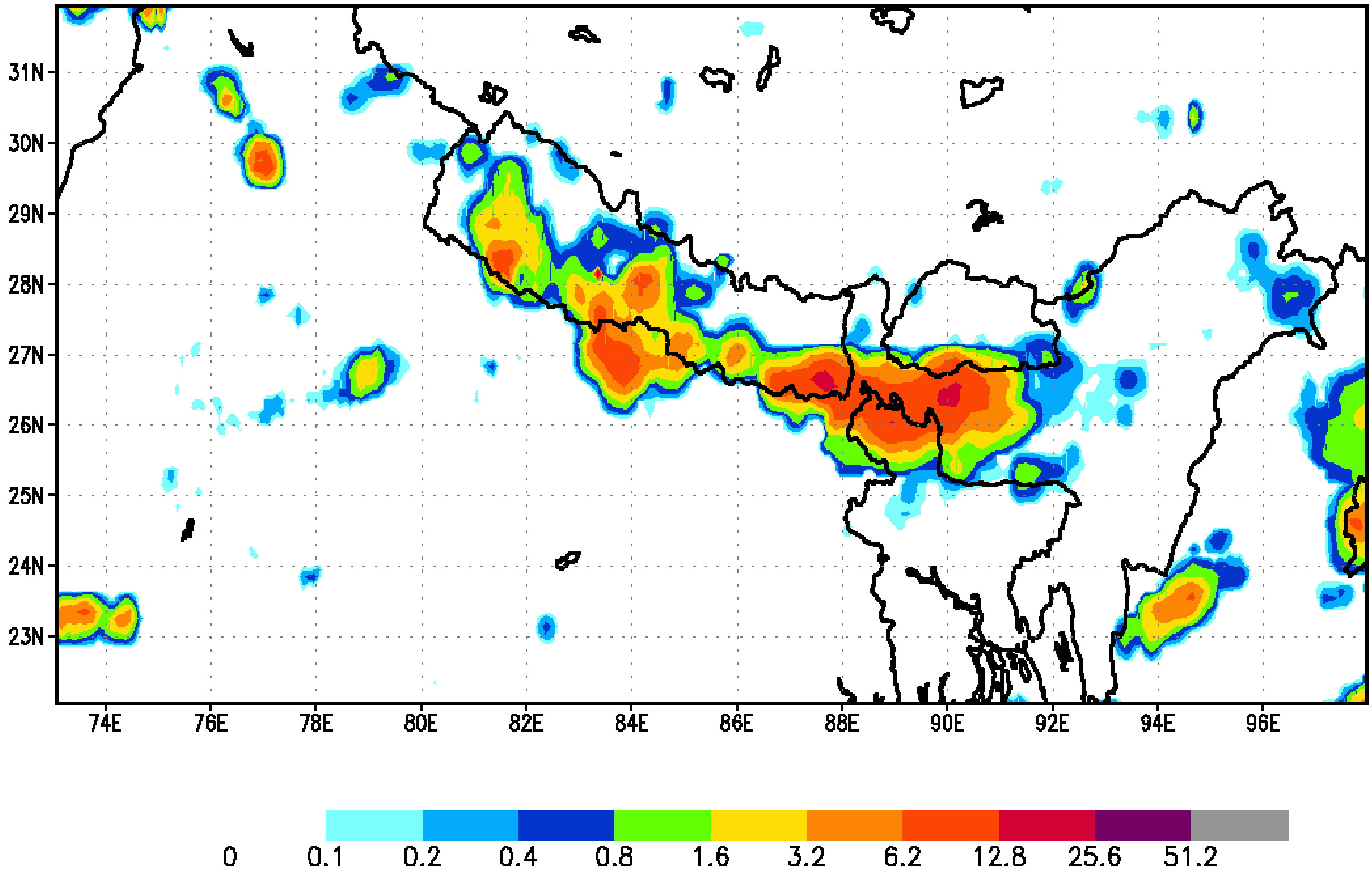
- **Flood warning using CDR (Call Detail Record data) with mobile service providers to send targeted alerts to likely affected people.**

Meteorological Framework

- Customized High Resolution Precipitation Products
  - Satellite estimates and forecasts- from an ensemble of sources, including gauge, remotely sensed monitoring data, and forecasts from Numerical Weather Prediction (NWP) models.

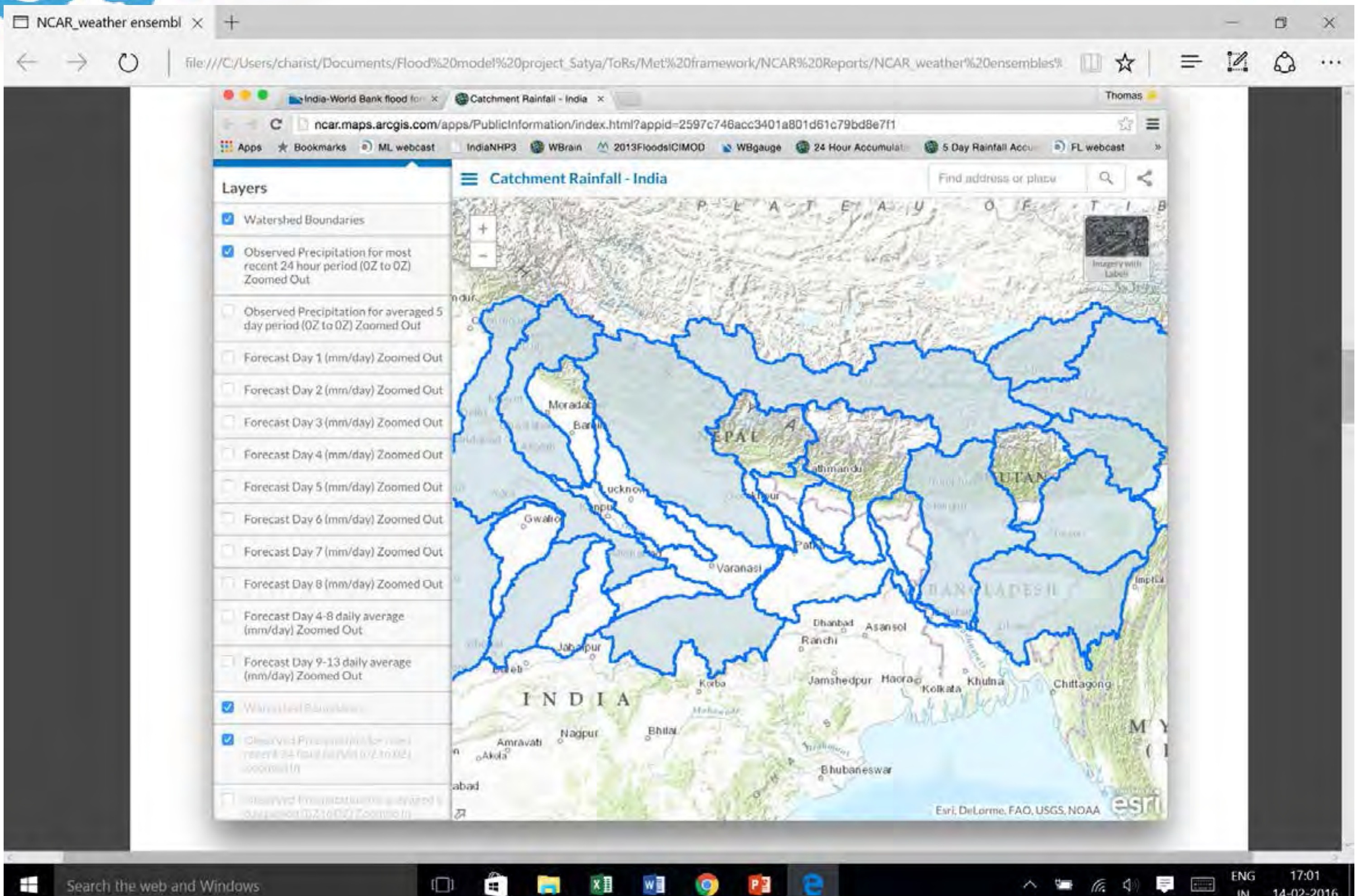
- Fill data gaps on real-time high frequency rainfall data, extend to medium term probabilistic forecasts
  - Lead rainfall forecast from 3-7-10 days

MERGE 0.1 deg PCP (mm/h) 2013070900



India-World Bank Flood Forecasting Project (https://gis.ucar.edu/india-world-bank-flood-forecasting)

SAWI SOUTH ASIA WATER INITIATIVE



http://indiawbg.rap.ucar.edu/precip/

Flood forecast and inundation model

- Review and improve model performance, including public domain and license-free model software
- Use satellite based rainfall ensembles and ensemble weather forecasts to improve reliability and lead-time.
- Convert model outputs to targeted SMS alerts.
- Capacity building to operationalize and sustain the model
- Plan stage-discharge data collection below Hayaghat, and if completed extend model downstream

Capacity Building

- Set up application systems interface for meteo-hydro to operationalize flood inundation outputs
  - through training,
  - expert visits,
  - workshops focusing on flood modeling and community outreach.
  - Conduct of workshops by international and national experts,
  - visits to international and national modeling centers,
  - Topical short-term training would be organized

Improving flood risk information, capacity and coordination in ***managing floods in Bihar***

Thank you!

Enhancing Hydrological Forecast Using Weather Forecast Ensemble Prediction System

Improving Flood Risk Management in Bihar
Expert Consultation Workshop
18-19 February, 2016
Patna, India

Dr. Dilip K. Gautam
Team Leader - Hydrology
RIMES, Bangkok

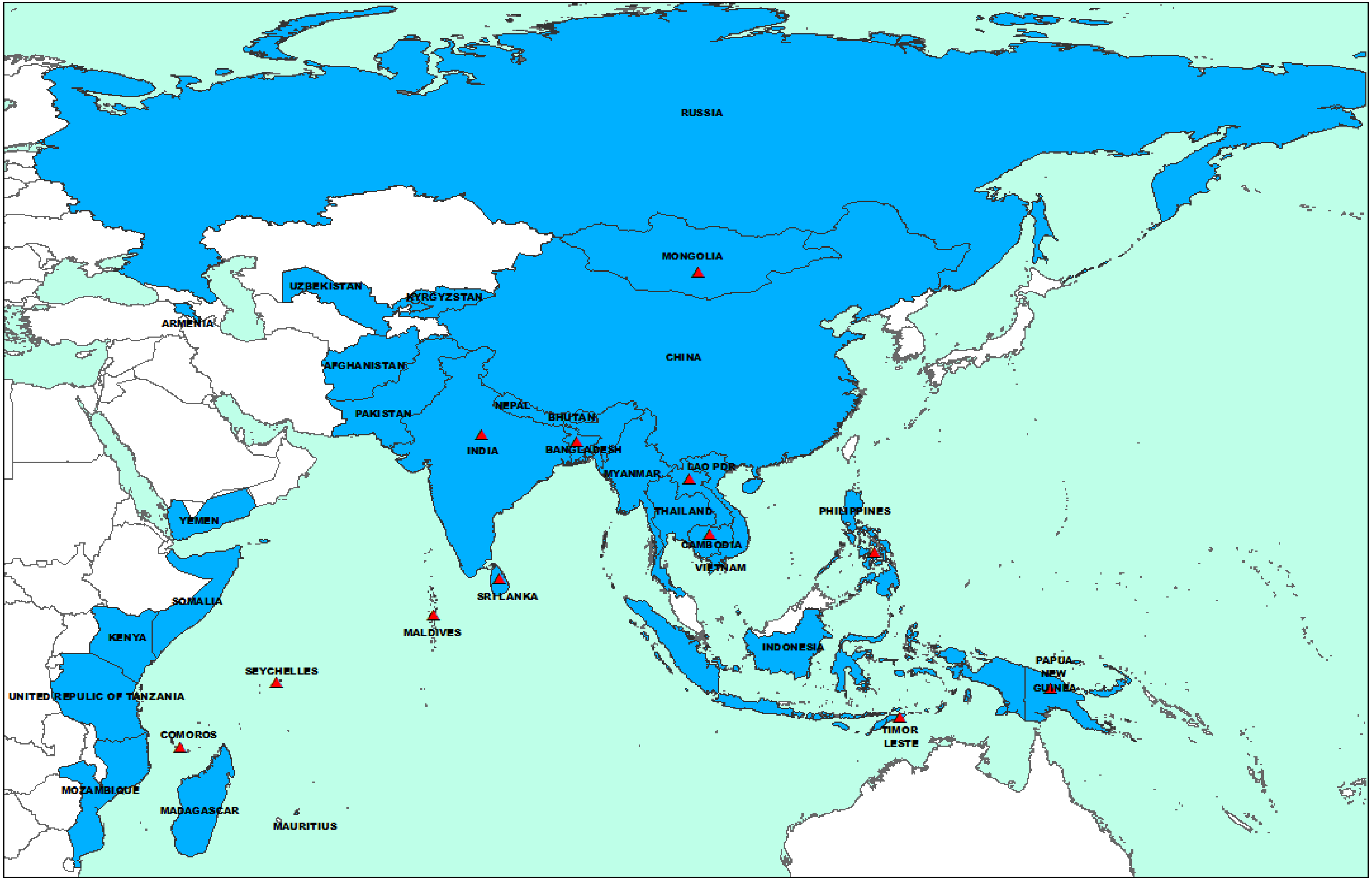
Contents

- About RIMES
- ECMWF Ensemble Prediction System
- Medium Range Flood Forecasting System
- Seasonal Flow Outlook System
- Conclusions

Regional Integrated Multi-hazard Early Warning System for Africa and Asia (RIMES)

- **Intergovernmental, owned and managed by its Member States**
- **Registered with the United Nations under Article 102 of UN Charter**
- **India - Council Chair, Maldives - Secretariat**
- **Regional Early Warning Center in AIT Campus, Thailand**
- **Institutional development support by UNESCAP**

Member and Collaborating Countries



Purpose and Objectives

- **Purpose:** Early warning services for natural hazards

- **Objectives:**
  - Core regional observation and monitoring networks
  - Data sharing for early warning
  - Regional tsunami watch within UNESCO/IOC framework
  - Support NMHSs to develop hydrological and meteorological forecasting systems within WMO framework
  - Enhance warning response capacities

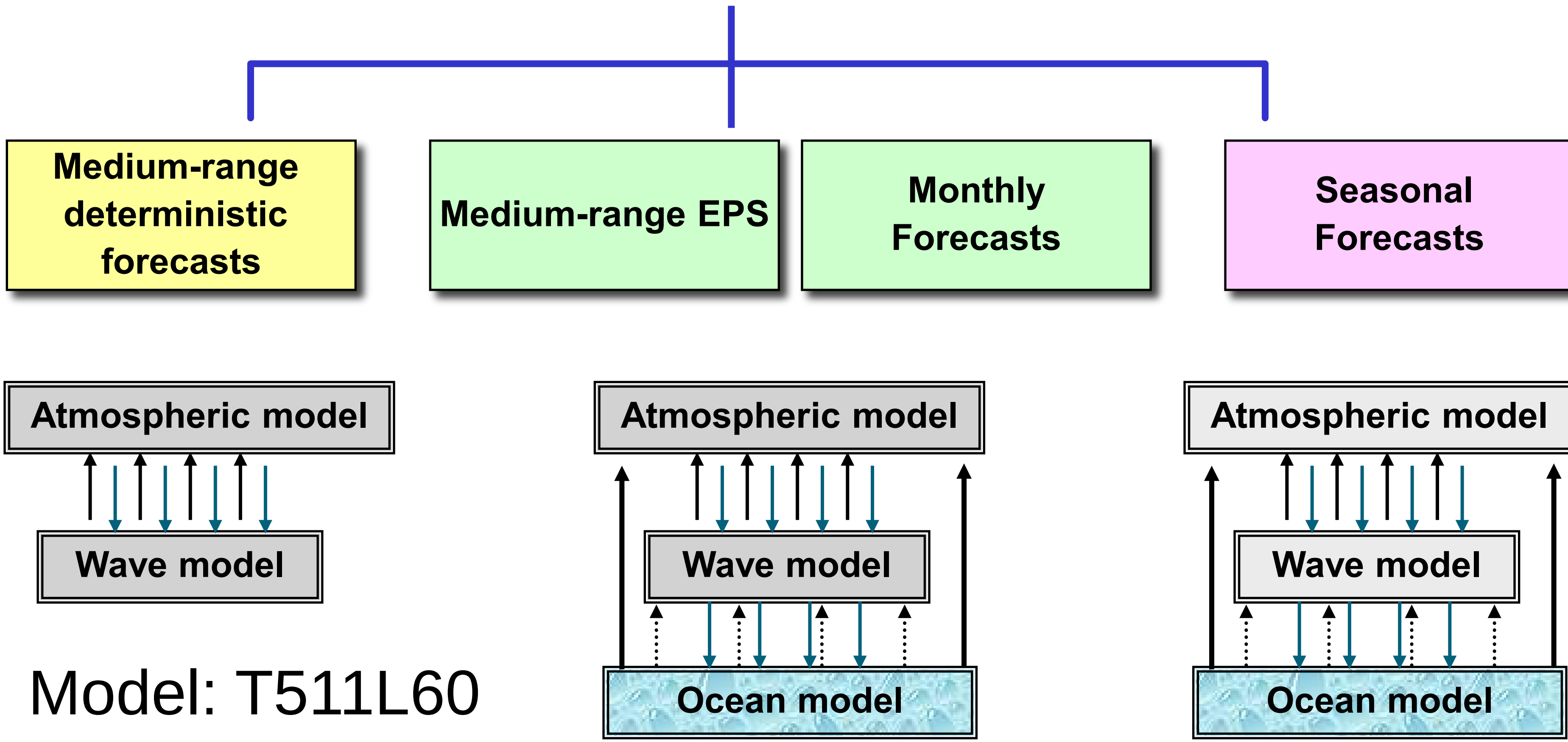
Application of Extended Range Forecasts

- Large scale evacuation planning
- Decision making for agricultural undertakings (seed-bed preparation, planting, harvesting)
- Fishery protection and management
- Livestock protection and management
- Disaster management planning
- Water resources utilization planning etc.

ECMWF Forecast Products

- 10-days deterministic forecast
- 15-days probabilistic forecast
- Monthly and seasonal forecast

ECMWF Forecasting Systems



Model: T511L60

Model: T255L40

Six Physical Laws

- The gas law,
- Hydrostatic equation,
- Equation of continuity,
- Equation of motion,
- Thermodynamic equation, and
- The conservation equation for moisture

	Assimilation 4DVar	Spatial resolution	No of members	Area Coverage	Forecast range	Forecast frequency	Ocean coupling
Deterministic model	12h	≈16 Km to 108km L91	1	Global	10 days	Twice a day	No
EPS	12h	≈30/60/108 Km L62	51	Global	15 days	Twice a day	00UTC Coupled after D+10 12UTC not coupled (persisted SST anom.)
					1 month	Once a week	Yes HOPE -- L29 1° (extratropics) 0.33 (equator)
Seasonal	12h	≈125 Km L62	41	Global	7 months	Once a month	Yes HOPE -- L29 1° (extratropics) 0.33 (equator)
Boundary condition	6h	≈16 Km L91	1	Global	3 days	4 times a day	
Ocean waves	OI 6h	28 Km	1	Global	10 days	Twice a day	No
		10 Km	1	European waters	5 days		
		≈30/60 Km	51	Global	15 days		

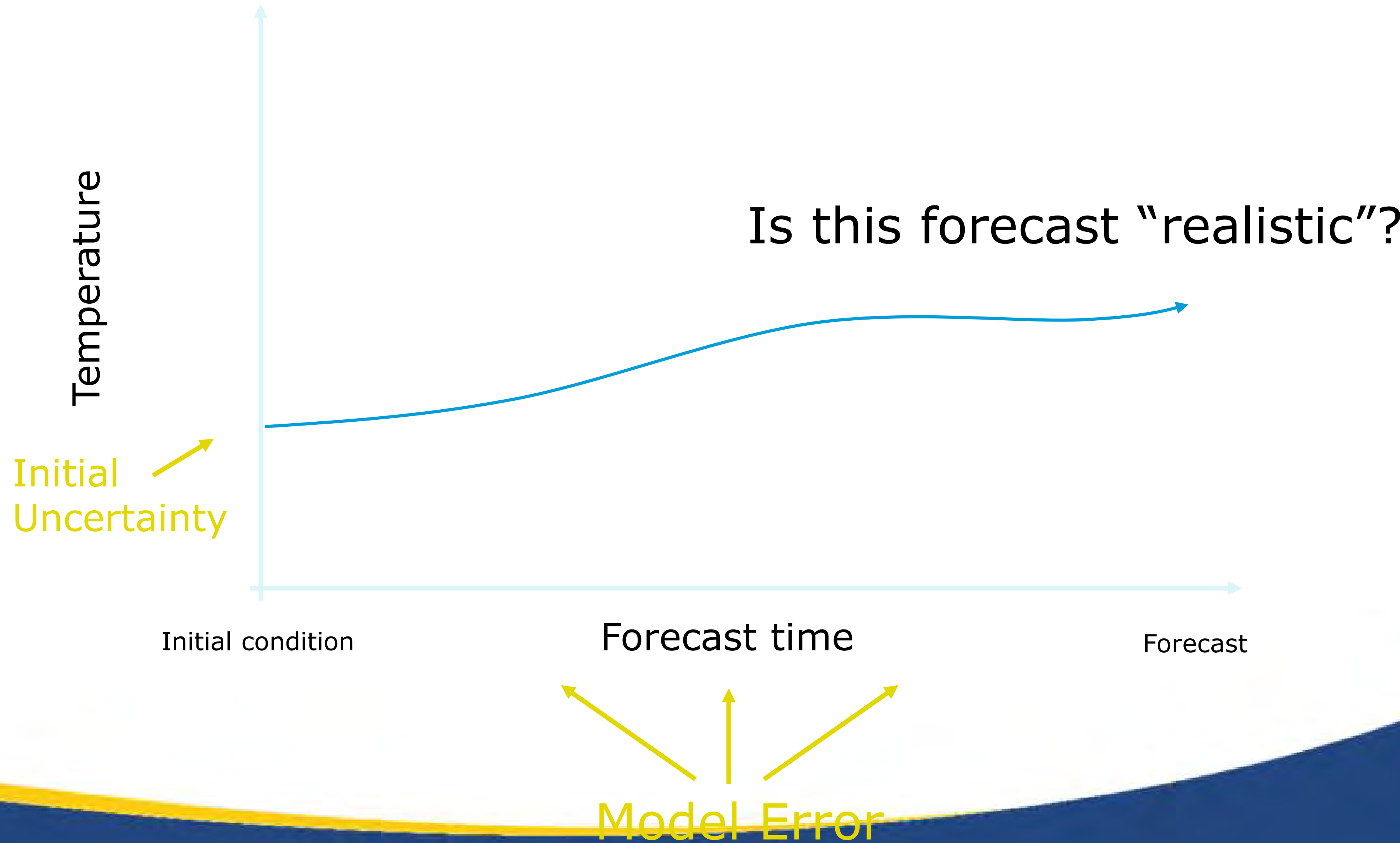
ECMWF Ensemble Prediction System

- Temporal resolution 15 min.
- 60 vertical layers up to 0.1 hPa
- For the horizontal resolution, the ECMWF model employs two different numerical representations:
  - a spectral method, based on a spherical harmonic expansion truncated at total wave number 511 for the representation of upper air fields and the computation of the horizontal derivatives (linear portion of the governing equations), and
  - a grid point representation (Gaussian grid) is used for computing dynamic tendencies and the diabetic physical parameterizations
- The operational model is initialized using the "four-dimensional variational data assimilation" (4DVAR) technique

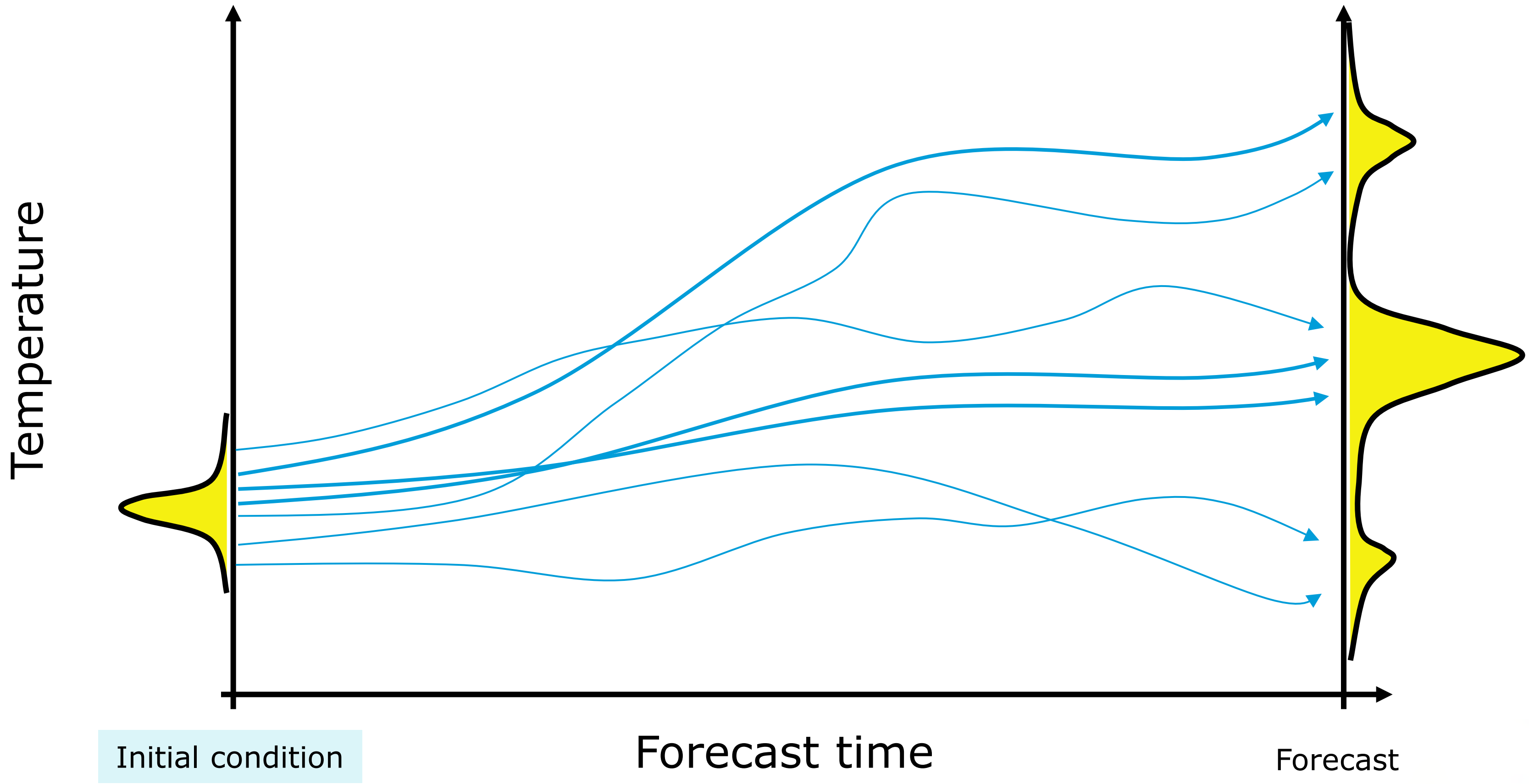
Ensemble Prediction System

- Initial condition uncertainties
  - Lack of observations
  - Observation error
  - Errors in the data assimilation
- Model uncertainties
  - Limited resolution
  - Parameterisation of physical processes
- The atmosphere is chaotic
  - small uncertainties grow to large errors (unstable flow)
  - small scale errors will affect the large scale (non-linear dynamics)
  - error-growth is flow dependant
- Even very good analyses and forecast models are prone to errors
- A set of forecasts run from slightly different initial conditions to account for initial uncertainties
- The ensemble of forecasts provides a range of future scenarios consistent with our knowledge of the initial state and model capability

Deterministic Forecast



Ensemble Forecast

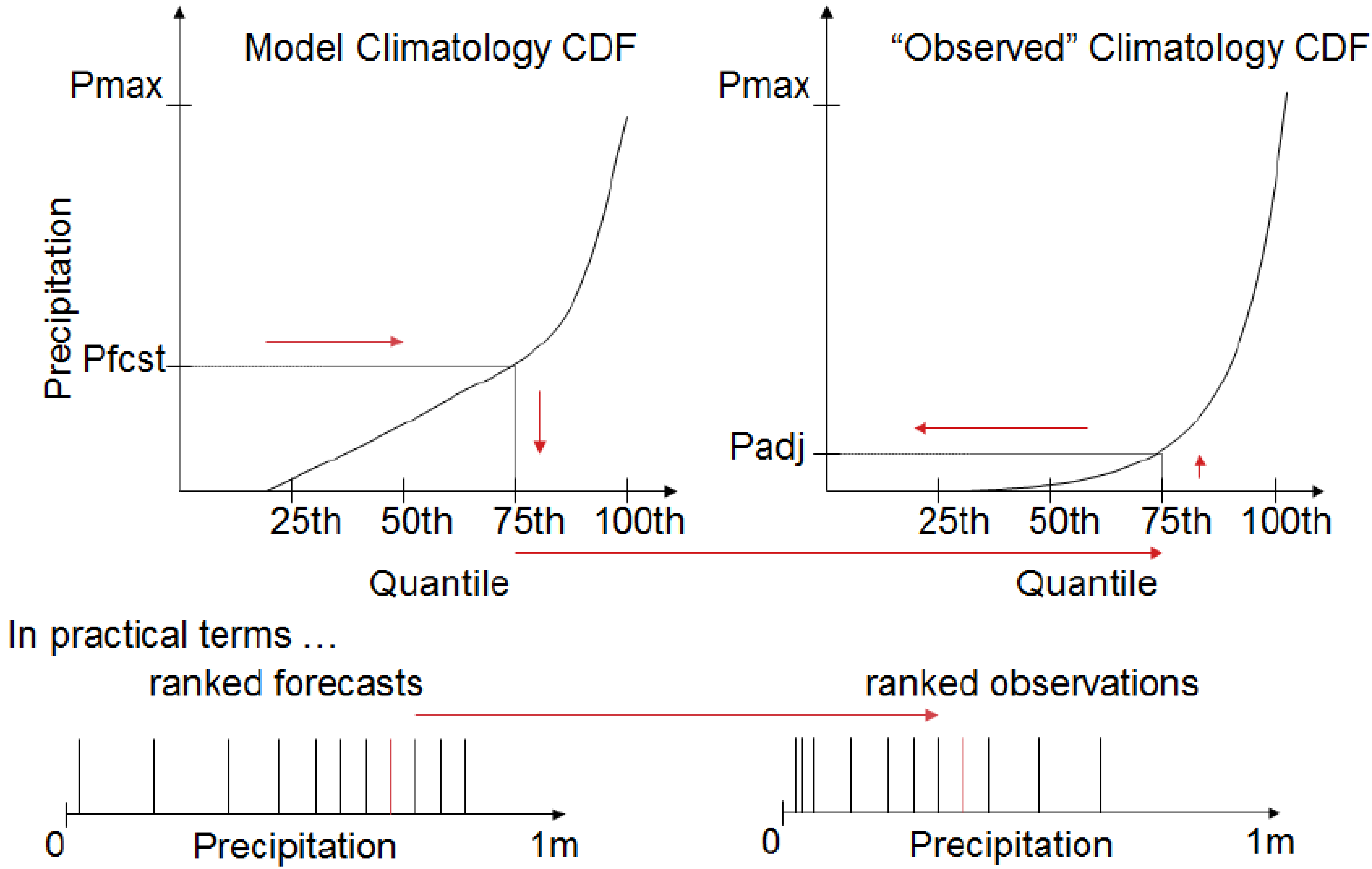


Complete description of weather prediction in terms of a Probability Density Function (PDF)

Correction of ECMWF Forecasts

- Biases are statistically corrected using "quantile-to-quantile mapping" method (model-space to climatology-space matching)
- A ”climatological” probability distribution function (PDF) was calculated using observed daily precipitation for each basin.
- An equivalent PDF was calculated using the ECMWF forecast precipitation data, a ”model-space” PDF.
- The adjustment to each forecast ensemble was then done by determining the quantile it corresponded to within the lookup table for that particular lead-time model-space PDF.
- The same quantile was then extracted from the observational ”climatology” lookup table.
- This extracted quantile value was then used in the forecasting schemes.

Quantile to Quantile Mapping



Medium Range Flood Forecasting Model: CFAB-FFS

- Two Rainfall-Runoff Models developed:
  - Data Based Mechanistic Model (DBM) and
  - Distributed Catchment Model (DCM)
- ECMWF EPS Rainfall Forecast used
- Auto-regressive error correction module applied
- Two adjusted model outputs are then combined into one ”multi-model” output

Medium Range Flood Forecasting Process

(I). Initial Data Input

(II). Statistical Rendering

(III). Hydrological Modeling

(IV). Generation of Probabilistic Q

(V). Forecast Product

Discharge data

Hydrologic model parameters

NOAA and NASA (i.e.CMORPH and GPCP) satellite precipitation & GTS rain gauge data

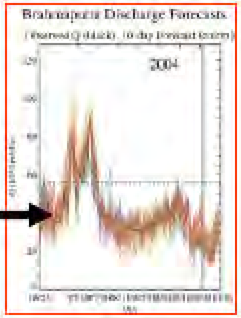
ECMWF Operational ensemble forecast

Hydrological Model

- Lumped
- Distributed
- Multi-Model Discharge Forecasting

Downscaling of forecasts
Statistical correction

- Accounting for uncertainties
- Final error correction
- Generation of discharge forecast PDF
- Critical level probability forecast



Application in Bangladesh

RIMES supported FFWC of BWDB to develop

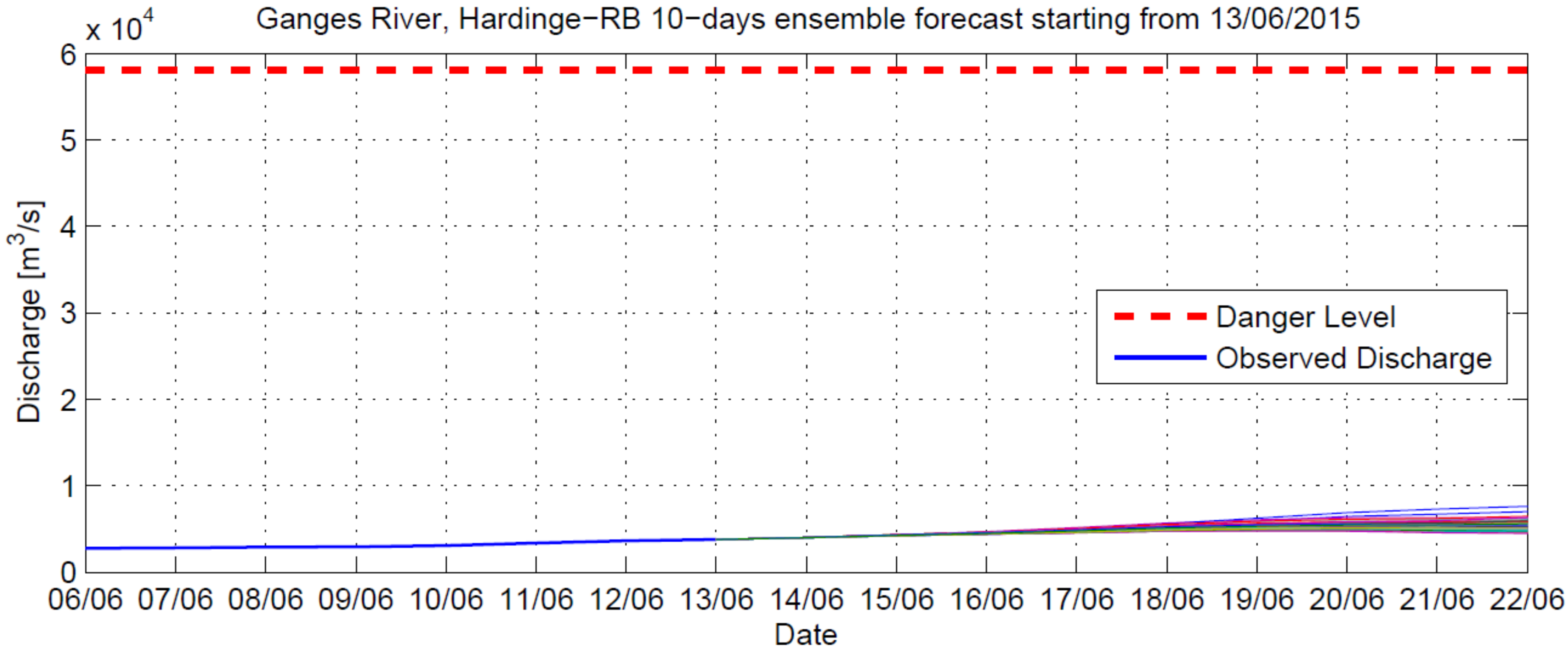
- Medium range (1-10 days) flood forecast
- Long range (1-3 month) hydrological outlook

- Funded by USAID through CARE Bangladesh

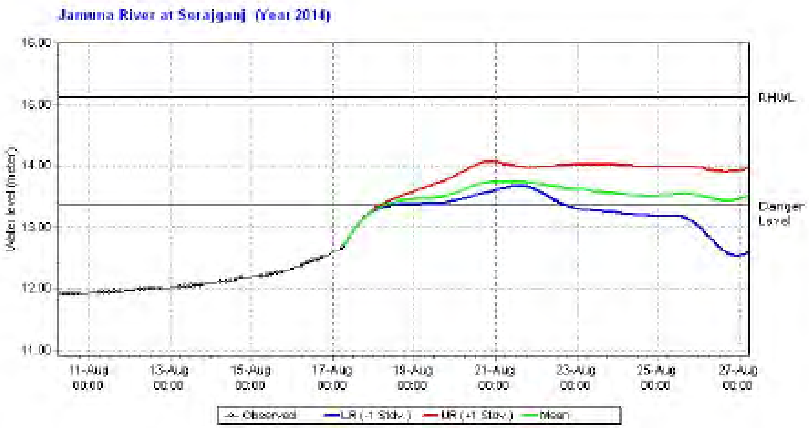
10-day Flood Forecast

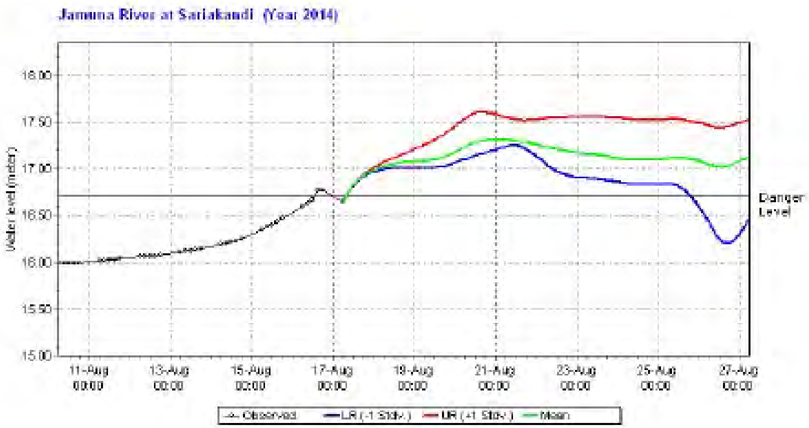
- 10-days probabilistic flood forecast
  - based on discharge forecast boundary condition at Hardinge Bridge on Ganges River and Bahadurabad on Brahmaputra River
  - uses ECMWF EPS rainfall forecast, CFAB-FFS model and MIKE11 model

10-days Forecasting



Integration into FFWC System





ilistic forecasts (51 ensemble series) on
Hardinge Bridge point)and ECMWF rainfall

tandard Deviation from the Mean and -1

rge and the mean rainfall forecast of all

t Board (BWDB) is acting as a background
rought out in FFWC model for this 10-day

with extreme care.

arning Center
lopment Board
com; ffwcbwdb@gmail.com

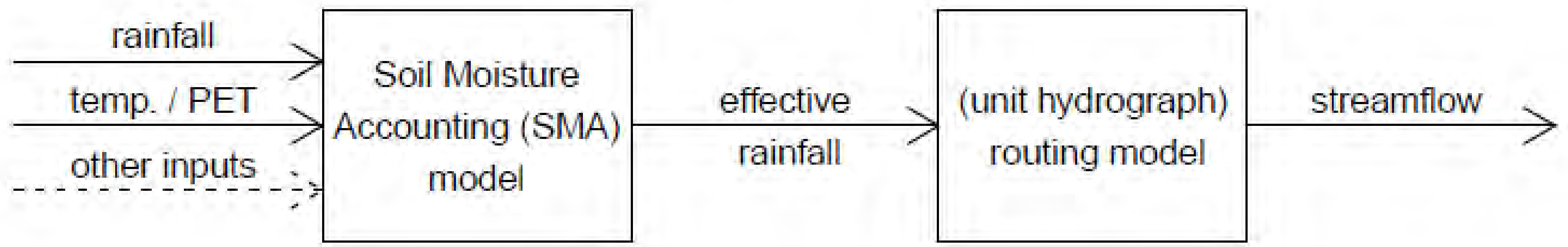
technical support from RIMES

Supported by USAID through CARE-Bangladesh with technical support from RIMES

Seasonal Flow Outlook Generation

1) Extract ECMWF seasonal ensemble (41) forecast of rainfall and temperature for the Ganges and Brahmaputra basins
2) Compute ensemble mean for each grid
3) Compute Mean Areal Precipitation (MAP) and Mean Areal Temperature (MAT) over the catchment
4) Customize the hydrological model for historical period
5) Develop ARIMA error correction module
6) Generate seasonal flow outlook by employing calibrated and validated model
7) Generate advisory and disseminate through Web-based Decision Support System
8) Automate the whole process

Hydrological Model for Seasonal Flow Outlook



Rainfall-runoff modeling in R-Hydromad package

For Ganges,

SMA: Catchment Wetness Index (cwi),

Routing: Exponential Unit Hydrograph (expuh)

For Brahmaputra,

SMA: Catchment Wetness Index (cwi),

Routing: AutoRegressive Moving Average with eXogenous inputs (armax)

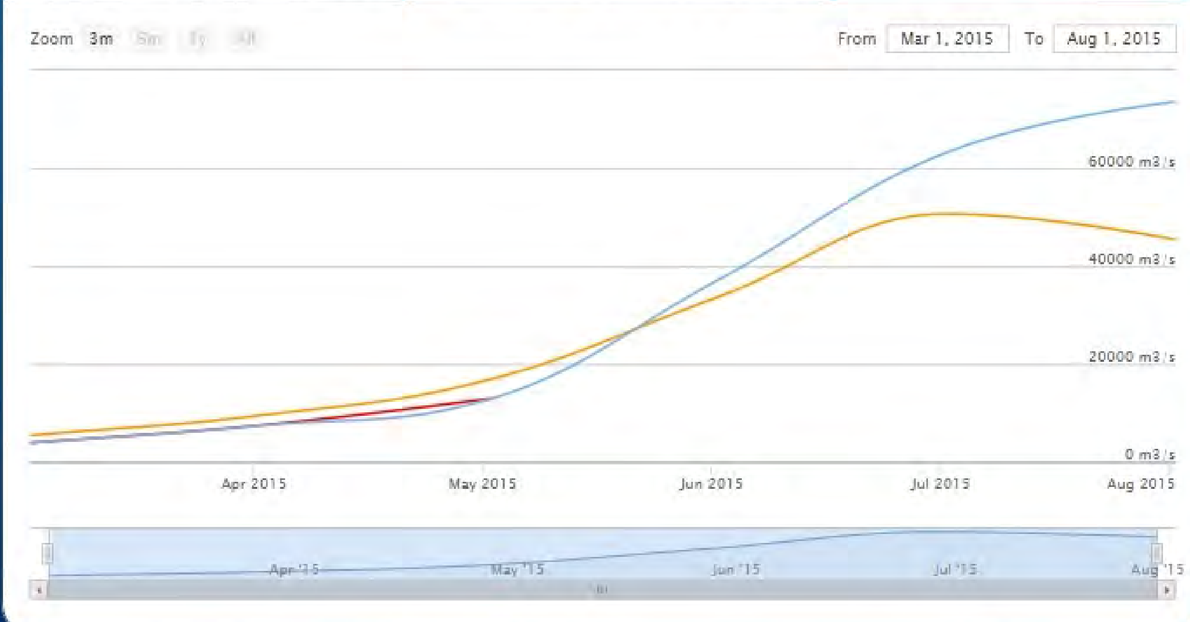
Web-based Dissemination System

Bangladesh Seasonal Flow Outlook

Home | Analysis | Logout

Select Month :: June Select Year :: 2015 Submit

MEAN MONTHLY FLOW OF BAHADURABAD STATION | MEAN MONTHLY FLOW OF HARDINGE BRIDGE STATION



Monthly and Seasonal Flow Outlook [Jun 2015 - Aug 2015]

Station	Latitude	Longitude	Mean Monthly Flow (m3/s)						Mean Seasonal Flow (m3/s)	
			Jun 2015		Jul 2015		Aug 2015			
			Normal	Forecast	Normal	Forecast	Normal	Forecast	Normal	Forecast
Bahadurabad	25.1655	89.7330	33,674	37,097	50,709	63,200	45,409	73,546	43,264	57,948
Hardinge Bridge	24.0658	89.0264	4,211	3,084	21,715	16,456	36,219	25,765	20,715	15,102

Conclusions

- **Different ranges of hydrological forecasts could be generated using ensemble prediction system.**
- **Long range hydrological forecasts provide adequate lead time for preparedness and response.**
- **Seasonal hydrological outlook will be very useful for planning and management of various water resources schemes.**

Thank You !

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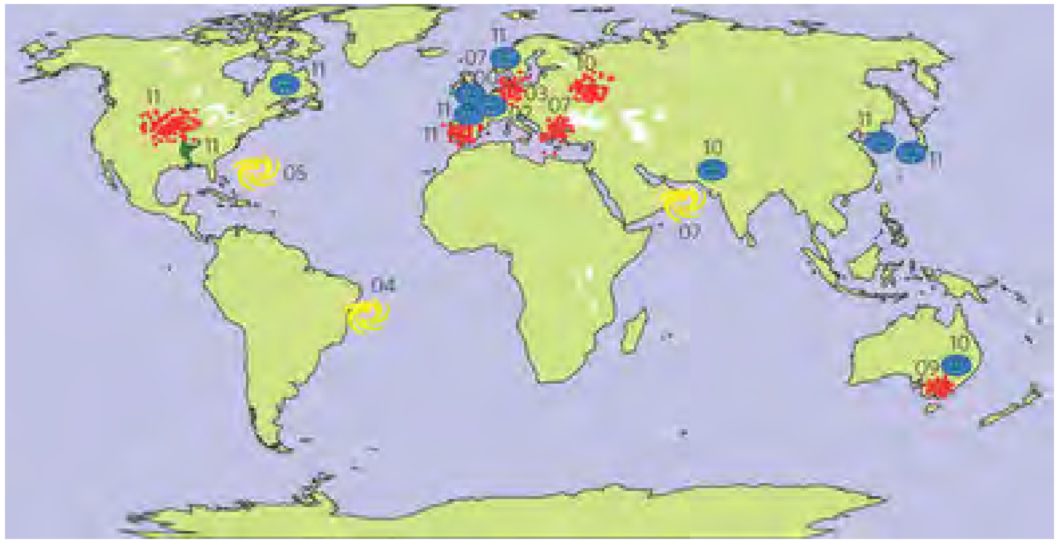
Real time monitoring and forecast of floods in India

Dr. Vimal Mishra
Assistant Professor, Civil Engineering
Indian Institute of Technology (IIT), Gandhinagar

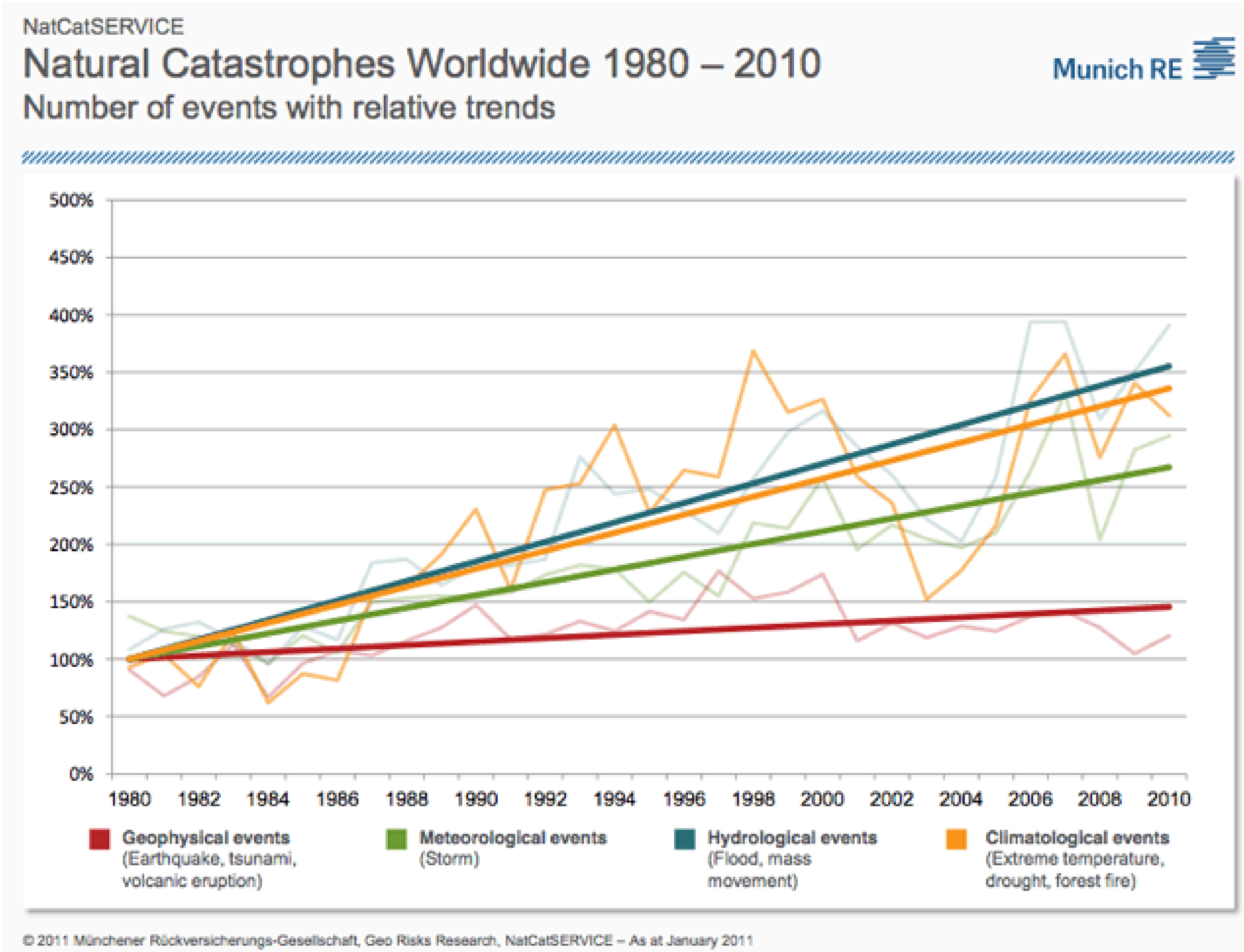
A decade of weather Extremes



Coumou and Rahmstorf, 2012, Nature Climate Change

“ there is now strong evidence linking specific events (heat waves and precipitation extremes) or an increase in their numbers to the human influence on climate”

“For other types of extreme, such as storms, the available evidence is less conclusive, but based on observed trends and basic physical concepts it is nevertheless plausible to expect an increase.”


NatCatSERVICE
Natural Catastrophes Worldwide 1980 – 2010
Number of events with relative trends
Munich RE
500%
450%
400%
350%
300%
250%
200%
150%
100%
50%
0%
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Geophysical events (Earthquake, tsunami, volcanic eruption)
Meteorological events (Storm)
Hydrological events (Flood, mass movement)
Climatological events (Extreme temperature, drought, forest fire)
© 2011 Münchener Rückversicherungs-Gesellschaft, Geo Risks Research, NatCatSERVICE – As at January 2011

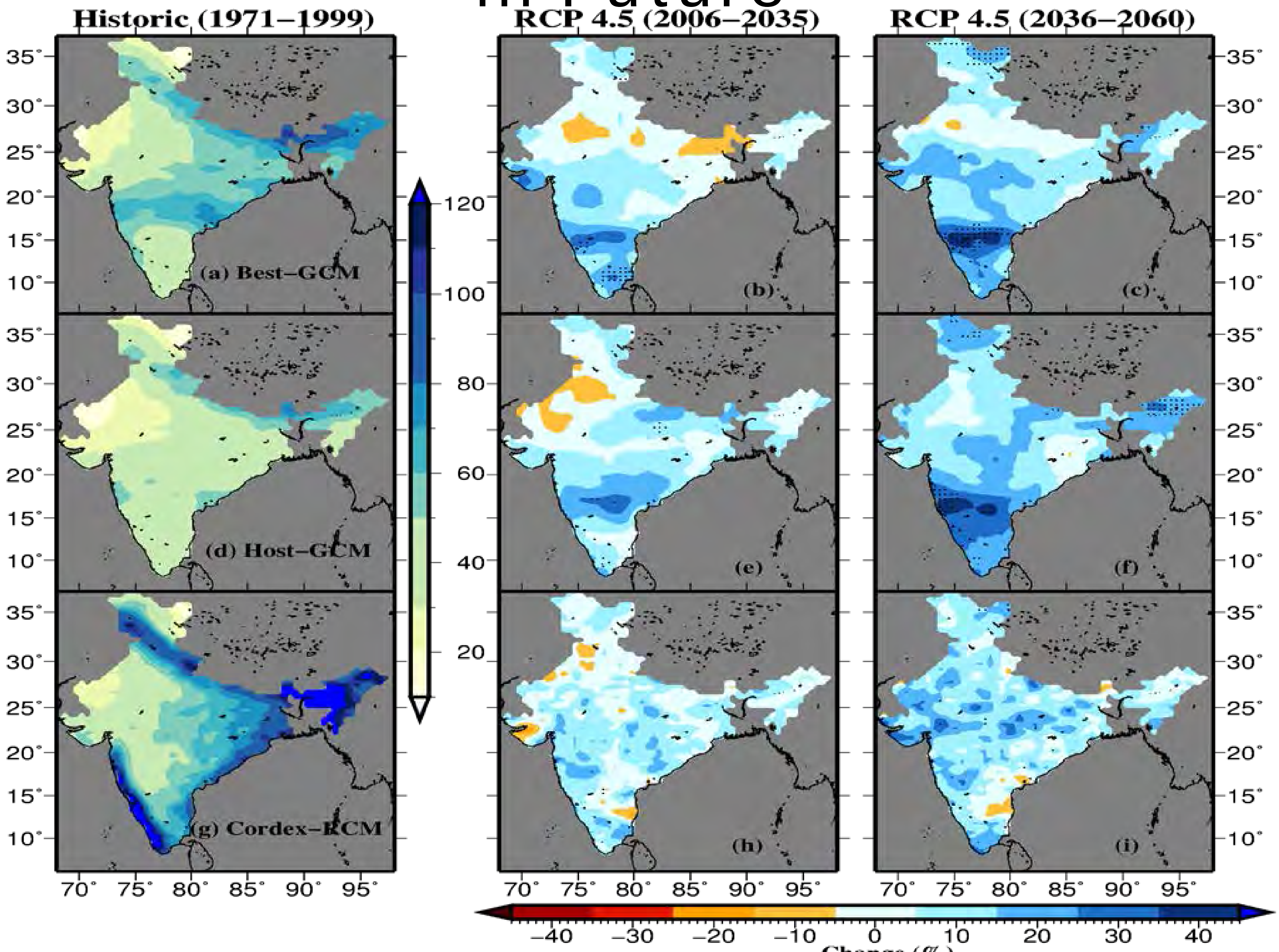
Floods in 4 states lead to economic loss of Rs 19,000 crore in past one year

http://www.downtoearth.org.in/news/floods-in-4-states-lead-to-economic-loss-of-rs-19000-crore-in-past-one-year-46847

Chennai flood losses estimated at Rs 20,034 crore to the India's economy, says Aon Benfield report

http://www.dnaindia.com/money/report-chennai-floods-losses-estimated-at-rs-20034-crore-to-the-india-s-economy-says-aon-benfield-report-2154521

Extreme Rainfall is Projected to Increase in Future



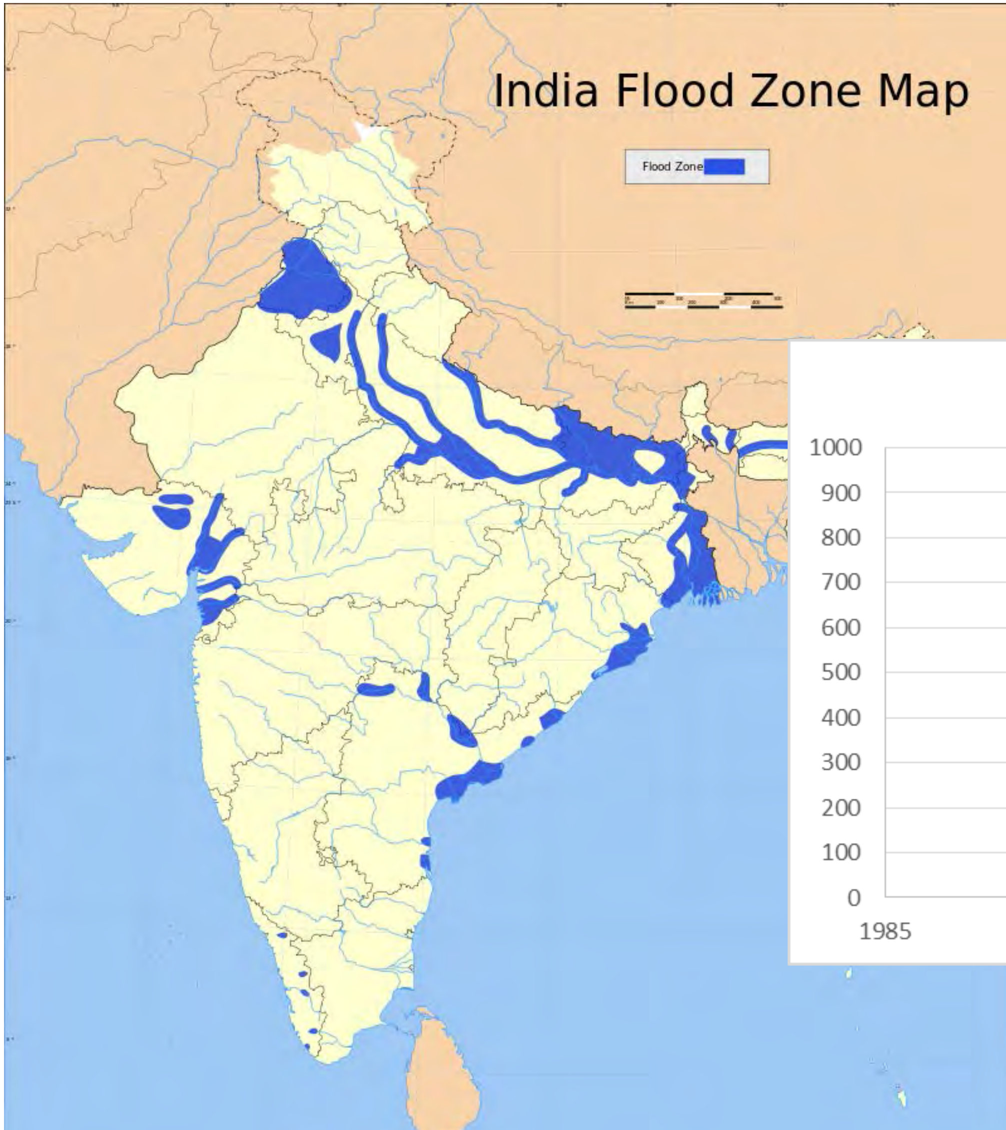
Modi et al. (2014)

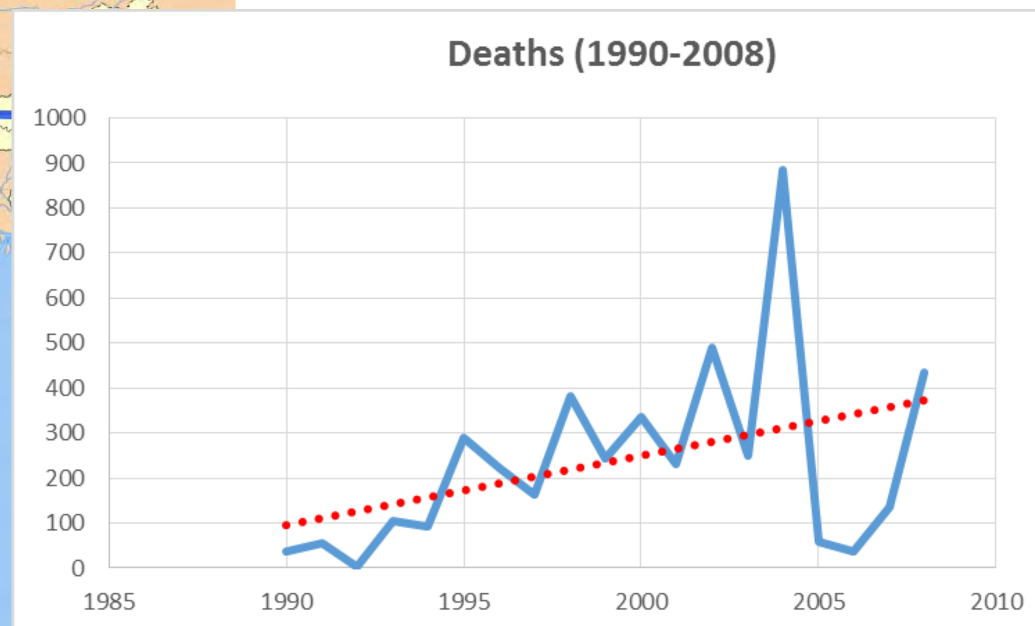
About 5% increase in annual maximum precipitation in Early and 10% increase in Mid 21st Century

Floods in Bihar

- India's most flood prone state
- 76% of north Bihar's population living under devastating floods
- About 73% area of the state is flood affected
- Kosi, Gandak,Burhi Gandak, Bagmati, Kamla Balan, Mahananda and Adhwara group of rivers originates in Nepal, carry high discharge and very high sediment load and drops it down in the plains of Bihar
- About 65% of catchments area of these rivers falls in Nepal/Tibet and only 35% of catchments area lies in Bihar.

Floods in Bihar





Real-time Flood Monitoring and Forecast: Challenges

- Lack of Data Availability in Real-Time
- Bias and Uncertainty in satellite based datasets and hydrological models
- Lack of observed streamflow data
- Human interventions: most of the river basins are highly affected
- Data availability on initial conditions (observed flow, soil moisture, rainfall)
- Reliability of weather forecast

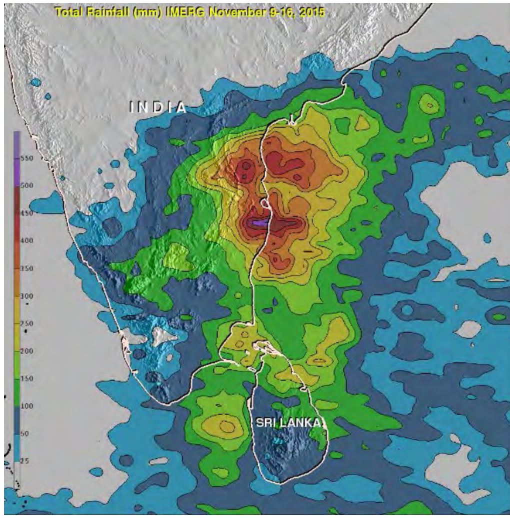
Motivation

- Damage due to floods increased substantially in India
- Lack of real-time monitoring and forecast affects the decision making

Satellite data based real-time monitoring and forecast system can help decision makers in planning

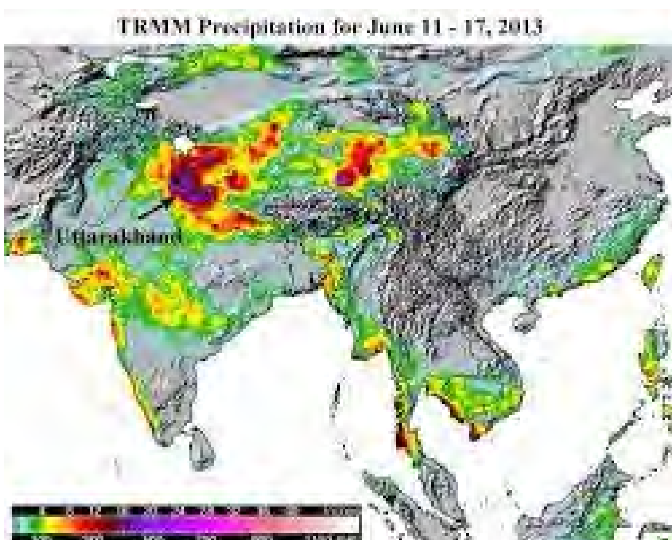
GPM

Chennai Heavy Rainfall



TRMM-RT

Uttarakhand Flood 2013: 6000 deaths

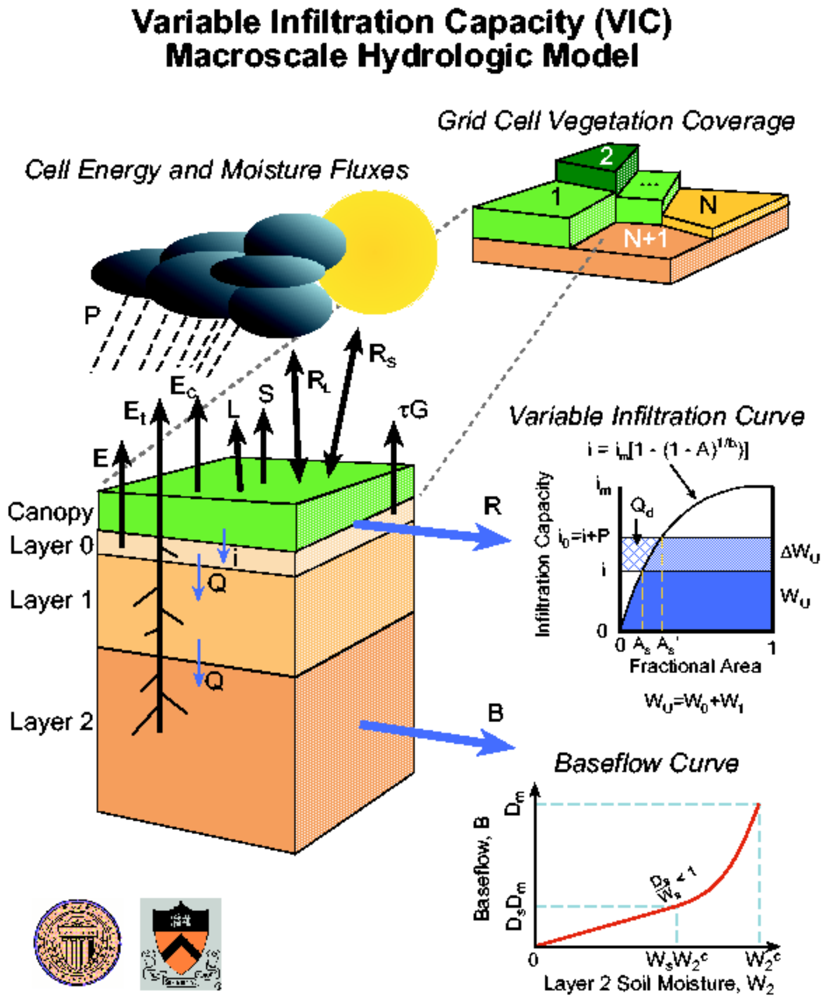


Data and Methods

- Observed precipitation and temperature: India Meteorological Department (IMD)
- Satellite Precipitation Data: TRMM-RT, CMORPH, PERSIANN, and GPM
- Real time temperature data: Global Ensemble Forecast System (GEFS) reforecast v2
- Evaluation of satellite precipitation data against the observed data
- Evaluation of GEFS air temperature against observed data
- Bias correction of precipitation and air temperature
- Bias corrected precipitation and temperature was used to run the VIC model to get soil moisture and runoff

The Variable Infiltration Capacity (VIC) Model

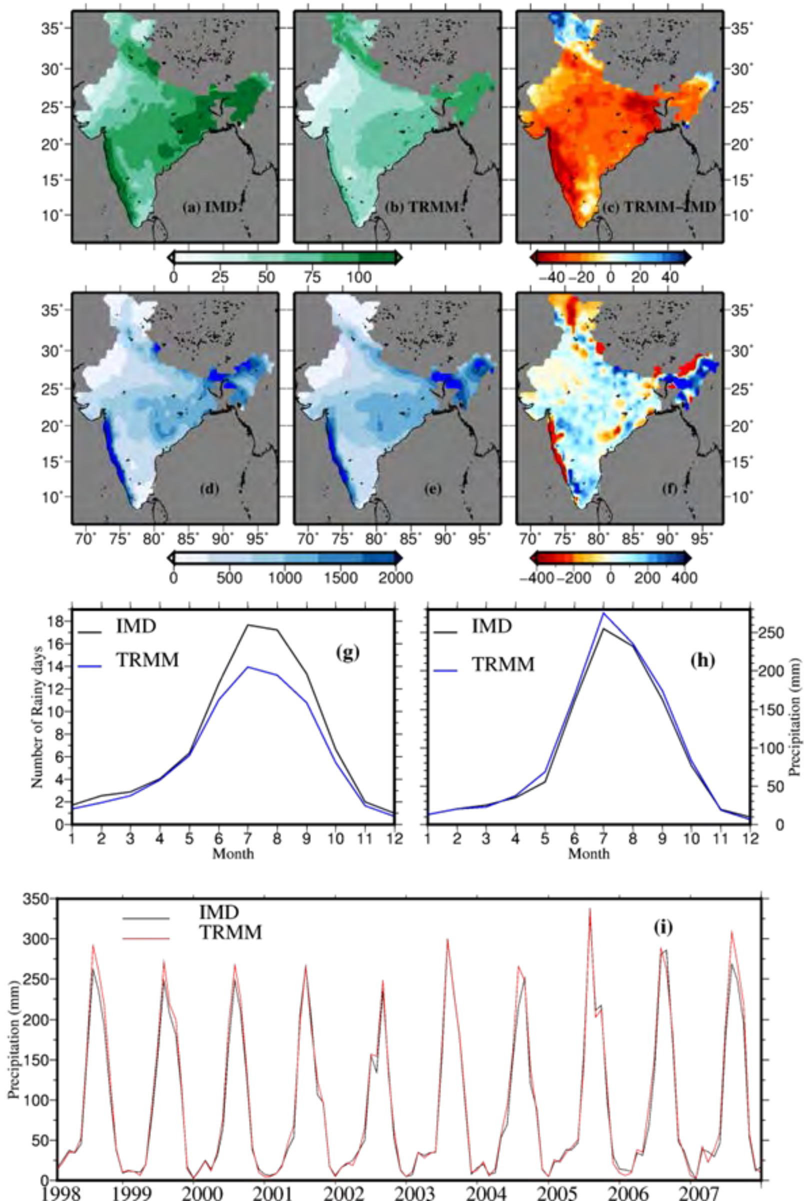
- Solves energy and water balance over grid cells
- Accounts for sub-grid variability in precipitation, topography, soil moisture, and land cover by partitioning grid cell in tiles
- Has been widely used for large-scale river basins



Cherkauer et al. (2003)

Evaluation of TRMM Precipitation

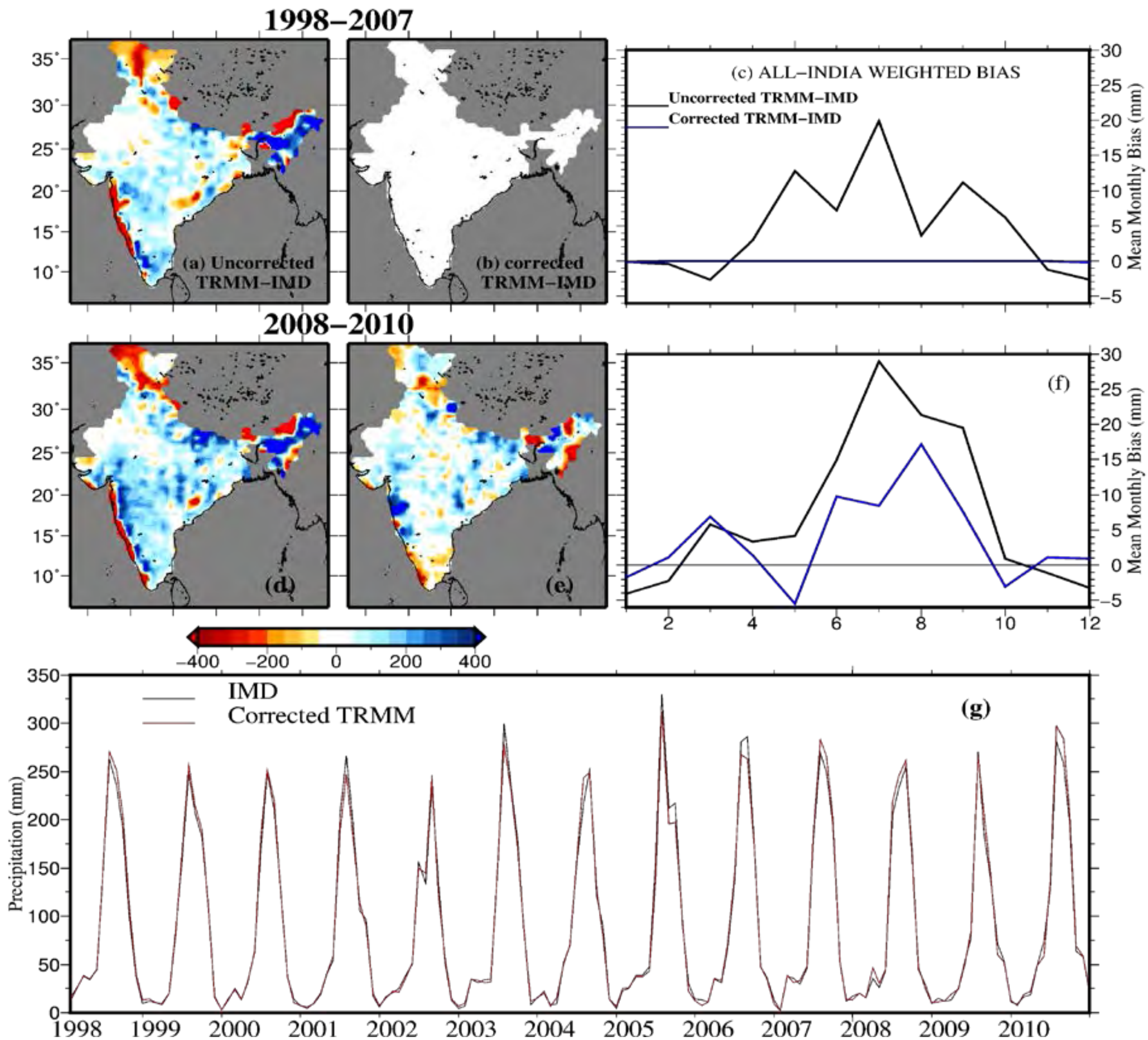
- TRMM-RT underestimates number of rainy days
- TRMM-RT overestimates total monsoon season precipitation
- TRMM-RT overestimates extreme precipitation



Shah and Mishra (2015), JHM

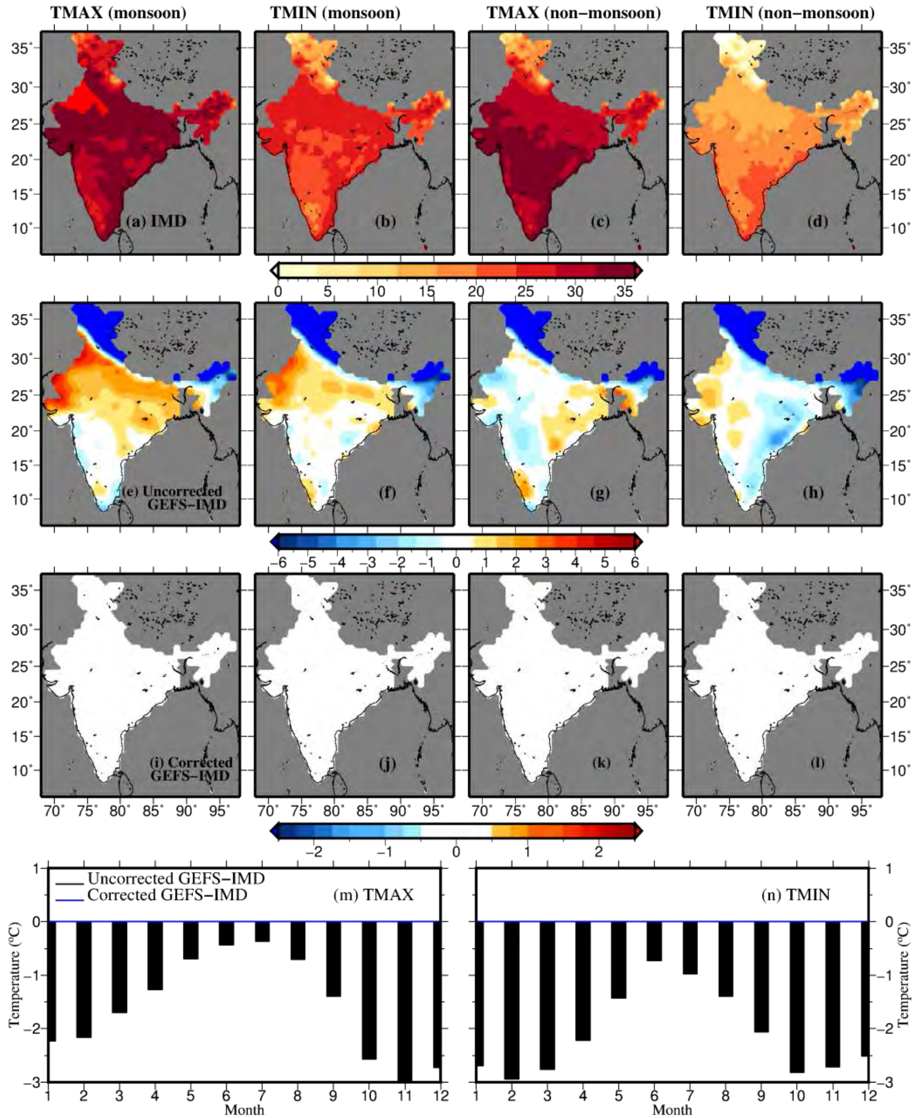
Bias Correction of TRMM Precipitation

- Bias in extreme and mean precipitation was successfully removed



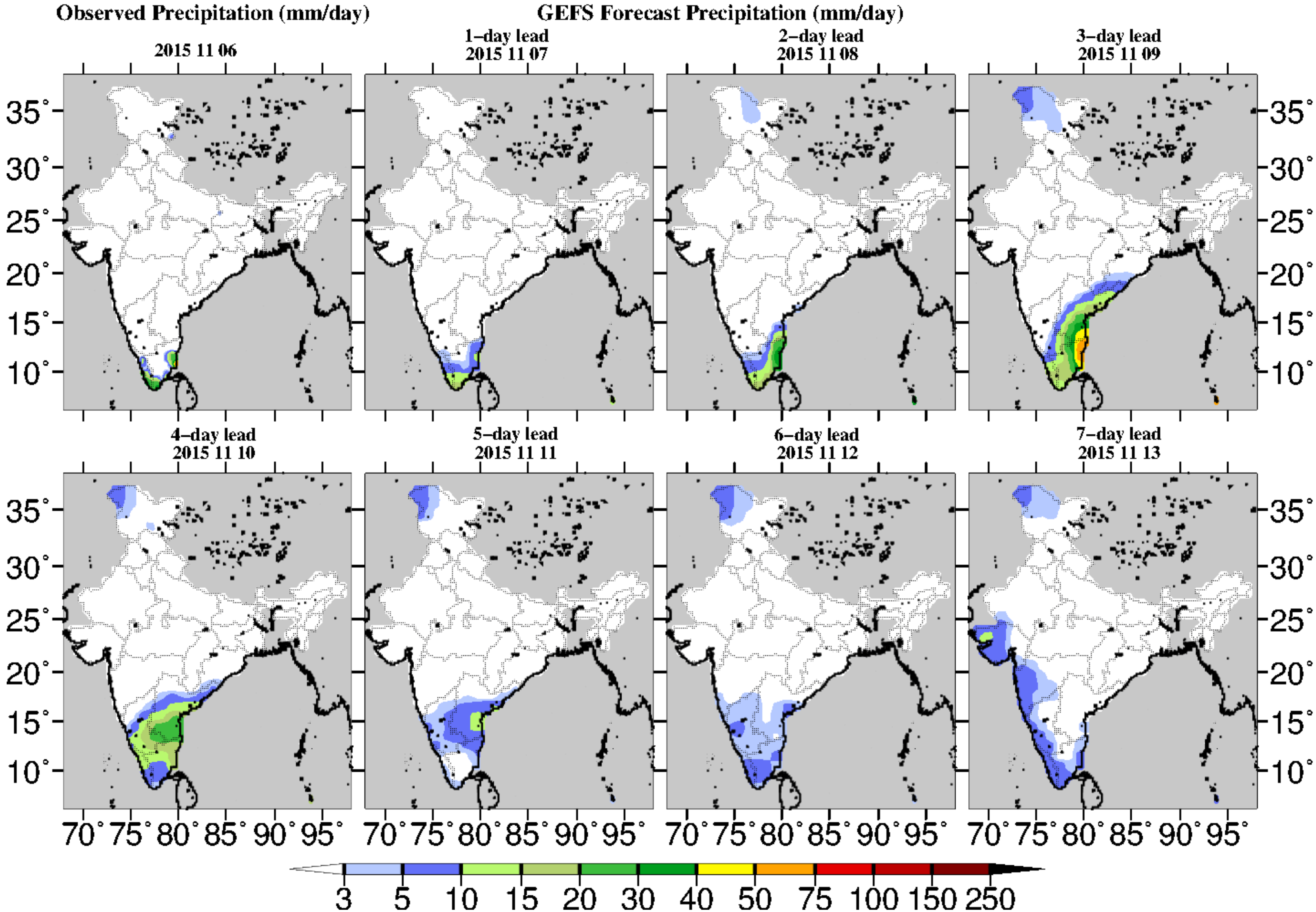
Bias Correction of GEFS Air Temperature

- Cold and Warm bias was found in the GEFS air temperature
- Bias was successfully corrected in maximum and minimum air temperature



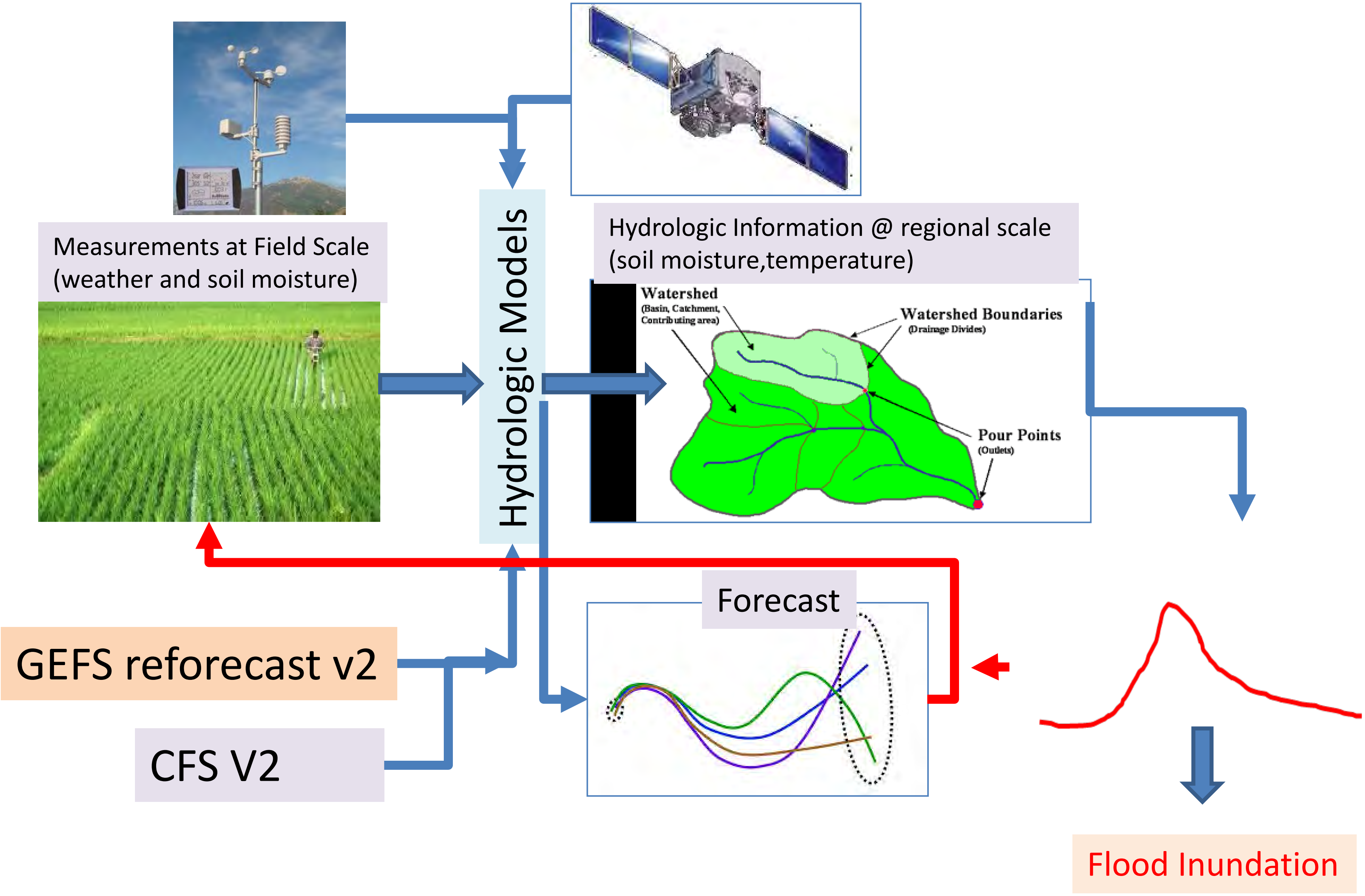
Shah and Mishra (2015), JHM

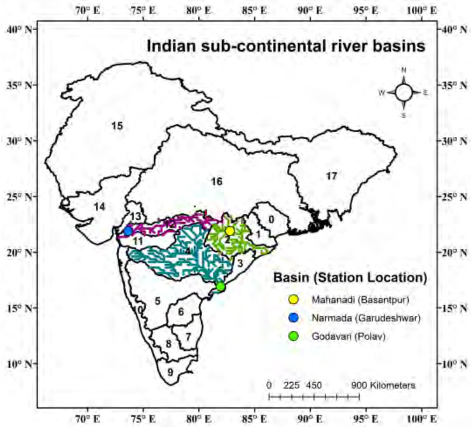
Rainfall Forecast @ 7 Day Lead



From: Experimental Drought Monitor

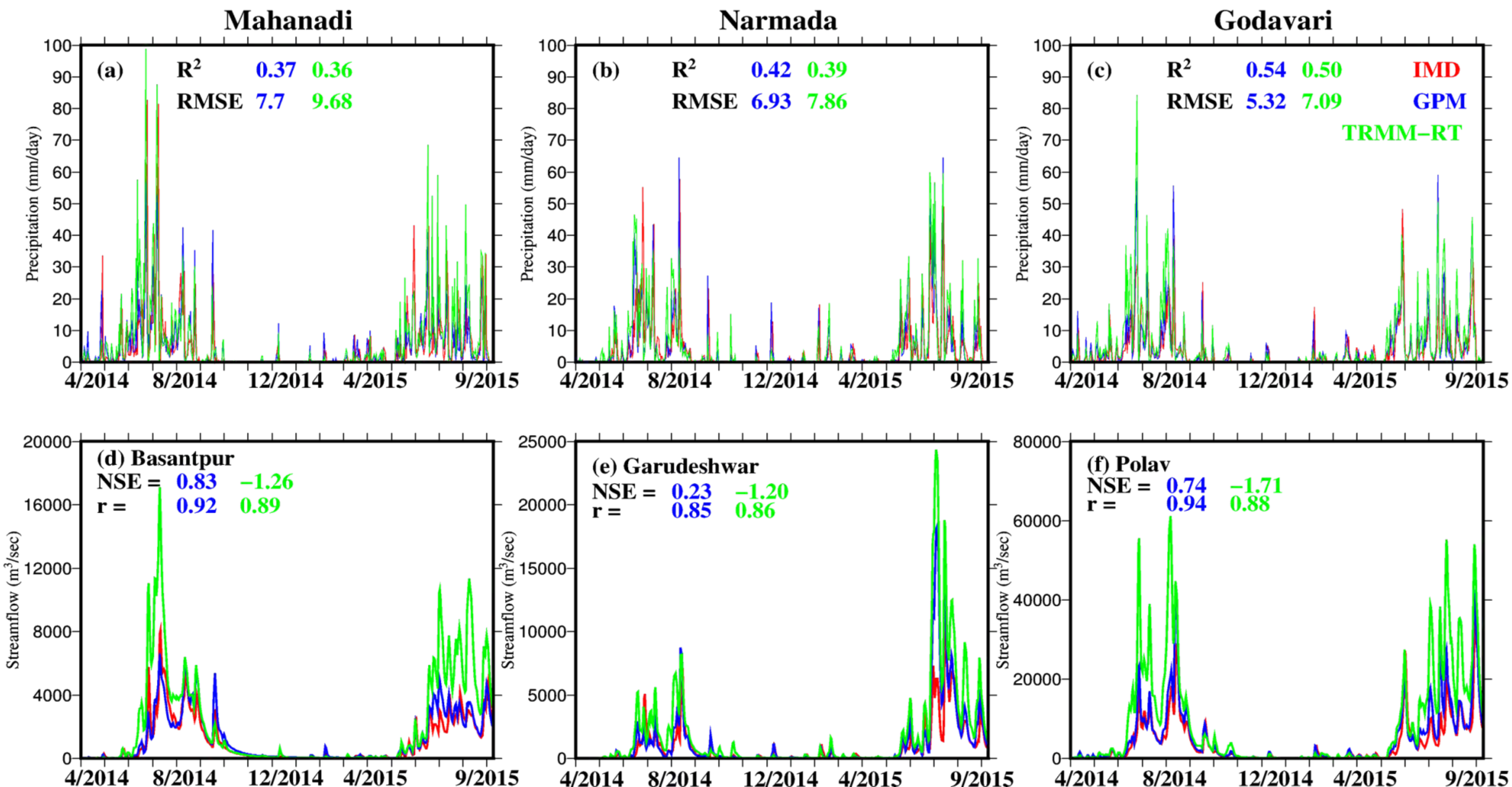
Real-time monitoring and forecast system





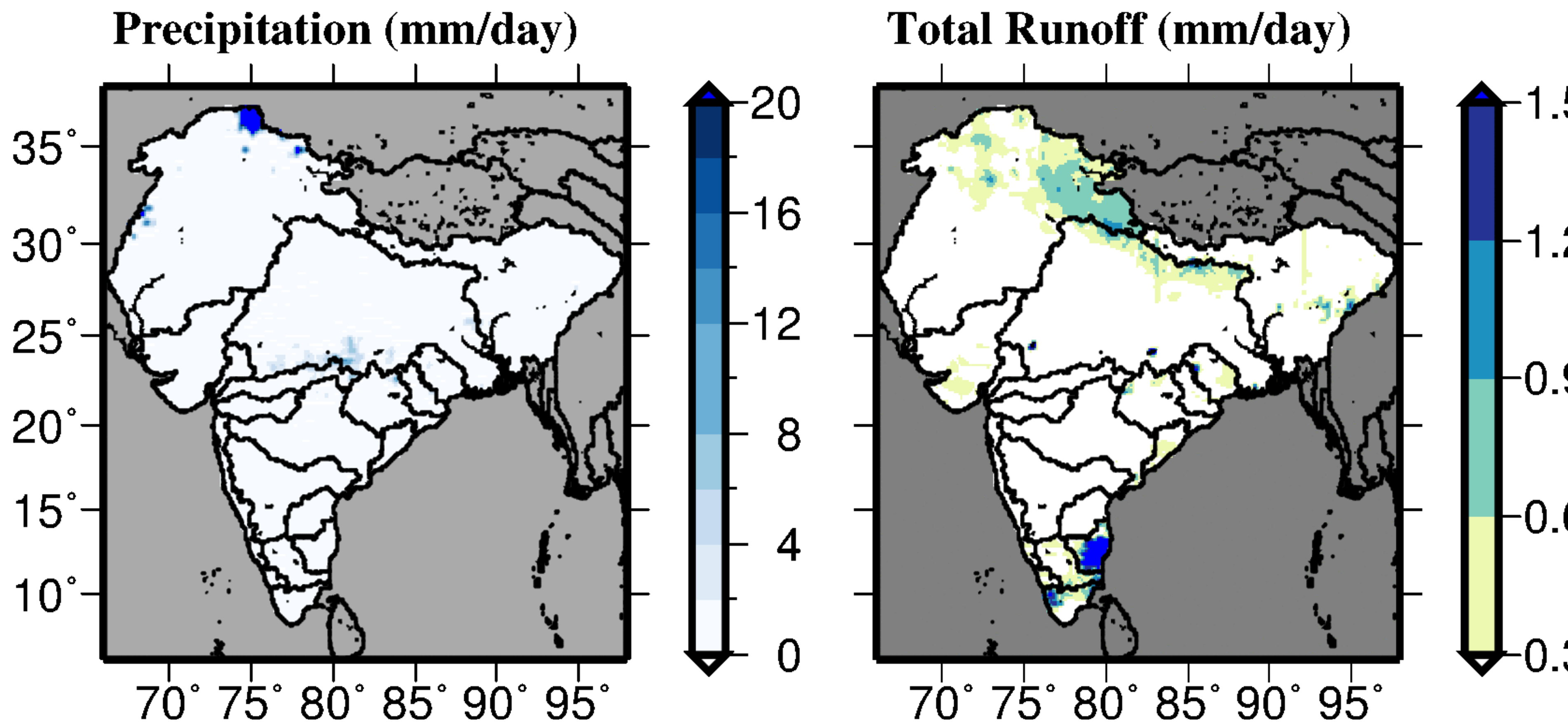
Near Real-time Flood Monitoring and Forecast System

- Precipitation from IMERG (GPM) outperforms TRMM-RT
- Bias in initial condition needs to be corrected using data assimilation



Real-time Streamflow Monitoring

18/01/2016



https://sites.google.com/a/iitgn.ac.in/experimental-flood-monitor/

Basin Scale Real-time Streamflow Monitoring

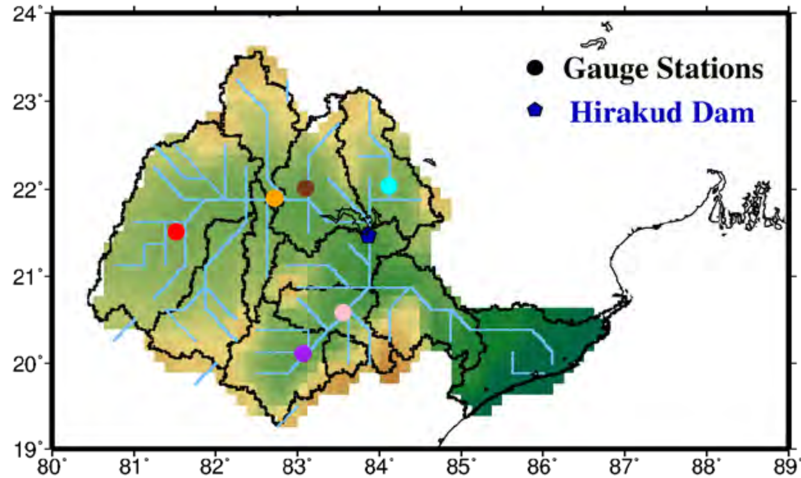
Useful for reservoir monitoring and management

Water allocation planning and canal water management

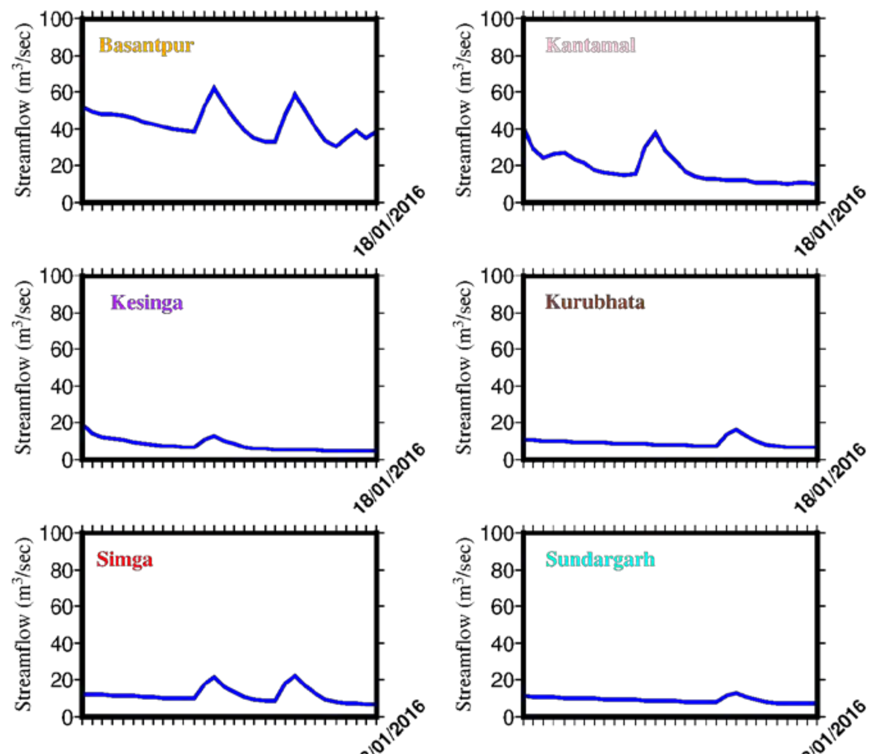
Irrigation Planning and water conservation

Flood water management and loss reduction

Mahanadi Basin

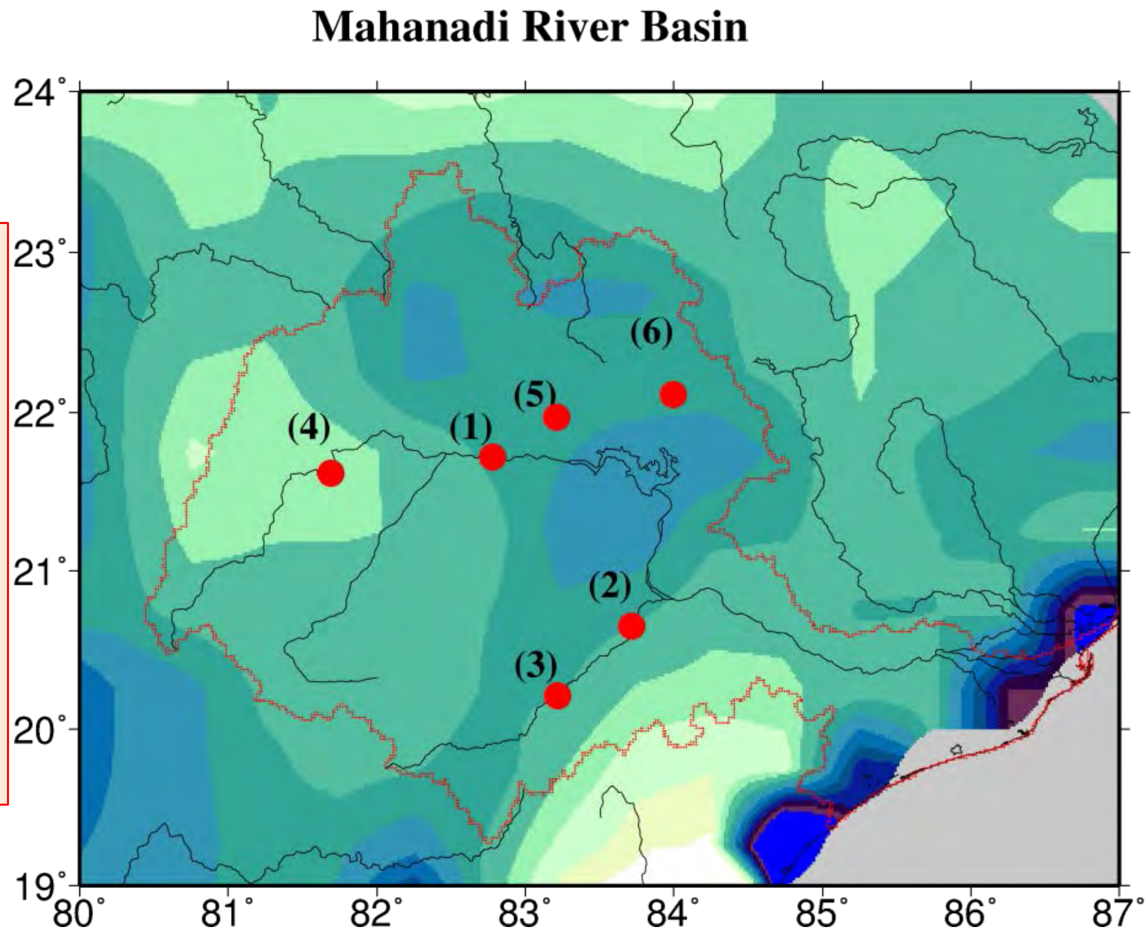


Last 30 days flow ending on 18/01/2016



Floods in Mahanadi River Basin

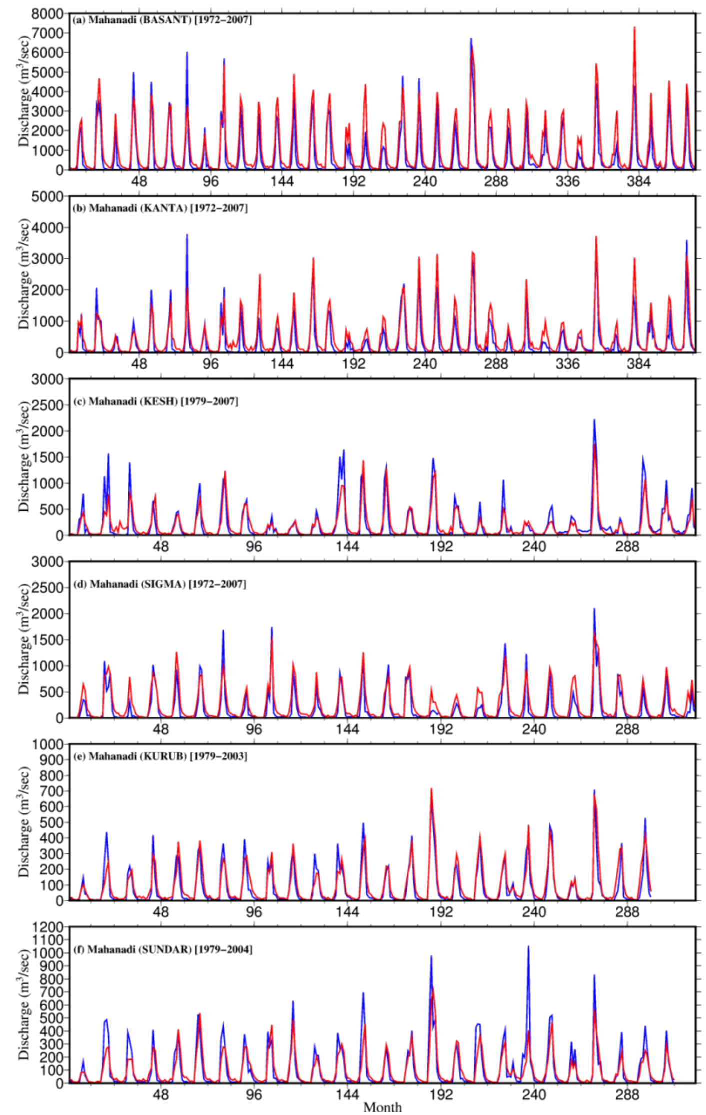
- Basin level studies are required
- Identification of flood prone areas need to be done
- Changes in flood frequency and flood inundation are required to be estimated
- Risk and Exposure assessment is required



Hydrologic Model: Calibration and Evaluation

Performance of the Hydrologic Model

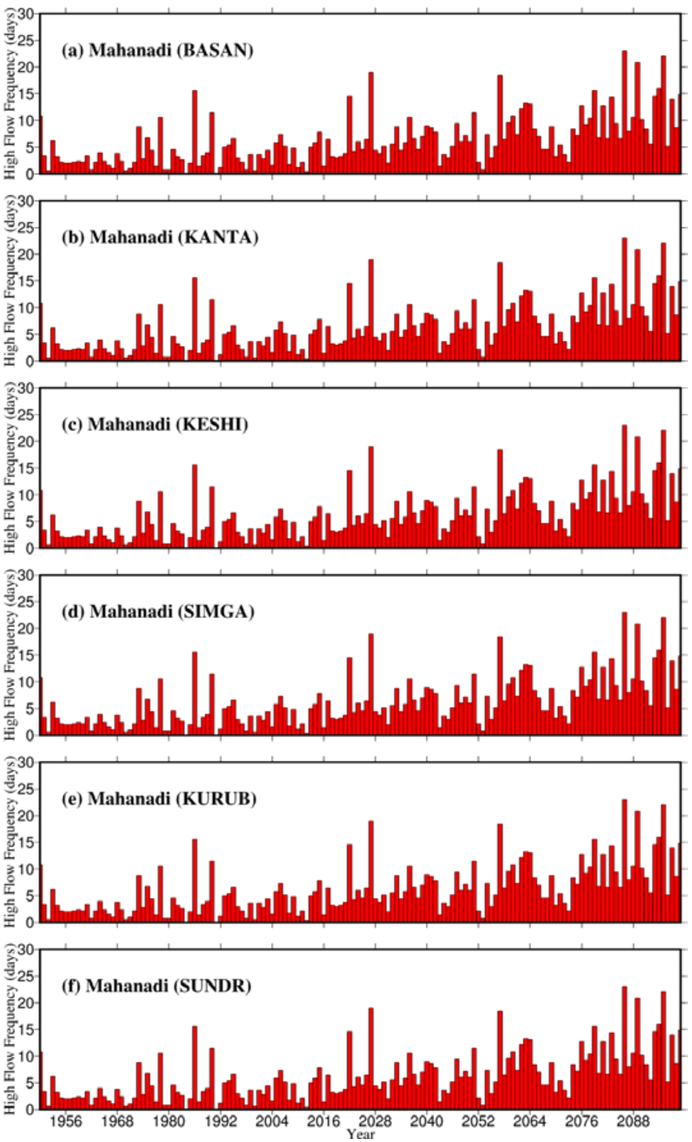
Mahanadi Basin



Floods in Changing Climate

Increase in flood frequency in the projected climate

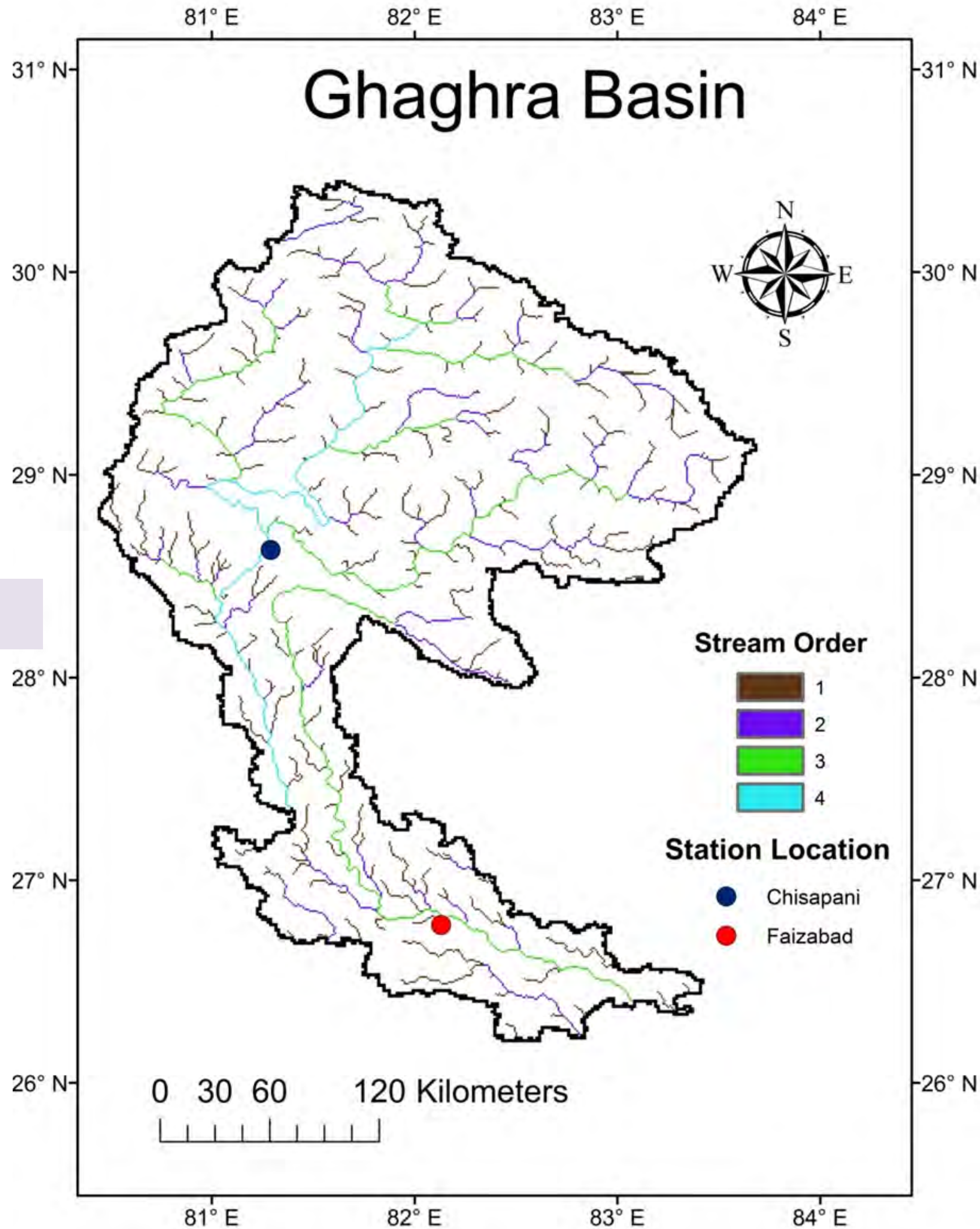
Mahanadi Basin



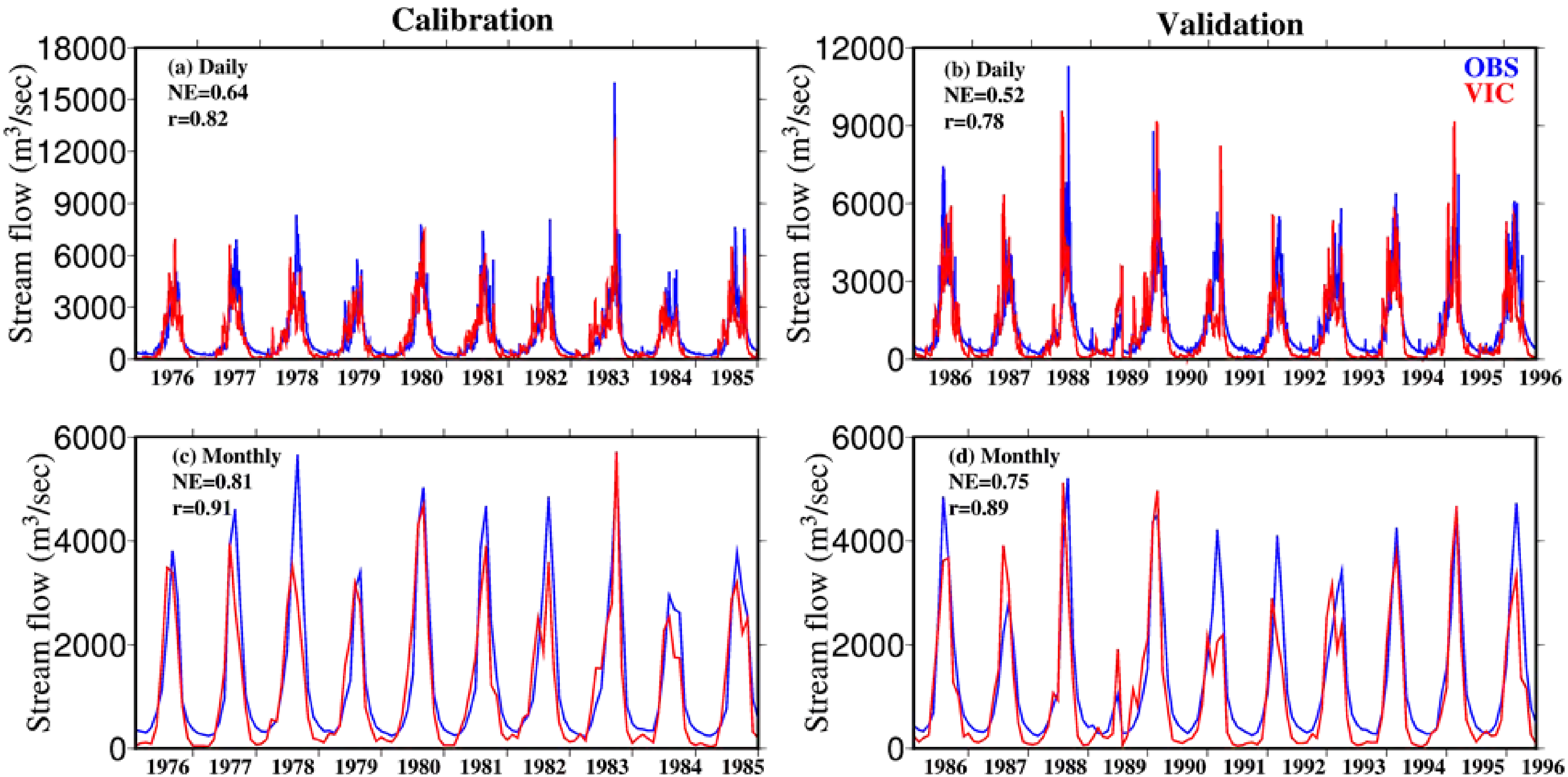
Flood monitoring and forecast systems (Ghaghra Basin)

Providing near real-time information
On flood peaks and inundation

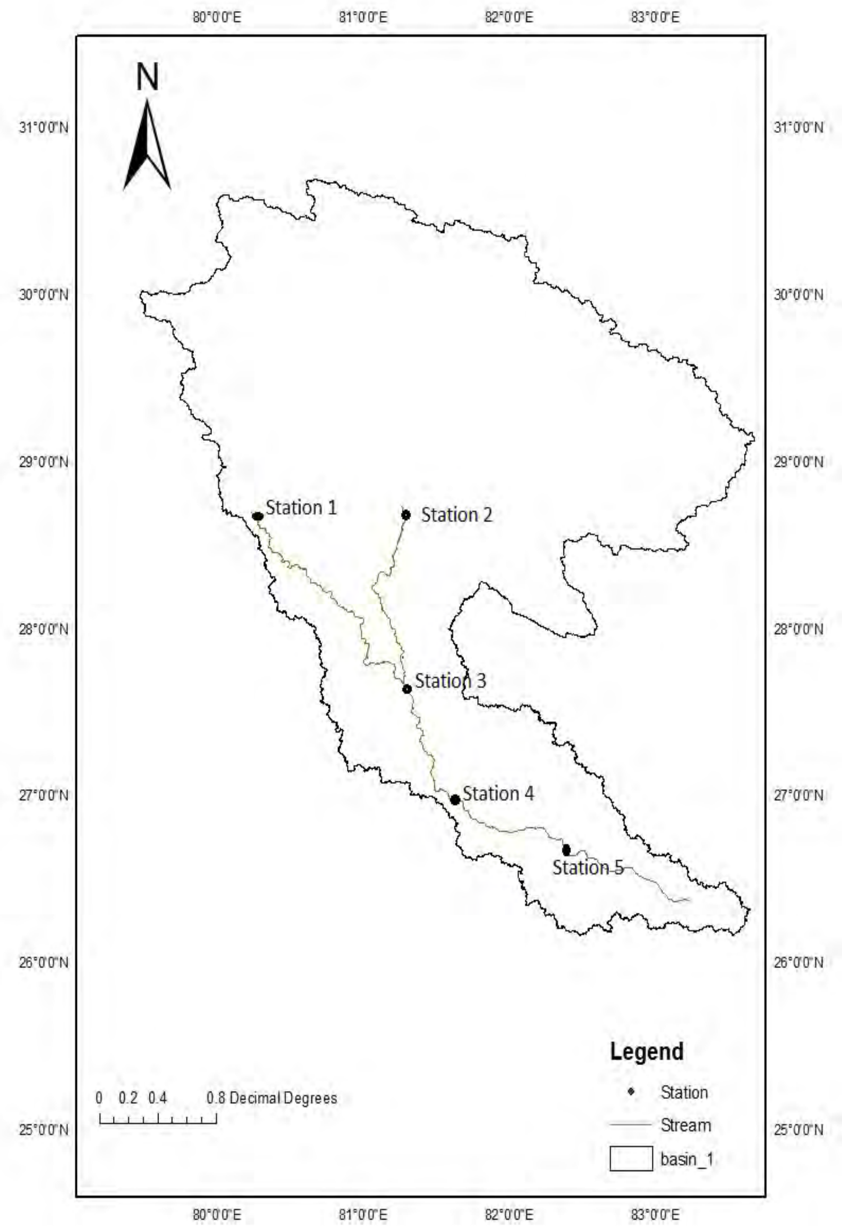
Forecast on inundated area in the basin



Observed and simulated flow (Ghaghra)

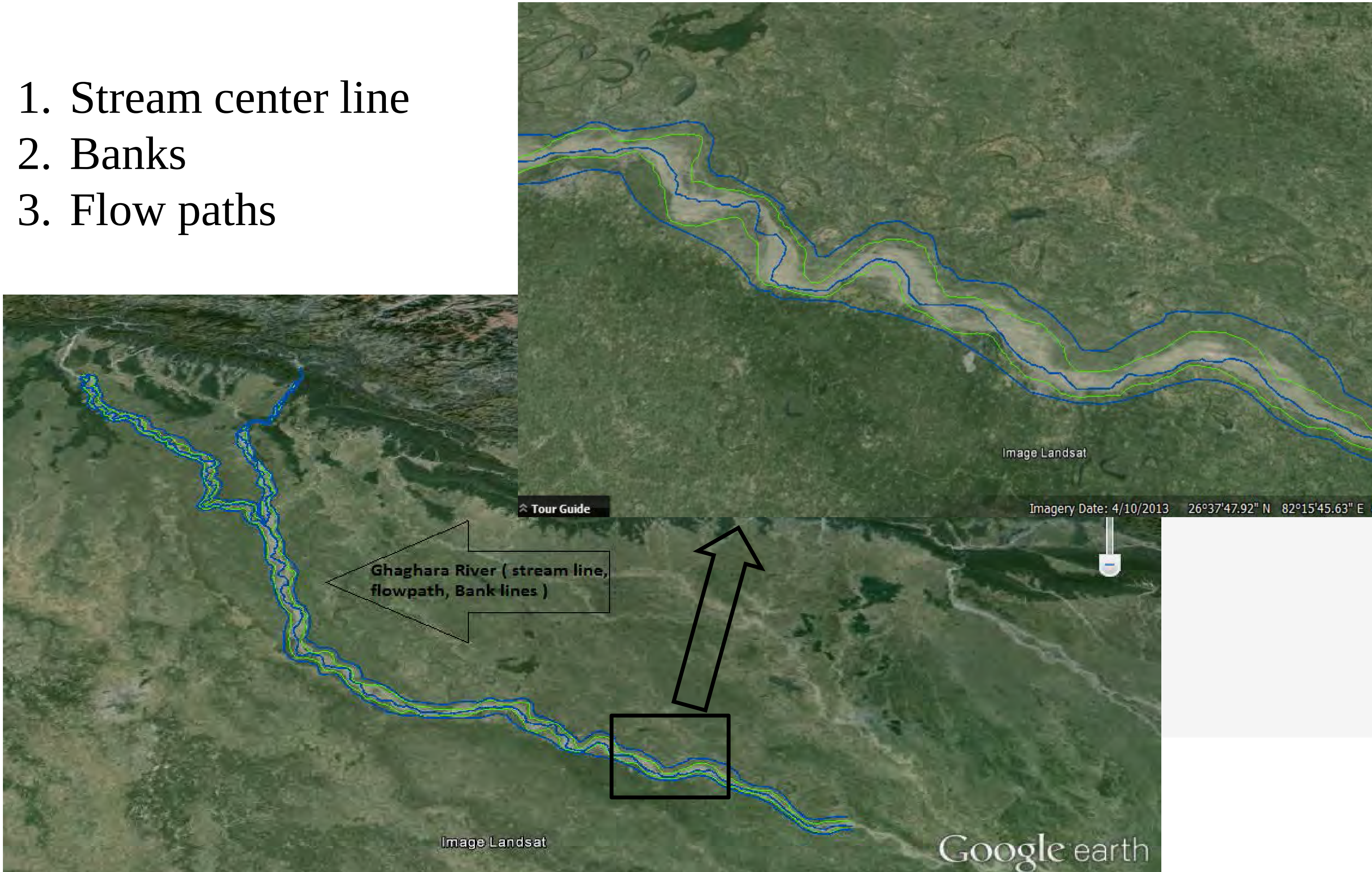


Return Period Estimation

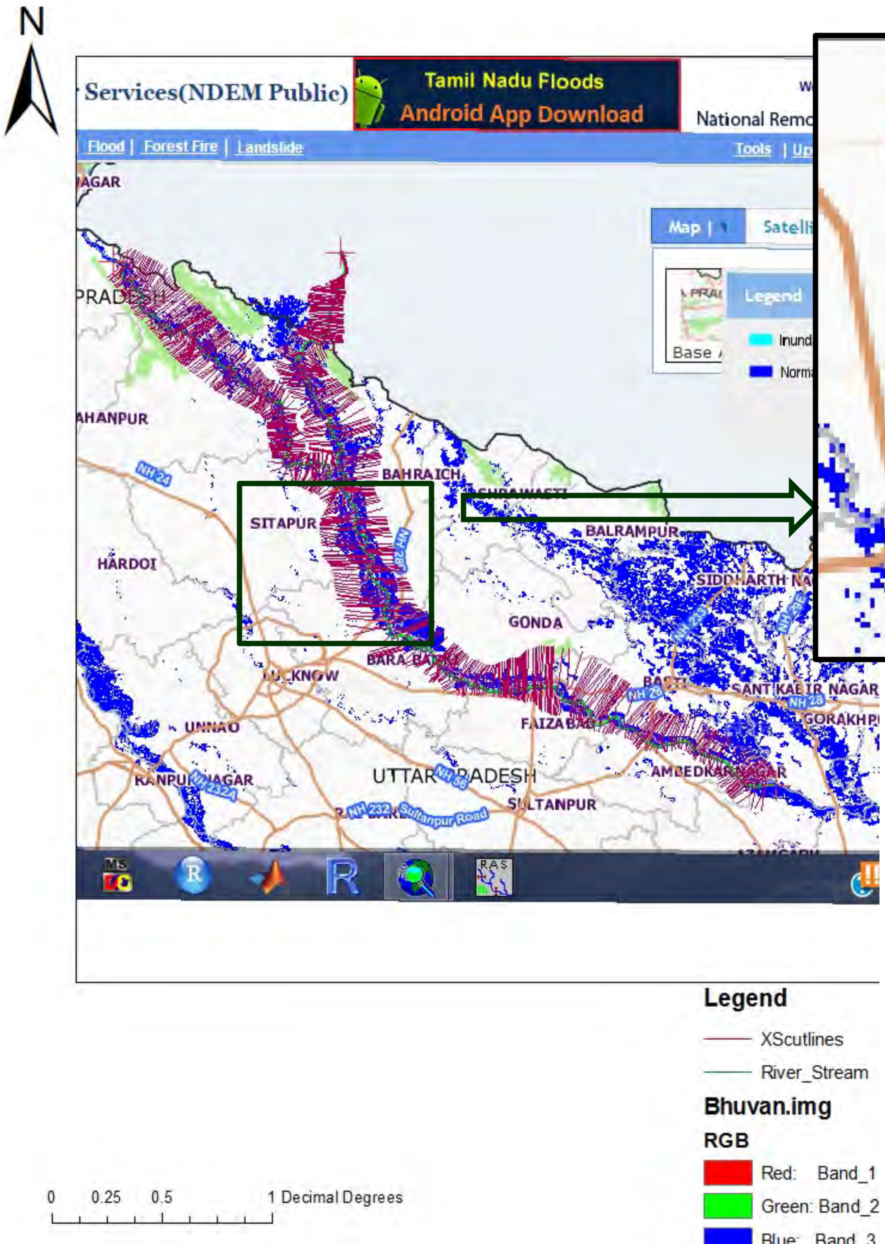


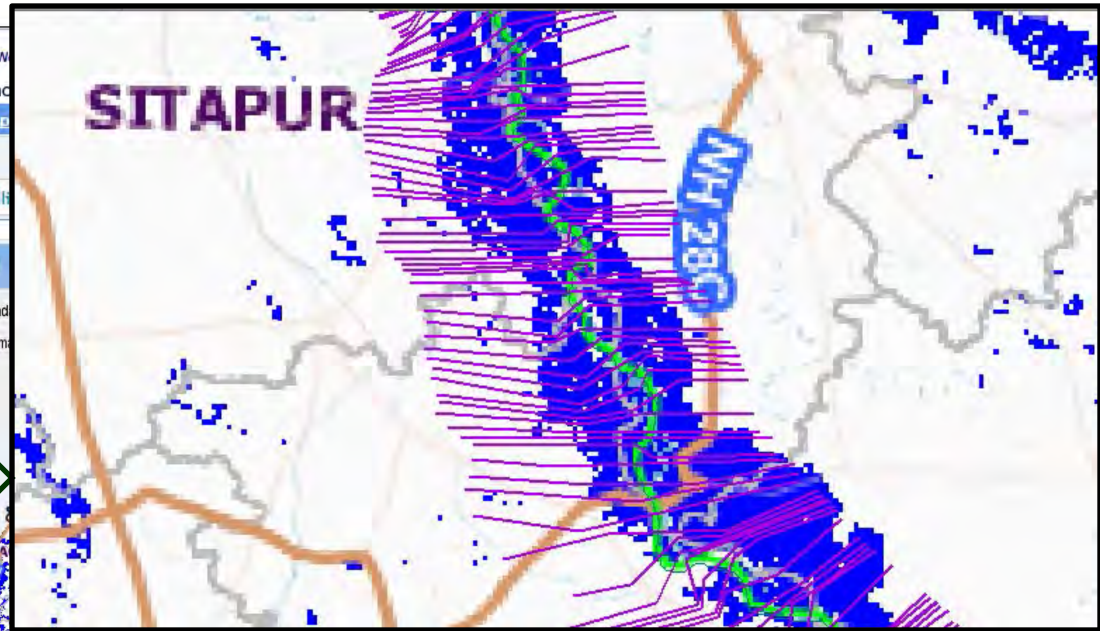
River Digitization

1. Stream center line
2. Banks
3. Flow paths



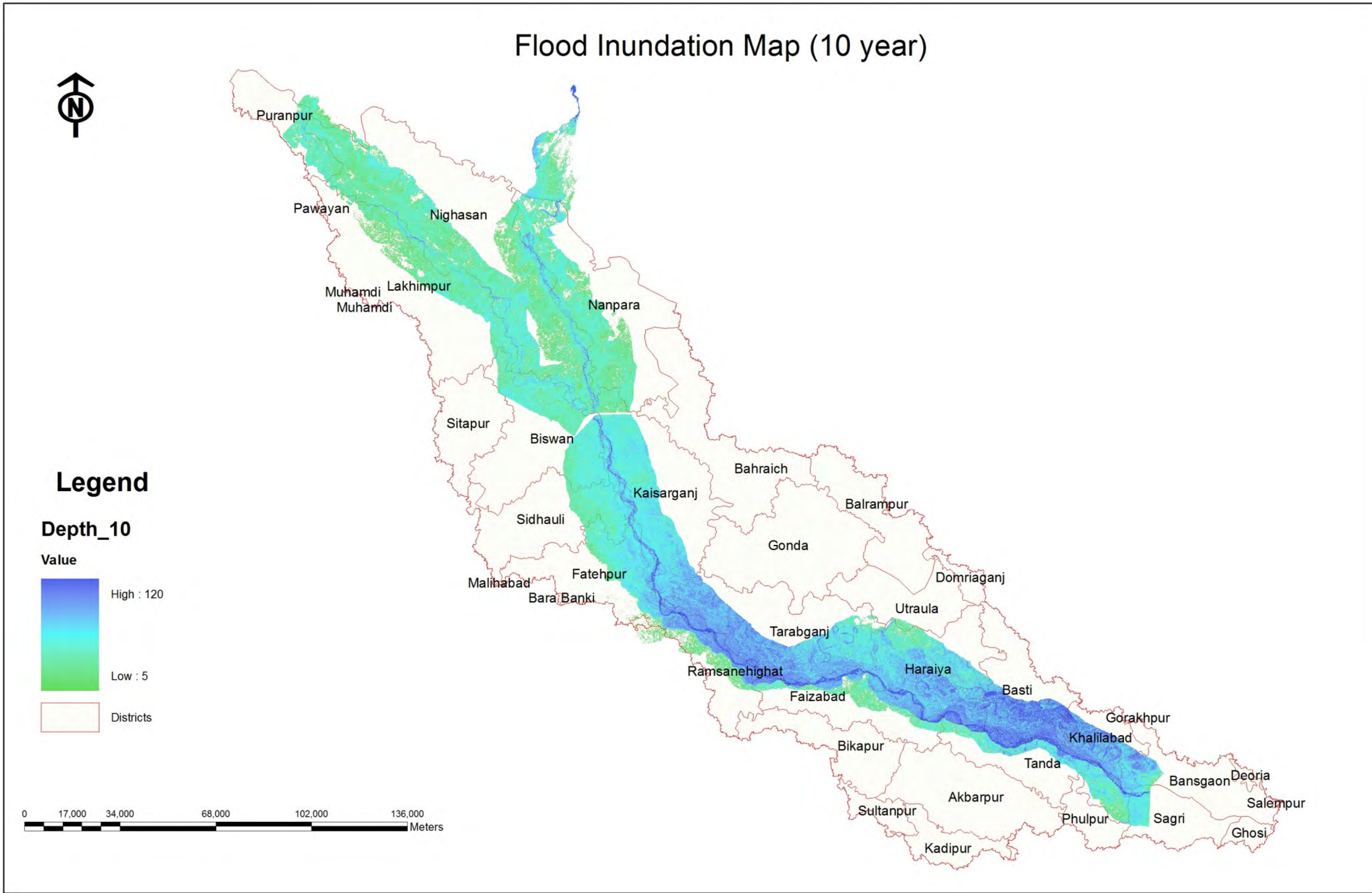
River Cross-sections



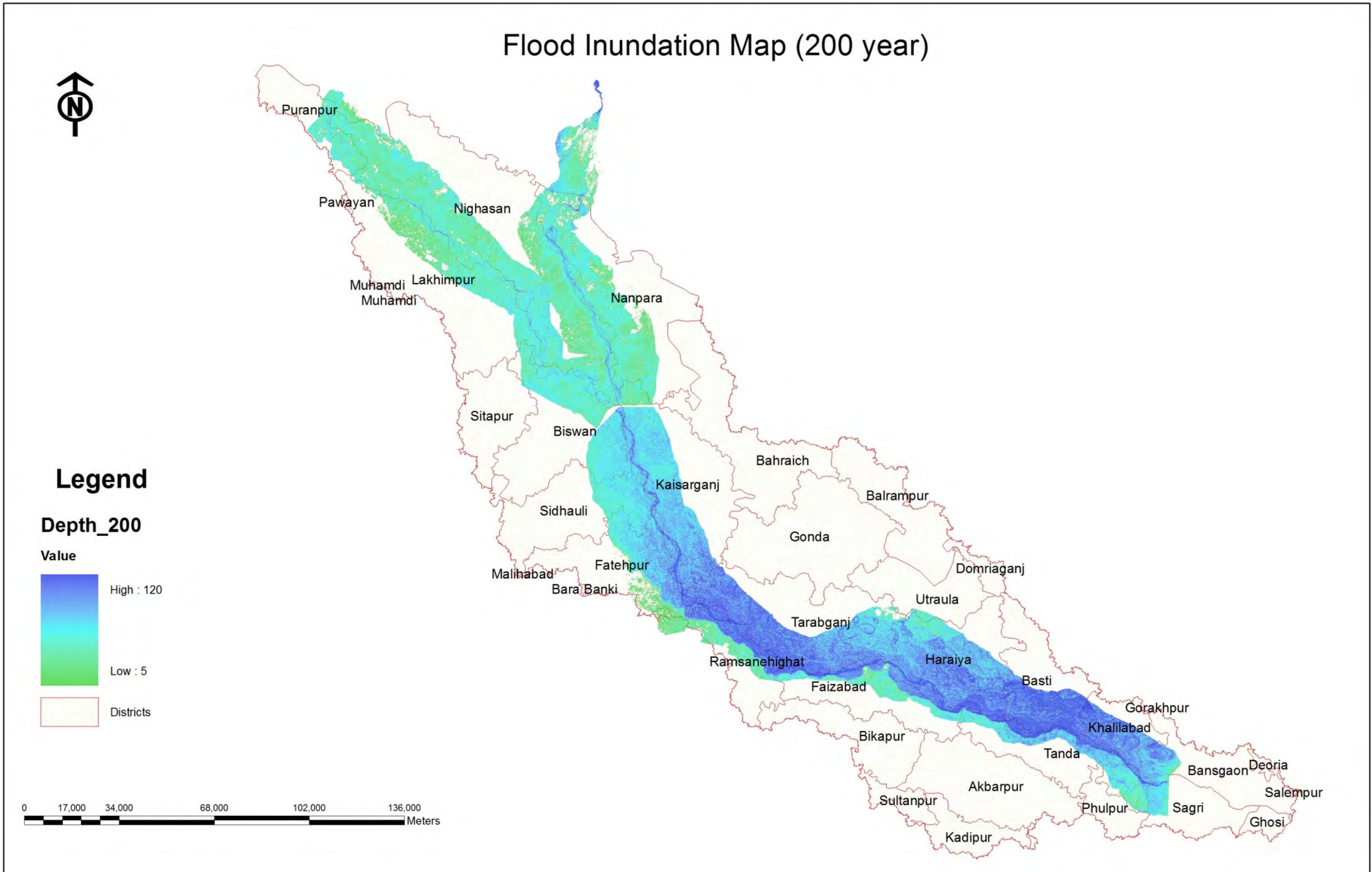


1. Geo-referencing of Bhuvan Image in GIS
2. Create Layer of XS cut lines in GeoRAS

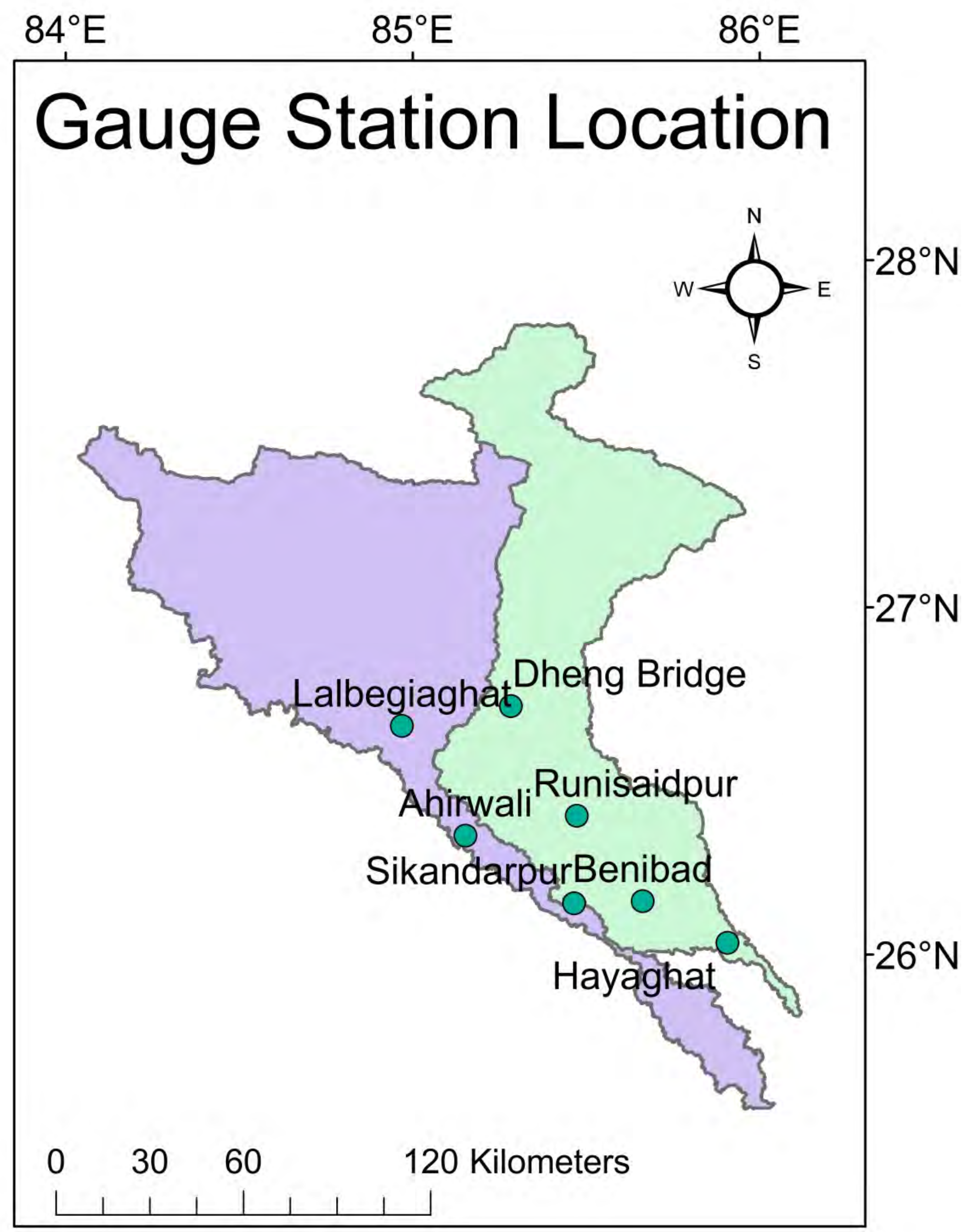
Flood Inundation in Ghaghara Basin



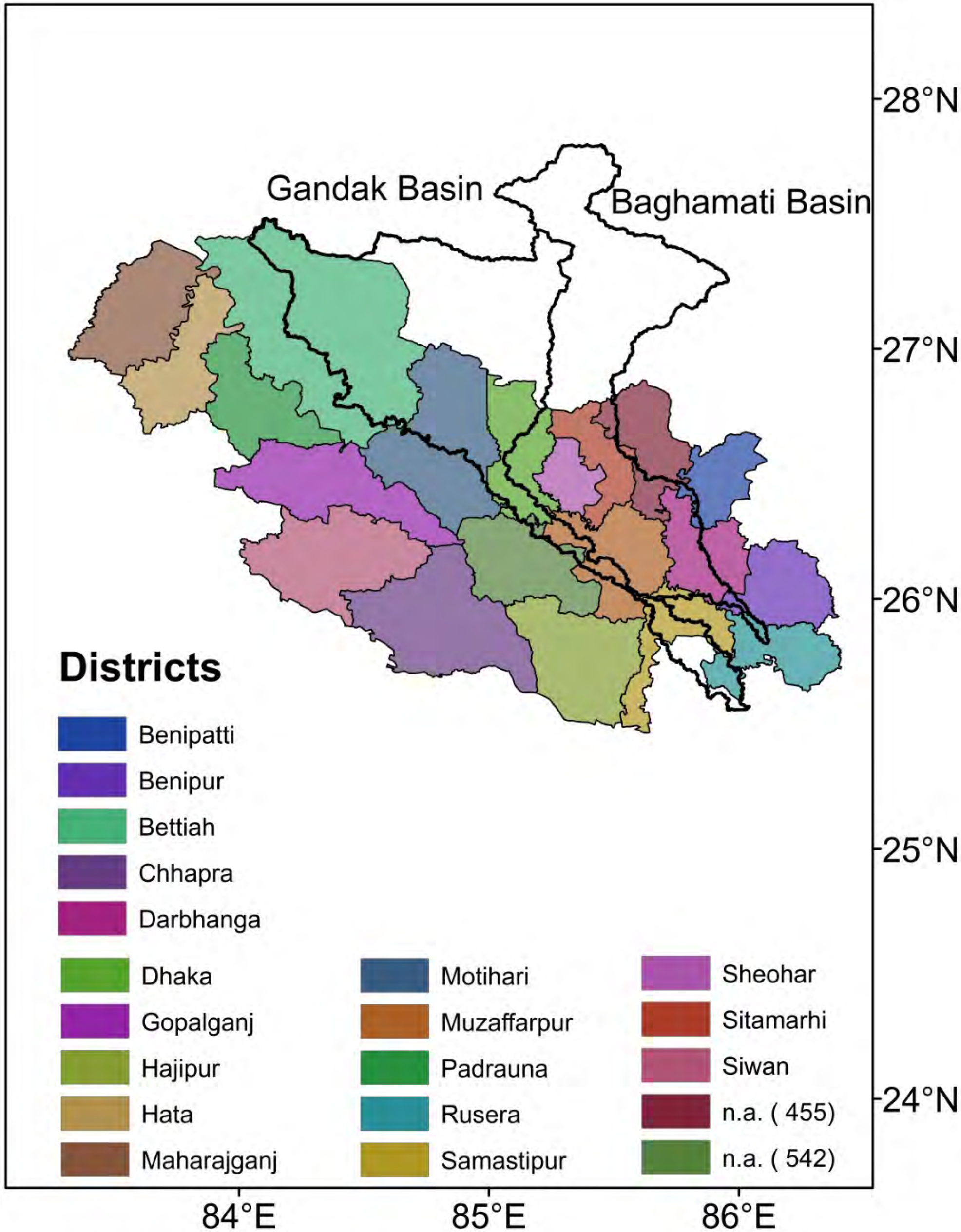
Flood Inundation in Ghaghara Basin



Flood Modeling in Baghmati and Budi Gandak



Flood Modeling in Baghmati and Budi Gandak



Flood Modeling in Baghmati and Budi Gandak

Frequency of daily high flow Events

Conclusions

- It is essential to develop real-time monitoring and forecast system for floods especially for the basins that face frequent floods
- High resolution (1 km and 30 minutes) data can be obtained in near-real time from Global Precipitation Mission (GPM)
- Near-real time observations of streamflow and soil moisture will help to improve monitoring and forecast
- Basins that has short response time may need dense AWS and Radar systems
- High resolution weather forecast can be useful for flood preparedness
- Best management practices for sediment load are desired

Thank You

REAL TIME DECISION SUPPORT SYSTEM
OF
RIVER SATLUJ & BEAS

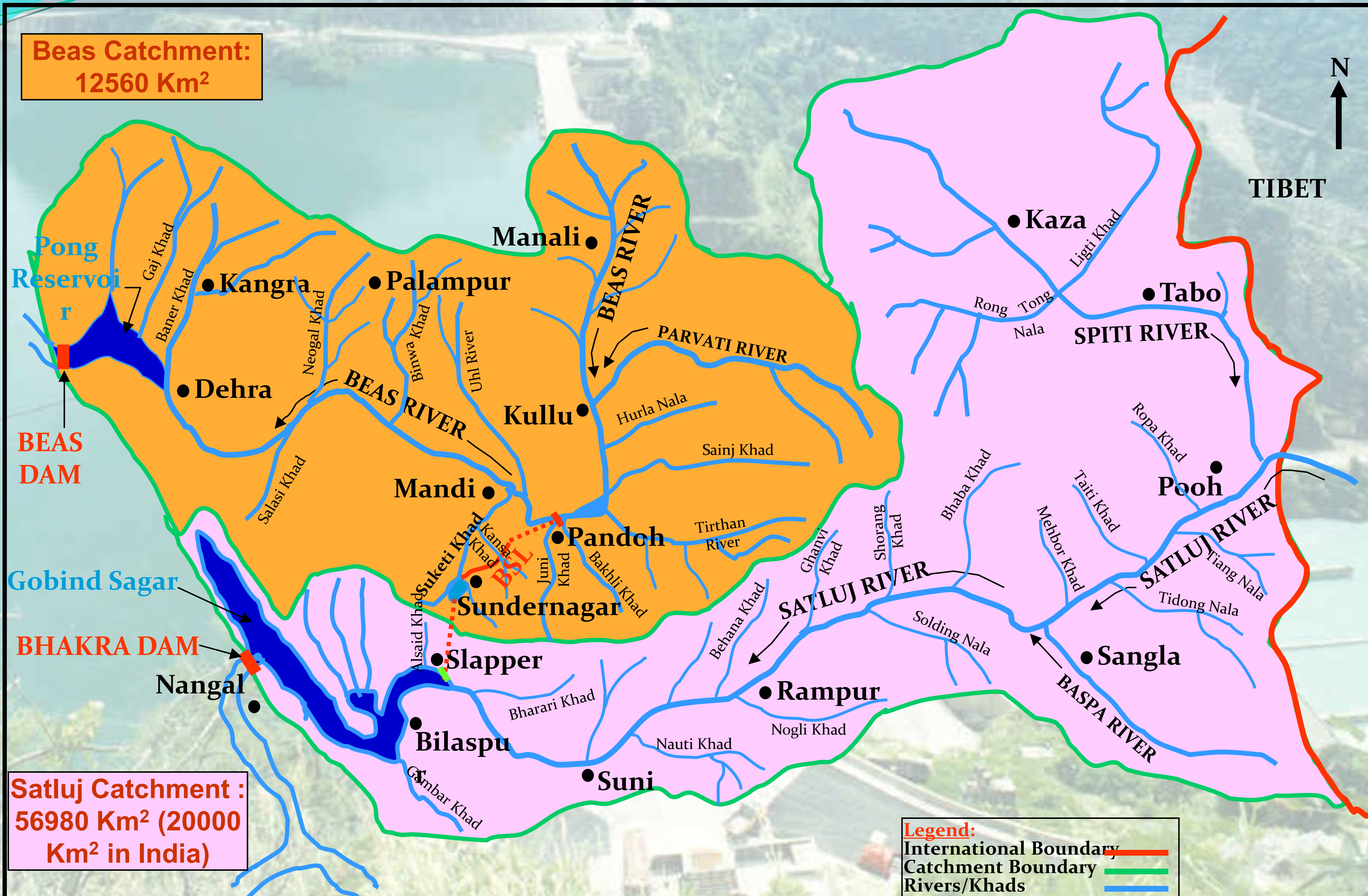
The Organization

- Bhakra-Nangal Project- A Joint Venture Punjab, Haryana and Rajasthan.
- Bhakra Management Board- Under Punjab Reorganization Act 1966 on 1st Oct. 1967 for administration, maintenance & operation of Bhakra Nangal Project.
- Beas Construction Board- For construction of Beas Project.
- Bhakra Management Board was renamed as Bhakra Beas Management Board (BBMB) w.e.f. from 15th May 1976 after transfer of Beas Project on its completion by Beas Construction Board.

Functions

- Regulation of the supply of water from Bhakra Nangal & Beas Projects to the States of Punjab, Haryana & Rajasthan.
- Regulation of the supply of power generated at BBMB Power Houses to Power utilities of Punjab, Haryana, HP, Rajasthan, Chandigarh and some Common Pool Consumers.
- In the year 1999, BBMB was entrusted with additional function of providing and performing engineering & related technical consultancy services.

CATCHMENT OF SATLUJ & BEAS(INDIA)

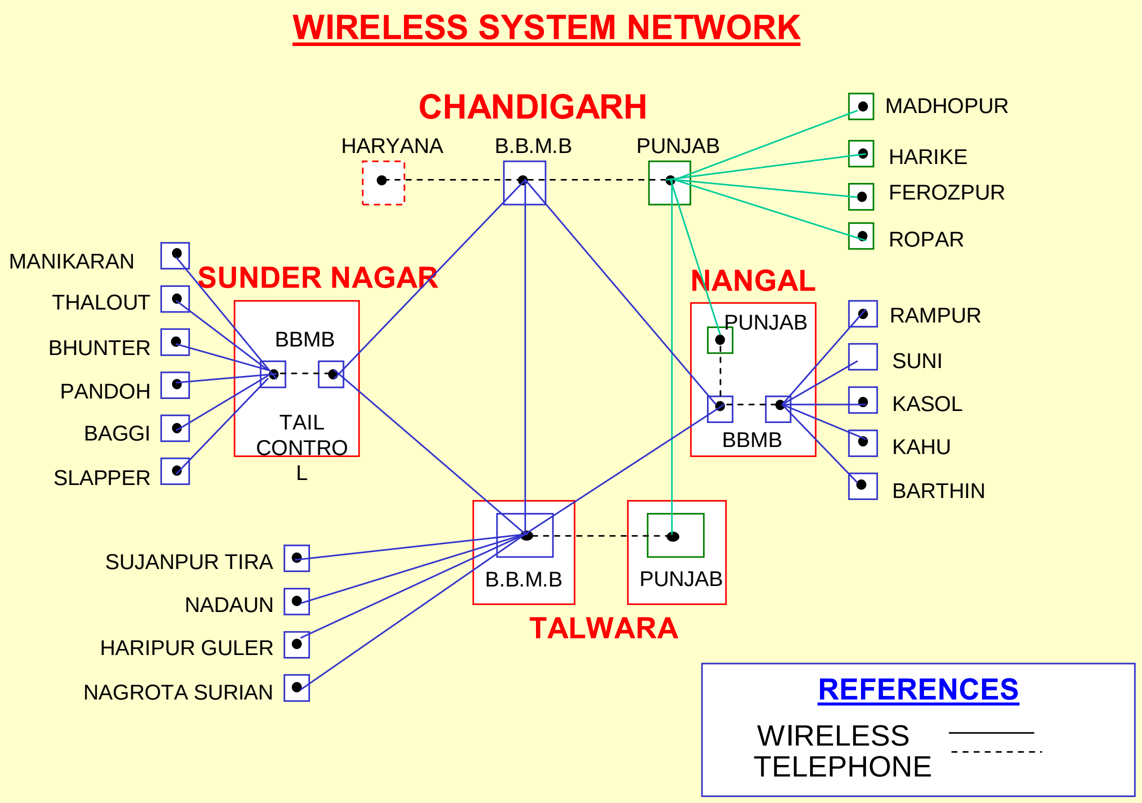


Hydro-Metrological Stations in Sutlej & Beas Catchments

Nomenclature	No. of Instruments	
	Sutlej	Beas
Snow Observatory	4	-
Snow Gauge Stations	17	-
Rain Gauges Stations	13	24
Discharge Sites	9	15
Evaporimeter	6	6
Meteorological Observatory	1	2
TOTAL	50	47

Hydro-meteorological Data Acquisition System Wireless Network

Hydro-Meteorological Data Acquisition And Transmission



LIMITATIONS OF PRESENT SYSTEM

1. Obsolete Communication System
2. Partial Coverage of Catchment Area
3. Forecasts Variance
4. Poor Decision Making Tool
5. Dependence on Remote Man Power

REAL TIME DECISION SUPPORT SYSTEM
HP-II
BHAKRA BEAS MANAGEMENT BOARD

ACTIVITES UNDER HP-II

1. MODELLING OF RIVER BASINS (SATLUJ & BEAS)
2. CALIBRATION OF MODELS WITH HISTORICAL DATA
3. UPGRADATION OF EXISTING HYDROMETRO-LOGICAL NETWORK
4. ESTABLISHMENT OF RTDSS CENTRE AT CHANDIGARH &WORKSTATIONS AT PROJECT STATIONS
5. LINKING OF DATA ACQUISITION SYSTEM WITH DEVELOPED MODELS
6. FINE TUNNING &DEVELOPMENT OF REAL TIME DECISION SUPPORT SYSTEM

MODELING

1.RIVER BASIN OR CATCHMENT

2.RIVER ANALYSIS

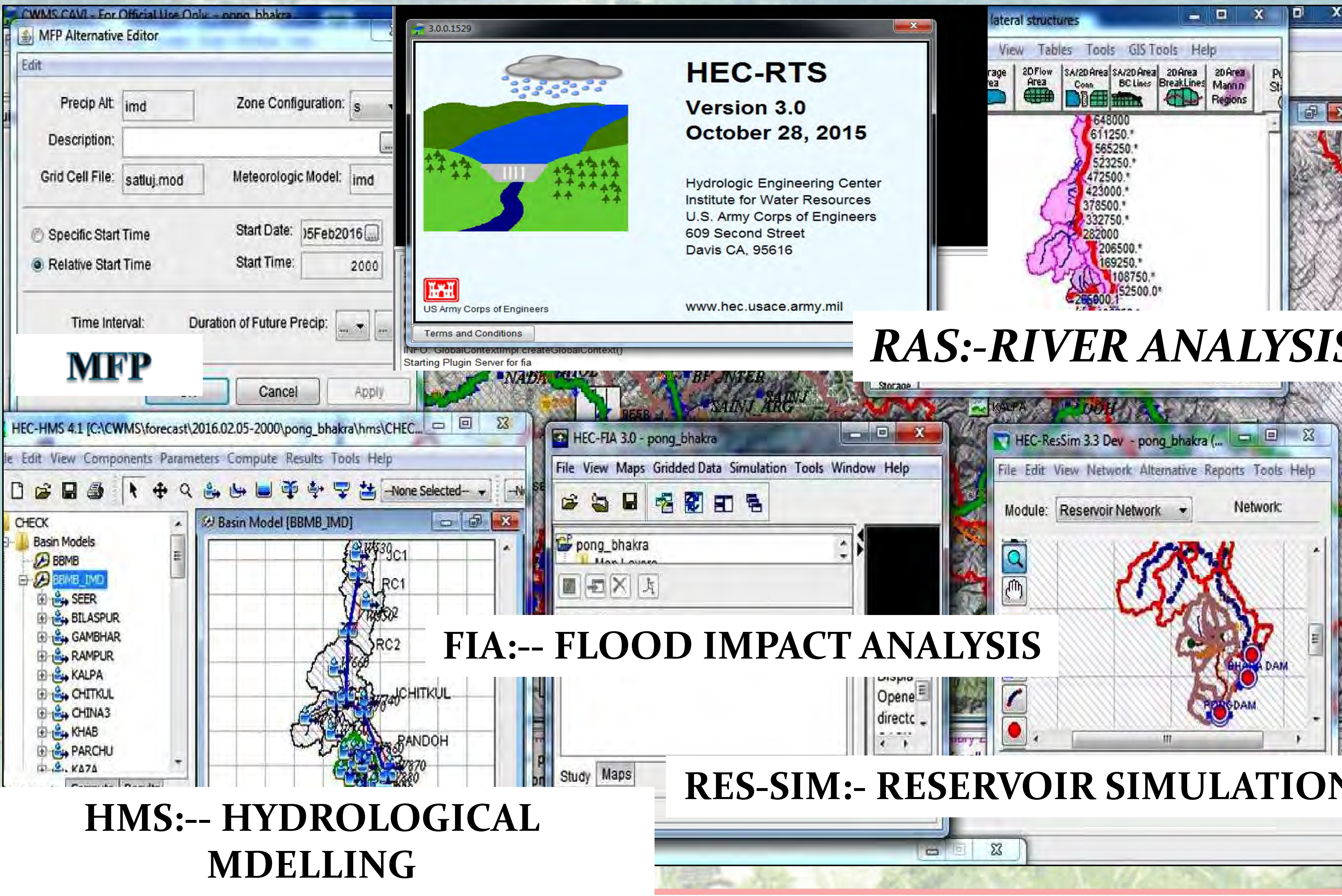
3.RESERVOIR SIMULATION

4.WATER DISTRIBUTION

5.DOWSTEAM FLOODING

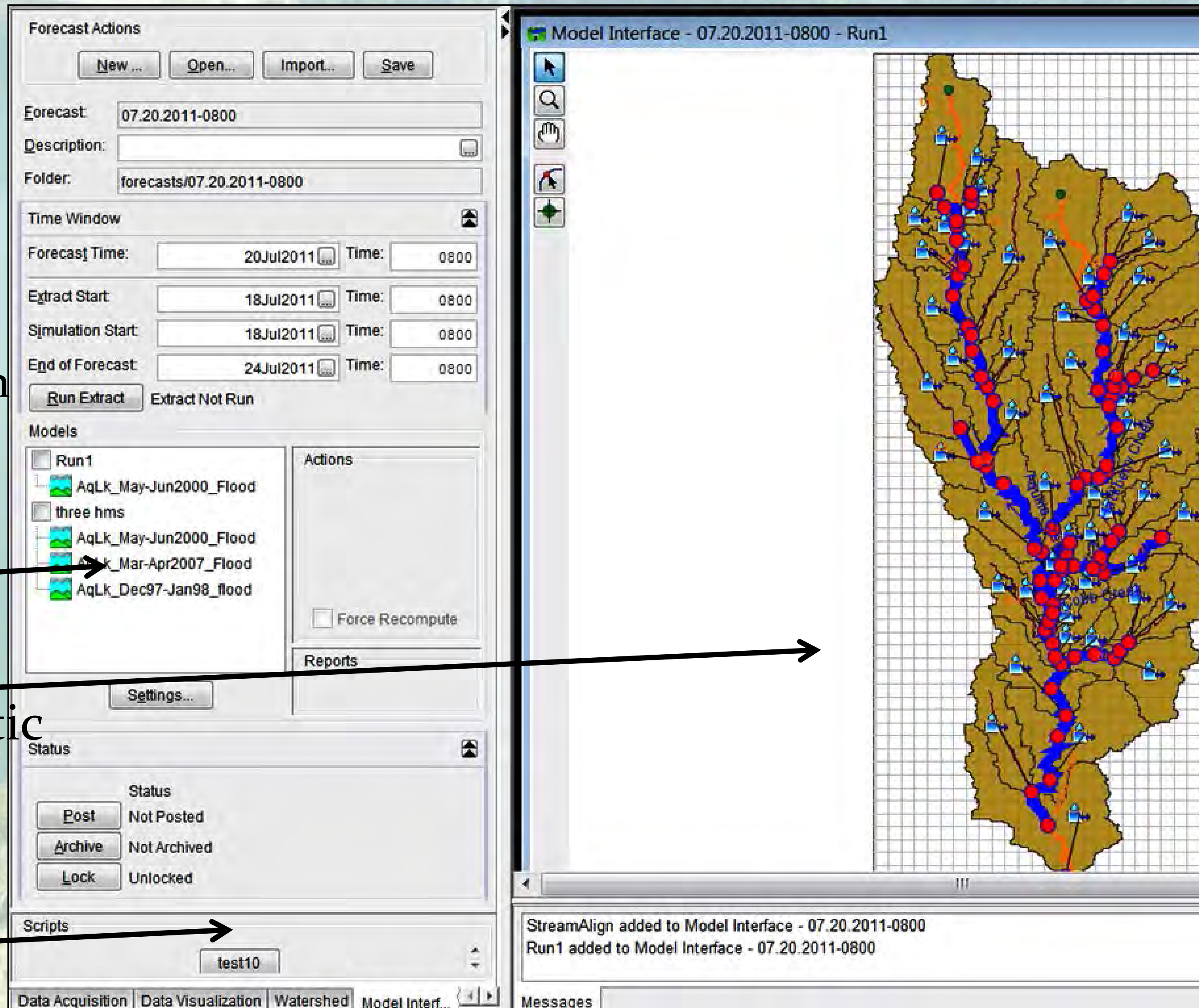
6.DISSIMINATION OF INFORMATION

HEC-RTS 3.0 IS A PUBLIC VERSION OF CWMS-CAVI WHICH CAN BE RUN FROM PC WITH DIFFERENT MODELING COMPONENTS LIKE MET-VUE,MFP, HMS, RAS, RES-SIM & FIA WITH HEC–GRID-UTILITY &HEC-DSS ON A SINGLE PLATFORM

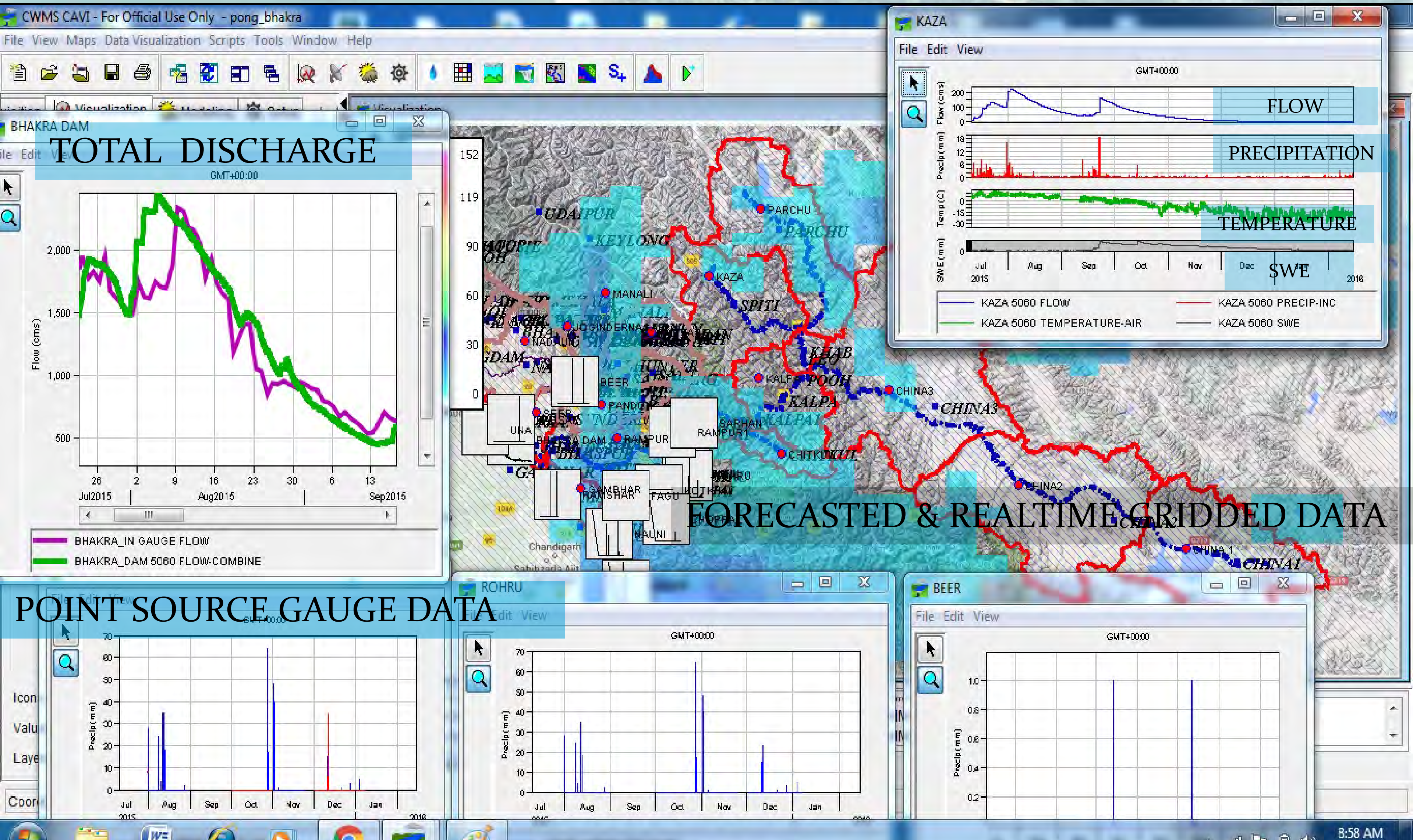


HEC-RTS Version 3

- Dockable Top Component Panels
  - Watershed Set-up
  - Data Acquisition
  - Data Visualization
  - Model Interface
- Tasks and Actions Panel
- Integrated Schematic
- Options and Supporting Information Panels



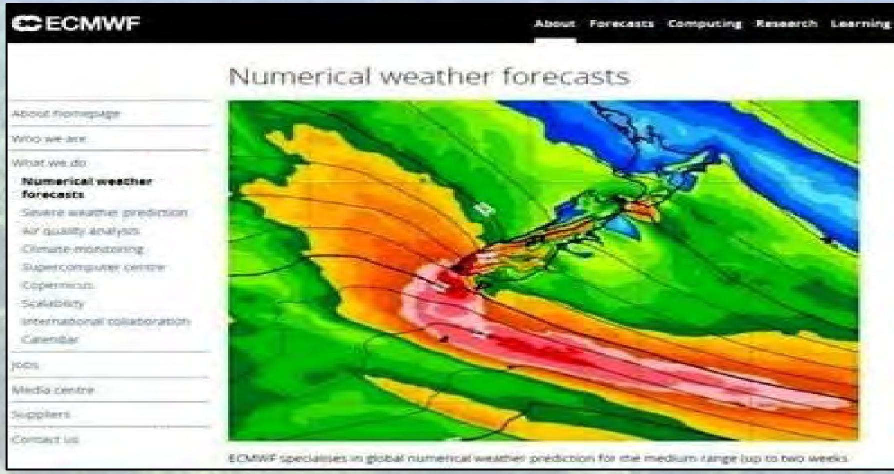
THE GUI OF HEC-RTS SHOWING PRESENT & FORECASTED CLIMATIC CONDITIONS OBS/SIMULATED RUNOFF ,CONTRIBUTION OF SUB-BASINS & POINT DATA FROM IMD & BBMB GAUGES CAN BE VISUALIZE DURING MODELING AND FORECASTING

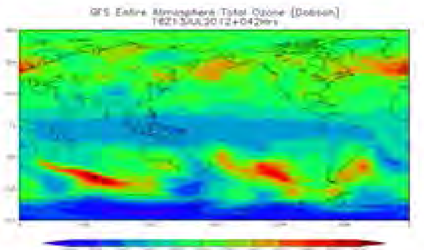


DATA ACQUSITION AND VISUALIZATION

15 DAYS QUANTITATIVE & ENSEMBLE PRECIPITATION AND INSTANTANEOUS-TEMPERATURE FORECAST WITH 0.25 DEGREE RESOLUTION CAN BE DOWNLOADED FROM NCAR – FTP SERVER AFTER EVERY 24 HOURS

ecmwf.wmv





Global Forecast System (GFS)

The Global Forecast System (GFS) is a weather forecast model produced by the National Centers for Environmental Prediction (NCEP). Dozens of atmospheric and land-soil variables are available through this dataset, from temperatures, winds, and precipitation to soil moisture and atmospheric ozone concentration. The entire globe is covered by the GFS at a base horizontal resolution of 18 miles (28 kilometers) between grid points, which is used by the operational forecasters who predict weather out to 16 days in the future. Horizontal resolution drops to 44 miles (70 kilometers) between grid point for forecasts between one week and two weeks. The GFS model is a coupled model, composed of four separate models (an atmosphere model, an ocean model, a land/soil model,

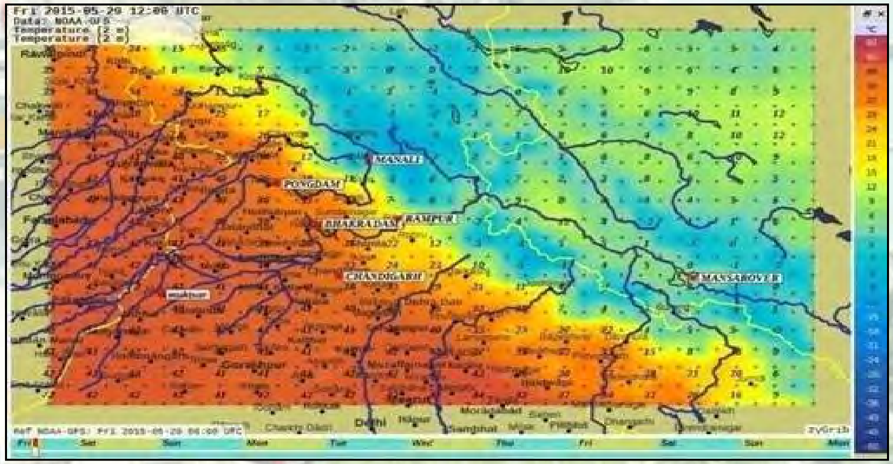
An animated image of GFS simulated total atmospheric ozone concentration, forecast from 00UTC on July 12, 2012 to July 16, 2012 at 00UTC—a four day forecast—in three hourly intervals. The lowest concentrations of ozone on the planet reside over the Antarctic during this period. This image was produced with the Grid Analysis and Display System (GrADS) and ImageMagick.

THE QUANTITATIVE PRECIPITATION FORECAST FOR 10 DAYS in GRIB FILE FORMAT REVISED AFTER EVERY 6 HOURS CAN BE DOWNLOADED FROM NOAA FOR GFS MODEL

gfs_prec.wmv

THE QUANTITATIVE 10 DAYS TEMPERATURE

gfs_temp.wmv



SHORT FORECAST AND REAL TIME DATA TRACKING

THE SHORT TERM PRECIPITATION AND TEMPERATURE FORECAST FOR NEXT 72 HOURS WITH 9KM X 9KM GRID CAN BE DOWNLOADED FROM IMD SERVER

rimes temp forcast.mp4

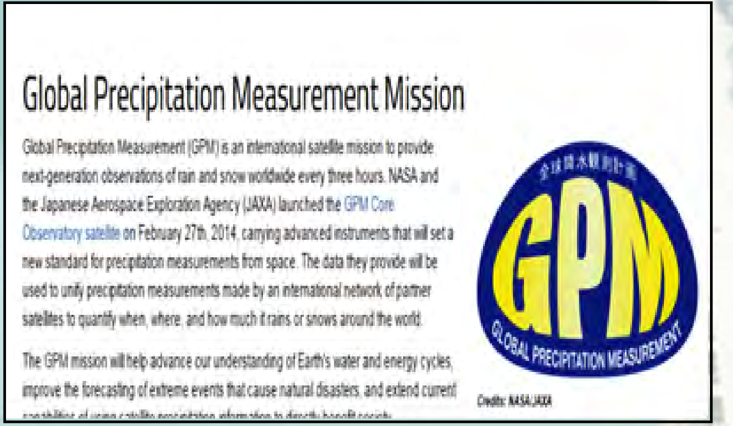
THE NEAR REALTIME TRMM(PRECIPITATION) DATA WITH 0.25 DEGREE FOR EVERY 3HOUR IS DOWNLOADED AND CONVERTED INTO HEC DSS GRID FILES

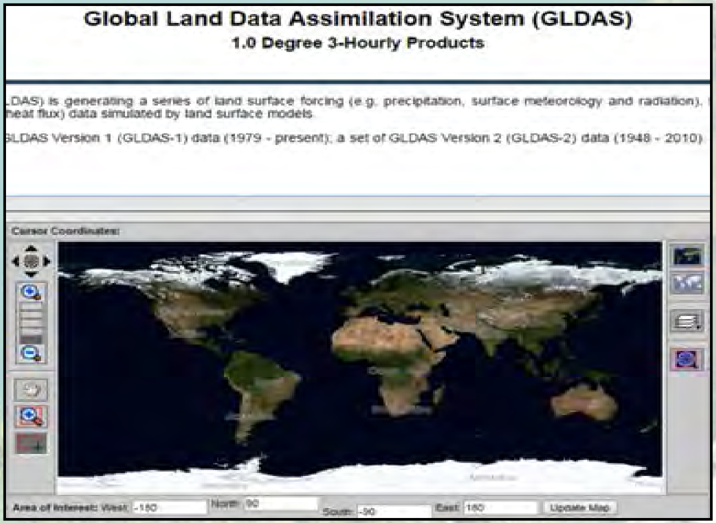
trmm.wmv

THE HOURLY REALTIME PRECIPITATION AND TEMPERATURE DATA FROM IMD AND BBMB SITES CAN BE DOWN LOADED AND CONVERTED INTOHEC DSS TIME SERIES AND CAN BE TRACKED

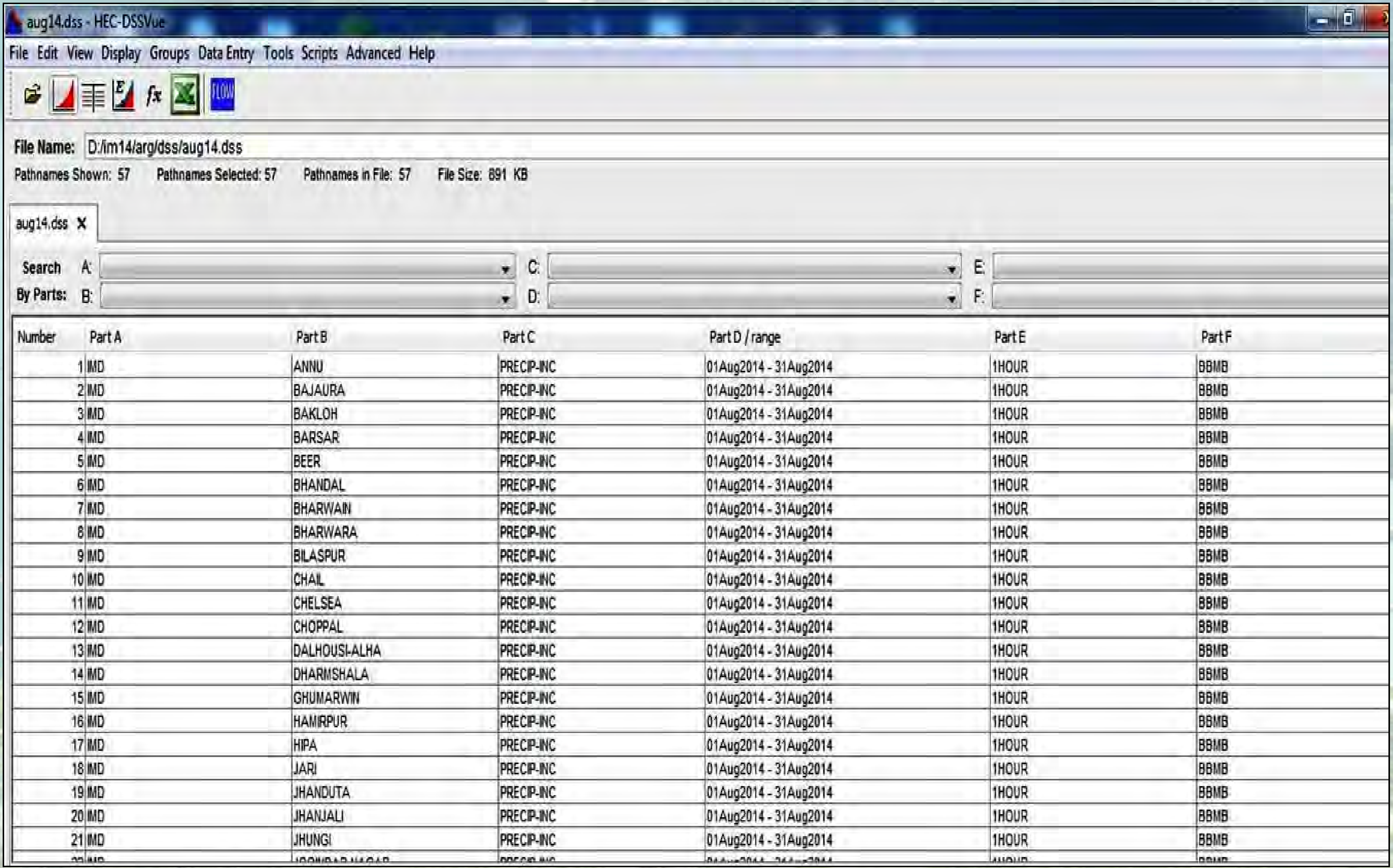
imd_prec.avi

GPM FOR NEAR REAL-TIME PRECIPITATION DATA WITH 0.1 DEGREE RESOLUTION & HALF AN HOUR INTERVAL REVERB ECHO NASA FOR 500 M MODIS SNOW COVER IMAGERIES AND OTHER SATELLITE PRODUCTS GLDAS FOR 0.125 DEGREE 3 HOUR TEMPERATURE & REMOTE SENSED SWE GRID AND OTHER HYDRO-MET DATA BBMB OBSERVED INFLOW OUTFLOW AND RESERVOIR LEVEL DATA ARE THE OTHER SOURCES USED FOR MODELING



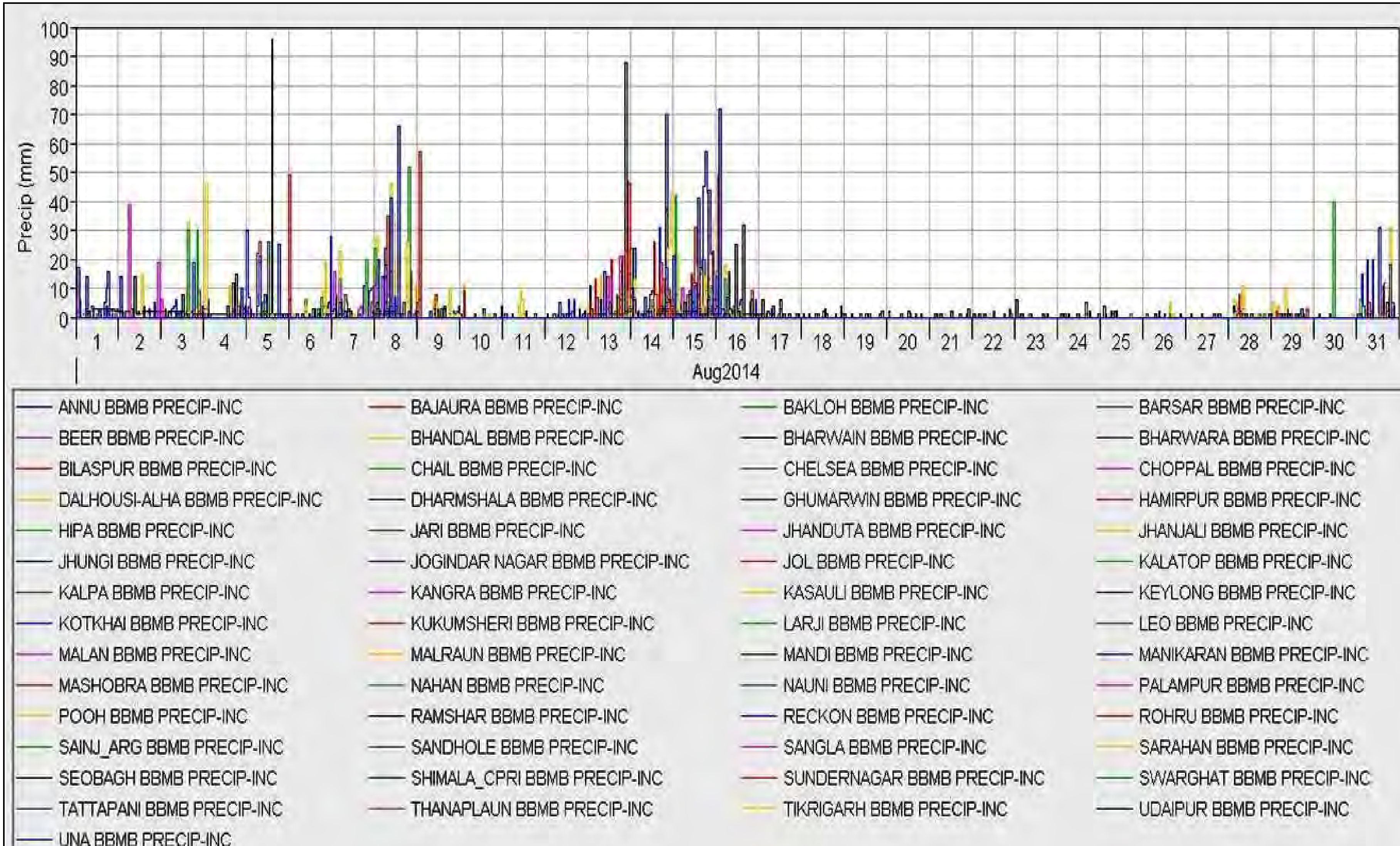


THE VIEW OF HEC-DSS DATA BASE WHERE ALL THE REAL TIME AND HISTORICAL DATA TIME SERIES ARE STORED



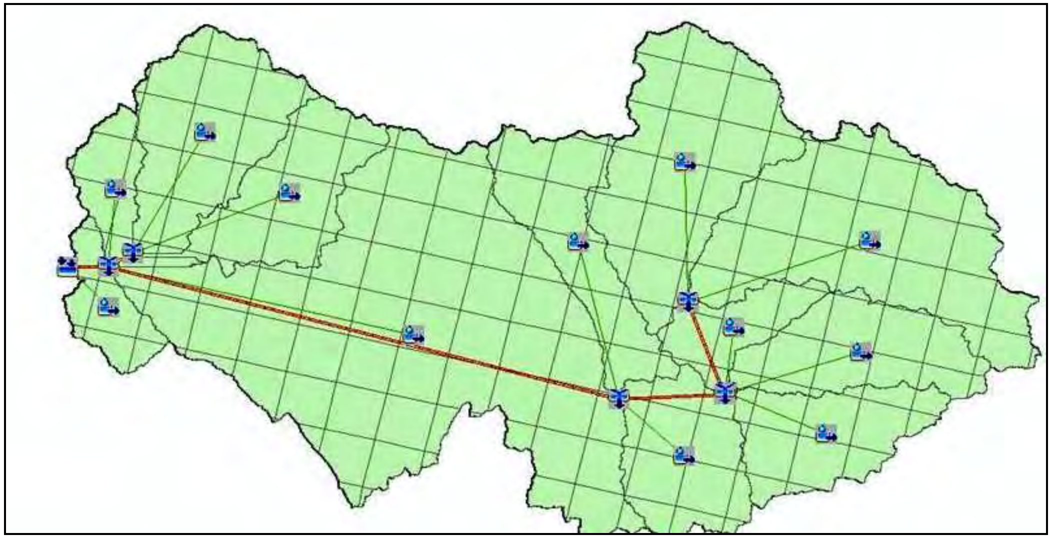
Number	Part A	Part B	Part C	Part D / range	Part E	Part F
1	IMD	ANNU	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
2	IMD	BAJAURA	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
3	IMD	BAKLOH	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
4	IMD	BARSAR	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
5	IMD	BEER	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
6	IMD	BHANDAL	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
7	IMD	BHARWAIN	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
8	IMD	BHARWARA	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
9	IMD	BILASPUR	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
10	IMD	CHAIL	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
11	IMD	CHELSEA	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
12	IMD	CHOPPAL	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
13	IMD	DALHOUSI-ALHA	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
14	IMD	DHARMSHALA	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
15	IMD	GHUMARWIN	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
16	IMD	HAMIRPUR	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
17	IMD	HIPA	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
18	IMD	JARI	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
19	IMD	JHANDUTA	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
20	IMD	JHANJALI	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB
21	IMD	JHUNGI	PRECIP-INC	01Aug2014 - 31Aug2014	1HOUR	BBMB

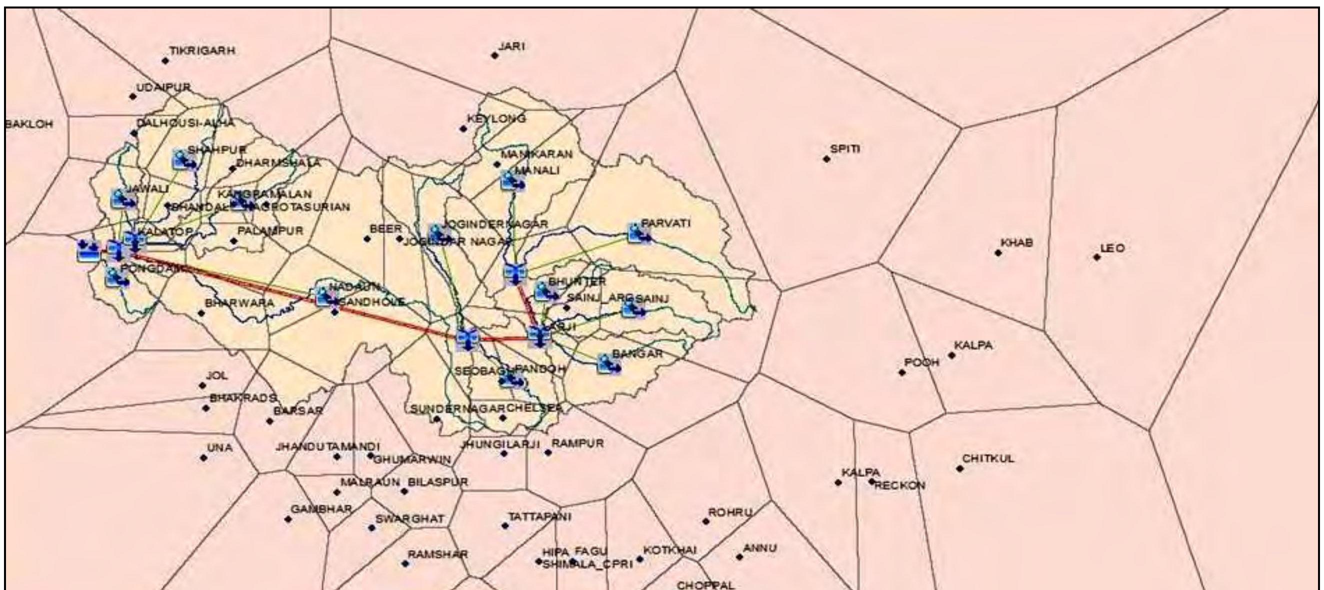
PLOTTING OF IMD GAUGES (ARG &AWS) HOURLY TIME SERIES DATA IN HEC-DSS AFTER APPLYING QUALITY CHECKS

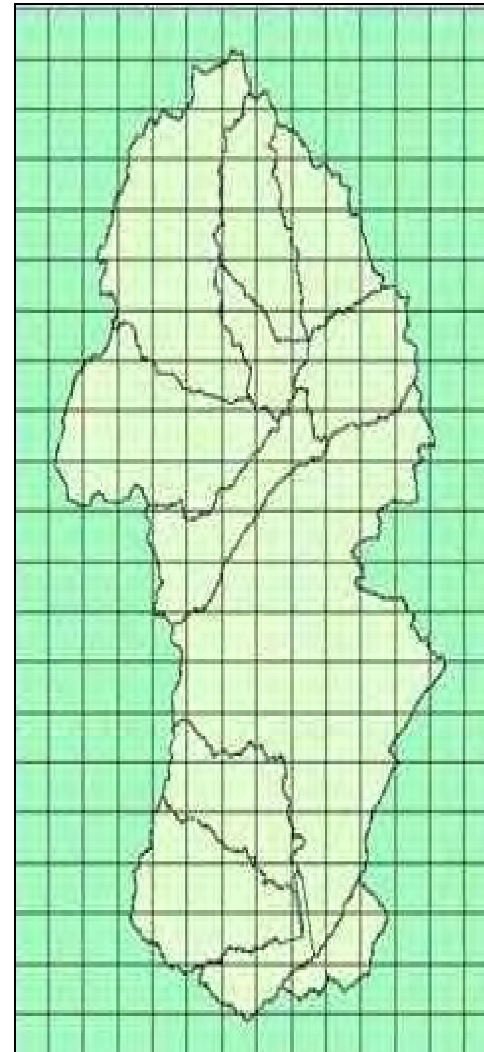


HEC-GEO HMS INTERFACE FOR CATCHMENT GRID DELINEATION SHOWING CATCHMENT AREAS OF RIVER SATLUJ AND BEAS

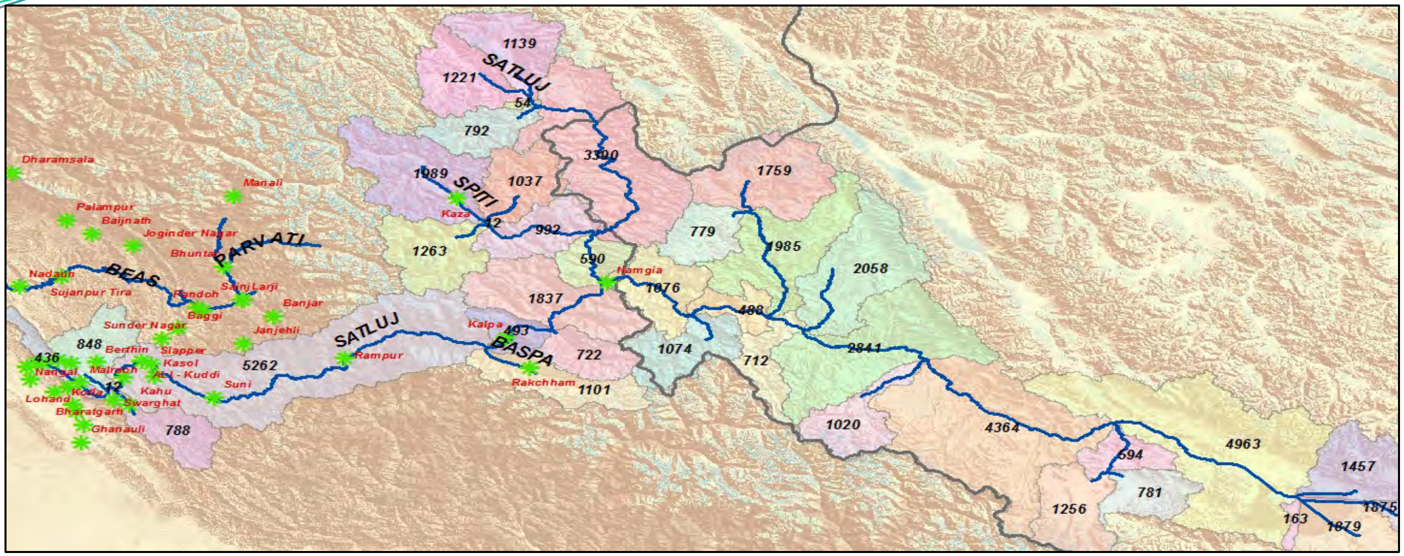
THE CATCHMENT AREA NETWORK FOR ANALYZING THE CATCHMENT RUNOFF BY MOD CLARK INITIAL AND CONSTANT LOSS METHOD &GAUGE WEIGHTS (THIESSEN POLYGON METHOD)

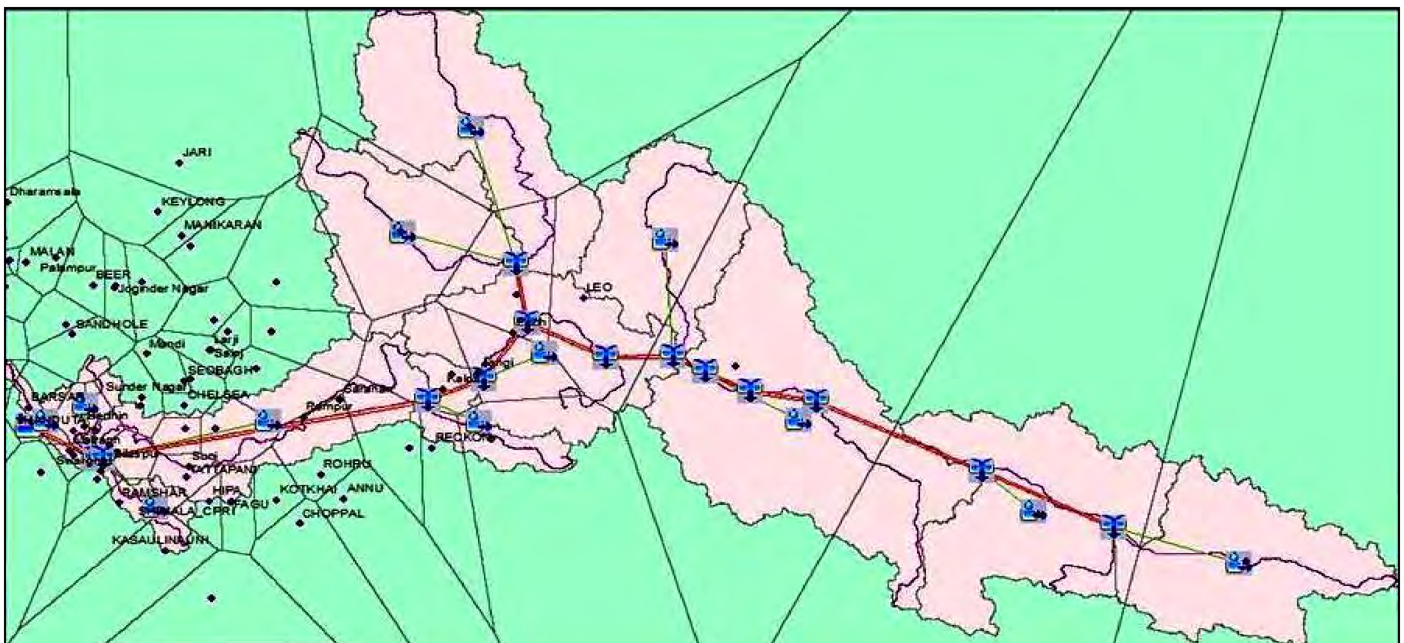


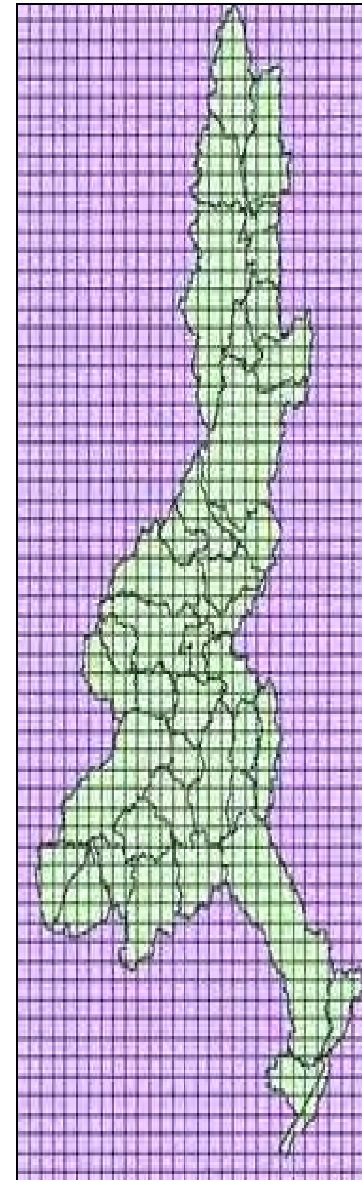




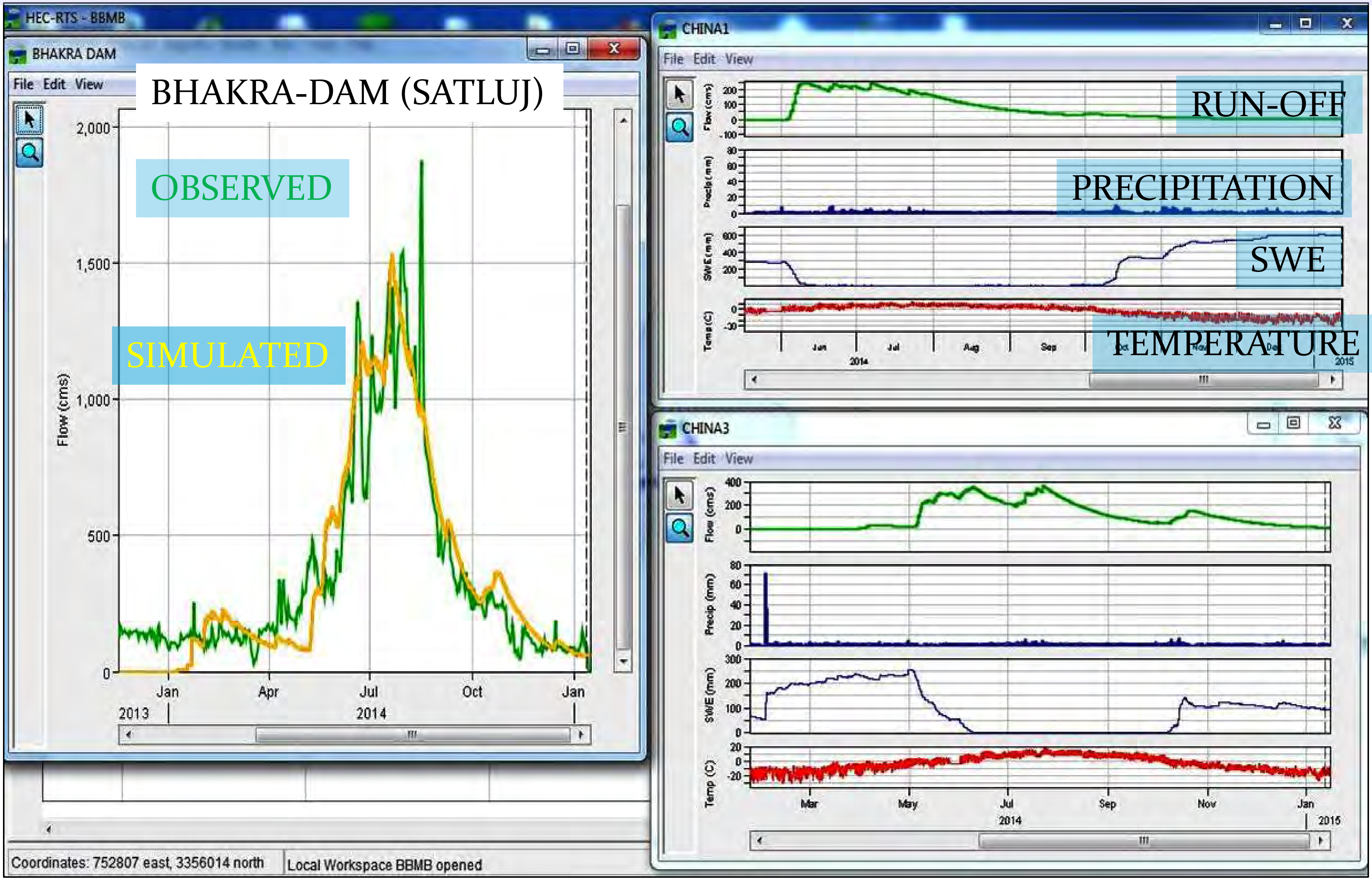
THE VIEW OF SATLUJ CATCHMENT WITH SUB-CATCHMENTS



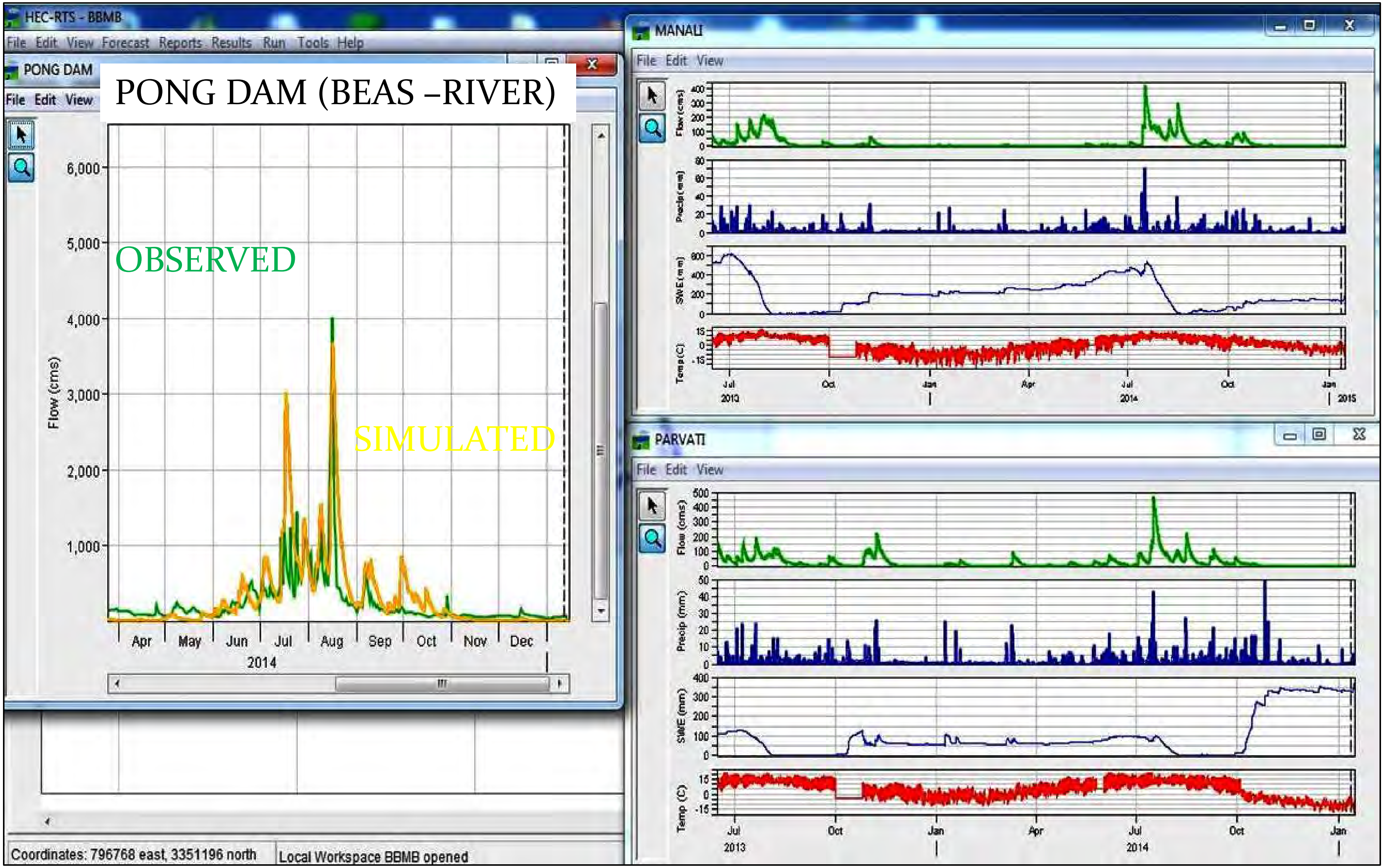




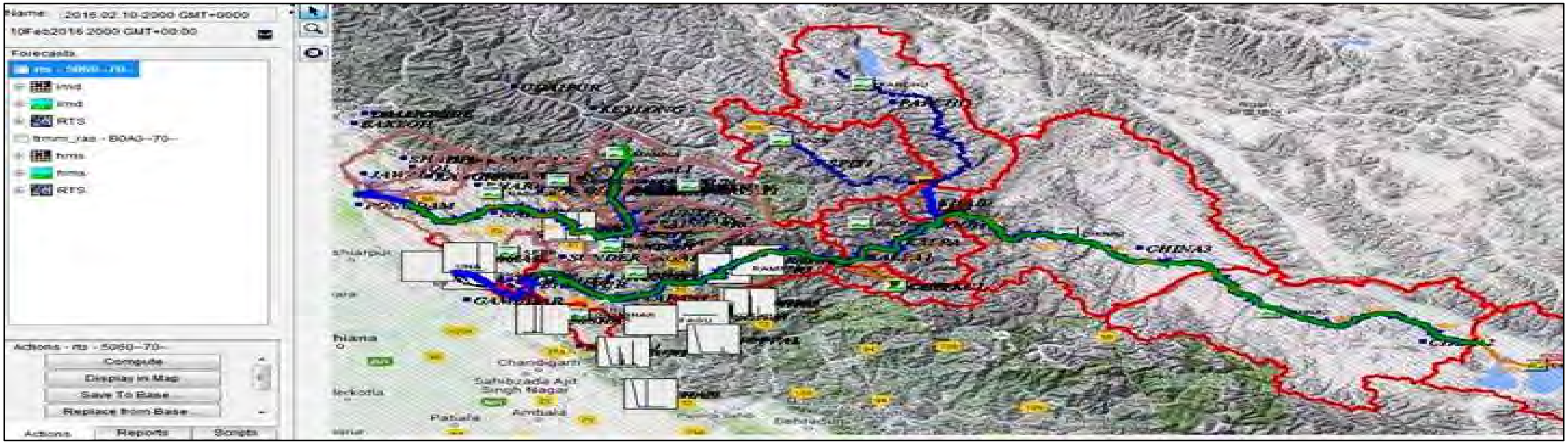
FORECASTED AND REAL-TIME PRECIPITATION AND TEMPERATURE GRIDS TIME-SERIES IS PROVIDED AS INPUT TO THE HMS MODEL & MODEL IS CALIBRATED FOR OBSERVED RUN-OFF & SWE DATA AT RESERVOIRS ,COMPUTATION POINTS AND SUB-BASINS

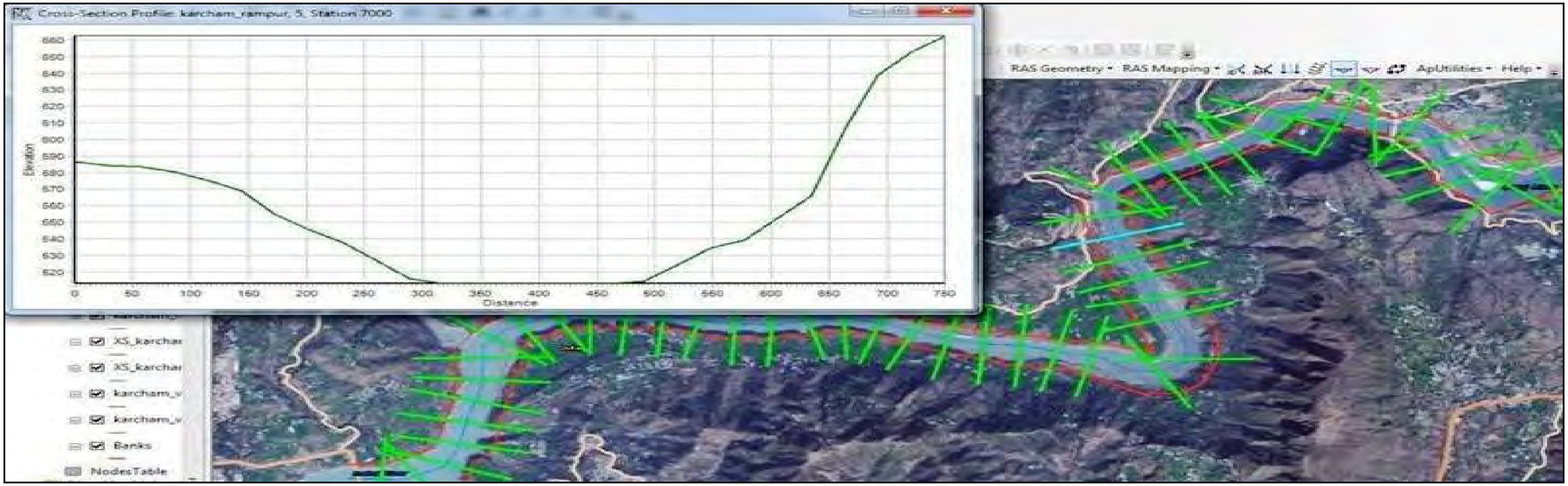


THE VIEW OF SUB-BASINS CONTRIBUTIONS AND COMPARISON OF OBSERVED V/S SIMULATED RUNOFF FOR THE PONG RESERVOIR AT RIVER BEAS

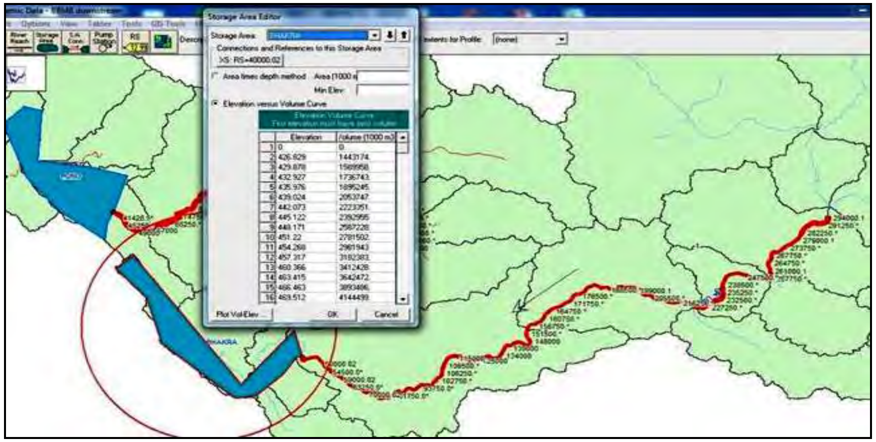


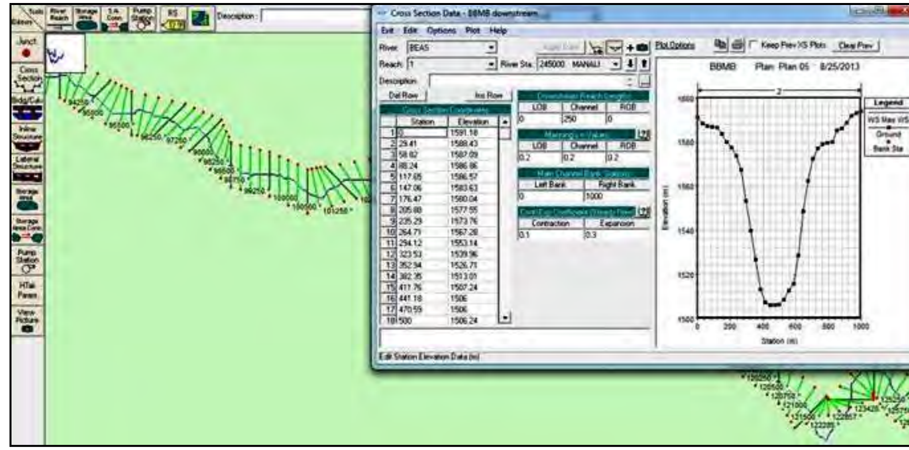
THE VIEW OF PONG AND BHAKRA RESERVOIR SHOWING RIVER CROSS SECTION IN HEC-GEORAS





HEC-RAS MODEL DEVELOPED FOR PONG AND BHAKRA RESERVOIR (RIVER CHAINAGE IS ALSO SHOWN FOR BEAS AND SATLUJ DOWNSTREAM TO UPSTREAM)

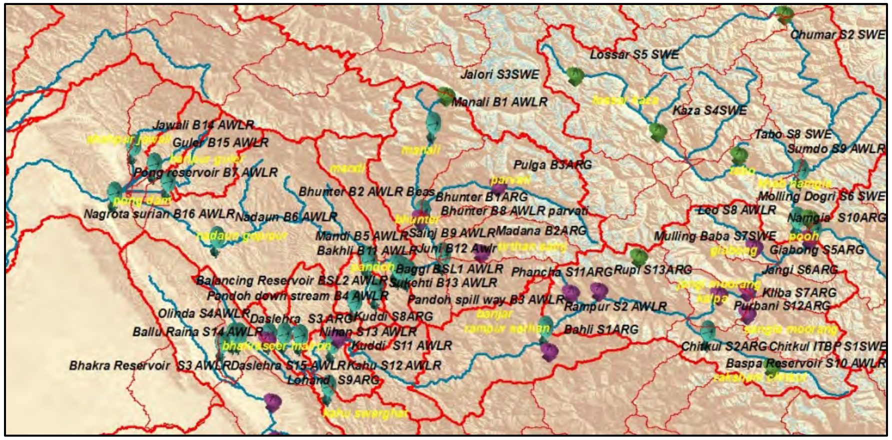


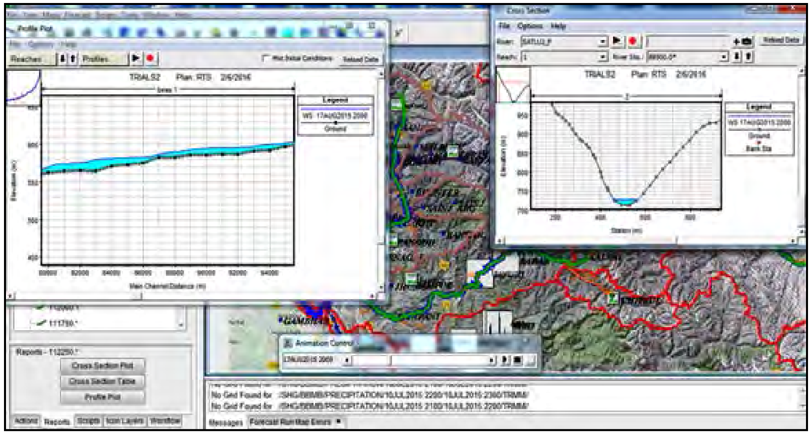


HYDRODYNAMIC MODELLING RESULTS AND ANIMATIONS

THE FULL NETWORK OF BBMB (SATLUJ AND BEAS BASIN) CAN BE TRACKED REAL TIME WITH THE VARIOUS SENSORS PLACED IN THE BASIN AND MODEL OUTPUTS

Tracking_animation1.avi



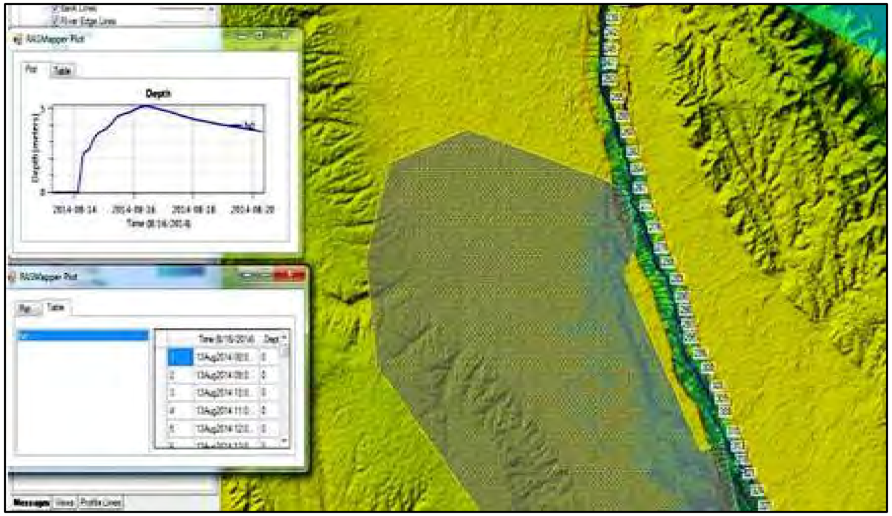


1 D HYDRODYNAMIC MODEL PROFILES RIVER L-SECTION AND X-SECTIONS

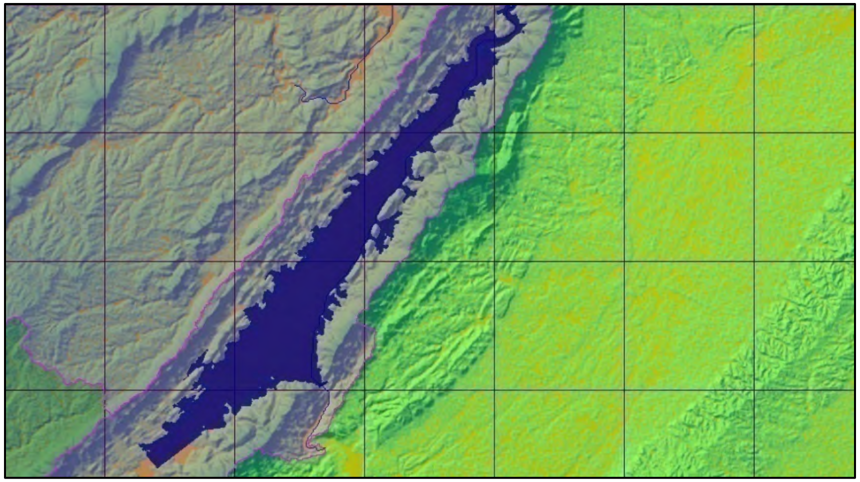
longi_profile.avi

2-D FLOOD MODELS FOR THE FLOOD PRONE AREAS D/S OF RESERVOIRS

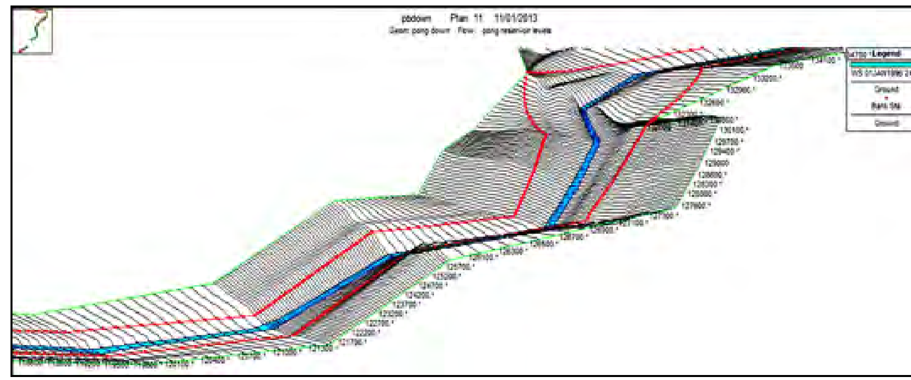
2016-02-15 at 20-46-46.mp4



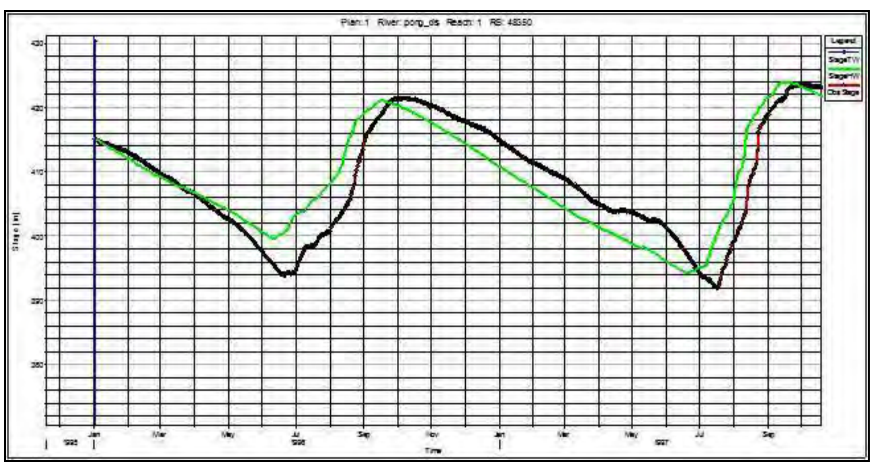
RAS MAPPER AND RIVER PROFILES



THE RIVER PROFILE WITH TERRAIN CAN BE SEEN RAS MAPPER
profile 1d.mp4

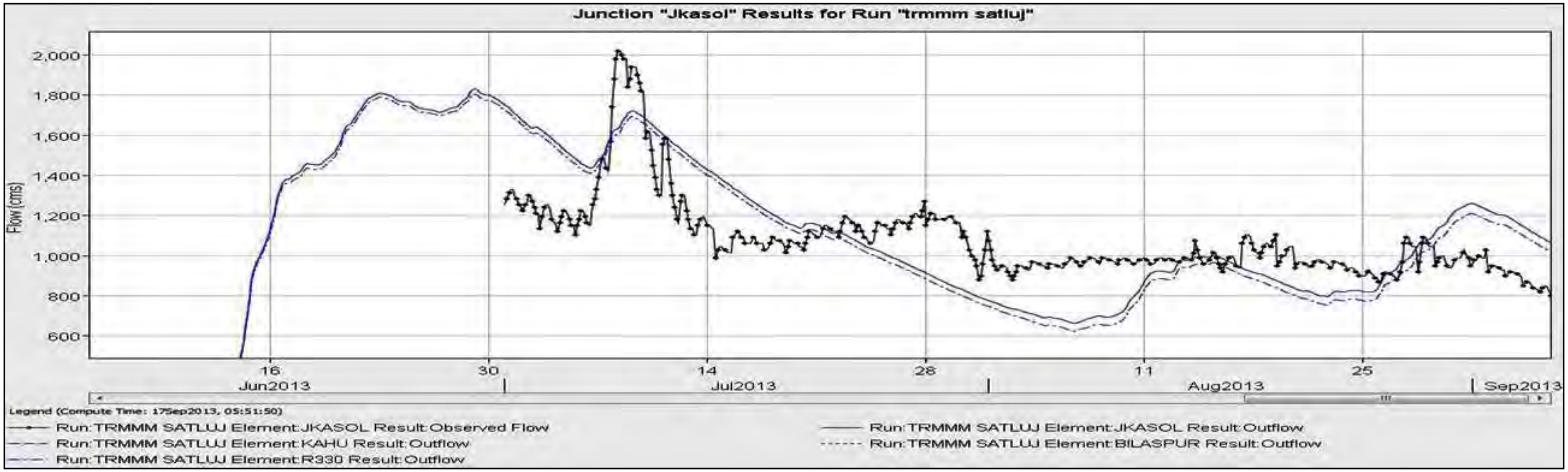


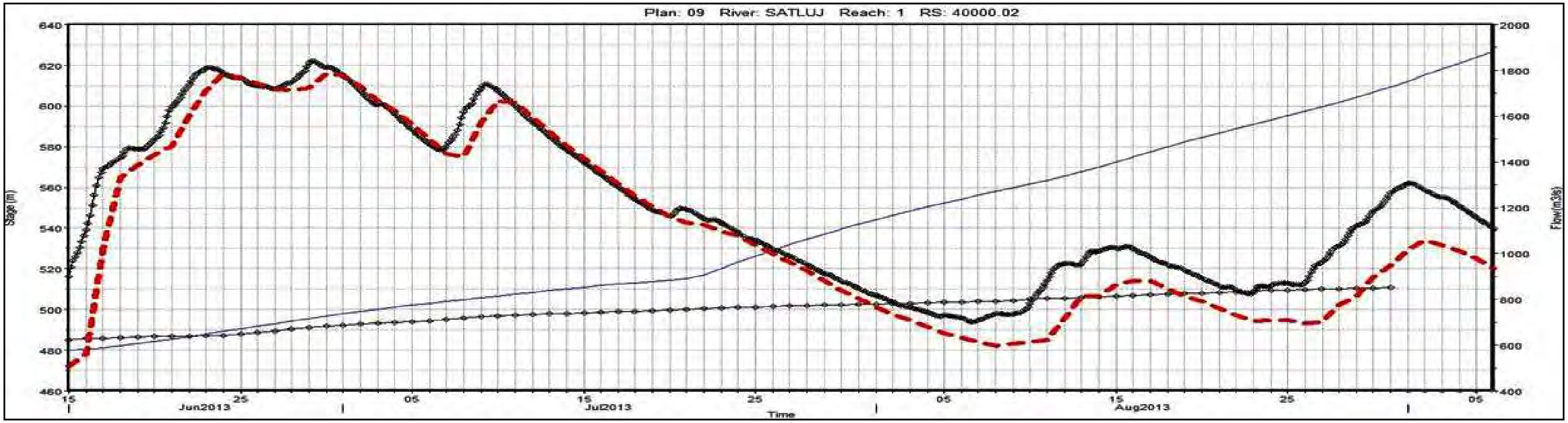
RIVER PROFILE ANIMATION
.river animation.avi



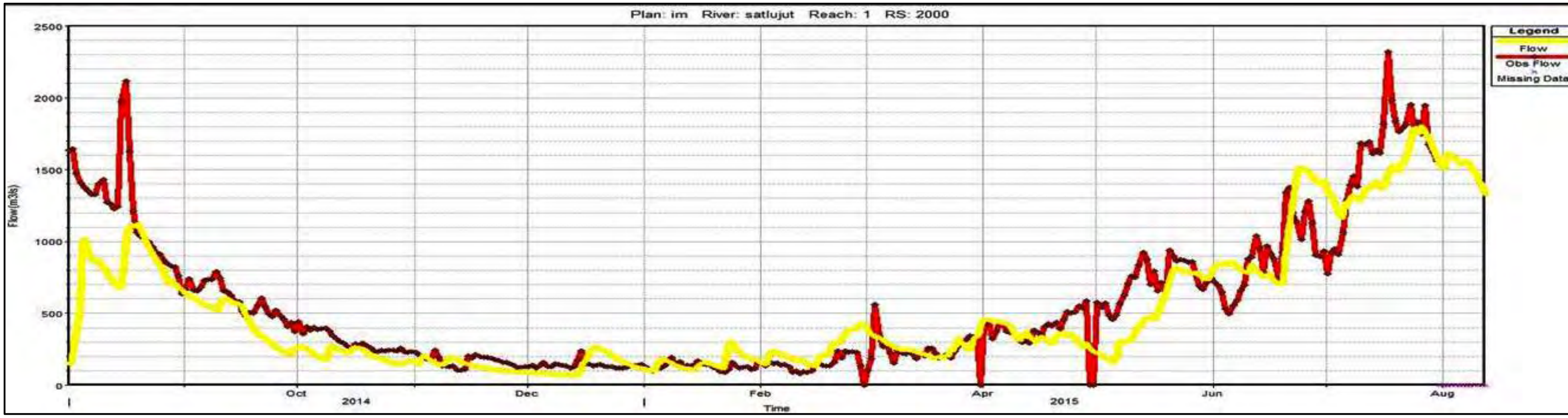
RESERVOIR LEVELS FOR THE FORECASTED INFLOWS AND OUT FLOWS CAN BE SIMULATED IN THE HYDRO DYNAMIC MODEL
Ras pong dam.avi

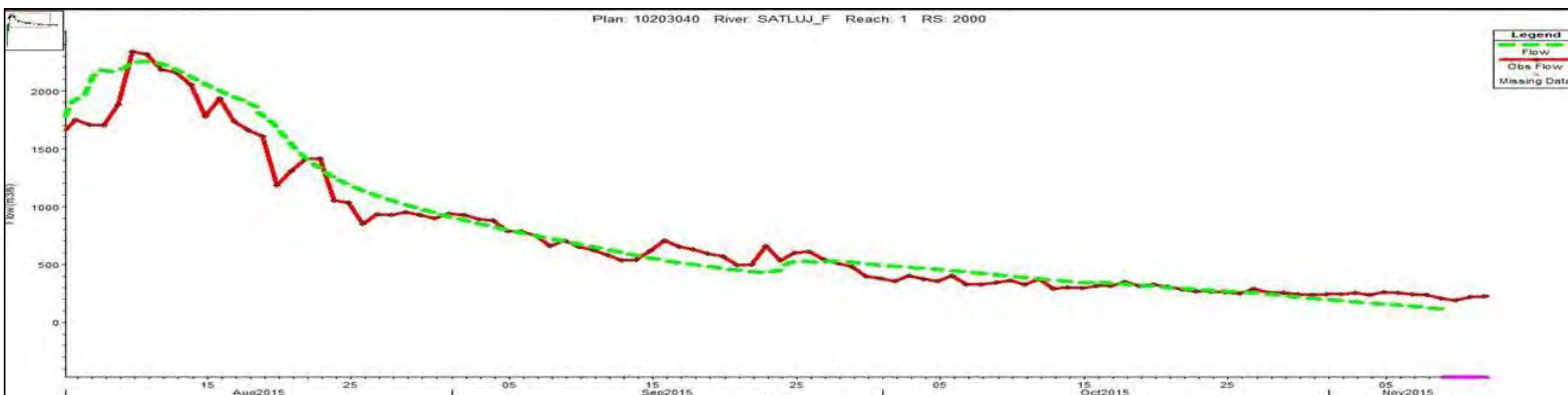
THE INITIAL RESULTS OF HEC-HMS MODEL WITH REAL TIME DATA IN MONSOON 2013 FOR BHAKRA RESERVOIR INFLOW



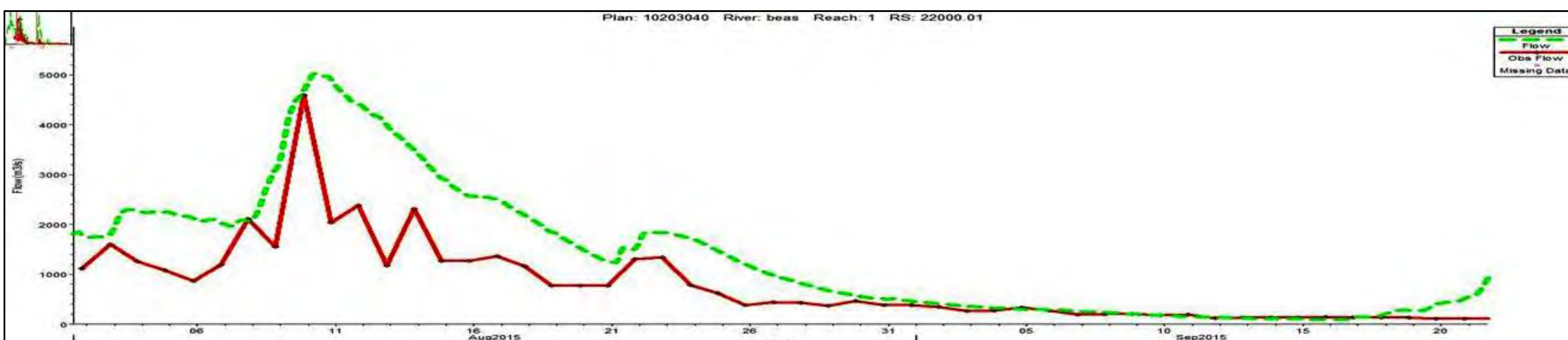


OBSERVED V/S SIMULATED PLOTS FOR BHAKRA DAM DURING SNOW MELT RUNOFF MONSOON 2015 FOR BHAKRA DAM ON RIVER SATLUJ

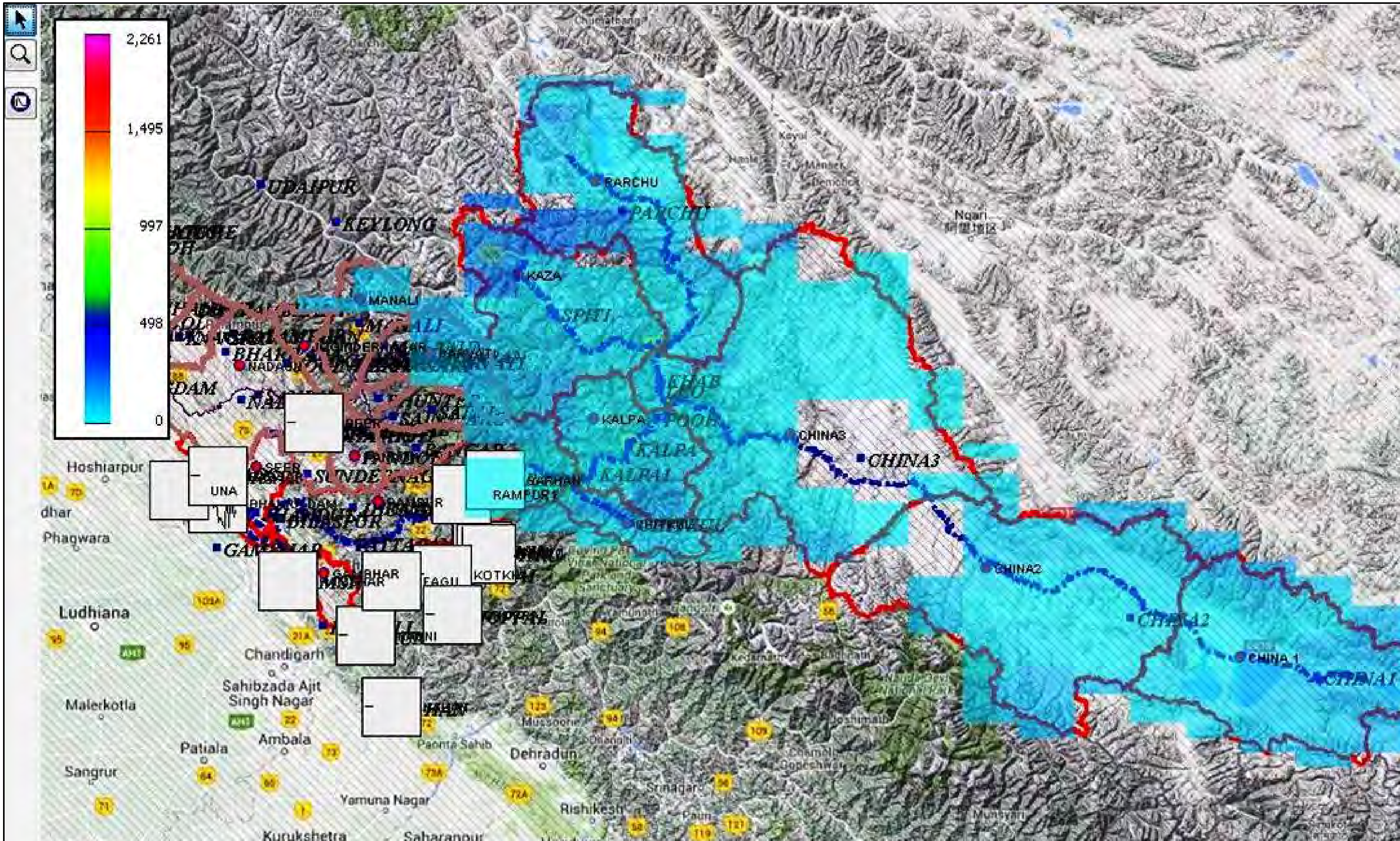




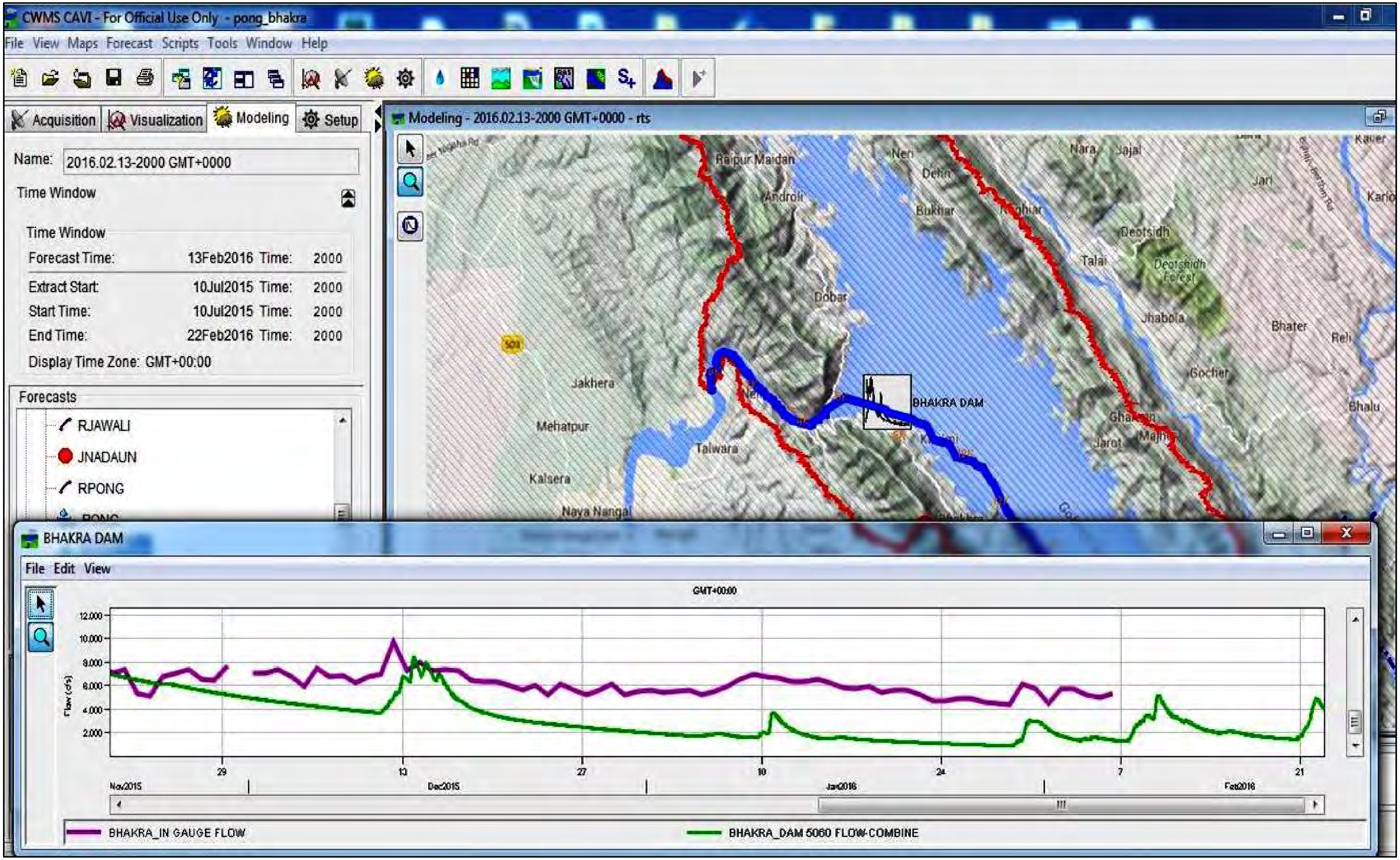
RESULTS OF PONG DAM AT BEAS DURING MONSOON 2016 & CLOUD BURST PHENOMENA 08-09 AUG 2015
(THE INCIDENT WAS NOT FORCASTED BY ANY AGENCY)



CURRENT SWE PRESENT IN SATLUJ AND BEAS CATCHMENT AS PER MODEL



CURRENT MODEL PERFORMANCE FEB 16

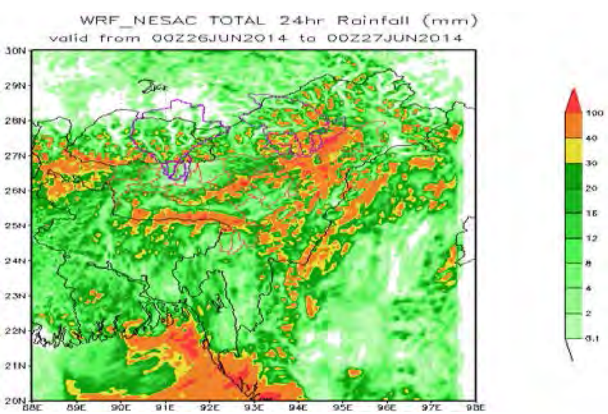


THANK YOU

ER. ANIL VYAS
A.D.E, HP-II
BBMB, CHANDIGARH

GIS BASED HYDRO-METEOROLOGICAL STREAM FLOW FORECASTING FOR FLOOD EARLY WARNING IN OPERATIONAL SCALE

(WORLD BANK CONSULTATIVE WORKSHOP AT FMIS, PATNA)

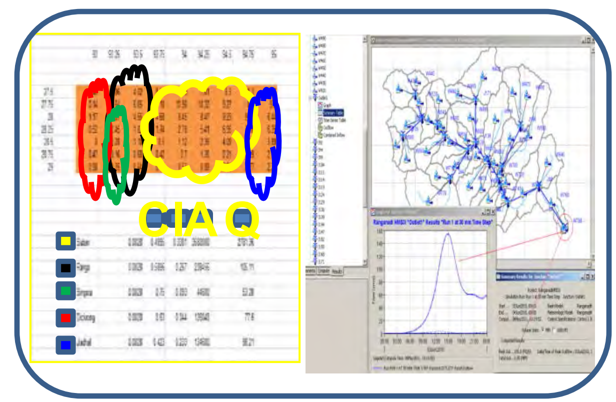


By

Dr. Diganta Barman

Scientist/Engineer "SE"

(Project Manager, NER-DRR)



North Eastern Space Applications Centre (NESAC), ISRO

Govt. of India, Department of Space

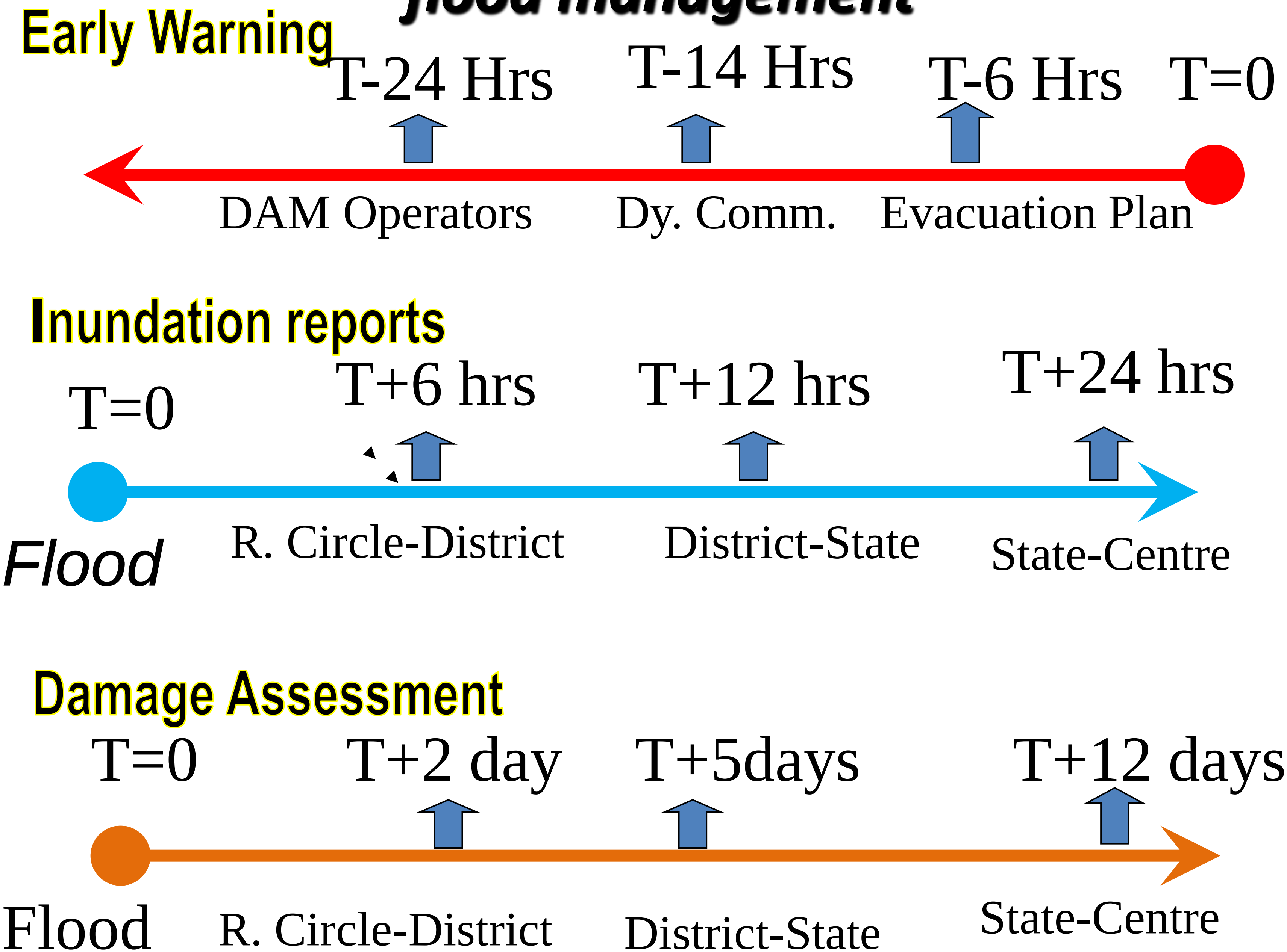
Umiam (Shillong), Meghalaya – 793103

Date: 18-02-2016

Overall flood Management

- Weather watch using satellite data
- Rainfall data collection & analysis
- Run-off estimation
- Flood level/stage assessment
- Early warning
- Risk assessment
- Damage assessment
- Relief & Rehabilitation

Time Dimension of Information Needs in flood management



BACKGROUND

- The state of Assam is fully covered by the Brahmaputra and Barak basins. They are both very erosion and flood prone rivers.
- Along with their various tributaries, these rivers cause havoc in the state of Assam.
- Severe flood event affected Lakhimpur district of Assam during June, 2008 causing enormous damage.
- NESAC was formally requested by Govt. of Assam and the North Eastern Council (NEC) to develop an operational flood warning system at district level in Assam.
- The project FLEWS was initiated for Lakhimpur district as pilot during 2009-10.
- Today, the project covers all flood prone districts of Assam with actionable flood alerts in revenue circle level with lead time ranging from 12-36 hours

MODERN APPROACHES OF FLOOD EARLY WARNING SYSTEMS

APPROACH 1:

- **Automatic Stage gauges at various locations in flood prone rivers**
  - Advantages:
    - Accurate and possible for continuous monitoring of river stages
  - Drawbacks :
    - Very costly, manpower needs and continuous systems maintenance.
    - Not possible to predict spatial extent of the flood event.
    - Installation and maintenance problems in complex terrains

APPROACH 2:

- **Numerical Hydro-Met prediction system (Currently followed under FLEWS)**
  - Combination of Numerical Weather prediction, Distributed Hydrological and Hydraulic Modelling, Synoptic weather monitoring and In-situ gauge monitoring

Working Principles

FLOOD PREPAREDNESS (FORECASTING & EARLY WARNING):

METEOROLOGICAL COMPONENT

- **NUMERICAL WEATHER PREDICTION/FORECAST & WATCH**
  - Daily Weather forecast – WRF Numerical Prediction in NER domain
  - Real time satellite images and products – IMD , ISRO Kalpana-1, etc
  - Synoptic Weather Conditions Analysis & Advisory – IMD, AWS, etc

HYDROLOGICAL COMPONENT

- **HYDROLOGICAL MODELLING (Flood Discharge estimation & alert generation)**

  Distributed/Quasi-distributed /Lumped methods using forecasted WRF data

  Analysis of forecasted flood discharge with river water levels, threshold condition, etc

  Ground Reconciliation of current Flood level/stage with WRD-Assam, CWC, etc GD sites

DISSEMINATION of Flood Alerts (when threshold conditions are exceeded)

- SMS, E-Mails, Web dissemination etc

POST – FLOOD (Mitigation Component)

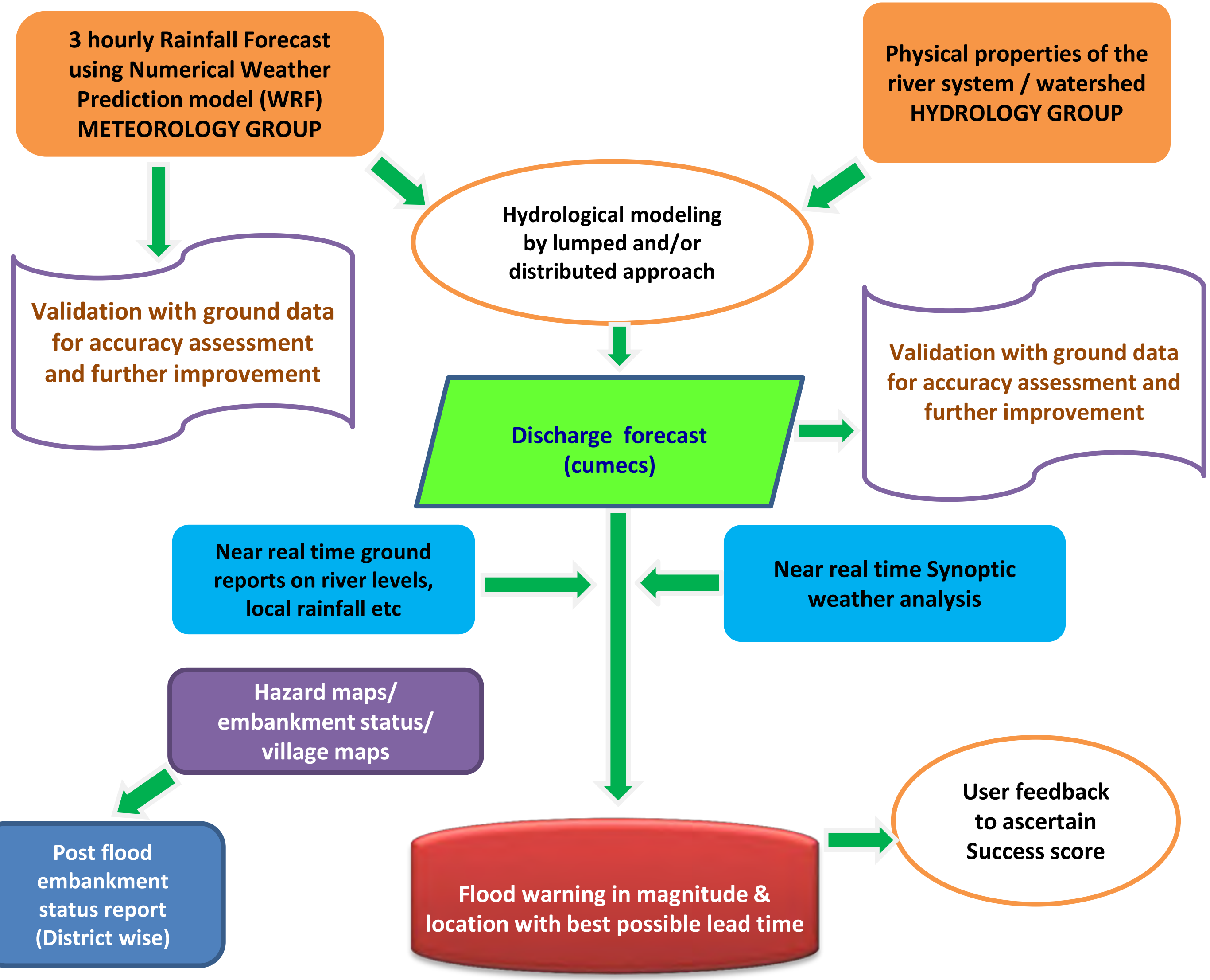
- River Embankment Breach Monitoring
- Flood Inundation Mapping (near Real-time)

OVERALL FLEWS WORKFLOW & MAJOR COMPONENTS

MAJOR COMPONENTS

- **Meteorology Component**
  - ✓ Weather Research Forecast (WRF)
  - ✓ Synoptic weather forecasting
- **Hydrology Component**
  - ✓ Distributed hydrological model
  - ✓ Hydraulic Modelling
- **Embankment breach watch**
  - ✓ Pre-flood protection structures monitoring
  - ✓ Post-flood embankment breaches

WORKFLOW CHART

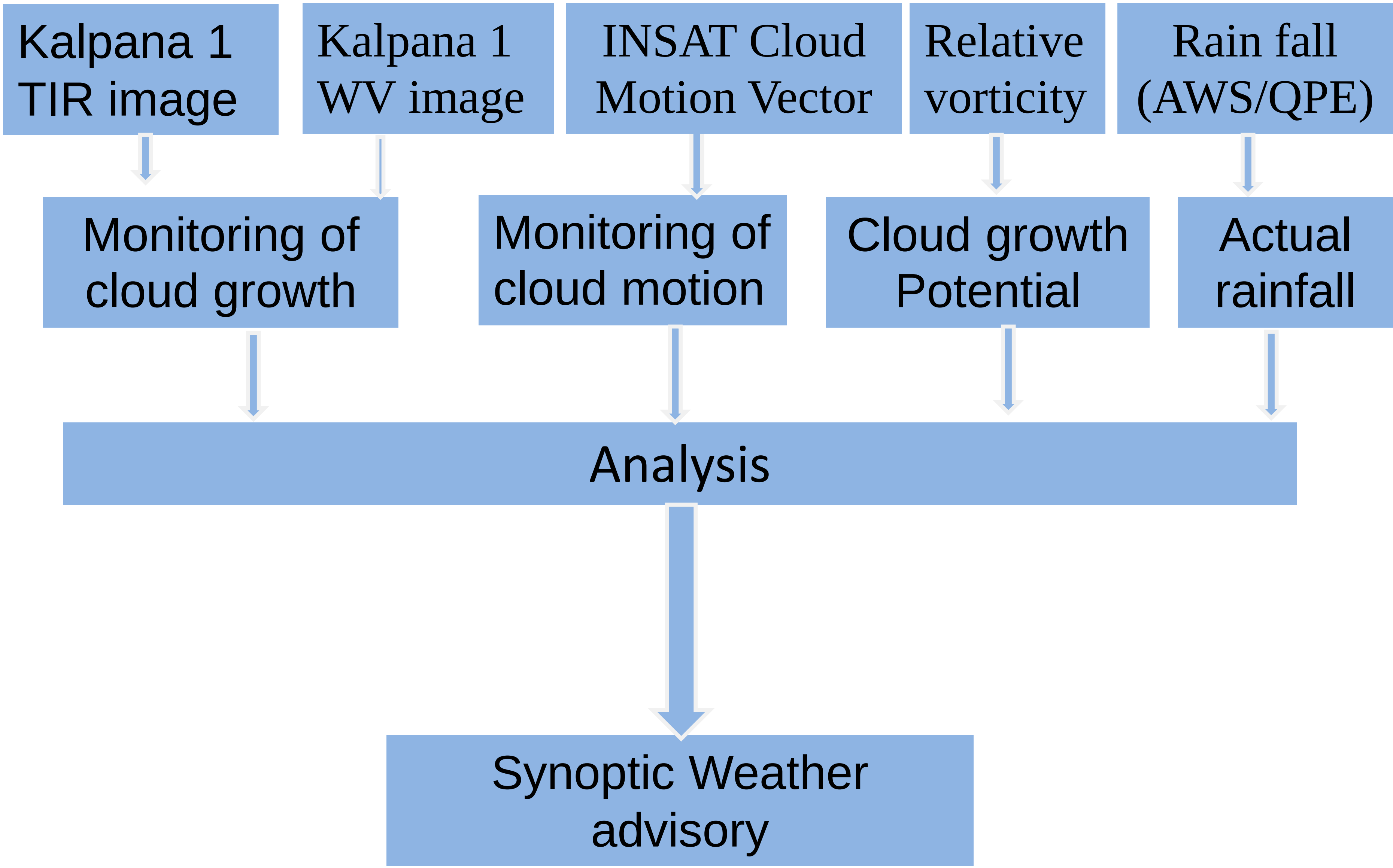


Synoptic Weather Watch

What is Synoptic Weather Watch?

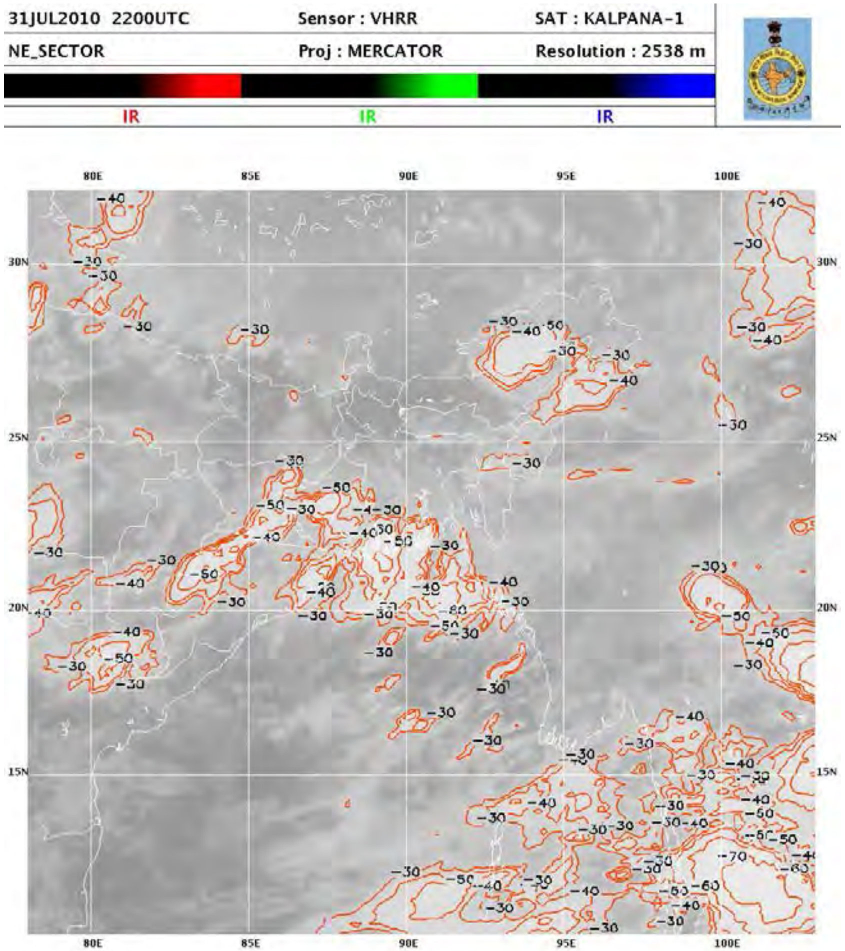
A meteorological observation made on the earth's surface in contrast with an upper air observation, at periodic interval of sky cover, state of the sky, cloud height, atmospheric pressure, temperature, precipitation, wind speed and direction etc. that prevails at the time of the observation or have been observed since the previous observation.

Synoptic Weather Advisory Flow Chart

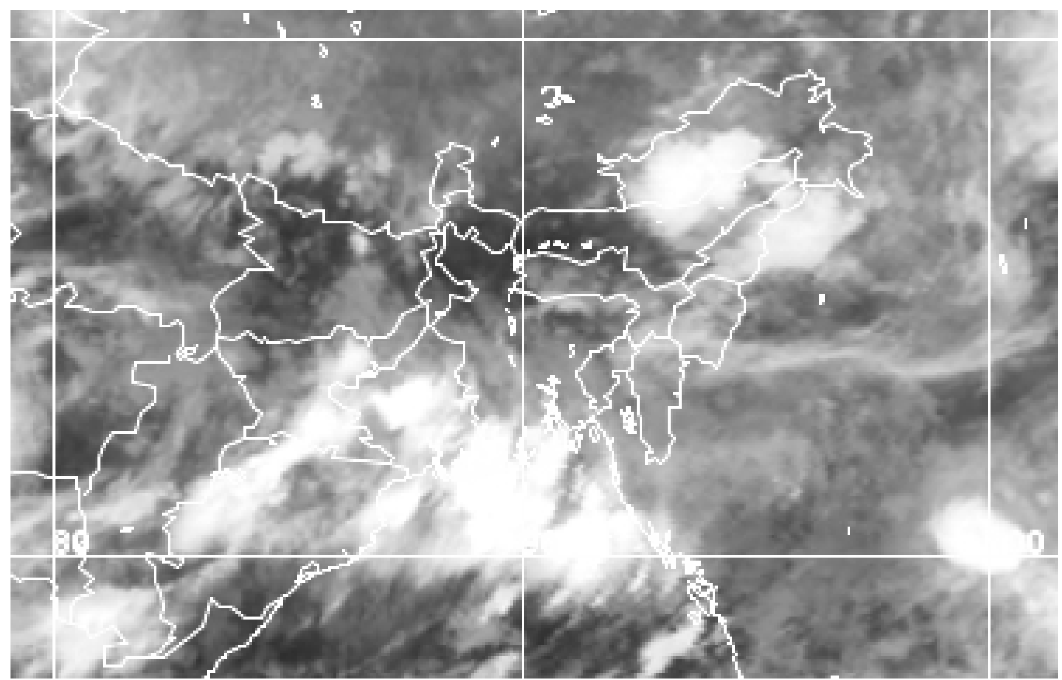


Monitoring of Cloud growth

Cloud top temperature from Thermal Infra Red (TIR) channel image



NER sector image is available with cloud top temperature (CTT). CTT value less than -40 °C indicates presence of cumulonimbus cloud (if not cirrus cloud), which normally gives heavy precipitation (apprx 25 mm/day)



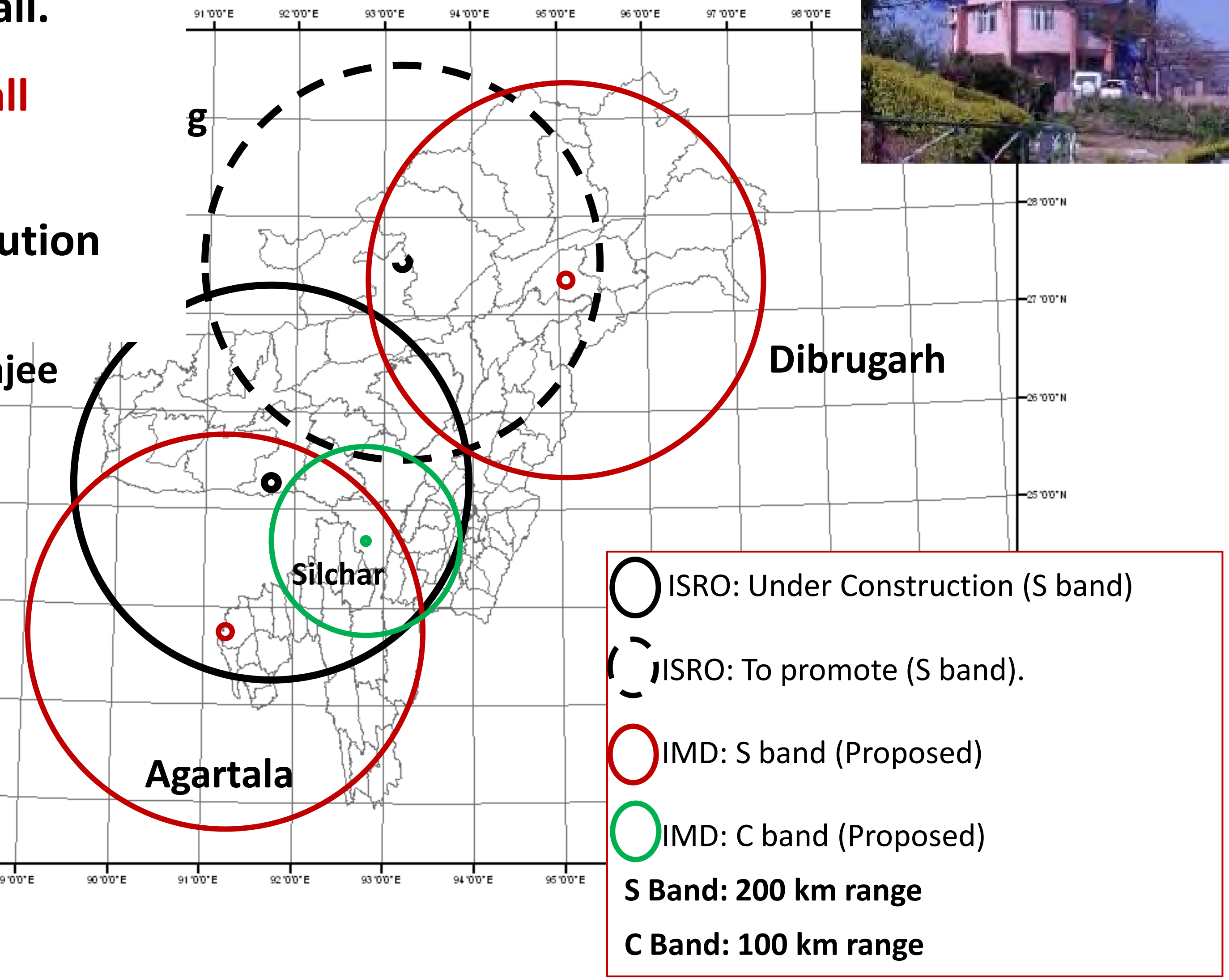
Source of data: IMD (JPEG), MOSDAC (HDF), NOAA (JPEG)

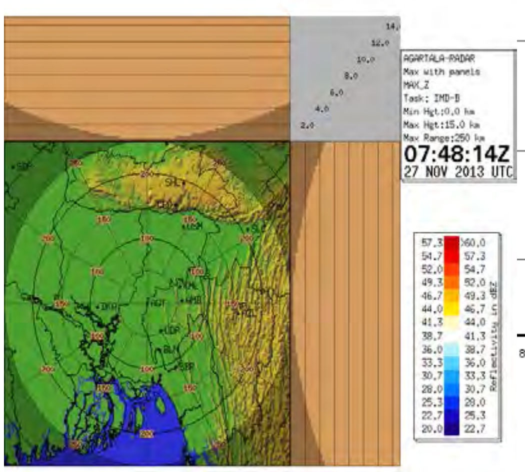
Flood forecasting using Weather Radars

High resolution Spatial distribution of rainfall.

Near accurate rainfall estimation.

High temporal resolution

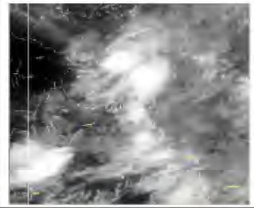




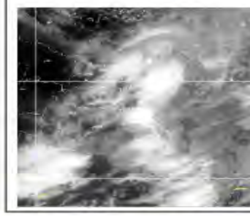
Synoptic Weather advisory for FLEWS

Synoptic weather advisory Bulletin as on 26th June, 2012

07:30 Hrs (02:00 GMT) TIR image (NER)

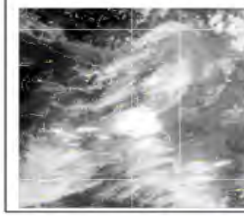


09:30 Hrs (04:0 GMT) TIR image (NER)

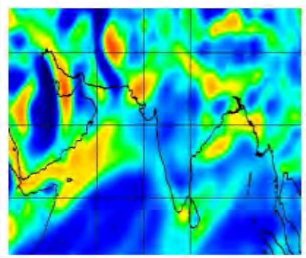


11:30 Hrs (06:00 GMT) TIR mage (NER)

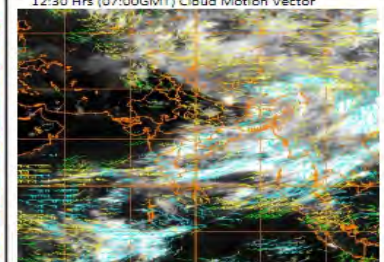
13:30 Hrs (08:00 GMT) TIR image (NER)



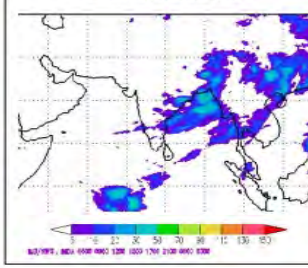
11:30 Hrs (06:00 GMT) Vorticity



12:30 Hrs (07:00GMT) Cloud Motion Vector



08:30 Hrs (3:00 GMT) QPE



Past 24 hrs rainfall (mm) as on 14:30 Hrs

Lakhimpur, Dhemaji and Sivasagar				Barpeta, Nalbari, Baksa, Dhubri and Goalpara		Darrang Morigaon and Sonitpor		Barak Basin	
Station Name	Rainfall	Station Name	Rainfall	Station Name	Rainfall	Station Name	Rainfall	Station Name	Rainfall
Lakhimpur	14 mm	Basar	20 mm	Bongaigaon	159 mm	Mangaldoi	55 mm	Karimganj	NA
Dhemaji	26 mm	Mengio	4 mm	Rangia	80 mm	Silghat	NA	Hailakandi	NA
Itanagar	NA	Daporijo	NA	Nalbari	NA	Viswanath Ch.	NA	Silchar	23 mm
Ziro	23 mm	Koloriang	NA	Barpeta	NA				
Yazeli	NA			Dhubri	52 mm			**Jowai**	194mm
Passighat	155 mm	Sivasagar	12 mm	Goalpara	180 mm				
Seppa	25 mm								

Quantitative Precipitation Forecast (IMD) rainfall in mm

Basin	Rainfall	Basin	Rainfall (mm)	Basin	Rainfall	Basin	Rainfall
Subansiri	NA						

NA- Not Available

IMD weather forecast (based on 25th June 2012 midday) up to 0830 hours IST of 26th June, 2012: Rain/thundershowers would occur at most places over northeastern states.

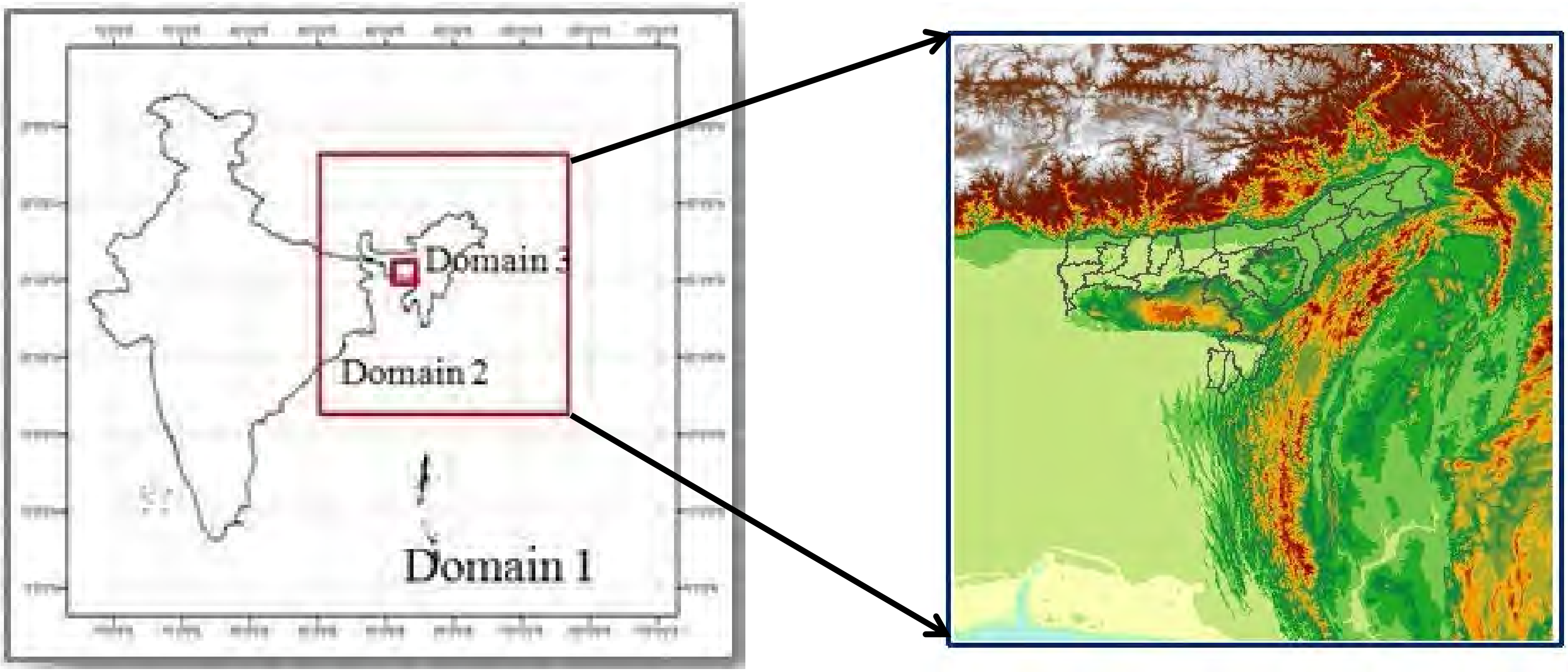
Synoptic Weather and rainfall probability for next 12 hrs:

East Assam area: Moderate rainfall amounting 20-40 mm expected over the area.
West Assam area: Moderate to high rainfall amounting 20-50 mm expected over the area. Some places over the northern part may get rainfall more than 50mm in next 24 hours.
South Assam area: High rainfall amounting 30-50 mm expected over the area. Rainfall more than 50 mm expected over some places. Need to monitor critically.
Middle Assam area: Moderate rainfall amounting 20-40 mm expected over the area.
Jaintia Hills area: High rainfall amounting 30-50 mm expected over the area.

- All thearea needs to be monitor continuously.

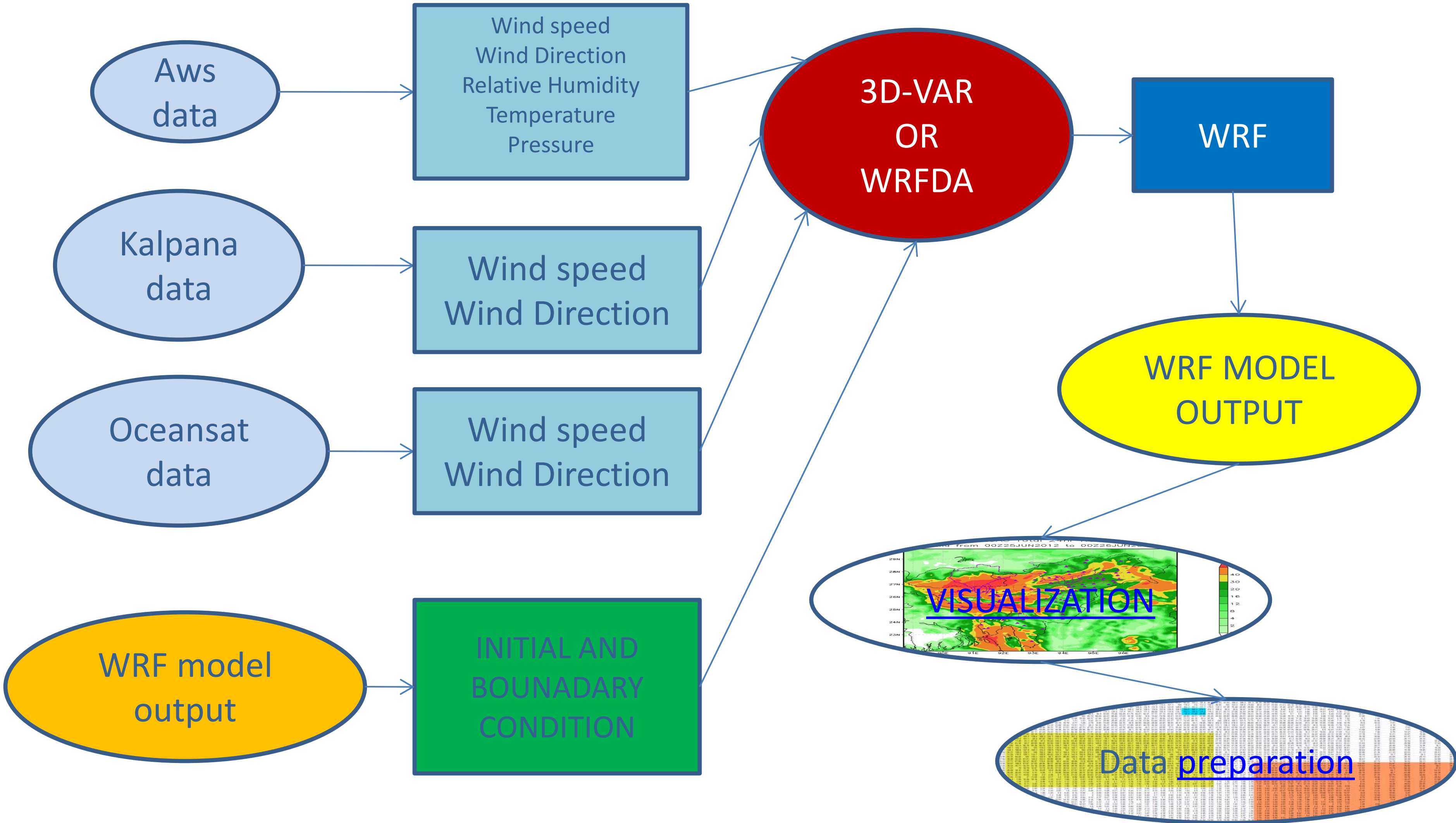
Prepared by: Meteorology team, NESAC

The Met Model Domain

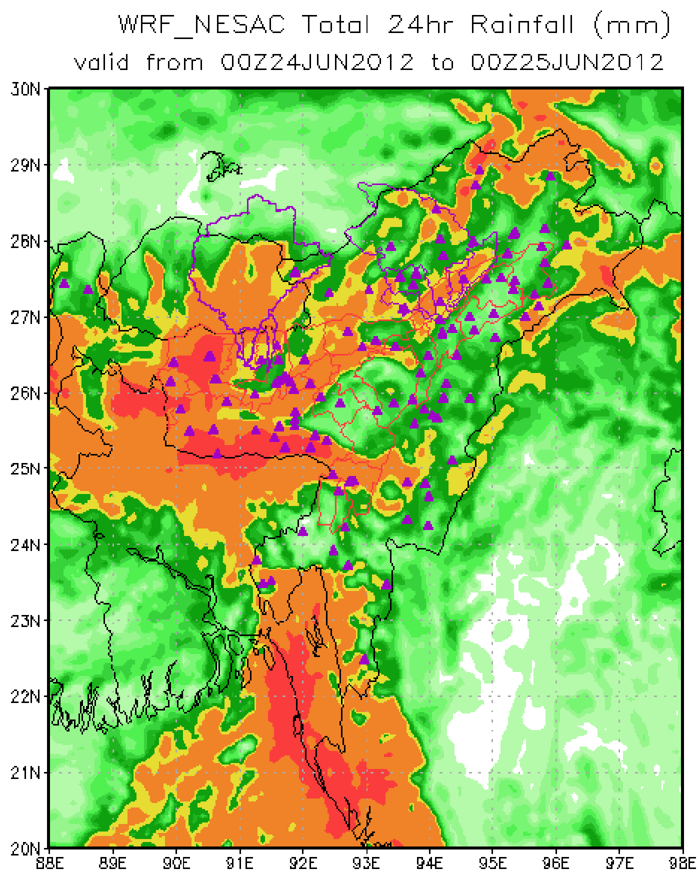


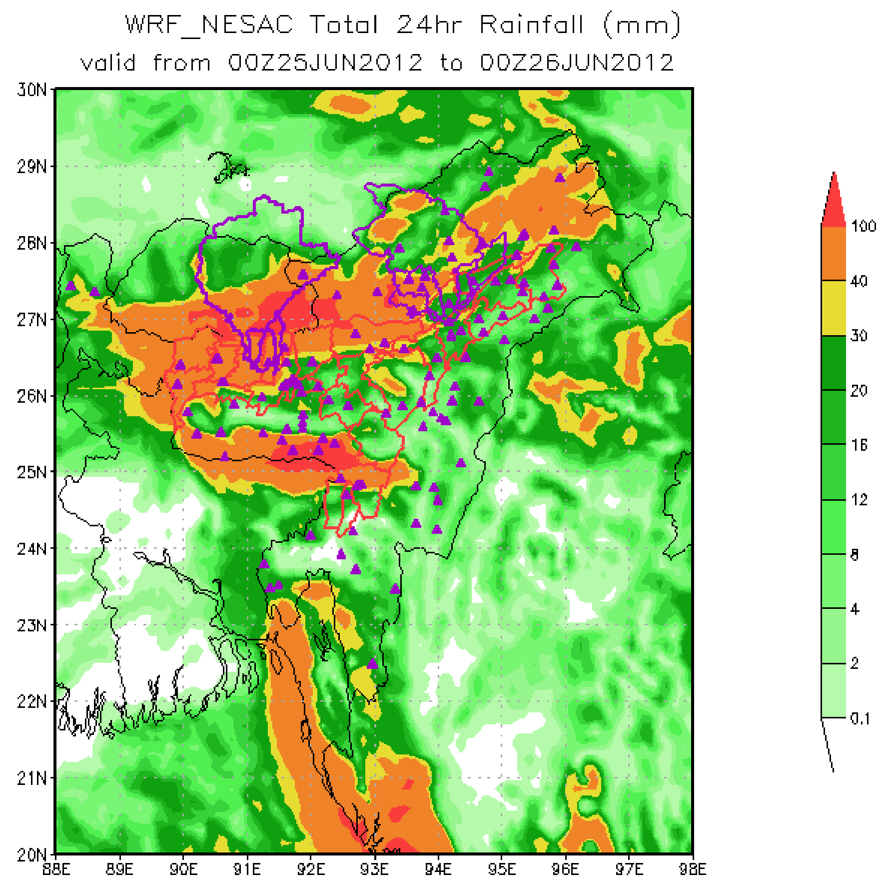
Central Lat Lon	**21°N 88°E**
Number of grids	**180 ×180 , 184 × 184**
Horizontal resolution	**27 km, 9Km, 3 Km**
Vertical levels	**36**
Time step	**120 sec**
Projection	**Mercator**

WRF MODEL SYSTEM FLOW CHART



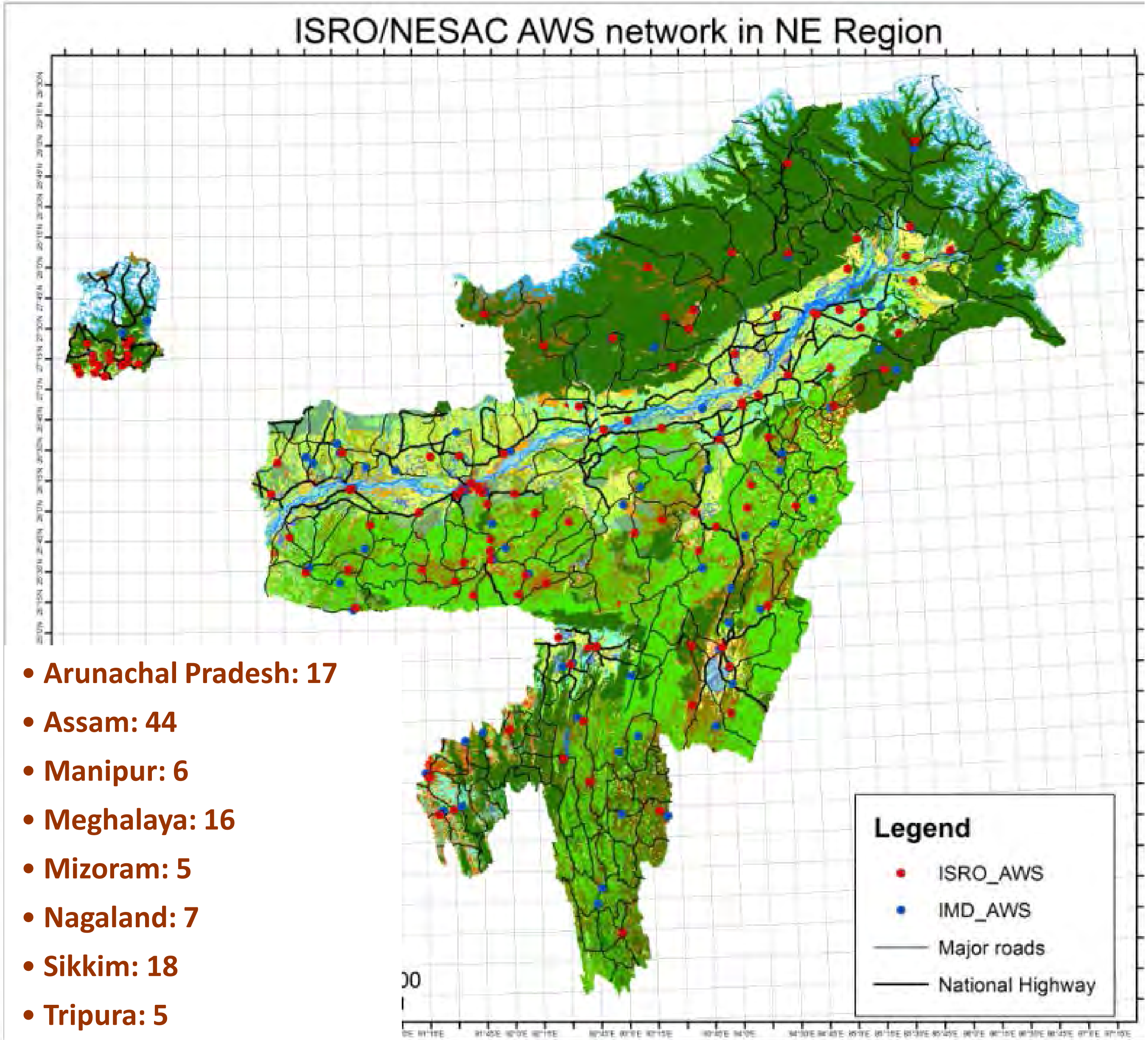
WRF FORCASTED RAINFALL





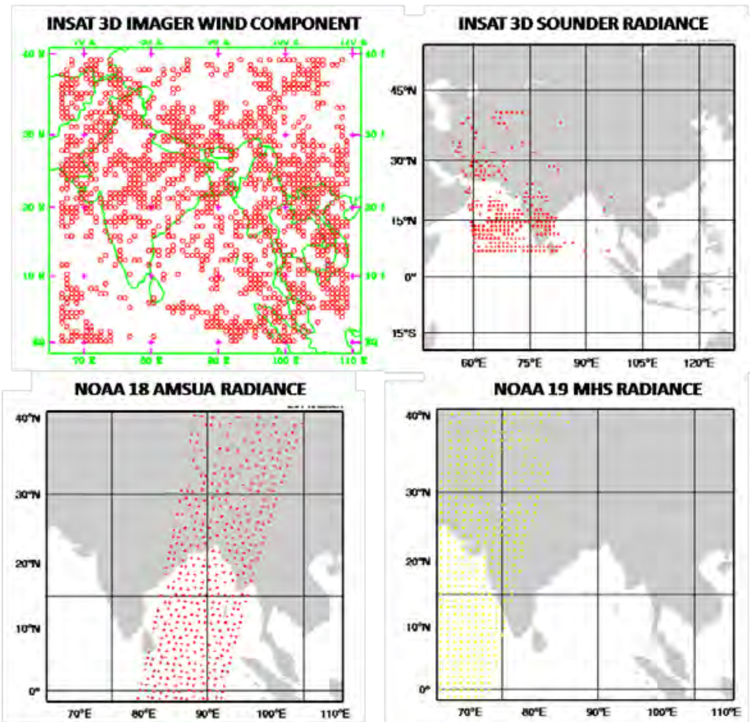
AWS network in NER of India

- Temperature
- Atm. Pressure
- Relative Humidity
- Rainfall
- Sunshine duration
- Wind Speed
- Wind Direction

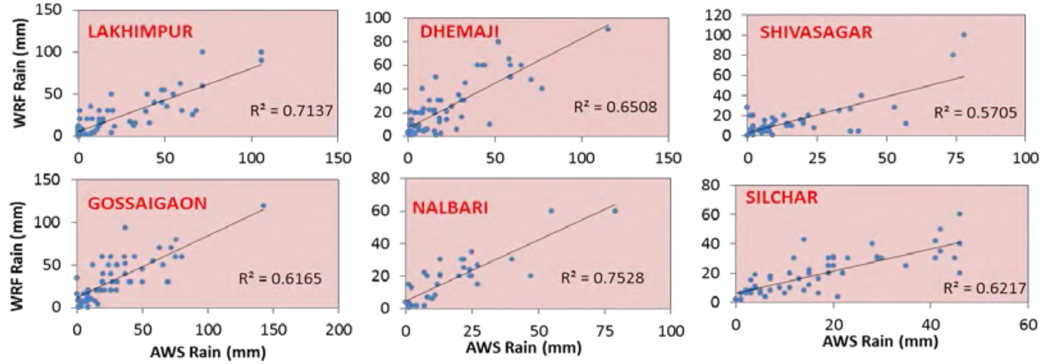


- Arunachal Pradesh: 17
- Assam: 44
- Manipur: 6
- Meghalaya: 16
- Mizoram: 5
- Nagaland: 7
- Sikkim: 18
- Tripura: 5

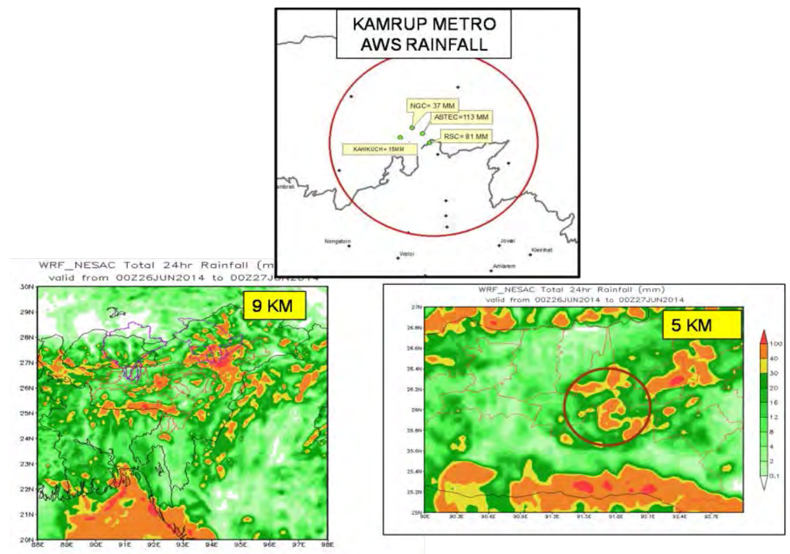
WRF Model Calibration & Validation



Spatial coverage of various data sources for assimilation in WRF model.

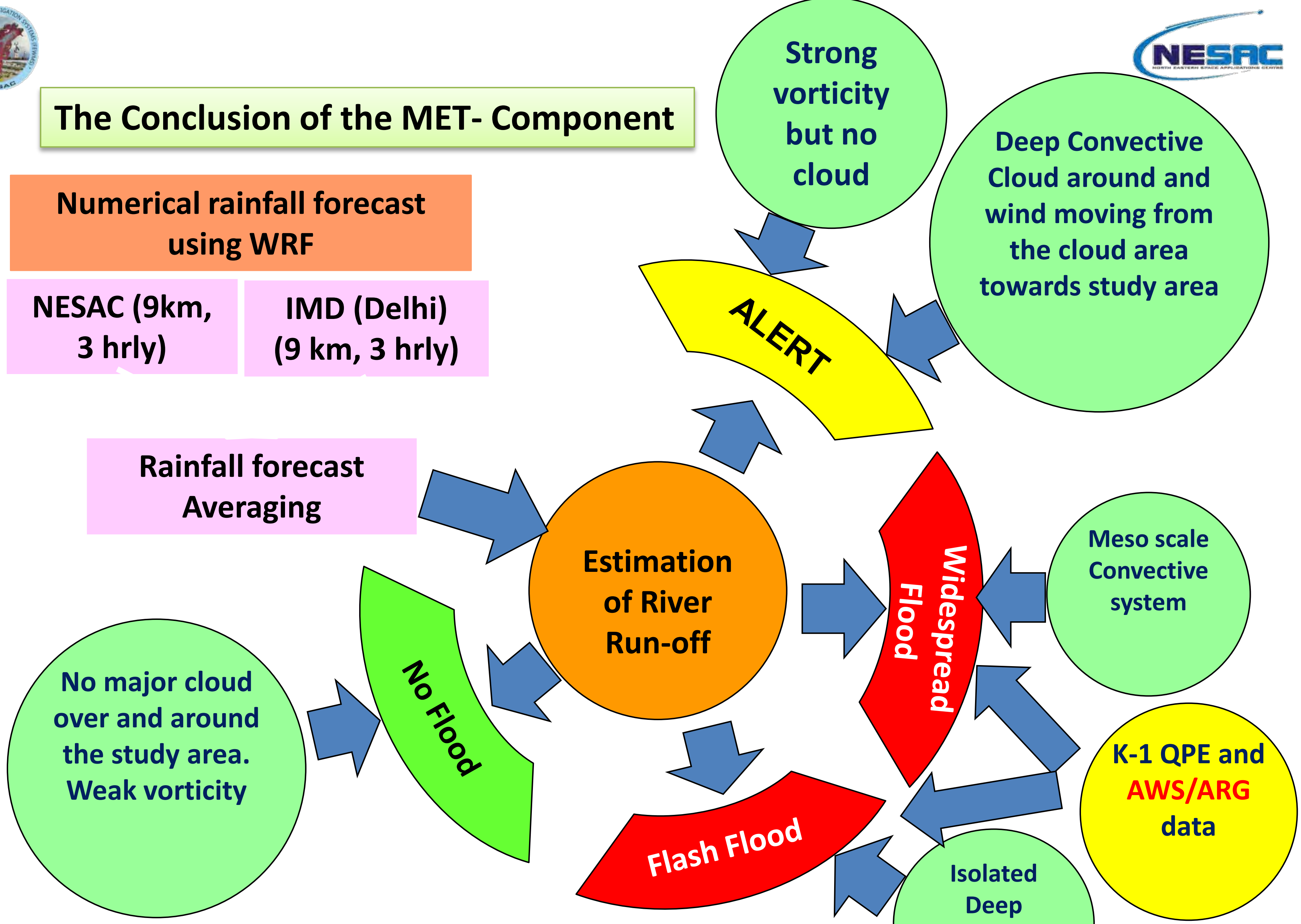


Comparison of daily accumulated WRF rainfall from June to August 2013 with AWS recorded rainfall for different stations located in Assam



WRF model forecasted rainfall on 26th June 2014 with 9km and 5km resolution

The Conclusion of the MET- Component



The warning is for hydrology team. Final flood warning based on assimilation of other ground info.

A line of caution..!!!

Rain is only a necessary condition for flooding and never a sufficient one.

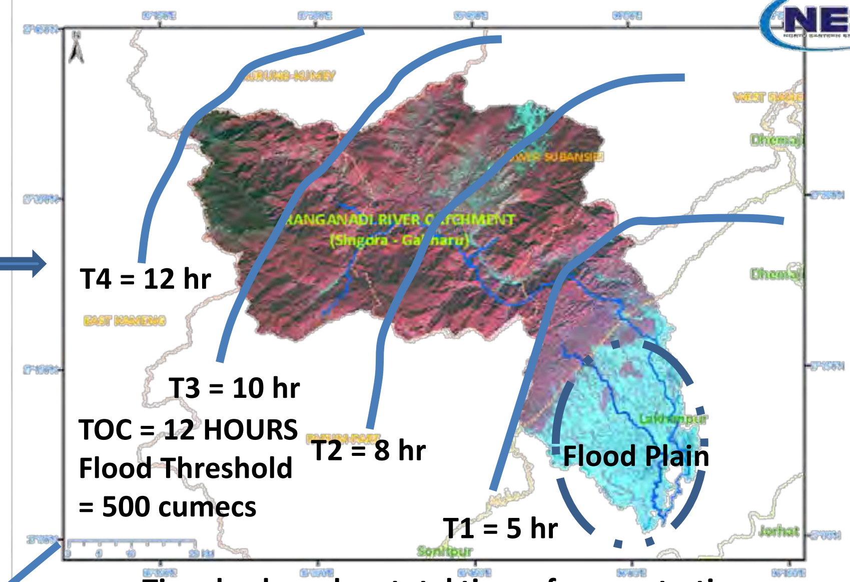
Correct forecasting of rain may not lead to correct forecasting of flood.

Incorrect assessment of rain is most likely to lead to incorrect forecasting of flood.

	93	93.25	93.5	93.75	94	94.25	94.5	94.75	95
27.5	1.48	2.86	4.02	8.54	9	7.41	5.5	6.1	[illegible]
27.75	0.14	1.64	6.65	10	13.96	10.32	9.27	8.3	5.3
28	1.17	1.07	4.55	4.68	8.45	8.47	9.23	9.41	6.44
28.25	0.52	0.45	1.82	1.74	2.78	5.41	6.95	7.78	6.35
28.5	0	0.28	1.18	0.5	1.12	2.36	4.09	4.93	3.89
28.75	0.47	0.16	0.68	0.42	0.7	1.36	2.21	2.9	2.73
29	0.98	0.35	0.64	0.14	0.55	0.89	2.09	2.77	2.33

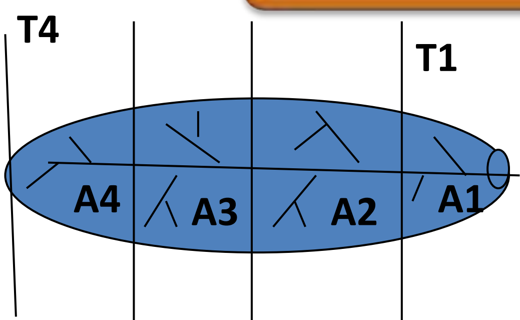
Suban		0.0028	0.4995	0.3381	3580000	2781.36
Ranga		0.0028	0.5896	0.267	238456	105.11
Singora		0.0028	0.75	0.093	44600	53.28
Dickrong		0.0028	0.63	0.044	126048	77.6
Jiadhal		0.0028	0.423	0.233	134600	98.21

Rainfall from WRF (Forecast) & AWS (Insitu)



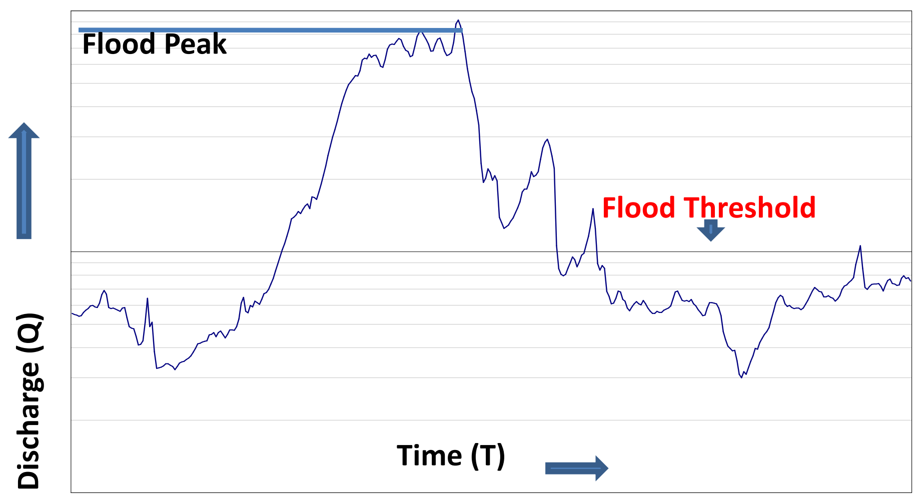
Time lag based on total time of concentration

The Rational Method of forecasting flood peak

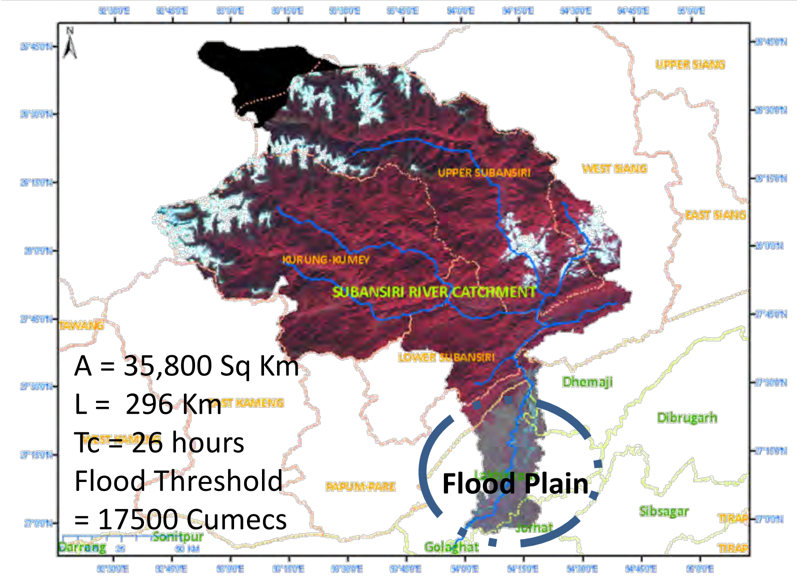


Q1 = .0028 C I A1 at T1
Q2 = Q1 + .0028 C I A2 at T2
Q3 = Q2 + .0028 C I A3 at T3
and so on.......

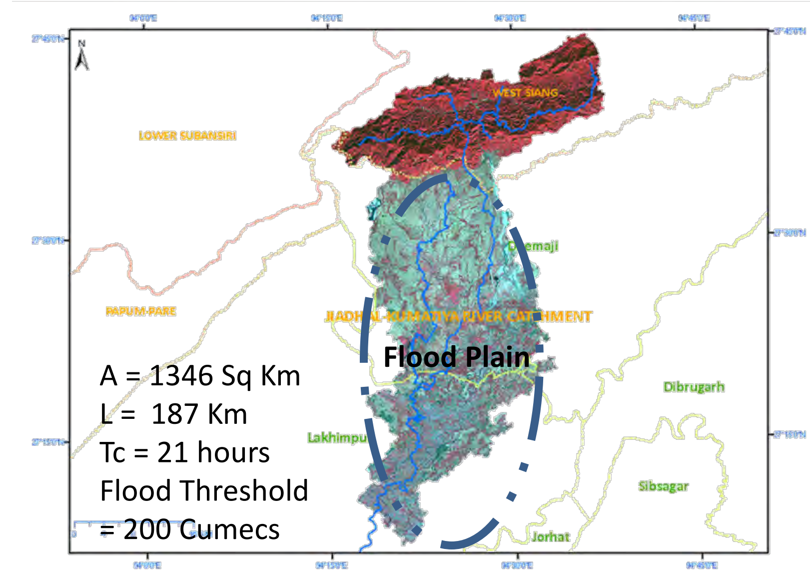
Flow accumulation with time in Rational model



Forecasted flood hydro-graph for issue of warning

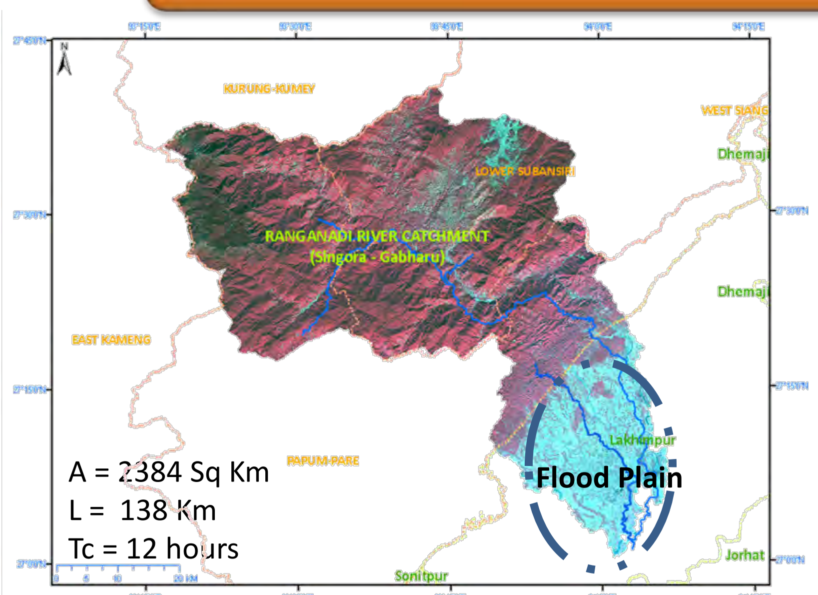


Subansiri river catchment

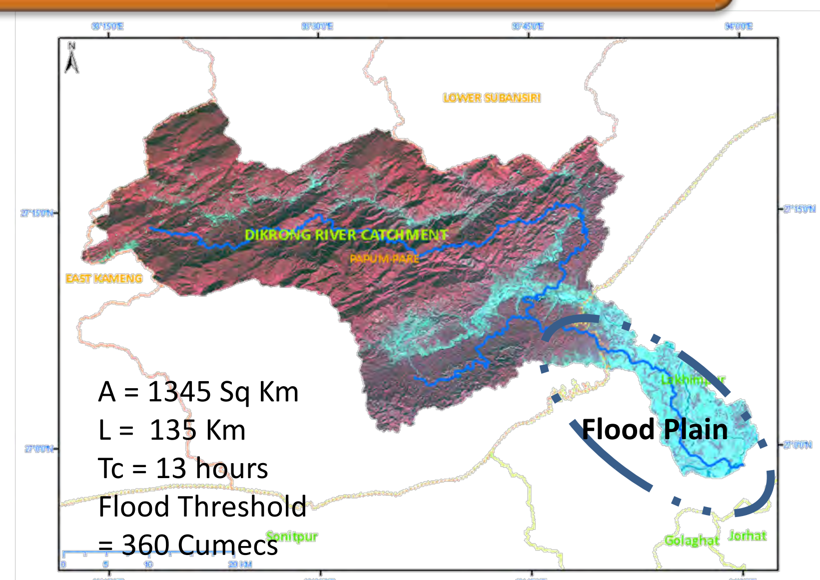


Jiadhal - Kumatia river catchment

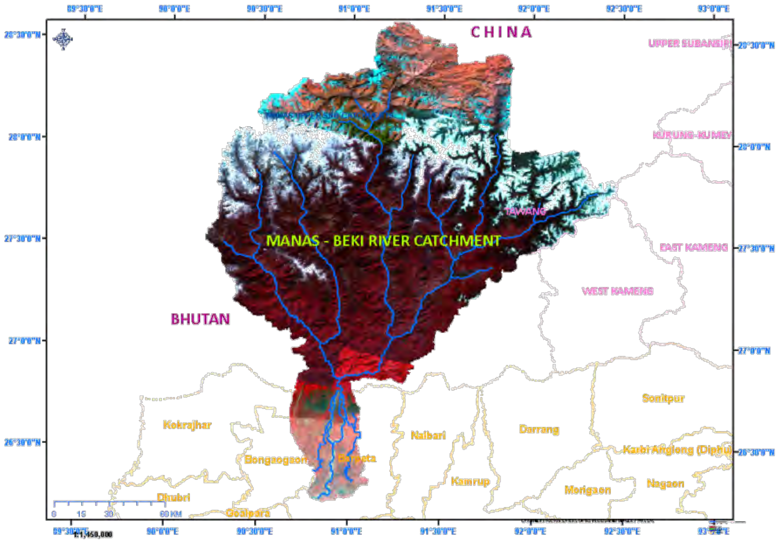
Major river catchments delineated for Lakhimpur & Dhemaji district



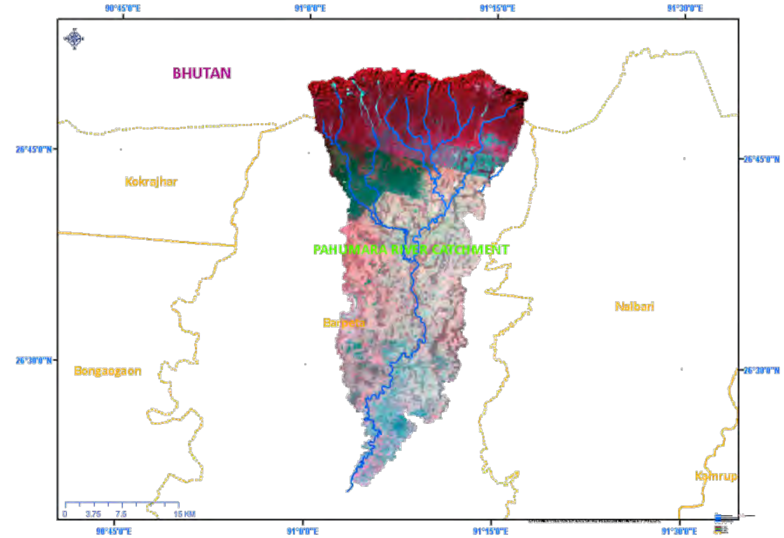
Ranganadi river catchment



Dickrong river catchment

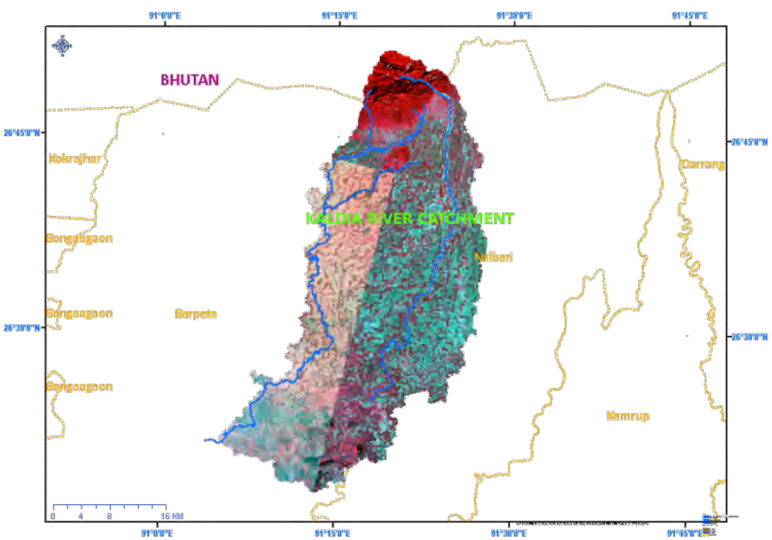


Manas- Beki river catchment

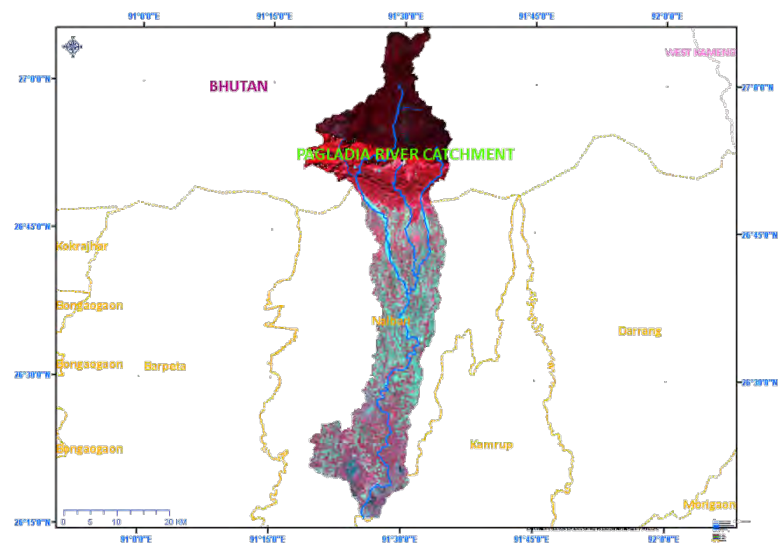


Pohumara river catchment

Major river catchments delineated for Barpeta, Nalbari & Baksa districts



Kaldia river catchment



Pagladia river catchment

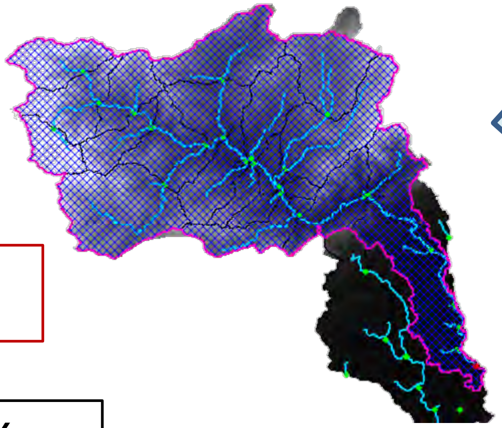
FLEWS - Distributed / Quasi Distributed Hydrological Model Building

Base Layer preparation – CN Grid (integration of **land-use land-cover** & **soil** layer, assignment of hydrologic soil group and defined *Curve Numbers*)

DEM pre-processing (reconditioning and fill sinks)

Stream processing (streamline grid and segmentation)

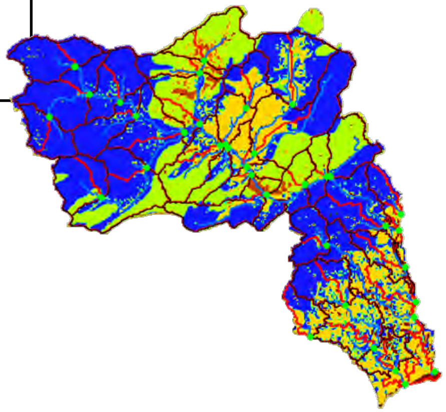
Catchment delineation



HMS **Project layer generation**

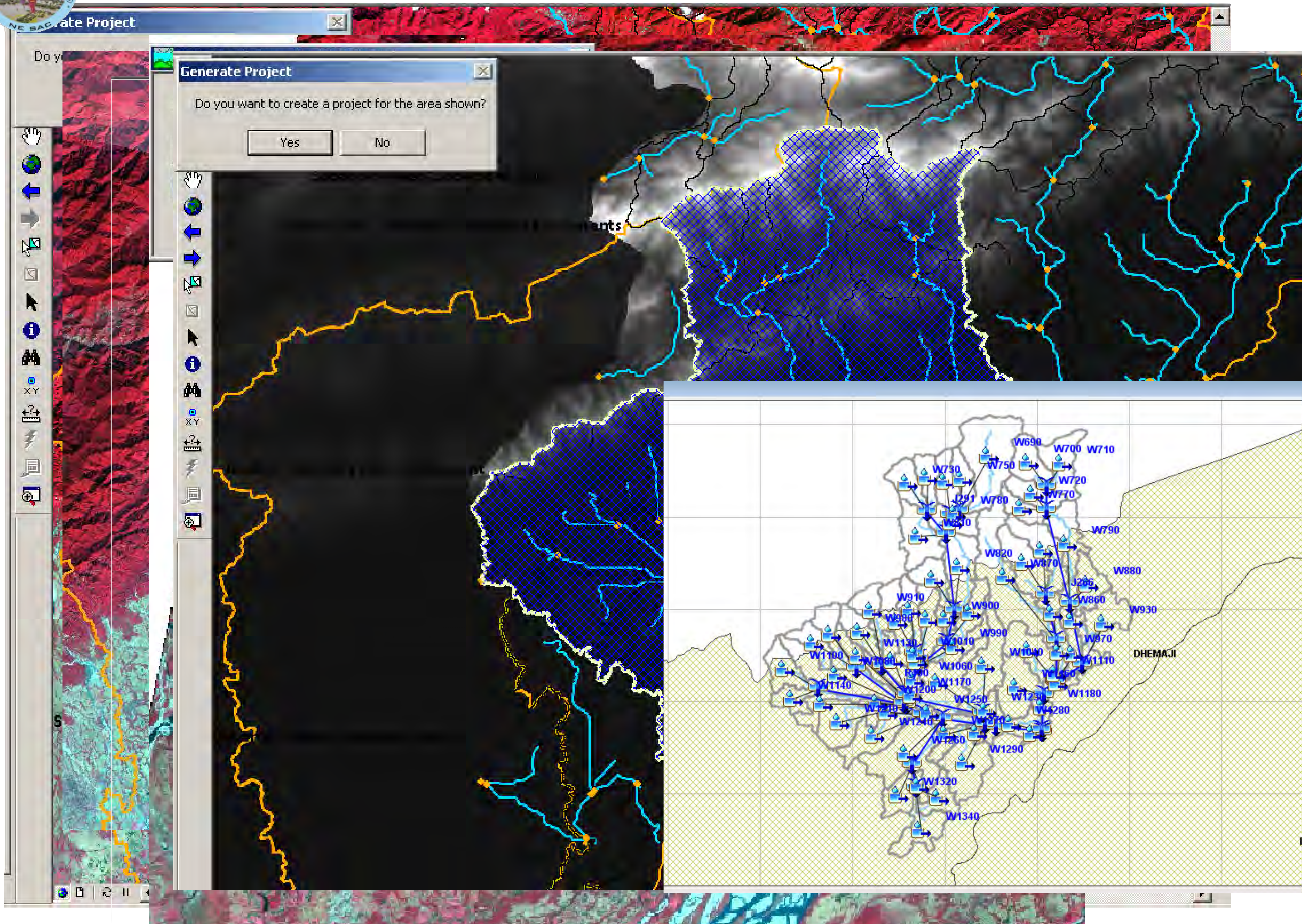
HMS process definition & morpho-hydrologic parameters (sub-basin parameters with CN Grid raster, basin lag time, etc)

Hydrologic FLOOD Routing : Muskingum > Routing Parameters K and X assignment
Meteorological Data: Time series Rainfall data

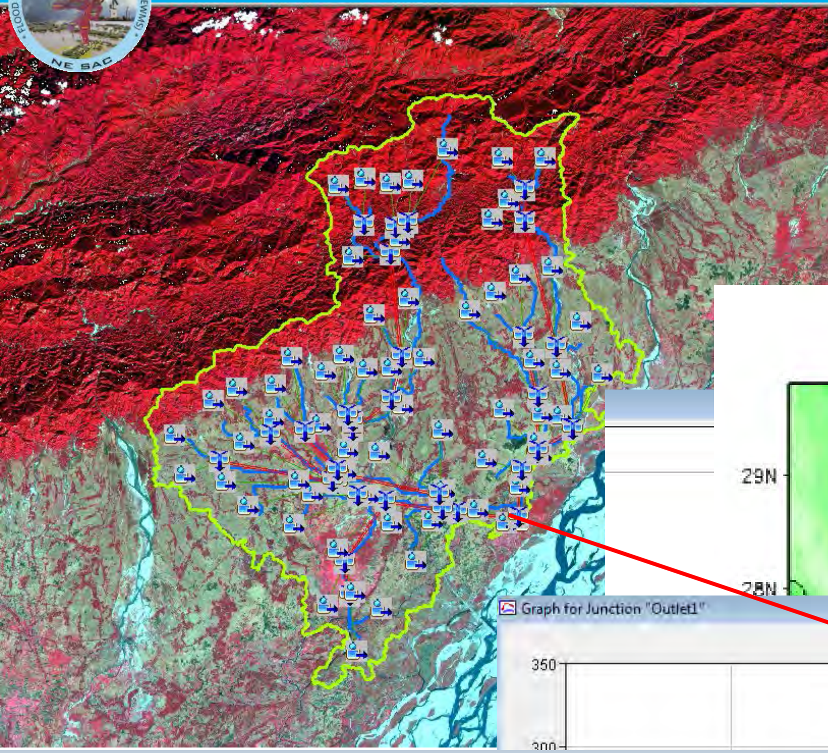


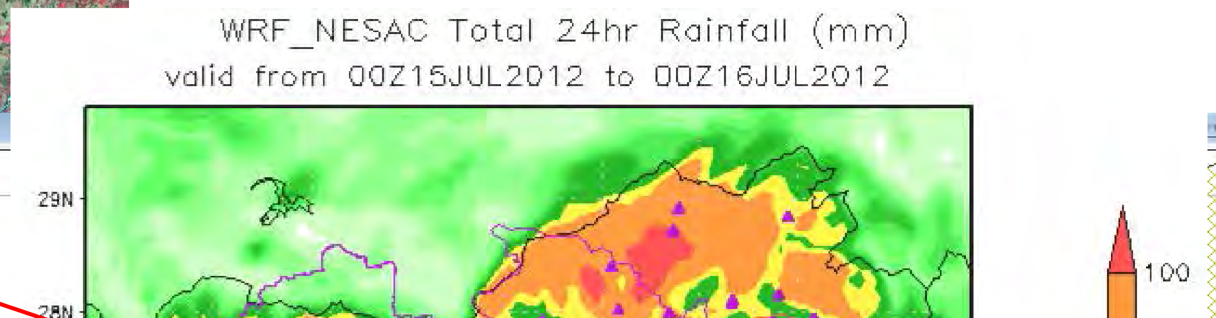
HMS MODEL RUN **& Computations (24 hourly Outflow Hydrograph, etc)**

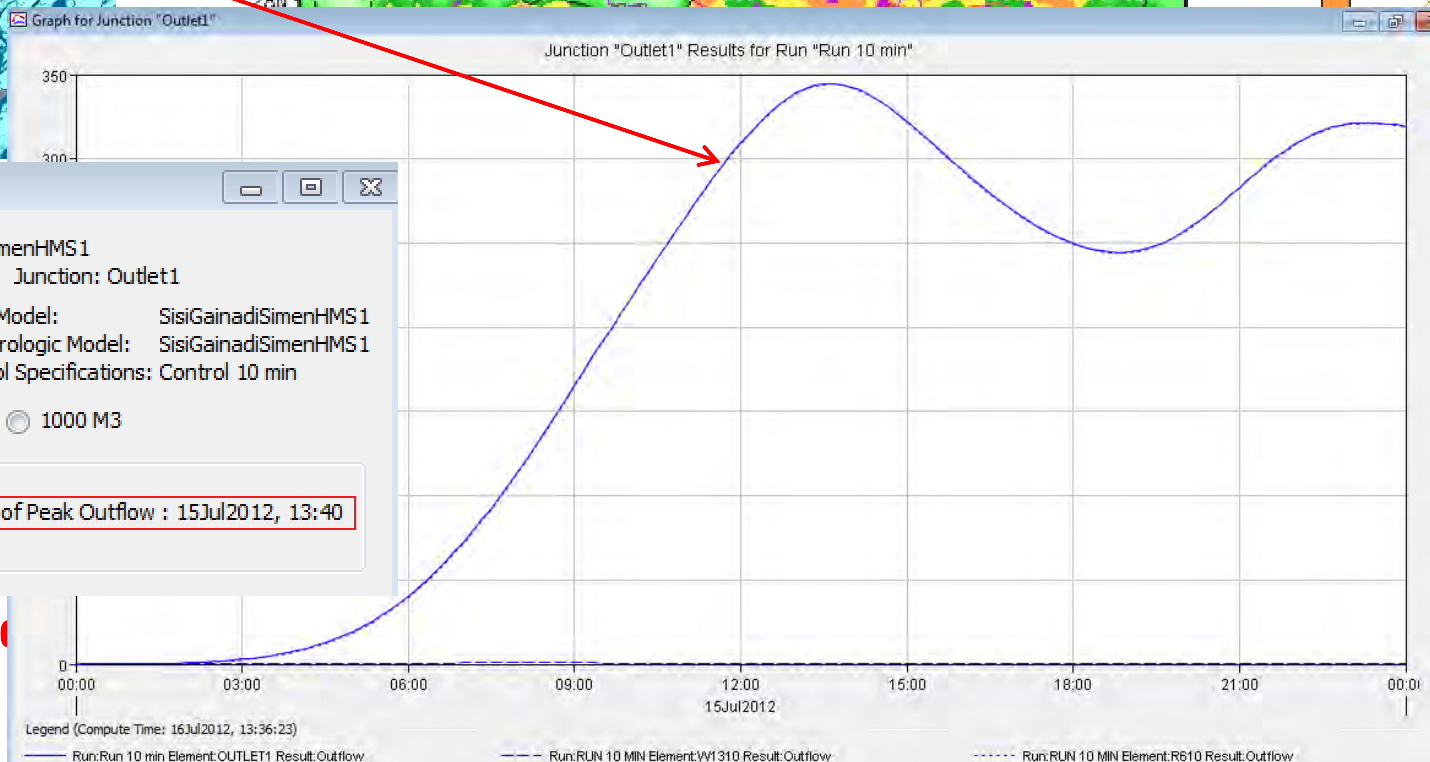
Distributed / Quasi Distributed Hydrological Model Building



Distributed / Quasi Distributed Hydrological Model RUN







Summary Results for Junction "Outlet1"

Project: SisiGainadiSimenHMS1
Simulation Run: Run 10 min Junction: Outlet1

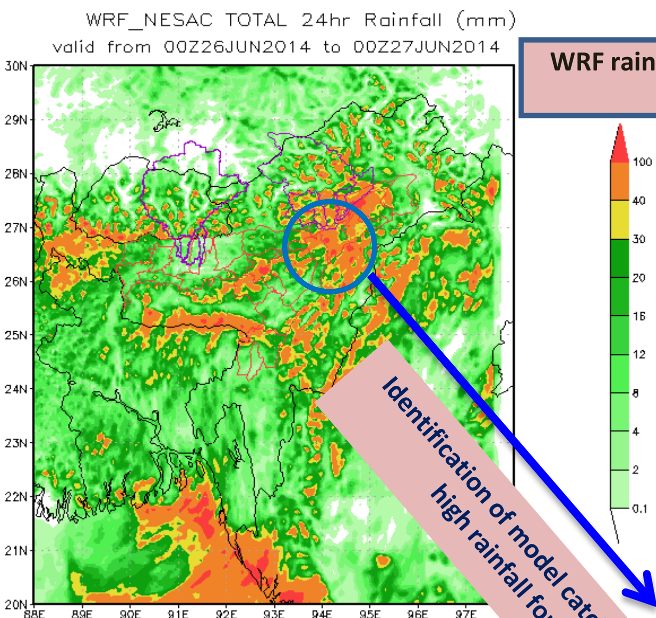
Start of Run:	15Jul2012, 00:00	Basin Model:	SisiGainadiSimenHMS1
End of Run:	16Jul2012, 00:00	Meteorologic Model:	SisiGainadiSimenHMS1
Compute Time:	16Jul2012, 13:36:23	Control Specifications:	Control 10 min

Volume Units: MM 1000 M3

Computed Results

Peak Outflow : 344.7 (M3/S) Date/Time of Peak Outflow : 15Jul2012, 13:40
Total Outflow : 18.51 (MM)

The Rainfall-runoff model

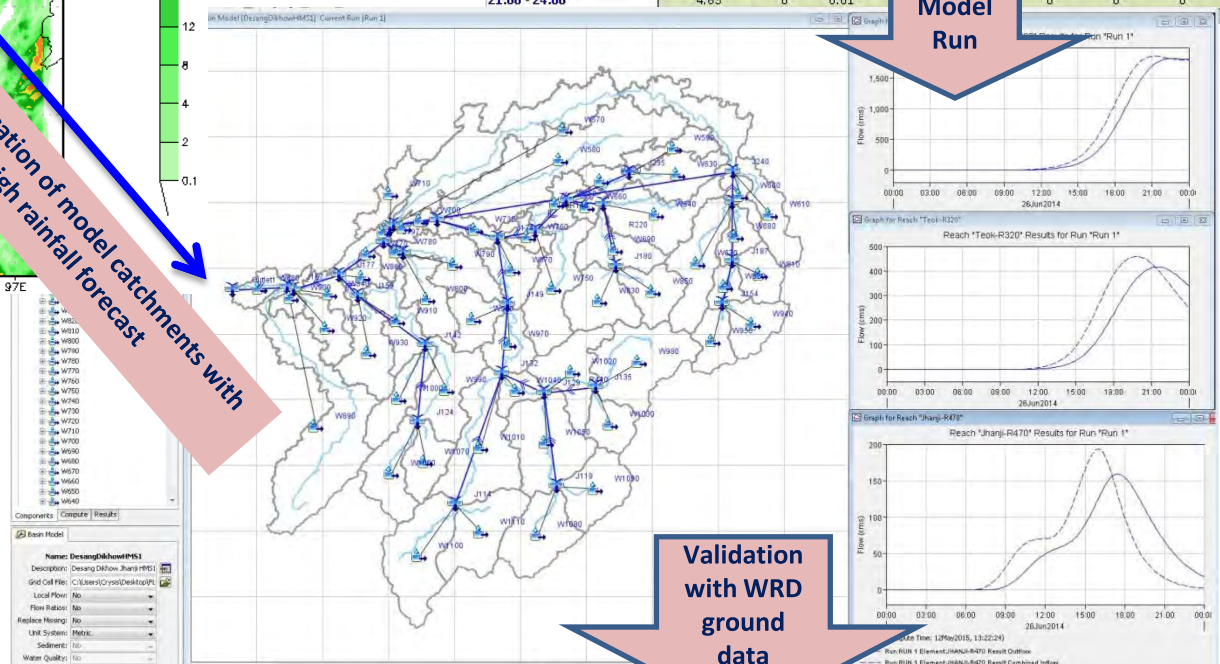


WRF rainfall Input for HEC-HMS

DISANG-DIKHOW-DORIKA-DIBRU Sub Basin - wise 3-hourly Precipitation (mm) 26.06.2014

Co-ordinates "Lat:Long" (centred)	26.86 N 94.24 E	26.55 N 94.42 E	26.71 N 94.42 E	26.86 N 94.42 E	26.24 N 94.59 E	26.40 N 94.59 E	26.55 N 94.59 E	26.71 N 94.59 E	26.86 N 94.59 E	27.02 N 94.59 E	26.24 N 94.76 E	26.55 N 94.76 E
SUB-BASINs (GeoHMS Codes) / TIME INTERVAL ↓	W880 W900	W890	W920 W930	W770 W840 W860	W1100	W1060 W1070	W990 W1000	W910	W780 W800	W700 W710 W720 W740	W1110	W1010 W1040
00:00 - 03:00	0	0	0	0	0.57	0.47	0.19	0	0	0	3.94	1.55
03:00 - 06:00	0	0.03	0	0	2.58	0.02	0	0	0	0	5.36	0.03
06:00 - 09:00	0	0.26	0	0	13.6	10.38	0.13	0	0	0	11.23	1.45
09:00 - 12:00	3.94	5.38	7.91	2.41	3.74	5.26	3.72	4.86	3.15	2.32	9.63	15.16
12:00 - 15:00	47.8	29.36	21.75	23.19	11.59	13.01	10.01	41.86	49.15	23.11	5.37	34.18
15:00 - 18:00	101.99	0.07	10.31	79.07	0.07	0.42	1.77	7.48	20.29	17.07	0.31	9.75
18:00 - 21:00	8.18	0	0.01	[illegible]	[illegible]	0	0	0.02	1.2	2.57	0.02	0
21:00 - 24:00	4.63	0	0.01	[illegible]	[illegible]	0	0	0	0	19.1	0.11	0
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73.79	64.17	35.97	62.12

Identification of model catchments with high rainfall forecast



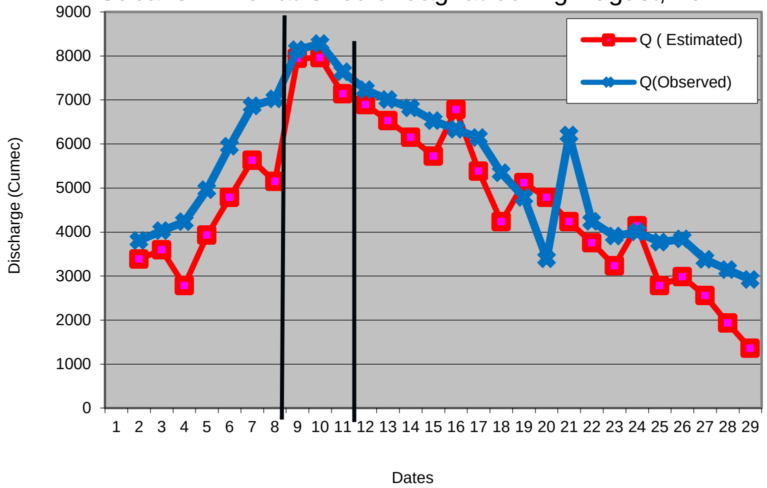
Model Run

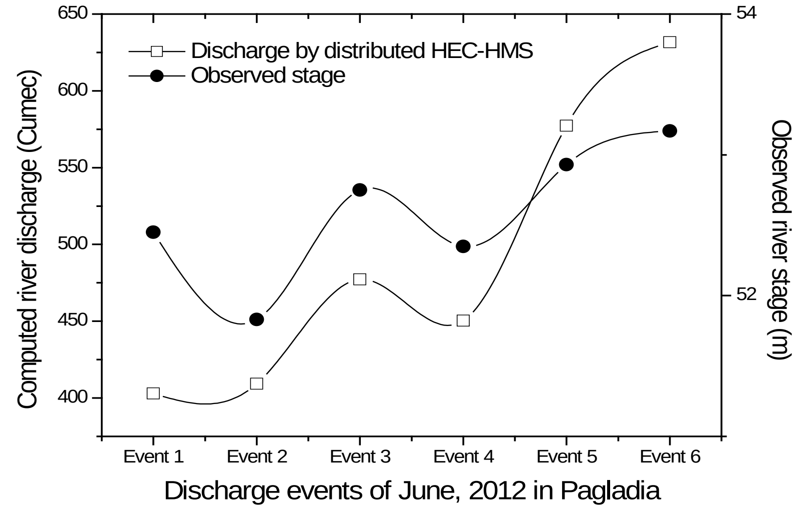
Validation with WRD ground data

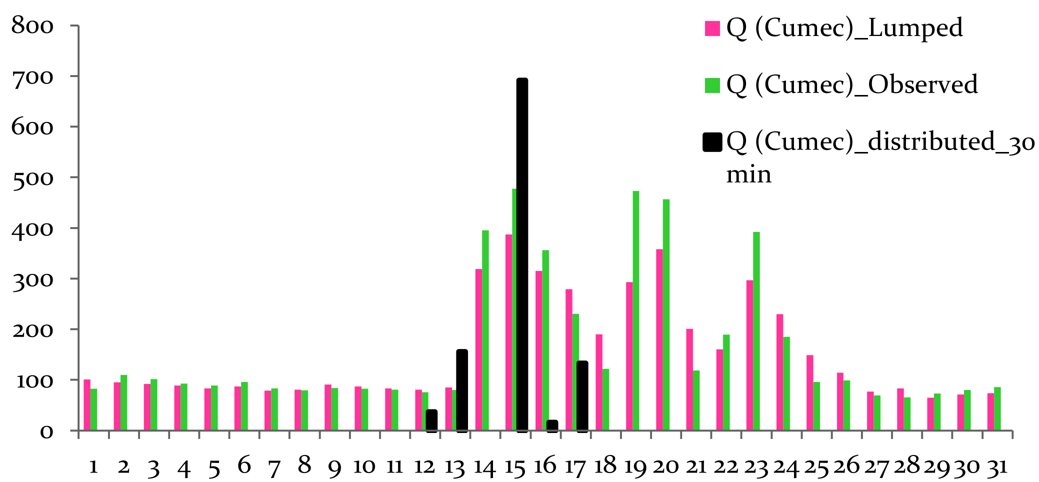
JORHAT DISTRICT					
RIVERS	Bhogdoi	Jhanji	Brahmaputra	Dhansiri	
G/D SITE	A.T Road Crossing	A.T Road Crossing	Nematighat	Numaligarh	
DANGER LEVEL	89	93.83	85.04	------	
DATE	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)	
June 25, 2014	88.4	90.78	85.38	75.79	Rising
June 26, 2014	88.3	91.23	85.42	75.67	Falling
June 27, 2014	88.30	93.73	85.35	75.76	Steady

HEC-HMS Model Validation

Comparison of Estimated and observed discharge for Subansiri river at Chouldhuaghat during August, 2012

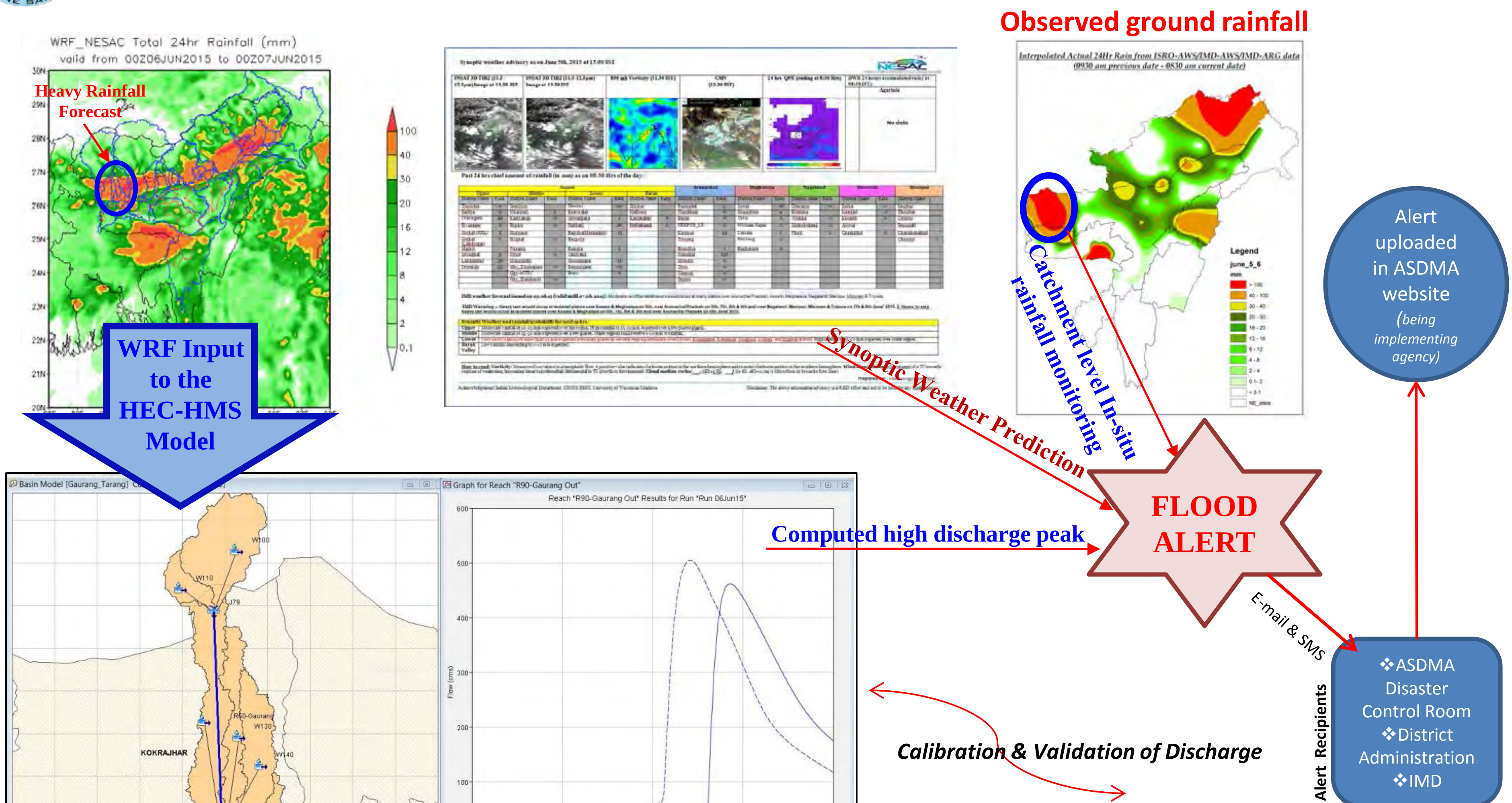






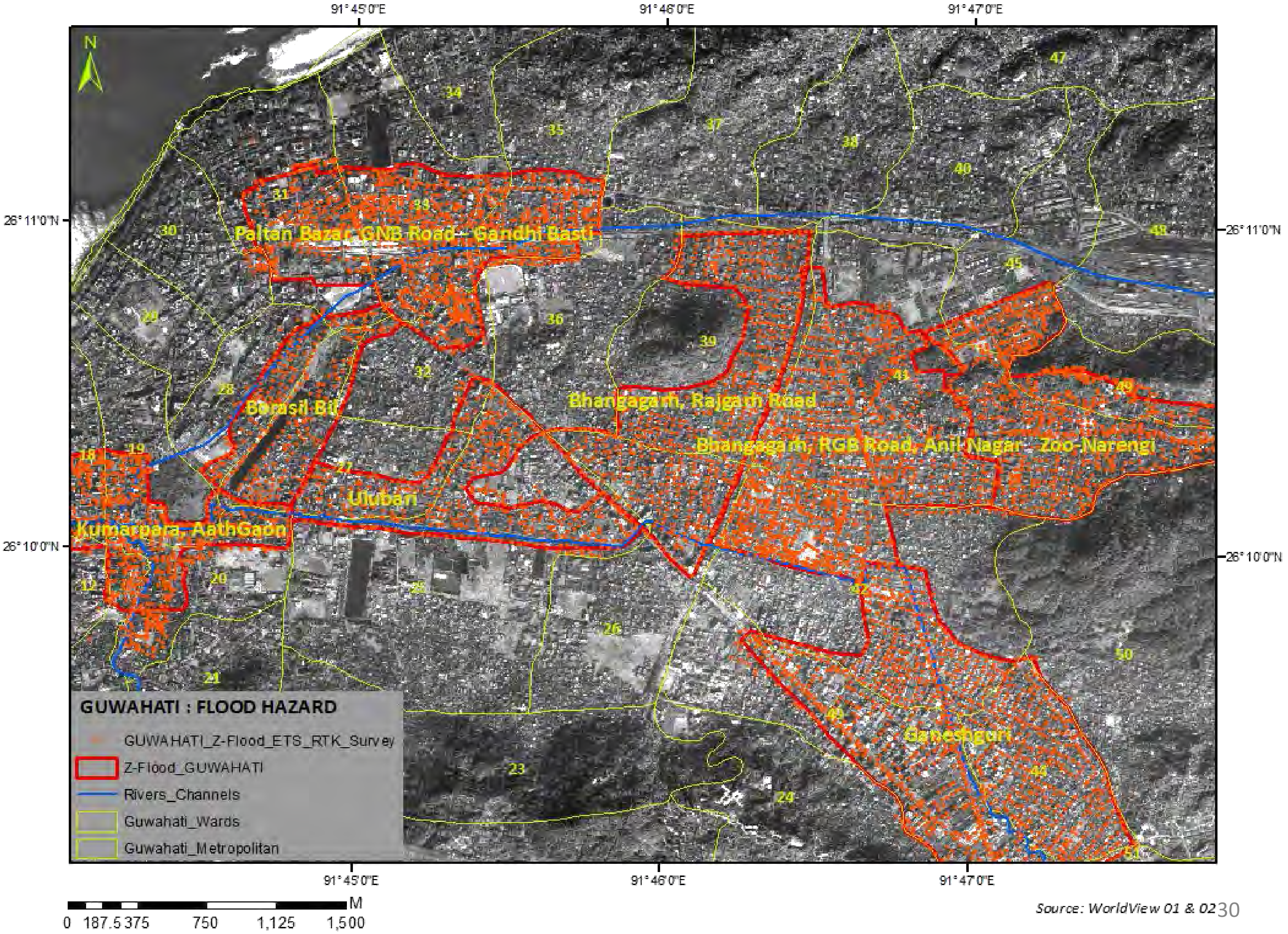
Comparison of Computed versus observed discharge on Ranganadi in July, 2012

FLEWS Alert : DSS & Dissemination



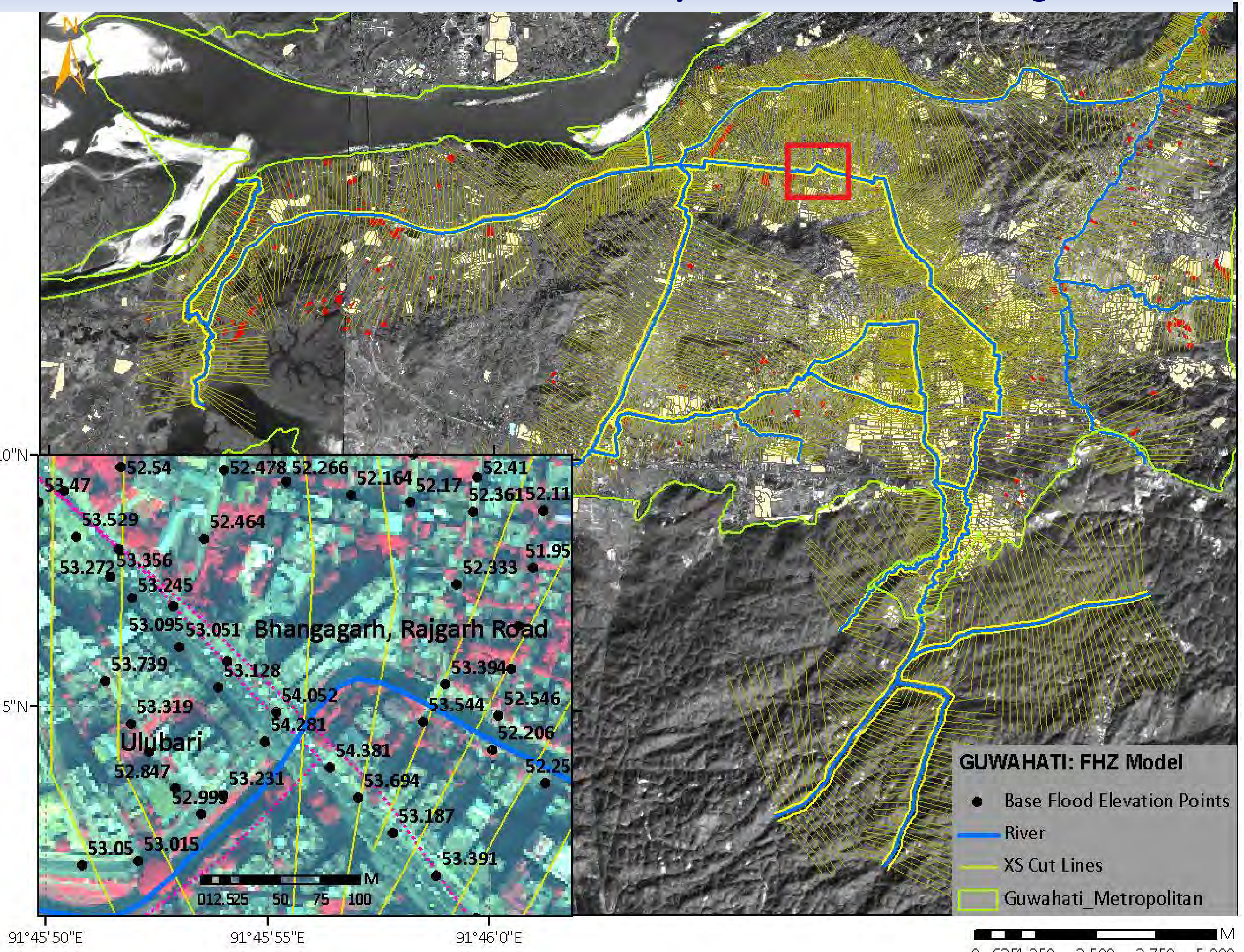
Daily water levels for rivers falling under Kokrajhar District								Ph. No. 03661270657
Rivers/ Date	Gourang	Champamati	Sonkosh	Modati	Garuphella	Saralbhanga		Below WL
WARNING LEVEL	41.85	64.52	47.50	44.90	51.50			
Danger Level	42.85	65.52	48.50	45.90	52.50	------	RAINFALL(mm)	Above WL
DATE	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)	Above DL
June 5, 2015	41.39	58.12	47.53	43.76	50.55	63.53	0.2	
June 6, 2015	42.26	59.66	47.77	43.93	50.64	64.47	245.2	
June 7, 2015	41.91	58.56	47.95	44.84	50.69	64.02	49	
June 8, 2015	41.43	63.92	47.76	44.47	50.8	63.92	67	
June 9, 2015	41.49	63.82	47.67	44.1	50.87	63.89	130.6	
June 10, 2015	41.73	63.97	47.7	44.21	51.04	63.89	80.6	
June 11, 2015	41.66	63.93	47.75	44.31	51.16	63.9	71.4	
June 12, 2015	41.73	63.97	47.71	44.21	51.04	63.89	80.6	
June 13, 2015	41.28	63.76	47.65	43.75	51.18	64.27	11.8	

GUWAHATI Metropolitan – Ground Survey using RTK/ETS/DGPS

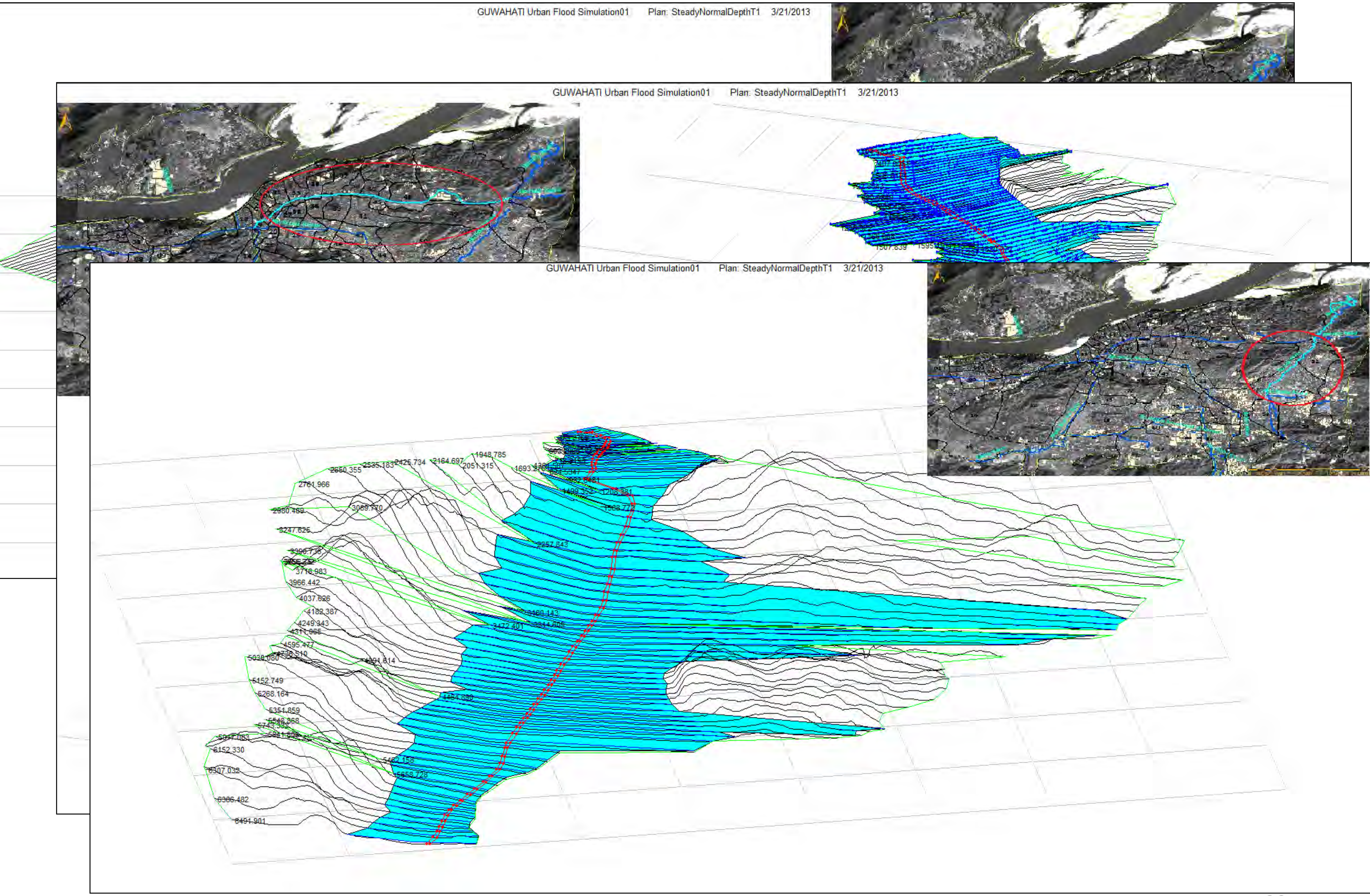


Source: WorldView 01 & 02

GUWAHATI Urban Catchment – Hydraulic Flood Modeling

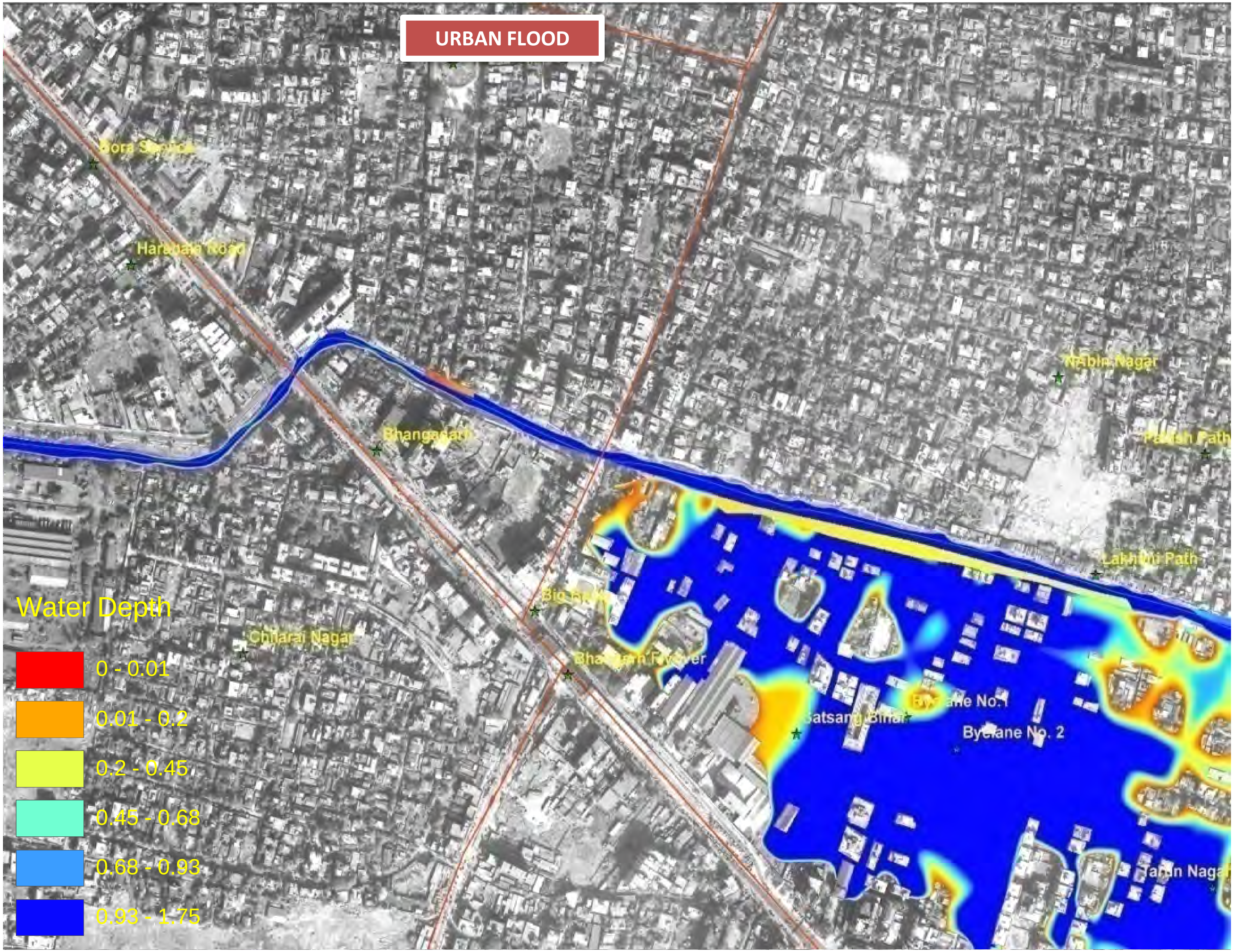


GUWAHATI Urban Catchment – Hydraulic Flood Simulation



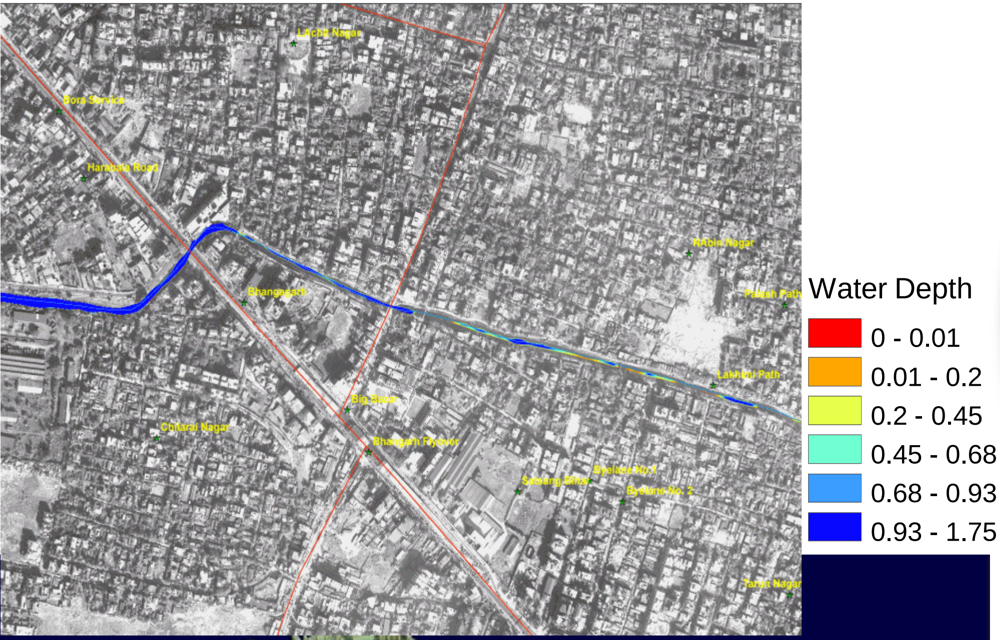
Flood Simulation using MIKE FLOOD 1D-2D Coupled Hydraulic Model

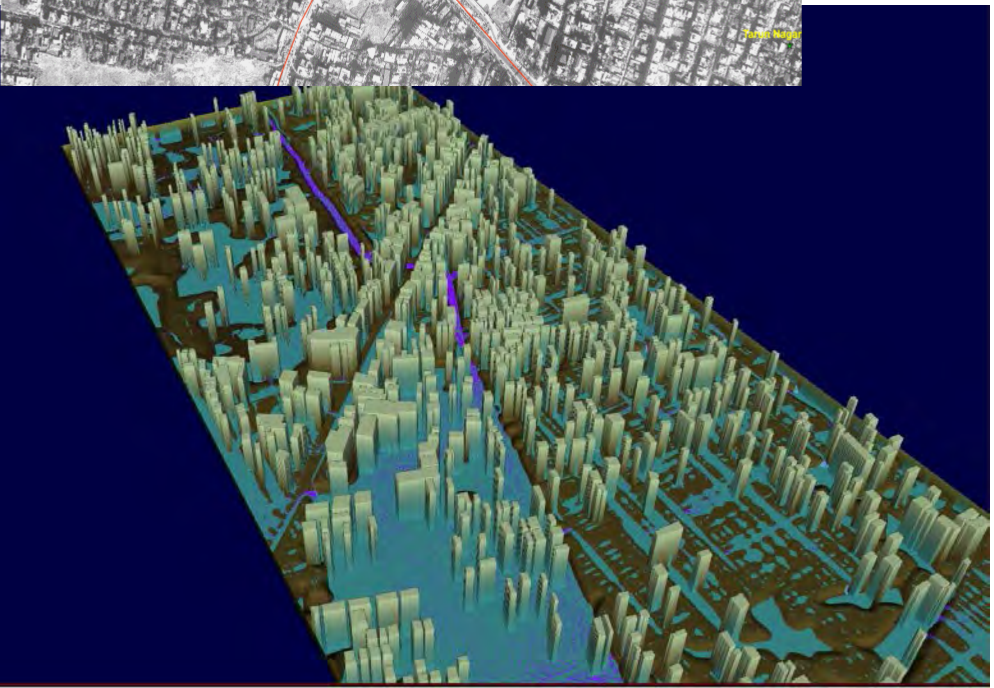
(Two case studies in Ranganadi river (450 cumecs) in Lakhimpur District and Bharalu River(210 cumecs) in Guwahati city, Assam)



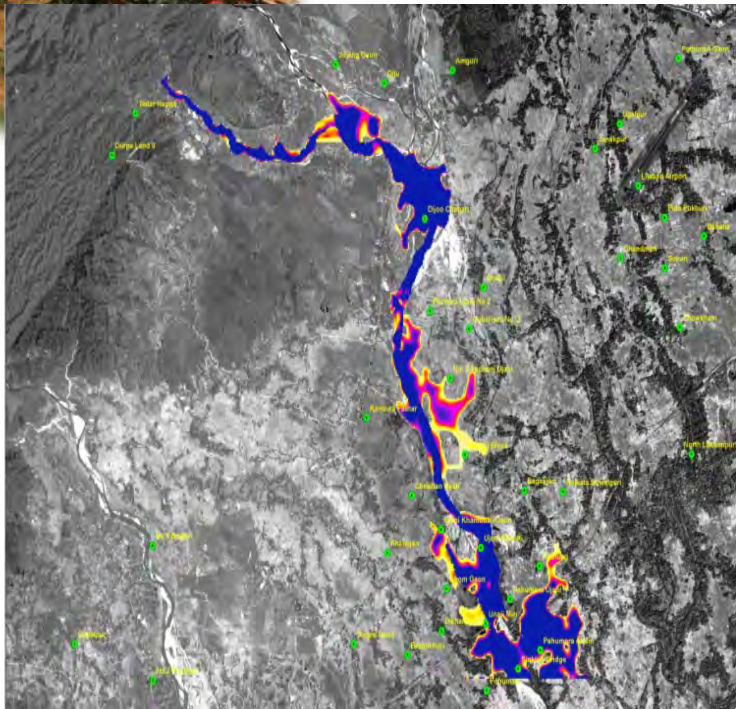
Flood Simulation using MIKE FLOOD Coupled 1D-2D model

Guwahati Zoo Tiniali

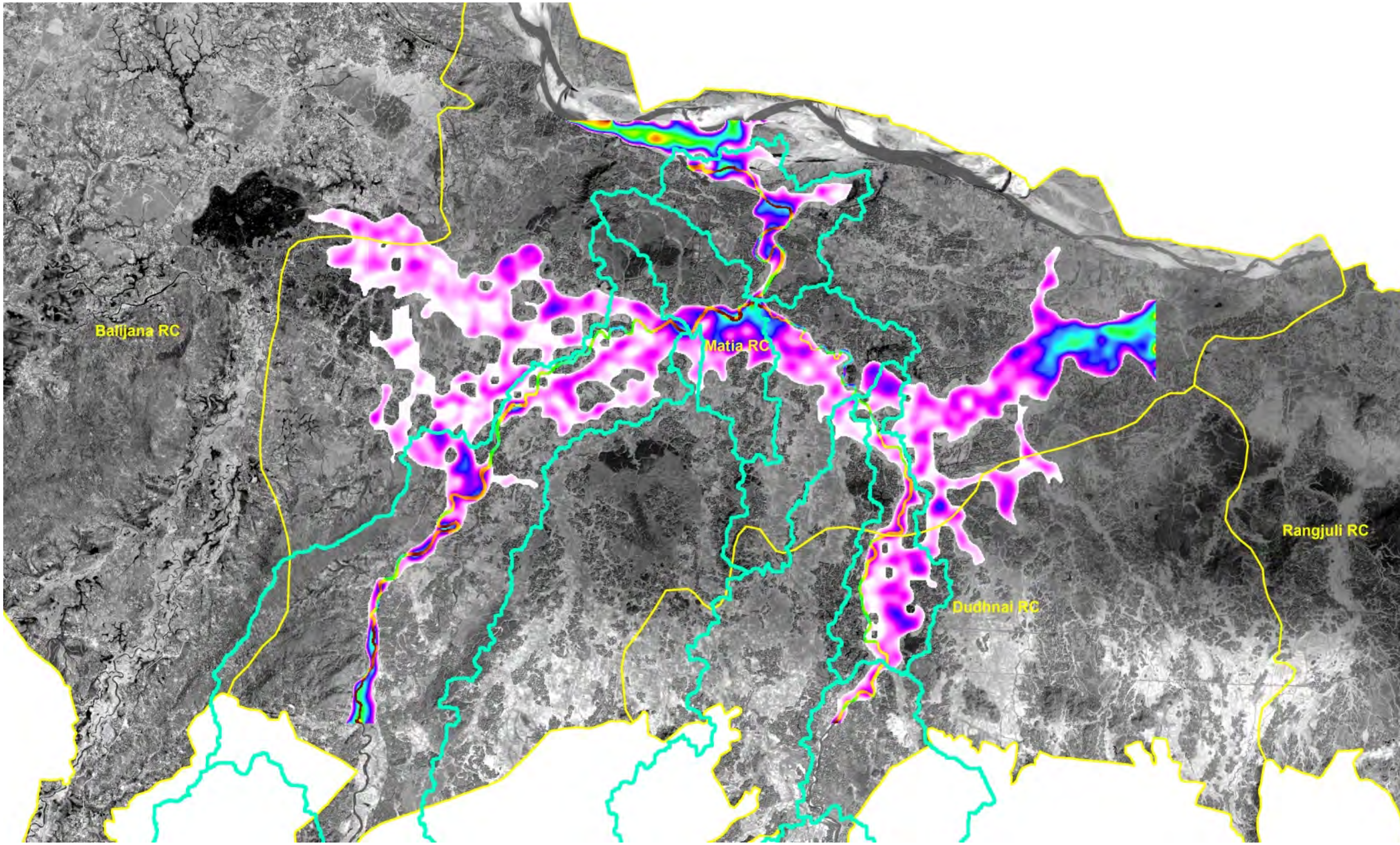




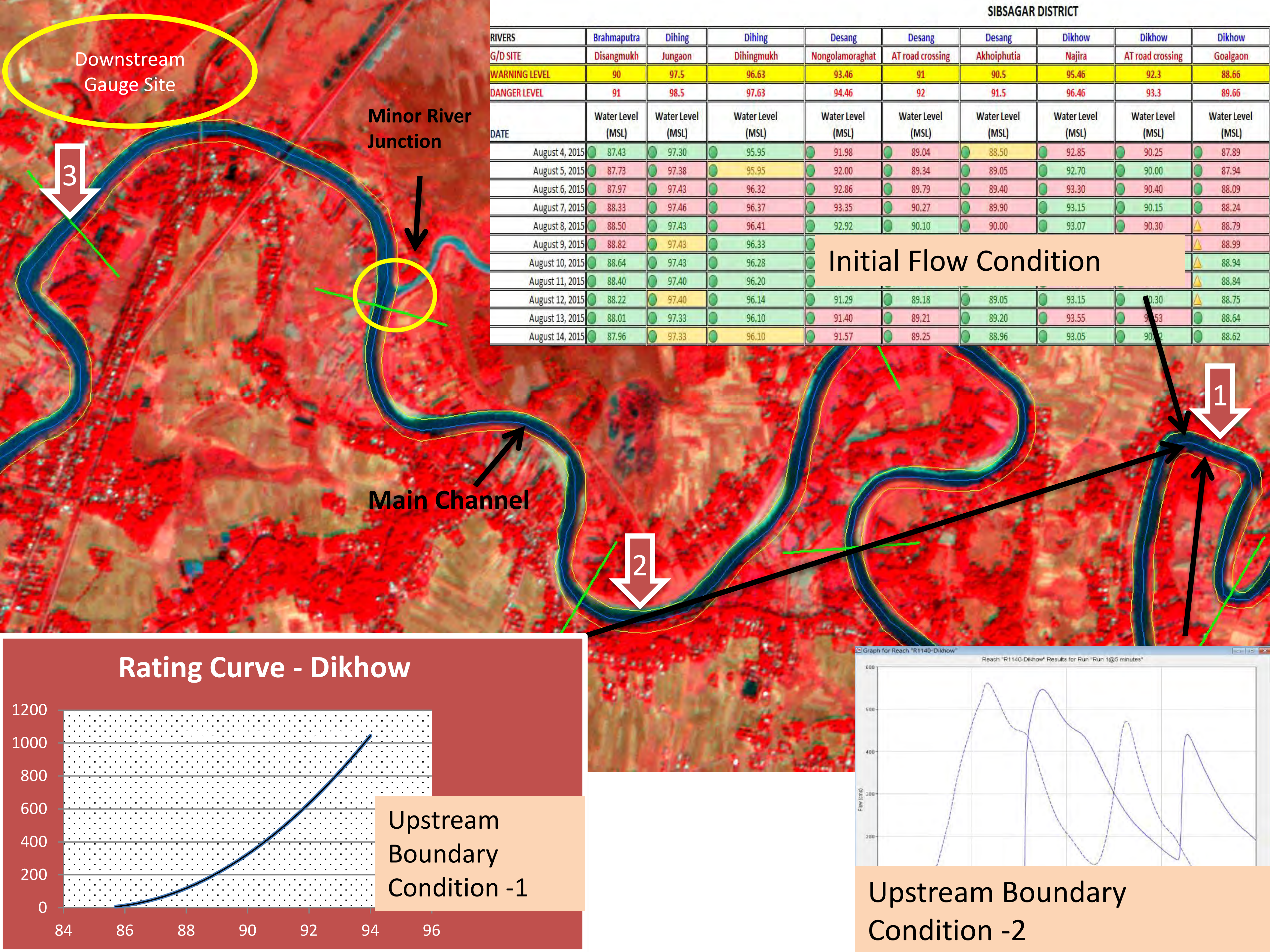
Two-Dimensional Hydraulic Simulation (Case study in Ranganadi river in Lakhimpur District, Assam)



Detailed Alert Issue using Hydraulic Models (Pilot)



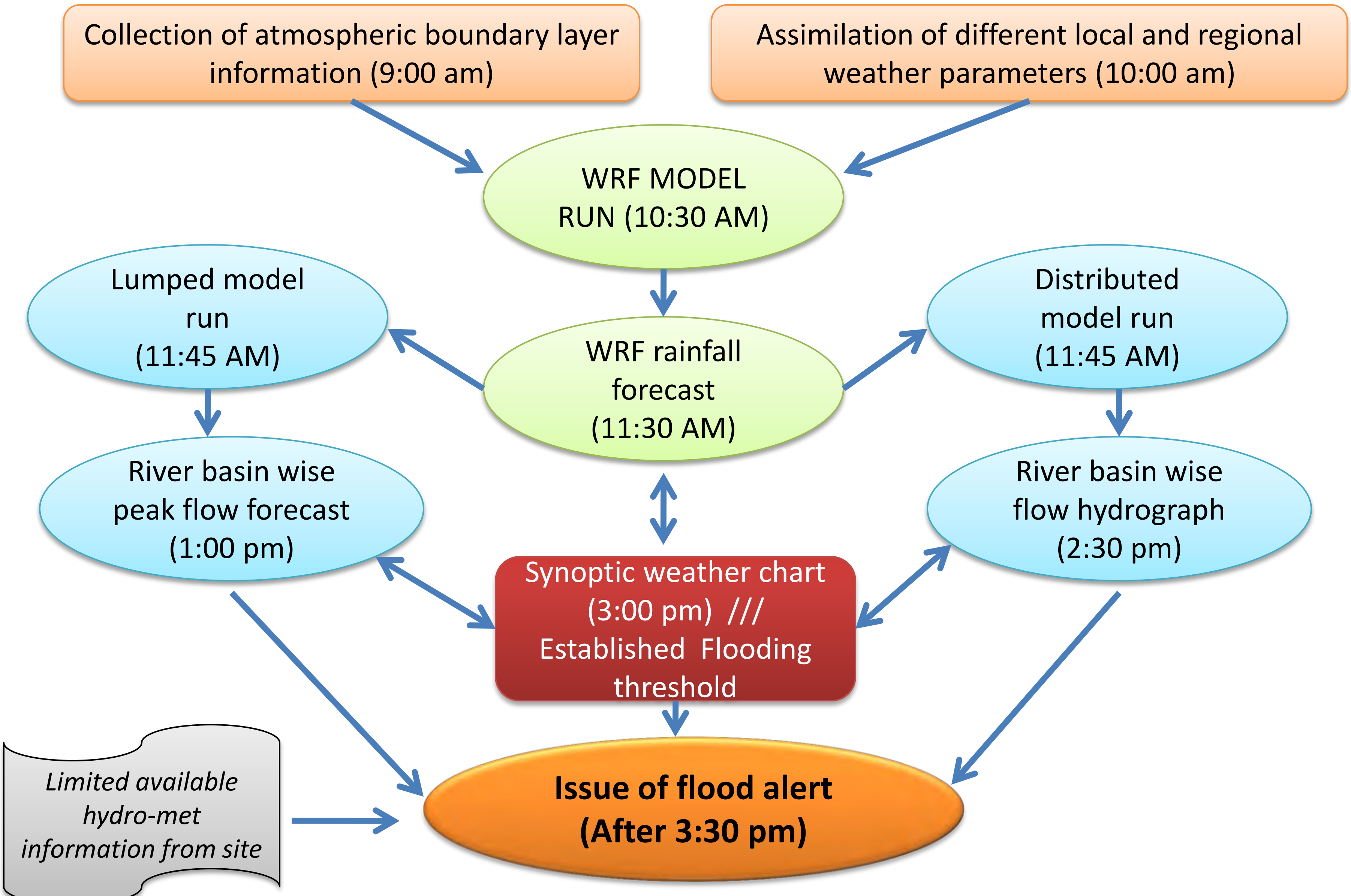
RC Level Inundation check



SIBSAGAR DISTRICT

RIVERS	Brahmaputra	Dihing	Dihing	Desang	Desang	Desang	Dikhow	Dikhow	Dikhow
G/D SITE	Disangmukh	Jungaon	Dihingmukh	Nongolamoraghat	AT road crossing	Akhoiphutia	Najira	AT road crossing	Goalgaon
WARNING LEVEL	90	97.5	96.63	93.46	91	90.5	95.46	92.3	88.66
DANGER LEVEL	91	98.5	97.63	94.46	92	91.5	96.46	93.3	89.66
DATE	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)
August 4, 2015	87.43	97.30	95.95	91.98	89.04	88.50	92.85	90.25	87.89
August 5, 2015	87.73	97.38	95.95	92.00	89.34	89.05	92.70	90.00	87.94
August 6, 2015	87.97	97.43	96.32	92.86	89.79	89.40	93.30	90.40	88.09
August 7, 2015	88.33	97.46	96.37	93.35	90.27	89.90	93.15	90.15	88.24
August 8, 2015	88.50	97.43	96.41	92.92	90.10	90.00	93.07	90.30	88.79
August 9, 2015	88.82	97.43	96.33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	88.99
August 10, 2015	88.64	97.43	96.28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	88.94
August 11, 2015	88.40	97.40	96.20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	88.84
August 12, 2015	88.22	97.40	96.14	91.29	89.18	89.05	93.15	[illegible]	88.75
August 13, 2015	88.01	97.33	96.10	91.40	89.21	89.20	93.55	[illegible]	88.64
August 14, 2015	87.96	97.33	96.10	91.57	89.25	88.96	93.05	[illegible]	88.62

Daily flow of Events leading to Issue of flood alert



ACTIONABLE ALERT FORMAT AS ISSUED

From: **FLEWS ASSAM**<flews.nesac@gmail.com>

To: asdma ghy <asdmaghy@gmail.com>,
Disaster Managememt control room <statedmcontrolroomassam@gmail.com>,
Nandita Hazarika <nandita.hazarika@gmail.com>,
b_ren <b_ren@rediffmail.com>,
Jayanta Dutta <mail2dpojayanta@gmail.com>,
P K Deka <dc-barpeta@nic.in>

FLOOD EARLY WARNING SYSTEMS (FLEWS)
NORTH EASTERN SPACE APPLICATIONS CENTRE

LOW to MODERATE Flood Alert - BARPETA

Dated : 15 August 20145(1615 hrs)

Respective All Concerned,

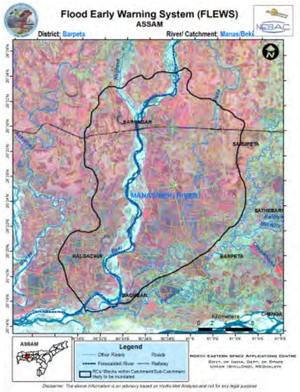
FLEWS Hydrological & Meteorological Analysis (with forecasted dataset) indicates a probable **LOW to MODERATE Flood situation** with the details specified as under:

District(s) : BARPETA
Rivers/Catchments : Beki, Pahumara, Kaldiya with SubTributaries
Revenue Circles/Blocks likely to be affected : Barpeta, Sarupeta, Baghbar, Bajali, Sarthebari,Barnagar, Kalgachia RCs
Validity : *24 - 48 hours*

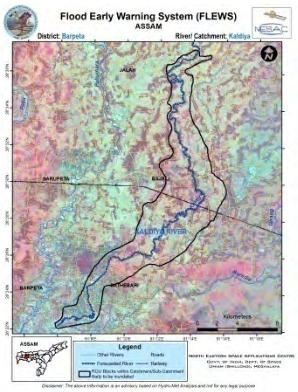
Pl refer to the attached Alert Maps for more spatial information.
This alert has the approval of Director, NESAC.

Regards,
FLEWS TEAM
North Eastern Space Applications Centre
Department of Space, Government of India
Umiam - 793 103, Meghalaya (India)

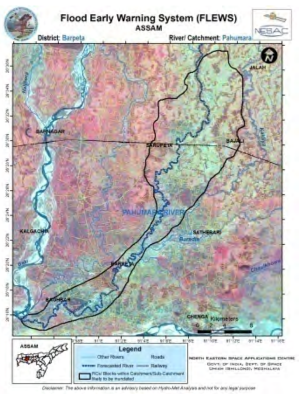
Disclaimer: The above information/advisory is based on Hydro - Met Analysis and not to be used for any legal purpose.



Beki River



Kaldiya River

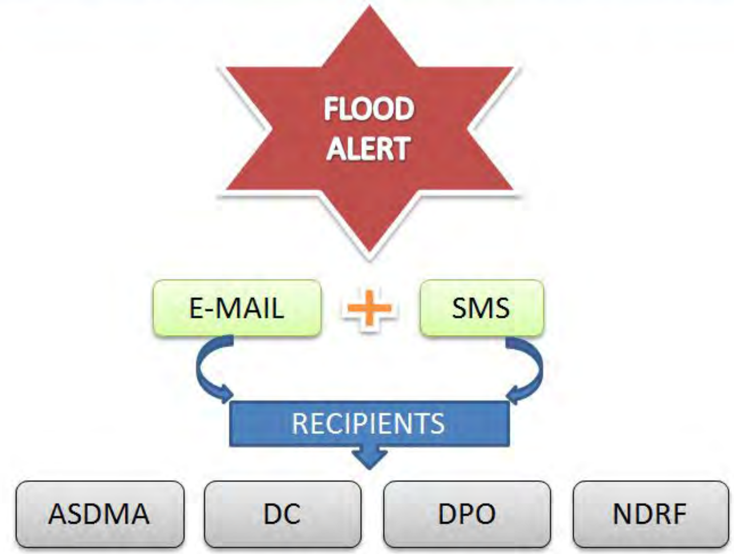


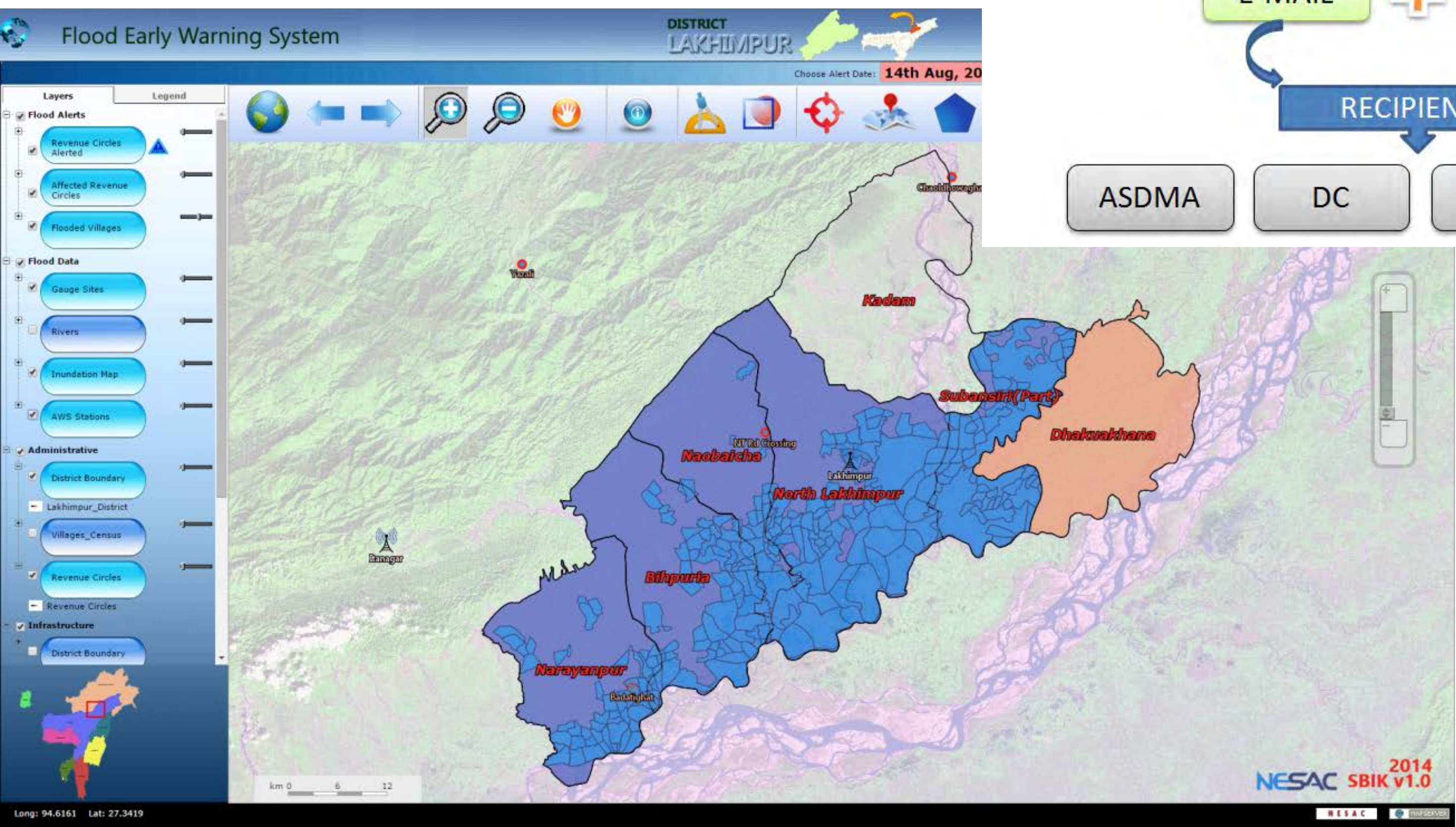
Pahumara River

ALERT DISSEMINATION MODES

- E-mails
- SMS
- Web-enabled decision support system with dynamic update interface to provide support to the user community (Planning phase)

FLOOD ALERT IN THE FORM OF GROUP SMS/E-MAILS





Government of Assam
Assam State Disaster Management Authority
FLOOD REPORT

Flood Situation as on Today i.e. 7th June , 2015

PARTICULARS	*Situation as on 7th June, 2015*		
Name of the Rivers flowing above Danger Level	Puthimari at N. H. Rd. Xing (Kamrup).		
No. of Districts Affected	06		
Name of Districts Affected	Barpeta, Sonitpur, Dhemaji, Kokrajhar, Bongaigaon, Lakhimpur		
No. of Revenue Circles affected	10		
Names of Revenue Circles affected	Barpeta	Barpeta, Sarthebari.	
	Sonitpur	Thelamara, Gohpur.	
	Dhemaji	Dhemaji, Sissiborgaon.	
	Kokrajhar	Kokrajhar, Dotma.	
	Bongaigaon	Dangtol.	
	Lakhimpur	Nowboicha.	
No. of Villages/ Localities affected	Barpeta	64	20 (Barpeta), 44 (Sarthebari).
	Sonitpur	08	06 (Thelamara), 02 (Gohpur).
	Dhemaji	11	07 (Dhemaji), 04 (Sissiborgaon).
	Kokrajhar	12	10 (Kokrajhar), 02 (Dotma).
	Bongaigaon	09	09 (Dangtol).
	Lakhimpur	04	04 (Nowboicha).

FLOOD REPORTED

Government of Assam
Assam State Disaster Management Authority
FLOOD REPORT

Flood Situation as on Today i.e. 15th June, 2015

PARTICULARS	*Situation as on 15th June, 2015*		
Rivers flowing above Danger Level	**Brahmaputra** at Nematighat (Jorhat) & at Dhubri (Dhubri) **River Jia Bharali** at N.T.Rd. Xing (Sonitpur)		
No. of Districts Affected	11		
Name of Districts Affected	Barpeta, Sonitpur, Dhemaji, Lakhimpur, Kokrajhar, Tinsukia, Darrang, Dibrugarh, Goalpara, Kamrup (Metro), Morigaon.		
No. of Revenue Circles affected	24		
Names of Revenue Circles affected	Barpeta	06	Barpeta, Sarupeta, Sarthebari, Baghbar, Chenga, Kalgachia
	Sonitpur	04	Thelamara, Tezpur, Halem, Gohpur
	Dhemaji	02	Dhemaji, Sissiborgaon
	Lakhimpur	01	Nowboicha.
	Tinsukia	01	Sadiya
	Darrang	03	Mangaldai, Patharighat, Sipajhar
	Dibrugarh	01	Dibrugarh West
	Kokrajhar	01	Bagribari
	Goalpara	03	Balijana, Lakhipur, Matia.
	Kamrup (M)	01	Chandrapur.
	Morigaon	01	Mayong.
	Total	24	

NO FLOOD REPORTED

Low Flood Alert for Kokrajhar District under NESAC & ASDMA Collaborative Flood Early Warning Project, 2015

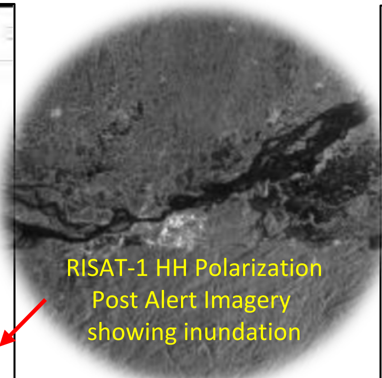
FFSA <flews.nesac@gmail.com>
to Disaster, asdma, Nandita, b_ren, bij_goswami, diganta, Amaljit, Dipima, Shyam, Rekha, Dr. Nilesh, partho, goswamikasturi., kksarma

Respected all concerned,

Our recent hydro-meteorological analysis reveals a probable "Low" flood situation as per following details.

District	Kokrajhar
Revenue Circle	Kokrajhar, Dotoma
Rivers	Gaurang, Sonkosh
Date & Time of Issue	06.06.2015; 18:50
Validity of alert	24-36 hrs

ABSOLUTE SUCCESS



Low Flood Alert for Bongaigaon District under Flood Early Warning System (FLEWS) Project, 2015

Flood Early Warning System (FLEWS), 2015 <flews.nesac@gmail.com>
to asdma, Disaster, Nandita, b_ren, anantasamant, diganta, Amaljit, Dipima, Shyam, Rekha, Dr. Nilesh, partho, goswamikasturi., kksarma

Respected all concerned,

Our recent hydro-meteorological analysis reveals a probable "Low" flood situation. as per following details:

District	Bongaigaon
Revenue Circle	Bongaigaon, Sidli (Pt),
Rivers	Manas, Aie
Date & Time of Issue	13.06.2015; 18:35
Validity	24-48 hrs

PARTIAL SUCCESS

তেজপুৰ, কোক্ৰাঝাৰ, বঙাইগাঁও, বৰপেটাত বান

FLOOD REPORTED

Validation of issued flood alerts from multisource information

RISE IN WATER LEVEL (ABOVE DL)

Daily water level ... under Bongaigaon

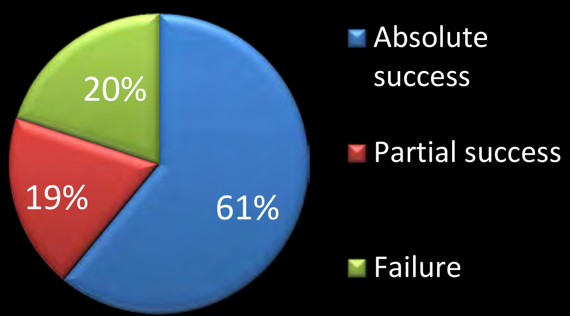
Rivers/ Date		AIE RIVER	AIE MANAS	Ph. No.	03678-241341	Rising
WARNING LEVEL		43.67	37.84		Below WL	Falling
Danger Level	36.27	44.67	38.84		Above WL	Steady
DATE	Water Level (MSL)	Water Level (MSL)	Water Level (MSL)		Above DL	
G/D SITE						
June 12, 2015	35.91	44.67	38.31			
June 13, 2015	35.97	44.77	38.31			
June 14, 2015	35.77	44.65	38.47			
June 15, 2015	35.44	44.82	38.41			

ADVANTAGES OVER CONVENTIONAL METHODS OF FLOOD WARNING

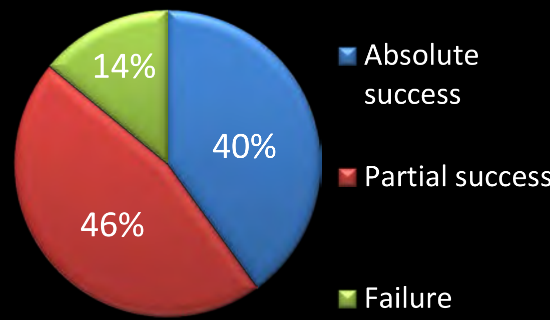
FLEWS Flood Alerts	Conventional Flood Alerts
Based on basin scale hydro-met rainfall and stream flow forecasting	Based on in-situ river level observations in real-time. Basically a now-casting
Improved flood forecast lead time due to use of forecasted rainfall from WRF model	Flood forecast lead time is less as based on real time river level data
River wise flood plain is considered while issue of alert for all major rivers of Assam	Forecasting station based alert only in few major rivers
Un-gauged rivers can be addressed	Only limited gauged rivers are addressed
Hydrological routing is done with effect of time lag	No routing is done
Flood alert is issued with district and revenue circle information	Flood alert is issued for a particular river station with no information on area of influence
Annual embankment breach monitoring is done as an additional service	No such monitoring of embankments

SUCCESS STORY & RECOGNITION

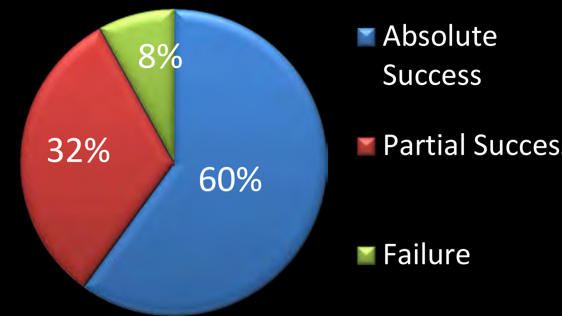
Alerts issued: 2012



Alerts: issued 2013



Alerts Issued: 2014



Note: Partial success is the rise in river level without reported inundation

FLEWS Technical training provided to Disaster Managers from all NER States under state level capacity building initiatives

AWARDS & RECOGNITIONS:

- **Winner of e-North East Award, 2013 in the category of e-Governance and Citizen Services Delivery.**
- **Declaration as "a good governance practice & funding for professional documentation" by the Department of Administrative Reforms under Ministry of Public Grievances & Pensions, Govt. of India in the year 2012.**
- **Short listed as a finalist for Prime Minister's award for innovations in 2012**
- **Several parliament questions have been answered till date on the feasibility of FLEWS implementation in other parts of the country.**

- **All flood prone districts of Assam covered in 3 years of operational existence**
- **Average percentage of annual alert success is 75% with lead time ranging from 12-36 hours**
- **Different Hazard zones created from hydrologic and hydraulic assessment**
- **Various Review meetings reflects user comments on reduction of loss of life**

An innovative approach to Flood Hazard Zonation

Flood Hazard/Risk Zonation – Why ?

For effective regulation of human interferences in flood plain areas for mitigating flood damages

To identify active flood plain areas for planning of flood mitigation measures

To assess the flood risk associated with various parts of a floodplain by incorporating socio-economic vulnerability

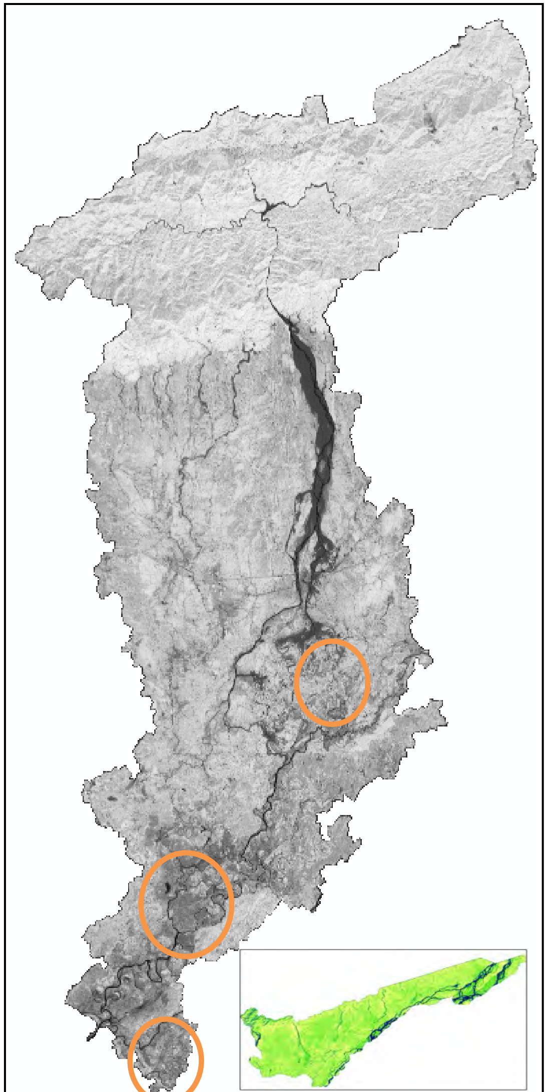
Flood hazard zonation – How ?

By mapping of periodic flood inundation over a good number of years (Statistical)

By hydraulic inundation simulation model over flood plain topography

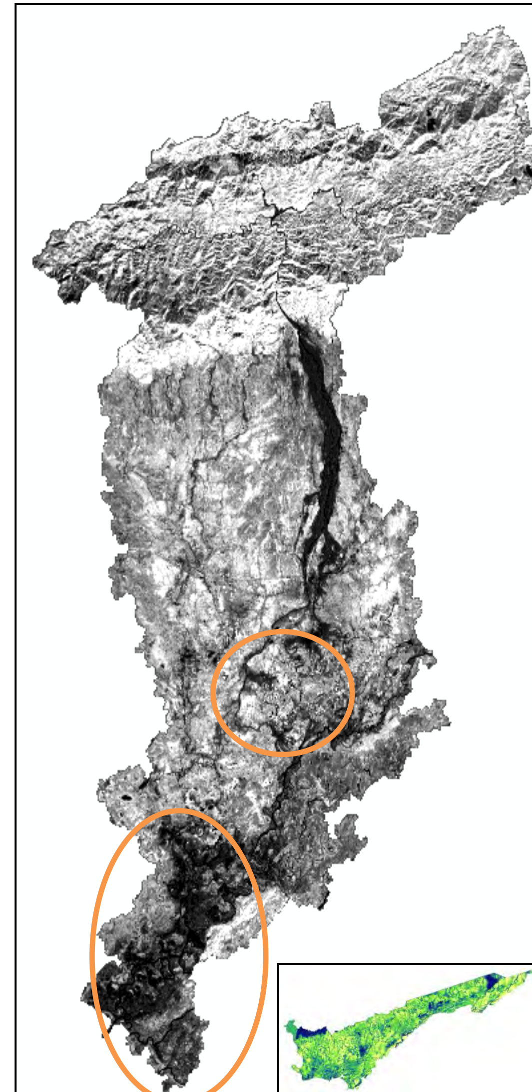
Multi criteria analysis using geospatial techniques for determination of areas with potential hazards

Active floodplain depicted by NDVI and NDMI as the indices based FHZ

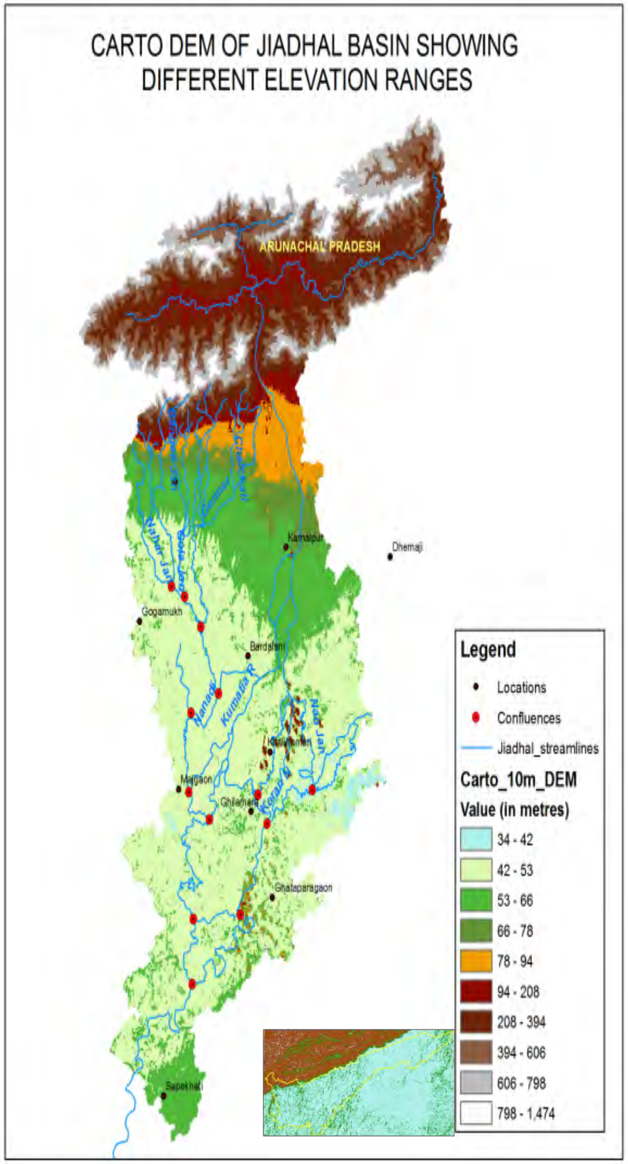


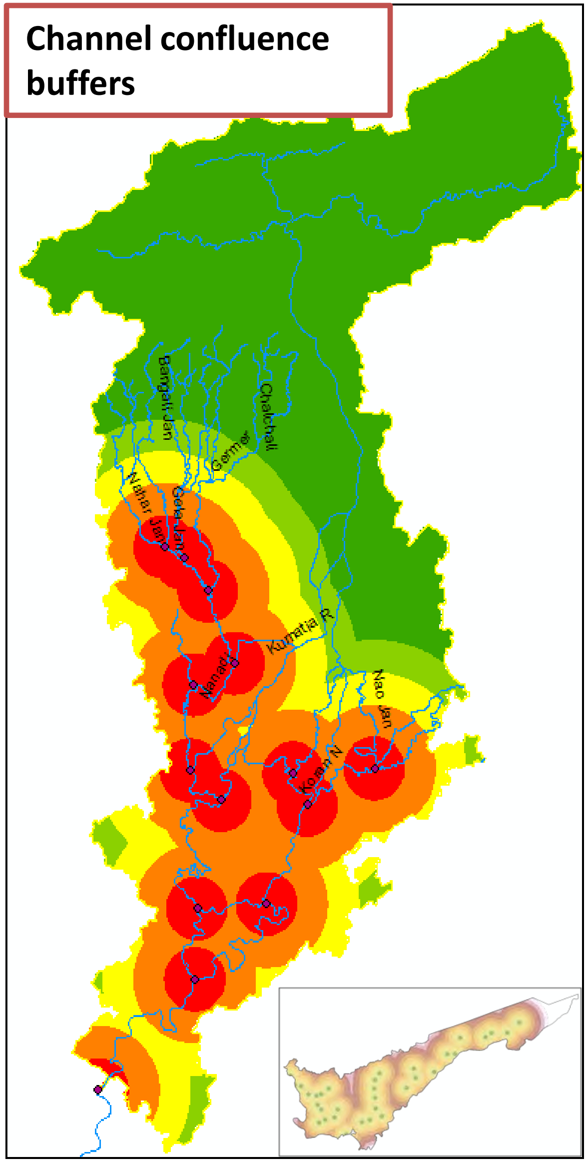
$$\text{NDVI} = \frac{NIR - R}{NIR + R}$$

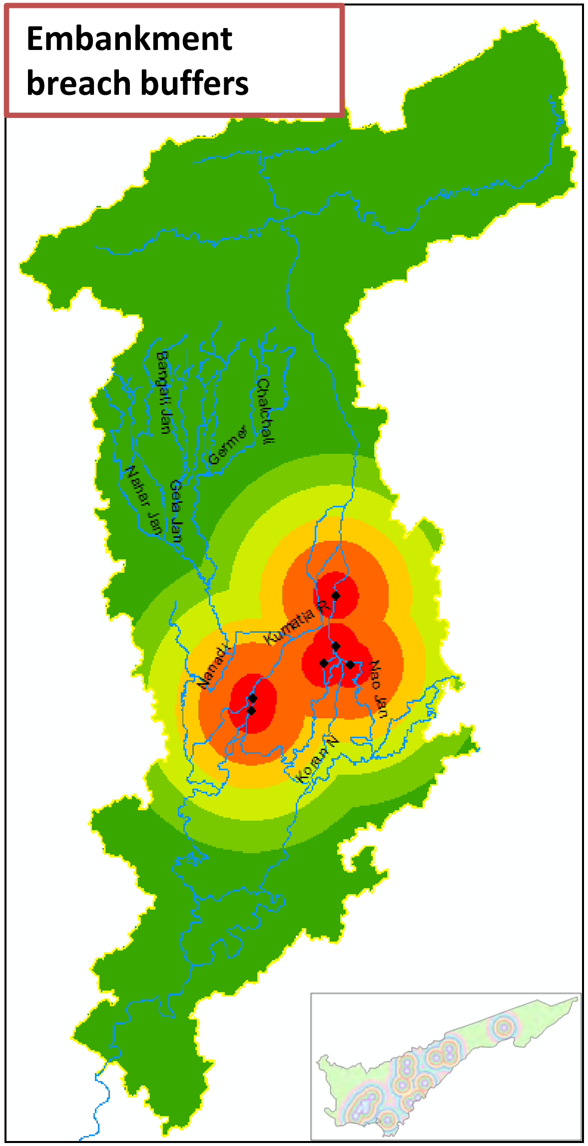
$$\text{NDMI} = \frac{IR - SWIR}{IR + SWIR}$$



The three field based hazard zonation criteria







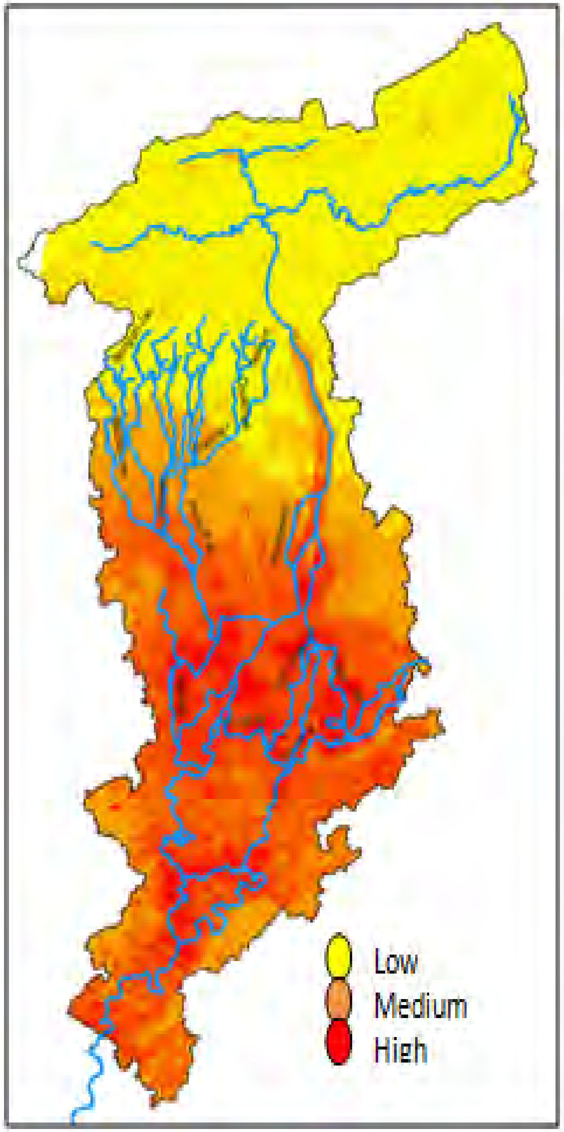
Multi-criteria Weightage allocation for FHZ

Criterion	Low (1 & 2)	Medium (3)	High (4 & 5)
Elevation	h > 90m	80m < h < 90m	h < 80m
Proximity to Confluence	d>6km	4km < d < 6km	d < 4km
Proximity to Breach	d > 5km	3.5 km < d < 5km	d < 3.5 km
NDVI	0.5 to 1	0.36 to 0.5	-1 to 0.36
NDMI	0.05 to 1	- 0.04 to 0.05	- 1 to -0.04
Total	0 to 10	10 to 15	15 to 25

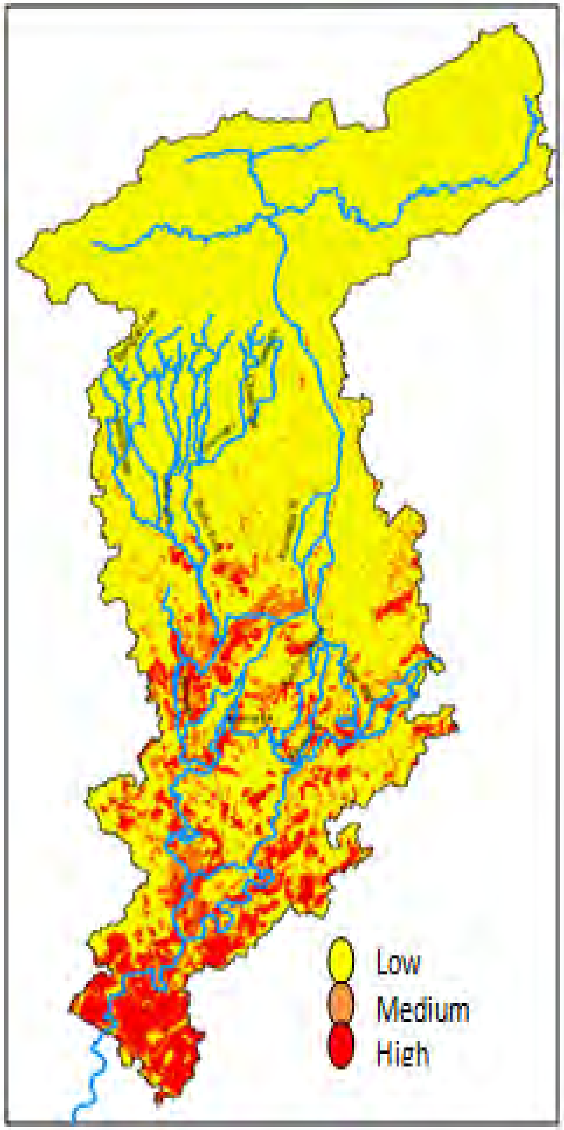
For ground validation with 10 year inundation data

No. of times flooded	Hazard
1 -- 3	Low
4 – 6	Medium
7 – 10	High

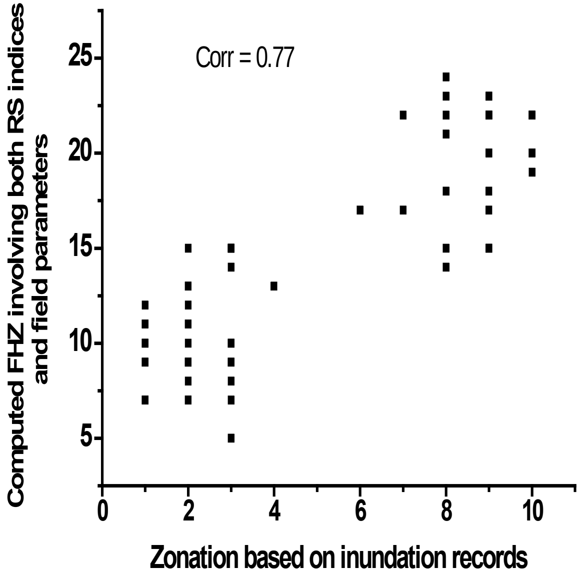
Jiadhal river whole floodplain with all criteria

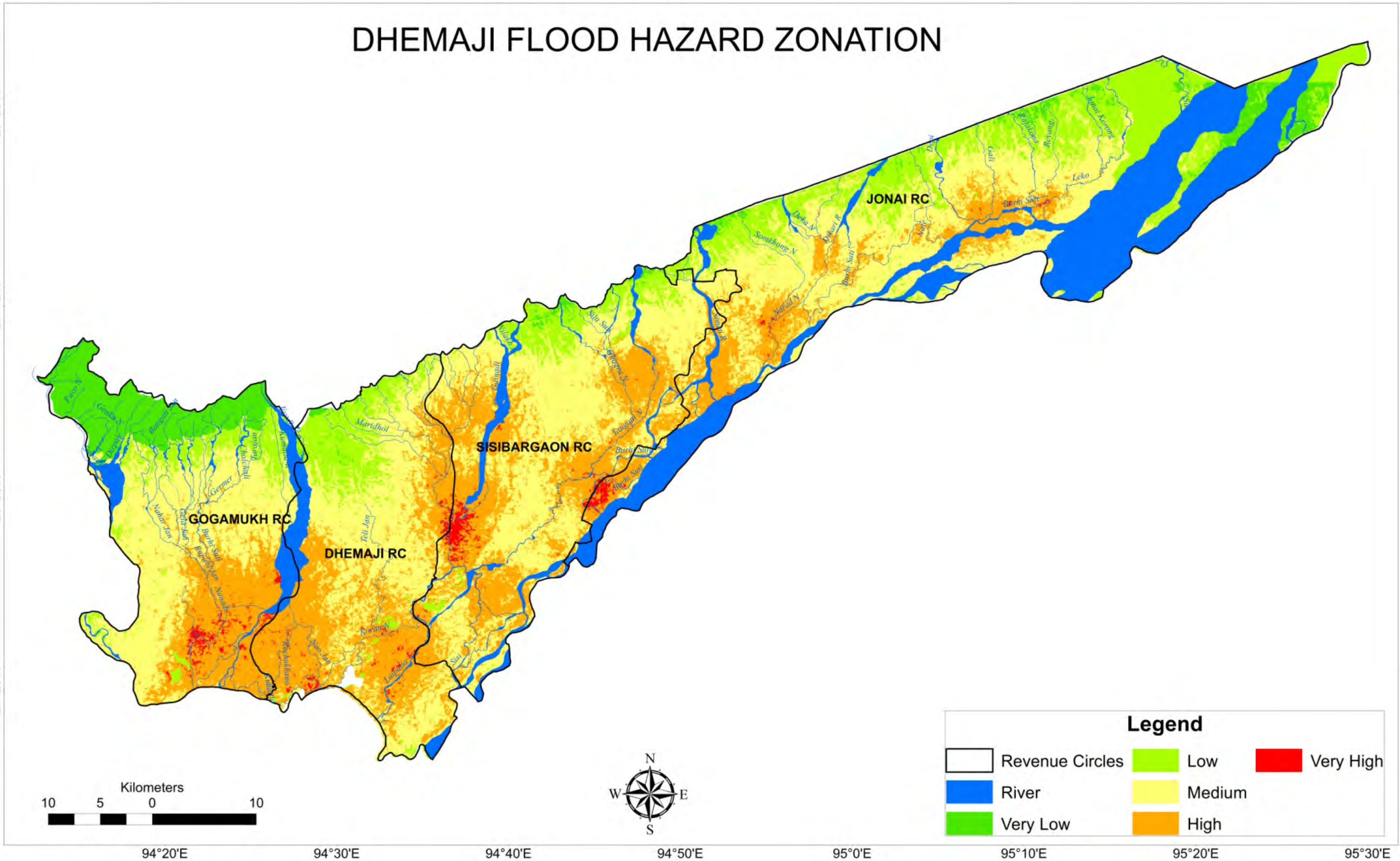


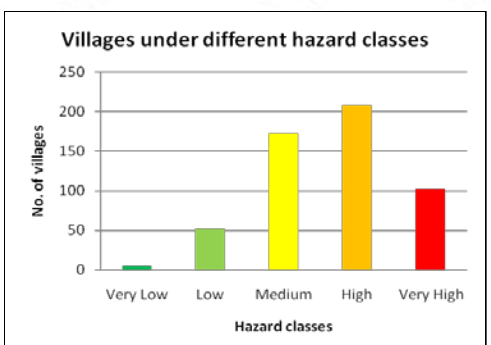
Multi-criteria FHZ

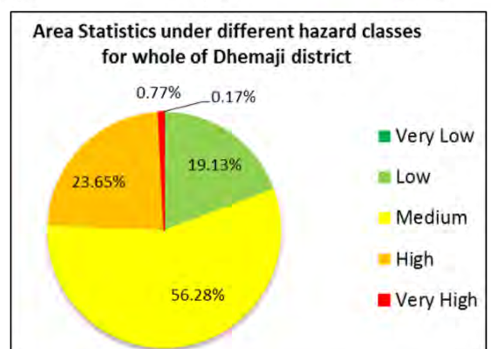


Historical inundation




DHEMAJI FLOOD HAZARD ZONATION
JONAI RC
SISIBARGAON RC
GOGAMUKH RC
DHEMAJI RC
Legend
Revenue Circles
River
Very Low
Low
Medium
High
Very High
Kilometers
10 5 0 10
N
W
E
S
27°50'N
27°40'N
27°30'N
27°20'N
94°20'E
94°30'E
94°40'E
94°50'E
95°0'E
95°10'E
95°20'E
95°30'E


Villages under different hazard classes
No. of villages
250
200
150
100
50
0
Very Low
Low
Medium
High
Very High
Hazard classes


Area Statistics under different hazard classes for whole of Dhemaji district
0.77%
0.17%
19.13%
23.65%
56.28%
Very Low
Low
Medium
High
Very High

Conclusions of multi criteria FHZ

In absence of precise **close contour information (a major handicap for 2D inundation simulation)**, **this multi criteria FHZ is a viable alternative** for identifying the degree of hazard associated with different parts of a flood plain as an input to flood plain regulation and management planning

The field parameters based FHZ approach may be concluded to be more robust than the RS indices based approach as it is based on the **morphological genesis of flooding in a floodplain**. The RS indices based approach performs particularly well in frequently flooded areas only irrespective of the causal factors

The FHZ by combination of both set of parameters also gives satisfactory results if the floodplain is considered as a whole

The scale of the multi-criteria FHZ is dependant primarily on the scale of input geo-spatial datasets

The new methodology that has been tried will be **a very cost effective geospatial technique for flood hazard zonation in alluvial floodplains** of Brahmaputra and other similar river valleys and may prove to be a valuable input for flood management for planners and decision makers

Major bottlenecks in developing a even better state of art system

Problems	Probable Solutions
Vertical resolution of the topography data of the flood plains and river bathymetry	Fine beam DEM generation by either LIDAR or SAR interferometry in order to achieve contour intervals of 30 to 80 cms + regular cross section survey by the custodian agencies
Calibration and validation of both the hydro and the met model associated with flood forecasting	A robust discharge collection network. The custodian agencies urgently needs to transform their "Gauge only" sites to at least Gauge & Discharge sites///// Similarly automated Met station density to be increased as per WMO guidelines
Inter agency sharing of data	A dynamic hydro-met data infrastructure in high resolution GIS domain to be shared freely among stake holder technical groups with restricted user access protocol through MOUs

Few issues on capacity building

What do we want ? ? A one time exercise or a sustainable process of development

Have we selected the right manpower ??

Is training programmes are customized to our need ??

Do we have adequate data to fit into these sophisticated softwares............ What about processing speed during disaster ??

Why not a small pilot exercise ??

The NESAC, Shillong

diganta_isro1@yahoo.co.in
diganta.barman@nesac.gov.in
Mob:+91-94350-10504

Thank you all

Major areas of activities

- RS & GIS
- Space and Atmospheric Science
- SATCOM
- NER-DRR

Cell Phone Data Analysis for Flood Risk Management

Presenter: Dr.Apichon Witayangkurn

Prof. Ryosuke Shibasaki, Dr. Wataru Ohira, Dr. Masahiko NAGAI, Dr. Ayumi Arai

Center for Spatial Information Science,
the University of Tokyo, Japan
apichon@iis.u-tokyo.ac.jp

CSIS 東京大学 空間情報科学研究センター
Center for Spatial Information Science The University of Tokyo

THE UNIVERSITY OF TOKYO

Flood in Bihar

Map of Flood Water over the Affected State of Bihar, India

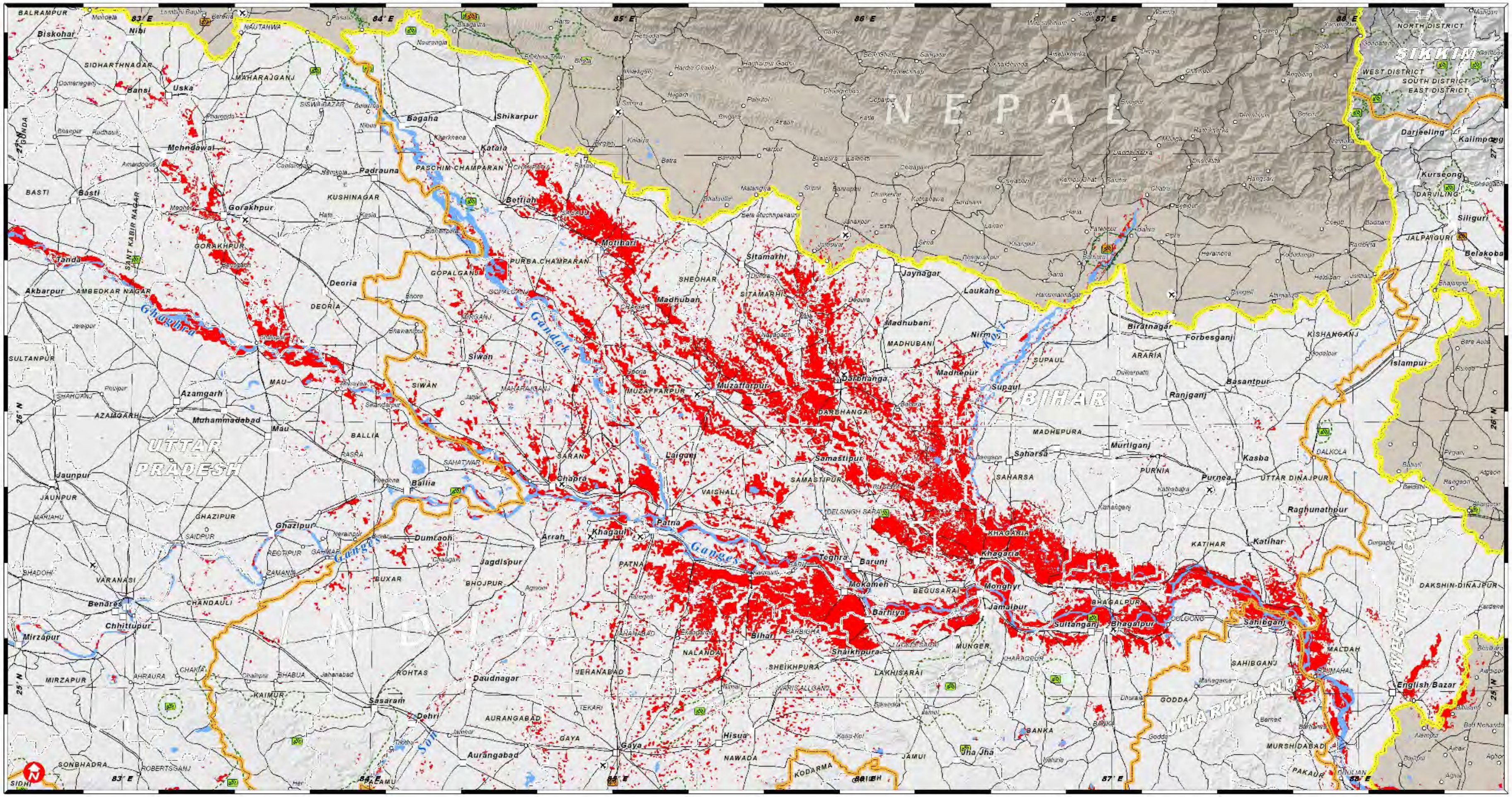
Flood Detection with MODIS Terra & Aqua Imagery Recorded on 22 August 2007

Flood Event July-August 2007

24 August 2007

Version 1.0

Glide No: FL-2007-000096-IND



Map Information

This map illustrates satellite detected flood water over the affected state of Bihar, India. Those areas likely covered with flood water as of 22 August 2007 are shown in red and are distinguished from pre flood water levels (in blue) as measured for 1-10 May 2007. This is a preliminary analysis and has not yet been validated in the field.

The depiction and use of boundaries, geographic names and related data shown here are not warranted to be error-free nor do they imply official endorsement or acceptance by the United Nations. This map was produced by the United Nations Institute for Training and Research (UNITAR) Operational Satellite Applications Programme (UNOSAT). UNOSAT provides satellite imagery and related geographic information to UN humanitarian and development agencies and their implementing partners.

Symbol Legend

Capital
Large City or Town
Village / Town
Airfield
Spot Height (m)
Flood Water (22 Aug 2007)
Pre-Flood Water (1-10 May 2007)
World Heritage Site
National Park / Natural Monument
National Park Boundary
International Border
State Boundary
District Boundary
Main Road
Secondary Road / Track
Railroad

PLACE NAMES

INDIA ..... Country
GOSTIVAR ..... State
LAKHIMPUR ..... District
DHAKA ..... Capital
Shillong ..... Large Town or City
Mutah ..... Town or Village
Ganges ..... River / Lake

Map Scale for A2: 1:1,100,000

1 Centimeter = 11 Kilometers

Kilometers: 0 10 20 40 60 80

Miles: 0 4.5 9 18 27 36 45 54 63

Contact Information: info@unosat.org
24/7 Hotline: +41 76 487 4998

Satellite Data .... MODIS Terra & Aqua (NASA)
Image Resolution .... 250m - 500m
Image Dates .... 1-10 May 2007, 22 August 2007
GIS Data .... USGS, NGA, UNJLC, WDPA
Population Data ..... LandScan 2004
Elevation Data .... SRTM (90m) - NASA
Flood Analysis ...... UNOSAT
Map Production .... UNOSAT (22 August 2007)
Projection .... Lambert Conformal Conic (WGS 1984)

UNOSAT
satellite imagery for all
www.unosat.org

Information on
People Distribution/Movement
“Where, How many ”
is an significant factor for
Flood Risk Management

Where is the effected area?

Shafiqul Islam/WPN

How many effected? And where they go?

Can we warn them before?

But,
Information on People Distribution/Movement is NOT sufficient.

- Population Census conduct every 5 -10 year.
- Questionnaire based survey
- It did not reflect real/current population.
- No dynamic movement of people at specific time/event

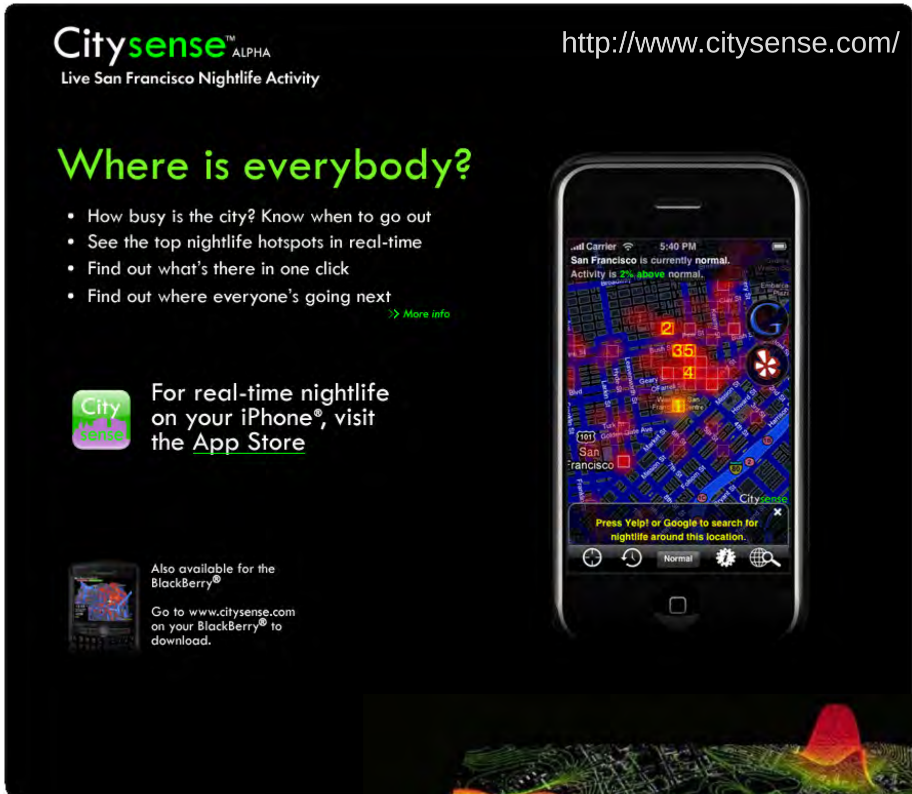
Proposed Solution

1. Estimating People Distribution/Movement with data from Cell Phone System to better understanding behavior and activity of people during flood (CDR data analysis)

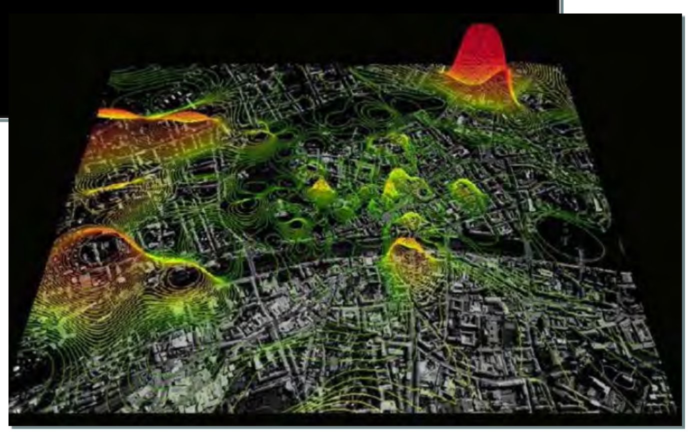
2. Deploying location-based warning system to people in possible effected area (SMS via operator)

More than 6 billion cellular phones

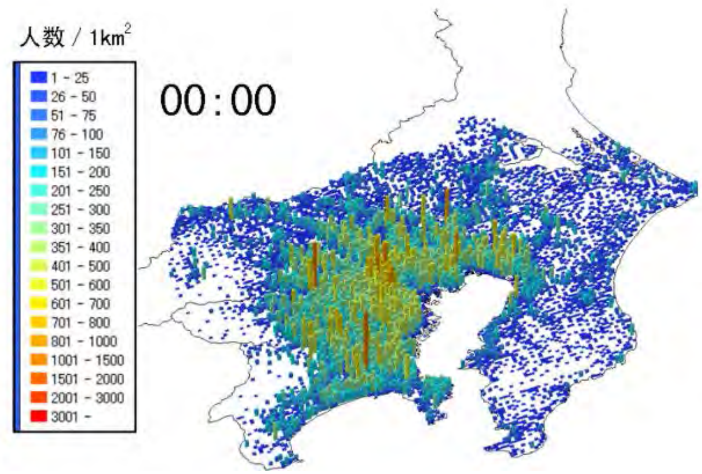
Mobile Phone as Human sensors



http://urban.cens.ucla.edu/



http://senseable.mit.edu/



http://shiba.iis.u-tokyo.ac.jp

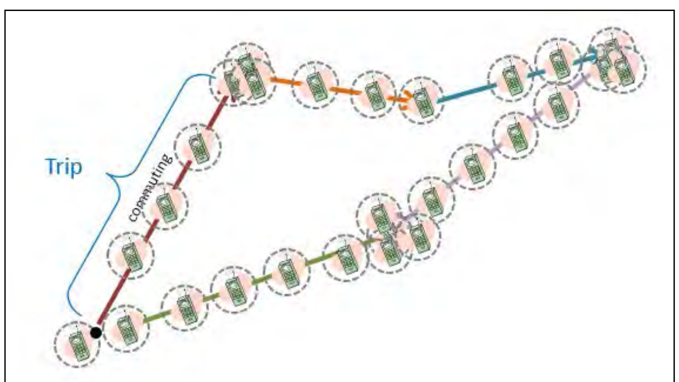
http://www.unglobalpulse.org/about-new

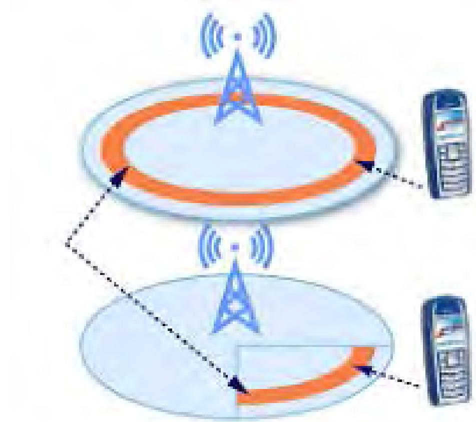
Localization of a Hand-set in Mobile Network

GPS

Location: <good>
10 m.– 200m.

- High frequency (1s – 5mins)
- Precise position accuracy
- Need to embed location data transmission software

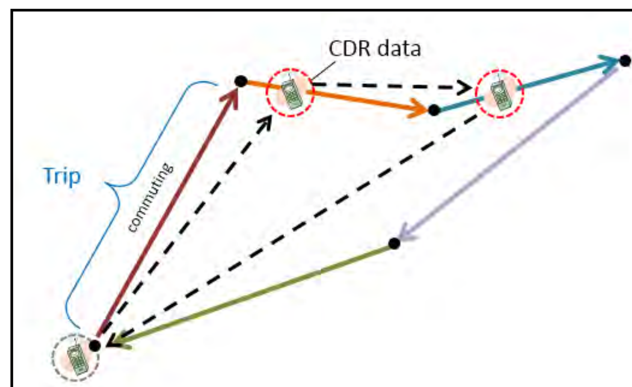




CDR:
Call Detail Record

Location: <coarse>
100 m.– 4km.

- Cell Tower Location
- Only when make a call, SMS, Data
- All hand-sets can be covered without any additional software for hand-sets.
- Available everywhere, Mobile Operator



Mar.11 2011, Japan

Big data of people flow (GPS)

Localization of a Hand-set in Mobile Network

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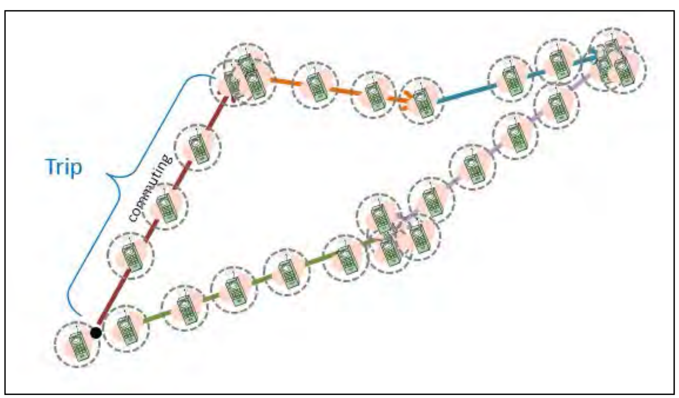

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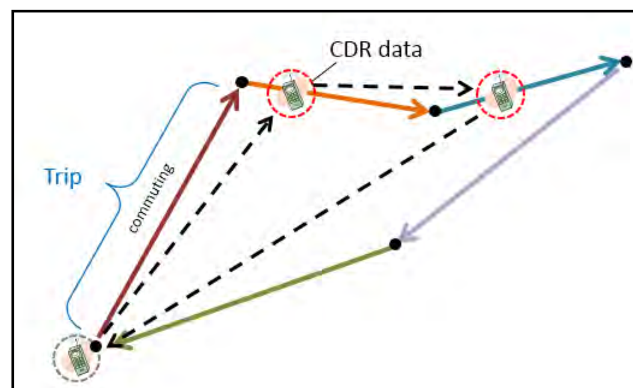
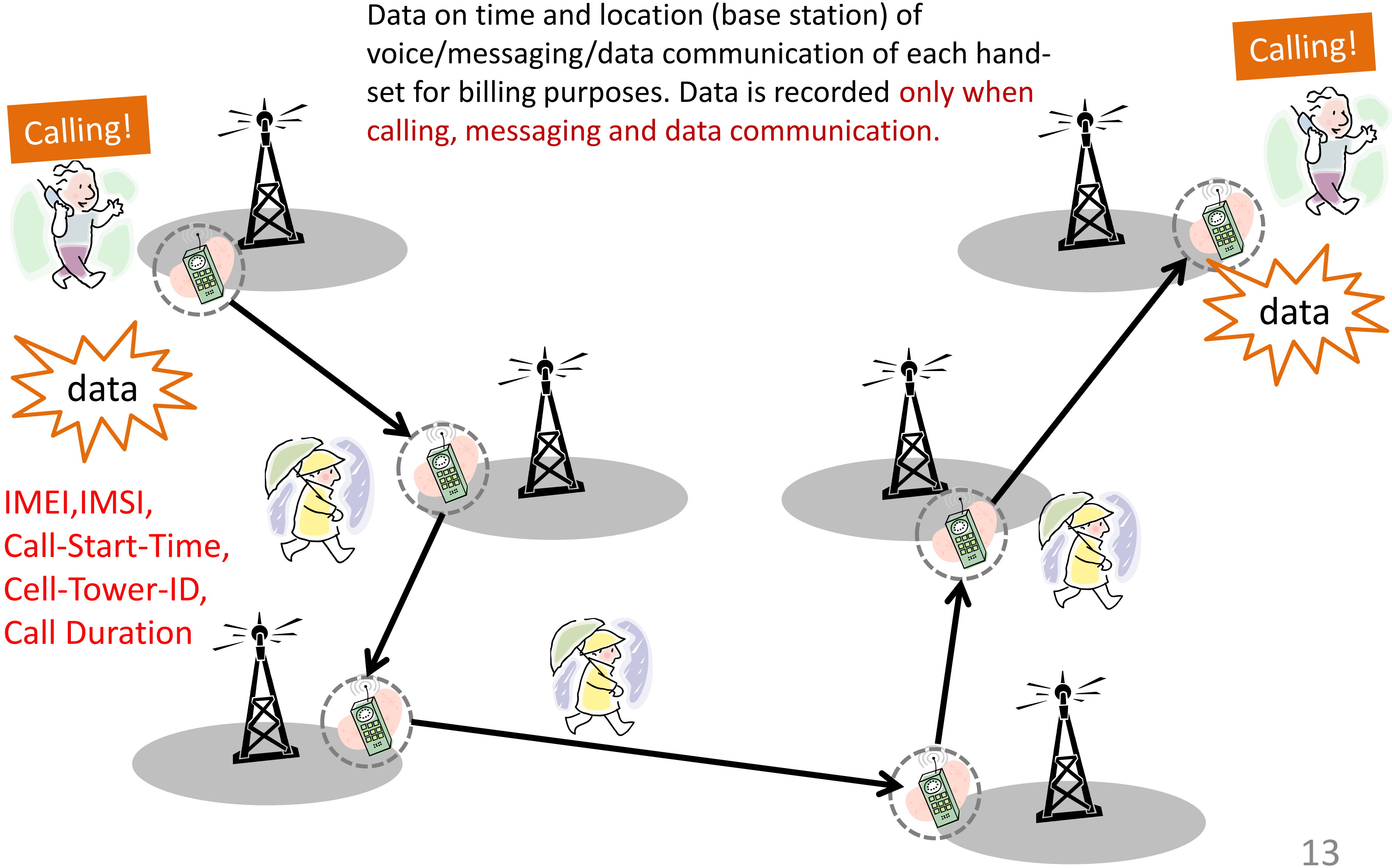


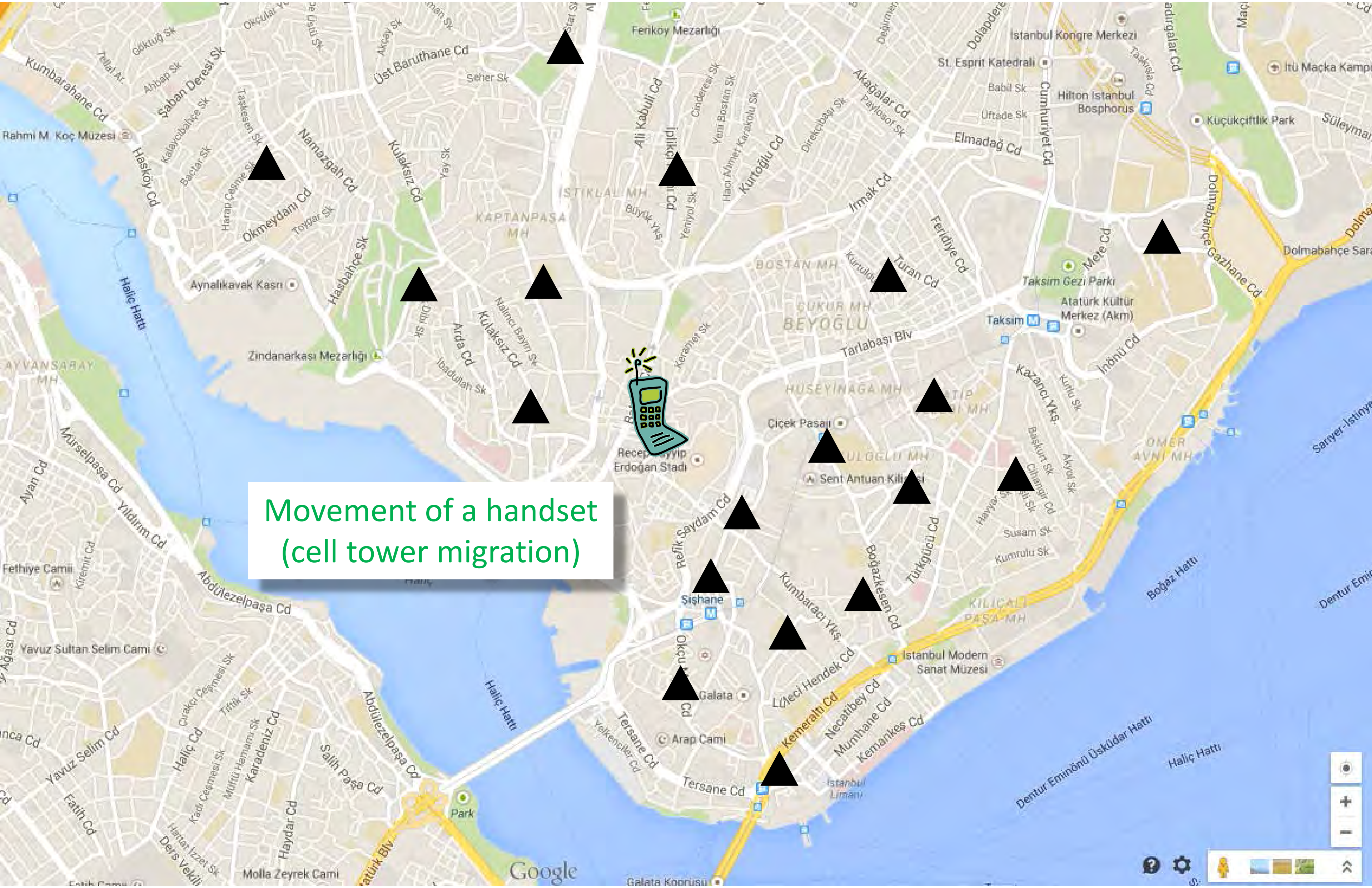
CDR(Call Detail Record) data

Data on time and location (base station) of voice/messaging/data communication of each hand-set for billing purposes. Data is recorded only when calling, messaging and data communication.

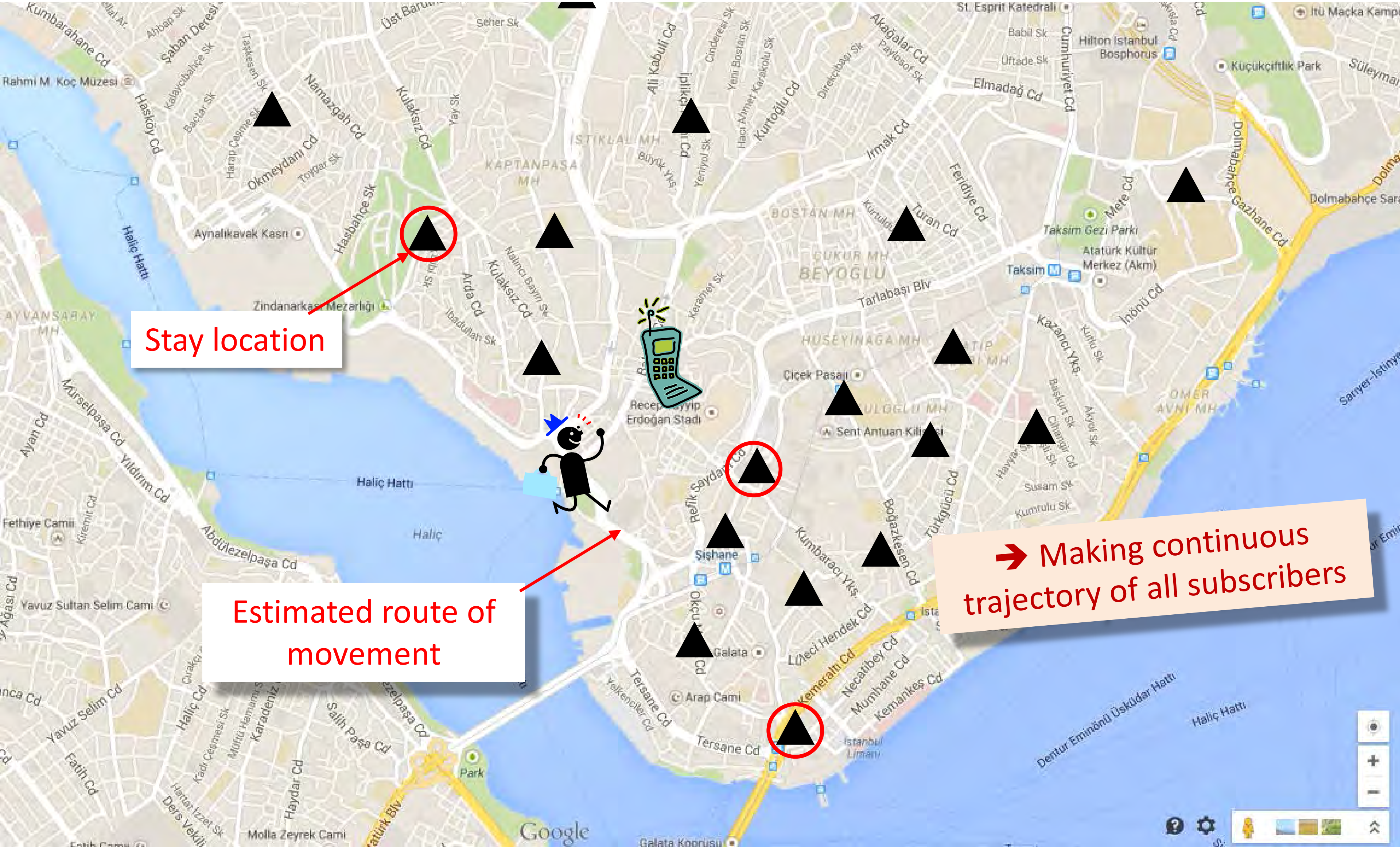


Big data of people flow (CDR)

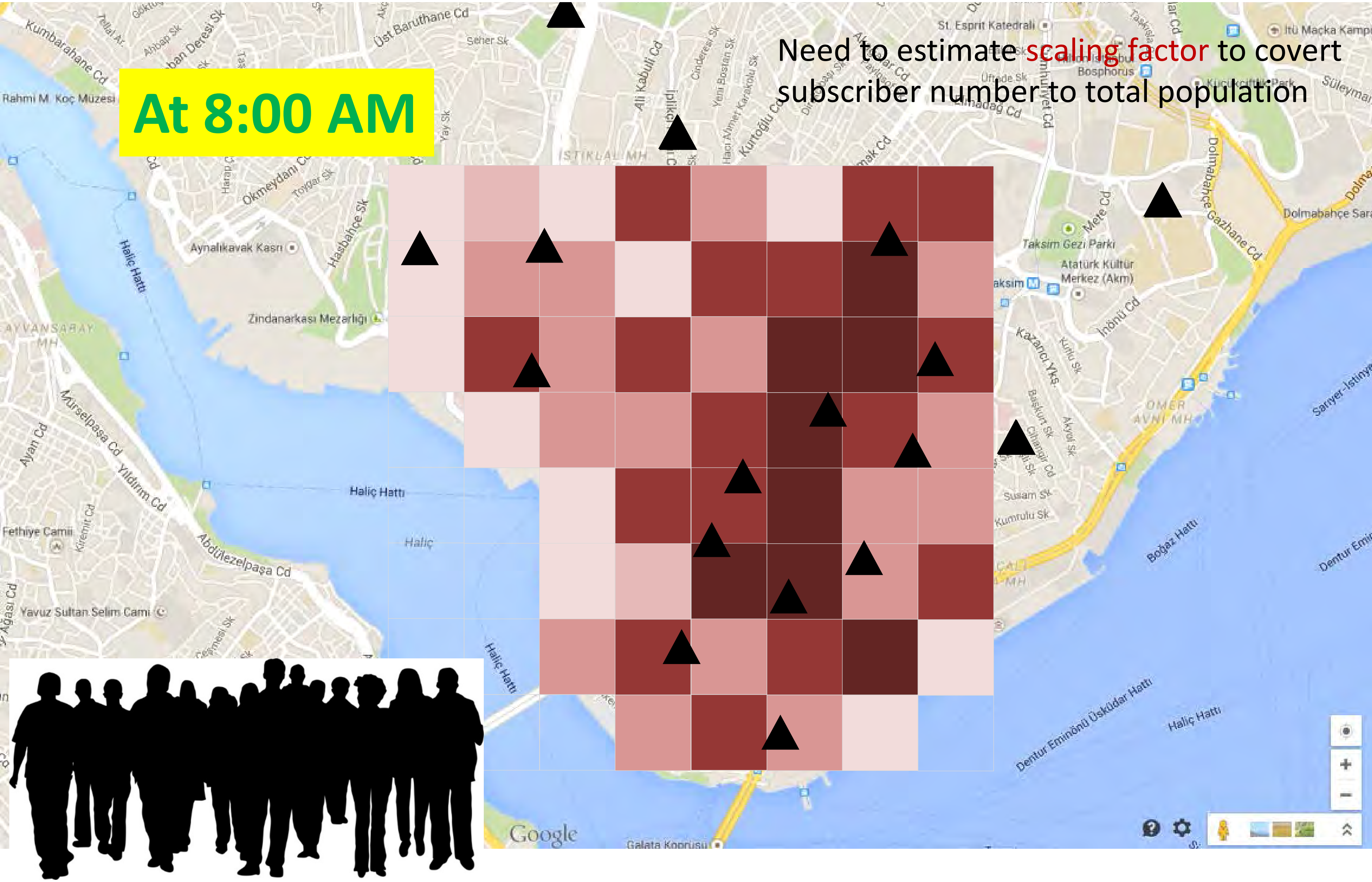
Mapping the Movement of a Handset from CDR data



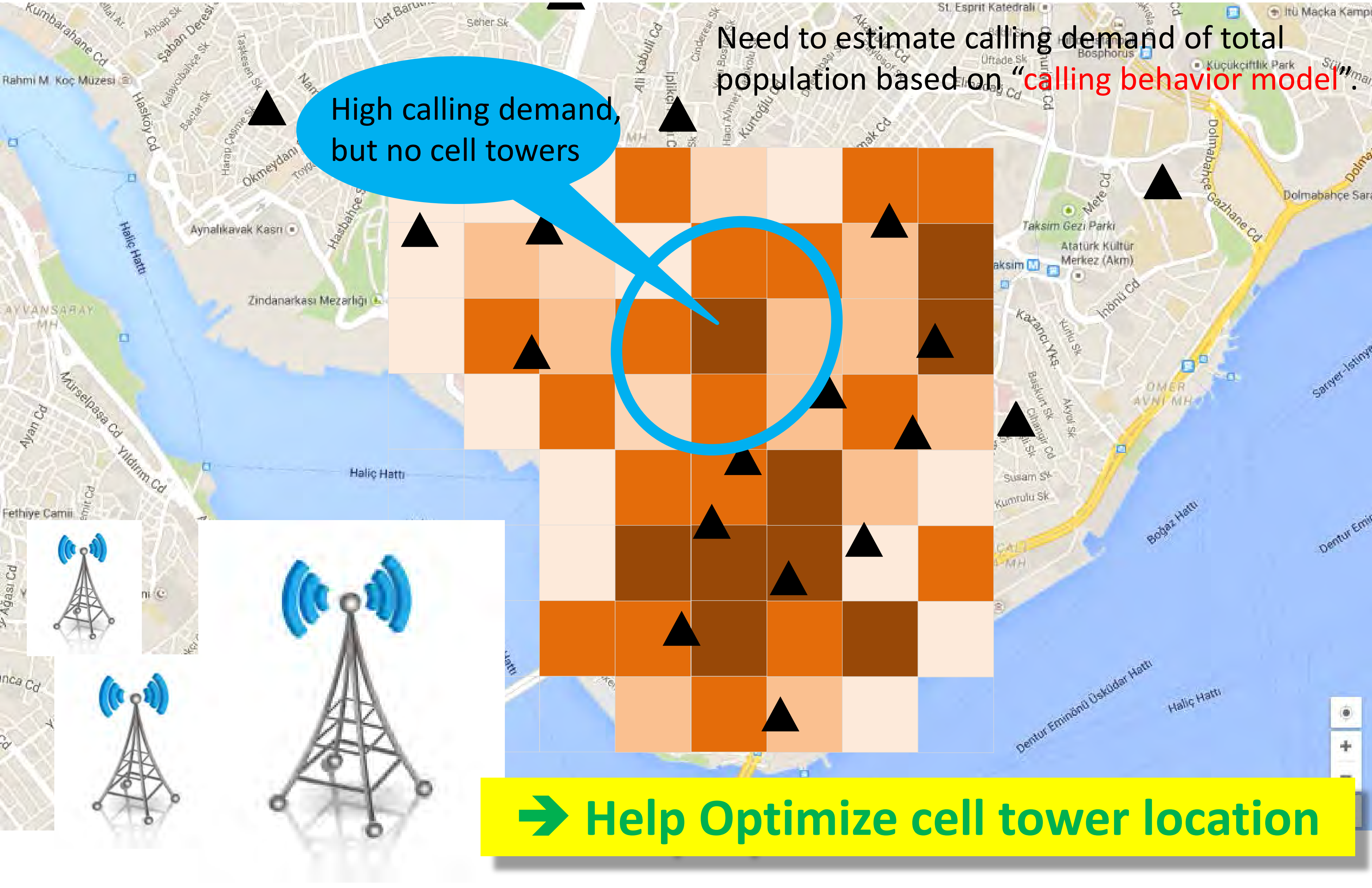
Estimating Movement Route/Stay Locations of a Subscriber from The Movement of The Handset



Estimating Population Density
by Aggregating number of people in a grid-cell at a Specific Time.



Estimating Calling Demand Density at a specific time by using population density and calling frequency.

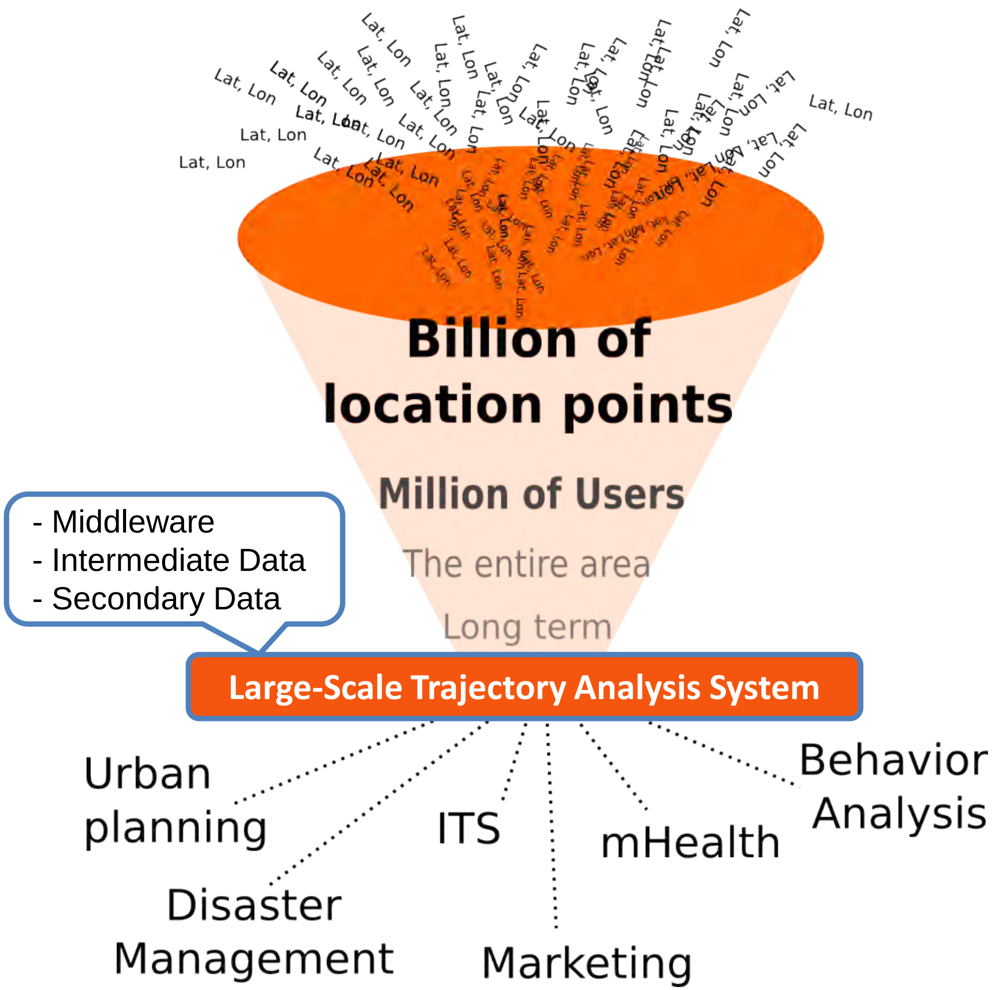


Limitation of CDR

- Not all movements are recorded.
- Representing only a part of total population (i.e. cell phone users)
- Anonymized (No demographic attributes)
- Data is too BIG (billion of records)

Big Data Analysis

- A lot of benefits / Large scale data



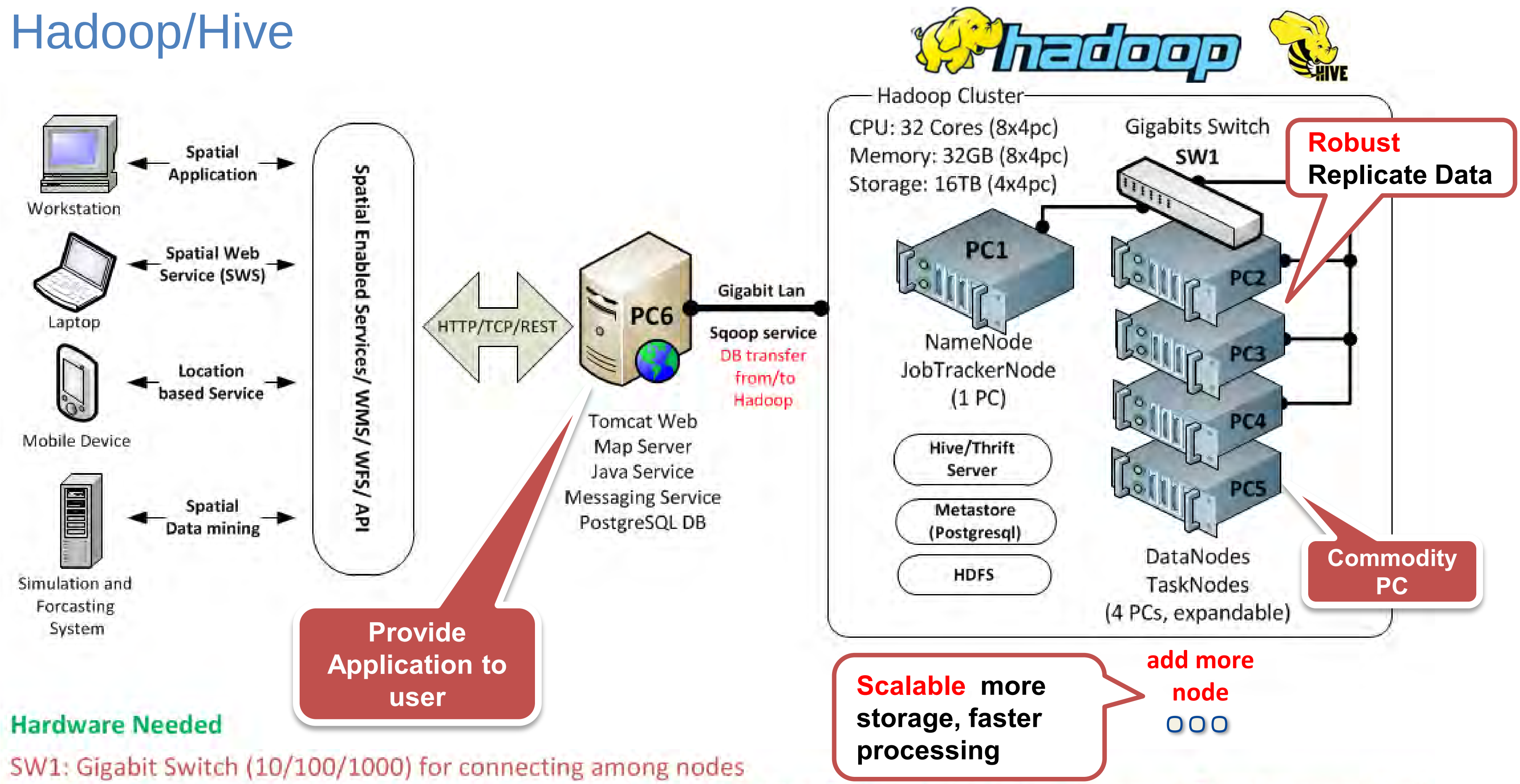
When
BIG DATA
Come with
Spatial
and
Temporal
Information

The potential cases for urban applications.

Large Scale Data Management

- Hadoop/Hive

Distributed Storage & Parallel Processing



Hardware Needed

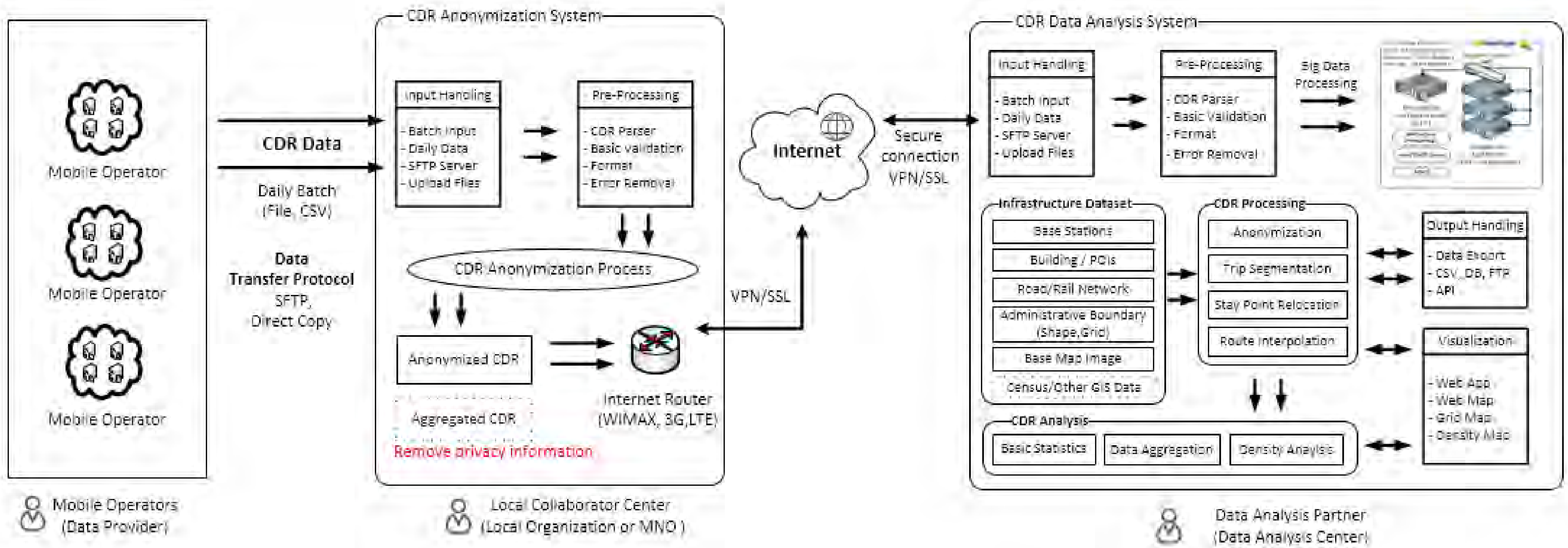
SW1: Gigabit Switch (10/100/1000) for connecting among nodes

PC1: NameNode and JobTracker for controlling all Hadoop nodes, Hive/Thrift (Provide SQL like support, Remote connection)

PC2-5: DataNode and TaskNode for storing data and processing Map/Reduce task

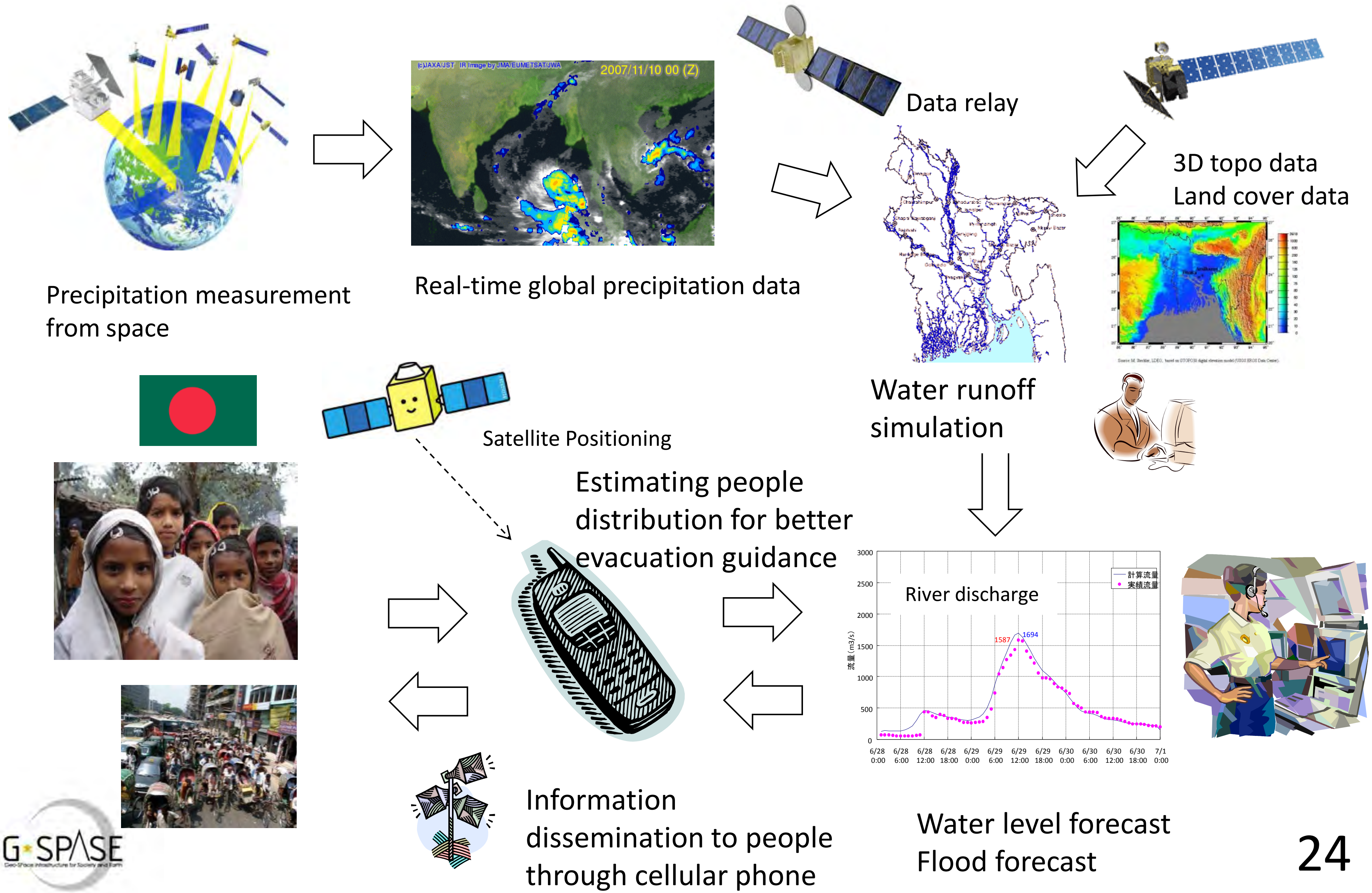
PC6: Provide web-based spatial application to user as well as API

CDR Analysis System

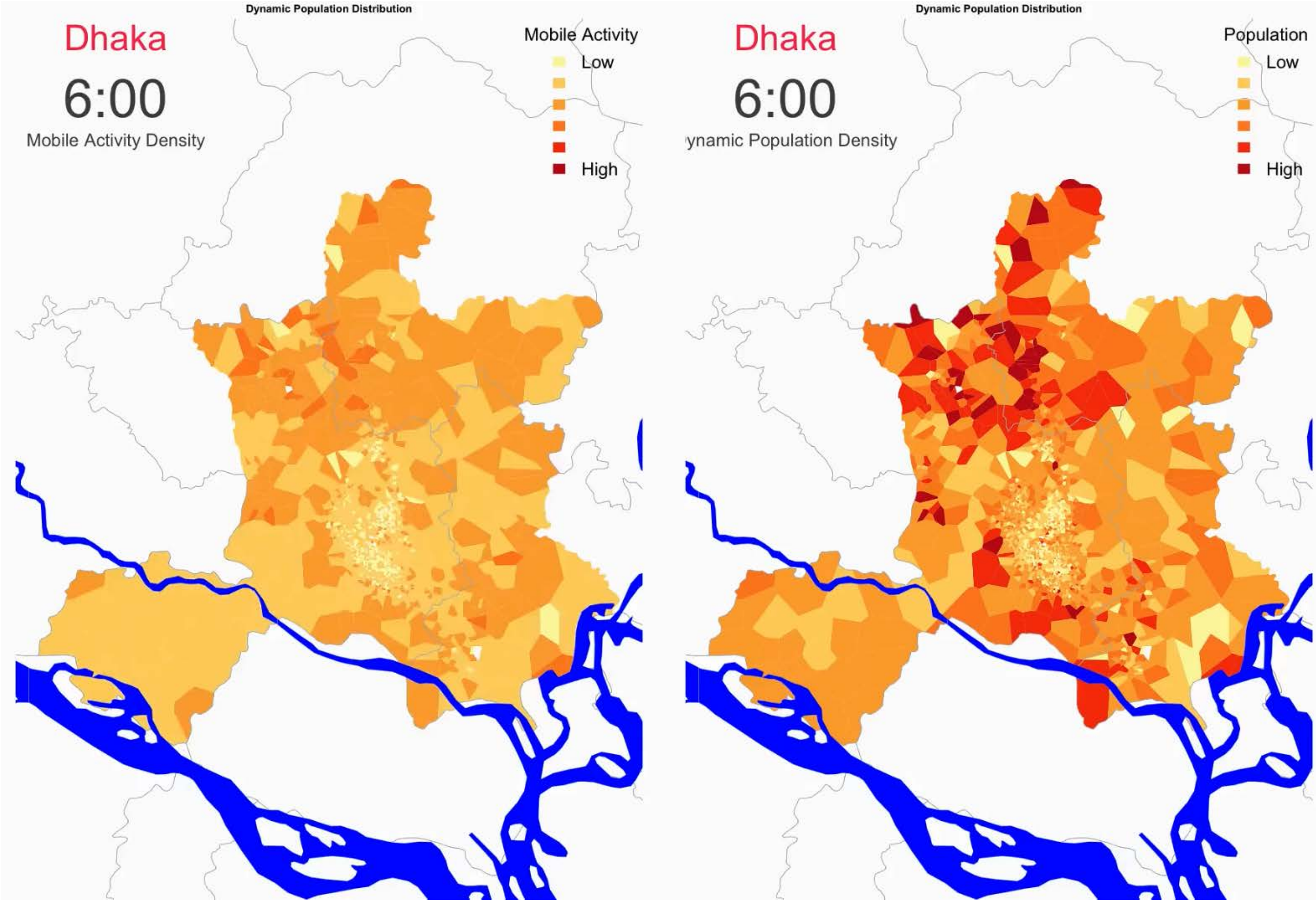


Applications & Cases

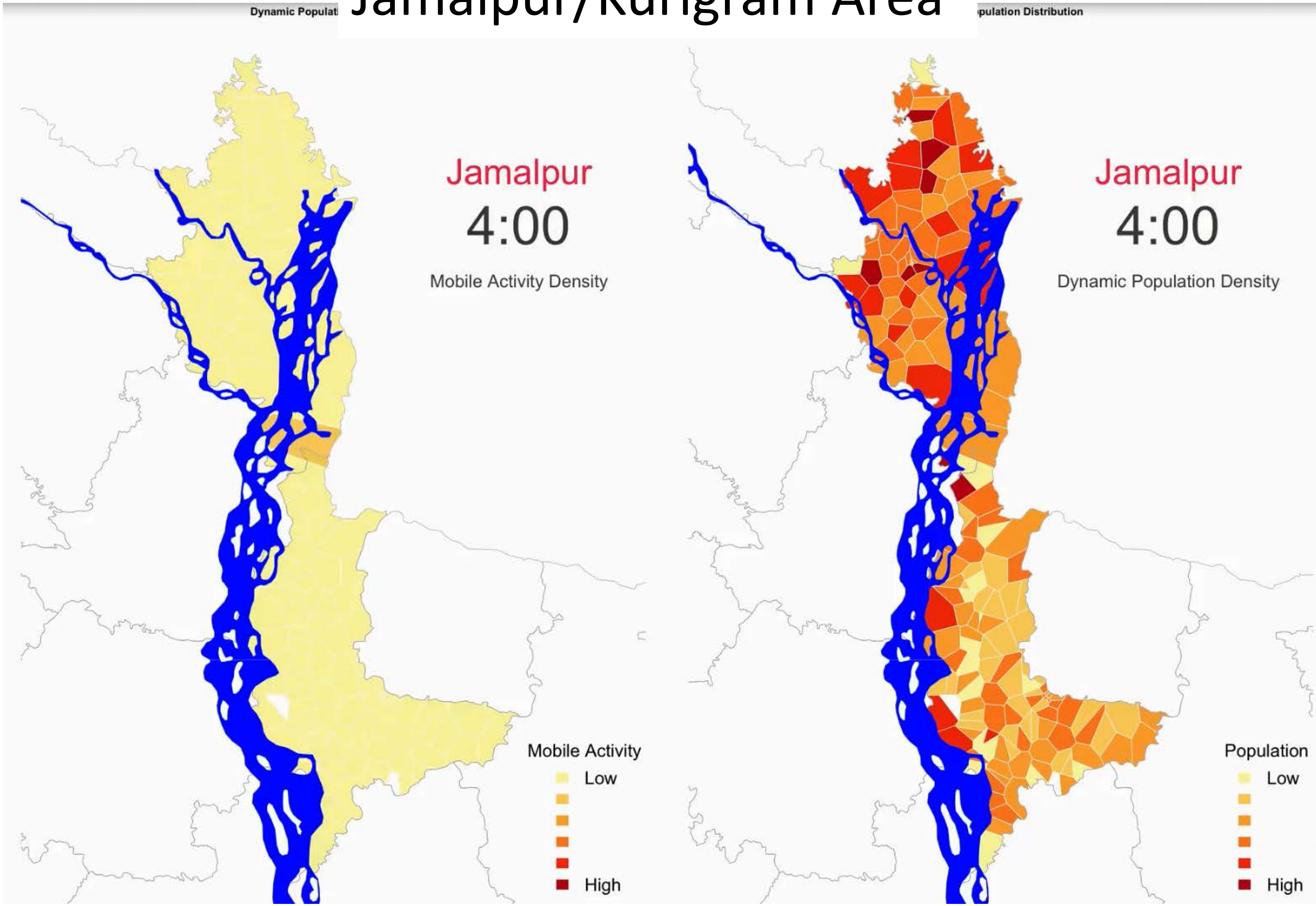
Social Benefit Services with Space Infrastructure (Observation, Communication, Positioning); Flood Warning Service for Bangladesh



Dynamic Population Density



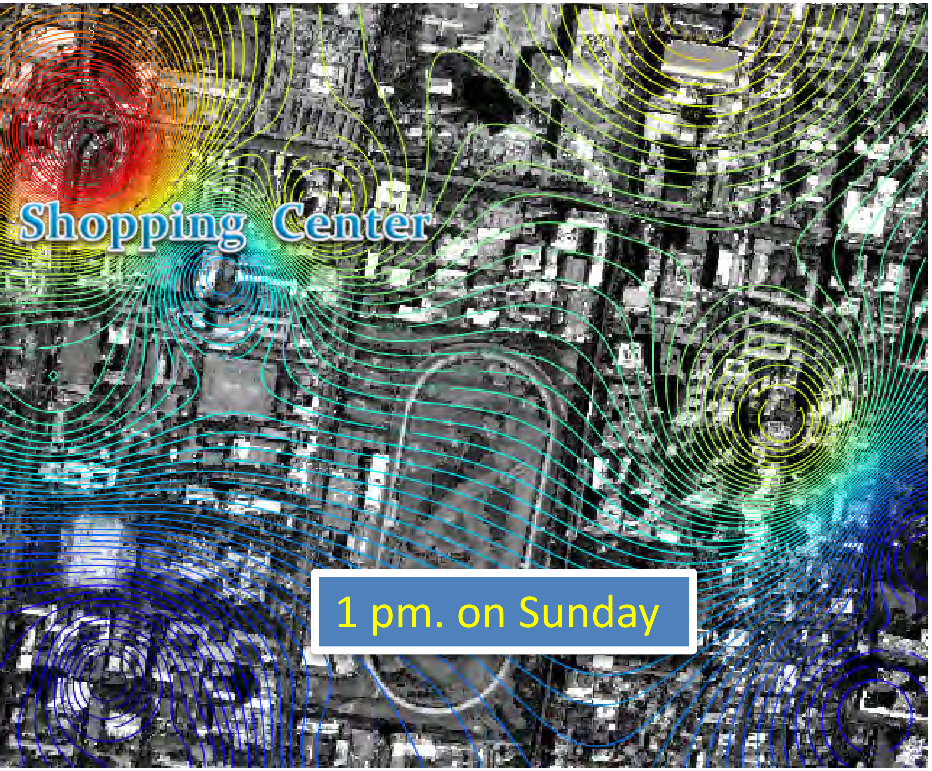
Jamalpur/Kurigram Area

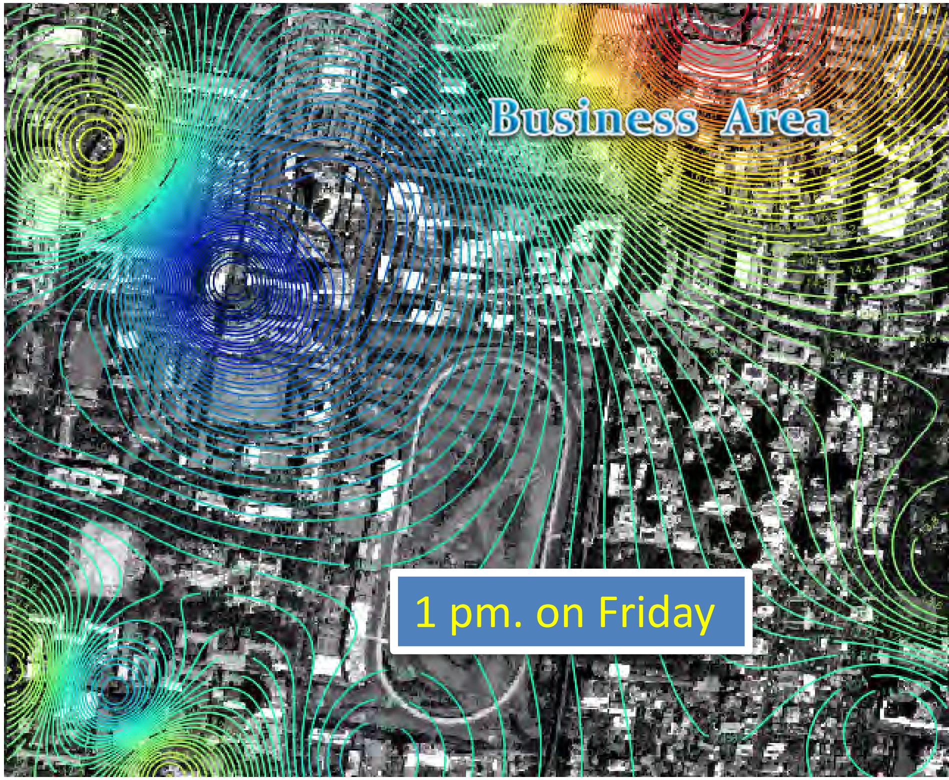


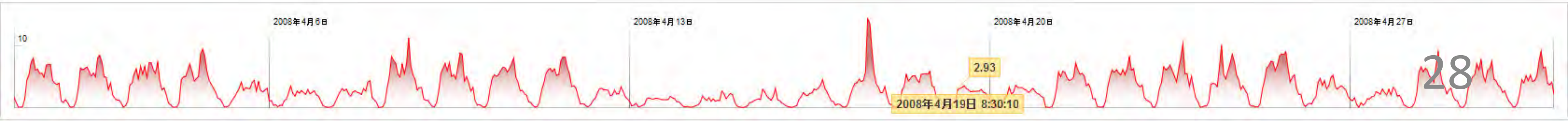
Findings and Experiences of Bangladesh Project (Mobile Phone Component)

- Warning Message Dissemination with Mobile
  - Cell broadcasting: technically possible, but not easy in implementation due to hand-set limitations.
  - SMS: Easy, but Location of subscribers needed
    - CDR analysis is indispensable to estimate subscriber locations.
- CDR Analysis of Estimating People Distribution and Movement
  - Indispensable to provide information on People Distribution at Risk of Flood.
  - Supporting effectively evacuation planning.
  - Real-time Monitoring is possible for Traffic and People Movement situations (not implemented in the Bangladesh Project)

Example of Communication traffic data of each base station (Bangkok, Thailand)

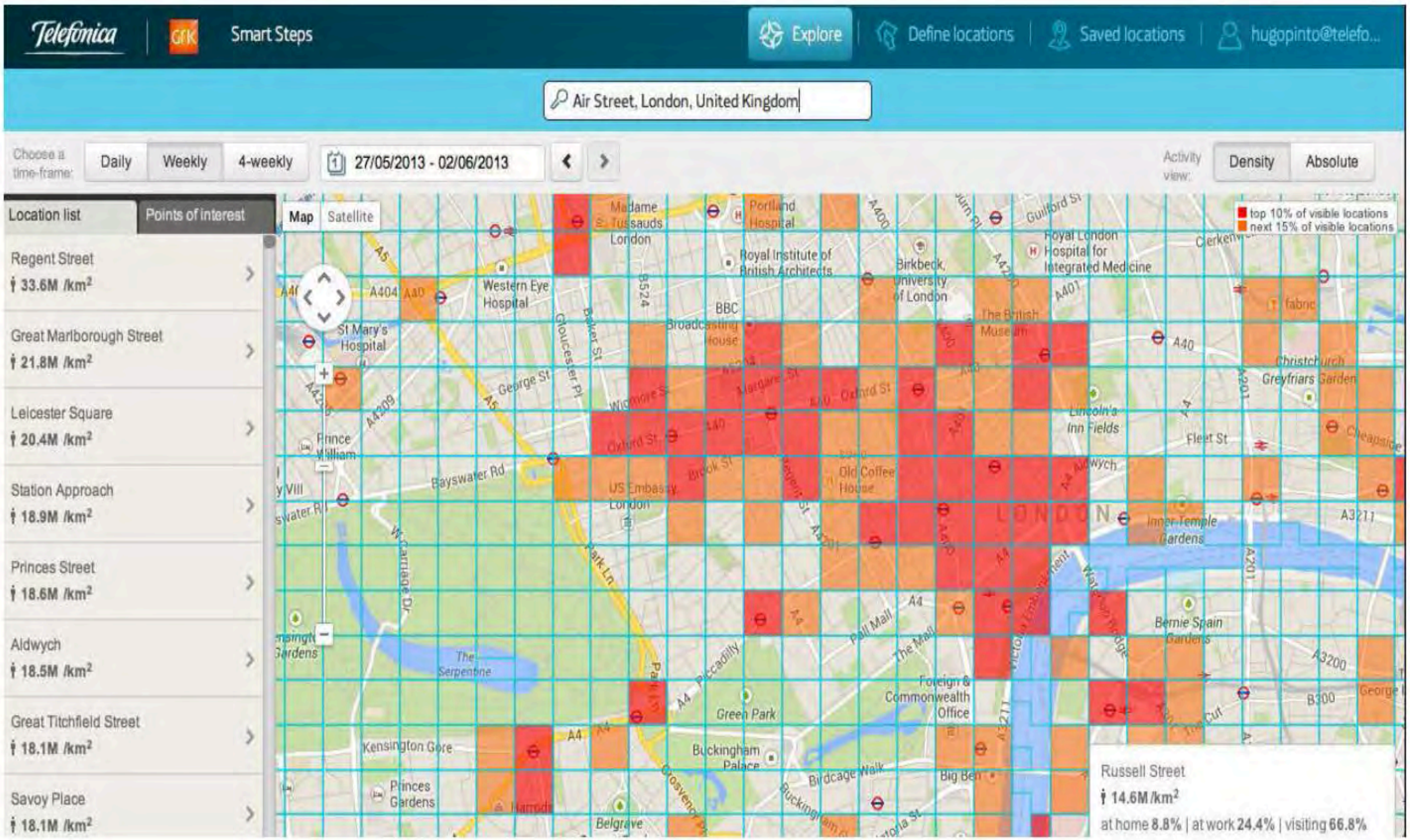






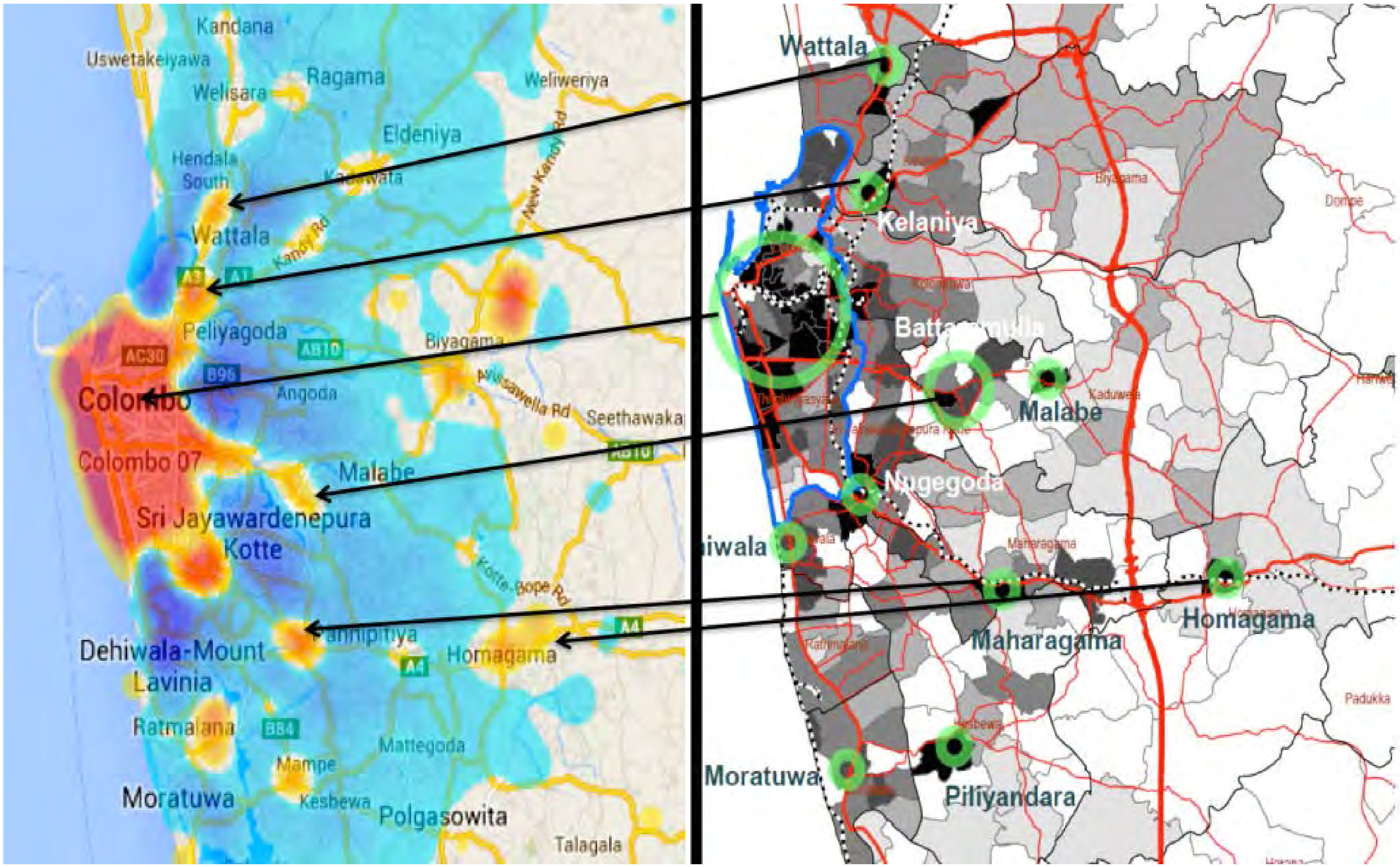
Retail & Big Data

IDC 2015 – Telefonica 'Smart Steps' Mobile data anonymized – footfalls as a result of marketing campaigns, opening of new store used by Morrisons



Transport & (Mobile) Big Data

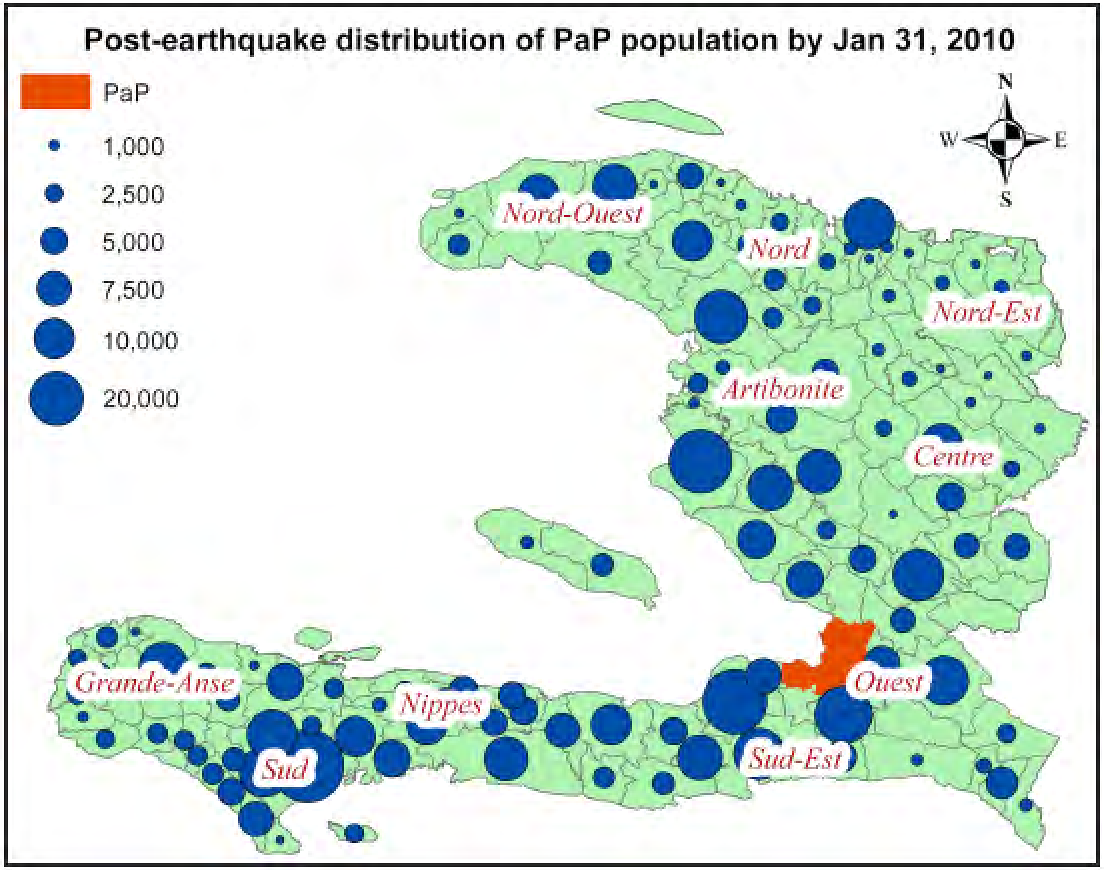
Colombo, Sri Lanka: a costly survey of 40k households to understand mobility patterns, which closely match the main points identified using big data analyses of mobile Big Data.



http://www.unglobalpulse.org

Disaster Response

Natural disasters give rise to emergency situations where providing time-sensitive information is crucial for fast allocation of resources, which aids the response and recovery process



Mobility patterns have been identified by analyzing CDRs, providing more accurate post-analysis of population migration during the Haiti earthquake.

Figure 1: The visualization shows the distribution of population migration from Port au Prince (PaP) after the Haiti earthquake obtained by analyzing CDRs. The circles represent locations that received at least 500 people from the estimated distribution of those in PaP on the day of the earthquake, but outside the city 19 days after the earthquake. Source: Lu et al., 2012.

http://www.unglobalpulse.org

Health: MAPPING MALARIA IN KENYA

By analyzing the regional travel patterns of mobile subscribers, researchers were able to map the specific locations to which disease had a higher probability of spreading. The researchers analyzed the mobile phone data together with a simple disease transmission model based on infection prevalence data, and in doing so were able to map routes of disease dispersal.

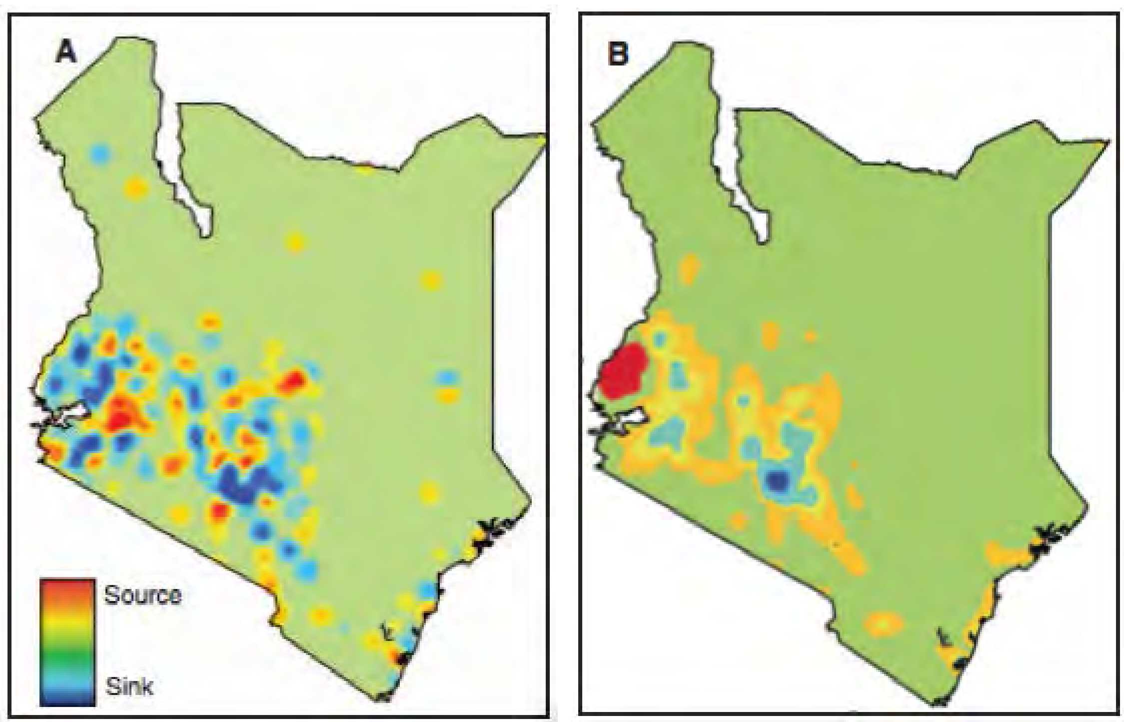
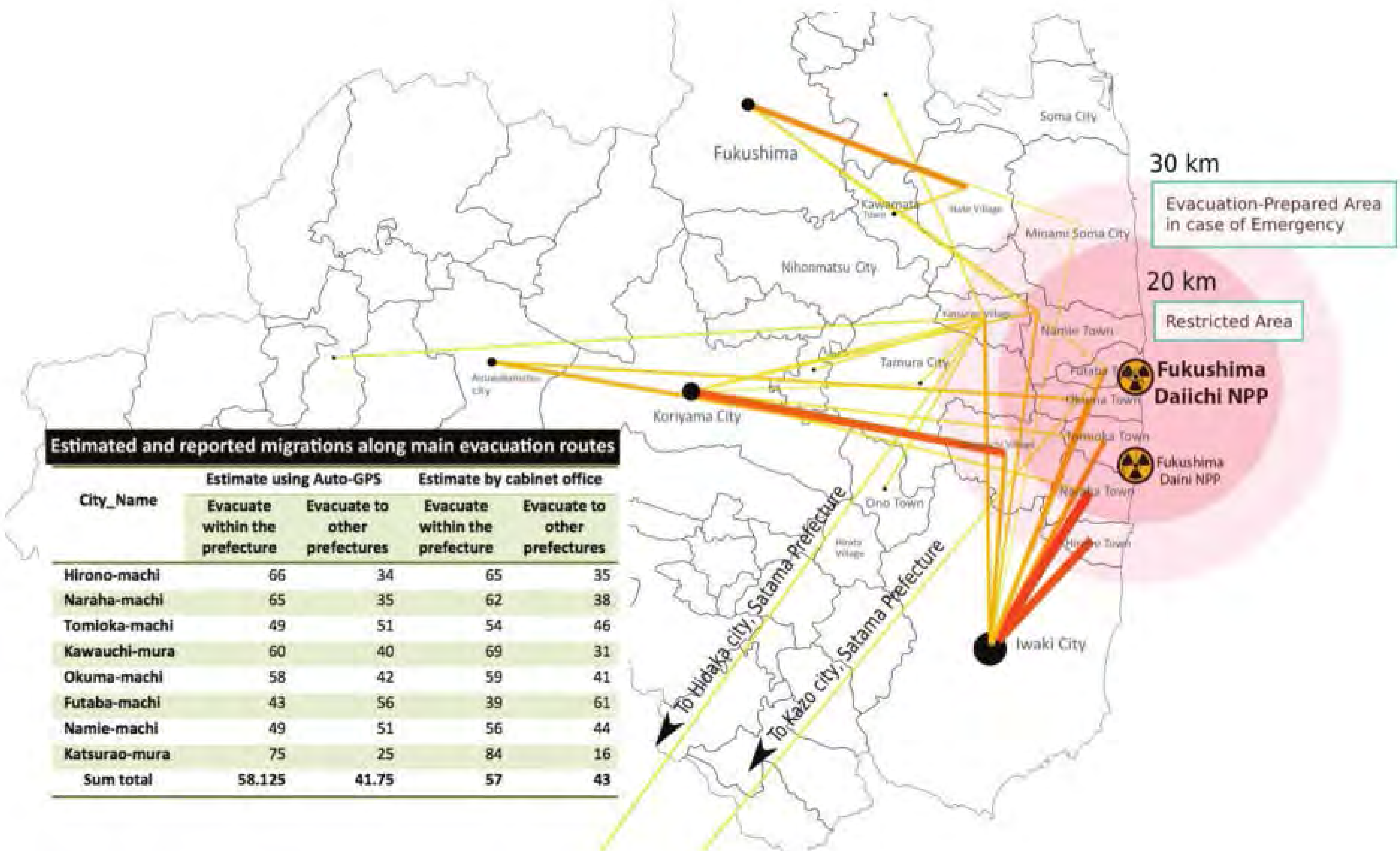


Figure shows sources and sinks of human travel and parasites. Kernel density maps show ranked sources (red) and sinks (blue) of human travel (2A) and total parasite movement (2B) in Kenya, where each settlement was designated as a relative source or sink based on yearly estimates. Source: Wesolowski et al., 2012.

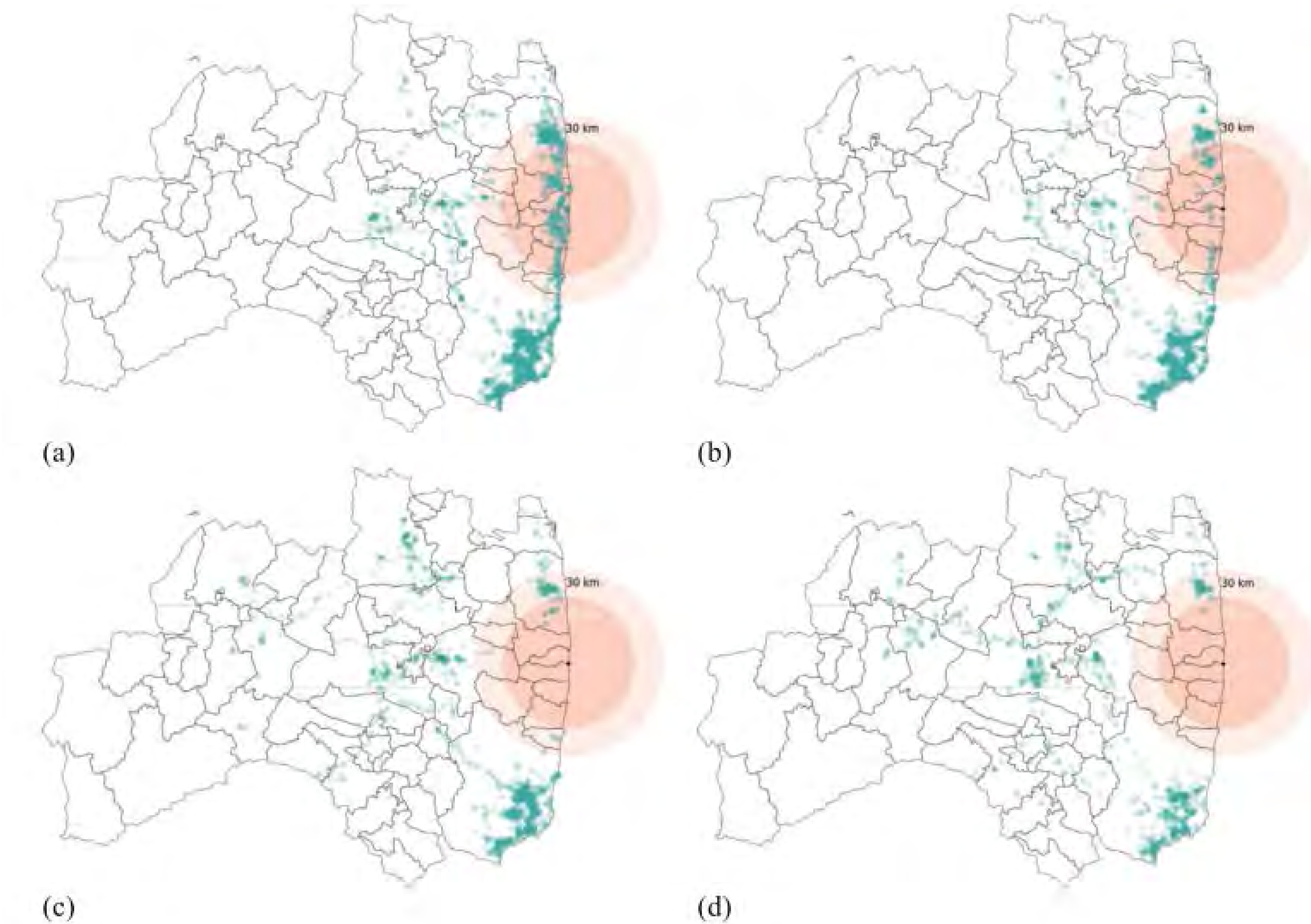
311 Earthquake: Emergency Evacuation Monitoring



Estimated and reported migrations along main evacuation routes

City_Name	Estimate using Auto-GPS		Estimate by cabinet office	
	Evacuate within the prefecture	Evacuate to other prefectures	Evacuate within the prefecture	Evacuate to other prefectures
Hirono-machi	66	34	65	35
Naraha-machi	65	35	62	38
Tomioka-machi	49	51	54	46
Kawauchi-mura	60	40	69	31
Okuma-machi	58	42	59	41
Futaba-machi	43	56	39	61
Namie-machi	49	51	56	44
Katsurao-mura	75	25	84	16
Sum total	58.125	41.75	57	43

311 Earthquake: Emergency Evacuation Monitoring



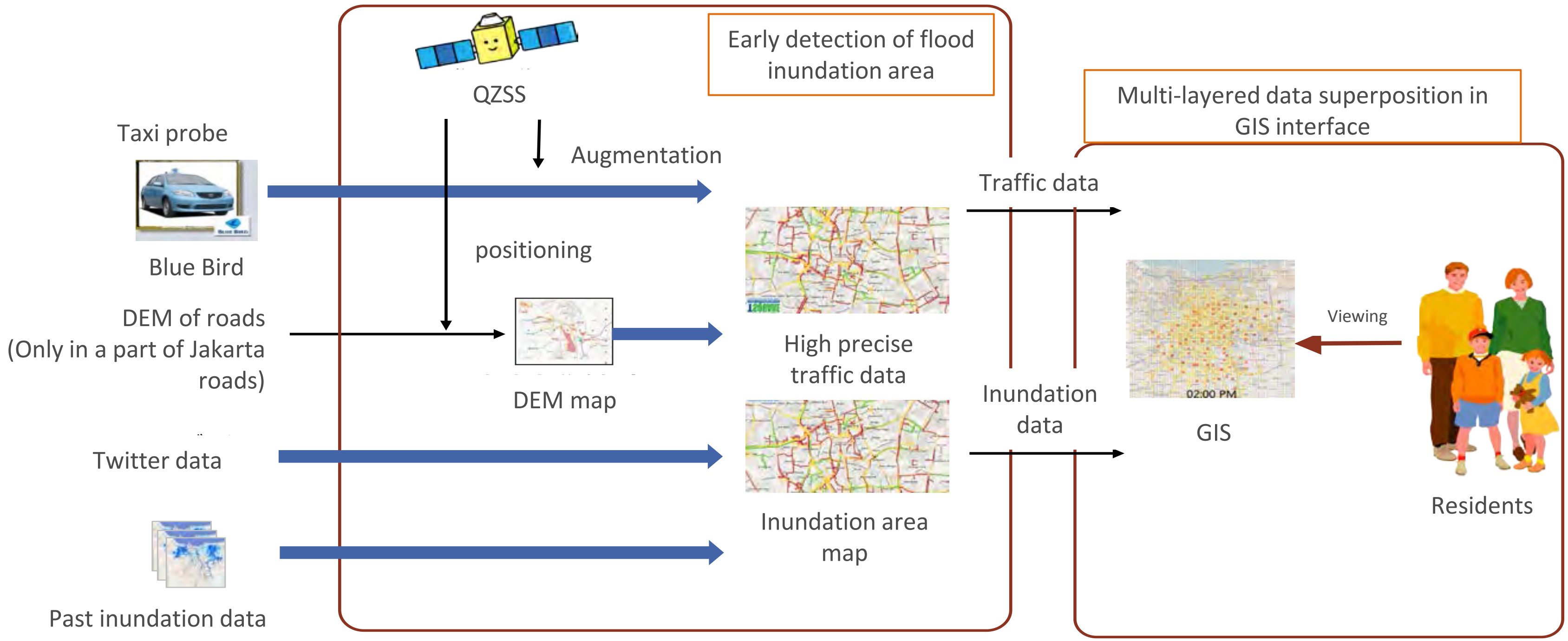
Trips with interpolation of people in Istanbul

Analysis Origin-Destination Trips of people in Istanbul.

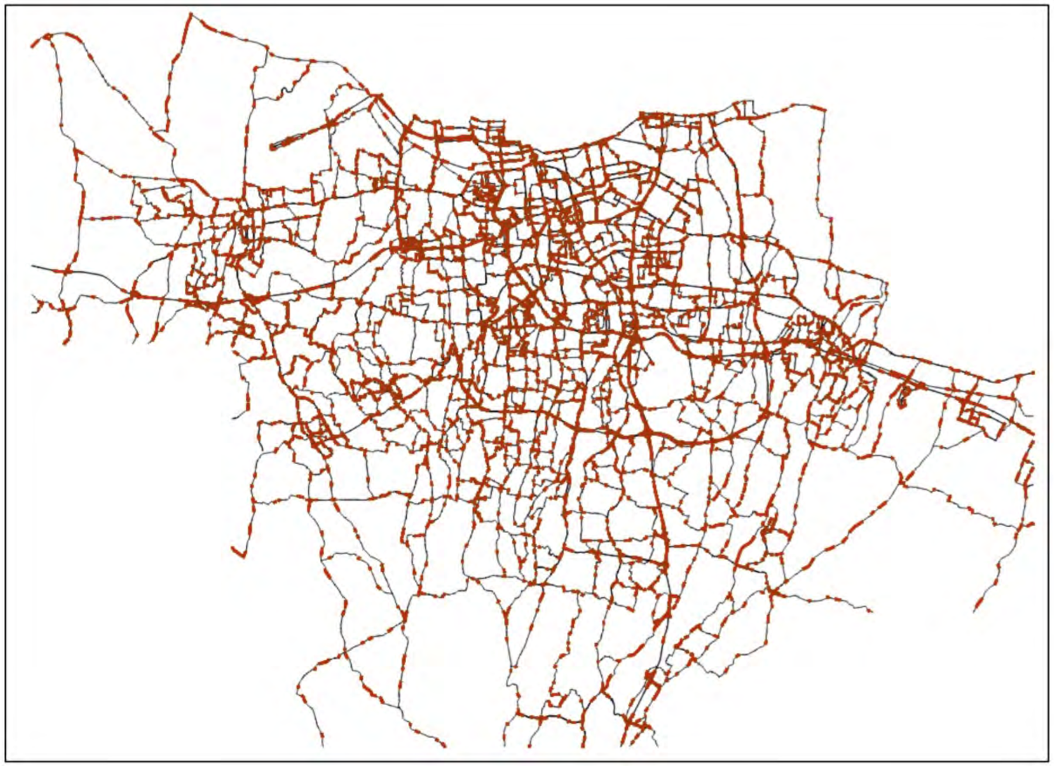
Urban Flood Response Support System

Our team develops “Urban Flood Response Support” system with;

- Analysis of taxi probe data and twitter data,
- Multi-layered superposition of flood inundation area map and digital elevation model data of roads.
- Data disclosure with GIS interface.



Probe Vehicle Working in Jakarta

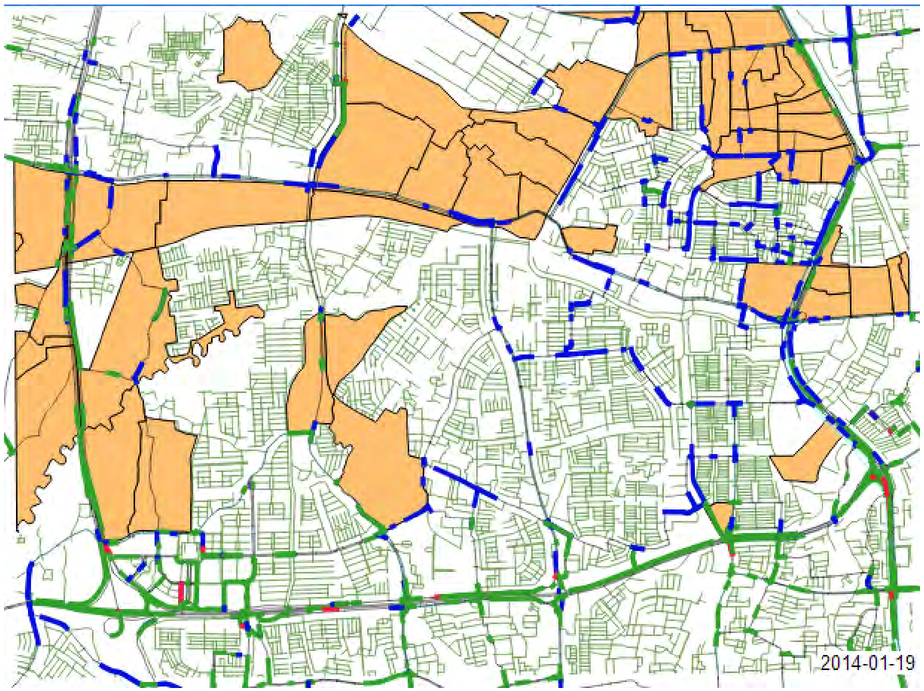


Coverage area in Jakarta

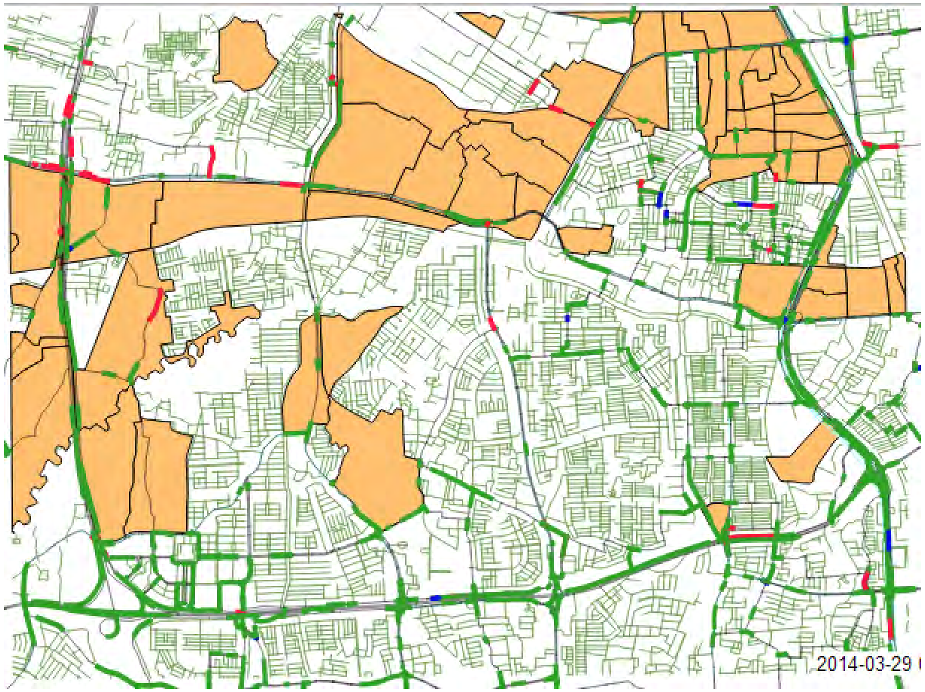
- Number of Taxi: 16,000 car/hour (during our experiment)
- Date: 2014/01/16-2014/04/15
- Data frequency: 30 – 270 seconds
- Number of Record: 4.6 hundred million
- Data: Taxi ID
  Latitude, Longitude
  Speed
  Customer on/off
  etc.

Anomaly at date level

During flood (2014-01-19)

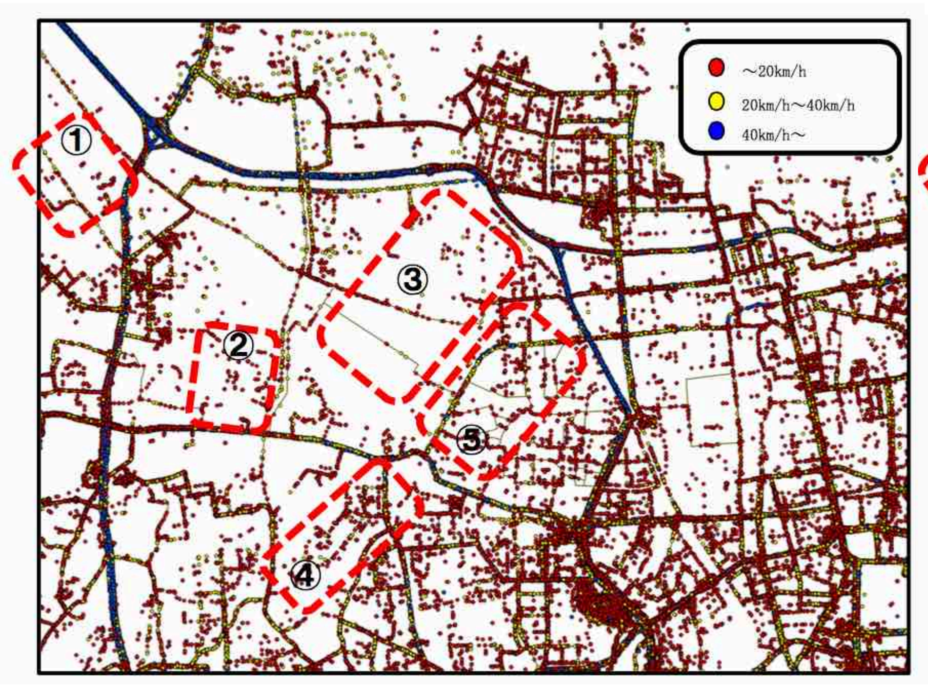


During no flood (2014-03-29)

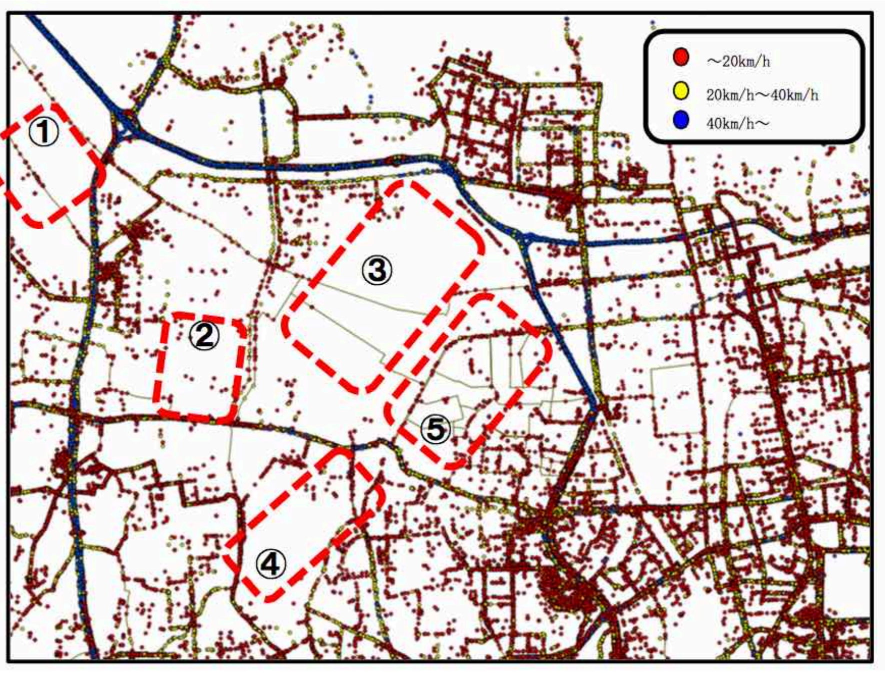


Blue : very less traffic, Green: normal, Red: very high traffic

Comparison between Normal and Flood



Normal: 19/03/2014



Flood: 22/01/2014

Then,
How to obtain CDR Data?

Let use it for our social benefit

How to Obtain CDR

Explain and get permission from Telecom Regulatory

Telecom Regulatory issue statement to Mobile Operator

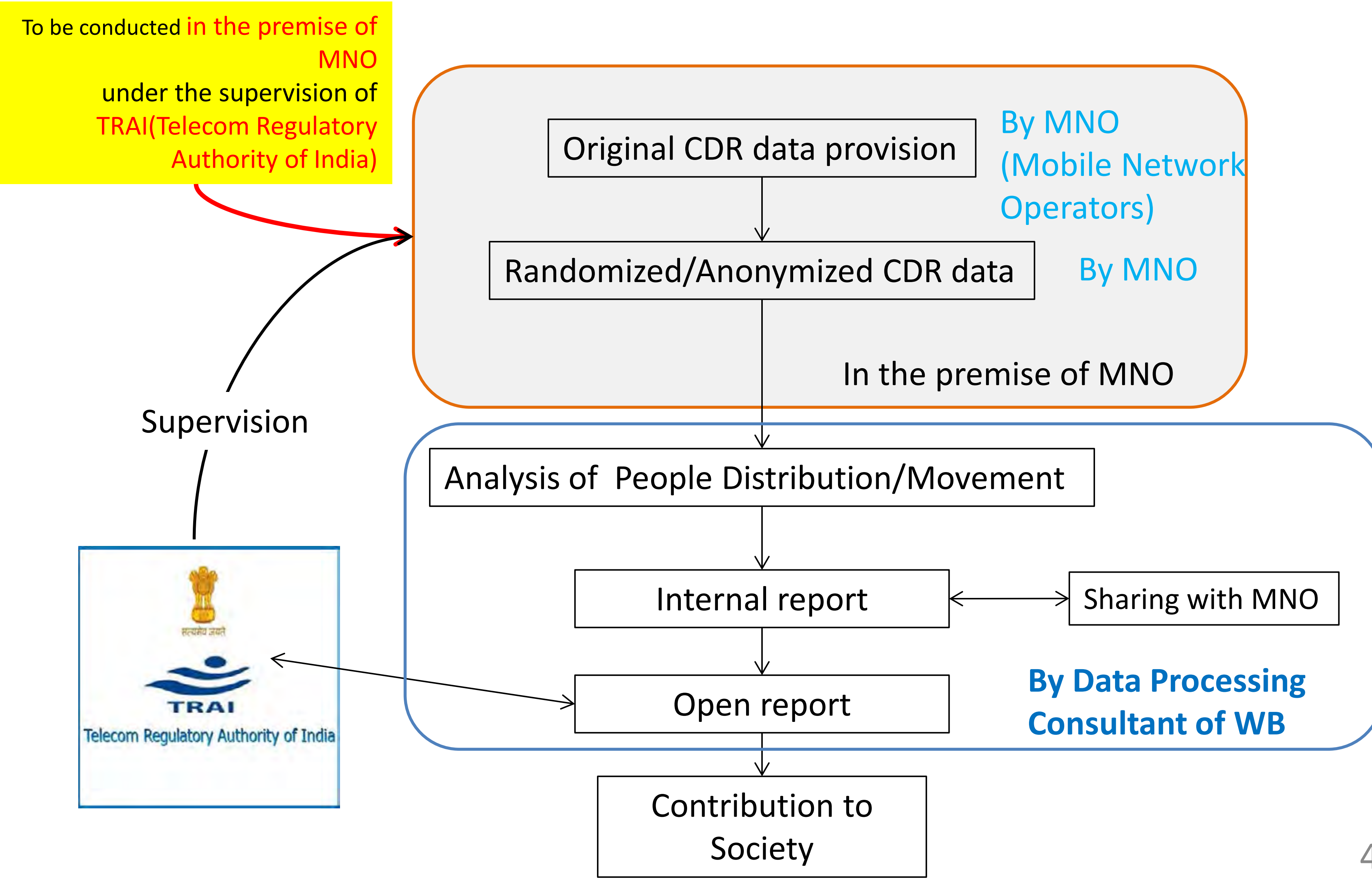
Talk with operator to get CDR Data

Contribution to Society

Issue License

Allow to use CDR for social benefit with privacy reserving

How to Implement CDR Data Analysis while Preserving Privacy? A Suggestion



Concluding remarks

- With CDR, people distribution and movement can be monitored quantitatively. CDR can be a very important source of information for disaster risk reduction.
  - It help to understand people activity
  - Estimate real dynamic population/ reflect with the event
  - Can provide support and service to the right person
  - It can contribute a lot of benefit to our social

Thank you

How to Anonymize CDR Data?

One to one mapping

IMSI,
IMEI etc

Encrypting algorithm

randomized ID

By MNO
(In the premise)

Identification information connected to a specific user

Randomized, unique number NOT connected to a specific user

Not disclosed.
Impossible to restore SIM ID from the Randomized ID.

Consultant hired by WB

Development of a regional flood outlook: opportunities for cooperation

Improving flood risk management in Bihar
Expert consultation, Patna, INDIA
18 -19 February 2016

Mandira Singh Shrestha (mandira.shrestha@icimod.org)

International Centre for Integrated Mountain Development

Kathmandu, Nepal

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Outline of presentation

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- Distribution of disasters globally and in the Himalayan region
- Flood disasters in the Himalayan region
    - ➢ Key issues
- Development of a regional flood outlook
    - ➢ Why a regional flood outlook?
    - ➢ Flood outlook model
        - – Data inputs
        - – Data assimilation
        - – Calibration and validation
        - – Flood outlook/flood forecast
        - – Performance of the model
- Challenges and opportunities
- Conclusion

Intergovernmental, knowledge, learning
and enabling centre

ICIMOD

Member countries

- Afghanistan
- Bangladesh
- Bhutan
- China
- India
- Myanmar
- Nepal
- Pakistan

Mission

Enable sustainable and resilient mountain development for improved and equitable livelihoods

Vision

ICIMOD's Vision is that the men, women, and children of the Hindu Kush Himalayas enjoy

2015 disaster events globally

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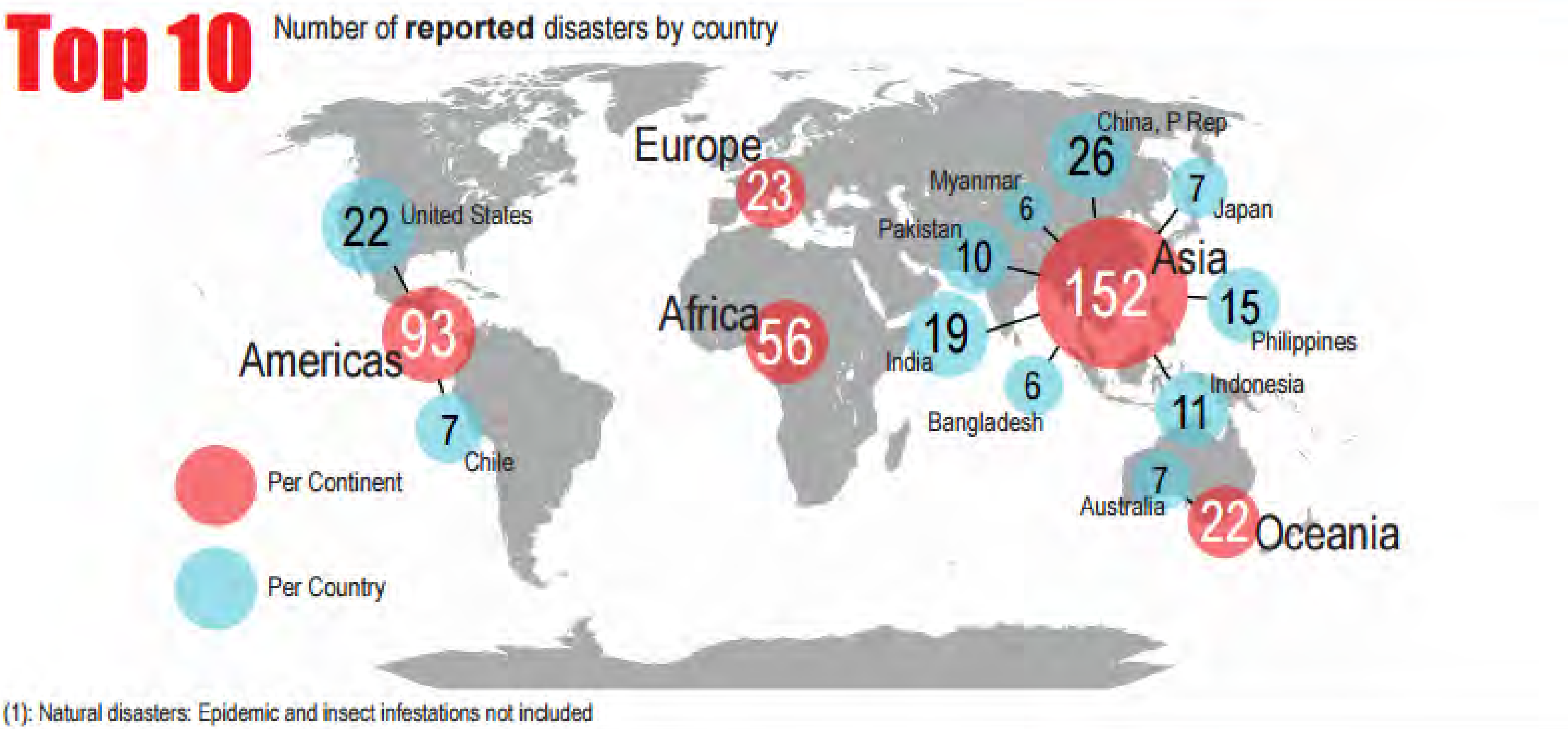

346 reported disasters US$66.5 billion economic damage 98.6 million people affected 22 773 people dead

Source: UNISDR

Disaster statistics from 1985-2014
Himalayan region countries

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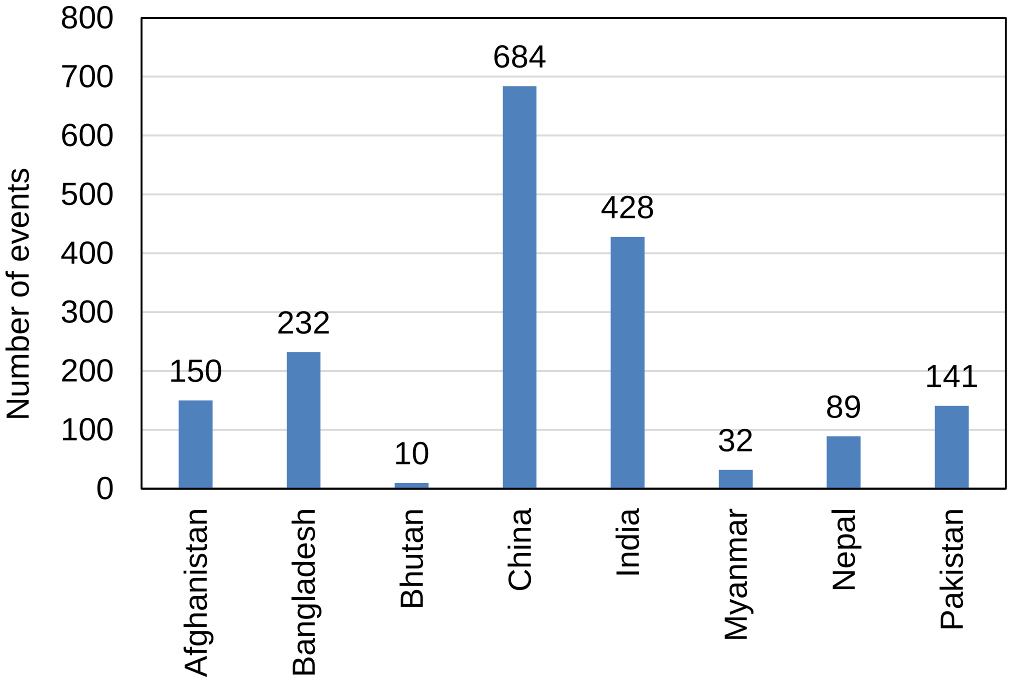
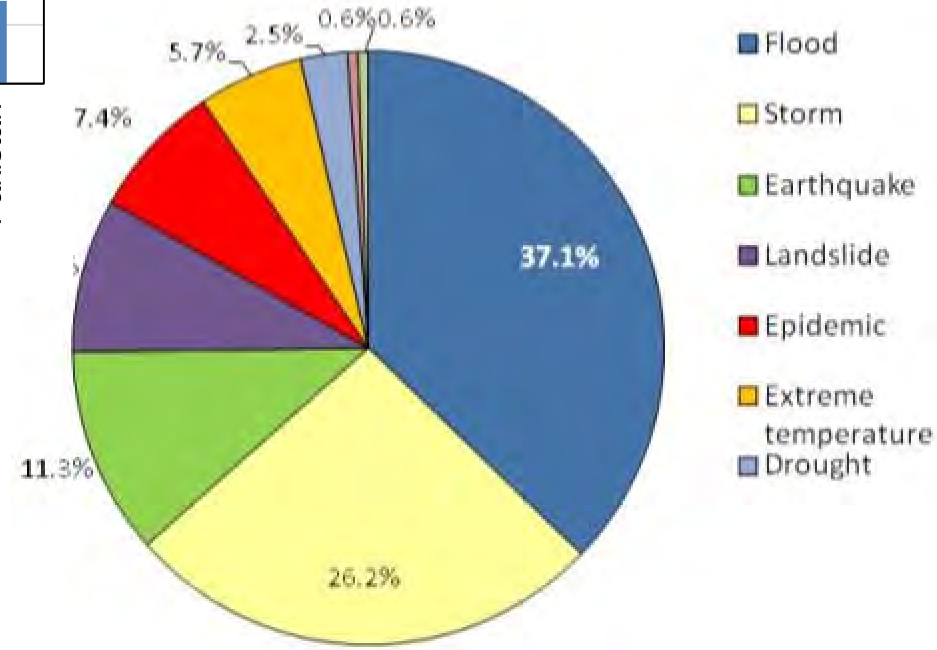
(Source: EM-DAT – The OFDA/CRED International Disaster Database)



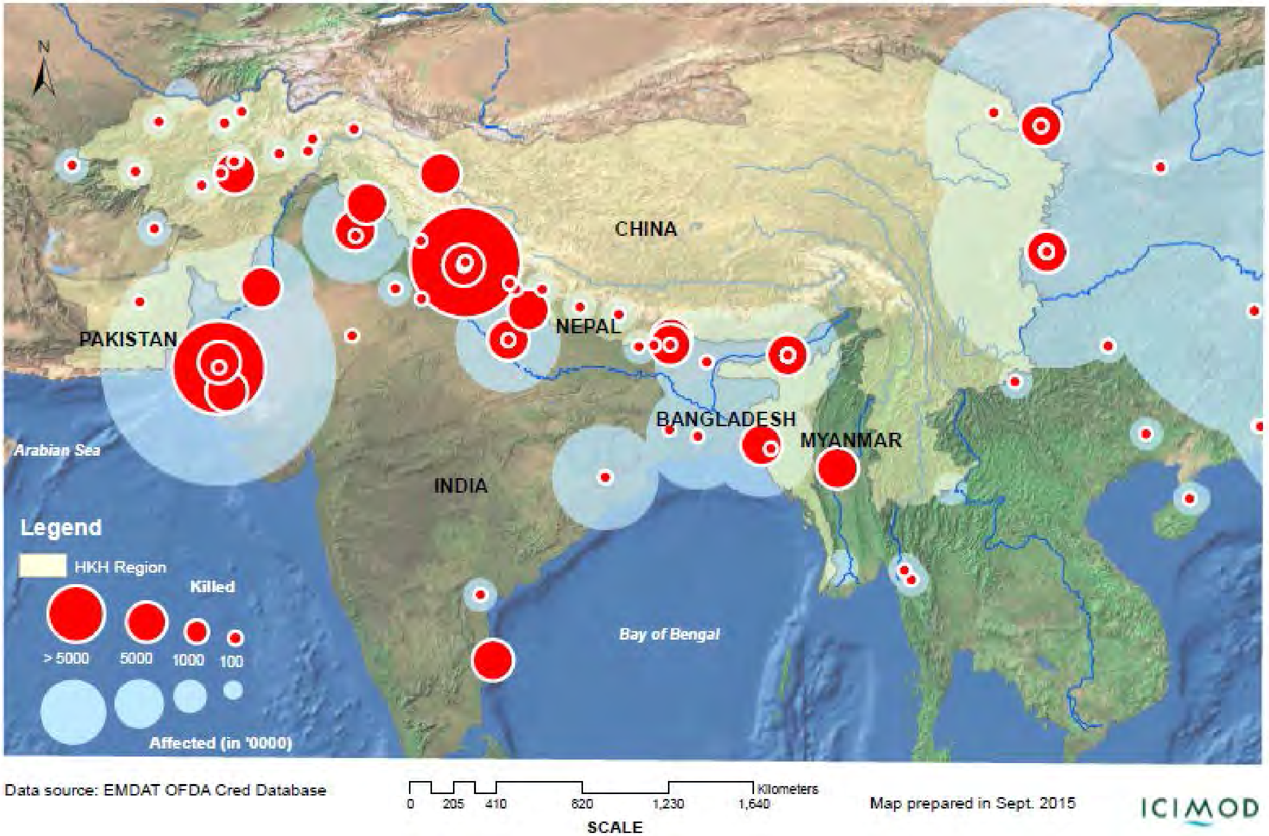
The region has an average of 60 disaster events each year

On average, annually more than 24,000 people are killed and 160 million affected by natural disasters .



One-third of these disasters are floods

People killed and affected by floods in the Hindu Kush Himalayan region (2010–2014)



- Transboundary floods - shared vulnerability across national borders
- Globally, 10% of all floods are transboundary, but they cause over 30% of all flood causalities and displace close to 60% of all those displaced by floods (Bakker 2006)

Key issues

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- There is a diversity of technical, scientific, and institutional capacity
- Opportunities for sharing knowledge, experiences and know-how
- Application of state of the art tools and technologies can provide timely and reliable flood forecasting and EWS systems to save lives
- The integration of risk information into EWS is still weak.
- There is limited exchange of real-time data especially across national boundaries - increase lead time

Global WMO WHYCOS framework

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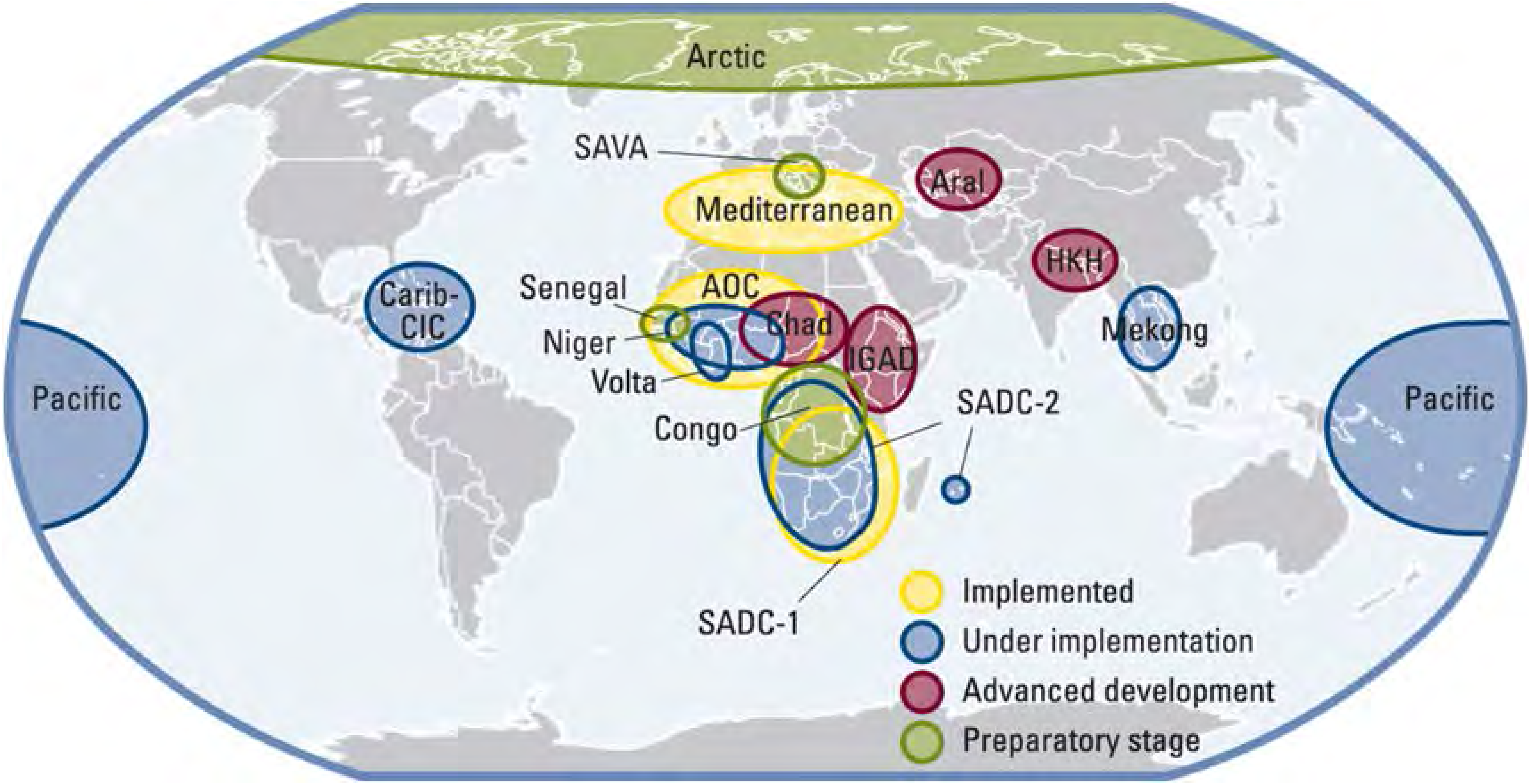

- To improve the basic observation activities,
- To strengthen the international cooperation and
- To promote free exchange of data in the field of hydrometeorology.

HKH-HYCOS: Setting up monitoring stations and establishment of real-time flood information systems

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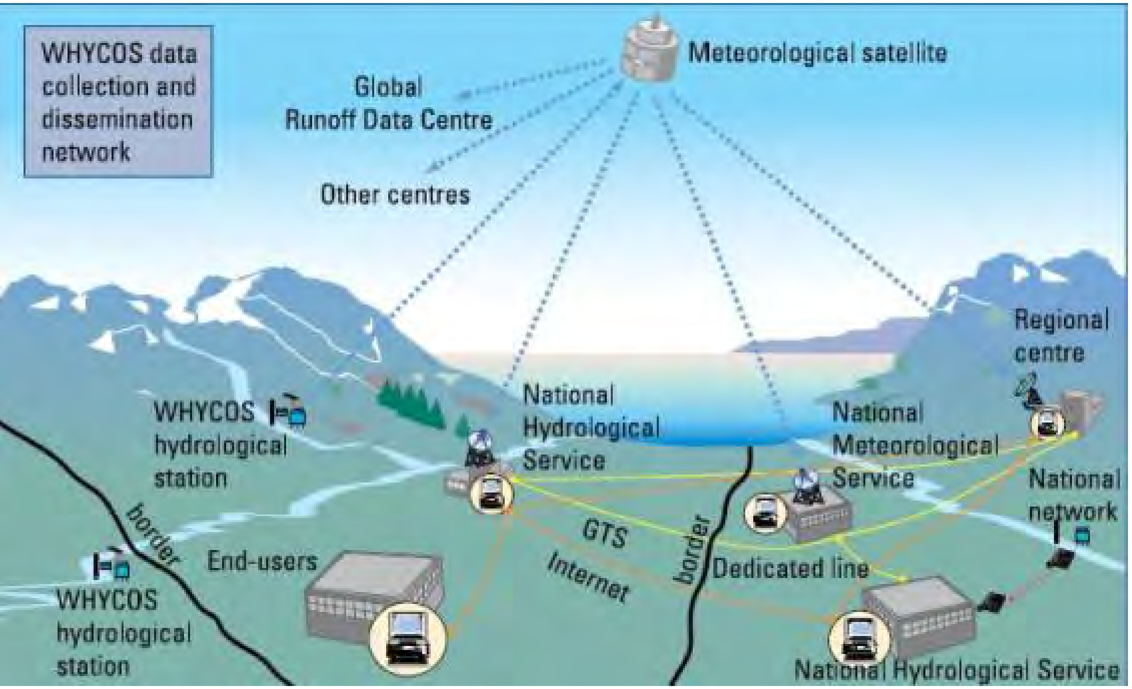
'Making Information Travel Faster Than Flood Waters'



Establishment of a Regional Flood Information System in the HKH-Region - Timely exchange of flood data and information through an accessible and user friendly platform

HYCOS is a vehicle for technology transfer, training, and capacity building

Achievements: Modernization of observation network

- 38 hydrometeorological stations upgraded in four countries (Bangladesh, Bhutan, Nepal, Pakistan)
- Access to > 300 Global Telecommunication Stations of WMO
- Additional stations contributed by partners

Achievements: real-time hydrometeorological stations

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- Use of latest technology for data collection
- Transmission (mobile phone using CDMA/ GSM, satellite communication)
- Establishment of regional and national flood information systems

HKH HYCOS
Regional Flood Information System

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HKH HYCOS
About
☑ Bangladesh
Kurigram
Sirajganj
Lalon Shah Bridge
Bhairab Bazar
☑ Bhutan
Korilla
Sumpa
Uzorong
Trashi Yantshe
Hongtsho
Gunitsawa
☑ Nepal (Hycos)
Jiri
Pachuwarghat
Mulghat
Dhankuta
Busti
Tumlingtar

http://icimod.org/hycosrfis

HKH HYCOS:
Regional flood information system
Regional flood outlook

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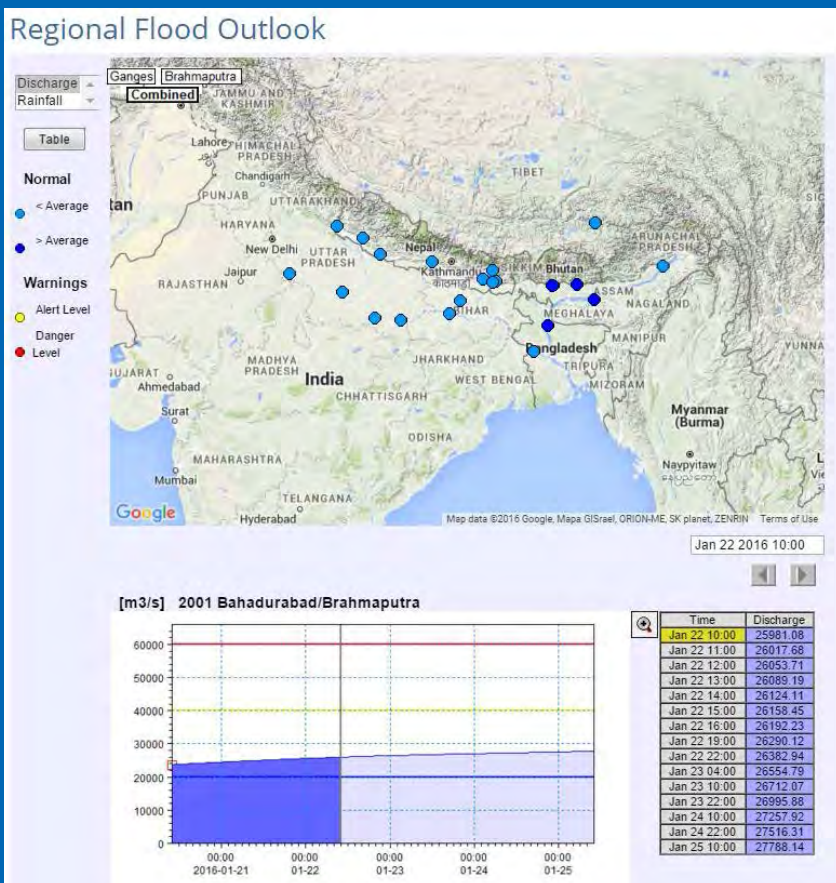

Objective:

- To develop a flood outlook system for the Ganges- Brahmaputra basin utilizing freely available data and weather forecasts

The outlook which, in essence, is a regional flood forecast based on a **mathematical model** describing the **precipitation-runoff process** in the catchments and **hydrodynamic flood routing** along the river system.

Conceptual 1D model

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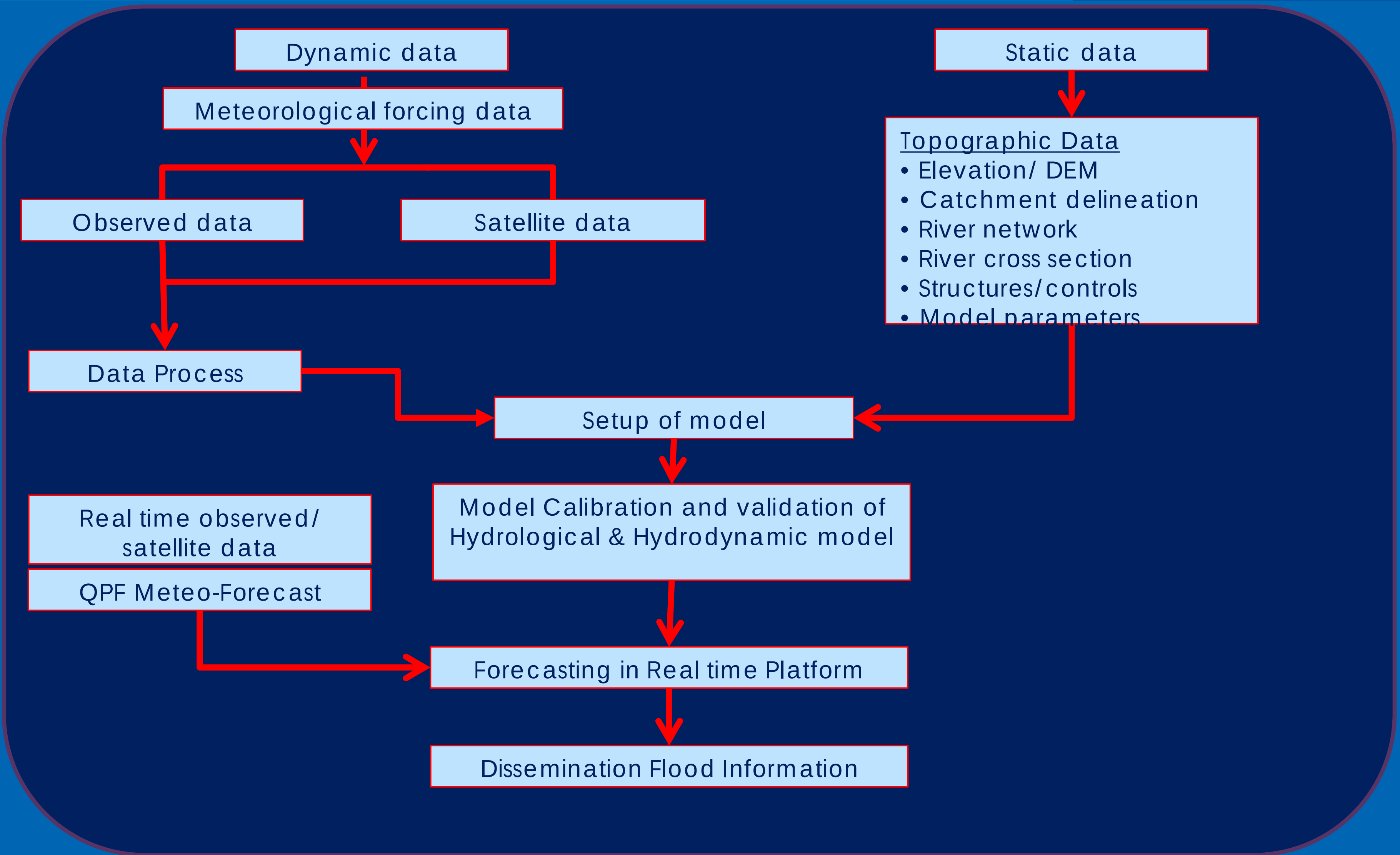

Data requirement for modeling

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Dynamic Data

- Precipitation
- Potential Evapotranspiration
- Temperature (snow catchment)
- Radiation (Optional)
- Discharge
- Water Level
- Q-H relationship
- Snow cover area

Static Data

- Basin/Water area
- River Network
- Longitudinal profile of river
- Cross section of river
- DEM
- Structure & controls
- General Basin information
- etc

Data/ tool used for modeling

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Observed data

- Rainfall (Bangladesh, Bhutan & Nepal)
- Temperature (Nepal)
- Discharge (Bangladesh, Bhutan & Nepal)
- Water Level (Bangladesh & Nepal)

Topography

- STRM 90m images
- Cross section (India & Nepal –Koshi only)

Software/ tool

- MIKE Zero platform
- ARC VIEW, Google earth
- Excel, Visual Basic, Python & R script

Satellite data

- TRMM Rainfall (3B42) & (RT)
- APHRODITE Temperature (V1204)
- Global ET(GDAS)
- MODIS Snow accumulation
- GFS Rainfall/Temp

Pilot basin: Ganges Brahmaputra

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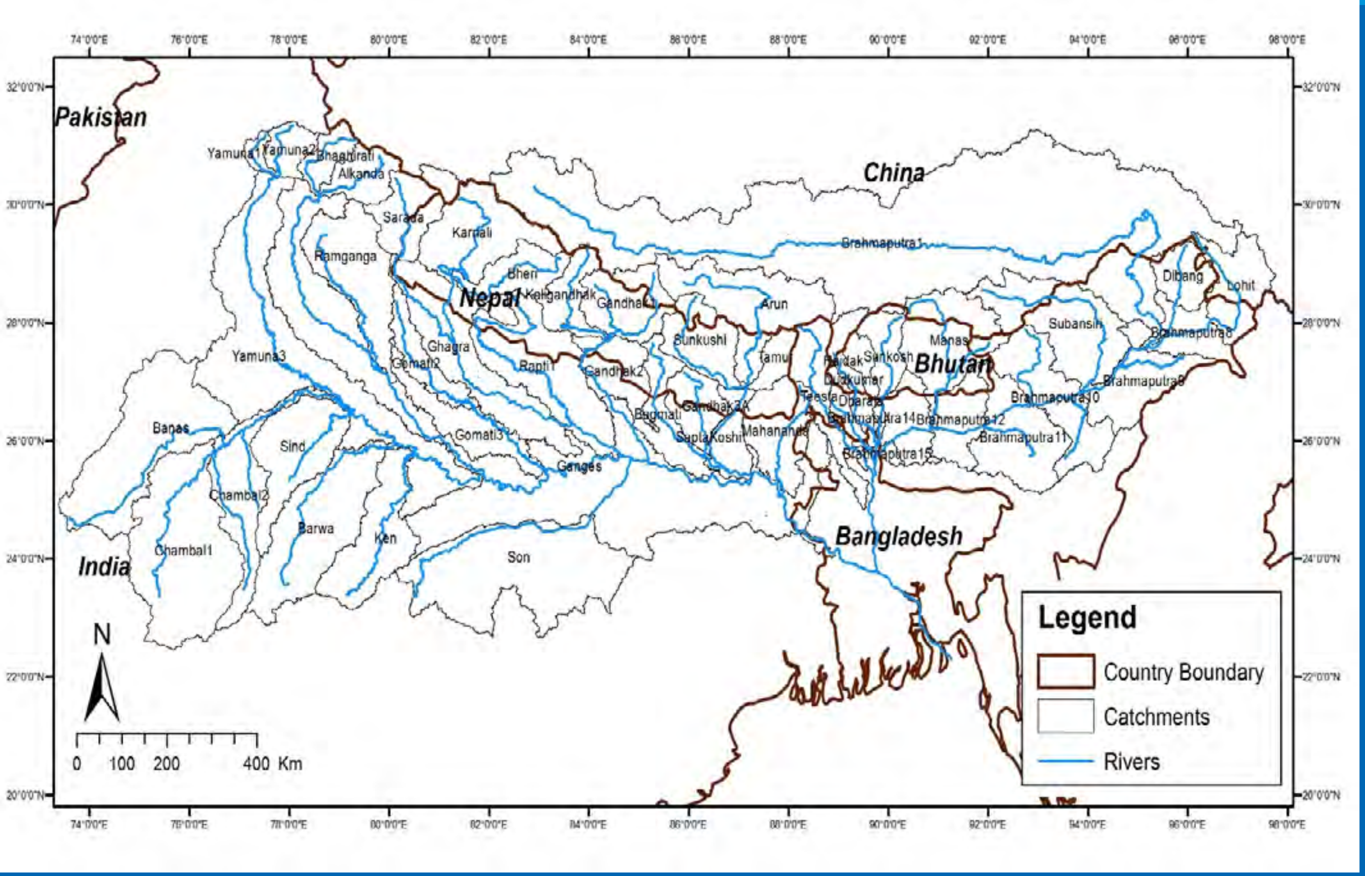

Domain area :

X: 73.4375 to 97.6875°

Y: 21.6875° to 31.4375°

Ganges Basin:
996,285 km2

Brahmaputra Basin:
552,650 km2

Countries: Bhutan, Nepal and parts of Bangladesh, China, India

River network & catchment delineation

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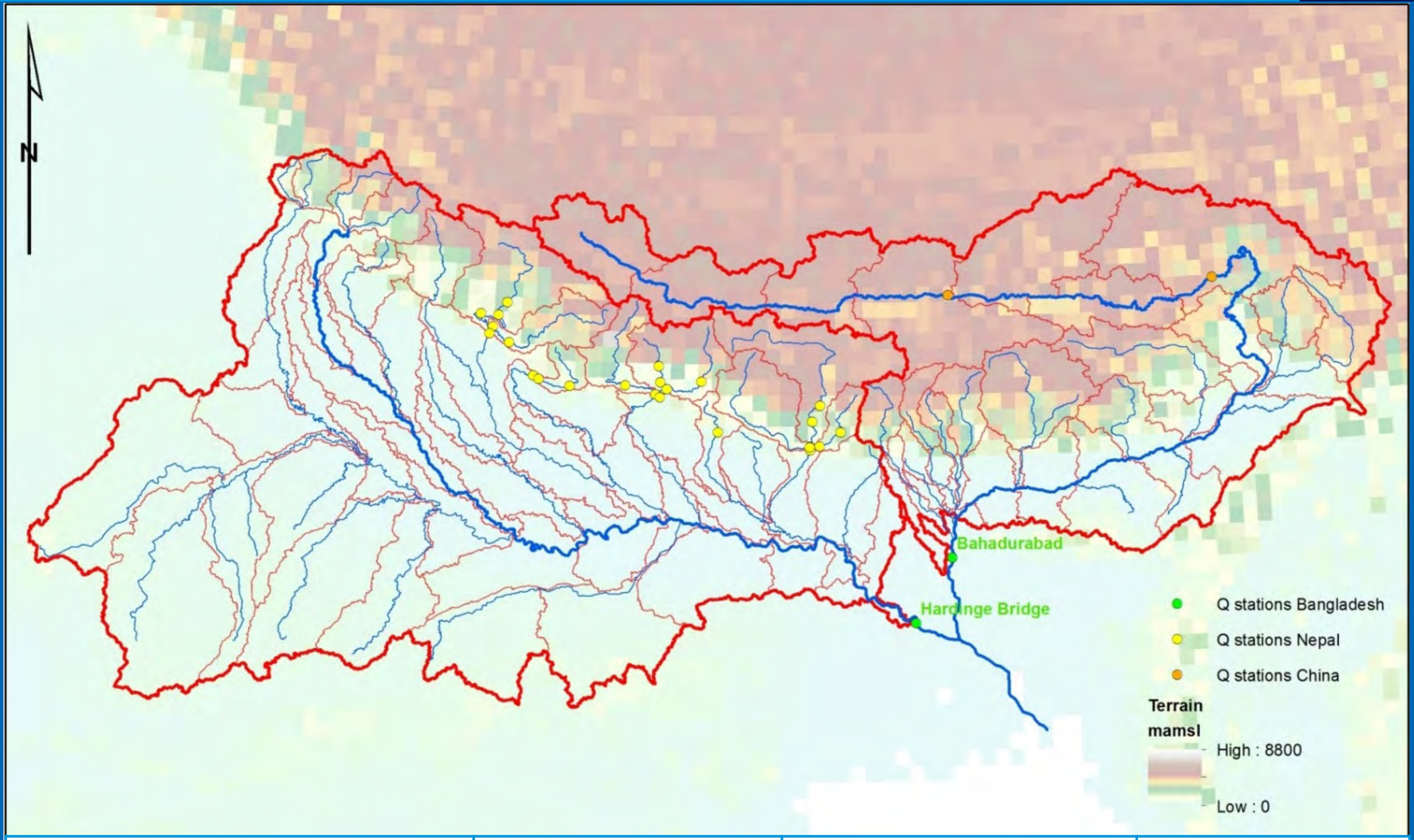

Basin	Ganges	Brahmaputra	Total
Rivers	31	15	46
Catchments	53	33	86

Preparation of rainfall data

Merge observed data and TRMM(3b42) data

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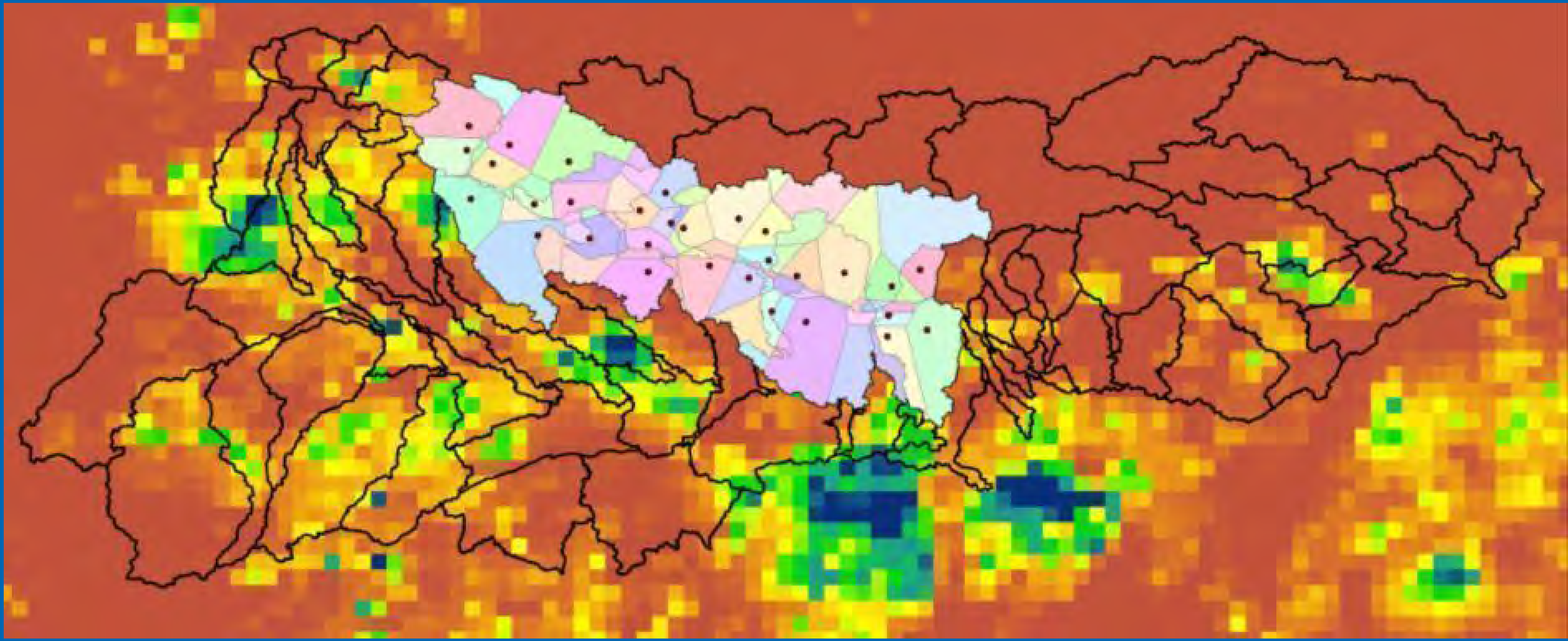
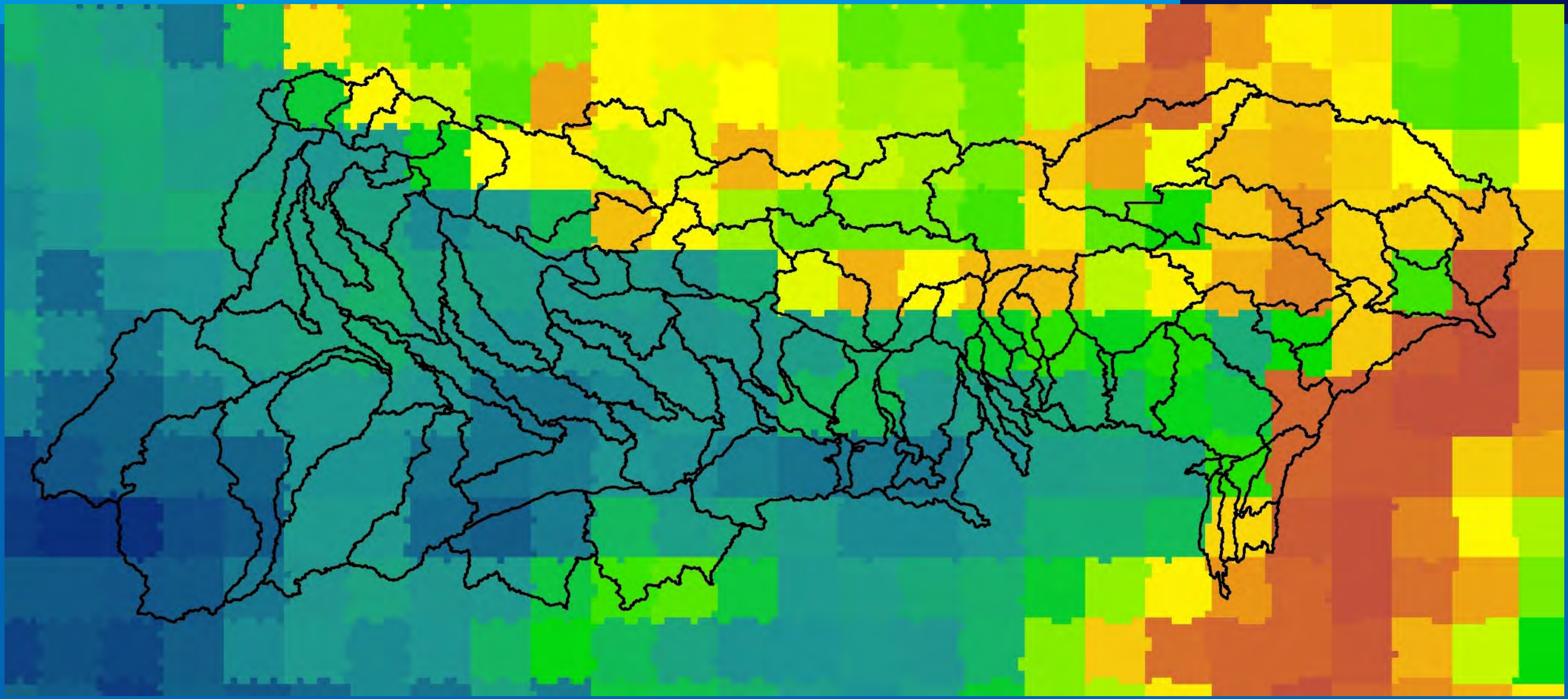


Spatial Resolution : 0.25 degree

Temporal Resolution : Daily

Source : NASA

Potential evapotranspiration data



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Spatial Resolution	: 1.0 degree
Temporal Resolution	: Daily
Source	: NOAA

Aphrodite temperature data

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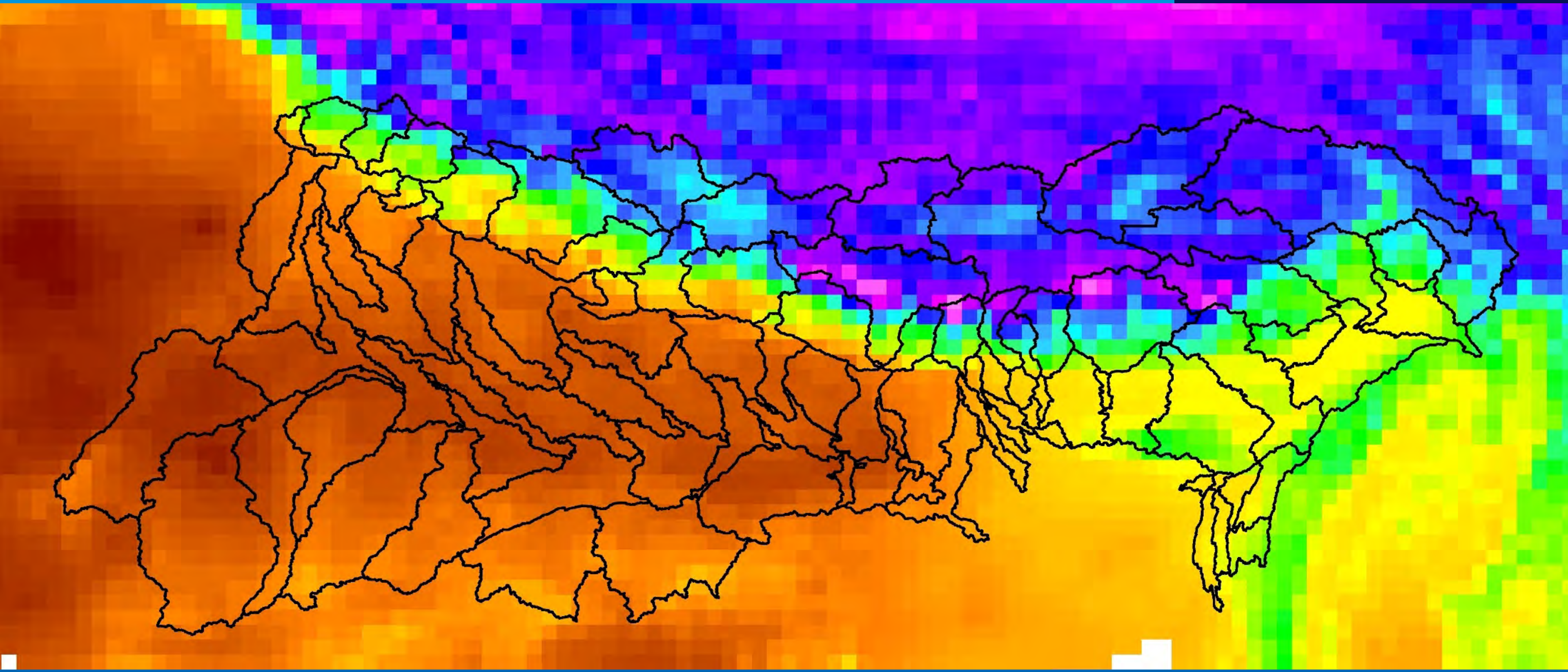

Spatial Resolution : 0.25 degree
Temporal Resolution : Daily
Source : JAXA

Regional flood information system

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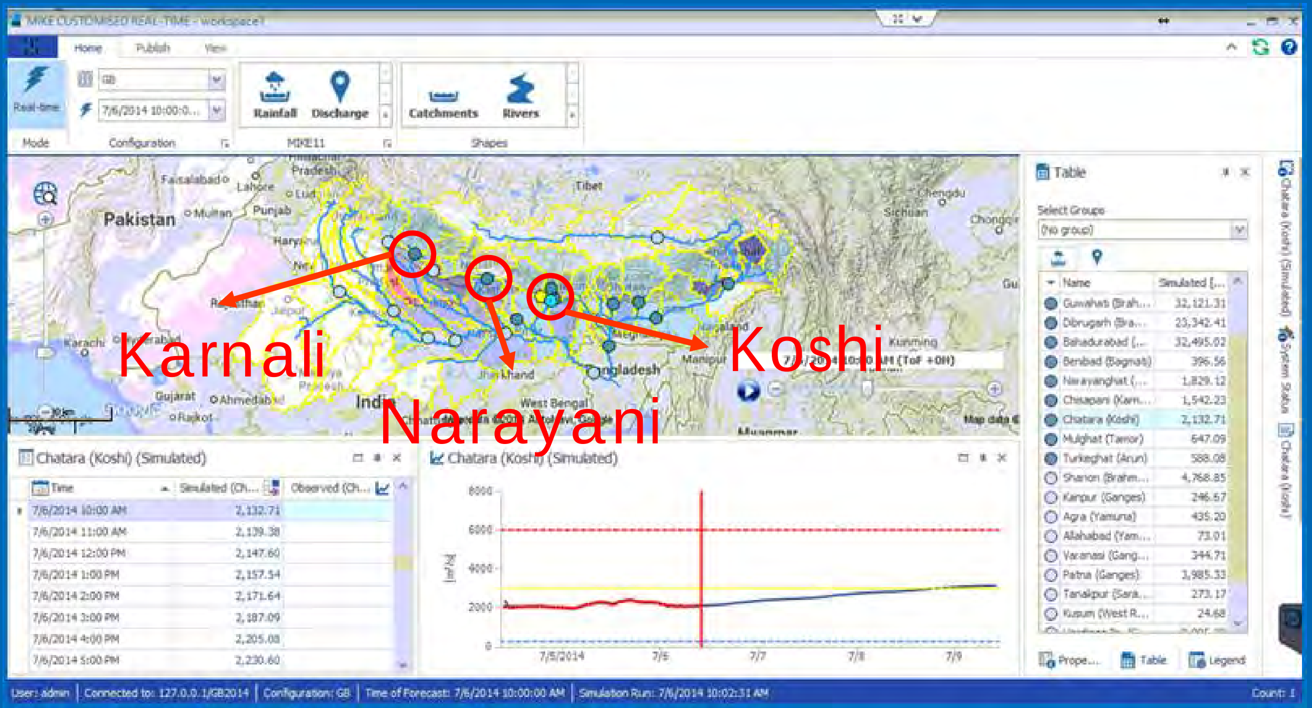
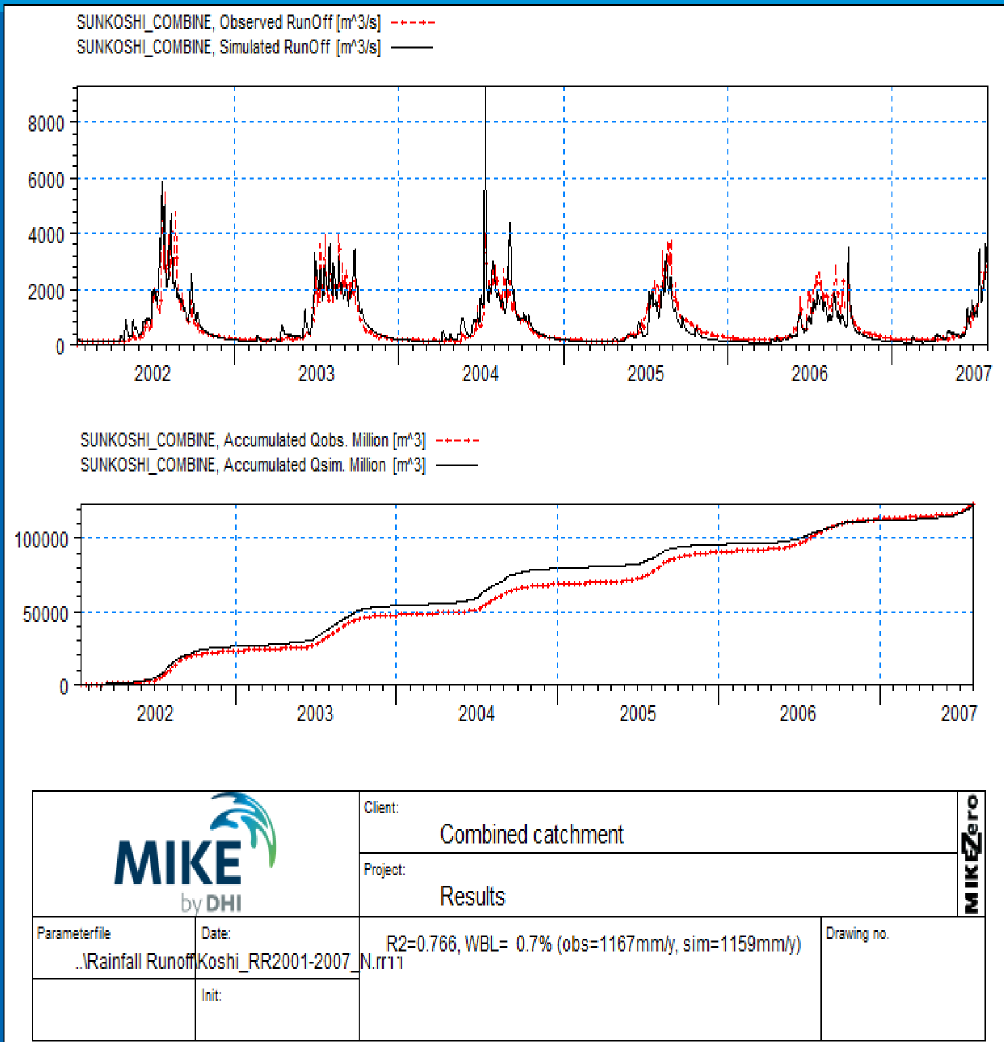
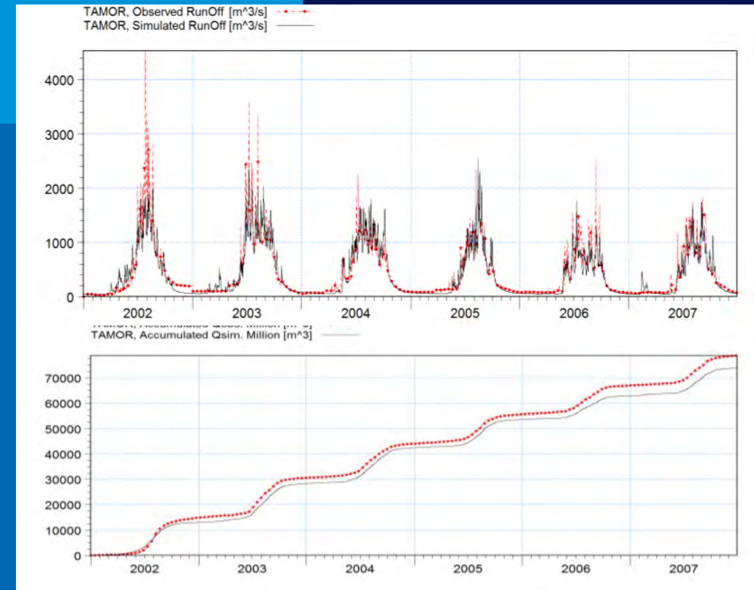
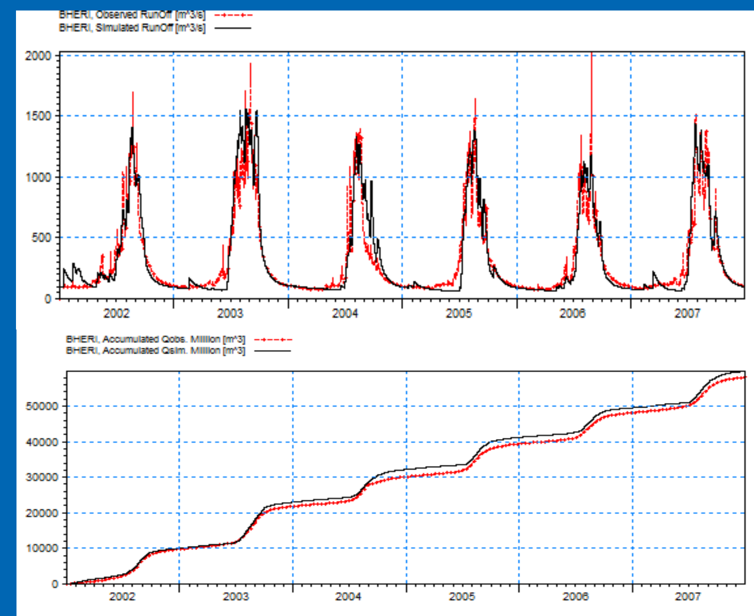
- Setup of a real-time Forecasting system for GB Basin
- 21 nodes have included for flood outlook in GB- basin with 3 days lead time
- Currently focus on major rivers of Nepal with "Alert level" and "Danger level"



Calibration of rainfall-runoff (NAM) model







Calibration at outlet of Basin

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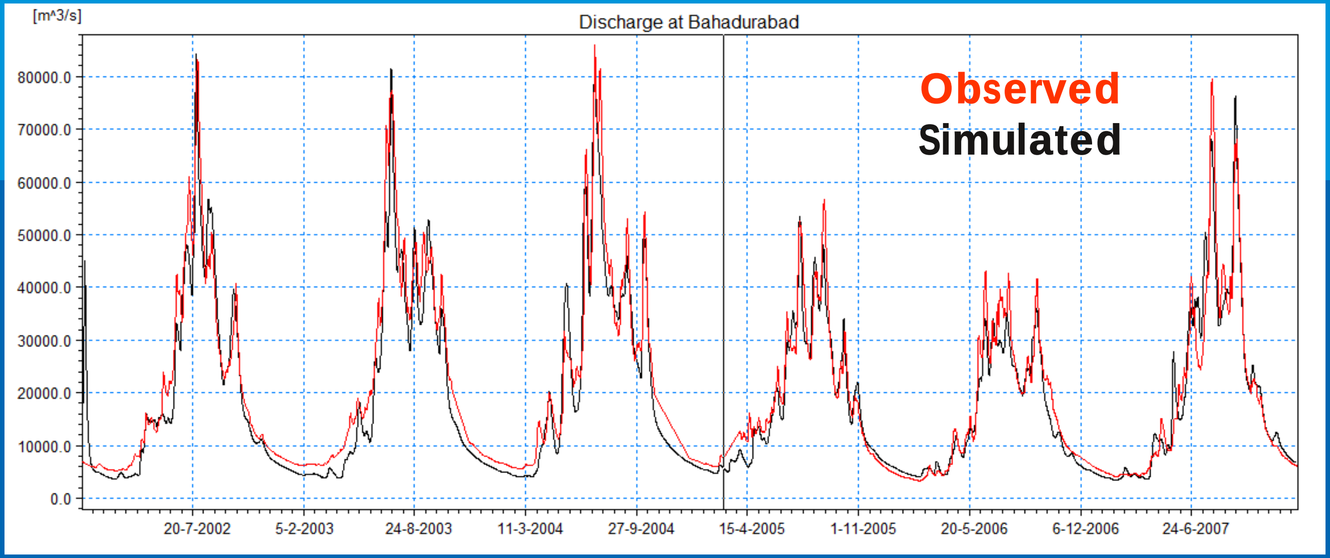
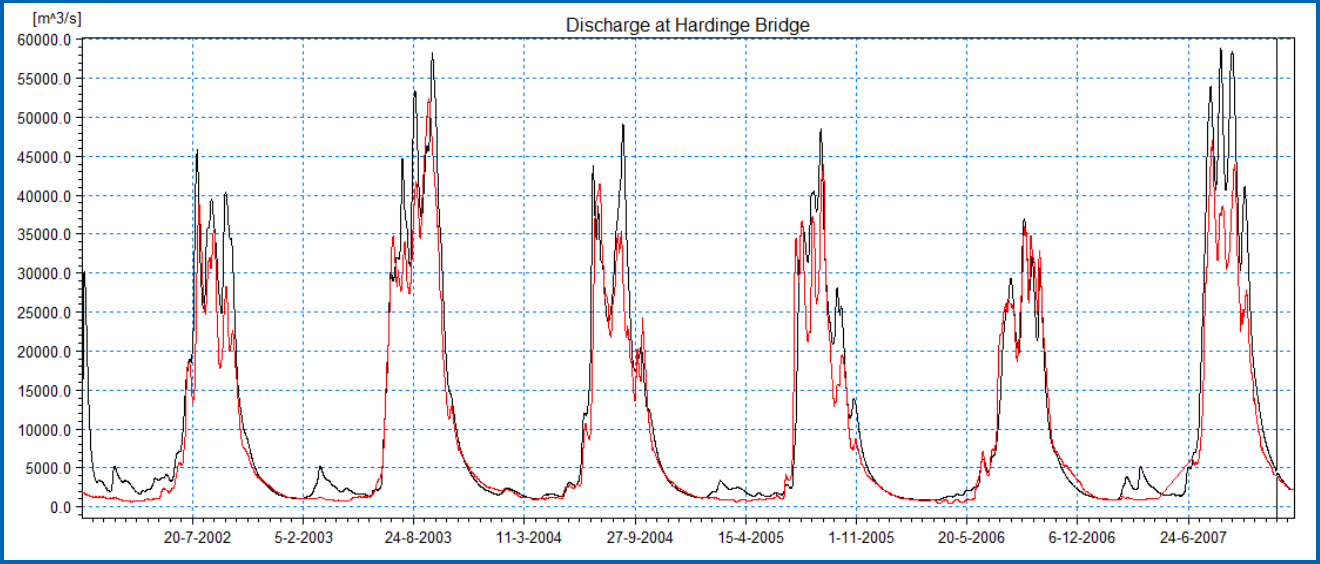
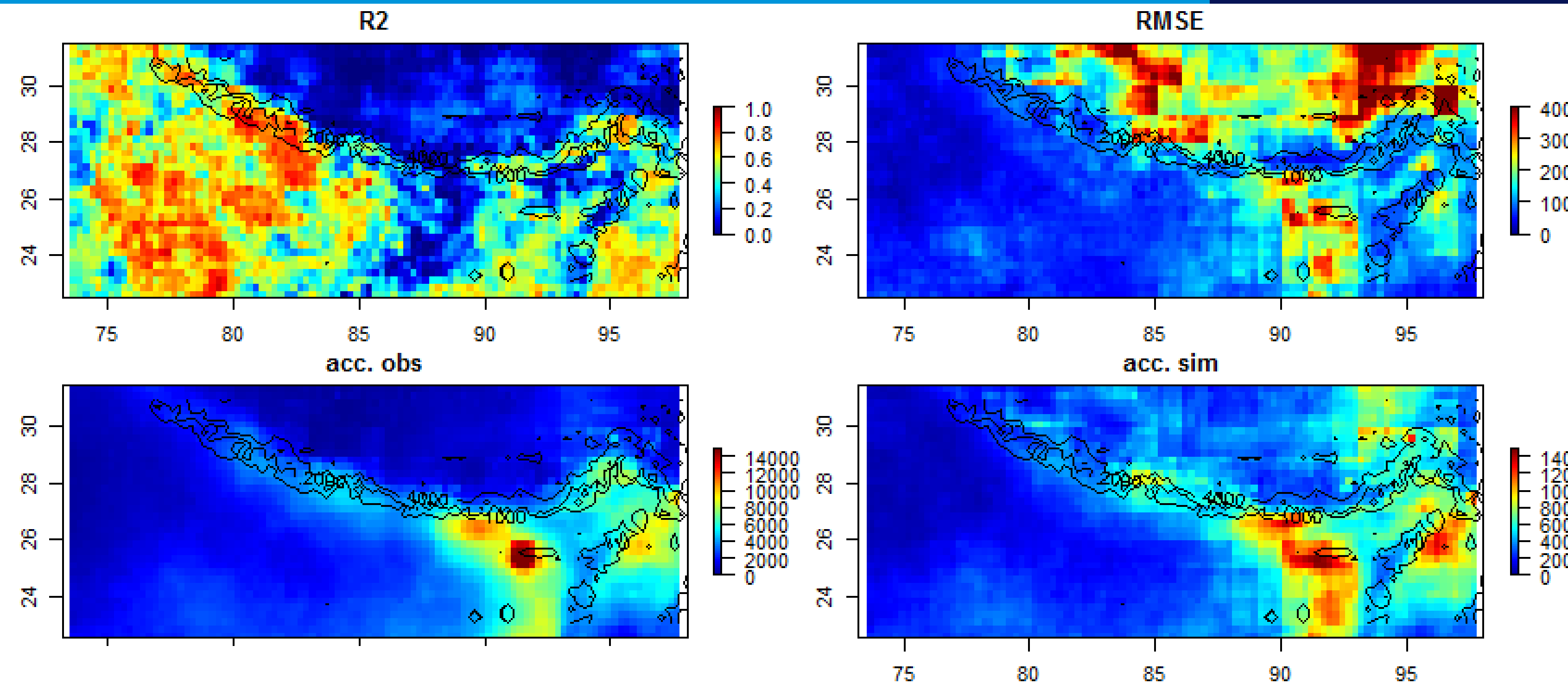


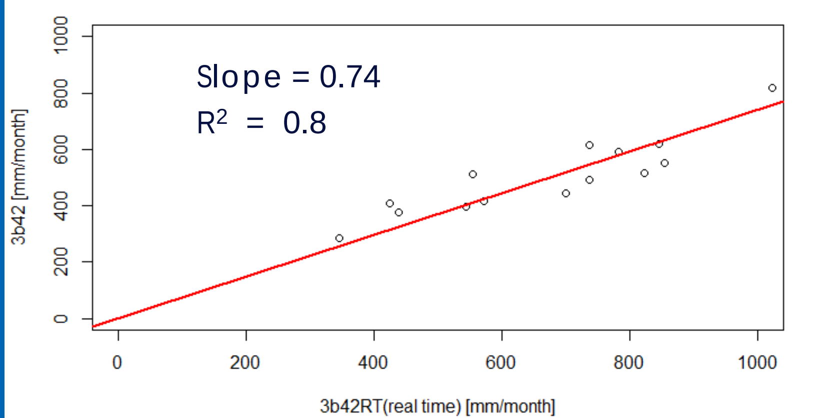
Brahmaputra River at Bahadurabad



Ganges river at Hardinge Bridge

Bias correction Satellite data





Linear regression in each cell point,

Between monthly values in years

2000 – 2013

HD simulation comparison - Bahadurabad

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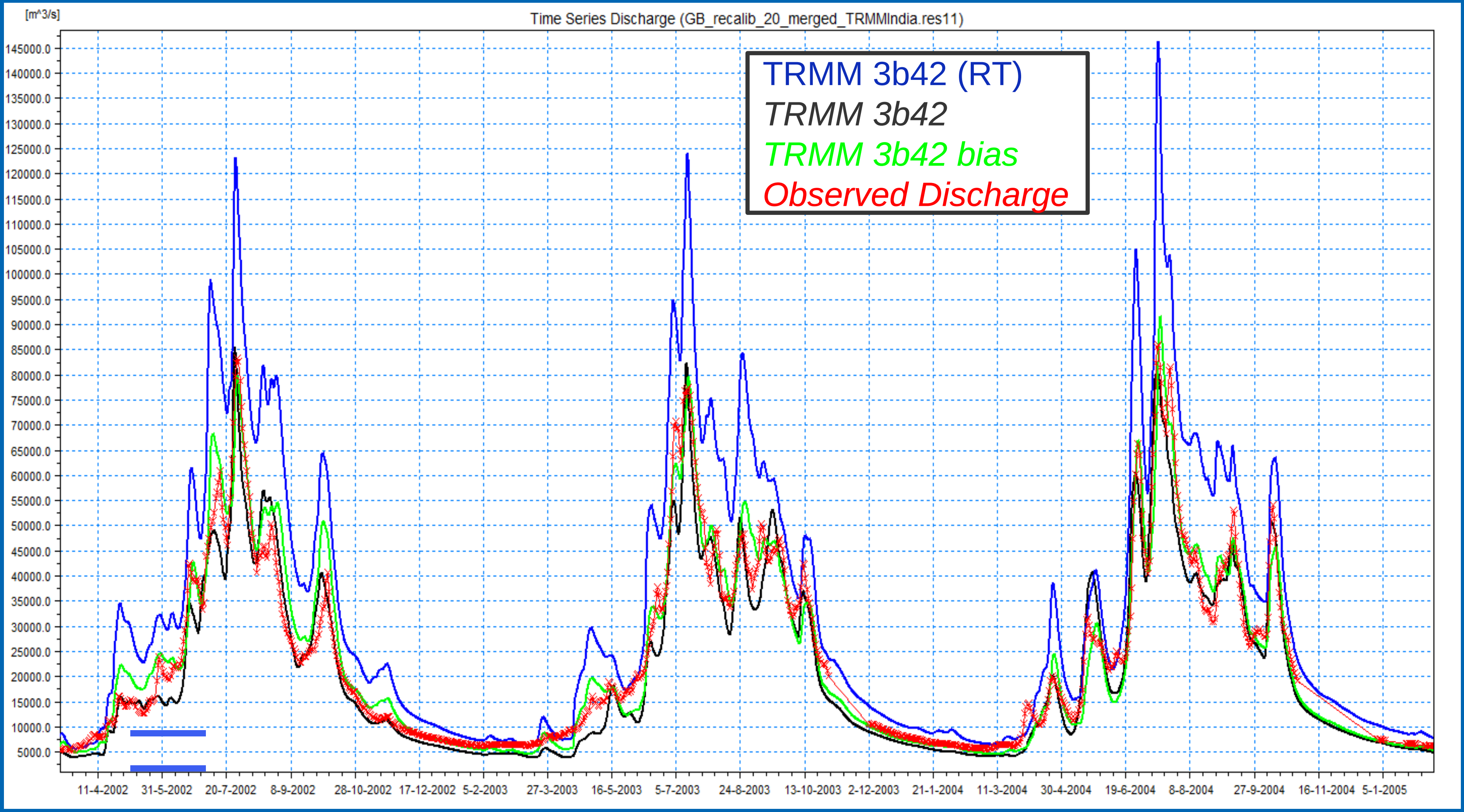


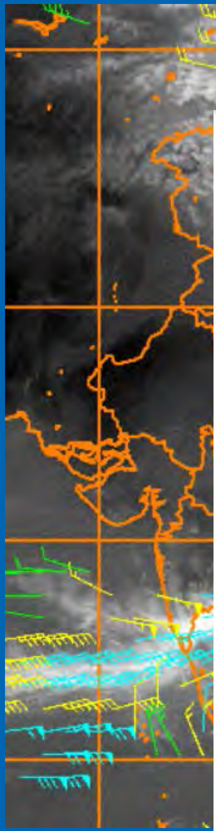
Real-time data and forecast data collection system

1. Real time Hydrometric data collected via ftp / WEB Crawlers
    - http://icimod.org/hycosrfis
    - http://hydrology.gov.np

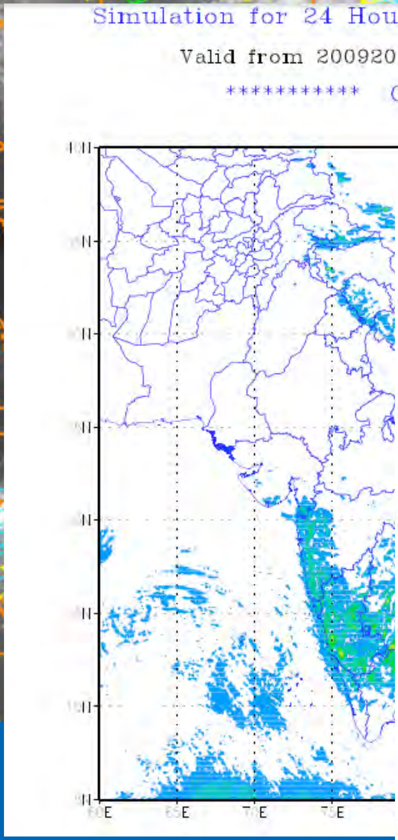
    - Satellite Precipitation from TRMM (3B42 RT)

2. Quantitative Precipitation Forecast from GFS, NOAA (25 x 25km Grid) for Precipitation and Temperature

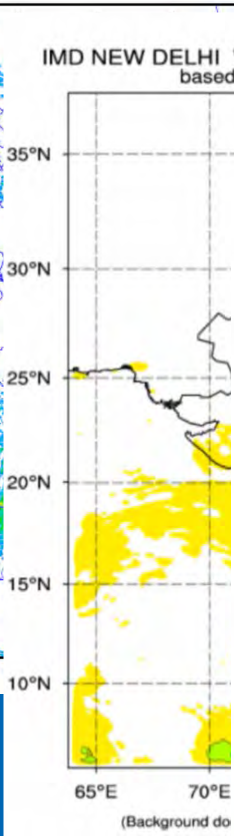
Satellite Image



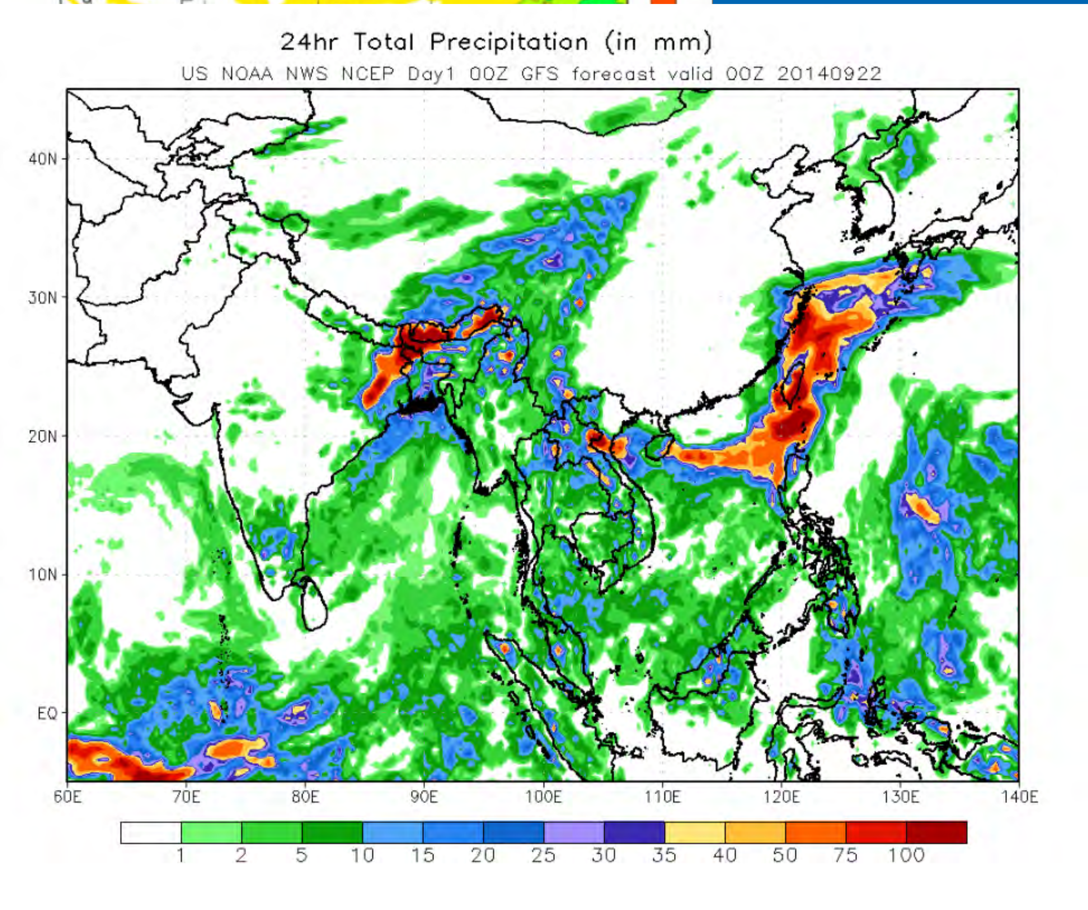
RIMES



WRF



GFS



Meteorological forecasts

System of flow forecast

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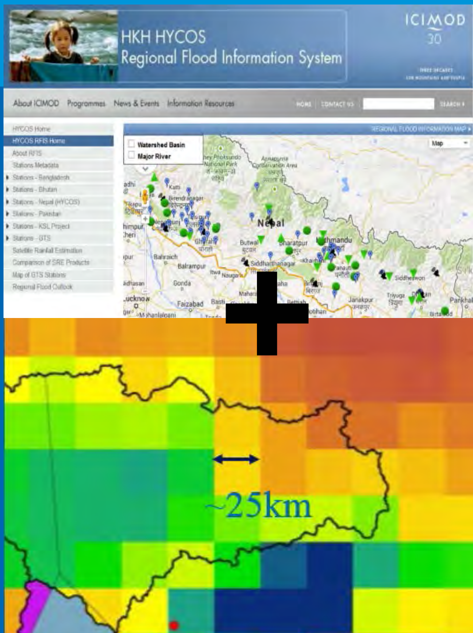
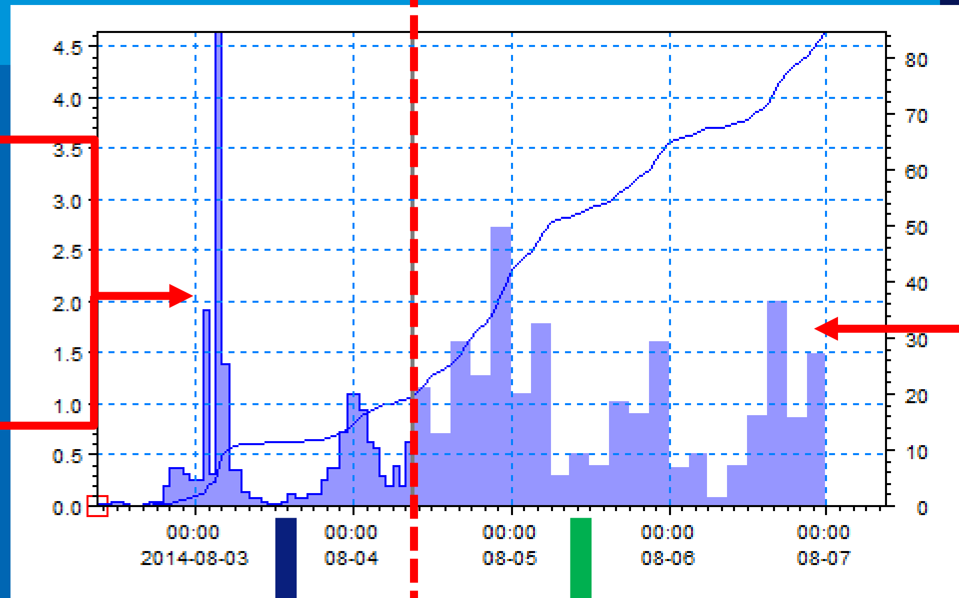
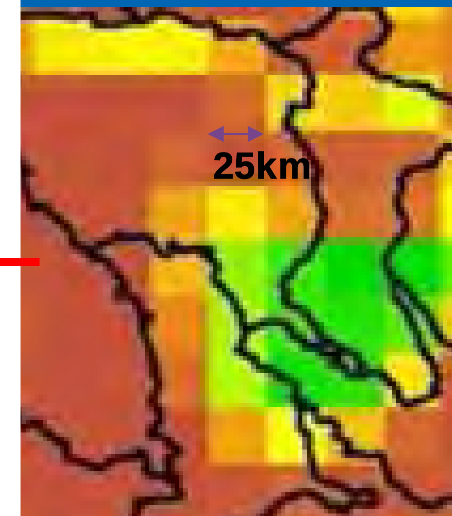
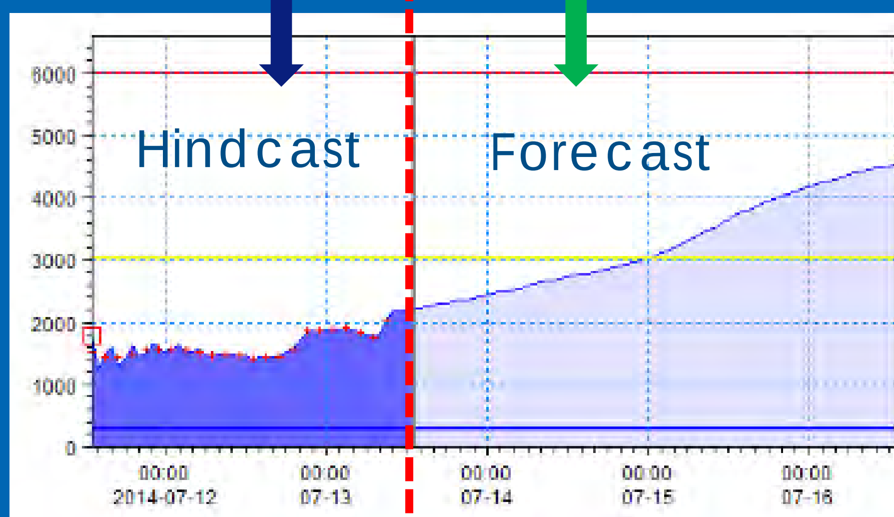
Time of Forecast









Hindcast (Observed RT data, TRMM (RT), NASA

Quantitative Precipitation Forecast (GFS, NOAA)

Testing G-B flood outlook in 2014

GFS rainfall forecast on 12th Aug 2014 07:00

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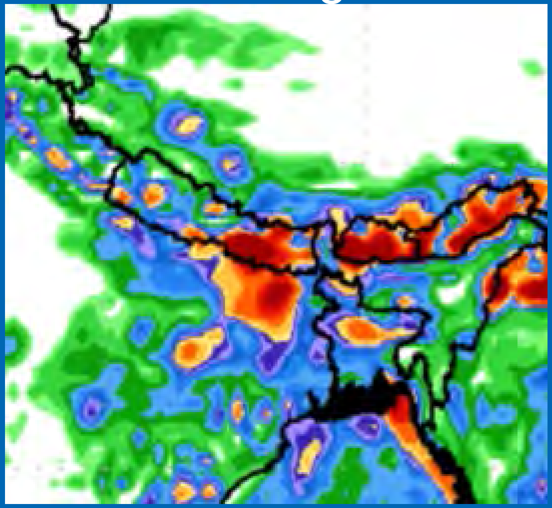
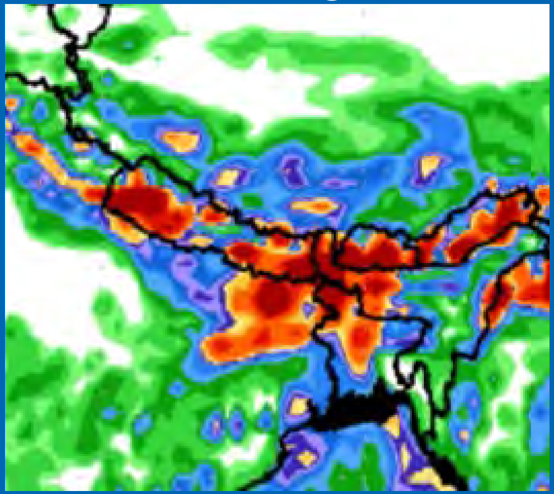
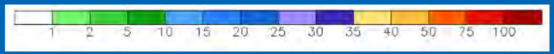
14 Aug

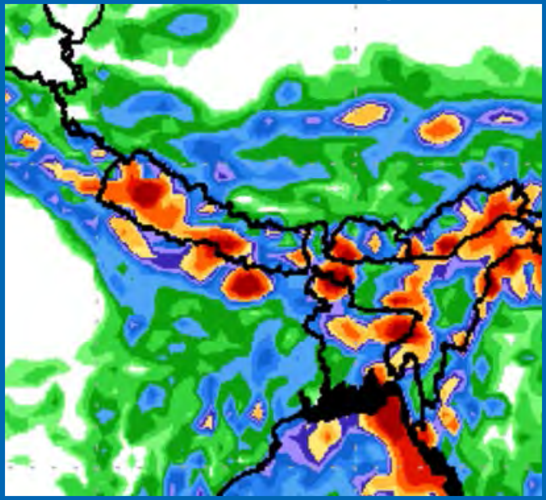


15 Aug





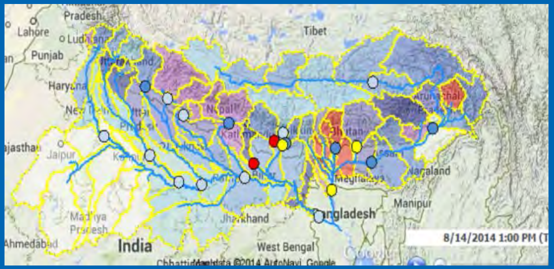
16 Aug

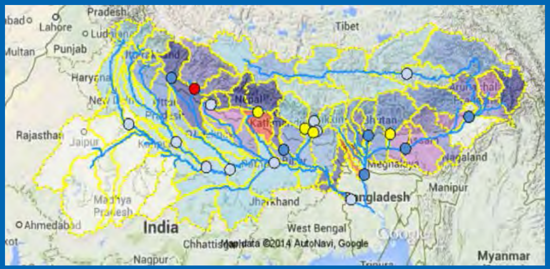


Pilot regional flood outlook

Legend

- Danger Level
- Alert Level
- Monthly average Level





Dissemination of information

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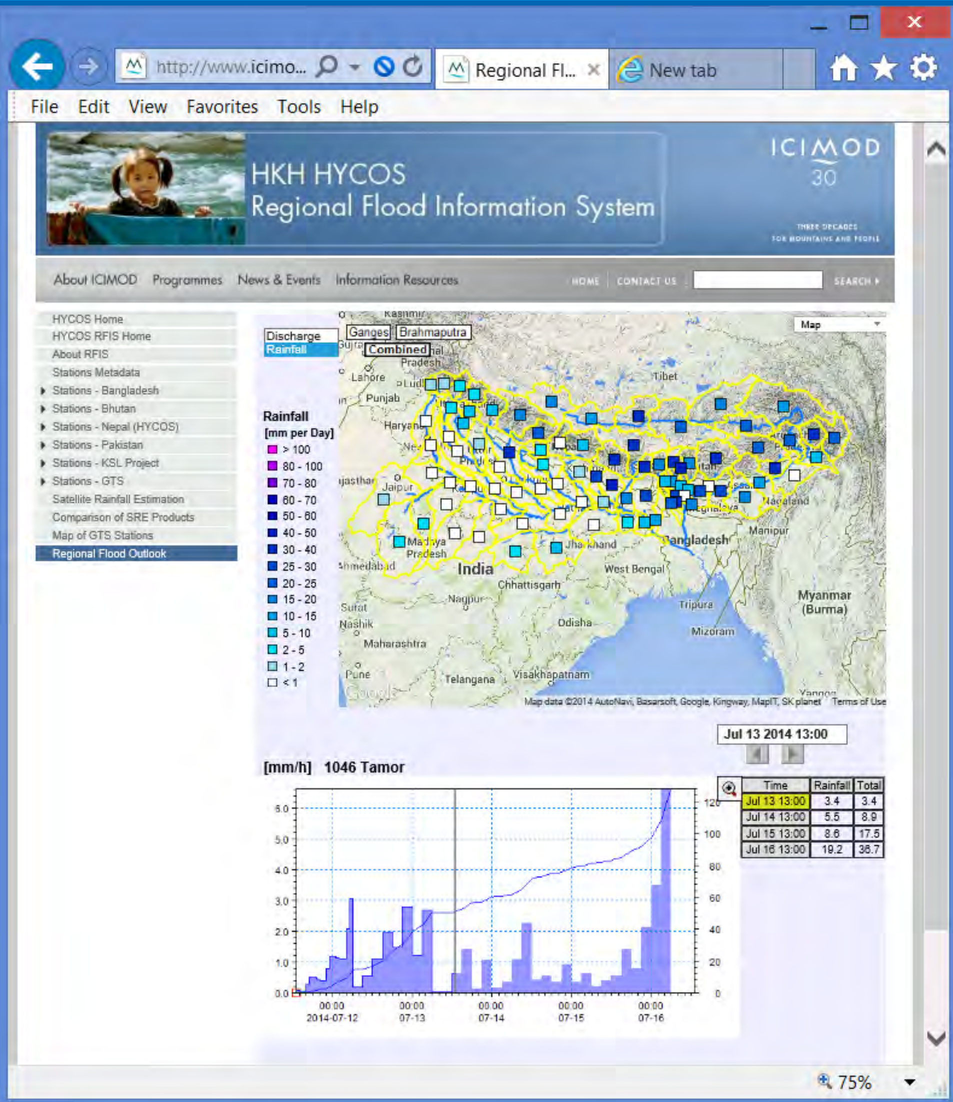

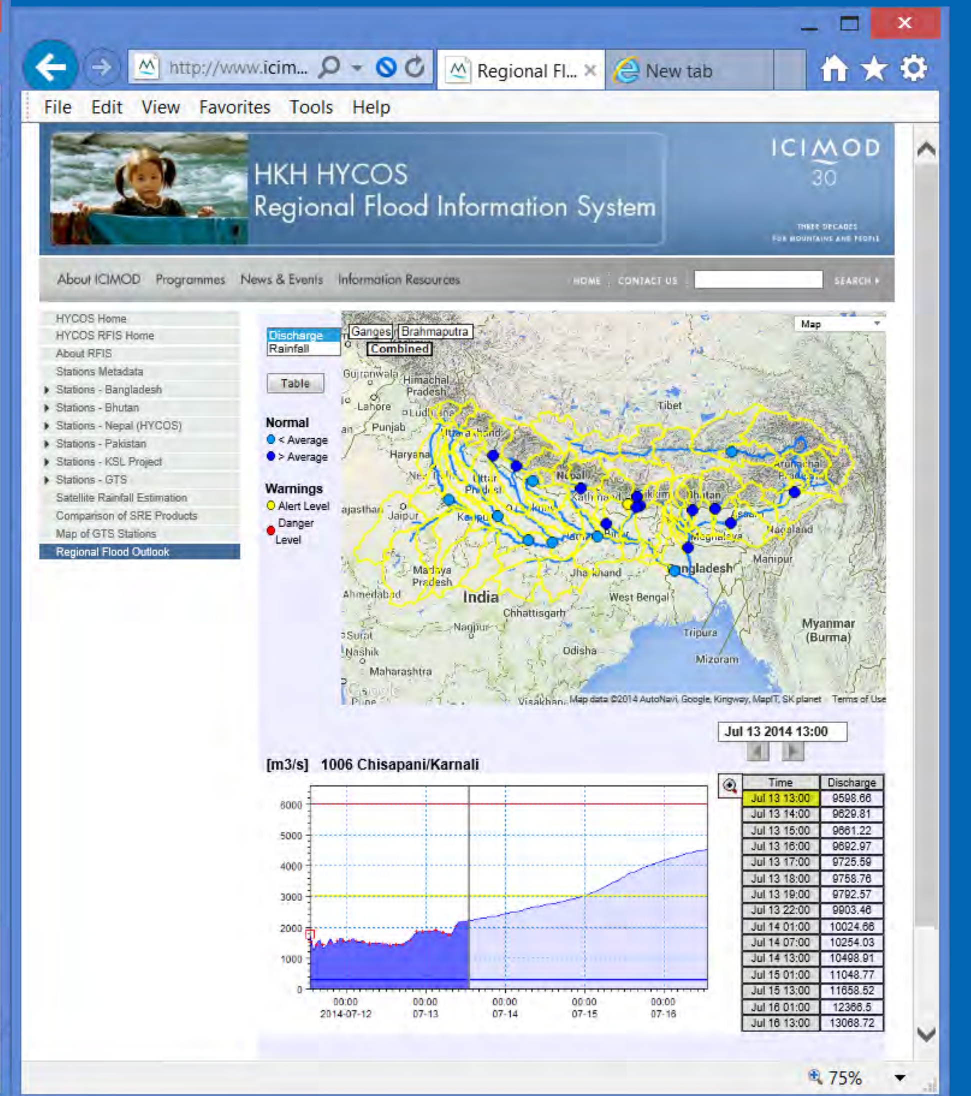

Tabular view of forecast

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		Warning Level		Hours after Time of Forecast = 2014/08/13 15:00															Maximum	
Station / River	Average	Alert	Danger	0	1	2	3	4	5	6	9	12	18	24	36	48	60	72	Time	Max
1001 Hardinge Br./Ganges	20000	40000	60000	9673.29	9709.83	9750.9	9794.01	9837.85	9881.92	9926.64	10074.1	10221.2	10540.4	10967.8	12036.1	13395.1	16708.7	23427.7	8/16/2014 3:00 PM	23427.7
1002 Turkeghat/Arun	1230	3000	4000	736.51	748.27	761.09	774.83	788.63	801.4	813.44	852.97	895.23	1008.96	1142.16	1397.22	1611.8	1733.51	1752.96	8/16/2014 12:00 PM	1755.4
1003 Rabuawabazar/Sunkoshi	603	1900	2900	1464.13	1482.76	1503.24	1524.56	1548.79	1574.3	1600.77	1782.41	2017.25	2766.25	3657.01	5315.35	6997.2	6909.55	6174.91	8/15/2014 7:00 PM	7110.55
1004 Mulghat/Tamor	1050	3200	4500	626.69	627.46	629.06	630.89	632.71	634.66	636.82	656.74	677.96	782.83	1029.9	2074.31	3156.53	3462.99	3202.73	8/16/2014 1:00 AM	3467.69
1005 Chatara/Koshi	4530	5567	8100	4543.23	4562.07	4592.71	4626.26	4661.43	4699.67	4739.86	4953.13	5244.55	6207.83	7486.86	10618.5	13792.2	14307.8	13338	8/15/2014 11:00 PM	14384.9
1006 Chisapani/Karnali	4270	8173	9900	3520.19	3504.32	3494.86	3497.66	3504.84	3506.35	3504.79	3523.26	3537.31	3560.55	3625.2	4464.78	7007.7	11060.8	12262.8	8/16/2014 3:00 PM	12262.8
1007 Kusum/West Rapti	371	1531	1972	20.2	20.43	21.21	22.77	25.04	27.78	30.64	37.7	40.87	41.95	51.34	160.32	232.27	308.89	343.88	8/16/2014 3:00 PM	343.88
1008 Narayanghat/Narayani	4650	7443	9992	4935.7	4959.21	4983.25	5007.9	5031.38	5053.61	5076.05	5221.57	5399.92	5910.97	6547.73	8043.86	8686.04	8924.54	8317.86	8/16/2014 2:00 AM	8941.76
1009 Tanakpur/Sarada	300	1300	1600	317.74	319.84	323.31	327.39	331.39	334.83	338.13	353.6	366.28	387.22	408.5	556.96	754.6	1066.65	1248.43	8/16/2014 3:00 PM	1248.43
1010 Benibad/Bagmali	300	3000	6000	242.49	256.4	281.11	314.86	358.3	410.48	470.1	1097.44	3138.01	9184.49	7377.91	5041.68	3819.14	2087.45	1380.19	8/14/2014 9:00 AM	9184.49
1011 Patna/Ganges	10000	20000	30000	4831.77	4900.07	4972.09	5046.12	5120.06	5191.47	5262.32	5473.36	5666.51	5974.51	6194.08	6828.14	7922.43	9473.31	11541.8	8/16/2014 3:00 PM	11541.8
1012 Varanasi/Ganges	10000	20000	30000	334.04	333.74	333.54	333.33	332.99	332.46	331.92	330.39	328.59	325.02	321.73	315.4	309.55	305.79	302.85	8/13/2014 3:00 PM	334.04
1014 Allahabad/Yamuna	10000	20000	30000	65.33	64.94	64.53	64.14	63.82	63.56	63.25	62.35	61.3	59.34	57.35	52.17	38.36	3.68	-24.68	8/13/2014 3:00 PM	65.33
1015 Agra/Yamuna	10000	20000	30000	1568.53	1574.52	1579.79	1584.4	1588.38	1591.81	1594.78	1601.65	1605.93	1608.42	1602.59	1571.25	1522.03	1481.39	1476.02	8/14/2014 8:00 AM	1608.58
1016 Kanpur/Ganges	10000	20000	30000	472.98	483.35	493.49	503.38	513.21	522.81	532.04	558.39	579.95	613.13	634.58	658.67	673.79	685.01	695.7	8/16/2014 3:00 PM	695.7
2001 Bahadurabad/Brahmaputra	20000	40000	60000	36646.7	36813.4	36979.7	37145.2	37310.3	37475.4	37641.1	38148.5	38681.2	39845.5	41173.5	45164.6	51819.3	61135.2	73369.4	8/16/2014 3:00 PM	73369.4
2002 Shanon/Brahmaputra	10000	20000	30000	5368.06	5411.39	5455.01	5498.88	5542.87	5586.9	5631.09	5766.79	5903.93	6174.21	6420.31	6933.26	7654.9	8585.59	9439.57	8/16/2014 3:00 PM	9439.57
2003 Dibrugarh/Brahmaputra	20000	40000	60000	29666.5	29877	30065.7	30240.1	30422.6	30614.7	30799.5	31260.2	31656.6	32893.1	34841.5	39472	44779	47528	48523.5	8/16/2014 1:00 PM	48546.3
2004 Guwahati/Brahmaputra	20000	40000	60000	34431.2	34525.4	34627.5	34731.6	34834	34930.8	35029.5	35361.3	35695.5	36403.8	37235.3	39592.4	43417.4	48444.3	53487.4	8/16/2014 3:00 PM	53487.4
2005 Bhutan1/Manas	300	3000	6000	2696.92	2792.38	2908.34	3043.77	3180.5	3295.85	3389.63	3721.68	4141.66	5225.48	6127.05	7273.84	9136.56	9386.23	7974.96	8/15/2014 9:00 PM	9628.82
2006 Bhutan2/Dudkumar	300	3000	6000	2200.69	2248.95	2299.92	2354.19	2411.19	2473.11	2538.43	2891.78	3414.69	4807.38	5771.04	6505.94	9528.2	10643.3	7945.69	8/15/2014 9:00 PM	11448.7

Performance

Evaluation of Flood Forecast on major rivers of Nepal

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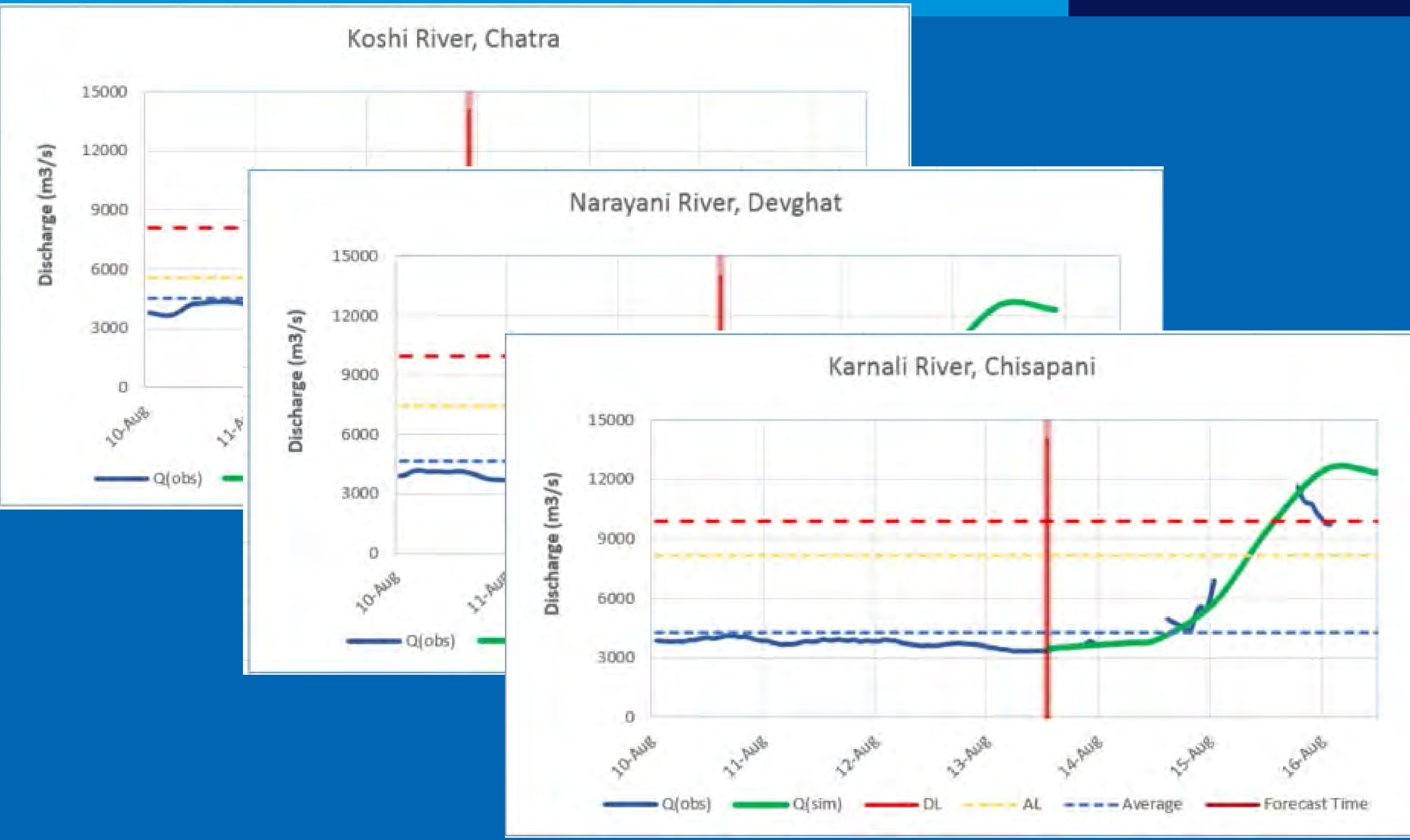
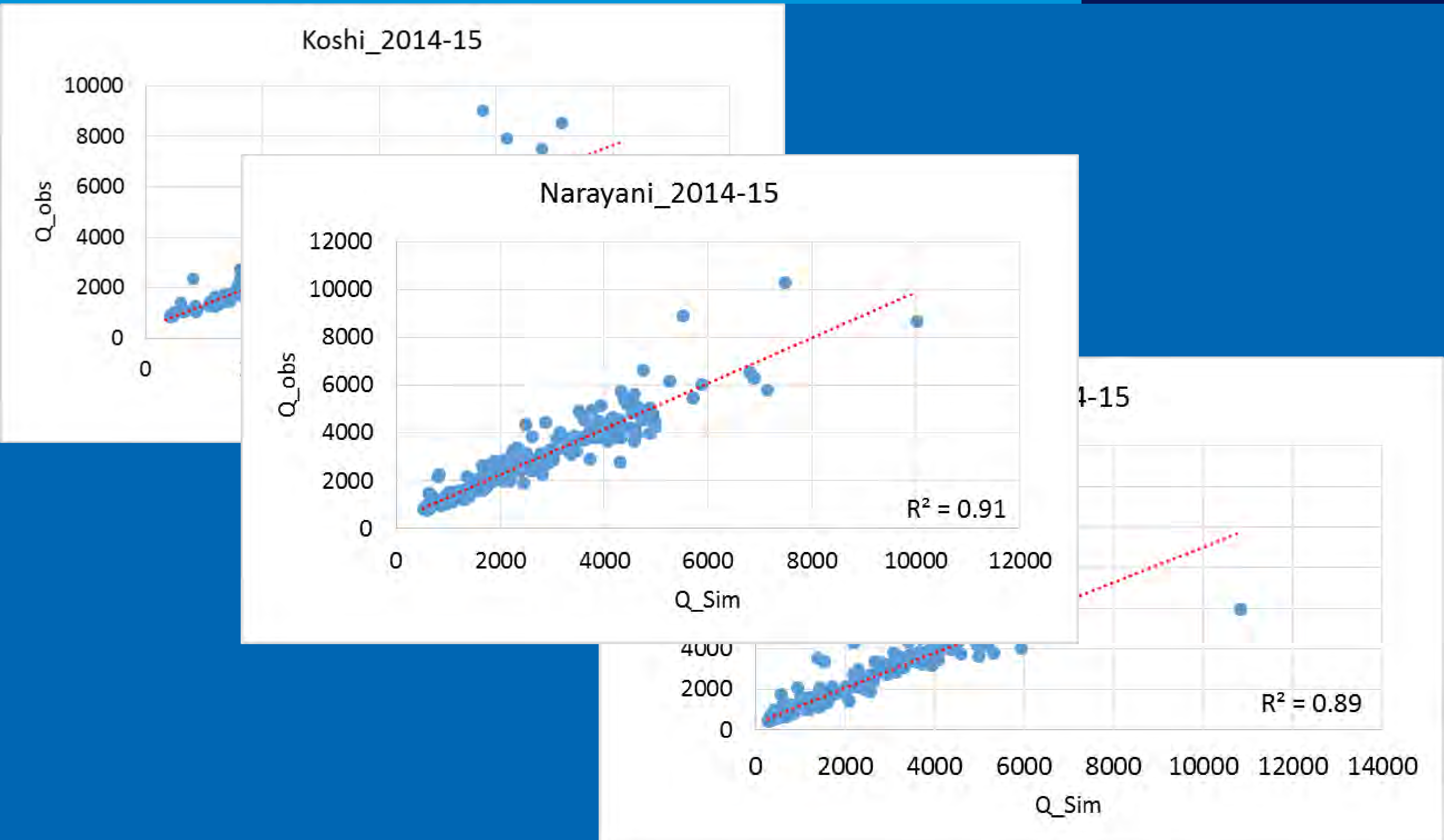


Performance

Evaluation of Flood Forecast on major river of Nepal



Koshi Basin:
Flood outlook & Inundation Mapping

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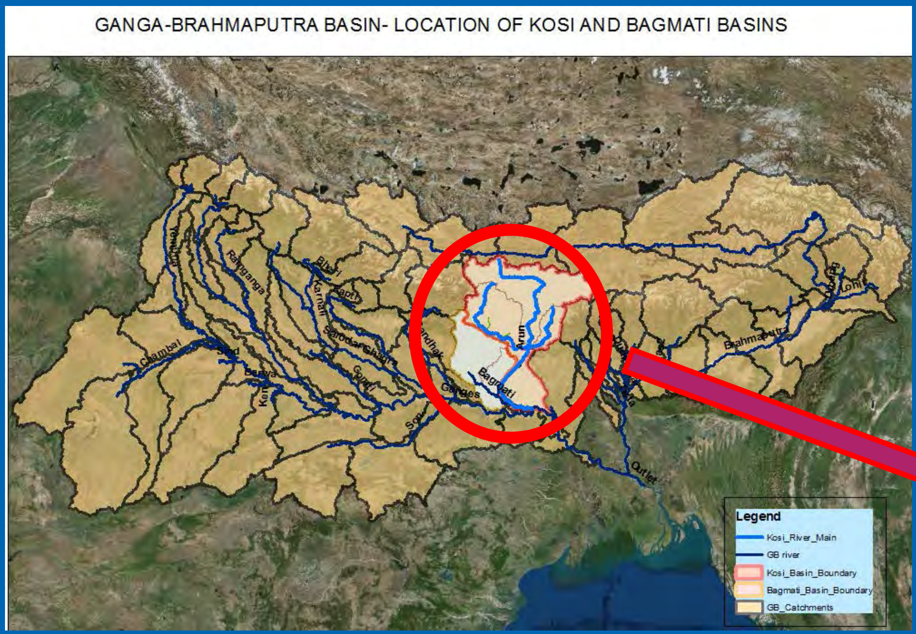
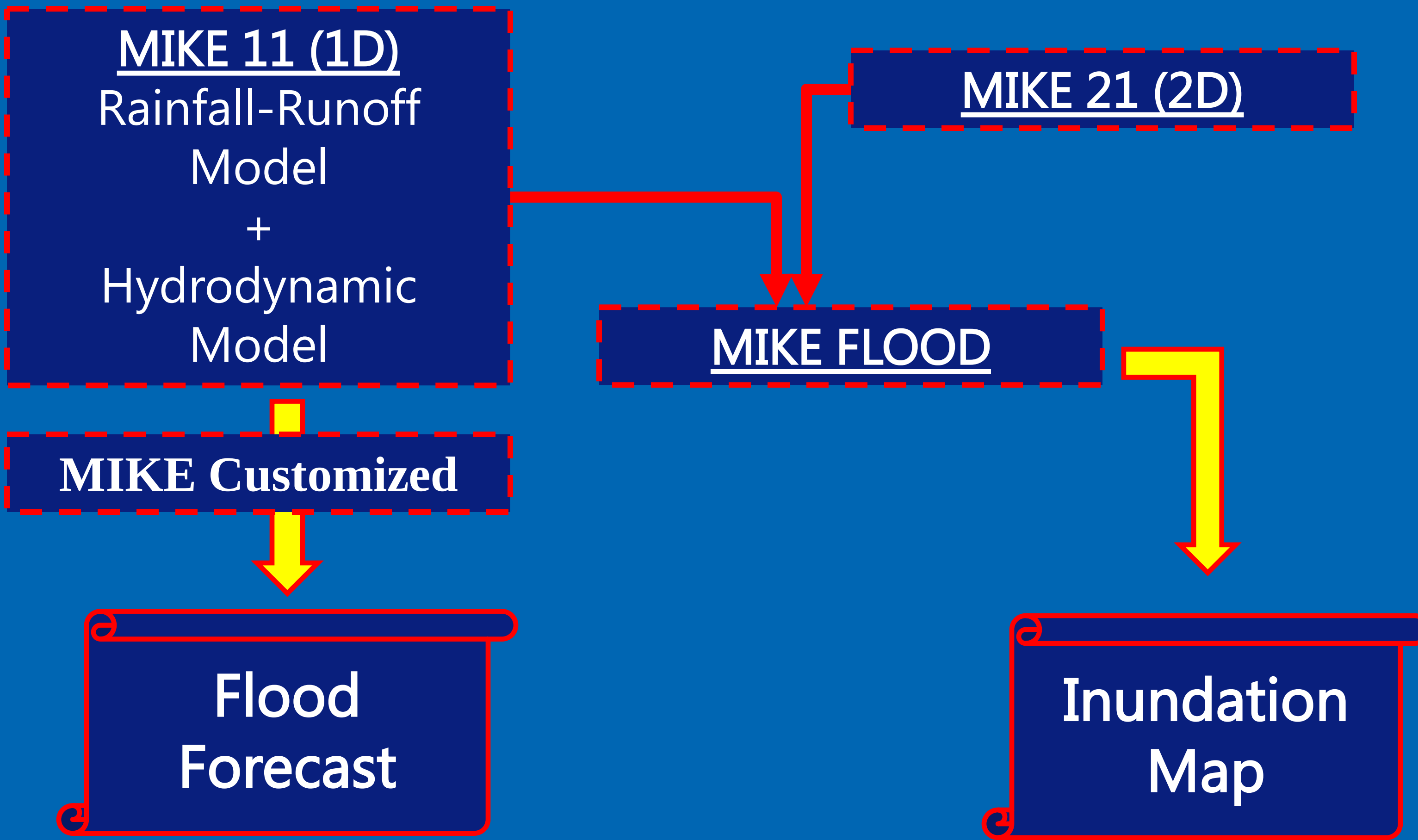


6 Sub-basin is selected

Coupling of 1D and 2D models



Koshi hydrodynamic model set up

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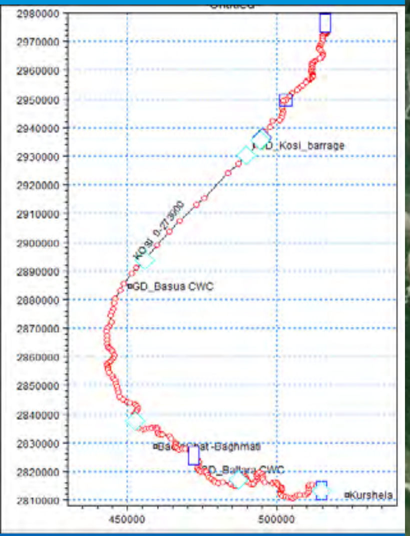

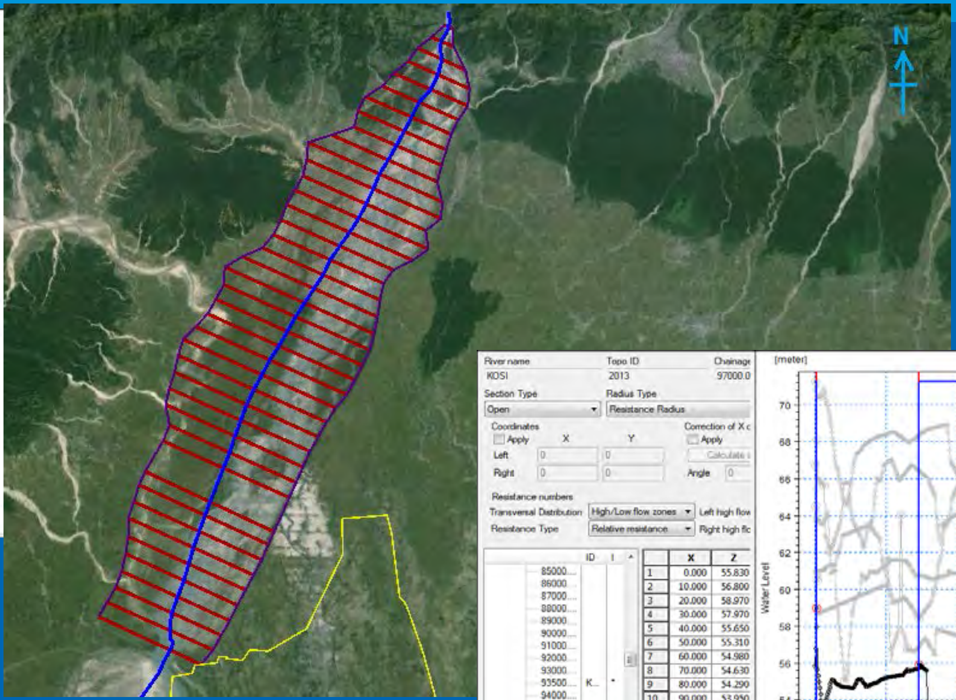

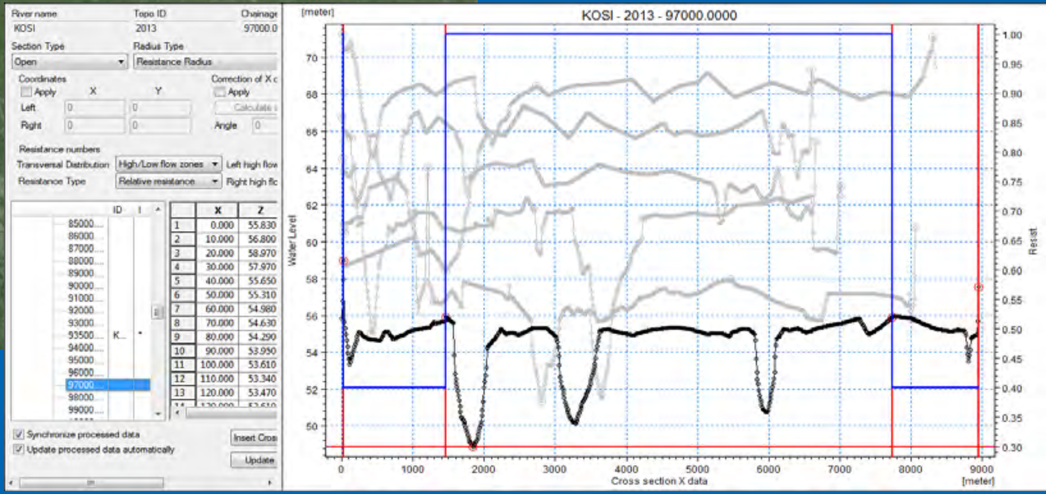

- The Hydrodynamic model consists of a segment of Koshi River having total length of 283 Km, setup from Chatara to Kurshela.
- The193 cross sections data available has been incorporated in the HD model.

KOSI BASIN- Inundation Mapping- 2008 inundation scenarios

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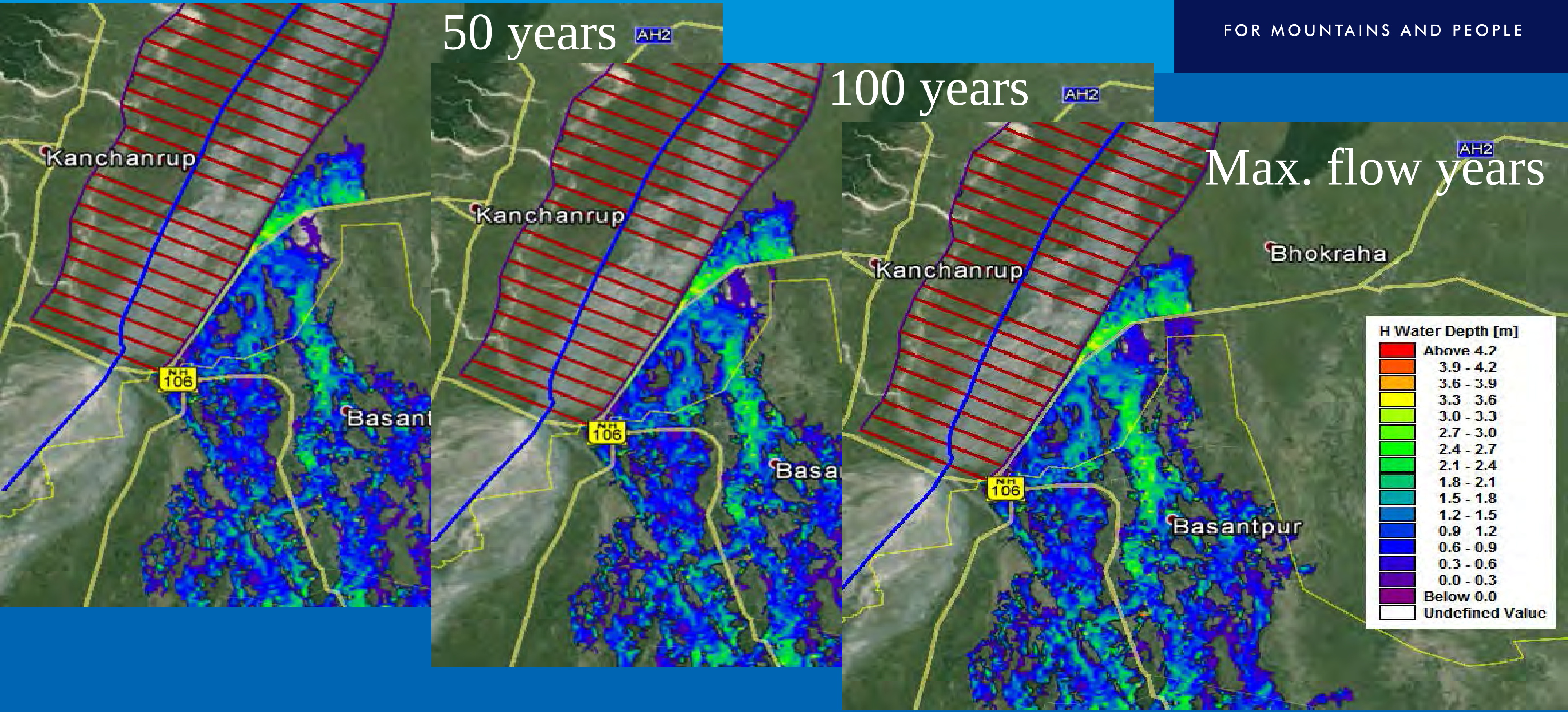

- The embankment breach corresponding to the event of 2008 has been considered as initial case for the simulations. The Koshi River left bank embankment has been considered as breached for length of 1725 m near Kusaha, 12 Km upstream of the Koshi Barrage.
- Simulated flood inundation extent for discharge corresponding to return period of 50 years (19740 m3/s)

Flood Inundation map of Koshi Embankment Breach 2008

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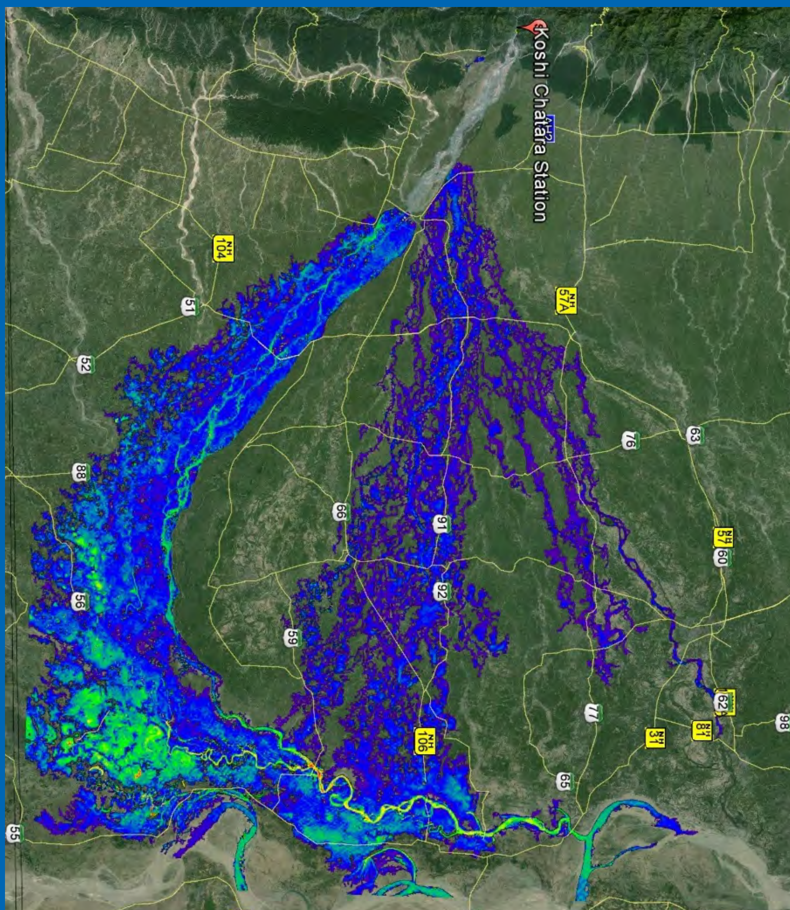
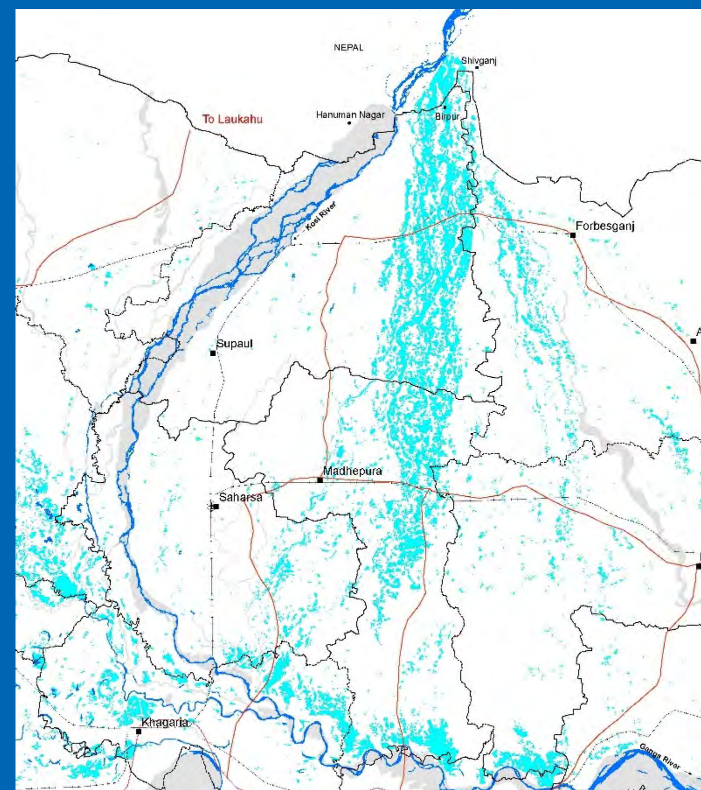


From MIKE FLOOD



Based on the analysis of IRS-P6 and Radarsat data (22-23 Aug 2008)
Source: FMIS

Challenges and road ahead

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- Availability of data - Topographic data (X-section)
- Selection of forecast data for (Amplitude and phase error)

    Ex:

    - RIMES (Daily, Grid – 9 X 9 km)
    - GFS (3 hourly, Grid – 50 X 50 km)

- Define “Alert” and “Danger” levels at given locations
- Further development of the flood outlook.

Lessons learnt

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- Latest development in the technology has enabled us to develop flood information system at basin scale
- Flood forecasting and warning needs to be integrated with the disaster risk management activities for an effective end to end flood early warning system
  - Efforts need to be made for risk communication, awareness and better preparedness
- Institutional mechanisms for provision of flood warning to communities need to be strengthened
- Limited networks in the region – need further strengthening and sharing
- Utility of data and information for developing flood outlook demonstrated the value of real-time data
- Capacity building and training enhanced cooperation and partnerships
- Regional cooperation is a long term process which requires building trust and confidence between and amongst countries


Thank you

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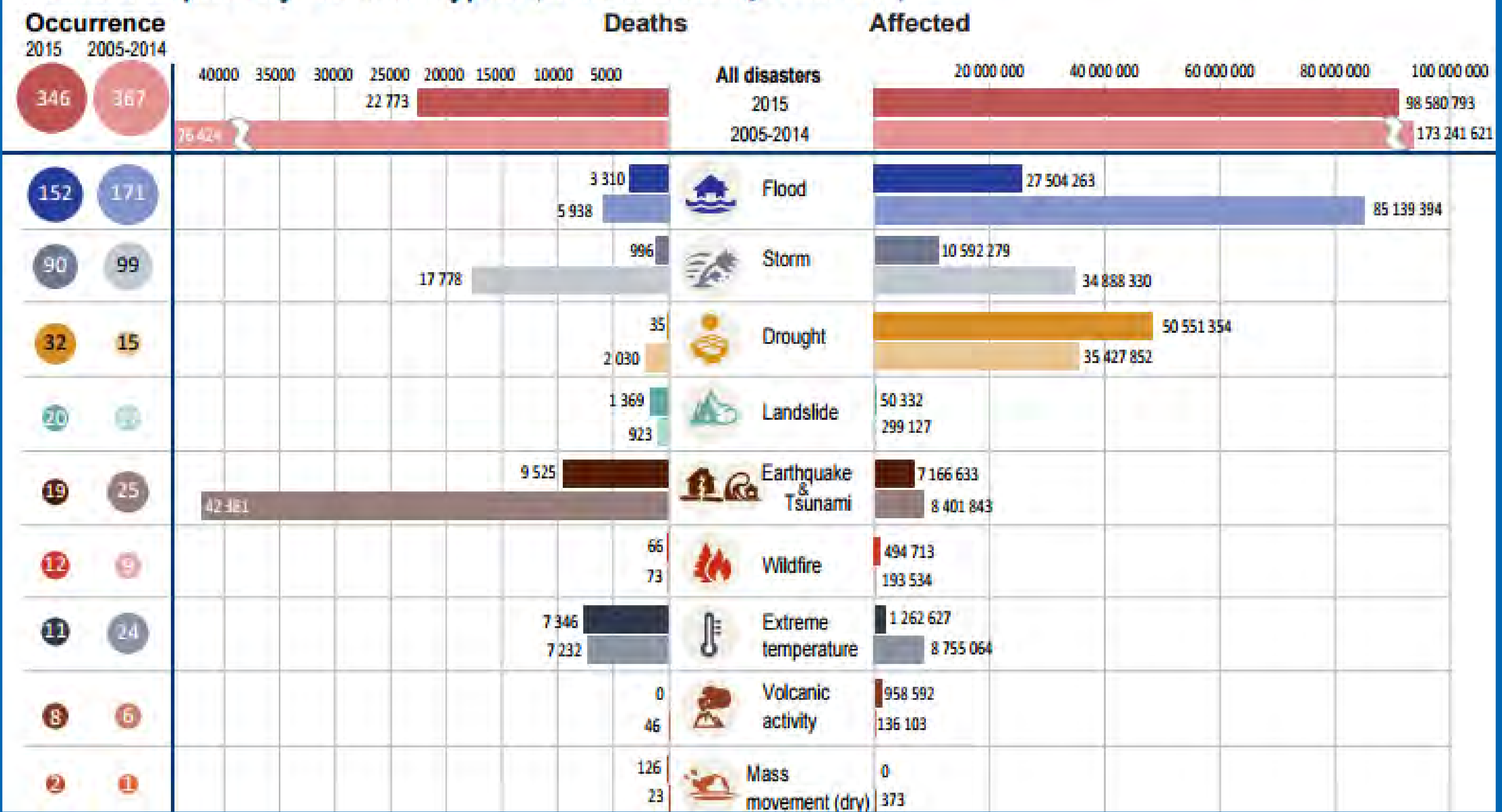
Human impact by disaster types (2015 versus average 2005-2014)



Coupling of 1D and 2D models

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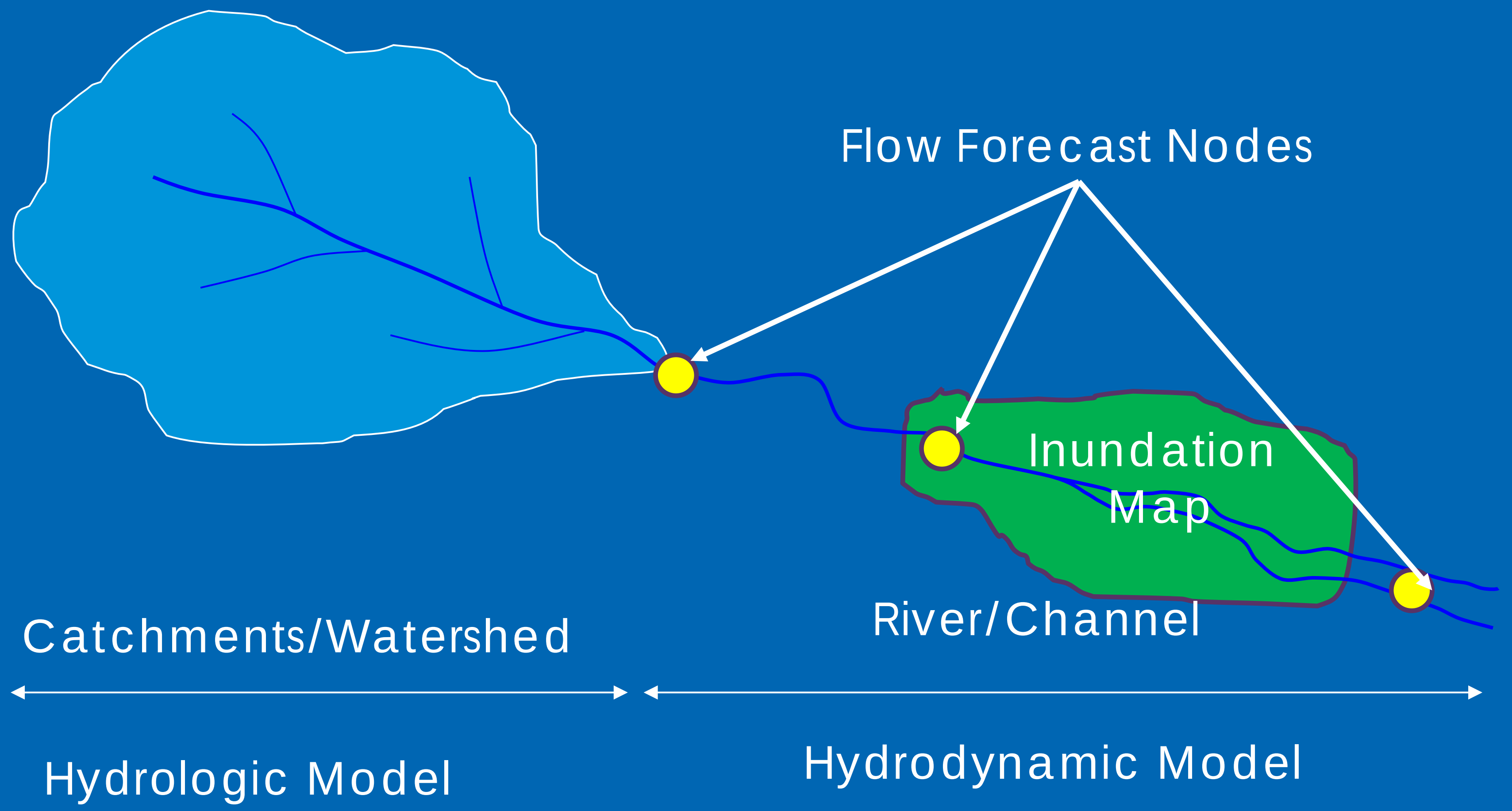


Expert Consultation Workshop on Improving Flood Risk Management in Bihar

Modelling River Morphological Trends

Sudipta Kumar Hore
Junior Specialist
River, Delta and Coastal Morphology Division
CEGIS, Bangladesh

Patna, Bihar, 19 February 2016

Introduction

- Prediction of river course and bank erosion for flood risk management provides
  - Identification of vulnerable reaches along the river bank
  - Planning of water resources management activities in the future
- But it is very difficult to predict in braided river like Kosi, Brahmaputra as channel changes very frequently.
- For such rivers prediction of bank erosion and early warning system has been developed which can help to improve flood risk management.

Introduction

- This Prediction consists of three elements
  - Prediction of river course with vulnerable reaches and bank erosion along the bank
  - Dissemination of the prediction results to stakeholders
  - Measures to prevent erosion, to reduce damages (river training works, evacuation of people etc.)

Introduction

- Time consuming, extensive effort required
- Time is important
- An alternative method developed using dry season satellite images (cloud free)
- Combination of empirical formula for different morphological characteristics
- Probabilistic approach- probability of occurrence with reasonable accuracy

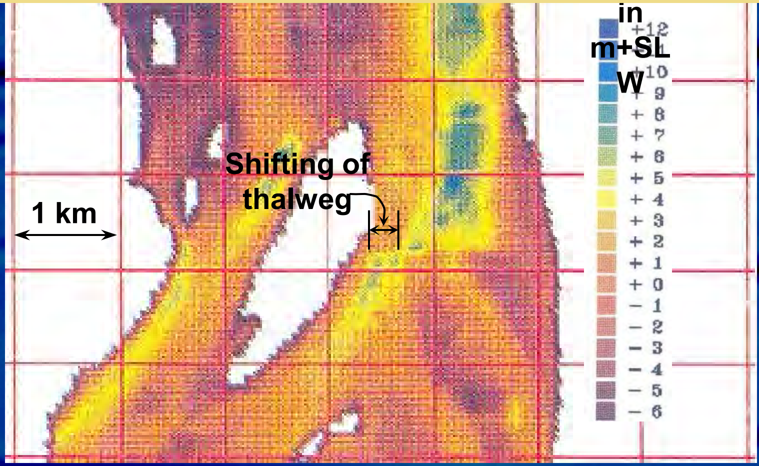
Experiences in Bangladesh (Jamuna)

- Last 12 years using dry season satellite images

- Very dynamic in nature

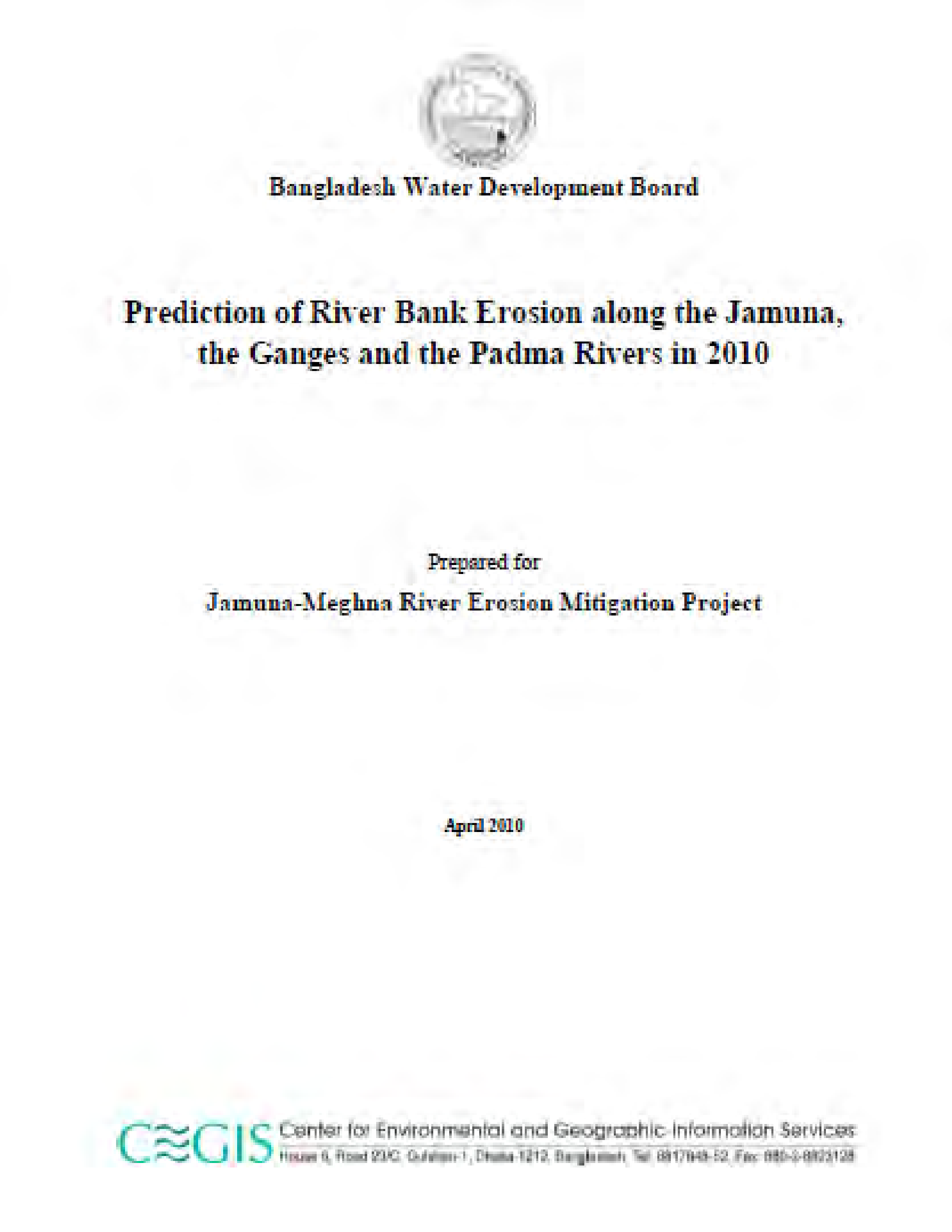
IRS Pan. images

In such a dynamic environment, satellite images are found to be suitable to monitor and study the different morphological aspects of the river.



Even within few days thalweg of the river may shift hundred of meter

Experiences in Bangladesh



Bangladesh Water Development Board

Prediction of River Bank Erosion along the Jamuna, the Ganges and the Padma Rivers in 2010

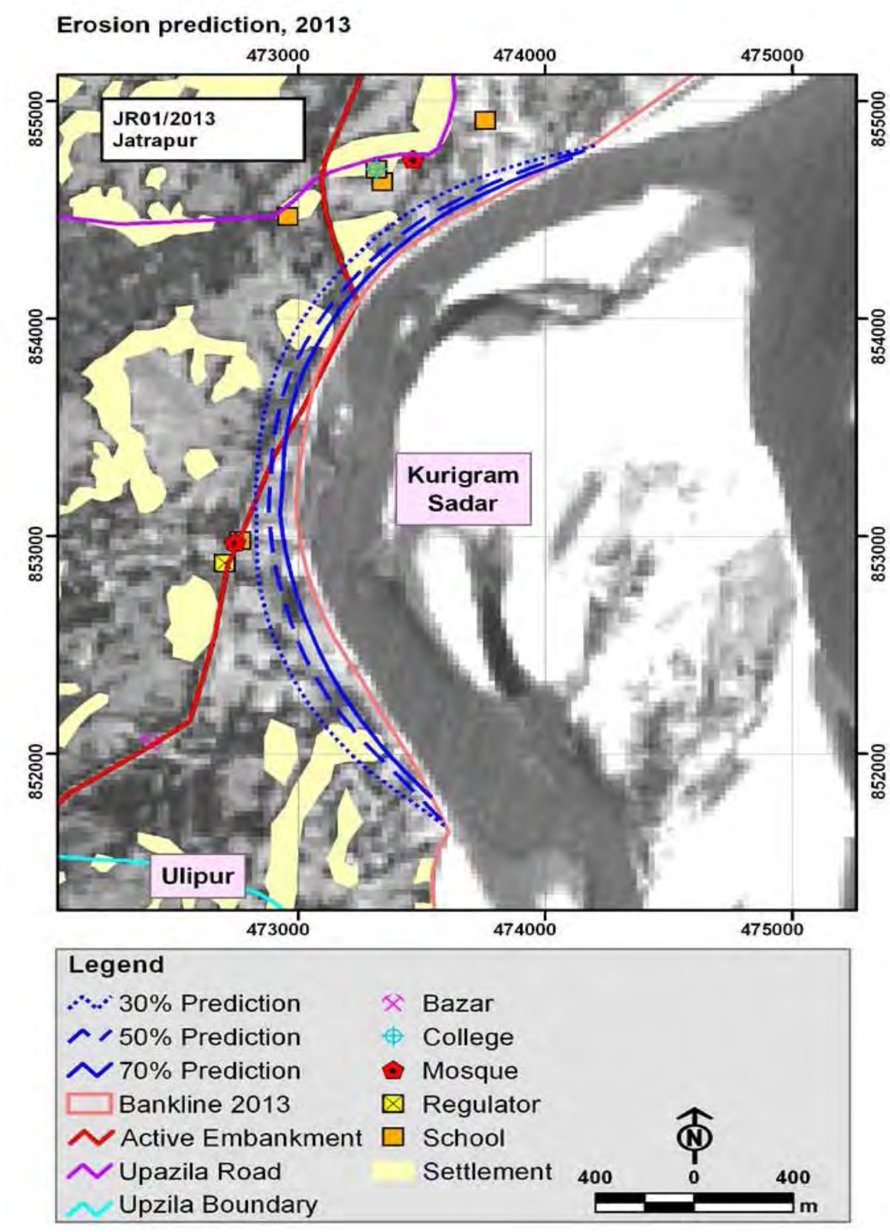
Prepared for

Jamuna-Meghna River Erosion Mitigation Project

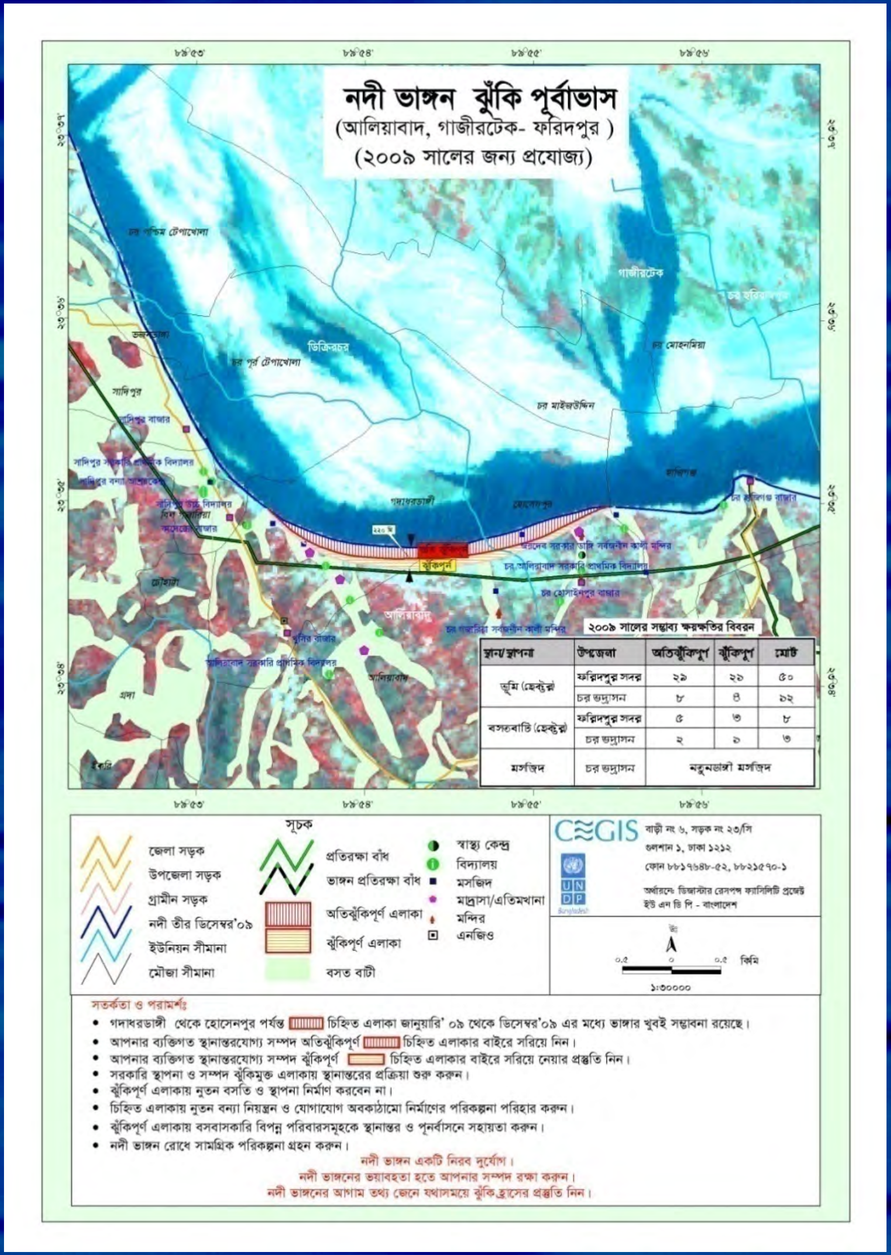
April 2010

CEGIS Center for Environmental and Geographic Information Services

House 6, Road 23/C, Gulshan-1, Dhaka-1212, Bangladesh, Tel: 8817648-52, Fax: 880-2-8823128

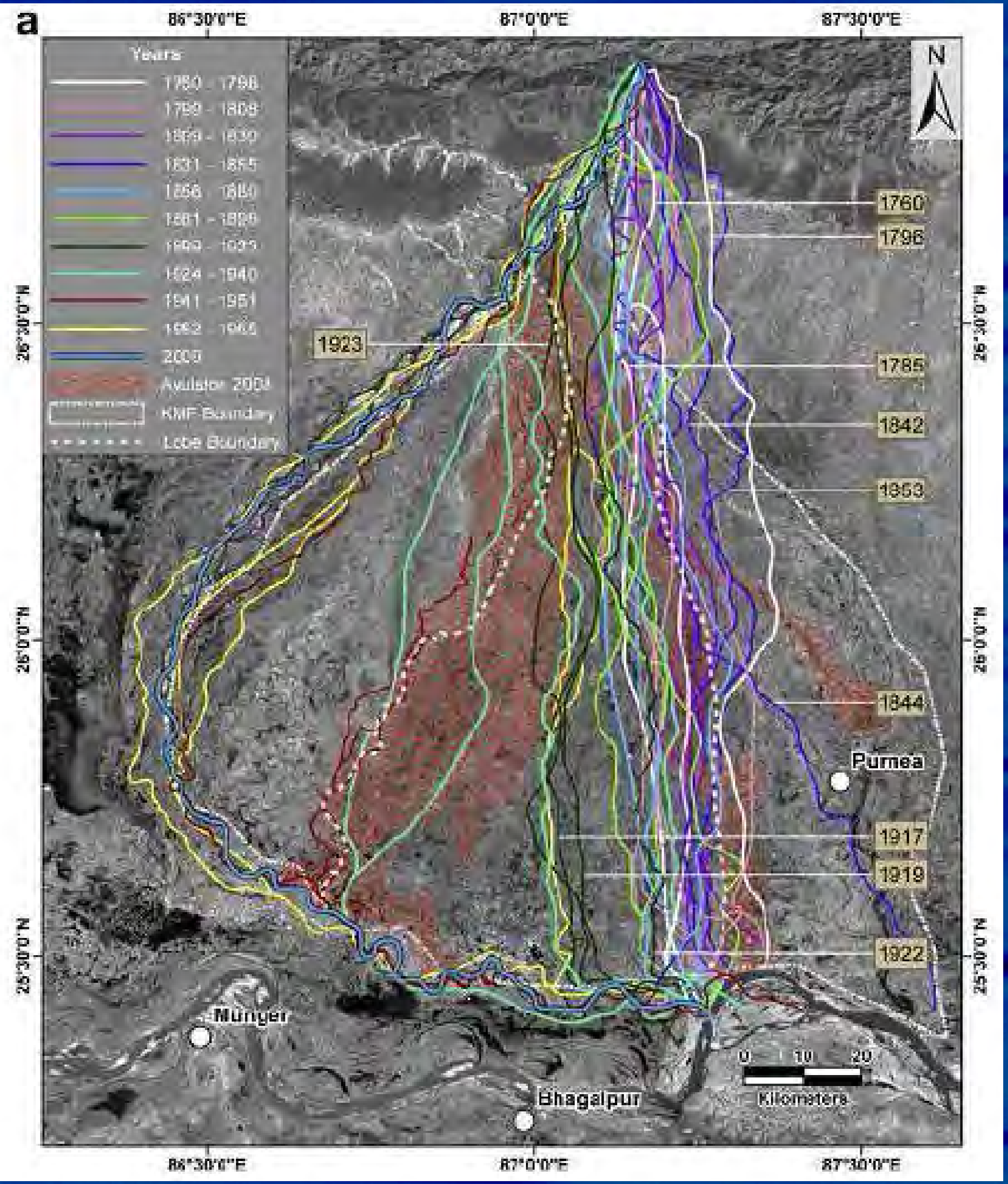


Experiences in Bangladesh



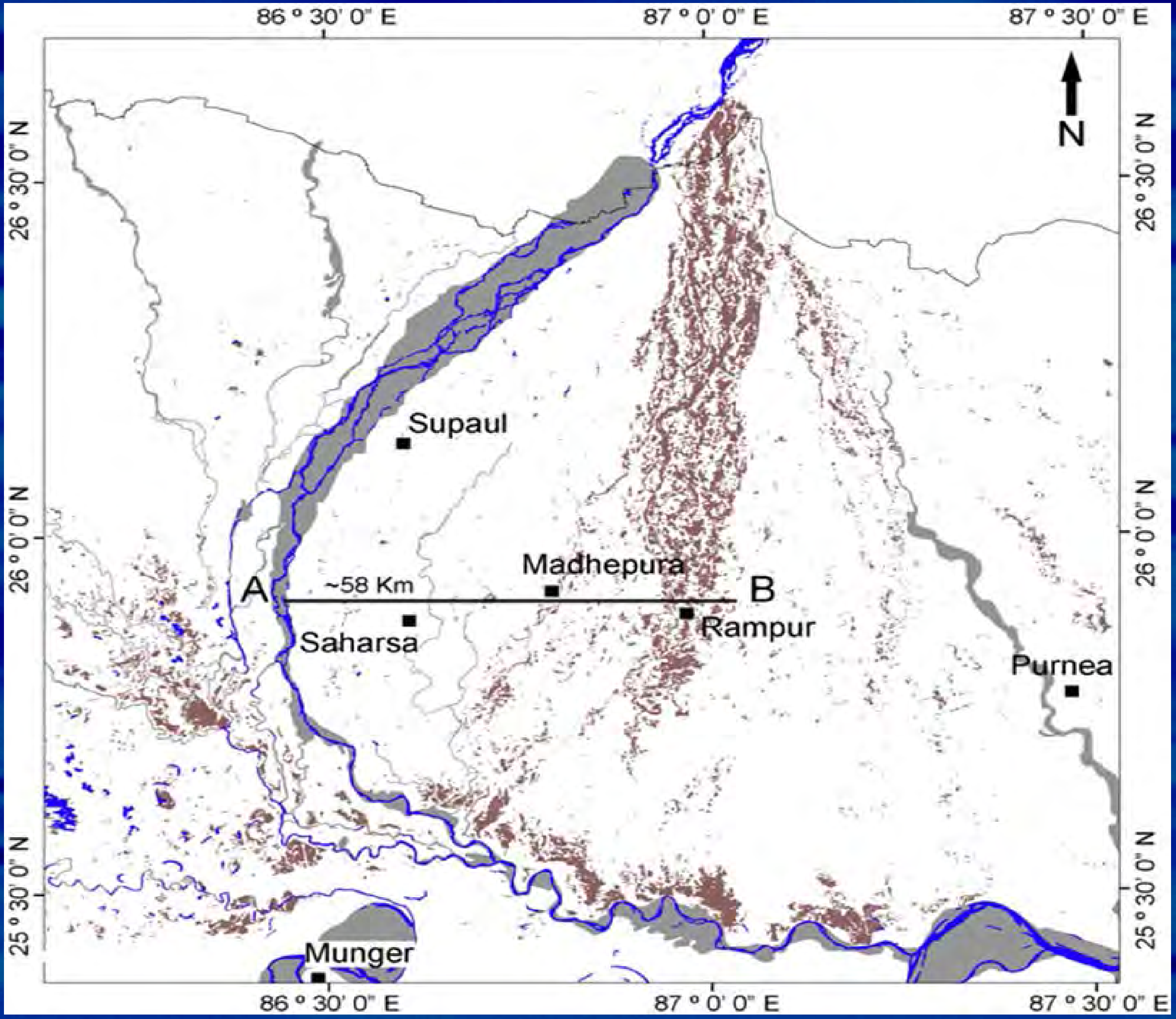
Dissemination to community

Experiences in working on Kosi River



- River changes its courses through several periodic avulsions

Experiences in working on Kosi River

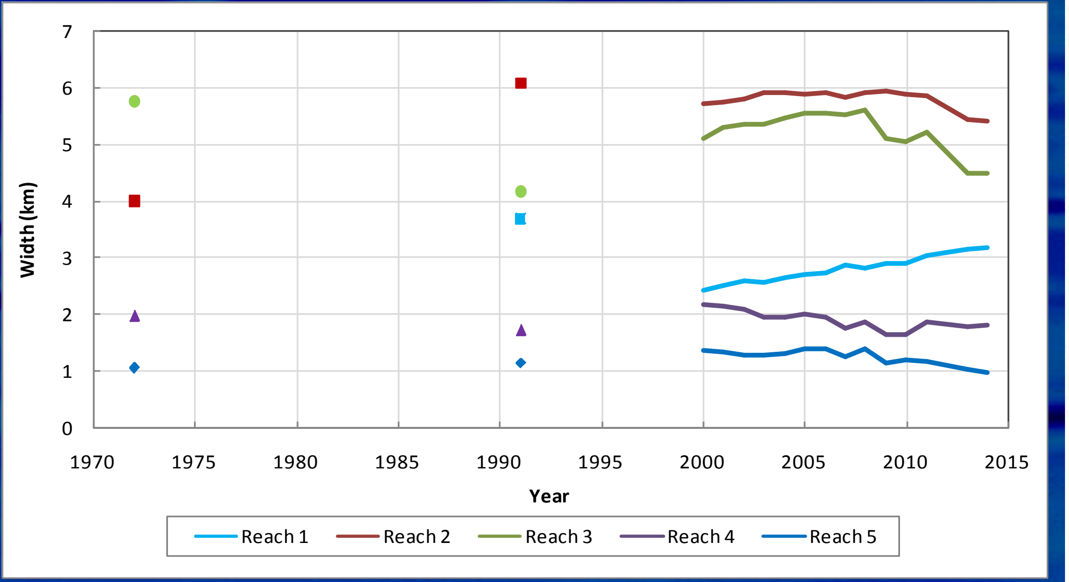


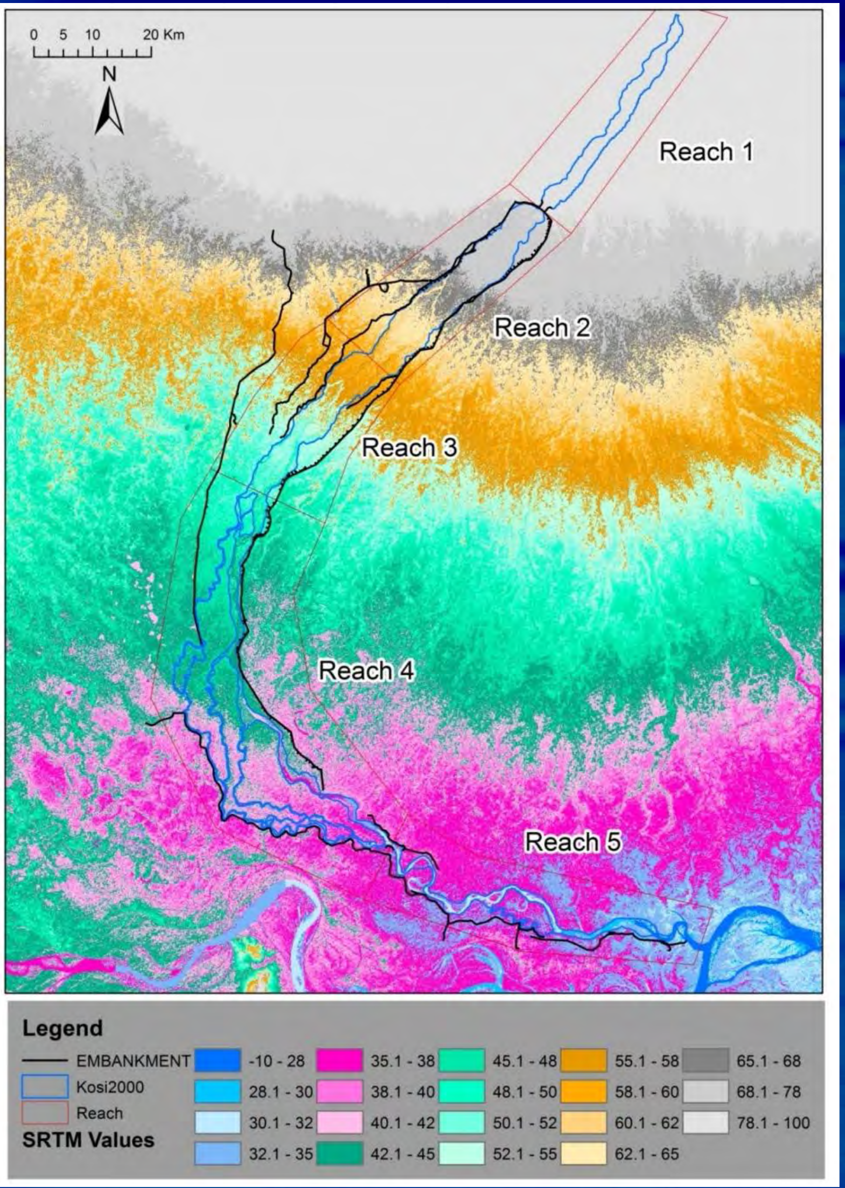
- Main issue is the safety of the embankment
- Rapid change of the anabranching channel makes the river more complex

Experiences in working on Kosi River

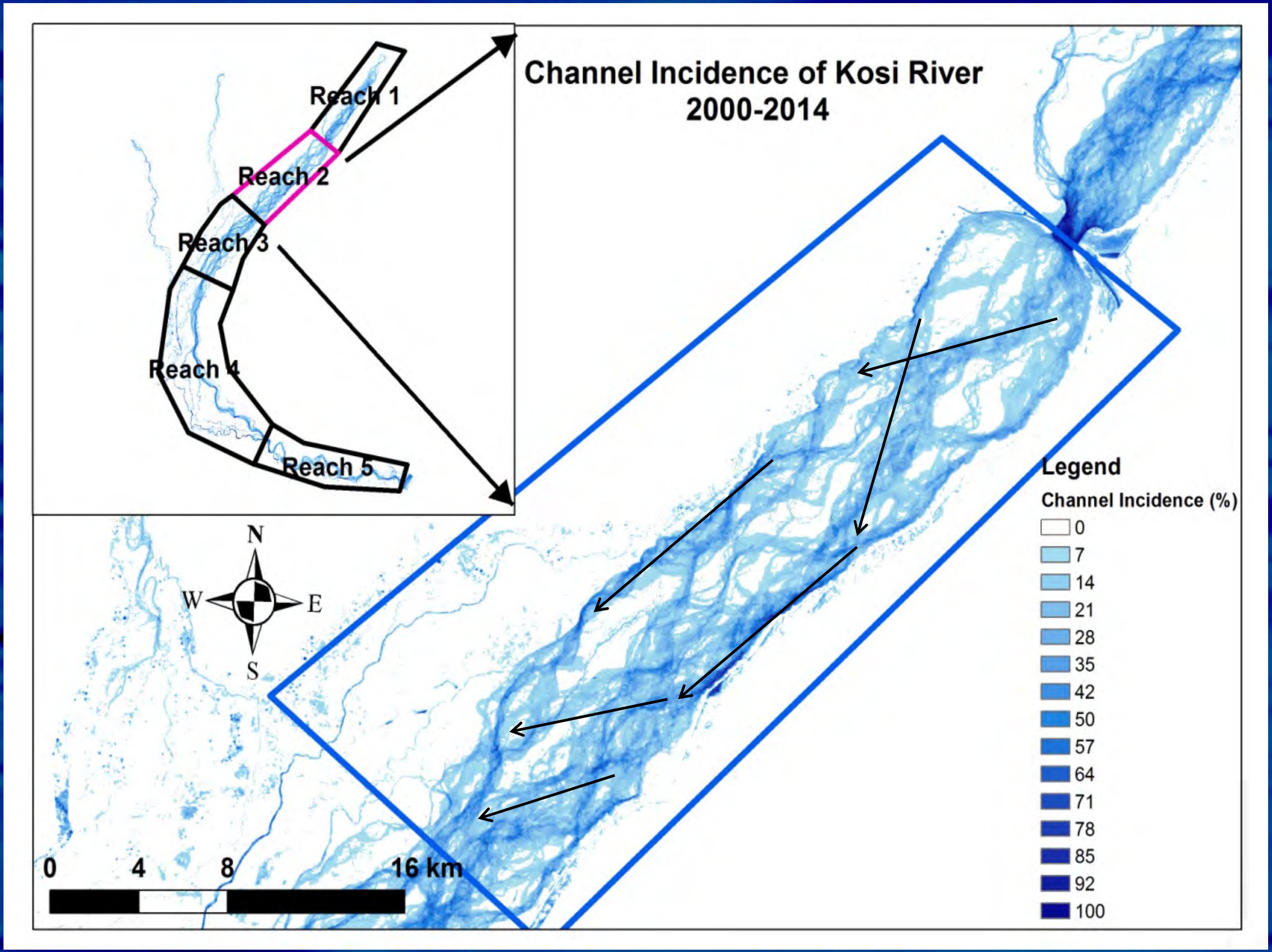
- Terrain slope varies 73 cm/km to 5 cm/km

- Reach-1 is braided, Reaches 2 and 3 is anabranching, Reach-4 is wandering and Reach-5 is meandering in planform.

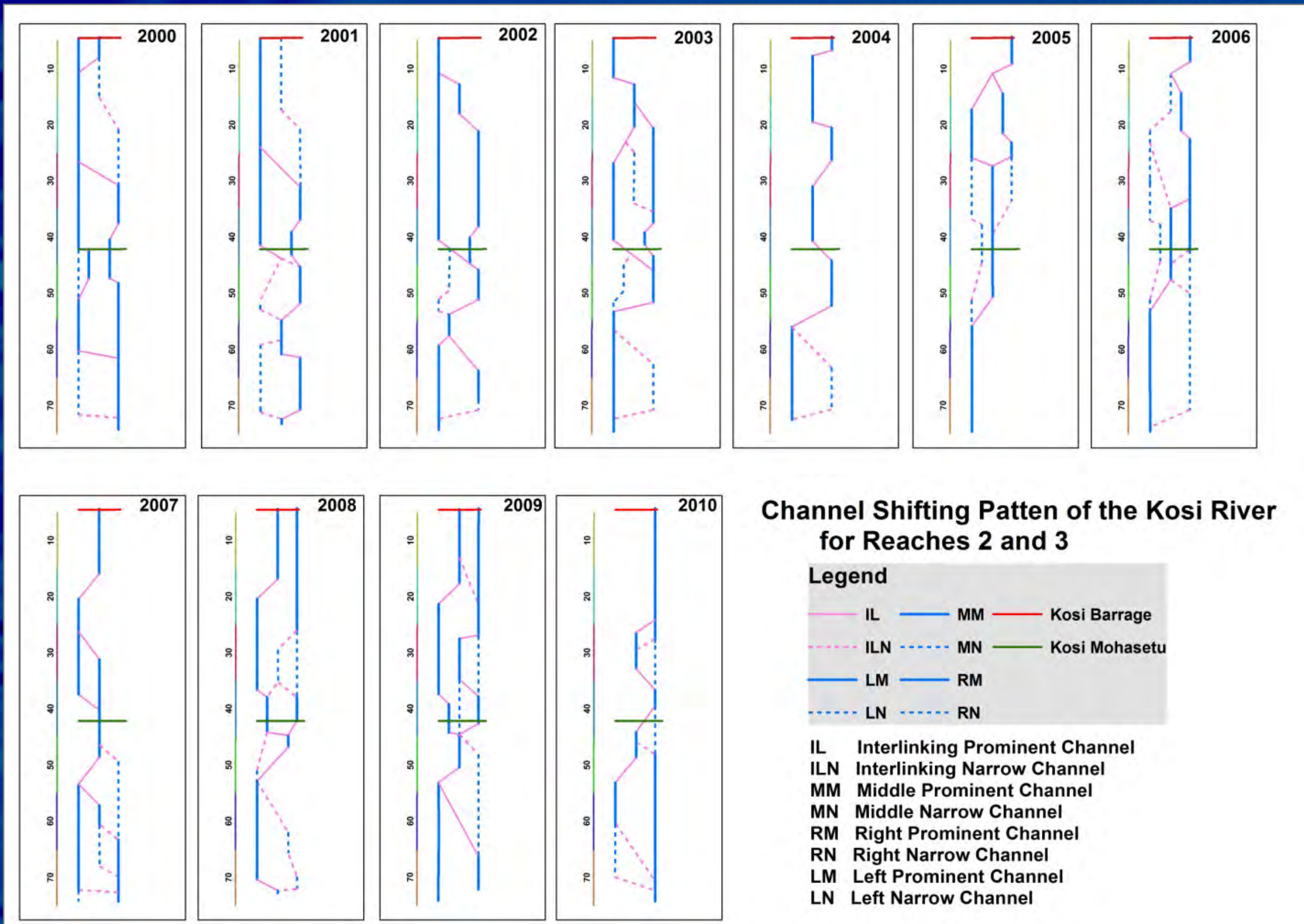




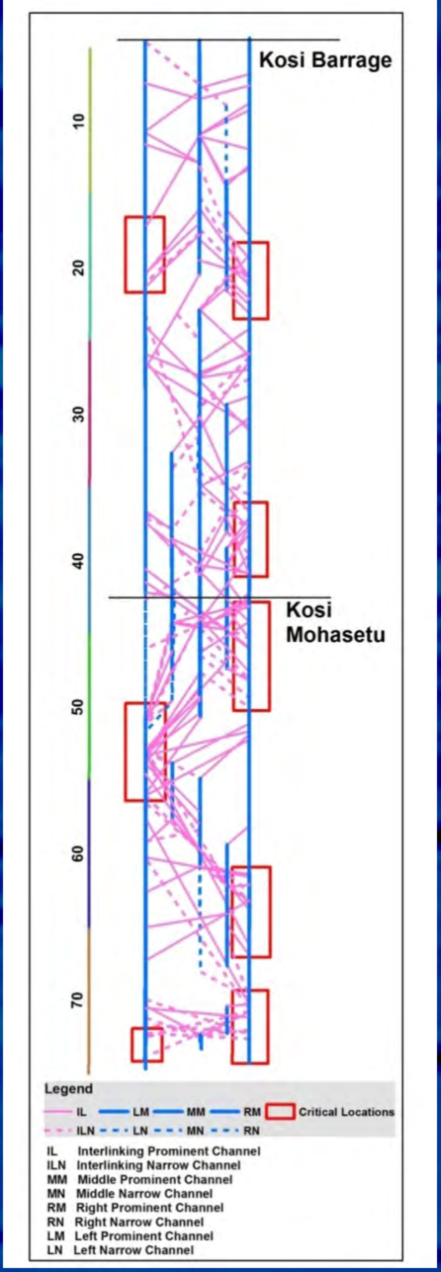
Experiences in working on Kosi River



Experiences in working on Kosi River



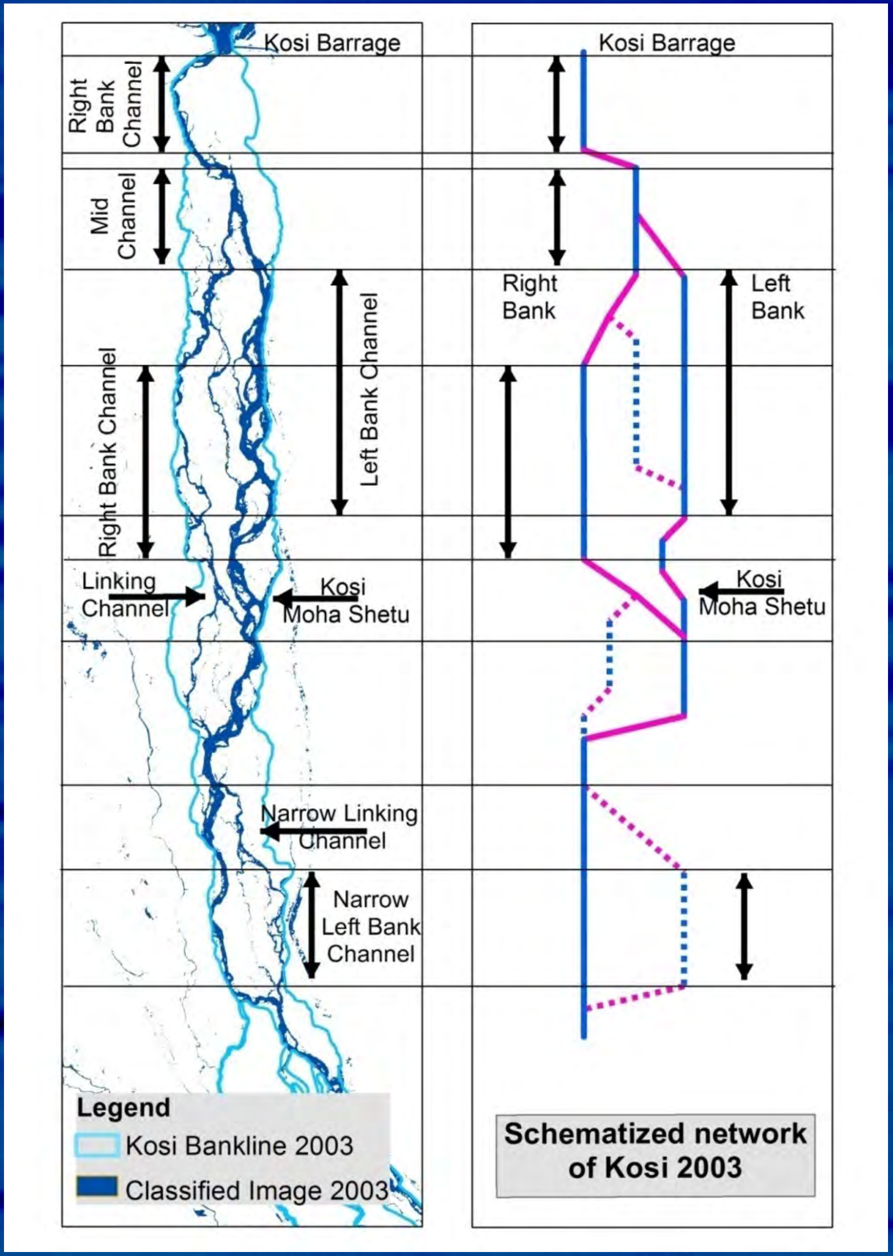
Experiences in working on Kosi River



- Anabranching channels are found to hit particular zone over last two decades
- There are few control points which determine the hitting zone in the following year

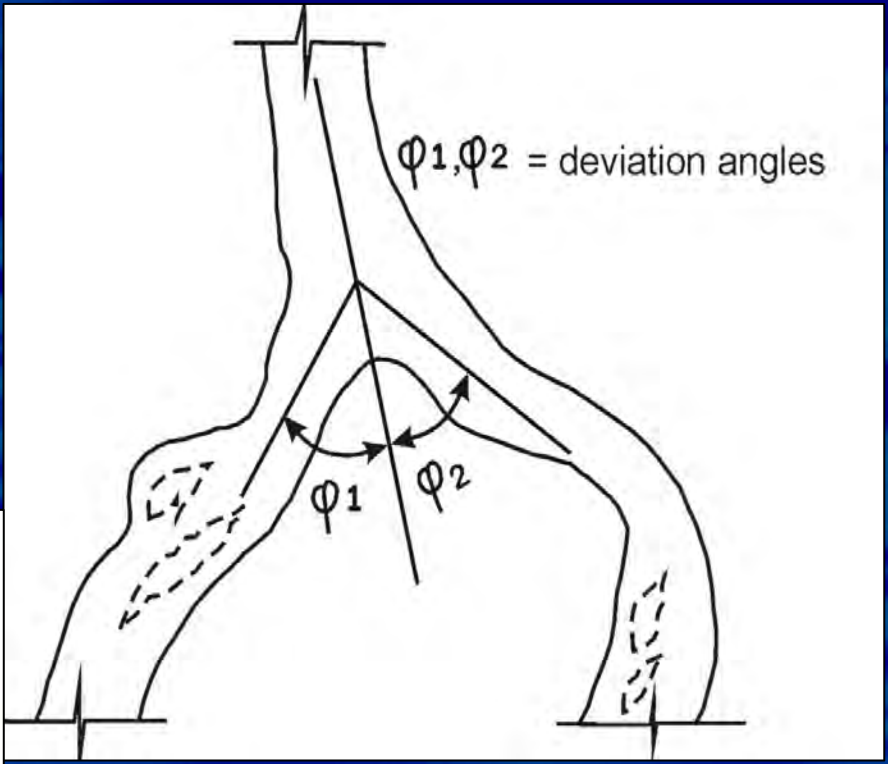
Input Data

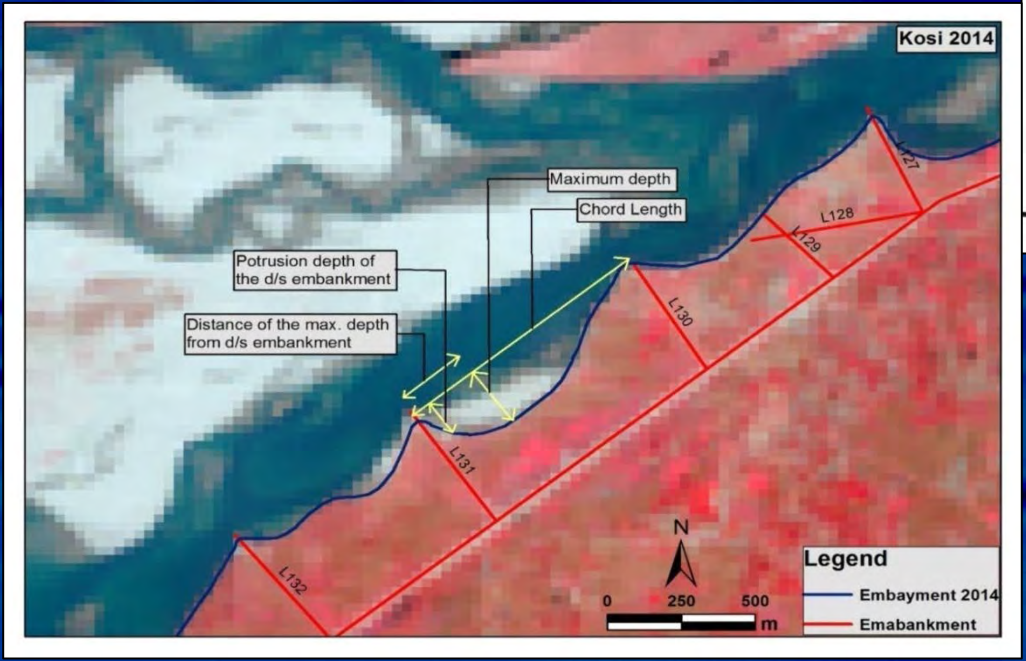
- Satellite Images are used to extract the Input Data
- Influence of Kosi Barrage on the channel alignment in the d/s
- Deviation Angle
- Parameters for the development of the embayment within the spurs



Input Data

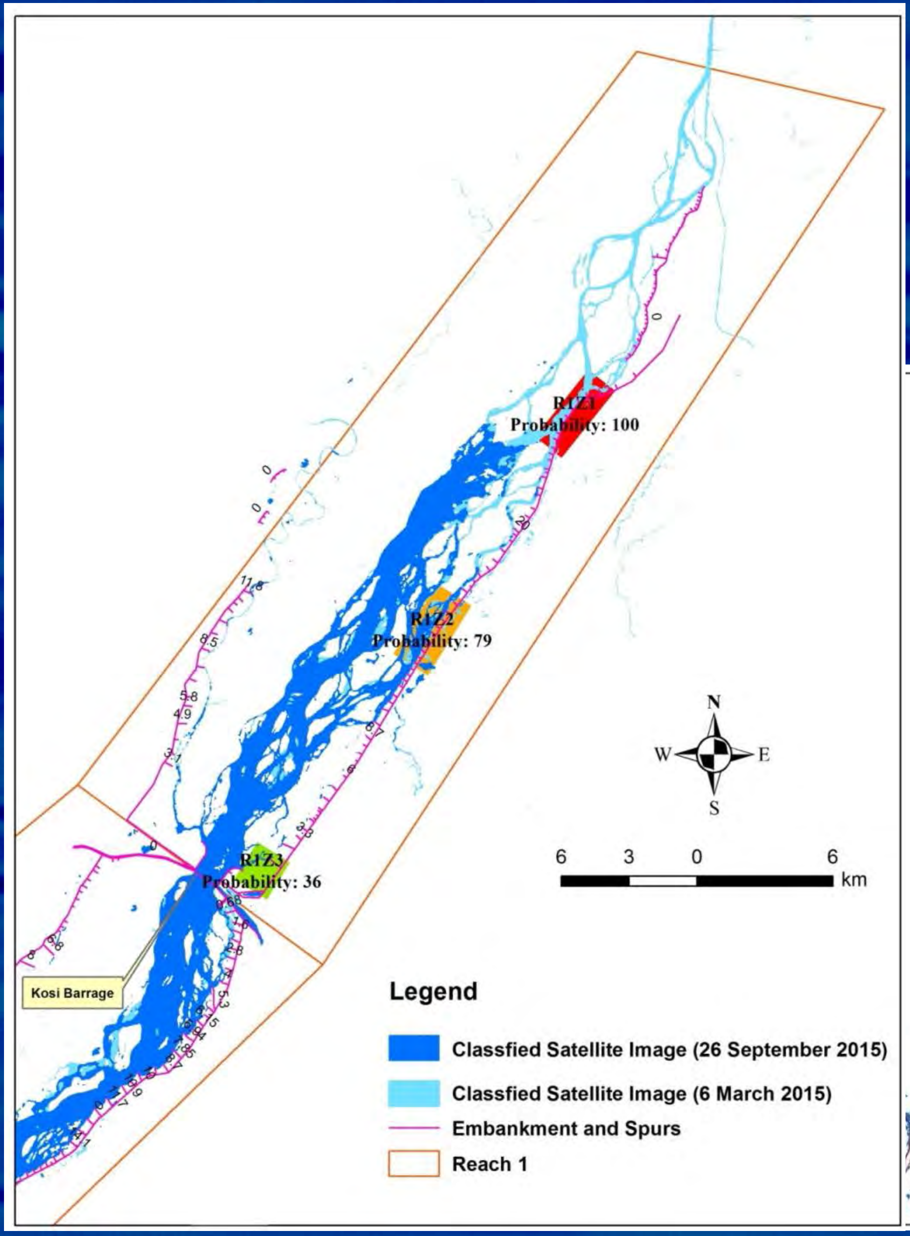
P=f (φ)
P= Probability of abandonment (%)
φ= Deviation angle



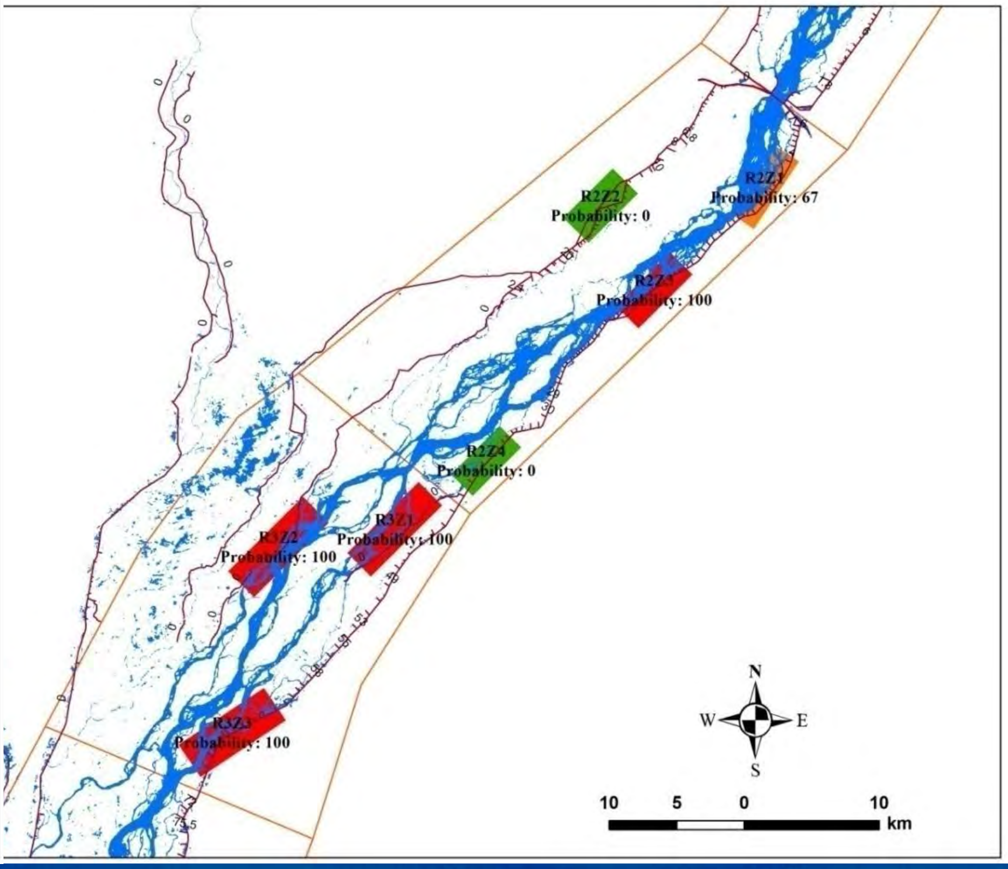


Parameters associated with development of embayment

Model Result

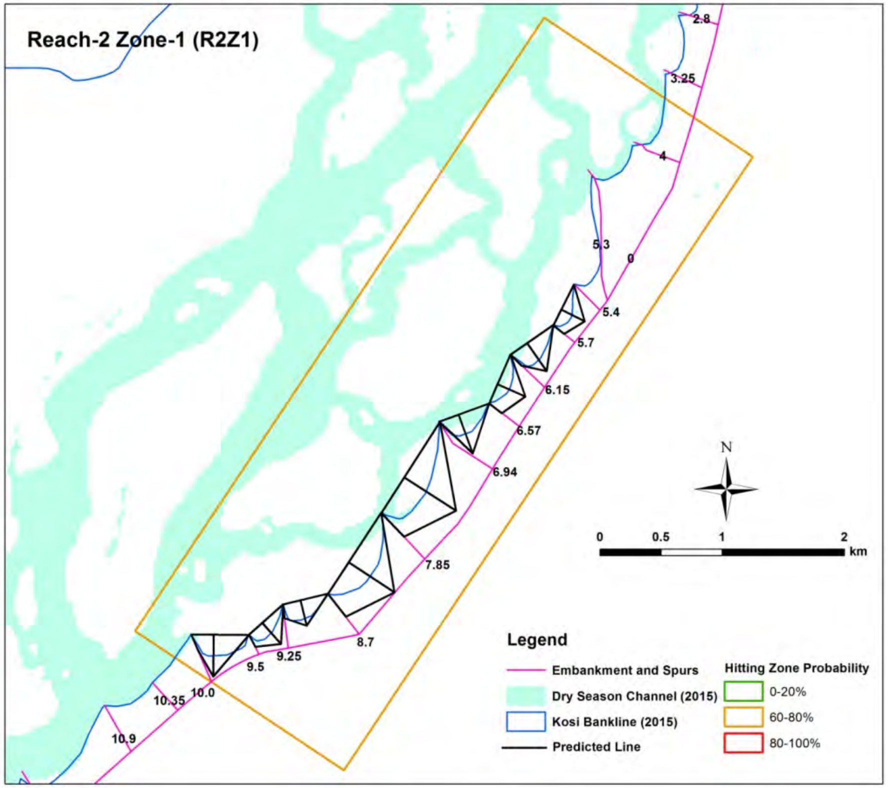


Bank Hitting/Vulnerable Zones



Model Result

Location: R2Z1 (Chainage 3.50 to 10.0 km along the Left Bank); Probability of Hitting at this Zone: 67%



Reach	Zone	Spur (Chainage-km)	Present		Predicted				Vulnerability	
			CL	ED	DSS	PL	D	ED	Floodplain Vulnerability	Embankment Vulnerability
Reach 2	Zone 1A	5.4 - 5.7	375	98	146	112	255	217	Yes	
Reach 2	Zone 1A	5.7 - 6.15	428	172	167	128	306	248	Yes	
Reach 2	Zone 1A	6.15 - 6.57	437	67	170	131	348	253	Yes	
Reach 2	Zone 1A	6.57 - 6.94	435	136	170	130	444	252	Yes	
Reach 2	Zone 1A	6.94 - 7.85	887	196	346	266	548	514	Yes	Yes
Reach 2	Zone 1A	7.85 - 8.7	794	211	310	238	469	461	Yes	Yes
Reach 2	Zone 1A	8.7 - 9.25	378	160	147	113	372	219	Yes	
Reach 2	Zone 1A	9.25 - 9.5	376	111	146	112	263	218	Yes	
Reach 2	Zone 1A	9.5 - 10	472	171	184	141	296	273	Yes	Yes

Condition for Vulnerability:

1. If Predicted ED< Present ED, Less Vulnerable
2. If Present ED<Predicted ED<0.9D, Vulnerable to Floodplain
3. IF Predicted ED> 0.9D, Vulnerable to Floodplain and Embankment

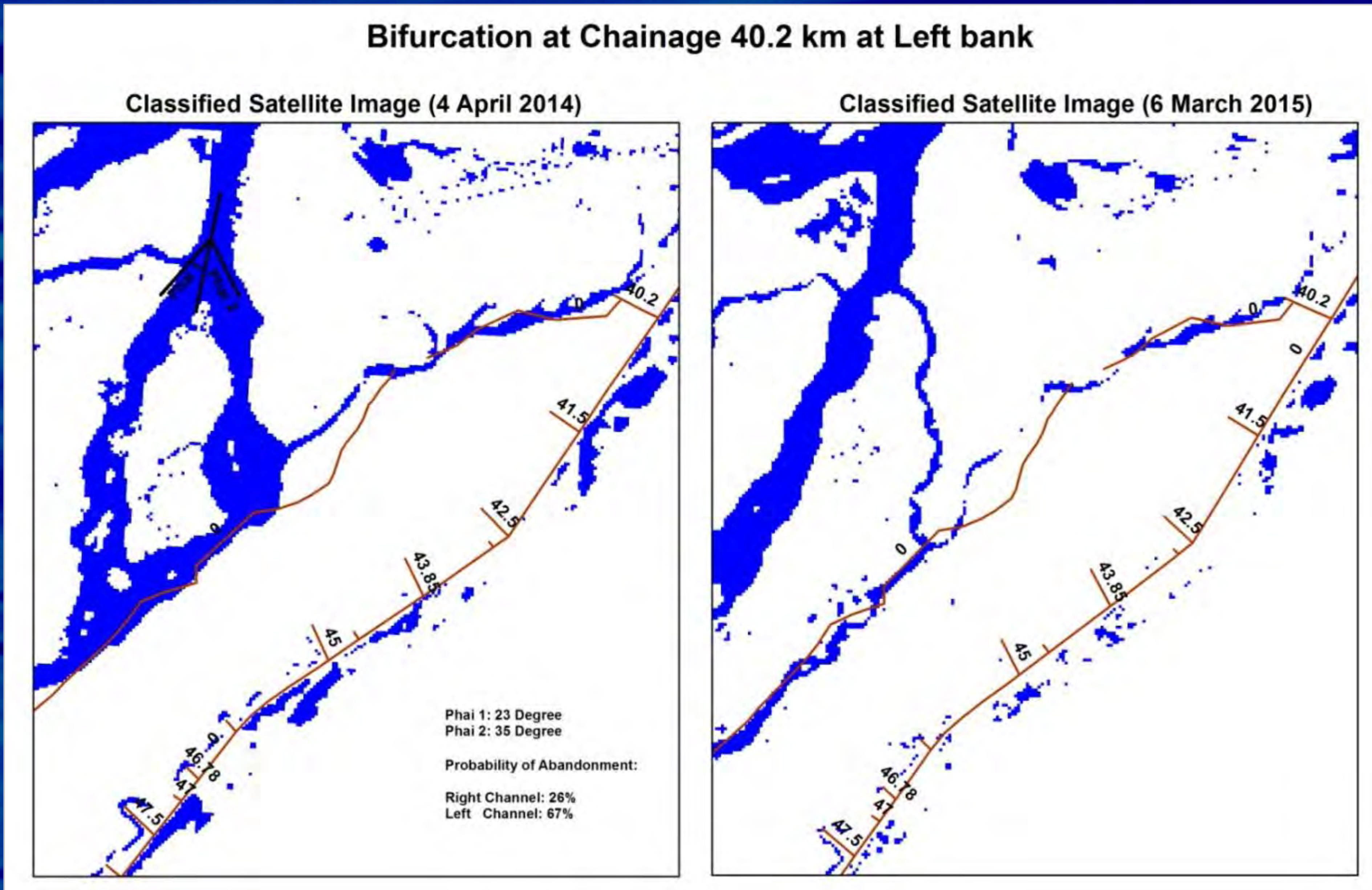
Note:

ED = Maximum Embayment Depth
CL = Cord Length
PL = Protrusion Length
DSS = Distance from downstream spur to the position of maximum embayment depth on Cord

Vulnerability Assessment

Reliability of the Model

Model Result



Strength and Limitations

- This model is very simple and derived from empirical observations extracted from time-series dry season satellite images.

- The prediction may take one to two months

- Annual cost for prediction is also cheaper.

- Availability of prediction models suitable for dynamic braided river is sparse. As this model is a simple one, it can easily be updated by the users.

Empirical observations, but not on physical process based analytical model.

Not effective in reaches, where new intervention have enough influence.

Updating and improving would be frequently needed.

Predict only one year ahead, Stochastic results, uncertainties

Meandering Bend

Overlaying of Time series Classified Images at least 3 Years

↓

Identification of Bend and Migration Processes

↓

Fixing the Probable Locations of Maximum Erosion, Starting & Ending Point of Erosion

↓

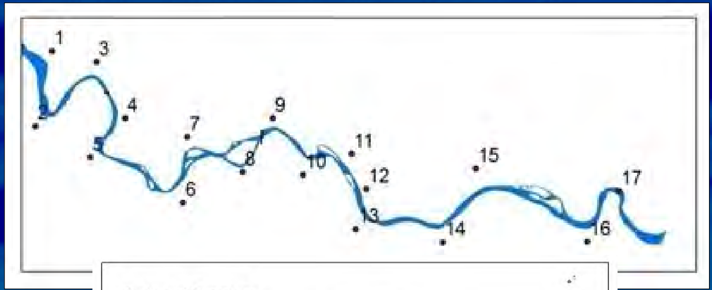
Estimating Radius of Curvature (R) and Width (W) of the Meandering Bend

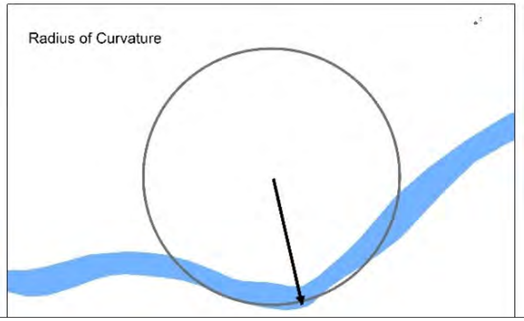
↓

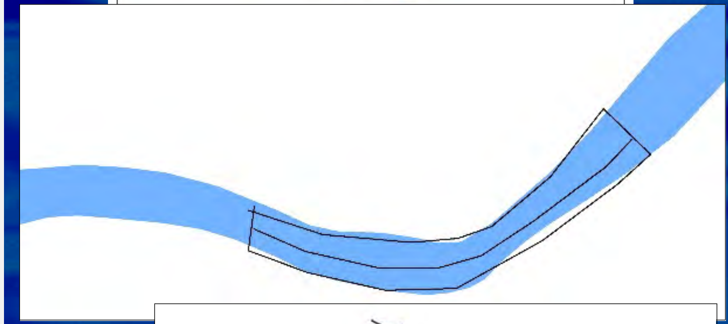
Range of R/W	Maximum Erosion, m (50%)		Maximum Erosion, m (20%)	
	Reach-4	Reach-5	Reach-4	Reach-5
0-2	120	100	180	158
2-4	120	100	200	177
4-6	130	116	220	210
6-8	140	128	245	235
8-10	150	140	260	250
>10	90	87	20	17

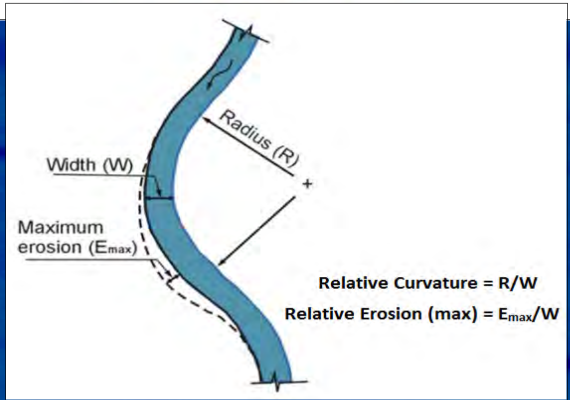
Prediction

Prediction





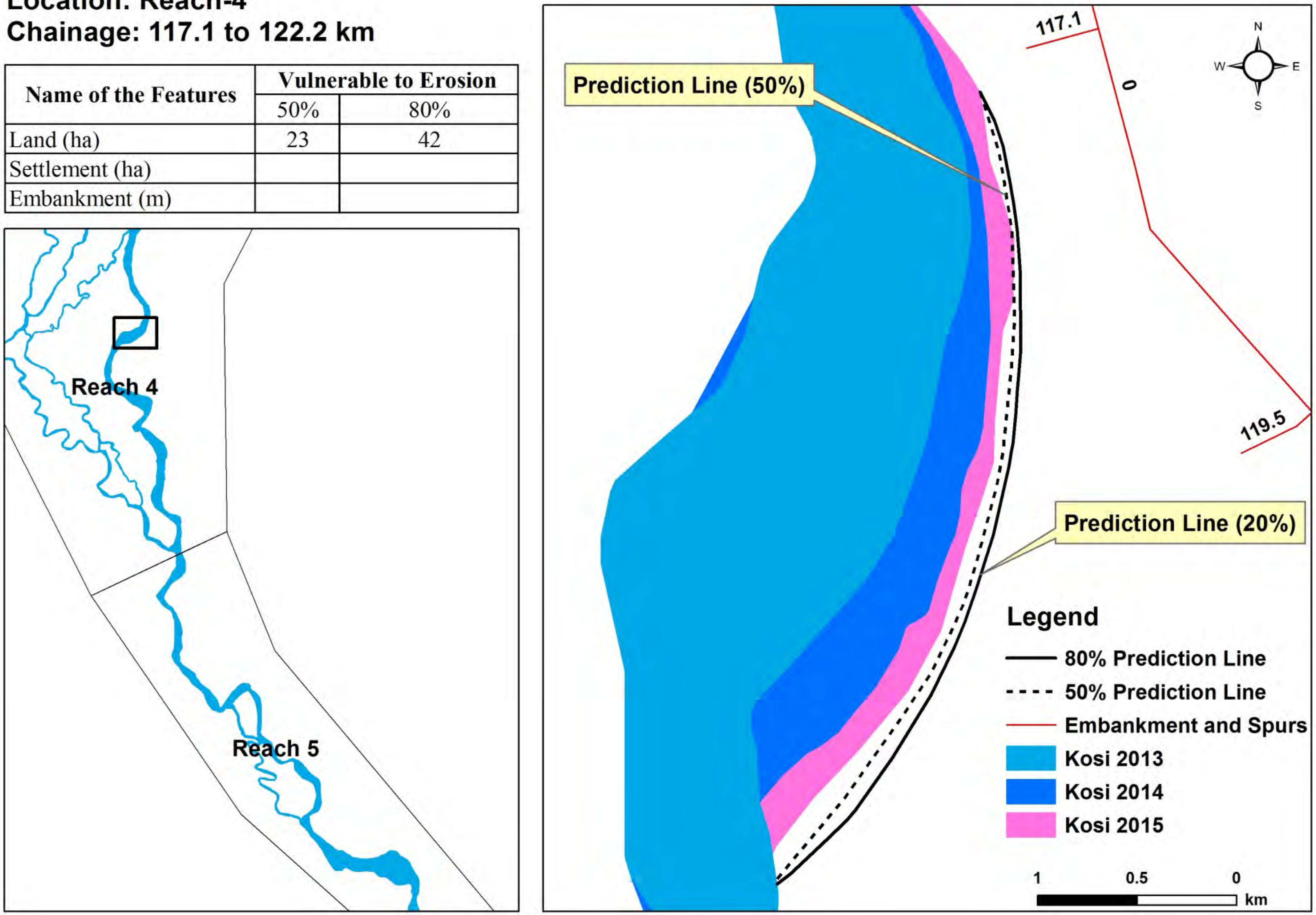




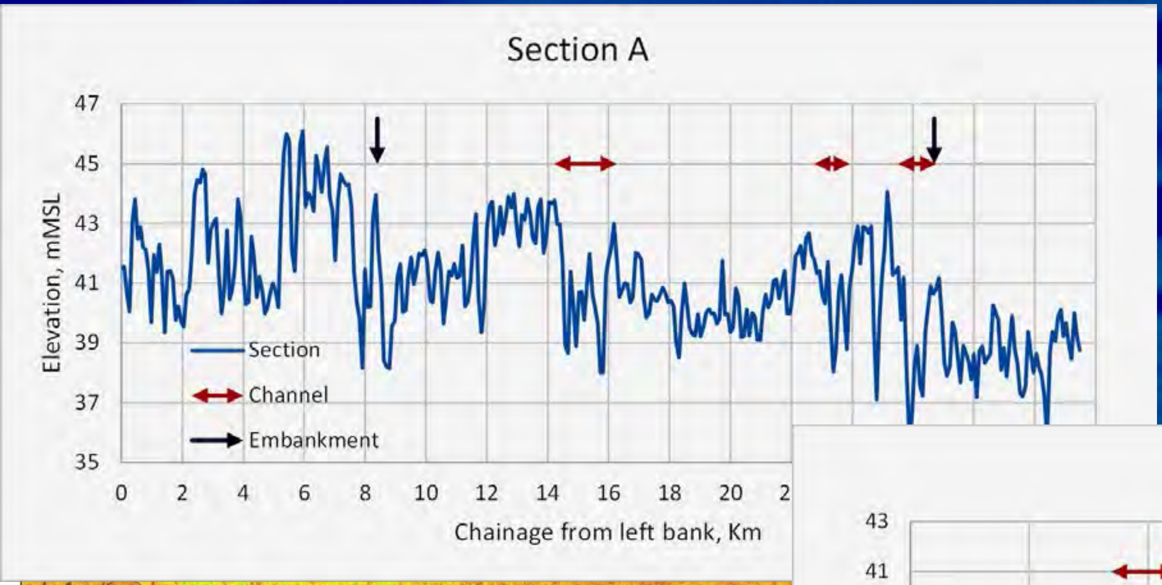
Erosion in the Meandering Bend

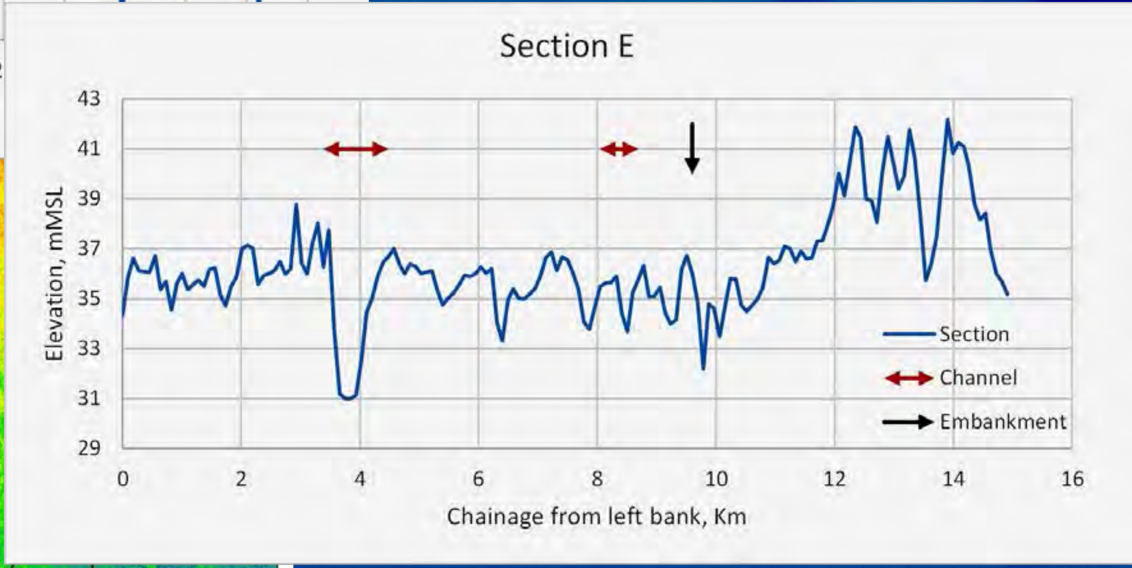
Location: Reach-4
Chainage: 117.1 to 122.2 km

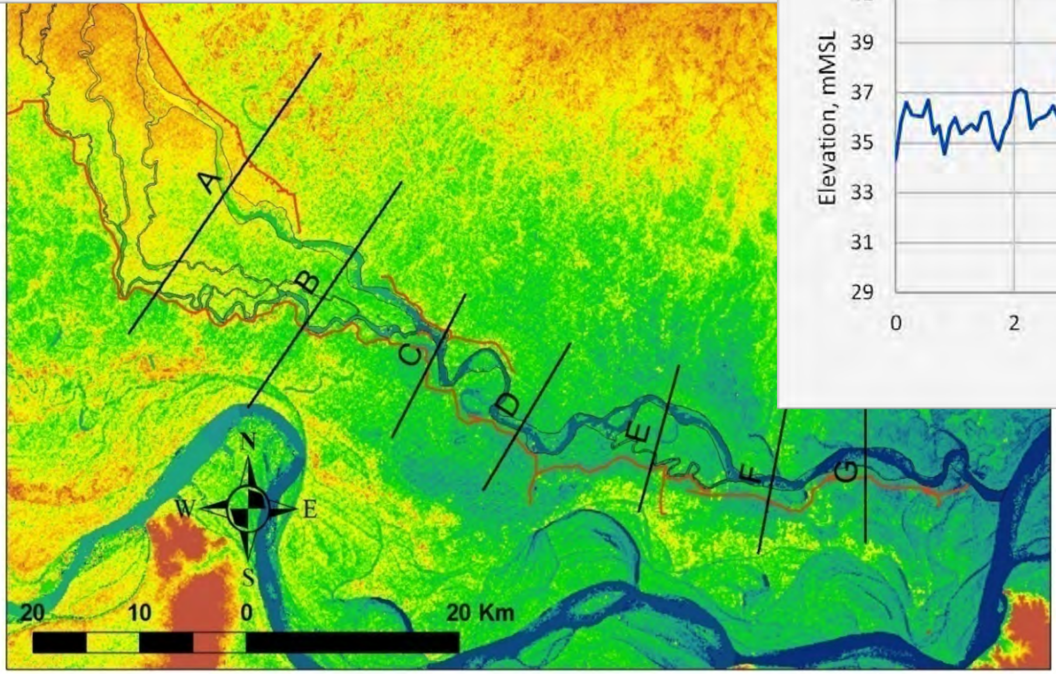
Name of the Features	Vulnerable to Erosion	
	50%	80%
Land (ha)	23	42
Settlement (ha)		
Embankment (m)		



Discontinuties of Embankment in LB







Conclusion Remarks

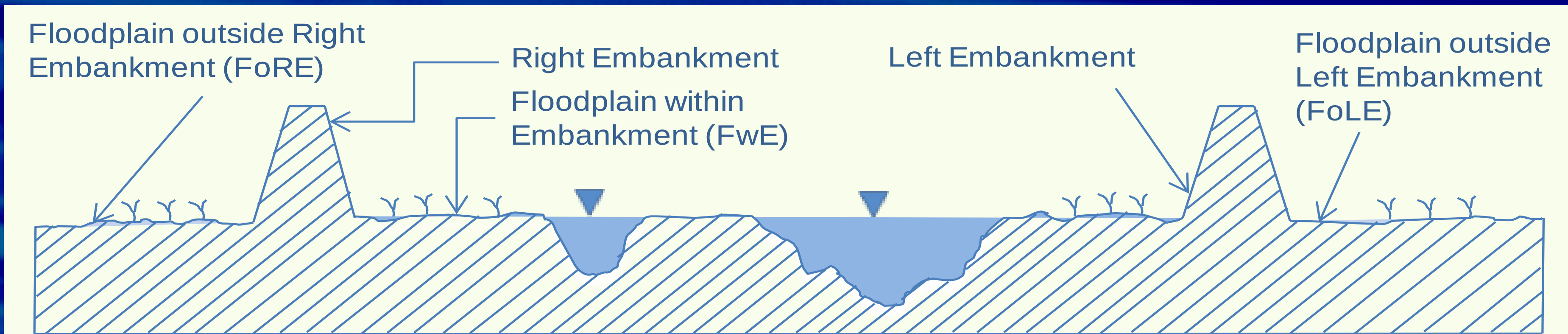
<u>**Every River is unique**</u>

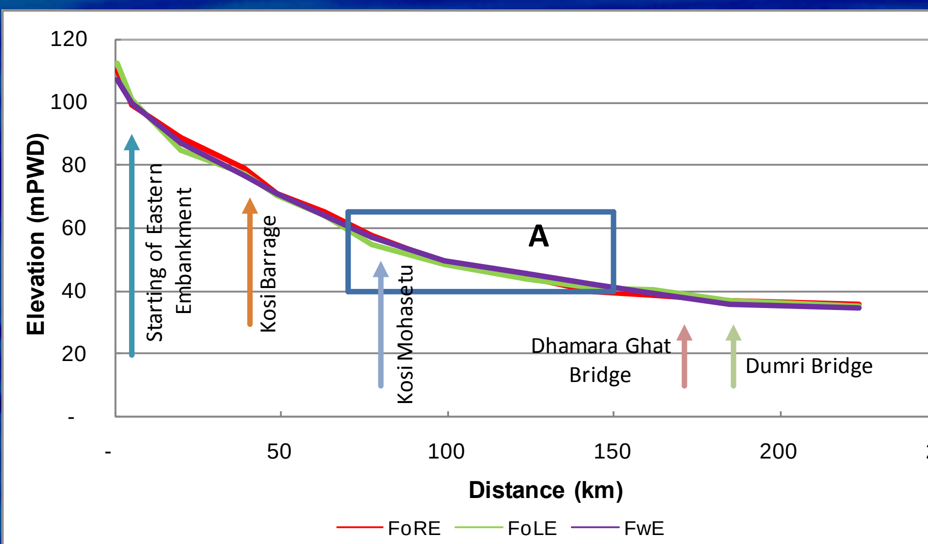
Our experiences in working on different types of very dynamic rivers suggests that we can not apply the same tools to every rivers.

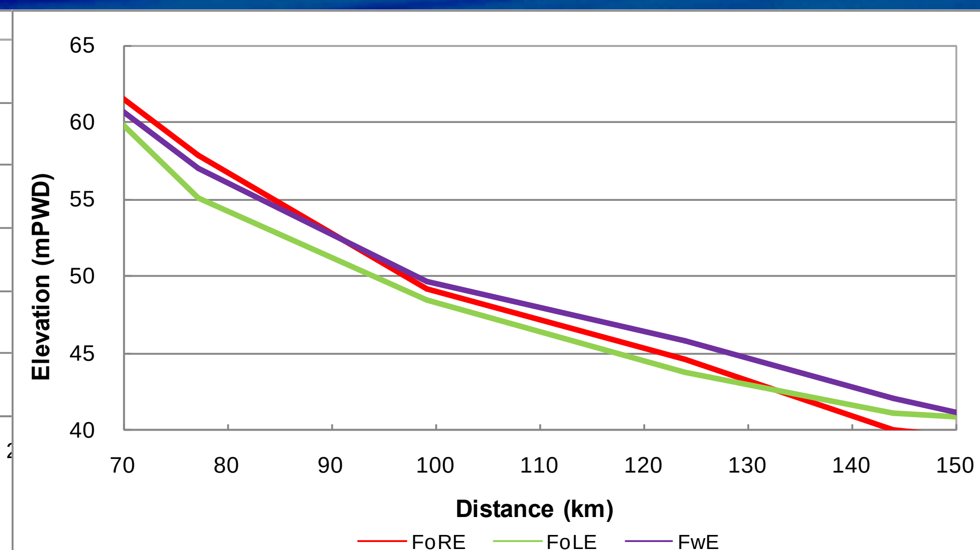
Problems and issues may be different.

Time-series satellite images could be intelligently used to monitor and predict the planform changes of the dynamic rivers with a reasonable accuracy, which proves an useful tools for River Management.

Thanks for your patience


Floodplain outside Right Embankment (FoRE)
Right Embankment
Floodplain within Embankment (FwE)
Left Embankment
Floodplain outside Left Embankment (FoLE)


Elevation (mPWD)
Distance (km)
Starting of Eastern Embankment
Kosi Barrage
Kosi Mohasetu
Dhamara Ghat Bridge
Dumri Bridge
A
FoRE
FoLE
FwE


Elevation (mPWD)
Distance (km)
FoRE
FoLE
FwE

Probability Range	Occurrence	Matching	Rank
Column 1	Column 2	Column 3	Column 4
81-100	Yes	Excellent	5
	No	No	1
61-80	Yes	Good	4
	No	Poor	2
41-60	Yes	Moderate	3
	No	Moderate	3
21-40	Yes	Poor	2
	No	Good	4
0-20	Yes	No	1
	No	Excellent	5

Flood Modelling in North Bihar

CHALLENGES and OPPORTUNITIES

S.Thiruvengadachari, Ph.D.
Flood Management Consultant

Current status of flood Forecasting in Bihar

CHALLENGES

Forecast of flood stage only at selected sites once or more times a day, based on gauge-to-gauge correlation

OPPORTUNITIES

Implement conceptual and physical based (lumped, semi-distributed or distributed) models

Input data – Adequacy and Quality

(rainfall. water level/discharge observations, rainfall forecasts, rating curves, river cross-sections, reservoir outflows and releases, etc)

CHALLENGES

Model selection and performance is Data driven

OPPORTUNITIES

Implement RTDAS for real-time high frequency data
Implement comprehensive data validation protocols
Integrate rainfall data sets- Satellite/RADAR/RTDAS
RADAR for now-casting and for flash /urban floods
Ensemble rainfall forecasts to improve accuracy and lead time

Trans-boundary Basins

CHALLENGES

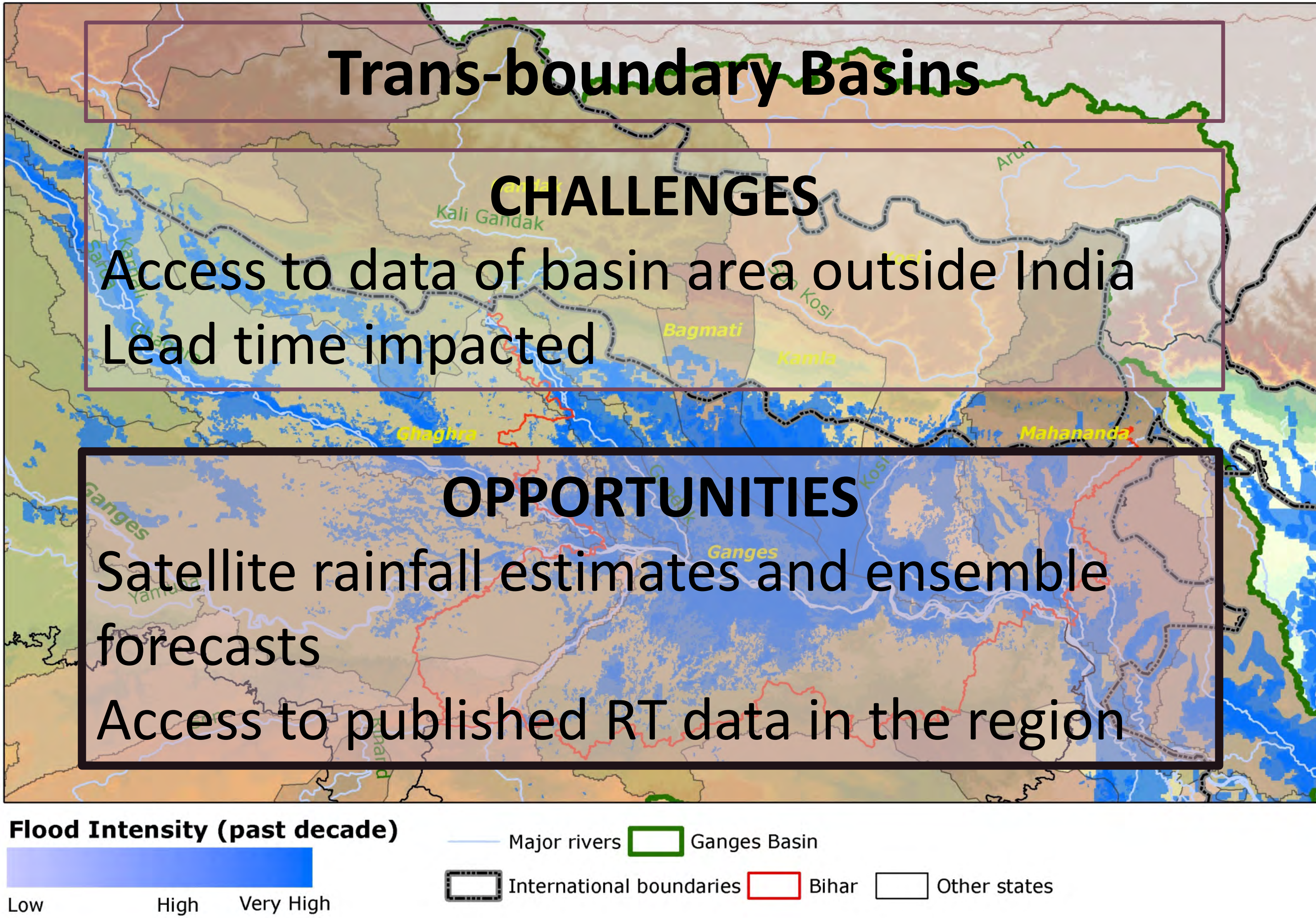
Access to data of basin area outside India

Lead time impacted

OPPORTUNITIES

Satellite rainfall estimates and ensemble forecasts

Access to published RT data in the region



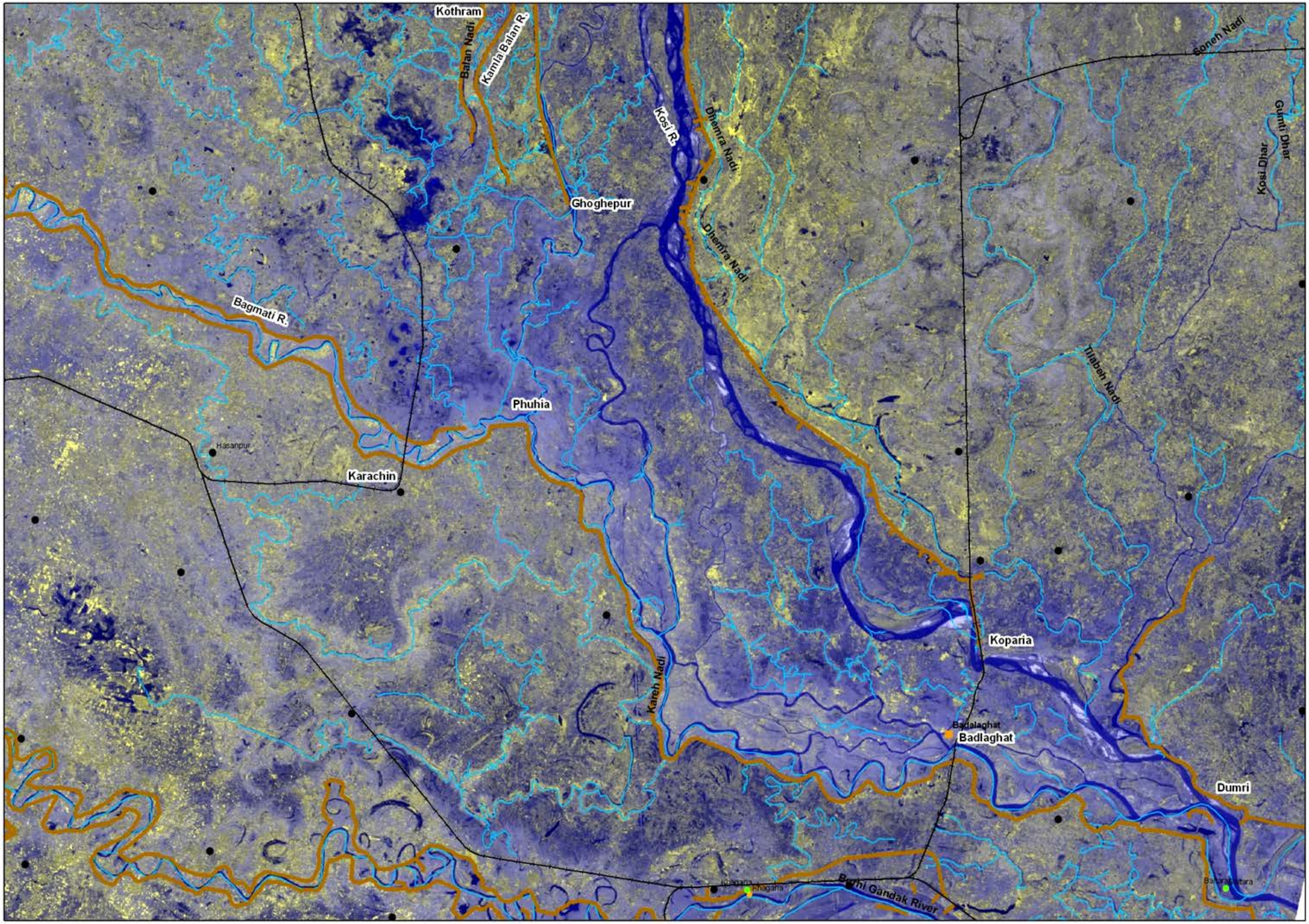
COMPLEX BASINS

CHALLENGES

Complex model set-up and operation

OPPORTUNITIES

Suite of different models (hydrologic and hydraulic; lumped and distributed; statistical and conceptual physical) versus single model


Kothram
Balan Nadi
Kamla Balan R.
Kosi R.
Dhemra Nadi
Soneh Nadi
Gumti Dhar
Kosi Dhar
Ghoghepur
Dhemra Nadi
Bagmati R.
Phuhia
Hasanpur
Karachin
Tilabeh Nadi
Koparia
Kareh Nadi
Badalaghat
Badlaghat
Dumri
Khagaria
Burhi Gandak River

MODELING APPROACH (1)

Systematic, hierarchal and iterative model development, starting from simple to complex, improved over time. The model is made successively more complex in an effort to match modelled to observed variables.

Suite of different models (hydrologic and hydraulic; lumped and distributed; statistical and conceptual physical) versus single model or bundle of similar models, as integral components of the Hydrologic Forecasting System

.

MODELING APPROACH (2)

Multi-model ensembles to address the problem of uncertainty in the forecasts arising from structural errors in the models (These ensembles may be formed by combinations of lumped or distributed, conceptual or physically based models)

.

SCALING-UP AND UPGRADING MODEL

CHALLENGES

Cost-effective and rapid customization for other basins

OPPORTUNITIES

Use public- domain and license-free model software

MAPPING INUNDATION SCENARIOS

CHALLENGES

While inundation extent is better mapped, what about duration and depth? Validation issues

OPPORTUNITIES

Satellite/LIDAR/Ground survey topo data

Community participation in inundation data collection

2 D hydrodynamic models with better ground representation

Dynamic link to forecast model for updating state

VALIDATION ISSUES

CHALLENGES

Absence of data and standard procedures

OPPORTUNITIES

Develop a verification system consistent with the goals of operational river forecasting system

CAPACITY CONSTRAINTS

CHALLENGES

Absence of coordinated time bound program

OPPORTUNITIES

Centre of Excellence in modelling
Capacity building for using model outputs
Cadre of flood modellers with assured career path and incentive
Continuous skill development
Sponsored/contracted academic research

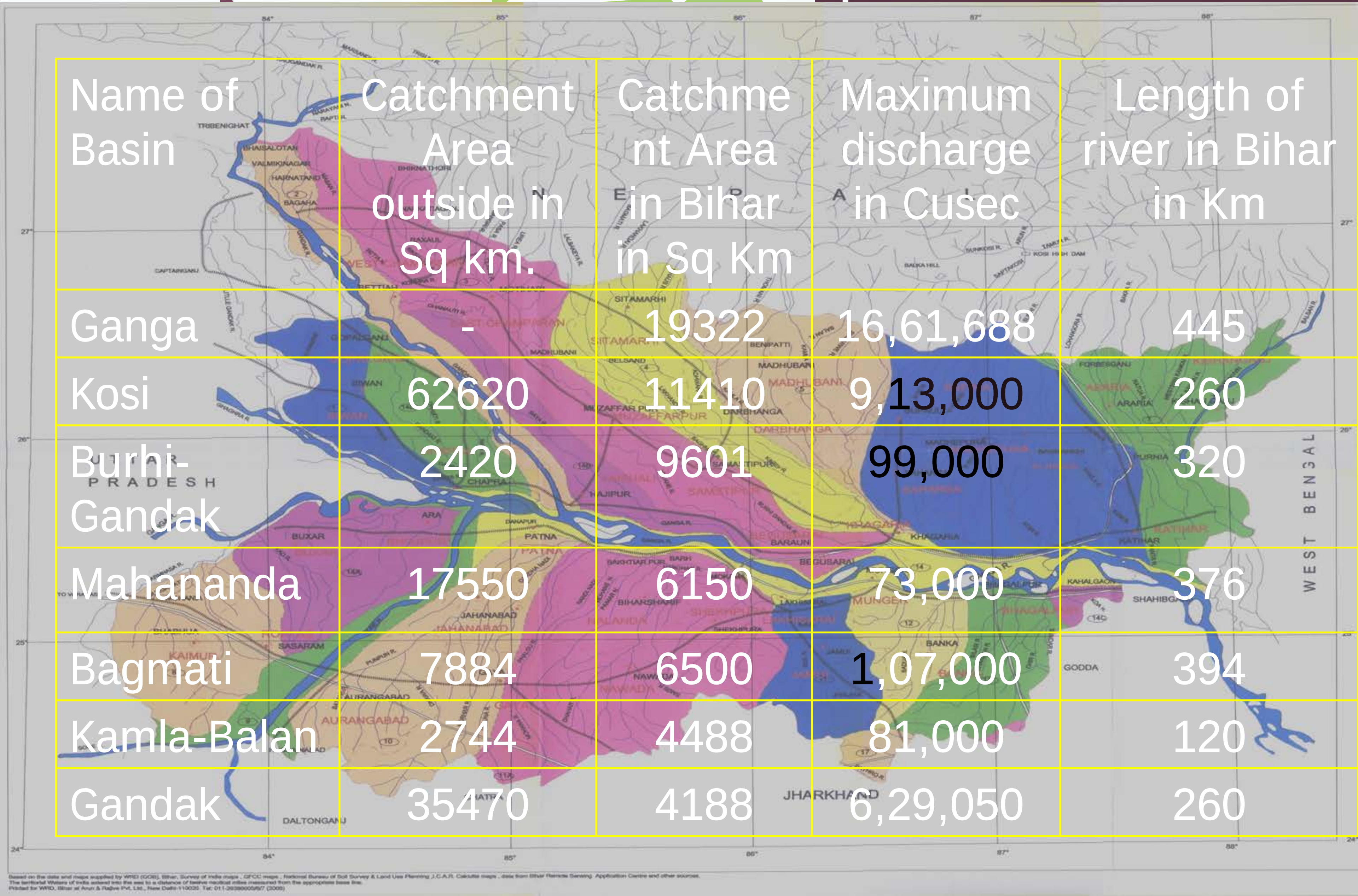
THANKS

MODELING APPROACH (3)

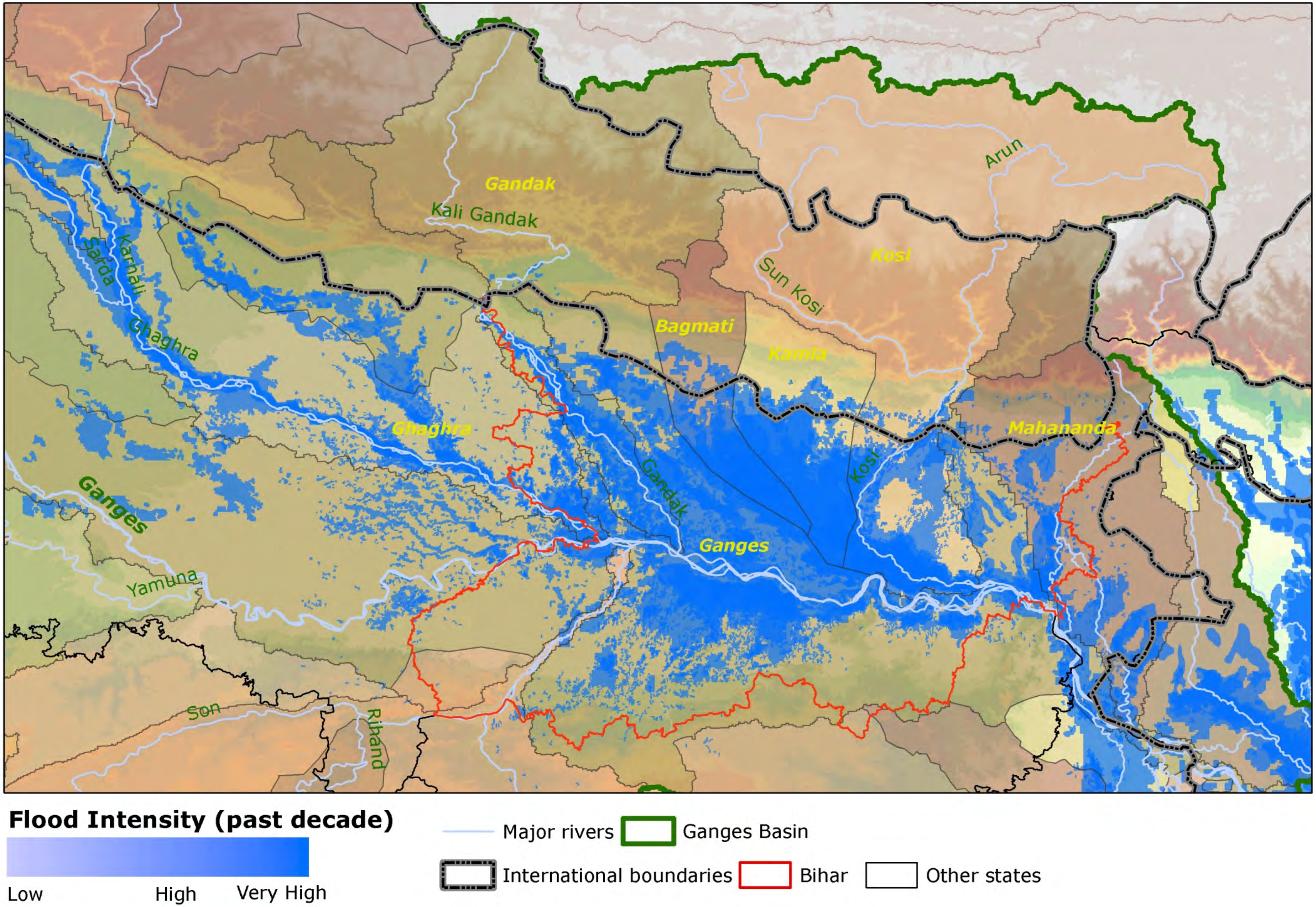
Cost-effective assimilation of all available informative data sources essential to reducing the uncertainties in initial conditions , observed and future boundary conditions (observed precipitation, observed temperature, etc.), and pedologic and physiographic boundary conditions (soil properties, basin geomorphology, channel geometry, vegetation, etc.)., and hence to improving and increasing the skill and lead-time of hydrologic and water-resource forecasts

Modelling embankment breach- breaches are likely to cause flooding in floodplains rather than well-defined channels. To model these types of floods accurately, two dimensional models may be needed.

All rivers of North Bihar(except Burhi-Gandak) originate in Nepal/Tibet (61% cathment in Nepal & Tibbet)



Name of Basin	Catchment Area outside in Sq km.	Catchment Area in Bihar in Sq Km	Maximum discharge in Cusec	Length of river in Bihar in Km
Ganga	-	19322	16,61,688	445
Kosi	62620	11410	9,13,000	260
Burhi-Gandak	2420	9601	99,000	320
Mahananda	17550	6150	73,000	376
Bagmati	7884	6500	1,07,000	394
Kamla-Balan	2744	4488	81,000	120
Gandak	35470	4188	6,29,050	260



Gandak
Kali Gandak
Arun
Kosi
Sun Kosi
Bagmati
Kamla
Sarda
Karnali
Ghaghra
Ghaghra
Mahananda
Kosi
Gandak
Ganges
Ganges
Yamuna
Son
Rihand
Flood Intensity (past decade)
Low
High
Very High
Major rivers
Ganges Basin
International boundaries
Bihar
Other states

Preparation of Master Plan for Flood and Sediment Management in Kosi River Basin

Client:

Flood Management Improvement Support Center.
Water Resources Department.
Government of Bihar.

Consultants

URS Scott Wilson India Private Limited **(An AECOM Company).**

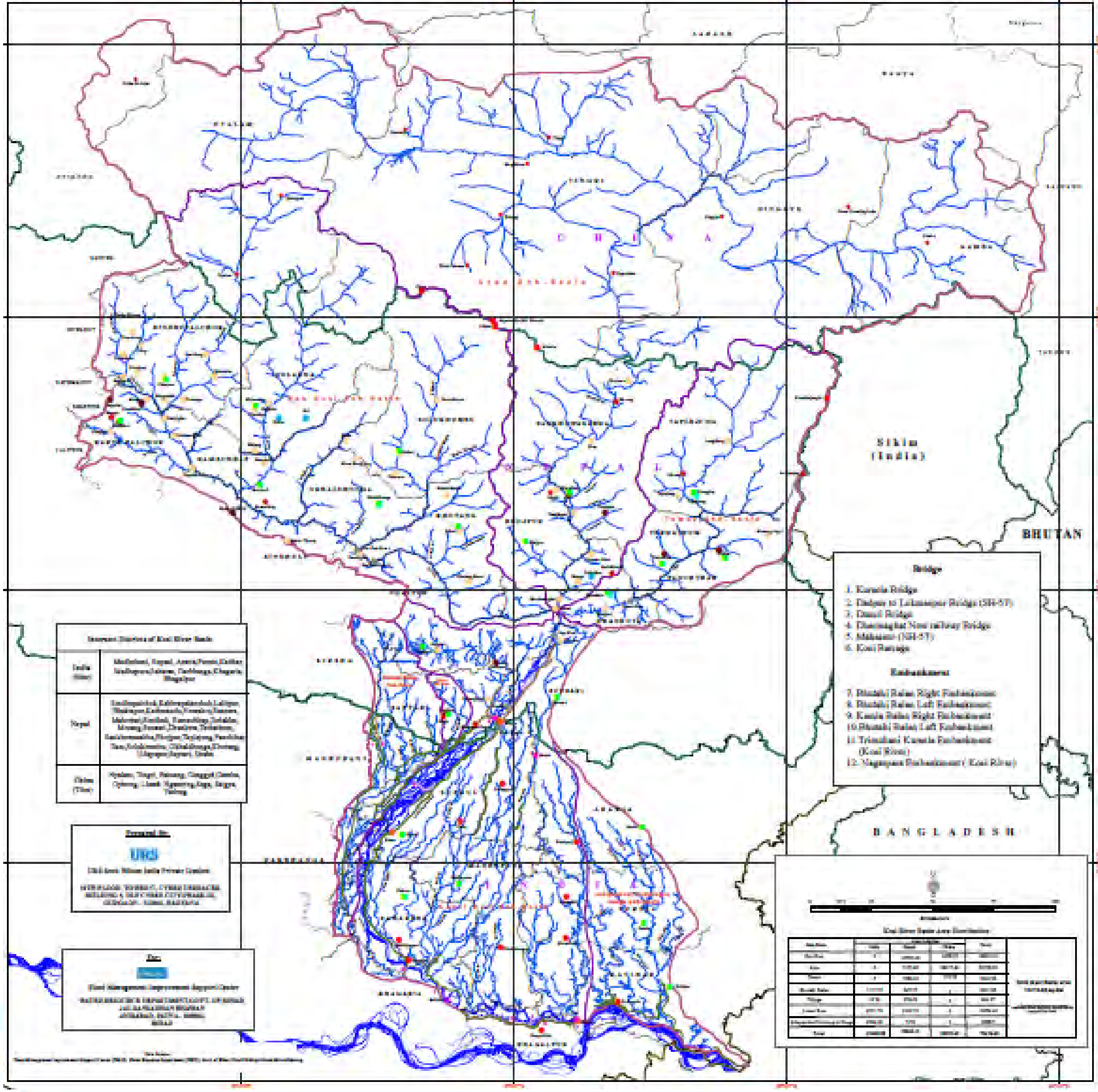
DHI (India) Water & Environmental Pvt. Ltd.

URS

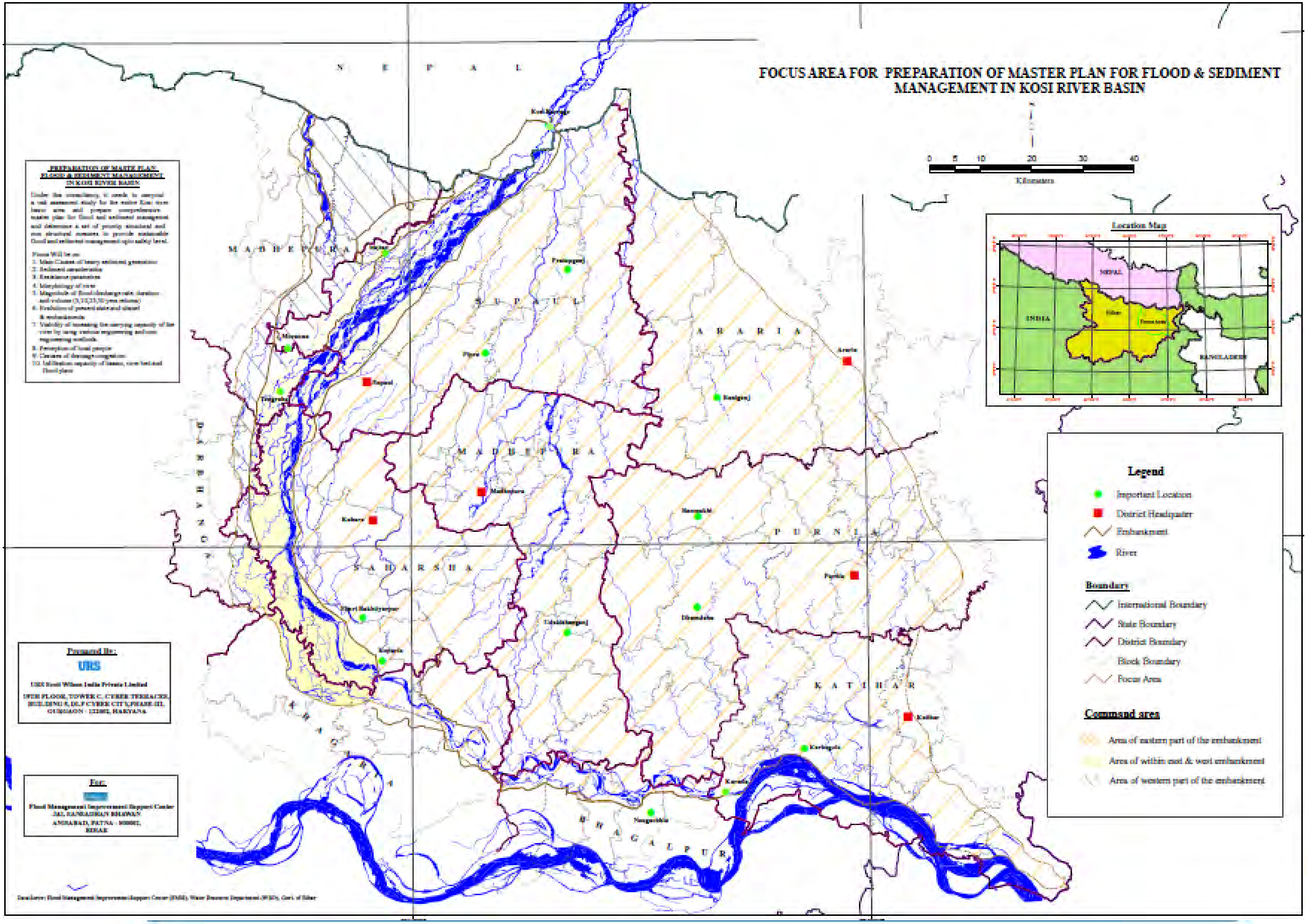
STUDY AREA

It consists of the following:-

1. **Catchment Area** including upper catchment area in Nepal.
2. **Kosi River Course** from Chatra in Nepal to Kursela in Bihar.
3. **Existing Structural Interventions**:
   - ✓ Kosi Barrage with appurtenant works.
   - ✓ Embankments on both banks.
4. **Eastern Kosi Canal System** – drainage congestion.
5. **Area within embankments**.



Sikim
(India)
BHUTAN
BANGLADESH



FOCUS AREA FOR PREPARATION OF MASTER PLAN FOR FLOOD & SEDIMENT MANAGEMENT IN KOSI RIVER BASIN
N E P A L
M A D H E P U R A
S U P A U L
A R A R I A
M A D H E P U R A
S A H A R S H A
P U R N I A
K A T I H A R
D A R B H A N G A
B H A G A L P U R
0 5 10 20 30 40
Kilometers
Location Map
NEPAL
INDIA
BANGLADESH
Legend
Important Location
District Headquater
Embankment
River
Boundary
International Boundary
State Boundary
District Boundary
Block Boundary
Focus Area
Command area
Area of eastern part of the embankment
Area of within east & west embankment
Area of western part of the embankment
Prepared By:
URS
For:

PROBLEMS

1. Excessive generation of sediment in upper catchments in Nepal.
2. Heavy siltation at u/s of Kosi Barrage.
3. Problem of shifting of course due to aggradation, degradation, braiding and meandering characteristics of the Kosi River.
4. Erosion leading to breaches of Kosi Embankments.
5. Inundation due to annual flooding of 395 villages located between the two embankments.
6. Flooding (450 sq. km) and drainage congestion of the area east of the Eastern Embankment.
7. Water logging and drainage congestion in the command of eastern Kosi canal.

CHALLENGES

The TOR envisages to prepare a Comprehensive Master Plan which is:

- Environment friendly;
- Socially acceptable; and
- Techno-Economically viable.

ESSENTIAL ASPECTS OF INTEGRATED WRD PROJECTS

1. Technical Feasibility.
2. Economic Viability.
3. Ecological Stability.
4. Environmental Quality.
5. Political Compatibility.
6. Social Acceptability.

REAL CHALLENGE

Integration of the following (three **E**’s):

- ❑Social Equity.
- ❑Economic Efficiency.
- ❑Environmental Quality.

Management Units

1. **The catchment area upstream of Chatra (Outside India) in Kosi river system.**
2. **Barrage and appurtenant works.**
3. **The Kosi River Course (From Chatra to Kursela):**
   a) From Chatra to Kosi Barrage;
   b) From Kosi Barrage to Koparia;
   c) From Koparia to Kursela.
4. **Embankments:**
   a) Upstream of Kosi Barrage;
   b) Downstream of Kosi Barrage – Eastern Embankment
   c) Downstream of Kosi Barrage – Western Embankments
5. **Area between embankments (between Barrage & Koparia)**
6. **Area east of the eastern embankment**
   a) Area suffering from drainage congestion;
   b) Area suffering from flood problem.
7. **Area west of western embankment suffering from drainage problem.**

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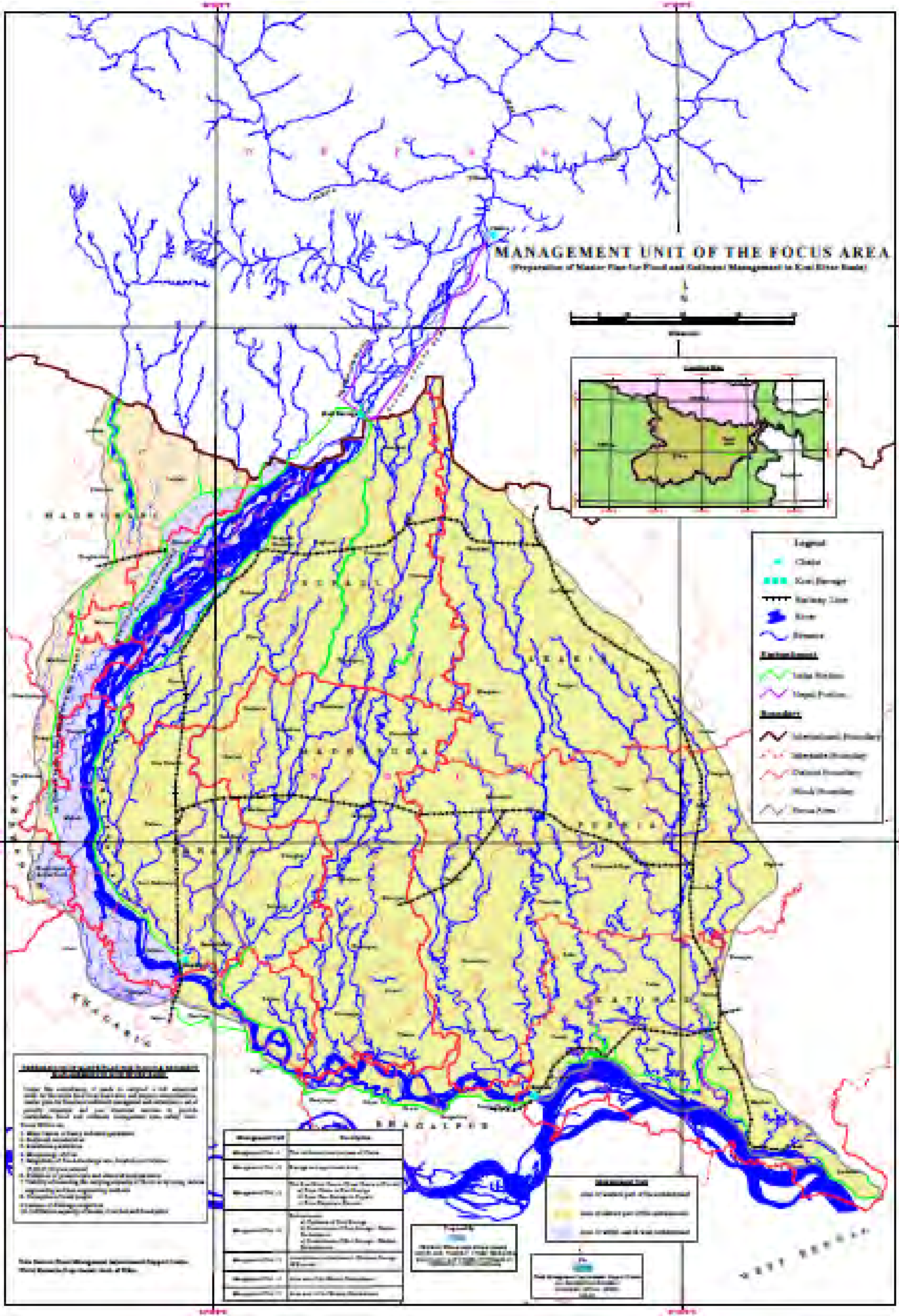
MANAGEMENT UNIT OF THE FOCUS AREA
(Preparation of Master Plan for Flood and Sediment Management in Kosi River Basin)

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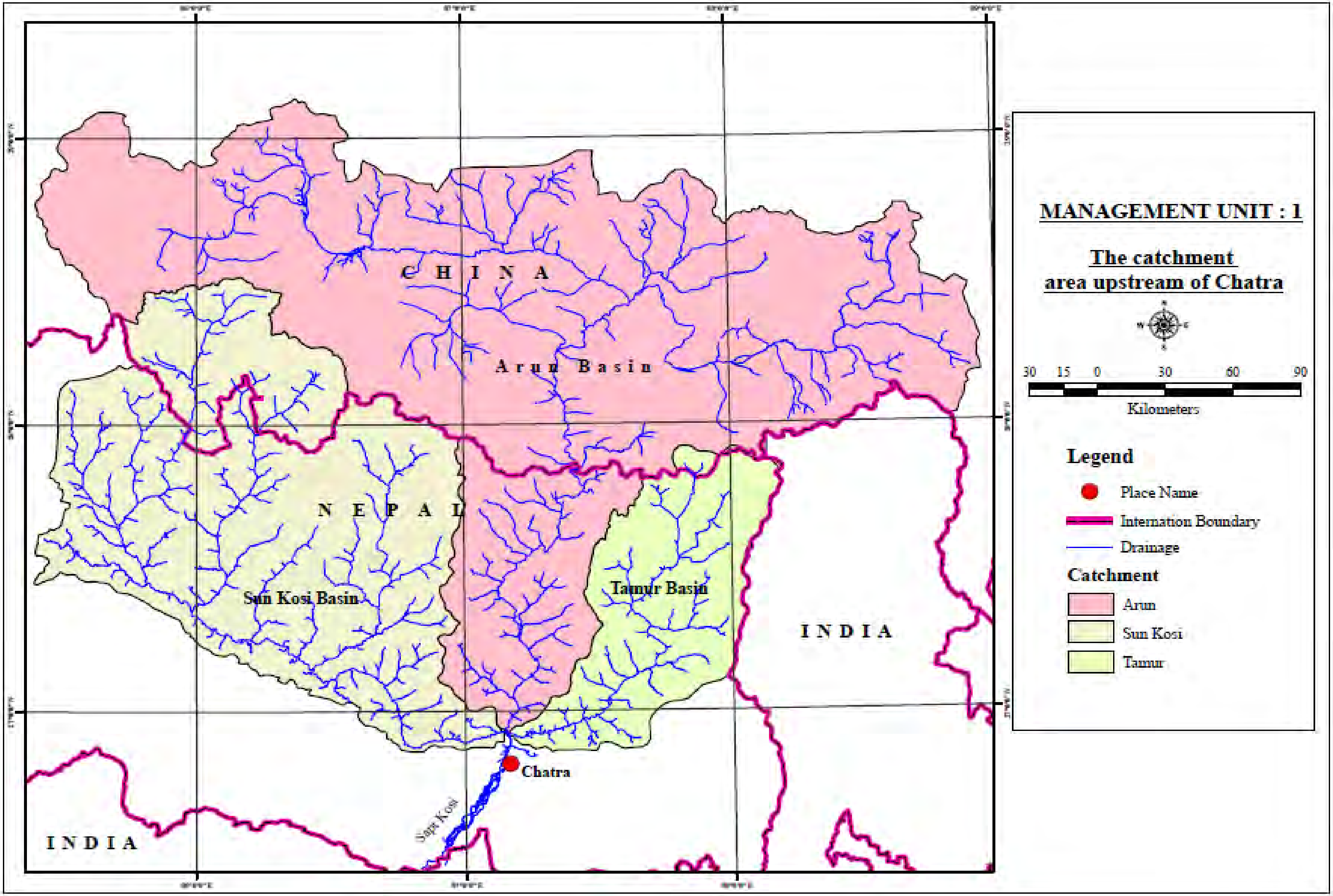
Framework of Master Plan for Management Unit No.1: Upper Catchments

URS

MANAGEMENT UNIT 1



Catchment Areas of Tributaries of the Kosi River at Barahkshetra			
SL No.	Tributary	Catchment Area	
		in sq. km.	percentage
1	Sun Kosi	19,000	31.91
2	Arun	34,650	58.19
3	Tamur	5,900	9.90
	Total=	59,550	100

Total Catchment Area of the Kosi River	
Country	Catchment Area in sq. km.
Tibet (China)	32,066
Nepal	29,046
Total area outside India	61,112
India	12,407
Total	73,519

- Area under perpetual snow cover above 4573 m altitude = 27,765 sq. km.
- Area under permanent glacier = 5700 sq. km.

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Contribution of Run-off And Sediment Load of Tributaries Of Kosi

Sl. No	Tributaries	Percentage of CA	Percentage of run-off	Percentage of sediment load
1.	Sun Kosi	31.9	43.8	47.5
2.	Arun Kosi	58.2	36.6	28.0
3.	Tamur Kosi	9.9	19.6	24.5

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Distribution of the Sediment Load in the Tributaries of Kosi at Barahkshetra (1948 – 1955)

Sl. NO	Tributaries	Sediment load in Million M^3							
		Coarse		Medium		Fine		Total	
		Volume	%	Volume	%	Volume	%	Volume	%
1.	Sun Kosi	9.37	38	19.00	49	34.29	50.3	62.66	47.5
2.	Arun Kosi	8.76	35	10.86	28	17.39	25.5	37.01	28.0
3.	Tamur Kosi	6.66	27	9.13	23	16.53	24.2	32.32	24.5
		24.79	100	38.98	100	68.21	100	131.98	100

PROBLEM

The River Kosi is notorious for its shifting course. The root cause of the problem is the excessive sediment load brought down by the river. This sediment load is generated in its upper catchment which is located in neighbouring countries of Nepal and Tibet (China).

OBJECTIVE

It is envisaged to propose/adopt measures which will reduce the high rate of generation of the sediment in the catchment and thereby help to stabilize the river course below the barrage by facilitating the transport of the sediment to the Ganga.

Probable Alternate Measures

- Soil Conservation.
- Construction of Dams.

Soil Conservation

- Types of erosion.
  - ✓ Heavy sheet erosion.
  - ✓ Extensive gully erosion.
  - ✓ Land Slide.
  - ✓ Soil erosion due to faulty irrigation.
  - ✓ Alignment and Constructions of hill roads.
- Immediate Short and Long Term Measure.
- Impact of Global Warming and Climate Change.

Soil Conservation (continued)

- Govt. of India Guidelines.
    - ✓ Integrated action plan on area saturation basis.
    - ✓ Implementing agency
        - ➢ Adequately strengthen;
        - ➢ Trained staffs;
        - ➢ Facility to work in difficult terrain.
    - ✓ Massive people Participation.
- Program Contents
- Constraints.

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Construction of Dams

- All sites located in neighbouring country Nepal.
- Proposals moving with very slow speed.
- It is a permanent measure with no alternative.
- Important considerations:
  - ✓ Flood storage vs. conservation storage.
  - ✓ Submergence area – environmental & social issues.

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Recommendations

- The catchment treatment plan as discussed above should be taken up on priority basis. It will serve as immediate and short term measures as well as a long term measure. This satisfies the criteria of social acceptability; environment friendly as well as techno-economic viability. In this case the international issue of political compatibility does not arise.

- The proposal of the construction of the Kosi High Dam on the main Kosi River as well as other feasible dams on tributaries should be pursued vigorously as they are indispensable for the long term solution of the problems in the Kosi River Basin.

- Both these recommendations will be helpful in the context of climate change when in future more severe and more frequent both floods and droughts are apprehended.

Framework of Master Plan for Management Unit No.5: Area within Embankments

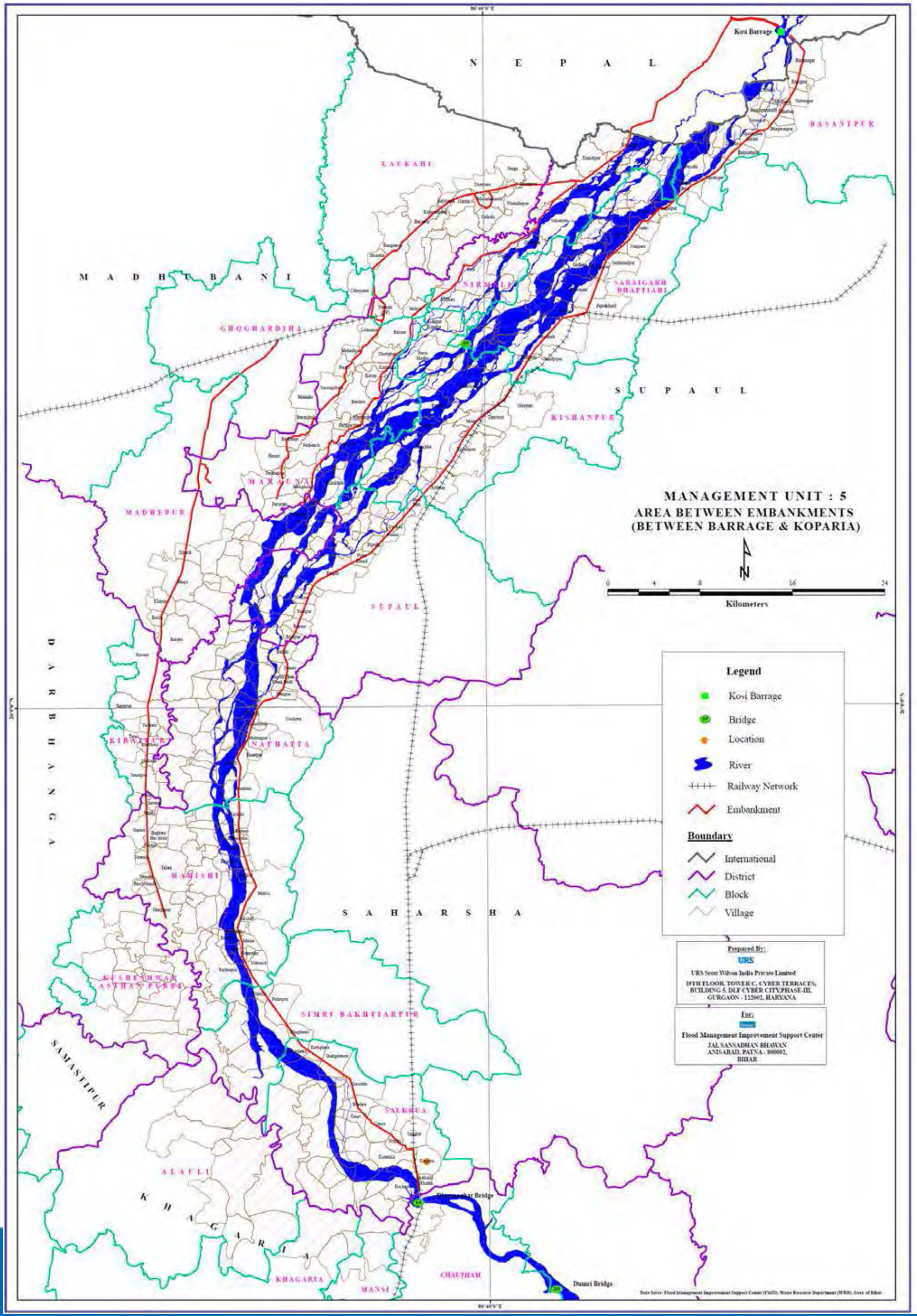
MANAGEMENT UNIT 5

Area

- It extends from Nepal border below Barrage in the north to Koparia in the south (where the Eastern Embankment ends).

- It consists of 395 villages under 19 blocks of 5 districts of Bihar.

- Total area is 128,155 ha (10%) and Total population is 11.75 lakh (9%).



MANAGEMENT UNIT : 5
AREA BETWEEN EMBANKMENTS
(BETWEEN BARRAGE & KOPARIA)
N E P A L
M A D H U B A N I
D A R B H A N G A
S U P A U L
S A H A R S H A
SAMASTIPUR
K H A G A R I A
LAUKAHI
GHOGHARDIHA
MADHEPUR
MARAUNA
SARAIGARH BHAPTIADI
KISHANPUR
BASANTPUR
SUPAUL
NIRMALI
KIRATPUR
NAUHATTA
MAHISHI
KUSHESHWAR ASTHAN PURBI
SIMRI BAKHTIARPUR
SALKHUA
ALAULI
KHAGARIA
MANSI
CHAUTHAM
Kosi Barrage
Dumri Bridge
Kilometers
0
4
8
16
24
Legend
Kosi Barrage
Bridge
Location
River
Railway Network
Embankment
Boundary
International
District
Block
Village
Prepared By:
URS
URS Scott Wilson India Private Limited
19TH FLOOR, TOWER C, CYBER TERRACES, BUILDING 5, DLF CYBER CITY,PHASE-III, GURGAON - 122002, HARYANA
For:
Flood Management Improvement Support Center
JAL SANSADHAN BHAWAN
ANISABAD, PATNA - 800002, BIHAR

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Problem

Confinement of the area within embankments leading to deposition of silt and rise in flood water level combined with braiding nature of the river due to excessive silt results into annual flood, which has become a permanent source of miseries, damage and inconvenience and the area remains devoid of any development activity.

Objective

- It is envisaged to propose / adopt measure or combinations of measures which may attempt to modify the susceptibility of flood damage and loss burden.
- At the same time it is intended to develop the concept of “living with flood” and encourage people to adopt the same.
- It is also intended to make best use of available natural resources like water and land.

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Probable Alternative Measures

1. Rehabilitation.
2. Raising of villages.
3. Flood Zoning.
4. Forward Embankments.
5. Dredging of Silt.
6. Living with the Floods.

Public Meeting

A public meeting was organized on the 23rd January 2016 at Karjain village under Raghopur Block of Supaul District.

About more than 150 people participated in the workshop. A large number of people from the villages within the embankments participated in the workshop by travelling on foot or cycle (as no other mode of transport is possible in this area) and crossing the mainstream of the River Kosi by boat,(which is following very close to the eastern embankment).

Following suggestions were made:

- Construction of parallel embankments.
- Removal of silt.
- Living with the Floods; and
- Reorganization of the administrative structure.

Public Meeting at Karjain

Proposed Measures

Five point plan:

1. Vigorous protection of embankments against erosion.
2. Parallel Embankments –
   to provide protection against floods,
   to streamline the river course.
3. Removal of silt by dredging –
   to streamline the river course.

Proposed Measures (contd.)

Parallel Embankment in conjunction with dredging

- Parallel embankment to be constructed around cluster of villages.
- Parallel embankment to be planned for dominant discharge of 8,500 cumecs (300,000 cusecs).
- Parallel Embankment to be constructed with geotextile tubes (2.5 to 3.0 m diameter).
- It is to be constructed in conjunction with dredging of silt.
- Dredged silt to be transported to the site of parallel embankment in the geotextile pipe through pumping.
- Parallel embankment in geotextile tubes to be covered on sides and top with 0.6m earth and turfing.

Proposed Measures (contd.)

4. Living with the Floods:

a) Flood Proofing :

- ✓ to be made on elevated concrete platform with all facilities like water supply, sanitation, storage for food grain and fodder;
- ✓ to be connected with all weather road already provided on the embankments;
- ✓ to be made wide enough for the movement of vehicle.

b) Flood proof/resistant buildings –

- ✓ public buildings like block development offices, police stations, schools, hospitals to be constructed on concrete pillars with plinth above HFL.
- ✓ provision for shelter during high flood on the top of public building to be made.

Proposed Measures (contd.)

- ✓ General public to be encouraged to construct flood proof/flood resistant building on pillars with plinth above HFL.
- ✓ Loan (on subsidised interest)/grant may be made available for construction of flood proof/flood resistant buildings.

c) **Roads:** Fair weather road with brick soling on normal formation level without high embankments to be provided.

d) **Transportation :** During high floods, ordinary/motorised boats to be used for transportation.

Proposed Measures (contd.)

5. Administrative Reorganisation:

- Number of development blocks in the 5 district to be reorganised.

- The headquarters of the development blocks, police stations, banks etc. to be located within the embankment in flood proof/ flood resistant buildings.

The proposed measures fulfil all the following required criteria:

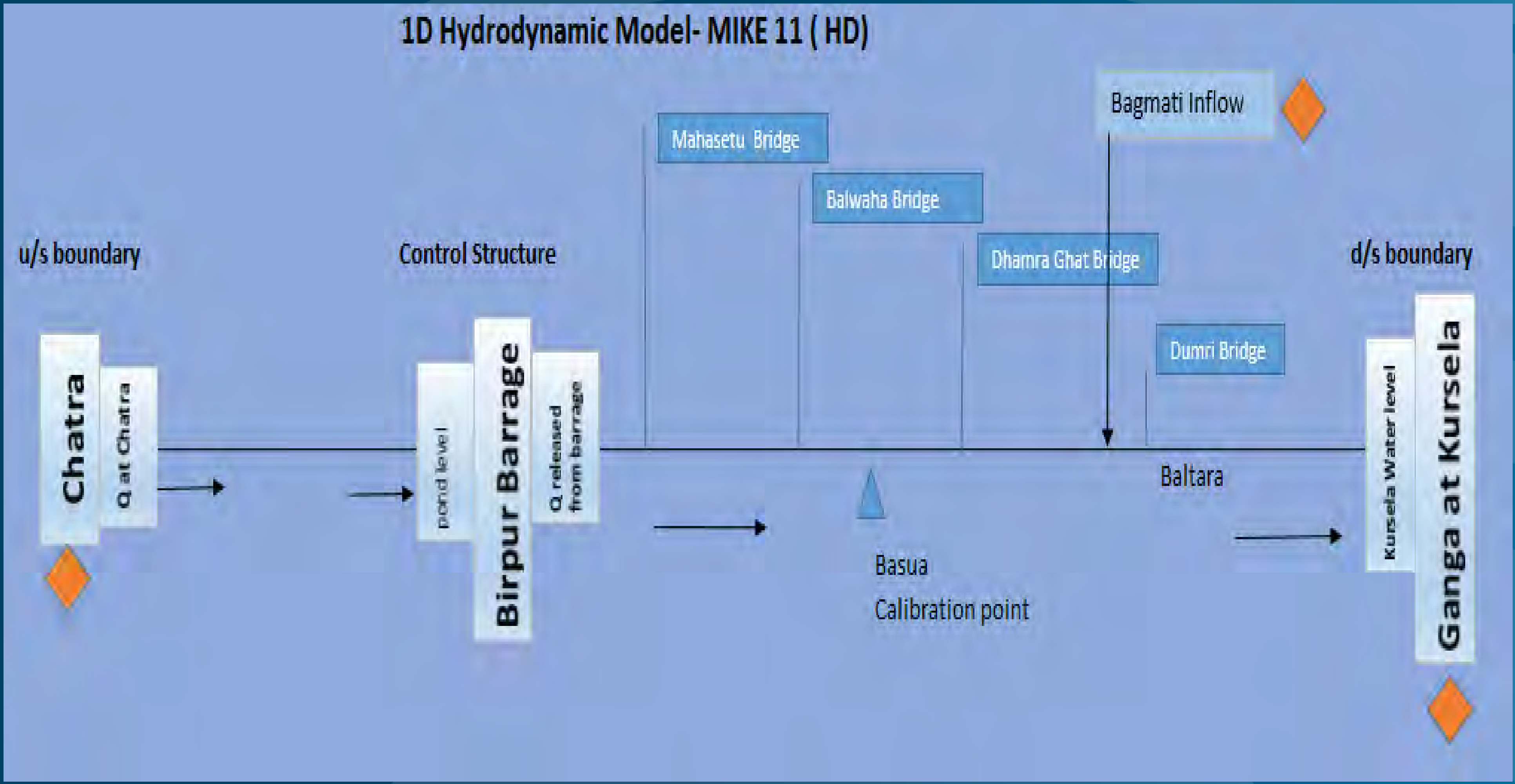
1. **Social Acceptability –** proposed measures have been suggested by the local people.

2. **Economic efficiency –** use of dredged silt in construction of parallel embankment makes it economically viable and environmental friendly.

ACTIVITIES:

- Hydrology
- Morphology
- Sediment yield
- 1D Modelling
- 2D Modelling
- Vulnerable reaches based on Imageries

1D Hydrodynamic Model



Modelling Framework

- **Model domain:** Chatra to Kursela, i.e., total 273 km length.

- **Boundary conditions:**

i. The observed inflow at Chatra was imposed as upstream boundary

ii. Observed water level at Kursela was imposed as downstream boundary.

iii. Baghmati inflow as lateral inflow boundary at upstream of the Dumri bridge

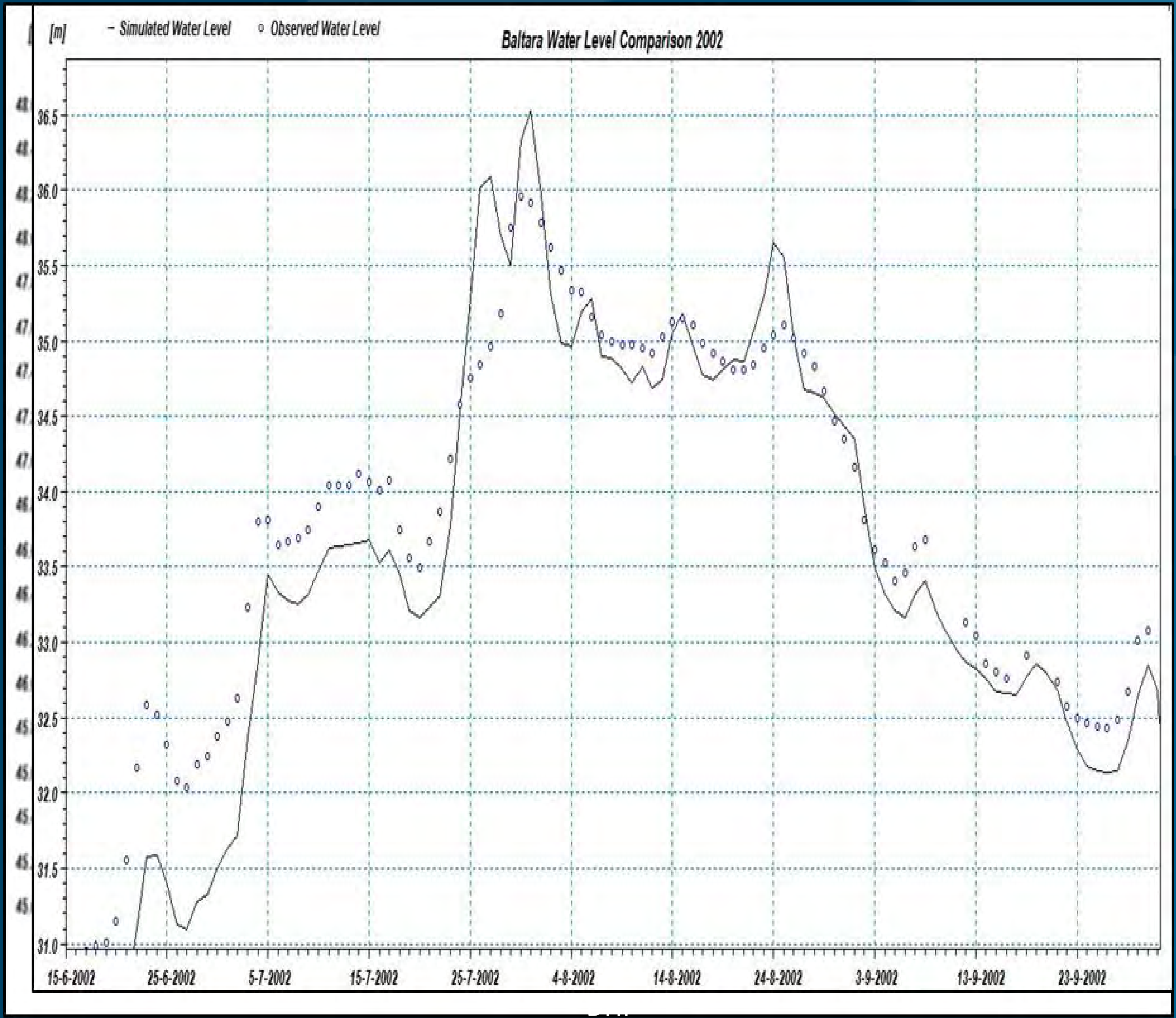
- **Initial condition:**

i. Cross sections surveyed in 2013 (Source-CE Birpur,Chatra to Dhamaraghat).

ii. d/s of Dhamaraghat, 8 cross sections surveyed in 2014 by DHI.

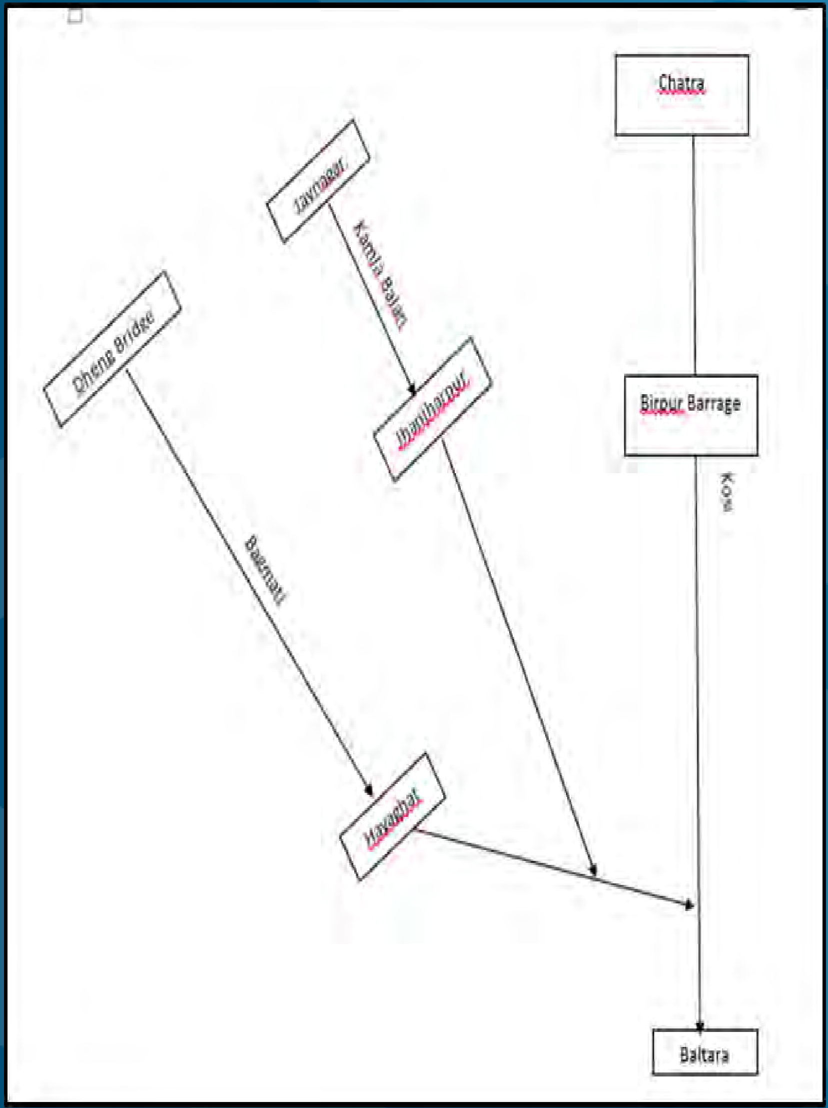
- **Control Structure:** Birpur barrage was integrated

Calibration and Validation for 1D HD



Calibration and Validation Details of u/s Model

SN	us/ 1D ST Model-Chatra to Birpur Barrage	MCM/year	Data period/Remarks
	Calibration		
1	With observed suspended sediment load at Birpur barrage	50.70	Mean of 2001-2011 (Table 3.16-Chapter 3)
2	Simulated total load at Birpur Barrage	55.00	Mean of 2013-2026
3	Simulated suspended load (assuming 10 % bed load of total simulated load)	49.50	
	Validation		
4	Observed suspended sediment load at Barakshetra	94.95	Mean of 1948-1982, 34 years (Table 3.13-, Chapter 3)
5	Observed suspended sediment load at Chatra	38.81	Mean of 2001-2005 (Table 3.14-Chapter 3)
6	Mean of means of two data sets of different periods (4 and 5 above)	66.88	
7	Simulated total load (model supplied total load) at Chatra	72.00	Mean of 2013-2026
8	Simulated suspended load (assuming 10 % bed load of total load)	64.80	

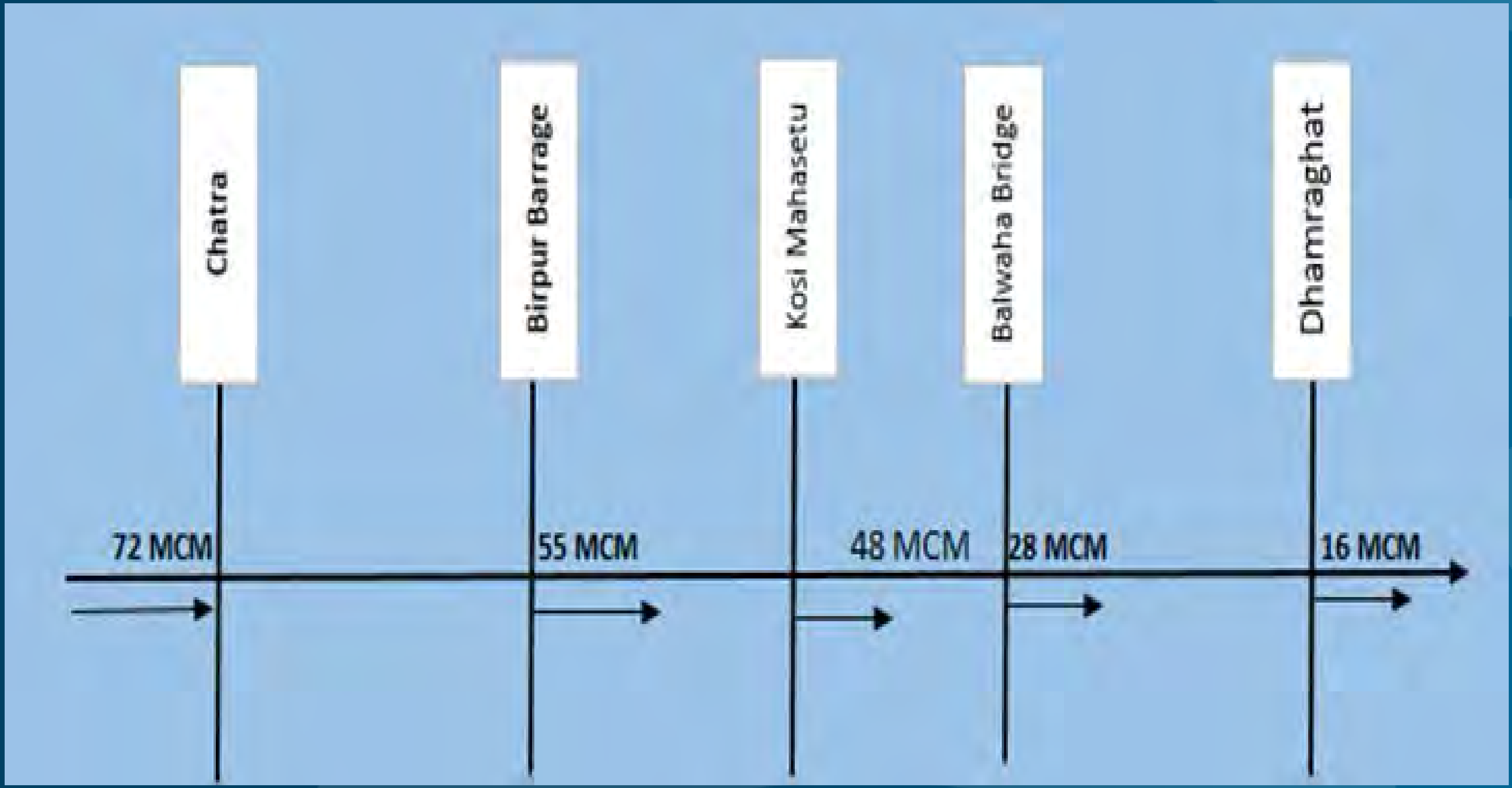


Calibration and Validation Details of d/s Model

SN	d/s 1D ST Model-Birpur Barrage to Kursela	MCM/year	Data period/Remarks
	Validation		
1	Observed suspended load of Kosi at Baltara	24.40	(Sinha & Jain, 1998)
2	Observed suspended load of Bagmati at Hayaghat	6.25	(Sinha & Jain, 1998)
3	Observed suspended of Kamala Balan at Bagmati confluence	2.11	(Table 9-2 Chapter 9)
4	Total observed suspended from Bagmati and Kamala Balan contributed to Kosi at Baltara	8.36	
5	Kosi's own suspended load at Baltara (Observed)	16.04	
6	Simulated total load at Baltara	16.00	Mean of 2013-2026
7	Simulated suspended load at Baltara (assuming no bed load)	16.00	

Simulation Result and Discussion

- **Sediment mass balance in different reaches**



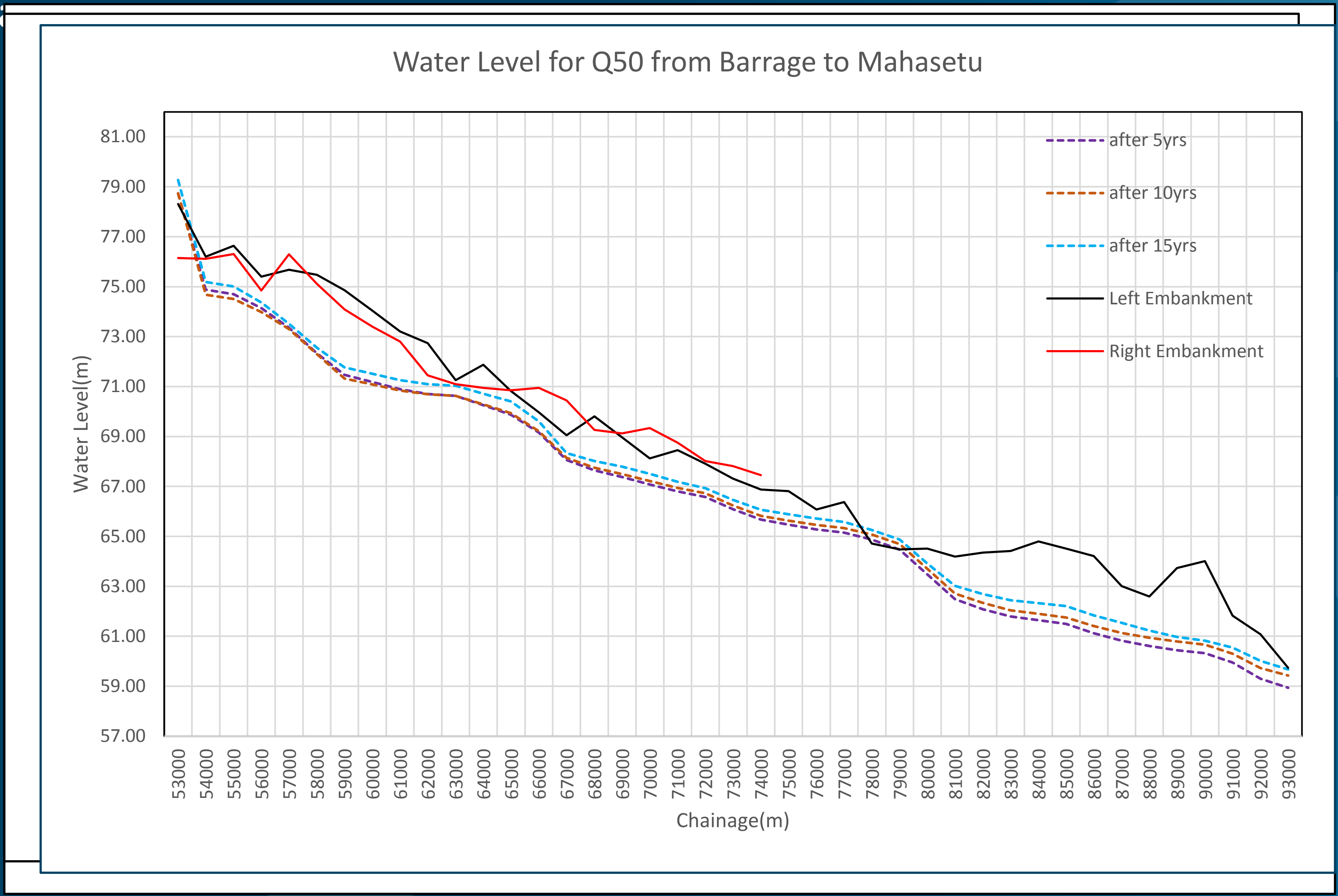
Simulation Result and Discussion

- Sediment mass balance in different reaches

SN	River Reach	Cubature Study by IIT Delhi Data 1955-74		Rate of rise of bed in next 25 years after 2013, Deposition
		Pre Barrage (1955-1963)	Post barrage (1963-74)	
I	Chatra to Jalpapur (27 Km)	1.76 cm/year (erosion)	12.34 cm/year (Deposition)	15.76 cm/year
II	Jalpapur to Bhimnagar Barrage (15 km)	16.56 cm/year (erosion)	10.7 cm/year (Deposition)	10.82 cm/year
III	Bhimnagar Barrage to Dagmara (26 km)	3.56 cm/year erosion	0.83 cm/year erosion	5.43 cm/year
IV	Dagmara to Supaul (34km)	0.37 cm/year erosion	1.86 cm/year erosion	9.72 cm/year
V	Supaul to Mahesi (40 km)	9.56 cm/year deposition	6.36 cm/year deposition	11.84 cm/year
VI	Mahesi to Koparia (25 km)		12.03 cm/year deposition	10.02 cm/year

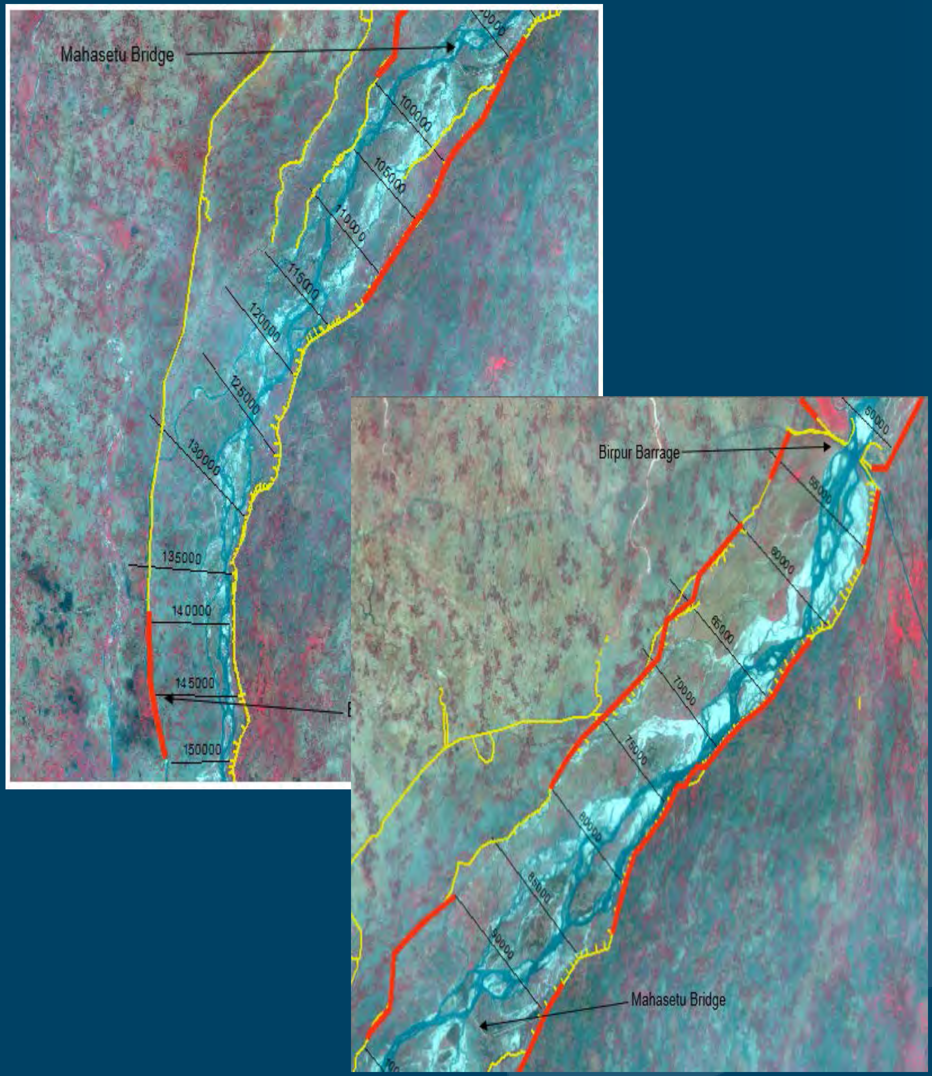
Simulation Result and Discussion

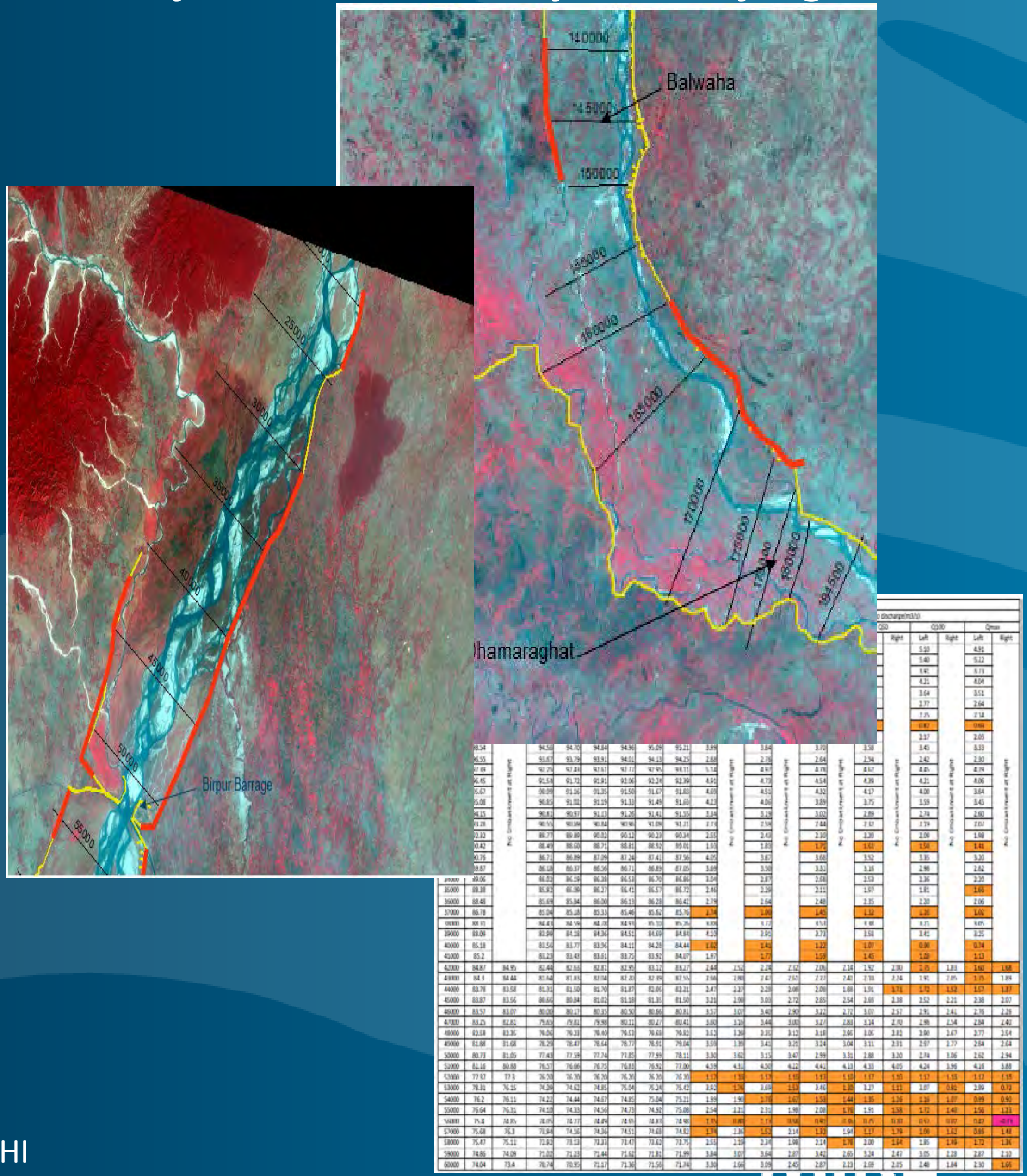
- Estimate the availability of freeboard over the years for different design discha



Simulation Result and Discussion

- Estimate the availability of freeboard over the years and thereby identifying vulnerable reaches





2D Hydrodynamic Model

i. Meso scale 2D HD model from Chatra to Birpur Barrage , i.e. u/s 2D HD Model

ii. Meso scale 2D HD model from Birpur barrage to Kursela, i.e. d/s 2D HD Model

iii. Micro scale model incorporating spurs for a selected small reach to assess the effectiveness of spurs as anti-erosion works.

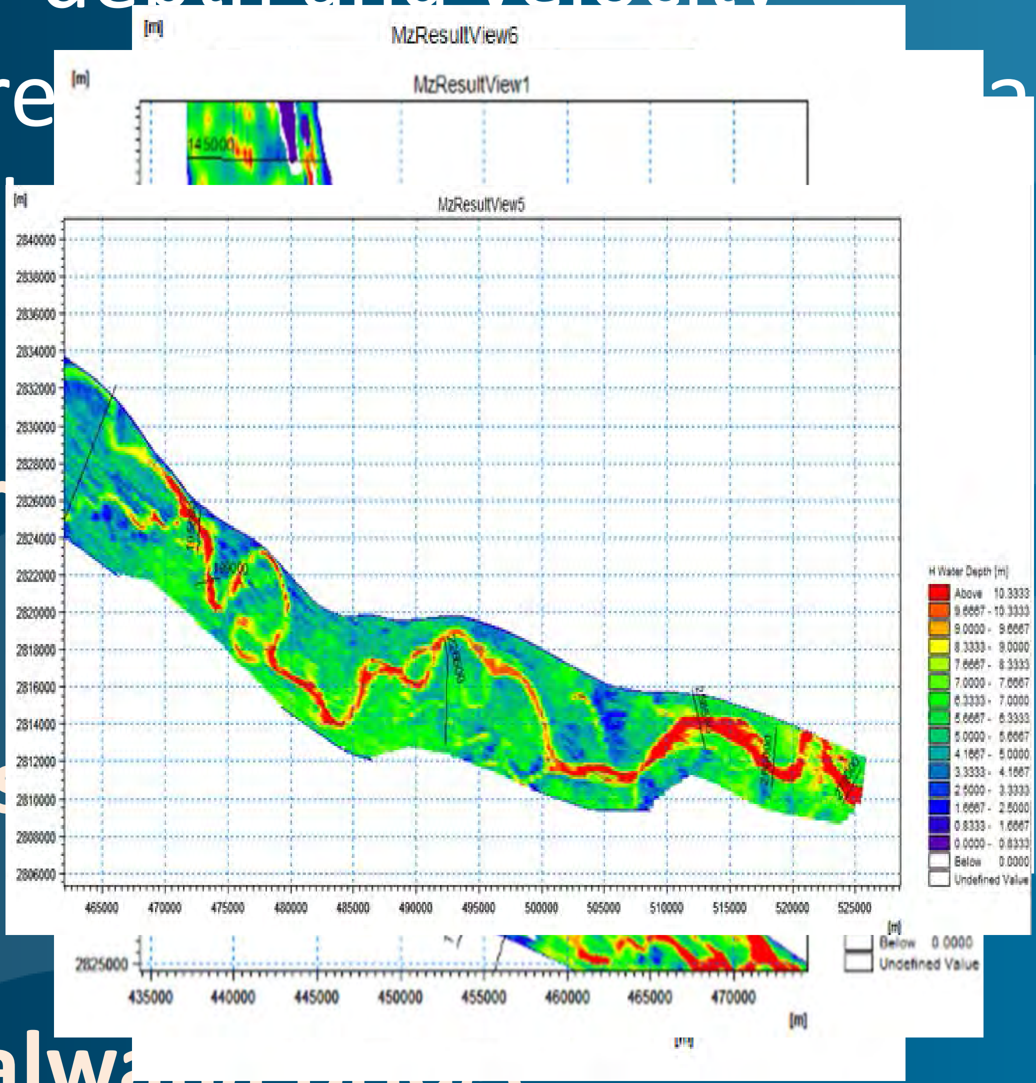
Simulation and Result

- The variation of water depth and velocity throughout the river re… …are presented in five reac…

i. Chatra to Birpur barr…

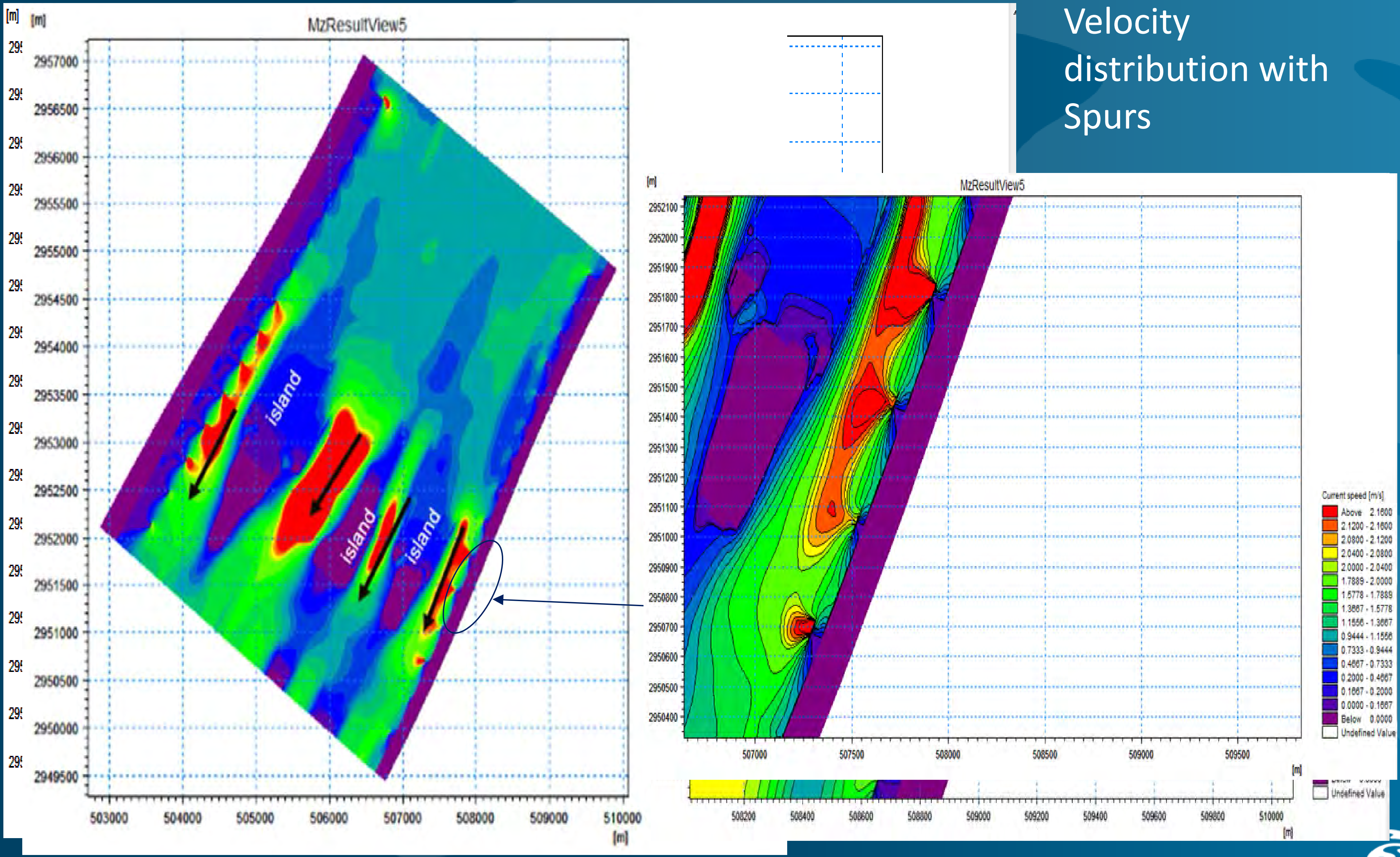
ii. Birpur Barrage to Kos…

iii. Kosi Mahasetu to Balwa… …



MIKE by DHI

Simulation and Result



Velocity distribution with Spurs

IDENTIFICATION OF VULNERABLE REACHES BASED ON IMAGERIES

Approach and Basis

- closeness of the channel with the embankment
- flow separation,
- island location, size and shifting,
- river curvature,
- existing anti-erosion works like number of spurs, length and alignment,
- existing structures like bridges/barrages,
- constriction of flow,

Closeness of the channel with the embankments

Chainage, m	Distance of shoreline from embankmants, m											
	2016	2015	2014	2013	2011	2010	2009	2007	2006	2004	2003	2002
9000-10000		50					50					
13000-14000		47								47		
16000-17000		95					95					
17000-18000		30				30						
18000-19000		60				60						
19000-20000		41				41						
20000-21000		0				0						
21000-22000		0				0						
23000-24000		45				45						
24000-25000		45				30						
25000-26000		50				50						
26000-27000		54				54						
27000-28000		98				98						
38000-39000		98				0						
43000-44000			85		85							
44000-45000			83		83							
65000-66000		96					108					
68000-69000		97					272					
69000-70000		95										95
70000-71000		30					30					
71000-72000		28										79
72000-73000		40										43
75000-76000		76										126
76000-77000		60									60	
77000-78000		46									49	
84000-85000		66					66					
86000-87000		53					155				163	
130000-131000		60				60			60			
131000-132000		30				20			20			
132000-133000		30				40			92			

Thank You

URS

Welcome!

to presentation on

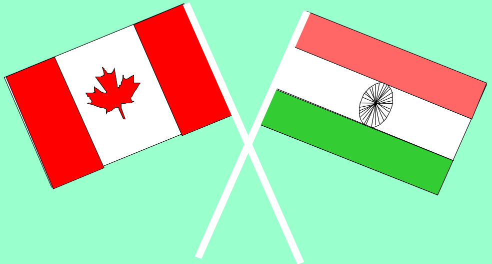
Consultancy Services for Designing, Deploying and Developing Embankment Asset Management System for Kosi Basin (K-EAMS)

By
Mr. Rajesh Kumar
(Chief General Manager—Water Resources)
LEA Associates South Asia Pvt. Ltd.

Date - 19 Feb 2016

ABOUT
LEA Associates South Asia Pvt. Ltd.

Ourselves -



- 50 years Old Consulting Engineering Firm
- 32 countries all across globe
- Providing its services to public and private sector and Multilateral Funding Agencies

LEA GROUP HOLDINGS INC

Incorporation : FEDERAL
Reg. Off. : Suite 900, Cochrane Drive
Markham, ON, L3R 9R9, Canada

CEO : Dave Saunders
Secretary : Paul Duncan

LEA International Ltd.

Incorporation : Ontario
Reg. Off. : Suite 900, Cochrane Drive
Markham, ON, L3R 9R9, Canada

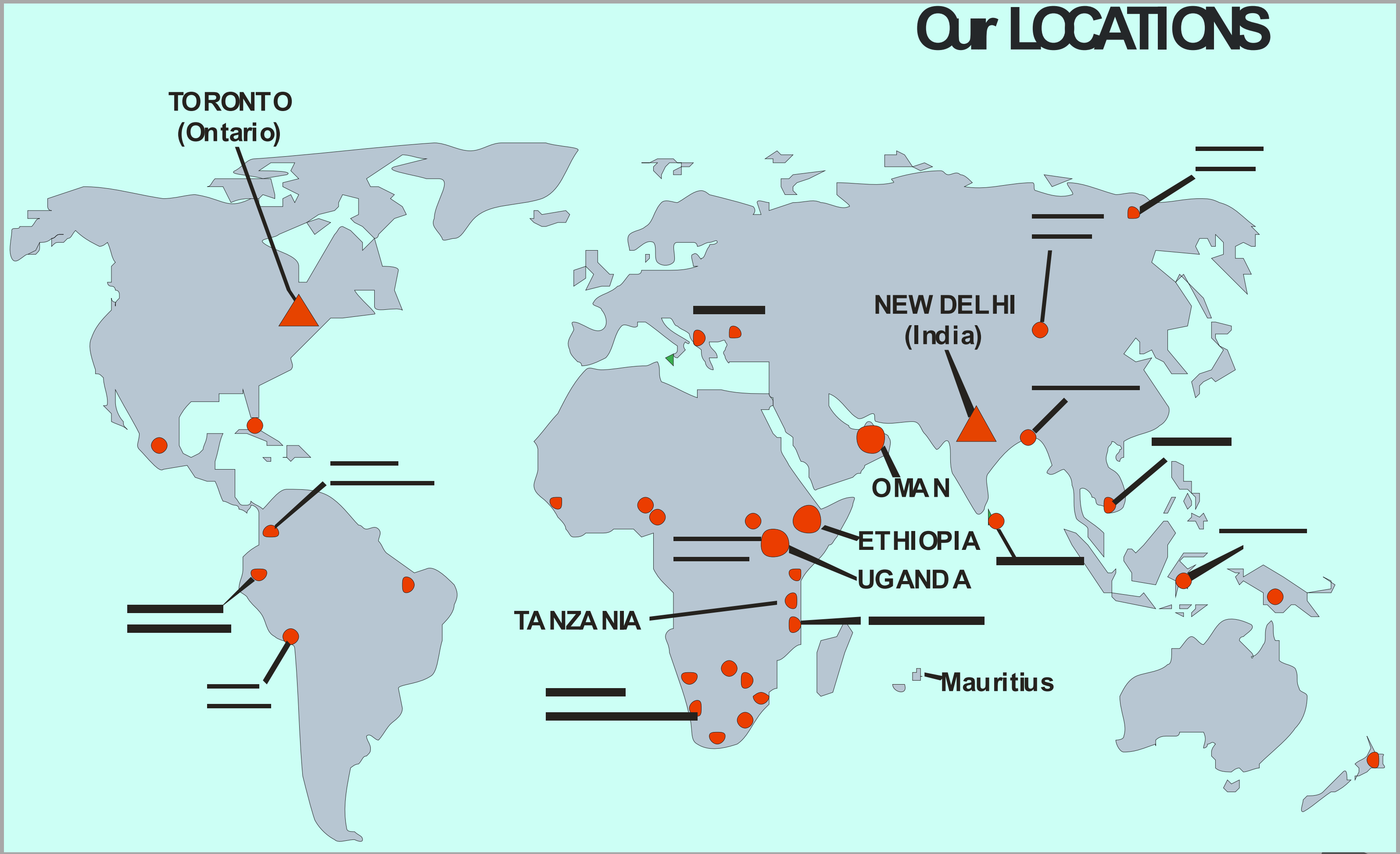
President : John Farrow
Secretary : Chaoba Singh

LEA Associates South Asia Private Limited

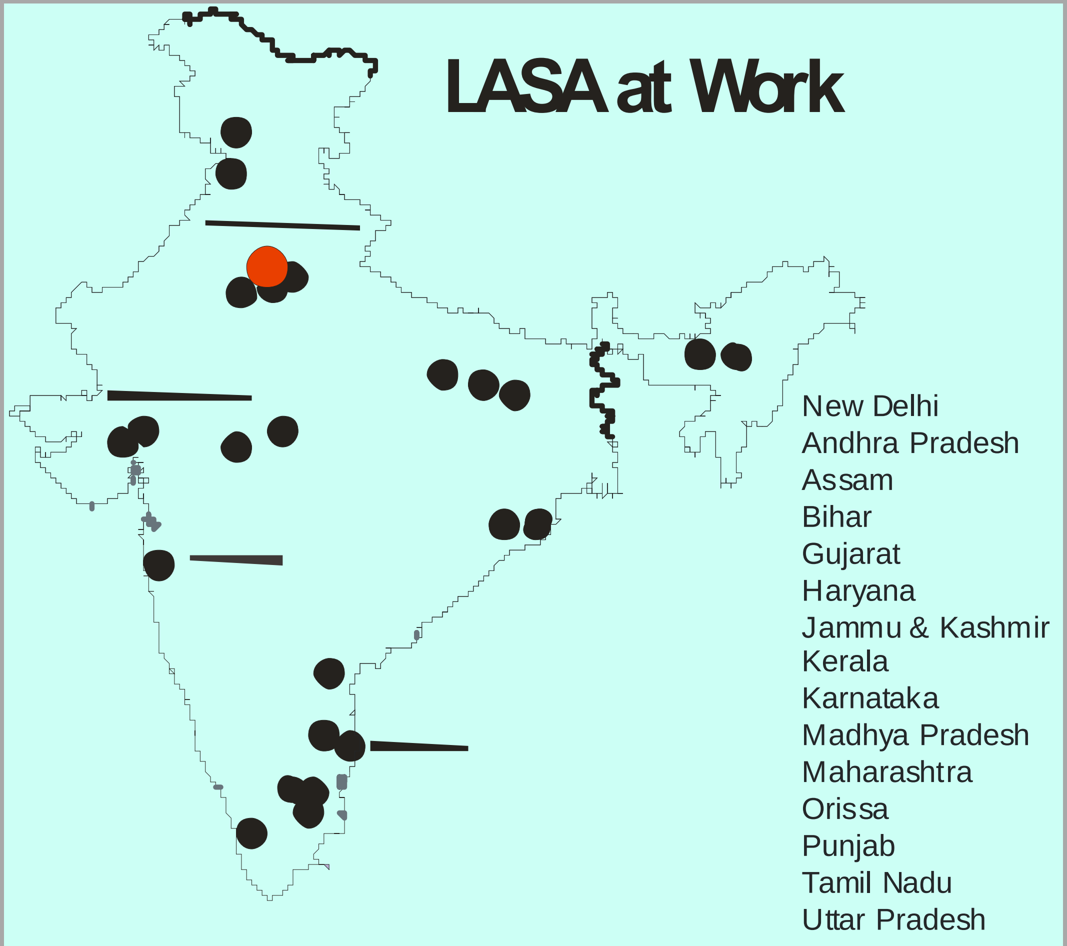
Incorporation : NATIONAL
Reg. Off. : B-1/E27, Mohan
Co-operative Industrial Estate,
Mathura Road,
New Delhi – 110 044, INDIA

Managing Director : Pinaki Roychowdhury
Managing Director : Dr. M.P. Raju

Network of Operations (Global)



Offices - in India



Spectrum of Services

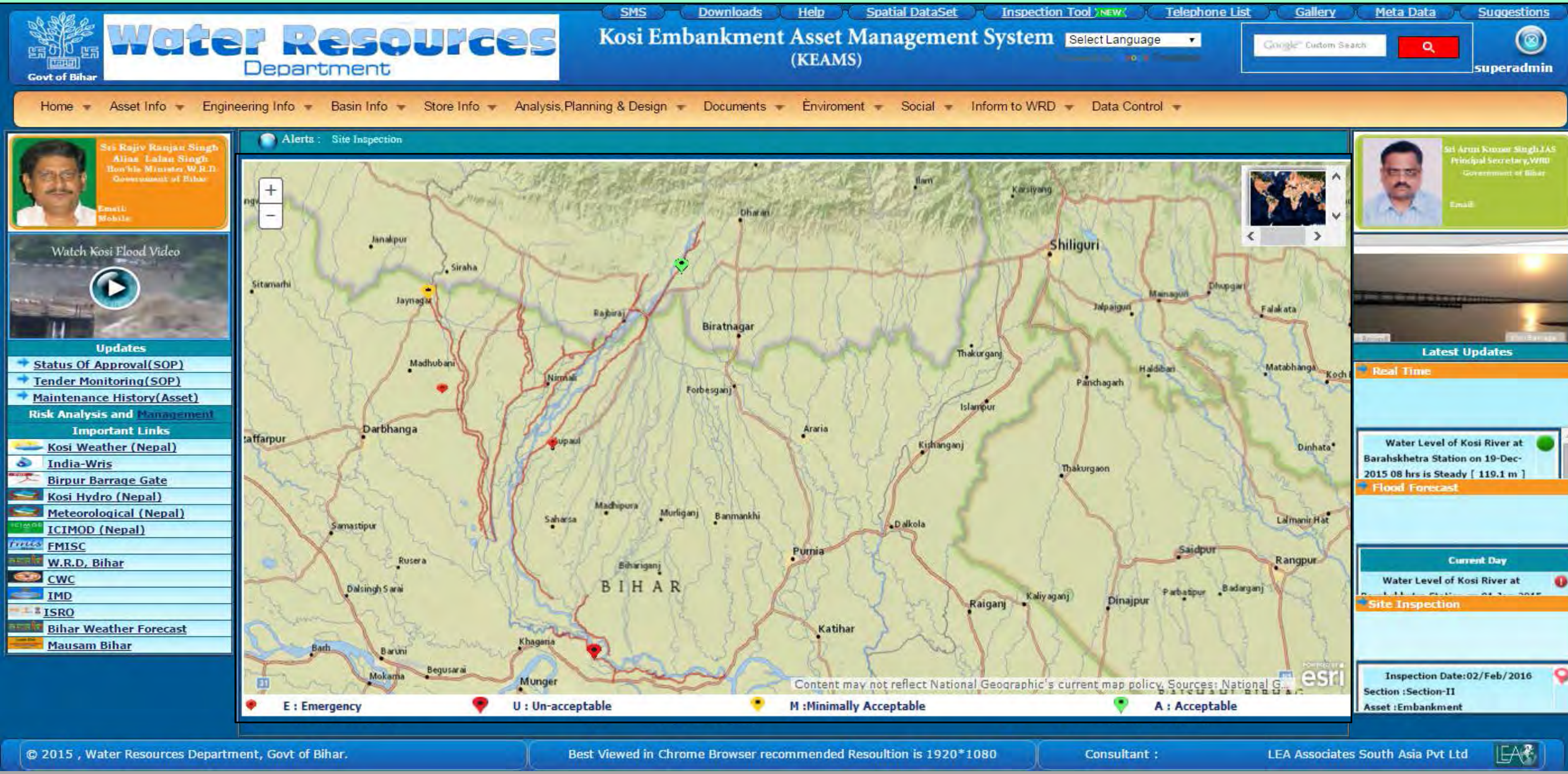
- Water Resource & Irrigation
- Roads & Highways
- Urban Development & Municipal Engineering
- Transportation Planning
- Traffic Engineering & Signals
- Social & Environmental Engineering
- Contract Administration
- Railways

Asset Management System
for
Kosi Basin

Asset, Asset Management, Asset Management System

- Asset: Anything which has value
- Asset Management: A systematic process of operating, maintaining, and disposing of assets cost-effectively
- Asset Management System: A system that encompasses all the processes, tools, data and policies necessary to achieve the goal of managing assets in the most effective, efficient and economical manner

Asset Management System for Kosi Basin



Basic Concept for Design of K-EAMS

- Collect all asset data of Kosi Basin and prepare a GIS map
- Identify other Information / Data Required to Store for Kosi Basin
- Use of K-EAMS in Asset Management of Kosi Basin during Life Cycle of Assets

Assets of Kosi Basin

- Embankment
- Spur
- Jamindari Bundh
- Guide Bundh
- Bridges
- Anti Flood Sluice
- Sluice Gate
- Head Regulator
- Weir
- Barrage
- Drainage Outfall
- Siphon
- Divide Wall
- Main Canal
- Revetment Works
- Silt Ejector
- Silt Excluder
- Site Store
- Flood Store
- Mechanical Store

GPS Survey for Asset Referencing and Asset Information System

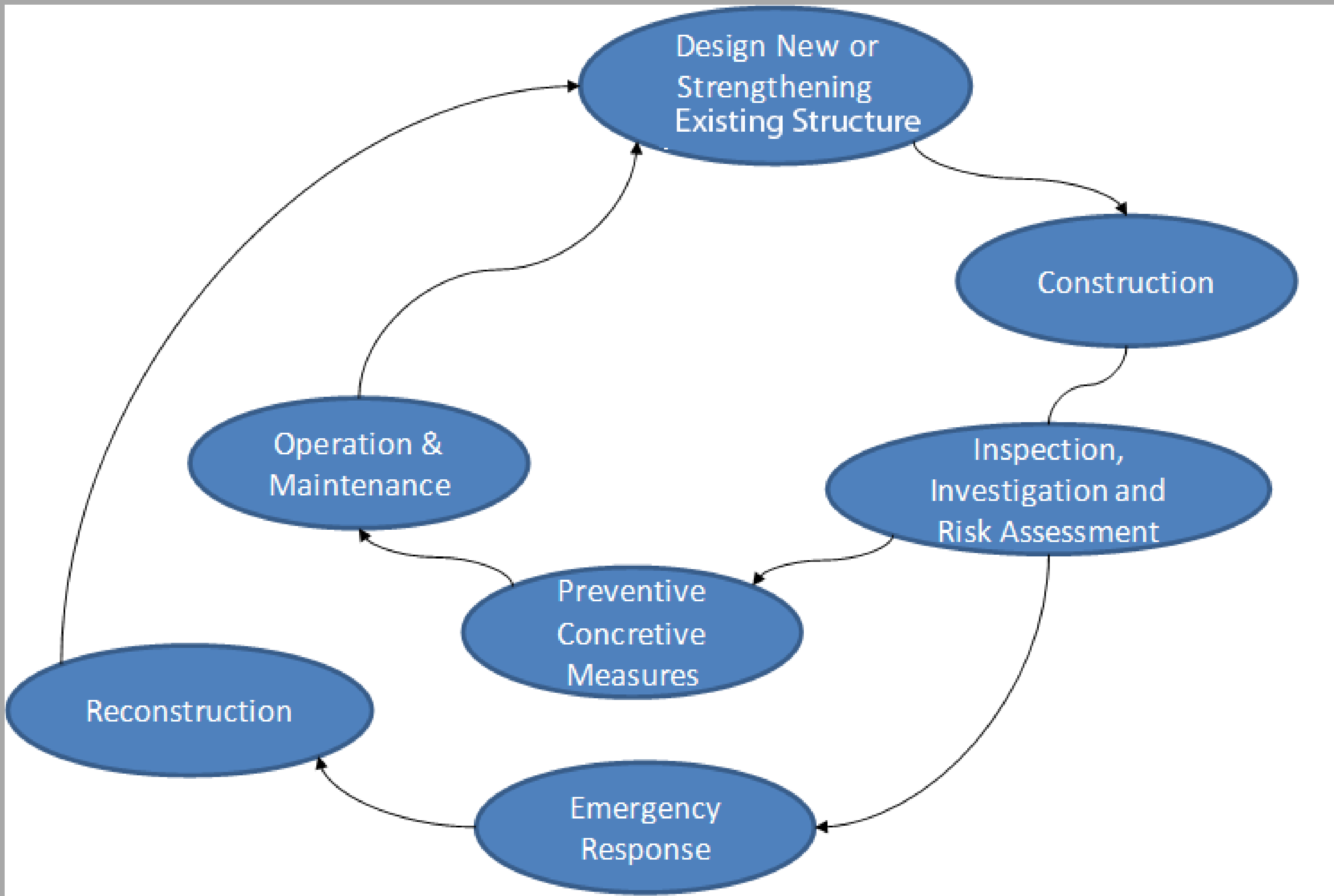
- **Referencing of all assets were done through GPS survey of nearly 650km length of embankment and more than 700 locations of spurs & other assets**
- **During referencing (GPS Survey) max satellite were in the range – gave 3 m accuracy (Normally 7-8m accuracy)**
- **Converted to Shape File through Map Source GARMIN GPS software**
- **These were overlapped on Google, Arc-GIS Base Map & Satellite Images – found OK**

These are stored in Asset Information System

Information / Data Required to Store for Kosi Basin

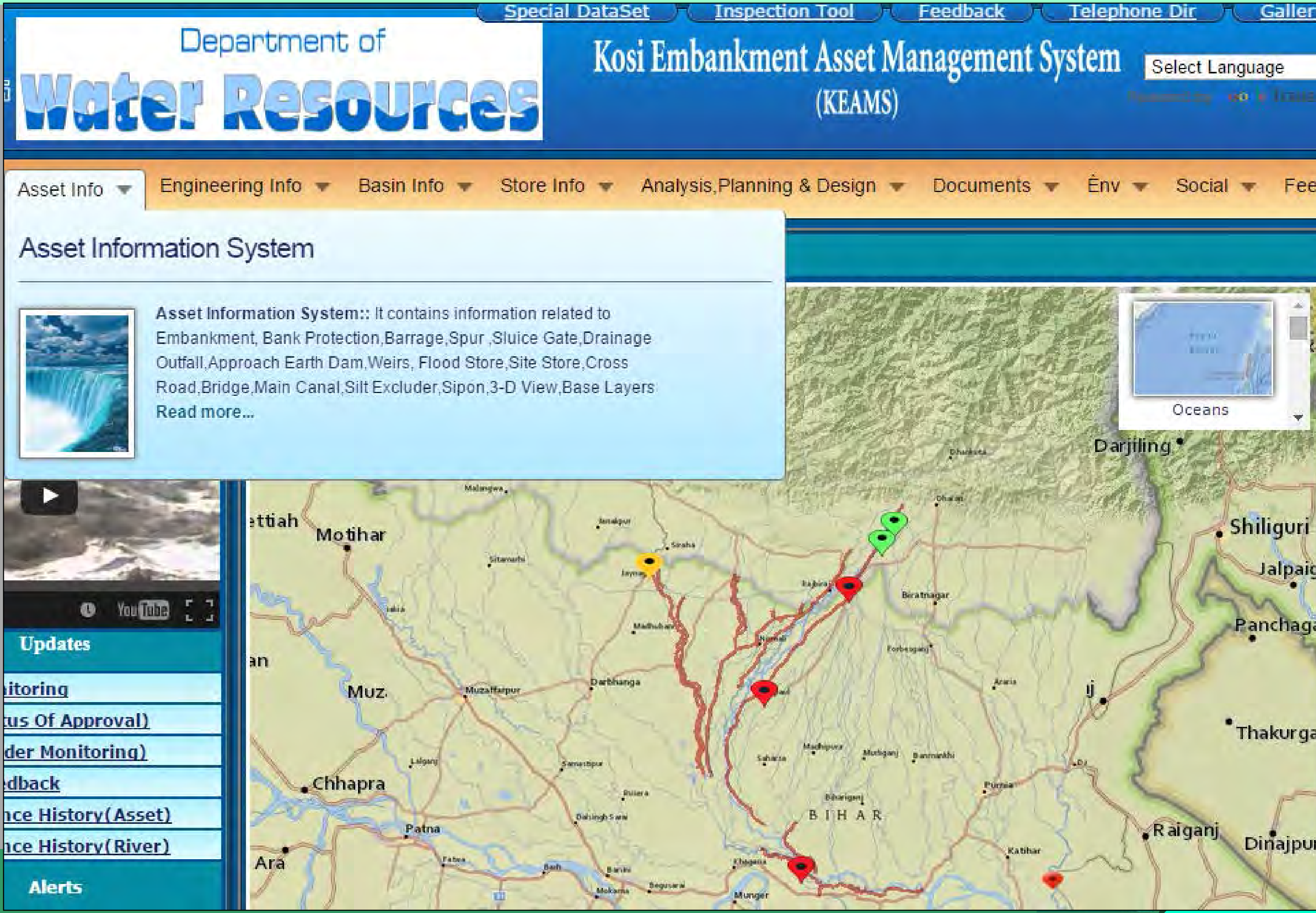
- Engineering Information System
- Basin Information System
- Store Material Information System
- Document Information System

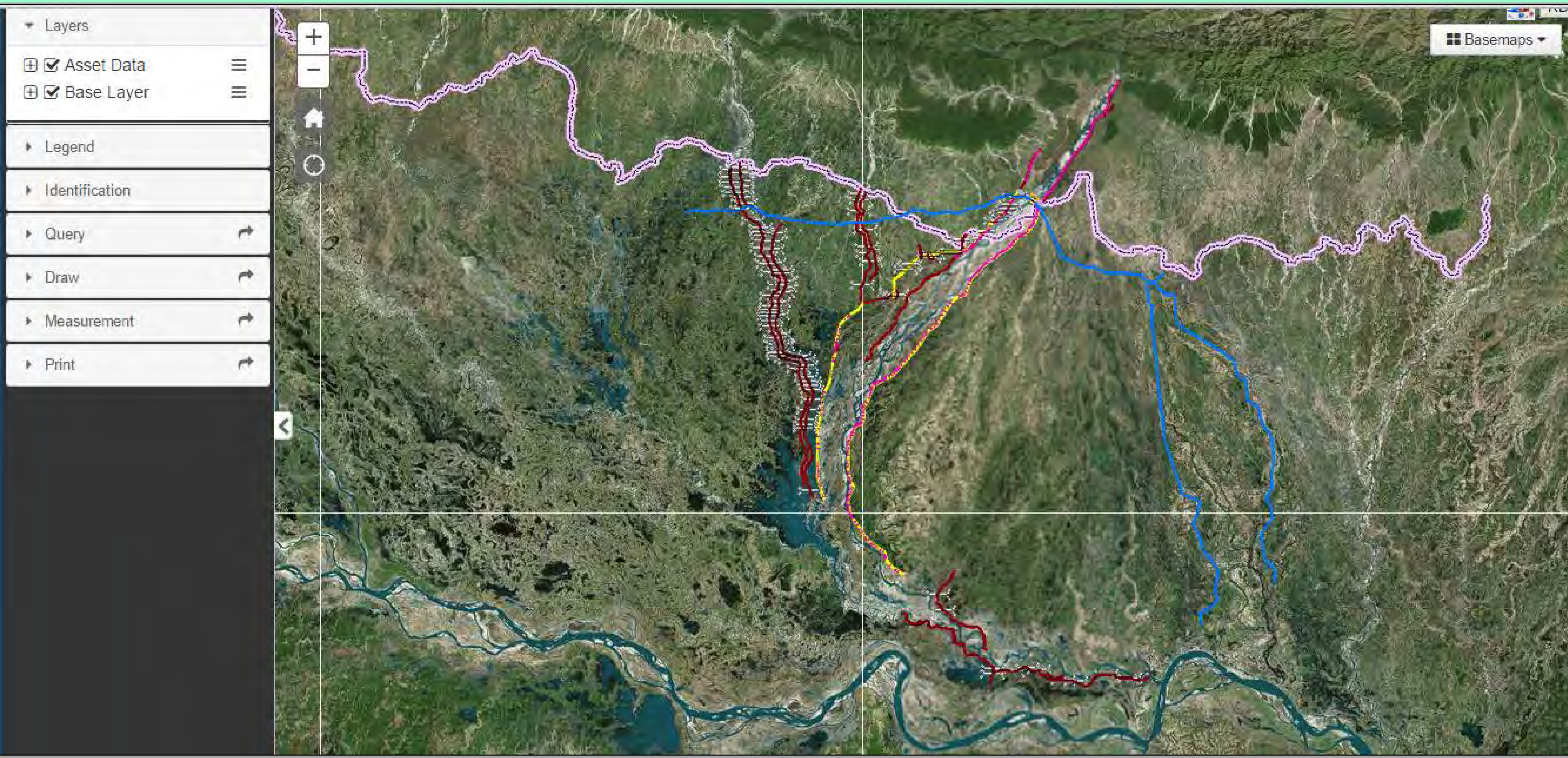
Use of K-EAMS in Asset Management



Component	Module in K-EAMS
Designing New or Strengthening Existing Structure	Design Tool
Construction	SOP (Status of Approval) SOP (Tender Monitoring)
Inspection and Investigation	Tablet Based Asset Monitoring • During Non Monsoon Period (routine measures) • During Monsoon Period (Emergency Measures) Web Portal for Community Feedback SMS Portal for Community Feedback
Risk Assessment	• Swapping Tool (for Annual River Migration Analysis) • Buffering Tool (for Study of River Behavior Approaching to Toe of Embankment)
Preventive or Corrective Measures / Emergency Response	Tablet Based Asset Monitoring Tool
O & M / Reconstruction	Progress of Work with Photo in Asset Monitoring Tool

Asset Information System (AIS)





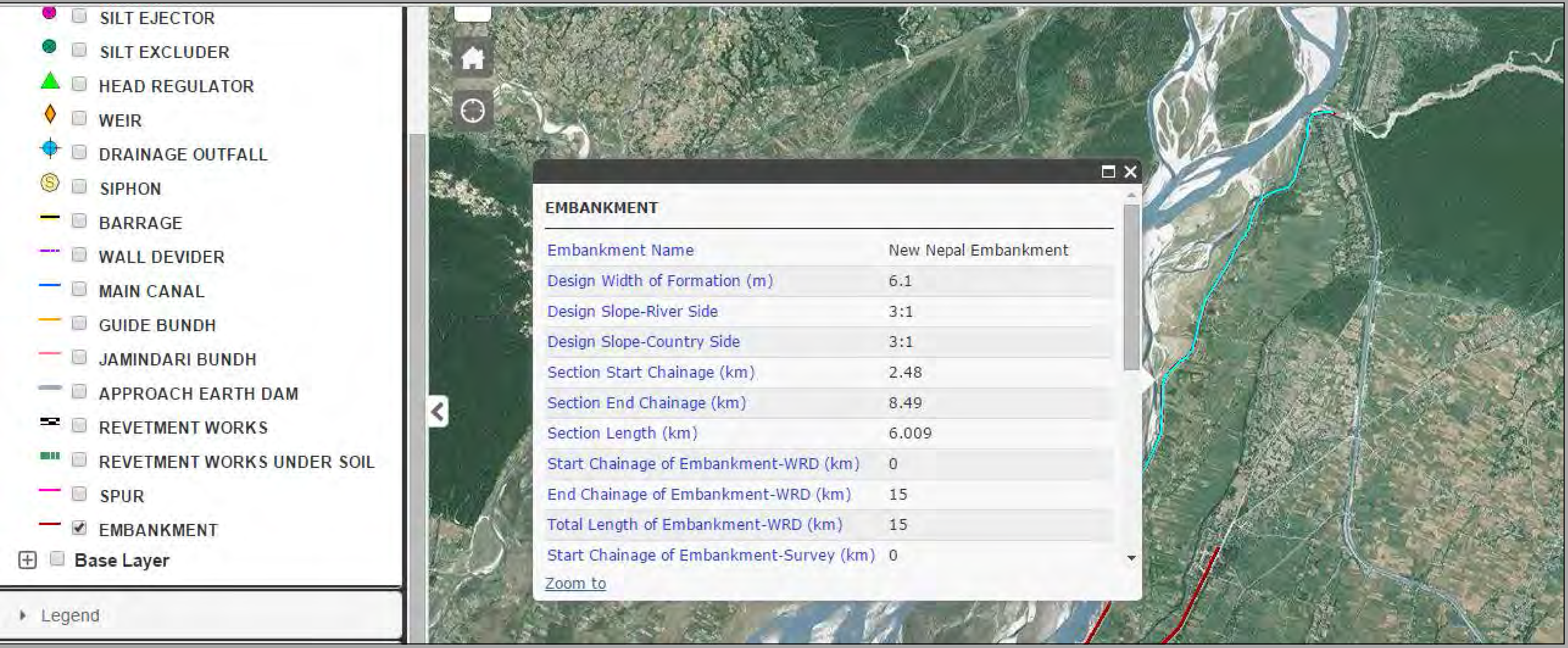
Layers
Asset Data
Base Layer
Legend
Identification
Query
Draw
Measurement
Print
Basemaps

Layers

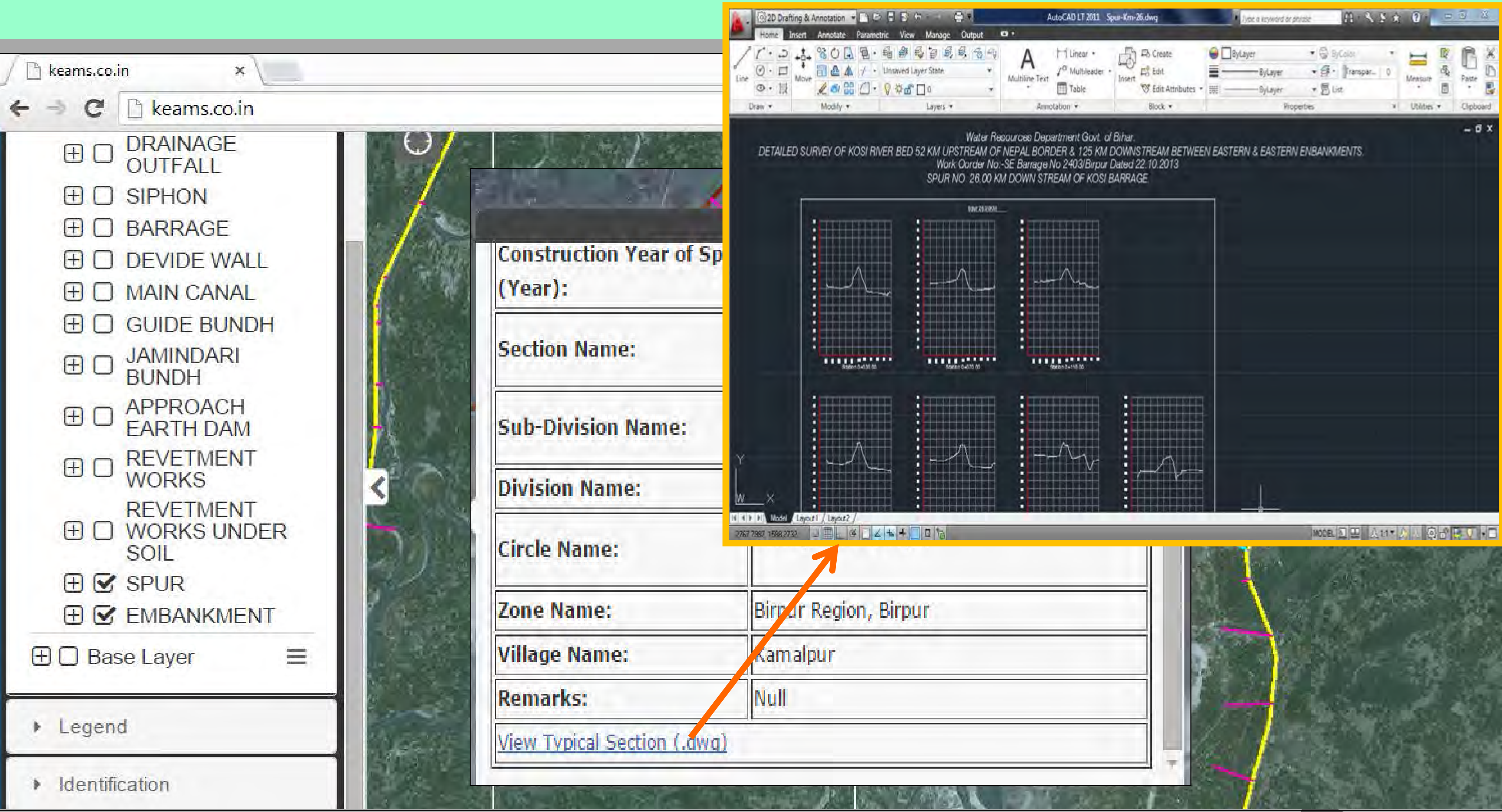
Asset Data

- [ ] KM STONE SURVEY
- [ ] KM STONE WRD
- [ ] BRIDGE
- [ ] ANTI FLOOD SLUICE
- [x] SLUICE GATE
- [ ] FLOOD STORE
- [ ] MECHANICAL STORE
- [ ] SILT EJECTOR
- [ ] SILT EXCLUDER
- [ ] HEAD REGULATOR
- [ ] WEIR
- [ ] DRAINAGE OUTFALL
- [ ] SIPHON
- [x] BARRAGE
- [ ] WALL DEVIDER
- [x] MAIN CANAL
- [x] GUIDE BUNDH
- [ ] JAMINDARI BUNDH
- [x] APPROACH EARTH DAM
- [ ] REVETMENT WORKS
- [ ] REVETMENT WORKS UNDER SOIL
- [x] SPUR
- [x] EMBANKMENT

AIS -Embankment



AIS - Spur

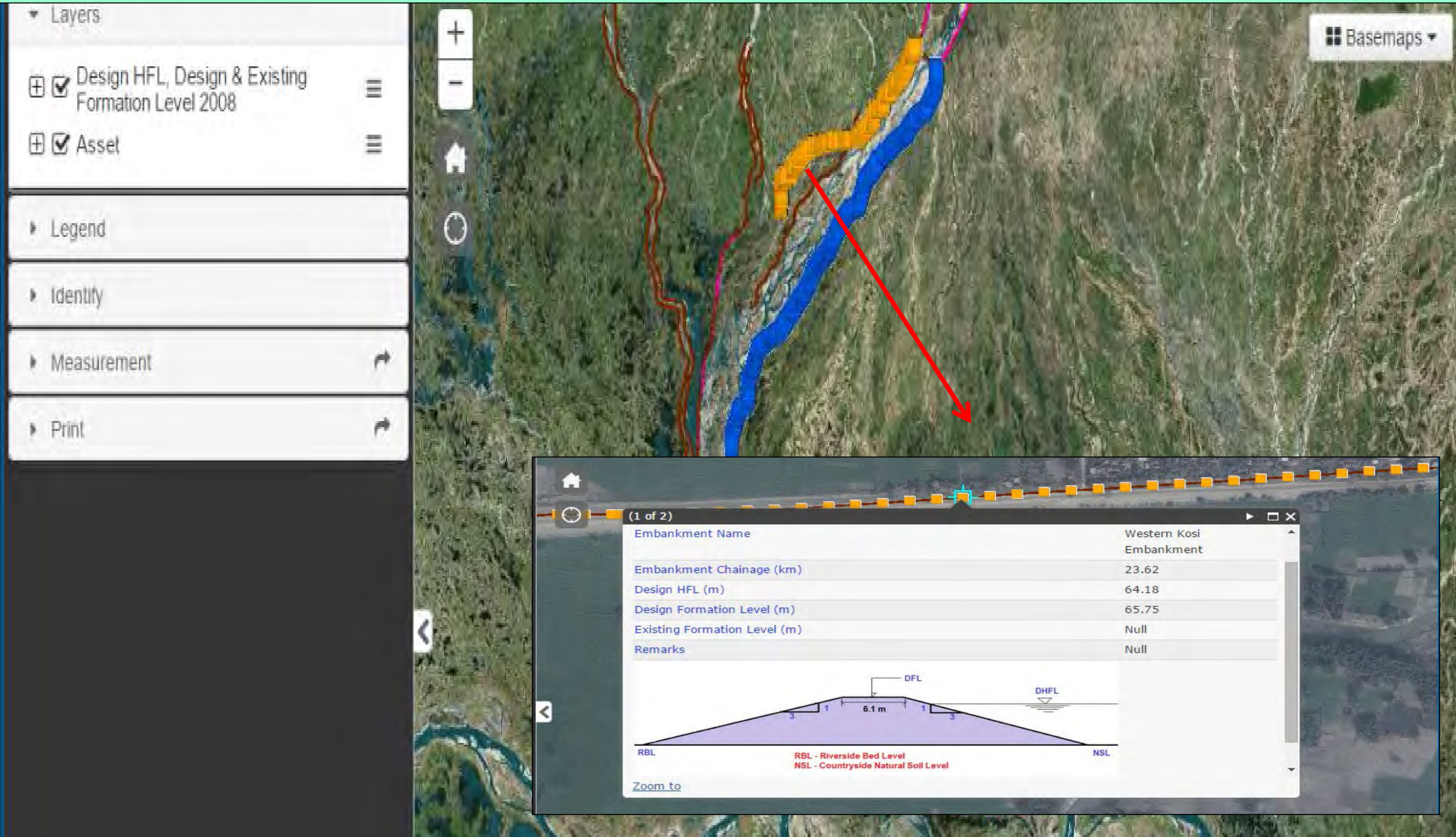

keams.co.in
DRAINAGE OUTFALL
SIPHON
BARRAGE
DEVIDE WALL
MAIN CANAL
GUIDE BUNDH
JAMINDARI BUNDH
APPROACH EARTH DAM
REVETMENT WORKS
REVETMENT WORKS UNDER SOIL
SPUR
EMBANKMENT
Base Layer
Legend
Identification
Construction Year of Sp
(Year):
Section Name:
Sub-Division Name:
Division Name:
Circle Name:
Zone Name:
Birpur Region, Birpur
Village Name:
Kamalpur
Remarks:
Null
View Typical Section (.dwg)
AutoCAD LT 2011 Spur-Km-26.dwg
Water Resources Department Govt. of Bihar.
DETAILED SURVEY OF KOSI RIVER BED 52 KM UPSTREAM OF NEPAL BORDER & 125 KM DOWNSTREAM BETWEEN EASTERN & EASTERN ENBANKMENTS.
Work Oorder No:-SE Barrage No 2403/Birpur Dated 22.10.2013
SPUR NO 26.00 KM DOWN STREAM OF KOSI BARRAGE

Engineering Information System (EIS)

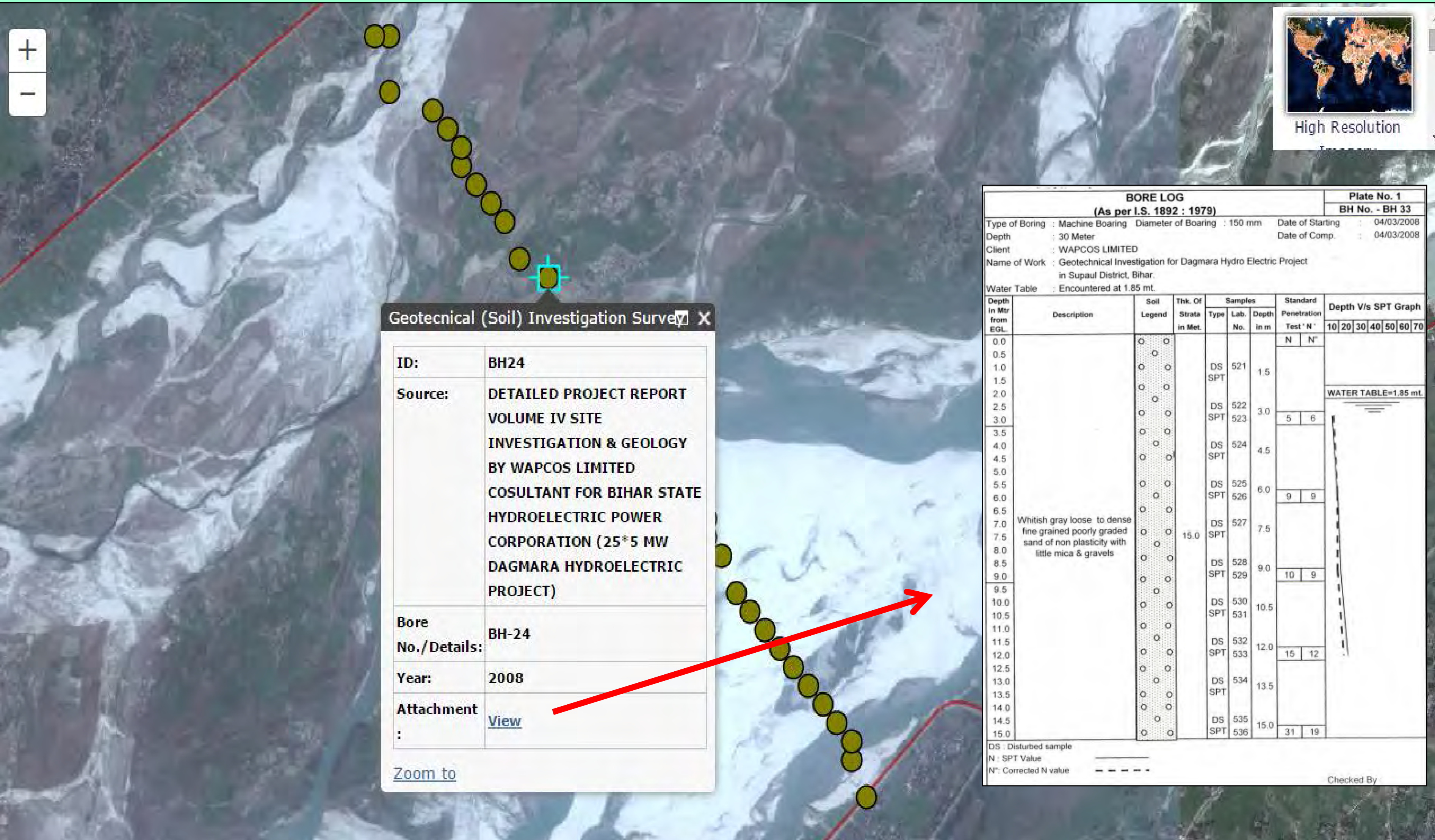
Engineering Parameters

- Design HFL & Formation Level
- Geotechnical (Soil) Investigation Survey
- Rainfall Data
- Gauge & Discharge Data
- Sediment Load
- Existing Cross Section of Embankment

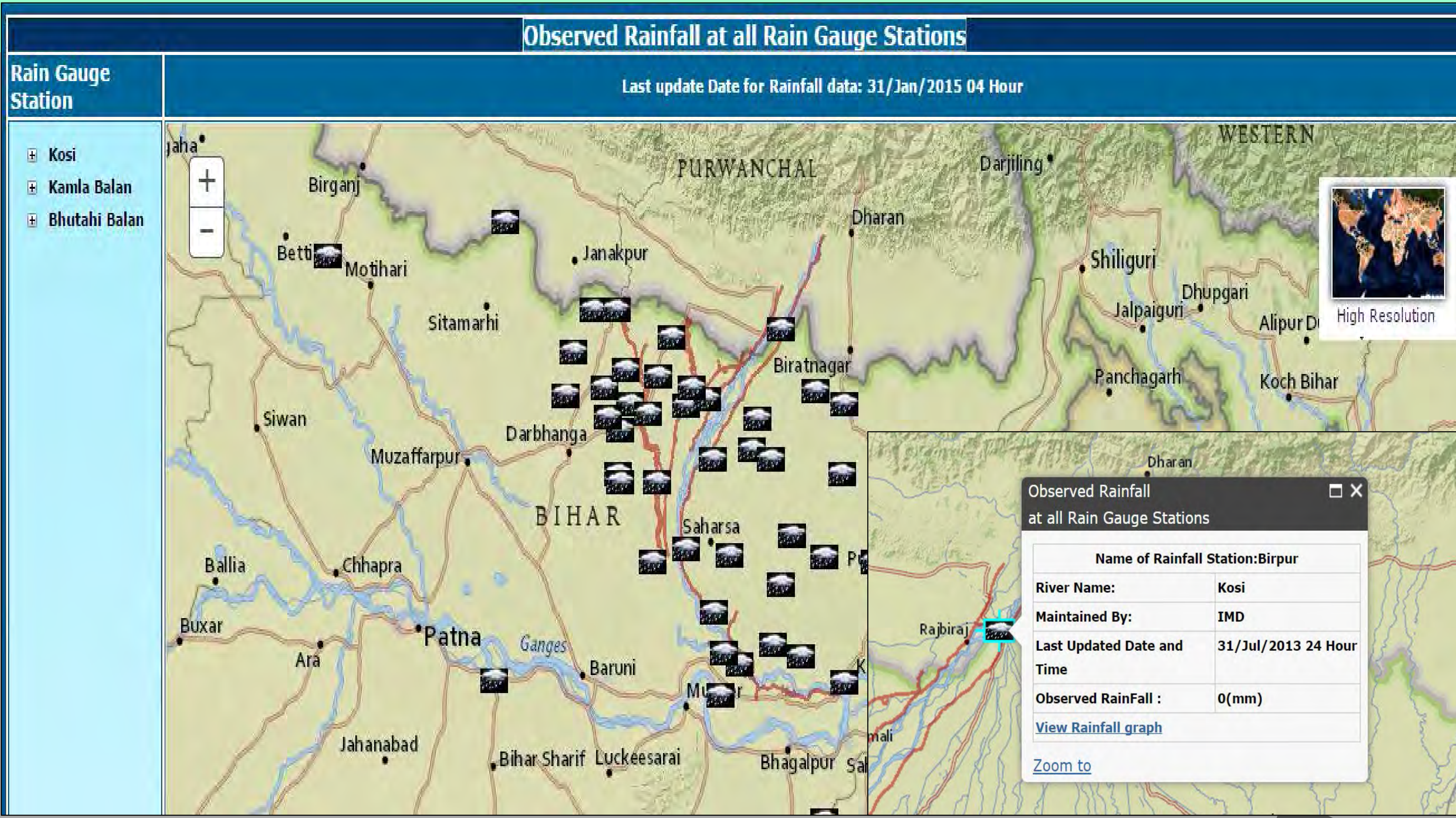
EIS -Design HFL & Formation Level- GFCC (2008)



EIS - Geotechnical (Soil) Investigation Survey



EIS - Rainfall

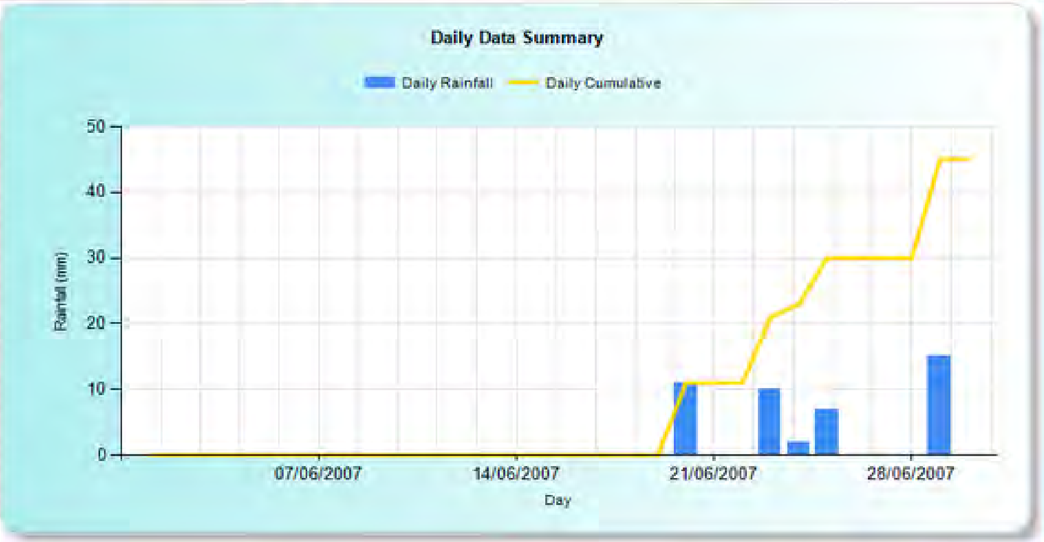


EIS - Rainfall

The current reading is 0 mm at hour 24 on date 31/Jul/2013

Select Date 12-06-2007 | Rain Gauge Station Birpur (Basantpur) | View Type Daily | View

Day	Daily Rainfall (mm)	Daily Cumulative (mm)
01/06/2007	0	0
02/06/2007	0	0
03/06/2007	0	0
04/06/2007	0	0
05/06/2007	0	0
06/06/2007	0	0
07/06/2007	0	0
08/06/2007	0	0
09/06/2007	0	0
10/06/2007	0	0
11/06/2007	0	0
12/06/2007	0	0
13/06/2007	0	0
14/06/2007	0	0
15/06/2007	0	0
16/06/2007	0	0
17/06/2007	0	0
18/06/2007	0	0
19/06/2007	0	0
20/06/2007	11	11
21/06/2007	0	11
22/06/2007	0	11
23/06/2007	10	21
24/06/2007	2	23
25/06/2007	7	30
26/06/2007	0	30
27/06/2007	0	30
28/06/2007	0	30
29/06/2007	15	45
30/06/2007	0	45



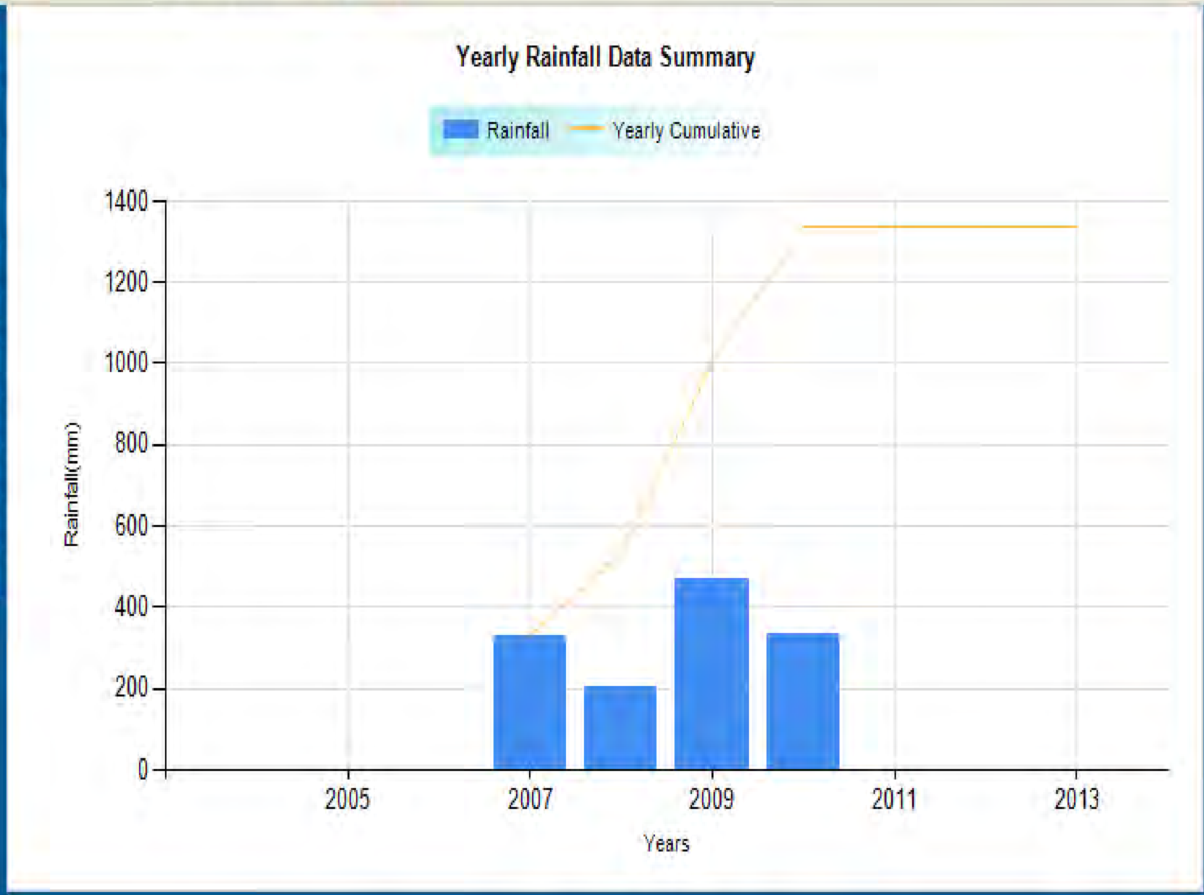
EIS - Rainfall

The current reading is 0 mm at hour 24 on date 31/Jul/2013

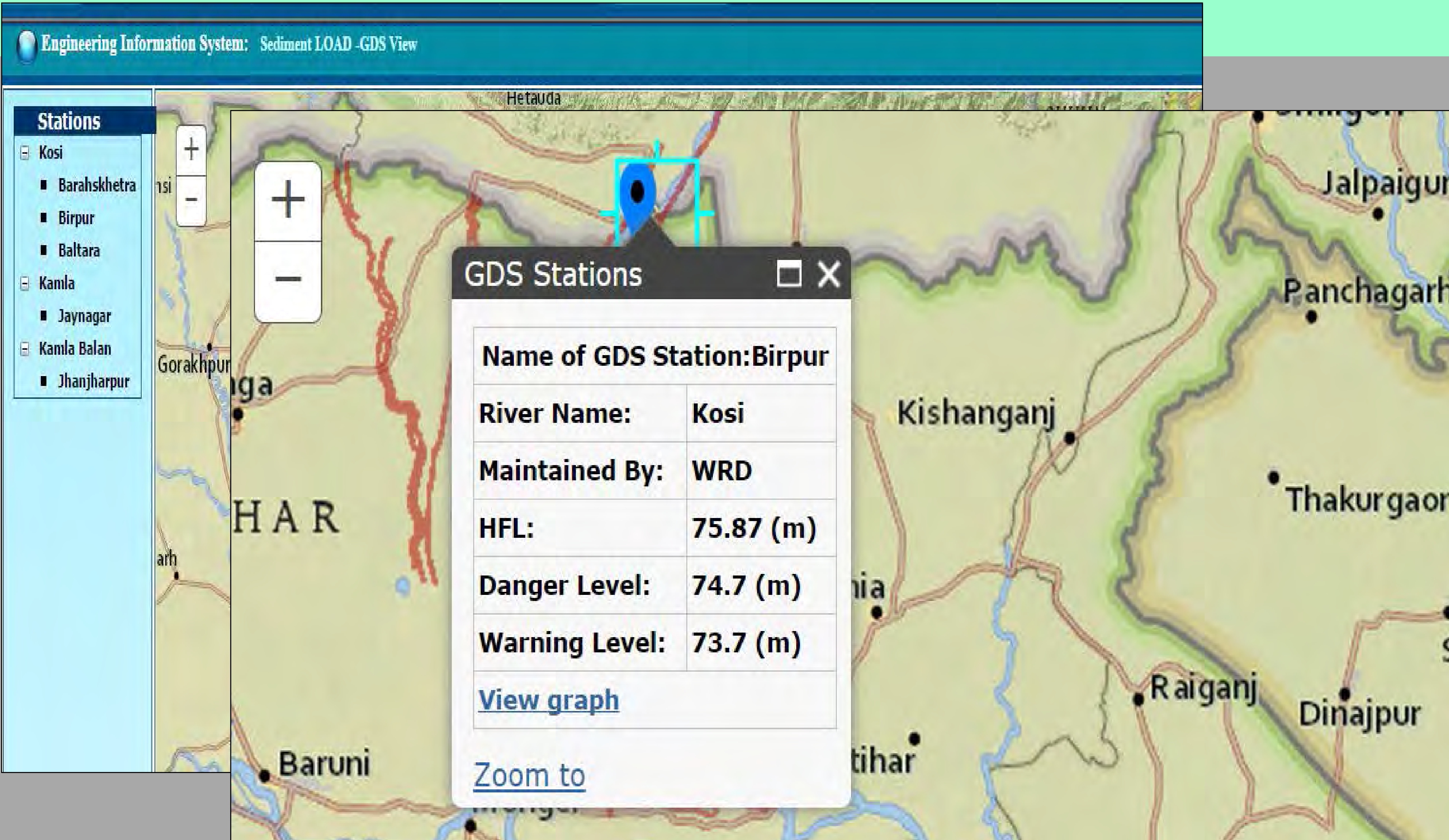
Select Date 31-07-2013 | Rain Gauge Station Birpur (Basantpur) | View Type Yearly | View

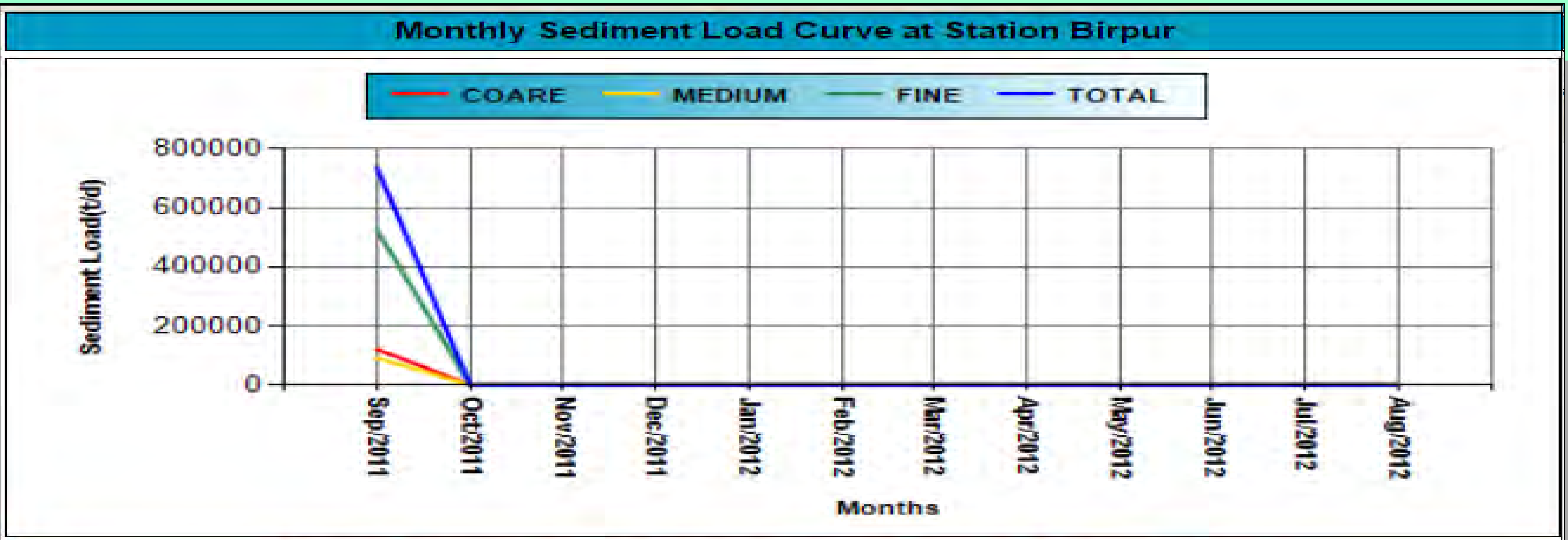
1 of 1 | Find | Next

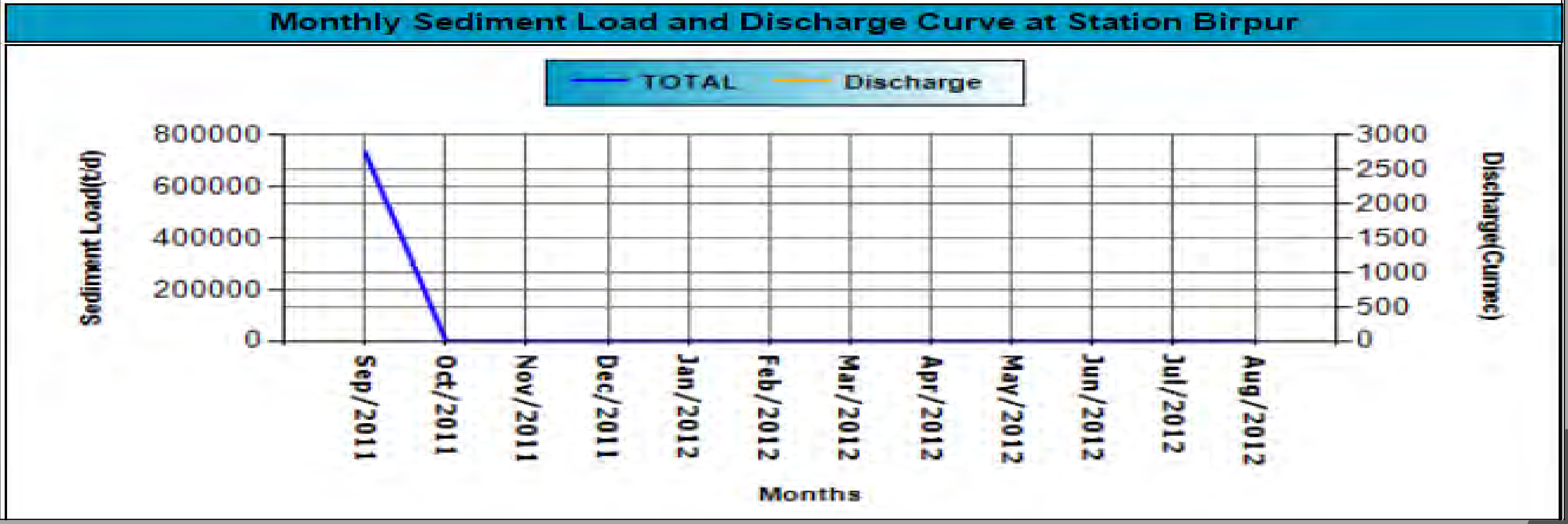
Years	Rainfall(mm)	Yearly Cummulative
2004		
2005		
2006		
2007	330	330
2008	205	535
2009	469	1004
2010	333	1337
2011		1337
2012		1337
2013		1337



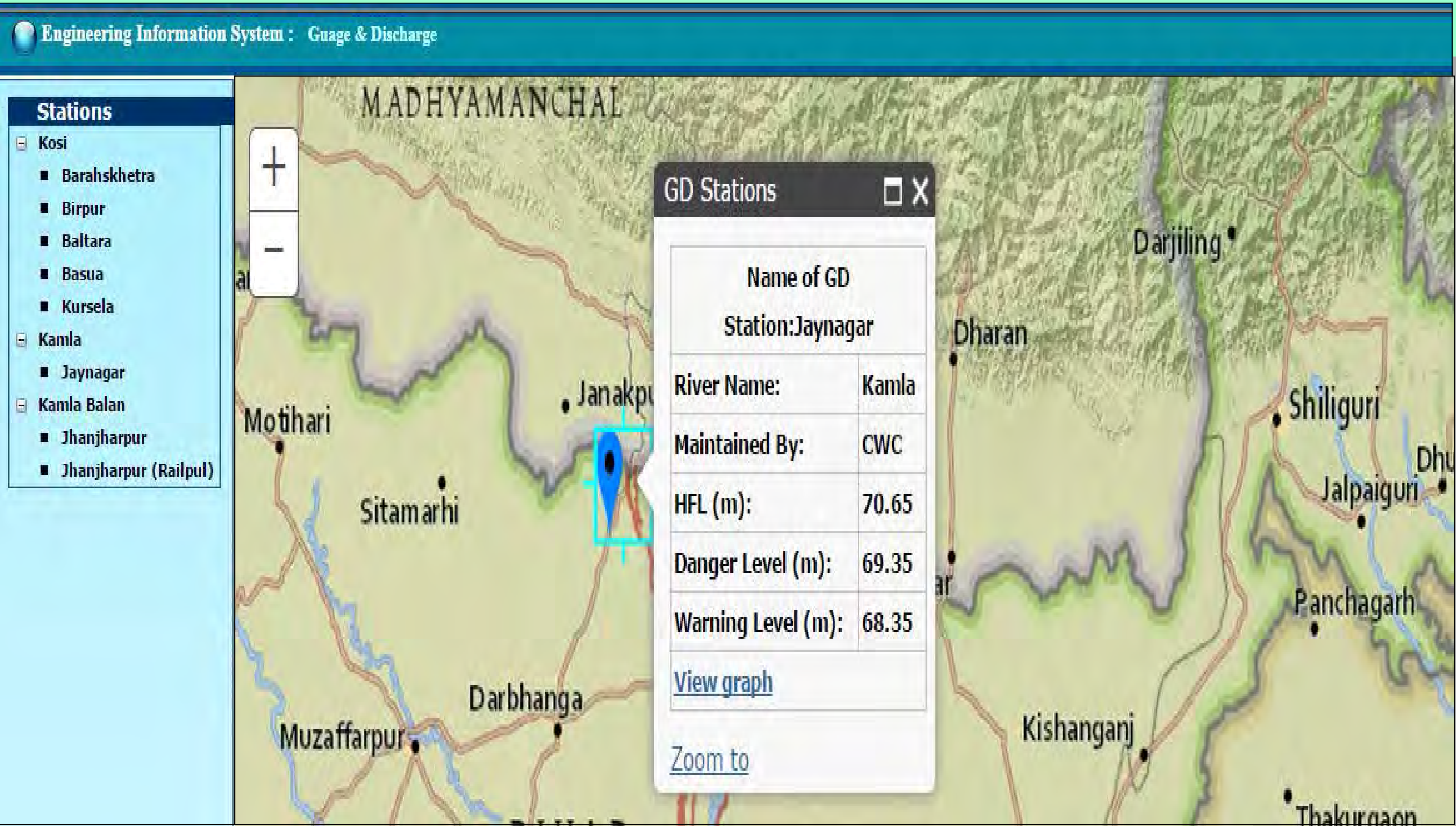
EIS - Sediment Load



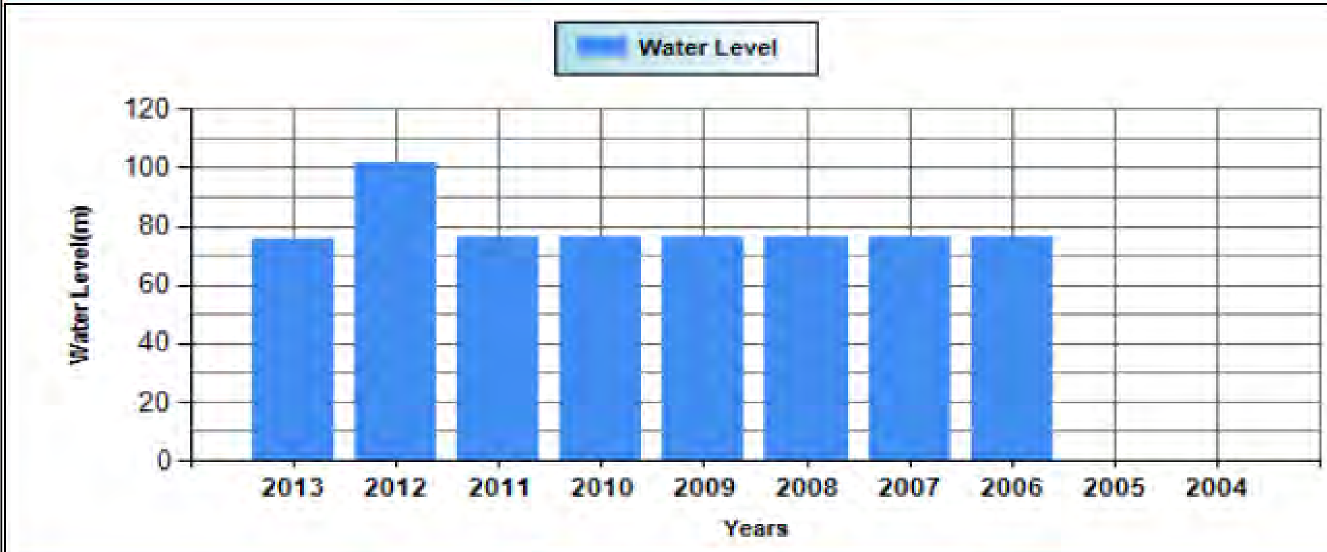

Monthly Sediment Load Curve at Station Birpur
COARE
MEDIUM
FINE
TOTAL
800000
600000
400000
200000
0
Sediment Load(t/d)
Sep/2011
Oct/2011
Nov/2011
Dec/2011
Jan/2012
Feb/2012
Mar/2012
Apr/2012
May/2012
Jun/2012
Jul/2012
Aug/2012
Months


Monthly Sediment Load and Discharge Curve at Station Birpur
TOTAL
Discharge
800000
600000
400000
200000
0
Sediment Load(t/d)
3000
2500
2000
1500
1000
500
0
Discharge(Cumec)
Sep/2011
Oct/2011
Nov/2011
Dec/2011
Jan/2012
Feb/2012
Mar/2012
Apr/2012
May/2012
Jun/2012
Jul/2012
Aug/2012
Months

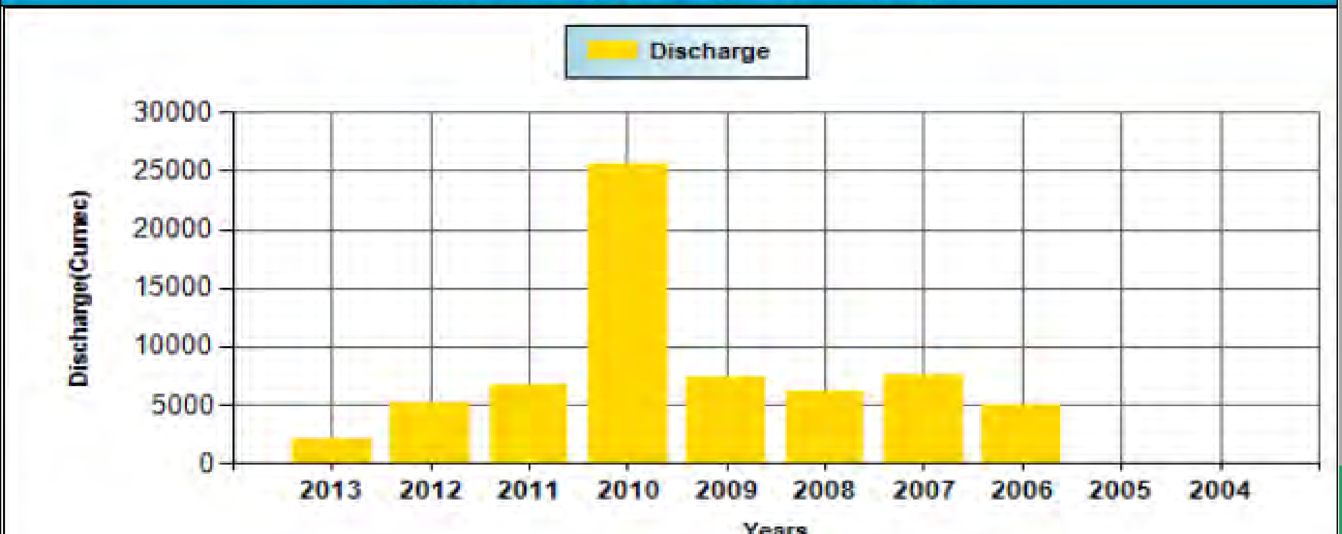
EIS - Gauge and Discharge



Status of Yearly Water Level at Station Birpur



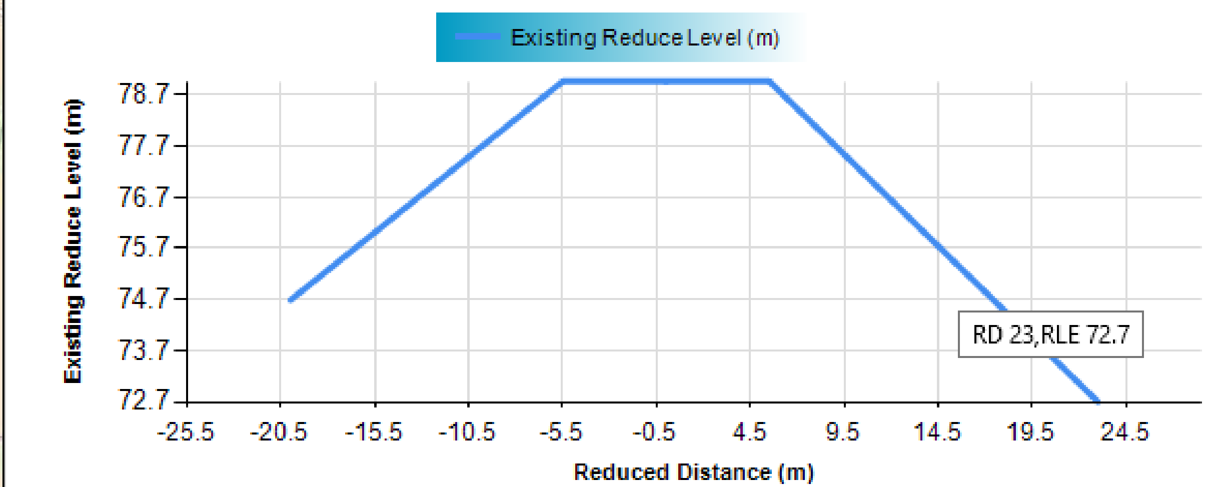
Status of Yearly Discharge at Station Birpur



EIS - Existing Cross Section of Embankment (2013)

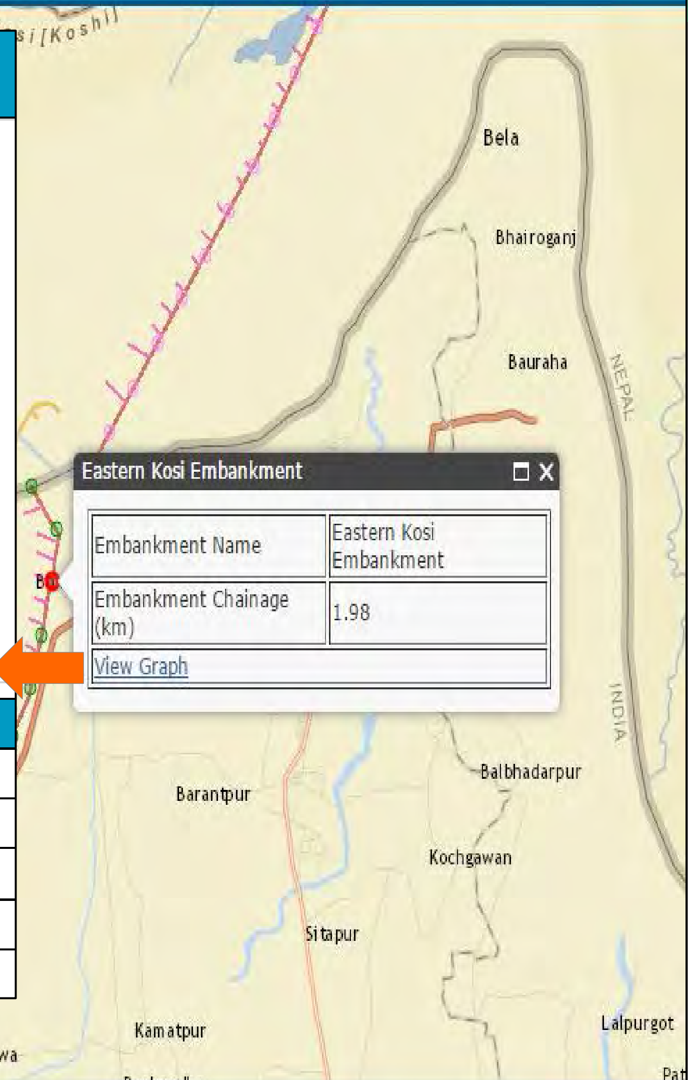
Engineering Information System: Existing Cross Section of Embankment(2013)

Existing Cross Section of Embankment (Eastern Kosi Embankment) at chainage .99 km Year-2013

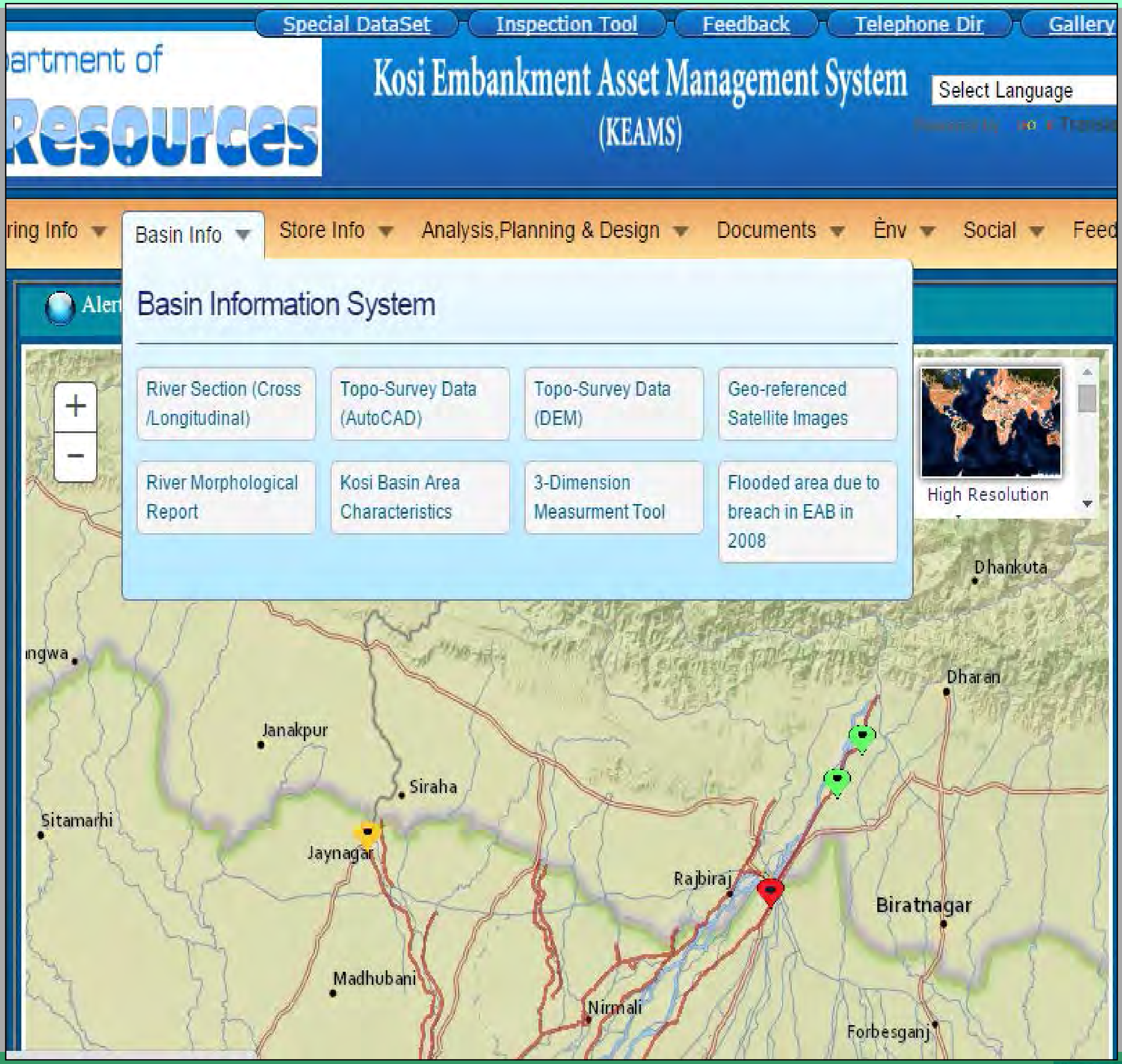


(Note:Negative values display Country Side and Postive Value display River Side)

Reduce Distance (m)	Existing Reduce Level (m)
-20	74.69
-5.50	78.97
0	78.97
5.50	78.97
23	72.70



Basin Information System (BIS)

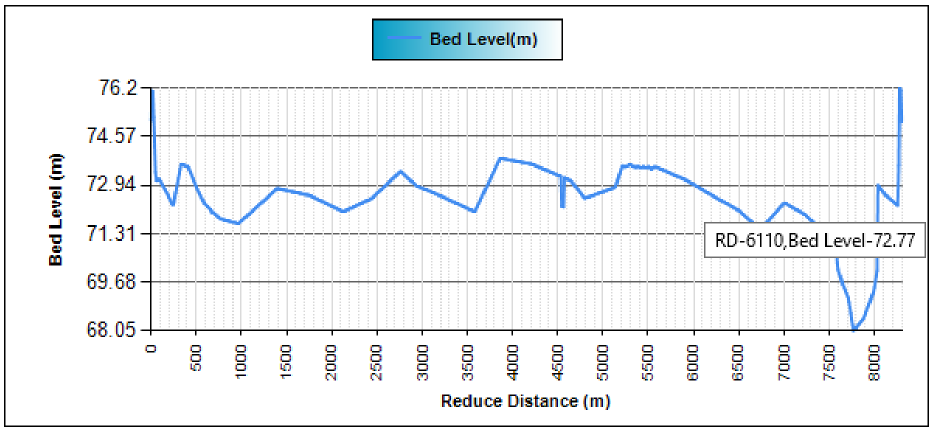


BIS - River Sections (Cross/Longitudinal)

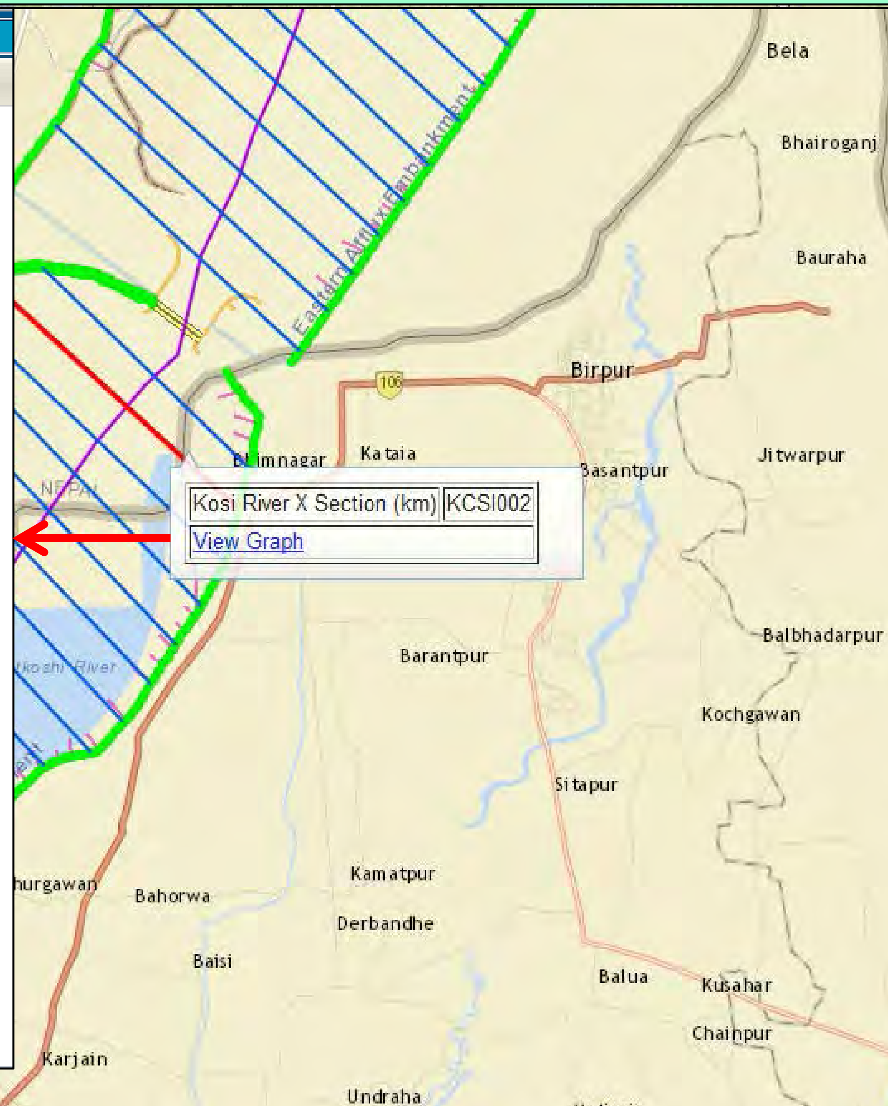
River Cross Section at 2 KM

1 of 1 Find | Next

River Cross Section 2 KM Downstream of Barrage (RD 0 Denotes Western Embankment - RD 8300 Denotes Eastern Embankment) Year - 2013



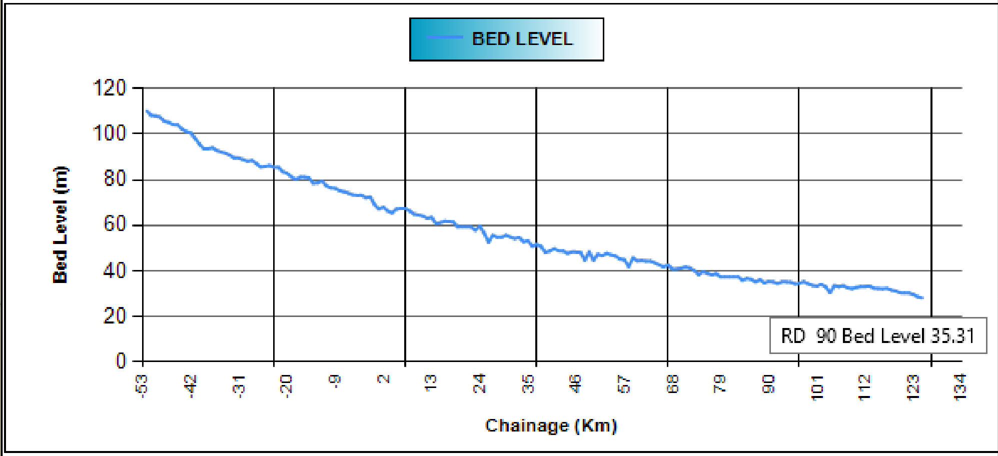
Reduce Distance (m)	Bed Level (m)
0	75.10
10	76.11
20	76.09
30	75.22
40	74.26
50	73.38
60	73.10
70	73.12
80	73.14
90	73.14
100	73.08



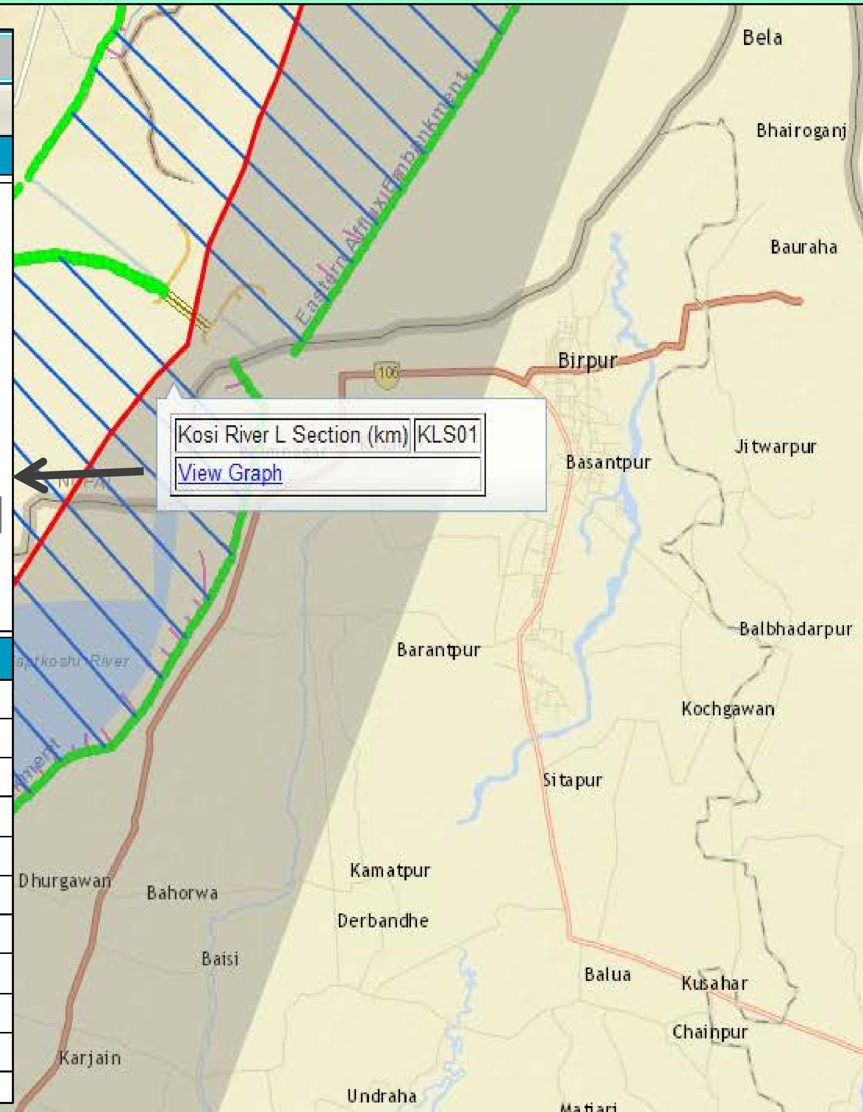
River Kosi View

1 of 1 Find | Next

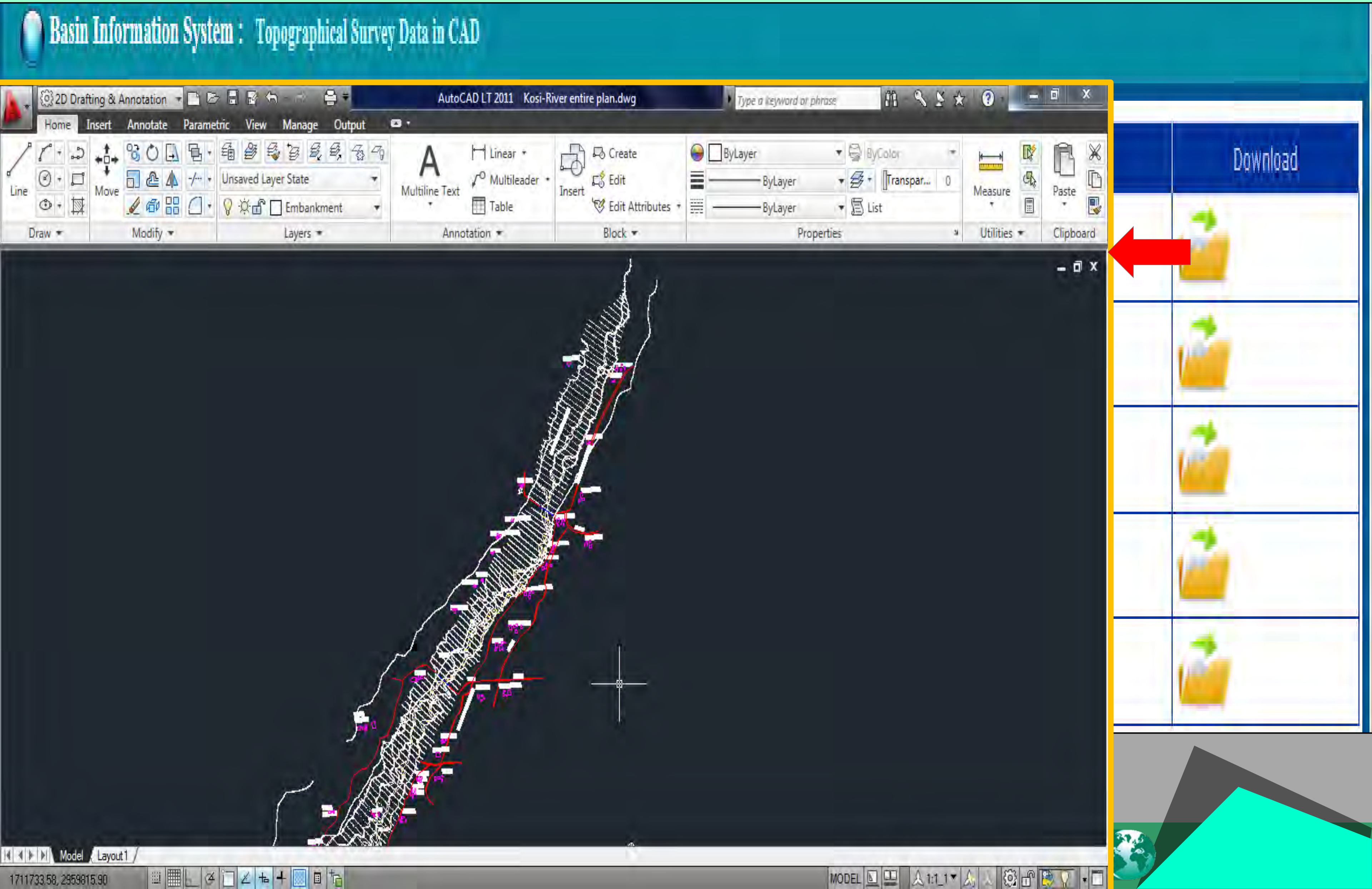
L section of Kosi River



Chainage(Km)	Bed Level (m)
-52	110.29
-51	108.29
-50	108.10
-49	107.51
-48	105.74
-47	105.27
-46	104.27
-45	104.23
-44	102.28
-43	101.18
-42	100.65



BIS - Topo Survey Data (Auto CAD)

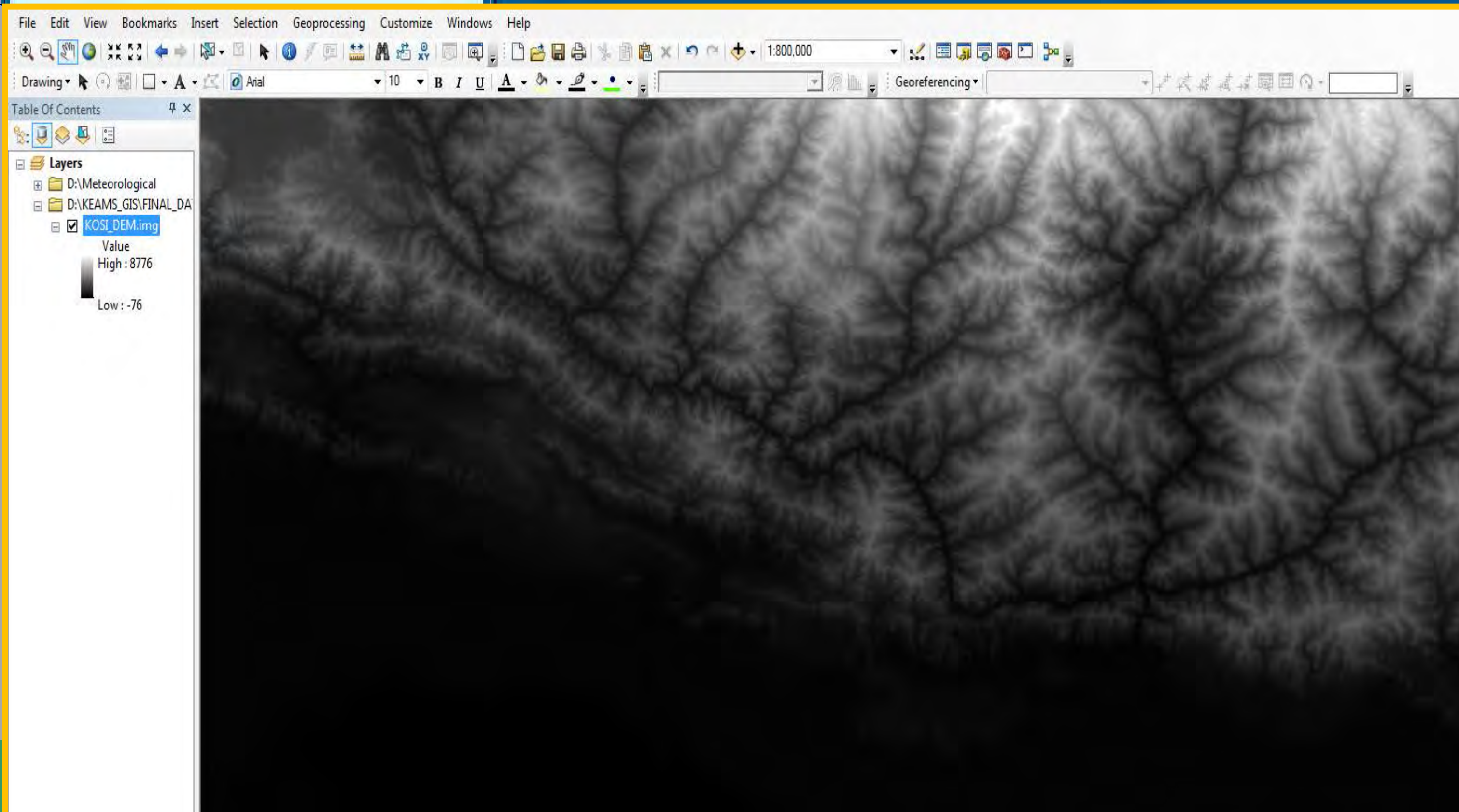


BIS -Topo Survey Data (DEM)

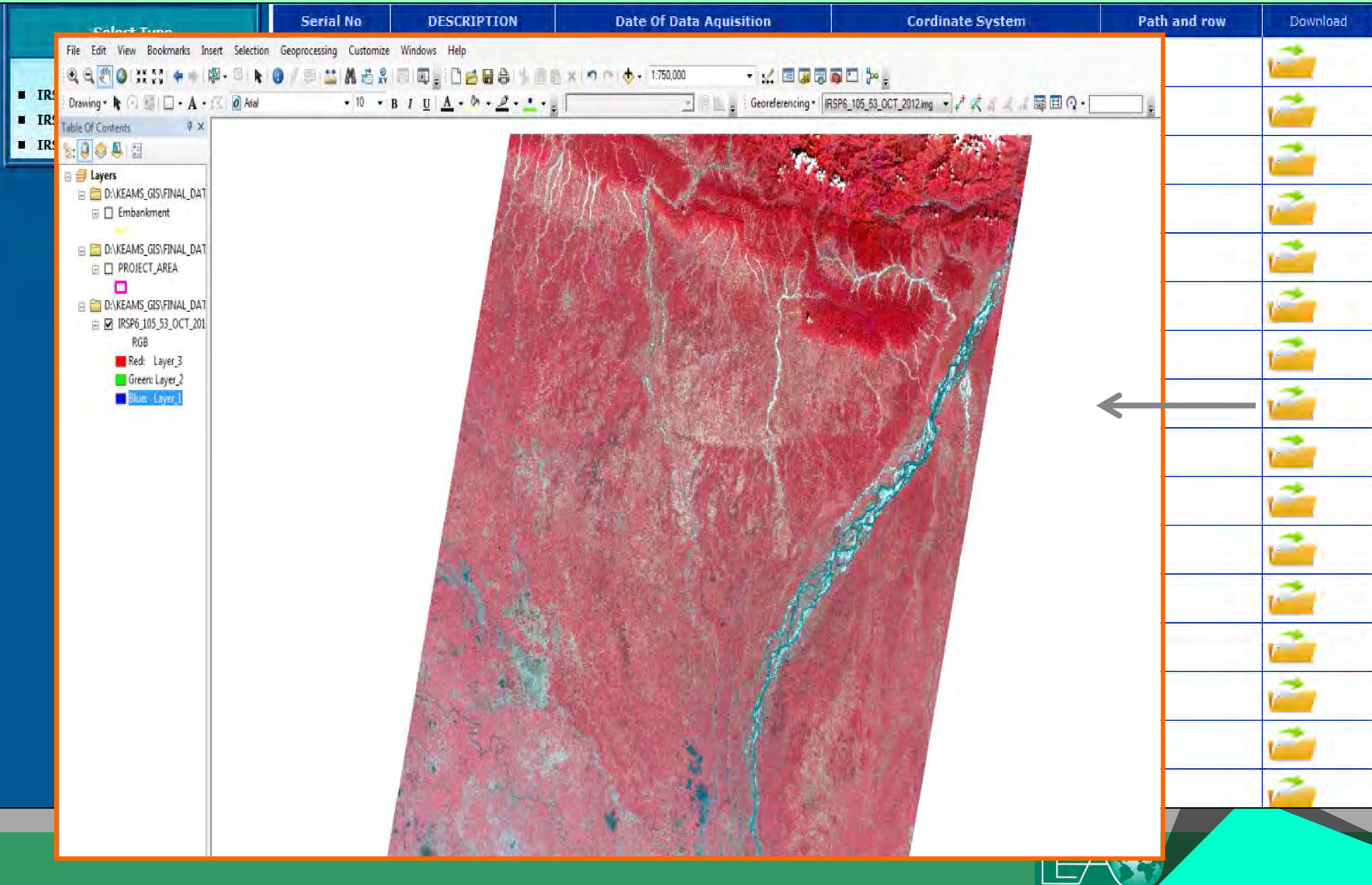
Select Type

- ASTER
- SRTM

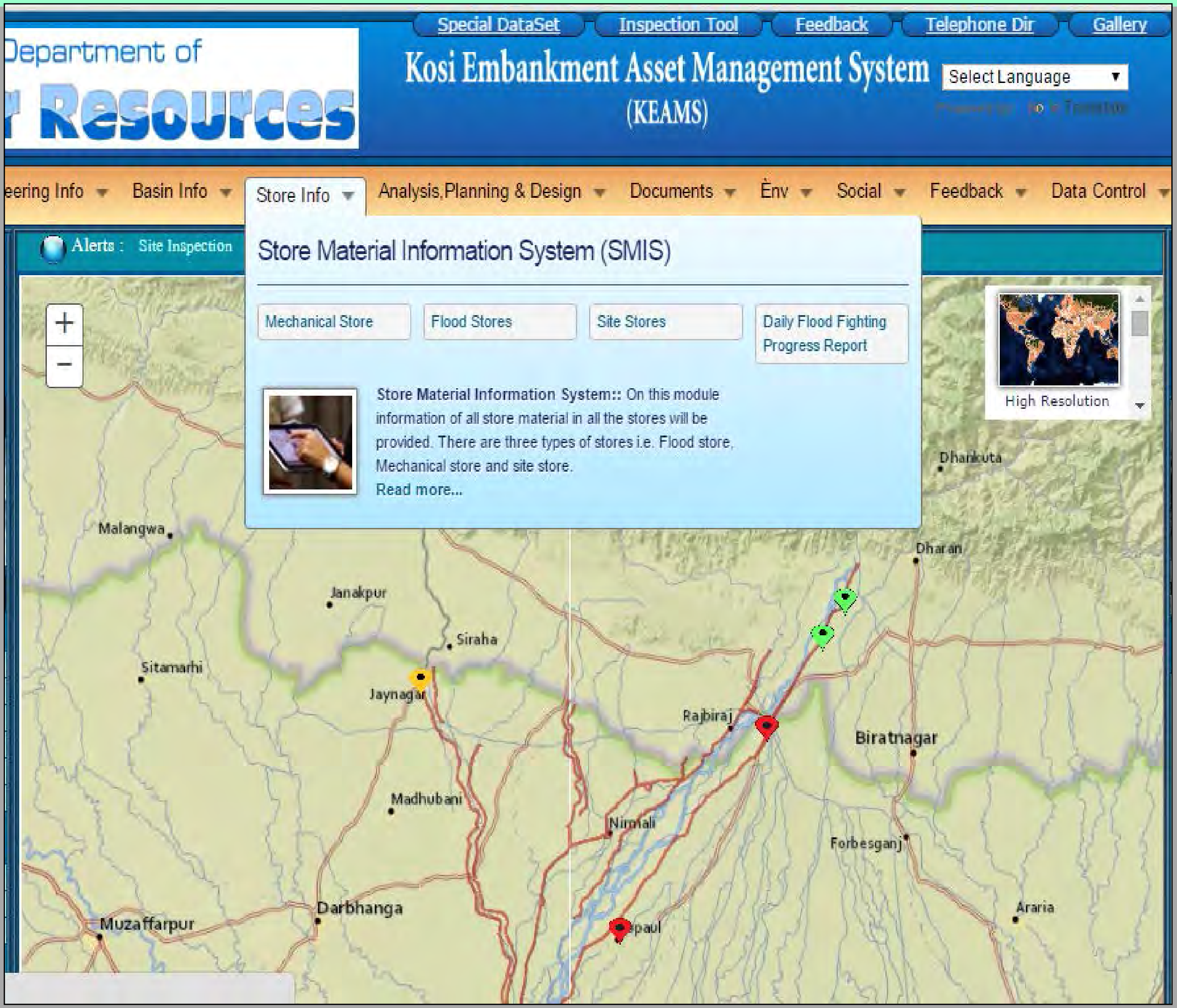
Serial	DECRIPTION	Date Of Data Aquisition	Download
1	Topographical Survey data Kosi Besin Test	2015	Downloads/BIS/BIS0000051.jpg
2	KOSI DEM	201110	Downloads/BIS/KOSI_DEM.img



BIS - Geo-referenced Satellite Images



Store Information System (SIS)



SIS - Mechanical Store

Store Information :Mechanical Store Report Screen

Filter By Store: All

Filter By Item: All

Show

Store Information :Mechanical Store Report Screen

Filter By Store: Mechanical Store,Birpur

Filter By Item: Crane(No's)

Show

S.No	Location	Item	Unit	Available Quantity	View History
1	Bhimnagar	Crane	No's	4	View History

SIS - Flood Store

S.No	Location	Item	Unit	Quantity	Updation by	Updation Date
1	Nehru Park,Kosi Barrage	Boulder	No's	20865.1570	Priya	15-01-2015 10:44:19
2	Nehru Park,Kosi Barrage	Boulder	No's	20865.1570	Priya	15-01-2015 10:50:57
3	Nehru Park,Kosi Barrage	Boulder	No's	20865.1570	Priya	05-02-2015 19:36:43
4	Nehru Park,Kosi Barrage	Boulder	No's	20865.1570	Priya	05-02-2015 19:36:54
5	Nehru Park,Kosi Barrage	Boulder	No's	20865.1570	Priya	06-02-2015 10:17:39
6	Nehru Park,Kosi Barrage	Boulder	No's	20865.1570	Priya	07-02-2015 13:25:19
7	Nehru Park,Kosi Barrage	Boulder	No's	20865.1570	Priya	07-02-2015 14:33:36
8	Nehru Park,Kosi Barrage	Boulder	No's	20865.1570	Priya	13-01-2015 18:24:11
9	Nehru Park,Kosi Barrage	Boulder	No's	20865.1570	Priya	13-01-2015 18:27:38
10	Nehru Park,Kosi Barrage	Boulder	No's	20865.1570	Priya	15-01-2015 15:52:02
11	Nehru Park,Kosi Barrage	Boulder	No's	20865.1570	Priya	29-01-2015 15:20:38

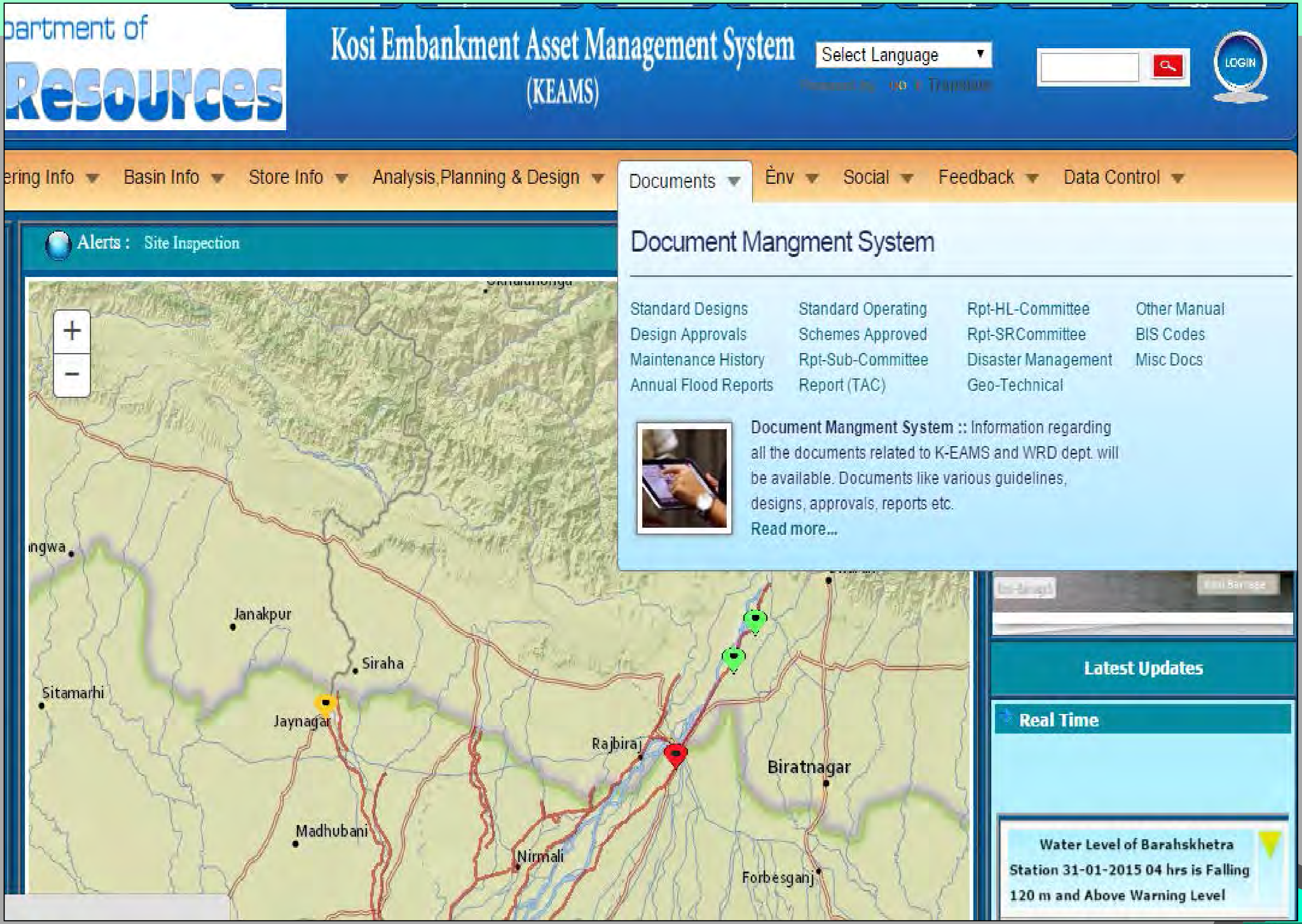
Filter By Store: Nehru Park,Kosi Barrage

Filter By Item: Boulder(No's)

Show

S.No	Location	Item	Unit	Available Quantity	View History
1	Nehru Park,Kosi Barrage	Boulder	No's	20865	View History

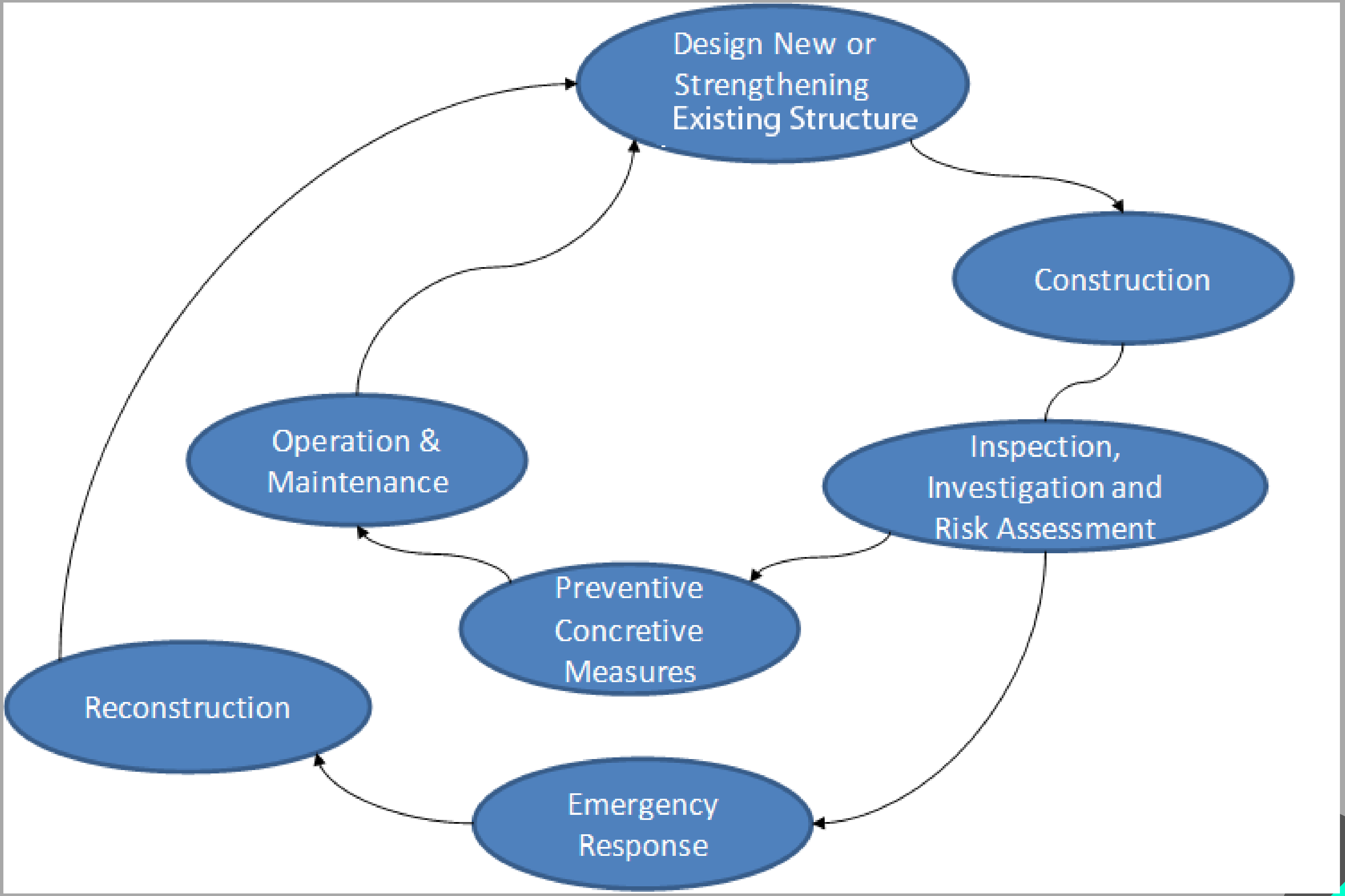
Document Management System (DMS)



Document Management System

Guidelines from other sister Organistation
Central Water Commission
Publications of Central Water Commission
BIS Codes
Revertment :
Embankments:
Spur:
NDMA
Guidlines on Flood:
Flood Hazard Atlas for Bihar State:
MOWR
Flood Control and River Managment Works:
FMP During XI Plan:
FMP During XI Plan:- Revised
FMP During XII Plan:
FMP During XII Plan:- Revised:
GFCC Guidelines on Flood Management
GFCC - Handbook on Anti Erosion works
Ganga wing- Flood Management Programme during XI plan
Status of Guidlines under GFCCC
Providing Cenrtal Assistance to State Goverment
Flood Management Programme during XI ...
Report of working group on Flood mangment & Region specific issues
MOWR Website Ownership Site Map
Detailed guidelines for convergence between NREGA and MoWR
Document
Document Information

Use of K-EAMS in Asset Management



Component	Module in K-EAMS
Designing New or Strengthening Existing Structure	Design Tool
Construction	SOP (Status of Approval) SOP (Tender Monitoring)
Inspection and Investigation	Tablet Based Asset Monitoring • During Non Monsoon Period (routine measures) • During Monsoon Period (Emergency Measures) Web Portal for Community Feedback
Risk Assessment	• Swapping Tool (for Annual River Migration Analysis) • Buffering Tool (for New Bank Protection Works / New Flood Effected Area)
Preventive or Corrective Measures / Emergency Response	Tablet Based Asset Monitoring Tool
O & M / Reconstruction	Progress of Work with Photo in Asset Monitoring Tool

Designing New or Strengthening Existing Structure – Design Tools

1. Help Tool for Scheme Design (Templates)

Raising & Strengthening or Construction of New Embankment

Download Templete

Anti-Erosion Works

Revetment	Download Templete
Spur	Download Templete
Bed Bars	Download Templete
Studs	Download Templete
Porcupine	Download Templete
Submerged Vanes	Download Templete
Protection by vegetation	Download Templete
Drainage Channels	Download Templete

2. Help Tool for Preparation of Report for SCHEMES

Download Templete

Scheme Preparation Guidelines

1. Design Guidelines for Flood Protection Works (By Mr. K.N Lal)

A PRACTICAL APPROACH TO DESIGN OF ANTI-EROSION WORKS IN RIVERS OF BIHAR.

0. FOREWORD

0.1 Rivers in North Bihar, are generally shallow and flow in a wide alluvial belt with meandering and/ or braiding characteristics. Such rivers cause erosion & scour due to steep gradient in upper reaches and excessive silt load. The section of the braided channels changes after every flood i.e. four to five times in single flood season. When the side channel becomes active, the safety of the embankment is threatened due to bank erosion. Hence, anti-erosion works are provided to check erosion of the banks protecting there the embankments, villages and fertile land. A carefully designed and planned anti-erosion work should aim at inducing siltation near the bank and in side channels, and guiding the main course of flow to the central channel.

0.2 The magnitude of anti-erosion works has increased manifold in last one decade. A huge amount is spent annually on these works. As such, it has become all the more necessary to exercise due caution in the selection, design and planning of anti-erosion works so as to effect proper economy without compromising on safety aspects.

0.3 In Bihar, various methods have been adopted for checking erosion as per requirements of the site condition. The most common practice is provision of spur and/or revetment. The Indian Standard Institution has laid down some criteria for design of impermeable spurs. Other methods of anti-erosion works have not been described in the I.S.I. code.

0.4 In this paper an effort has been made towards a practical approach to design of various types of anti-erosion works generally adopted in the rivers of Bihar. Instead of going into descriptive details, stress has been laid on the practical, aspects, so that the field Engineers may work out the design details and prepare the drawings in a short period.

0.5 It would be hazardous to generalize the remedial measures to problems in respect of river training works. Each case needs specific treatment as per site conditions. As such the

Planning of New Flood Protection Work

Analysis,Planning & Design Tool: Planninmg of new Flood Protection works

INTRODUCTION

Flood protection schemes are to be prepared based on the recommendations of the Anti-Erosion Committees and put up before State TAC for their consideration. Chief Engineer of the concerned sector will prepare a damage assessment report by compiling all damage data after thorough investigation and survey. This damage report should contain damage to various assets of Water Resource Department

IDENTIFICATION OF NEW FLOOD SCHEMES

Scheme identification should be very selective and well considered, supported by adequate investigation. For identification of proposed flood protection works, following points may be kept into consideration: The zone exactly affected by erosion. Morphological conditions of river flow in the reach b/w 5 km upstream and downstream of affected reaches. Bank lines for previous 5 years for assessing erosion trends and causes. River regime plan showing both bank based on latest satellite imageries. Losses incurred in the past due to the erosion at the site. Assessment of long term and short term effects of the proposed anti-erosion work on upstream, downstream and opposite bank. The location and effects of flood management works already executed in the vicinity, whether existing or damaged. Bank to bank river cross sections. The initial response in tackling the erosion should be towards channelizing the river in central. Impermeable spur or bed bar should never be constructed in isolation. Use sheet piles instead of launching apron of boulders for toe protection especially in critical erosion sites. Construction of bed bars should preferably be of submerged. Use of Geo textile bags filled with sand has emerged and should be adopted as substitute for boulders. For raising & strengthening of embankment schemes, justify by giving details of observed incidences of over topping or undesirable encroachment. Soil characterization of the river stability of the river banks is essential to successful bank erosion protection and construction of good quality stable embankments. Availability of bed material data and suspended silt very important for realistic planning of flood/erosion protection works. Drainage sluices are recommended to be made an integral part of embankments to prevent water-logging in the protected areas. Any new work in the vicinity of any on-going flood management should be prepared only after full implementation of the ongoing work. Stress has to be laid on improving the existing natural drainage system in the flood plains. The adequacy of existing sluices and drainage channels should be reviewed in areas suffering from drainage congestion.

Analysis and Planning of New Works

1. Along the Rivers:

Protection of River Banks for various measures Construction of New Embankment if the river is spilling over the bank causing damage to the important installations

2. Along the Existing Embankments:

Provision of protection works along the existing embankments which may be required in the following conditions:

Problem Encountered	Suggestion for Planning of New Works
Spilling of the river water in the country side & effecting the villages and important installations	Plan for new Embankment to check spill of water
*To control the erosion of meandering bank of the river *To check the erosion of the bank / embankment where erosion is severe and space is available *To repel the current away from the bank / to attract the current towards the bank of the river for distillation of the river	Construct spurs
Where there is sloughing of river bank / embankment Or there is scouring of the river bed	Bed bars should be provided for inducing siltation near the river bank
When river is flowing very near to the embankment / river bank, and no space is available for the construction of spurs	Revetment should be proposed where river is flowing very near to the river bank / embankment.
When erosion of the bank / embankment is taking place in a big length and it is not very much serious. Availability of the stone for the construction of spur / revetment is not feasible to construct	Plan for porcupine to check the erosion

Construction – SOP (Status of Approval)

Select Year 2014

Select River Bhutahi Balan

Show

Monitoring of SOP during Non Flood Period (To Know the SOP during Non Flood Period) **Click Here**

Technical Approval

Event No.	Event Description	Proposed Date as per SOP		Actual Date	Download Report
		From	To		
TA01	Submission of Inspection Report by each Executive Engineer concerning to flood damages / flood effected / eroded during previous flood season including the inspection of vulnerable reaches	15-Sep	20-Sep	21-Jan-2015	
TA02	Submission of Joint Inspection Report by Civil and Mechanical Executive Engineer for hydro-mechanical structures made on embankment	17-Sep	20-Sep	06-Jan-2015	
TA03	Submission of Inspection Report (for flood protection schemes other than Kosi River) by Anti-erosion Committee (AEC) represented by concerned C.E, Chairman Flood Fighitng Force, Concerned SE.	21-Sep	23-Sep		
TA04	Inspection by Sub-Committee of Kosi - High level committee and submission of report (To know the Constitutin and Function of the sub-committee)	27-Sep	30-Sep		
TA05	Submission of the recommendation report of the schemes by Kosi-high-level committee (KHLC) based on the recommendation of the sub-committee of KHLC after site inspection. (To know the constitution and function of KHLC)	18-Oct	21-Oct		
TA06	Submission of the schemes to the state Technical Advisory Committee (TAC).	01-Oct			

Construction – SOP (Tender Monitoring)

Status of Tenders View Screen

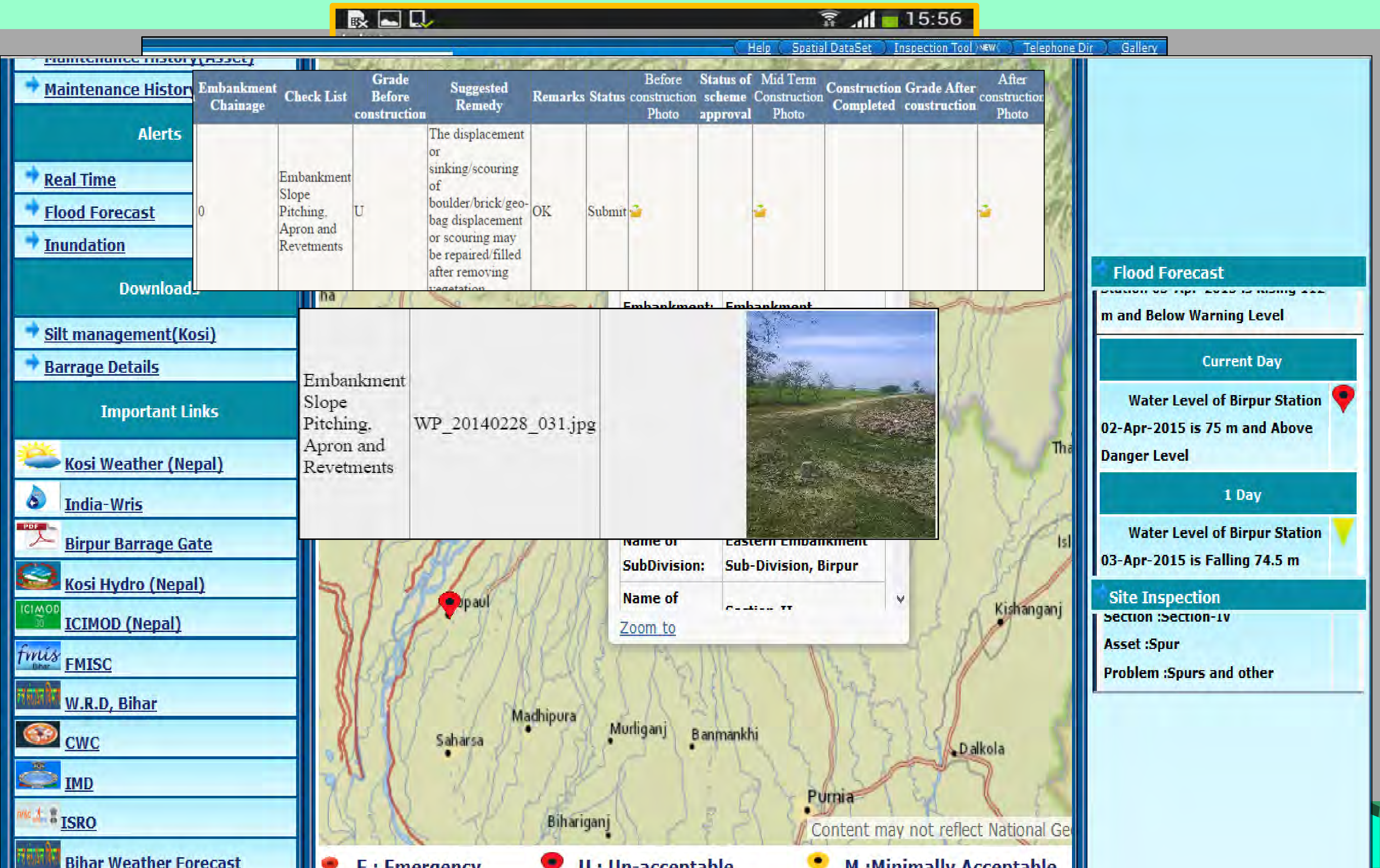
* Year of Tendering : 2015

* Division : EE, Bhagalpur

Show

				Amount(in Rs)						At Start of Work		At Completion of Work	
Agenda No.	Name of Work	Item Name	Division	Estimated	Approved by Administration	Status of Invitation of Tender	Status of Receipt of Tender	Status of Execution of Tender	Status of Work Allocation	Status of Work Start	View Photo	Status of Work Complete	View Photo
111	EMBANKMENT REPAIRING	SAND	EE, Bhagalpur	778868	688899	Behind Schedule View	Behind Schedule View	On Schedule View	On Schedule View	On Schedule View		On Schedule View	
2	Construction of H.L R.C.C Bridge (3x 18.00 m) across Parman River in place of Unabridge gap at 12th km of Nasir Chawk–Belwa–Manjhgama-Mongra Road	Construction of H.L R.C.C Bridge	EE, Bhagalpur	1200000	1200000	Behind Schedule View	Behind Schedule View	On Schedule View	Status - not updated View	Status - not updated View		Status - not updated View	

Inspection & Investigation – Tablet Based Asset Monitoring System



Inspection & Investigation – Web Portal for Community Feedback

Reference ID: GUS/24

Date of Defect Observed: 05/06/2015

Category of Defect Observed: Earthwork Compaction

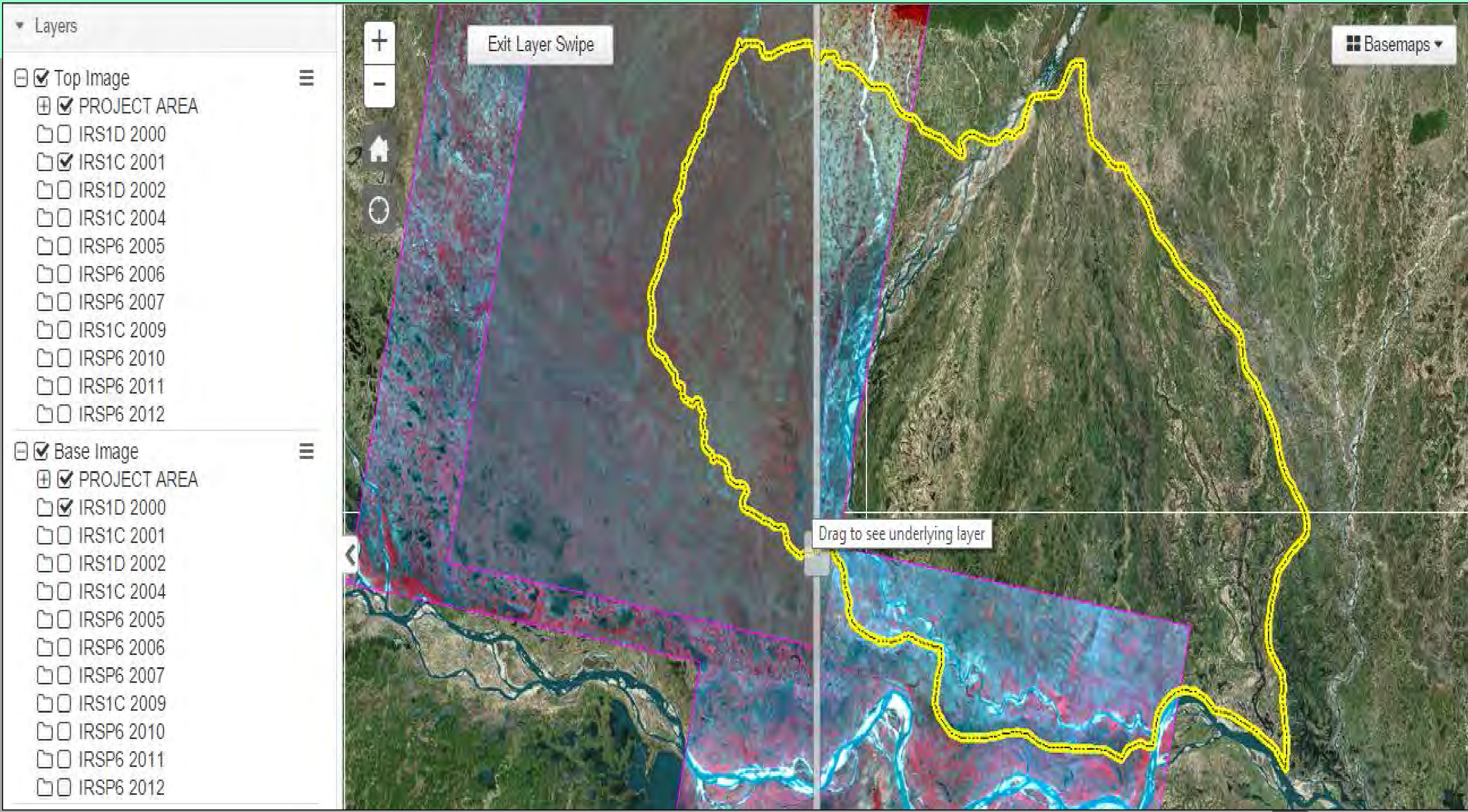
Village: Aadharpur

Type: Guest

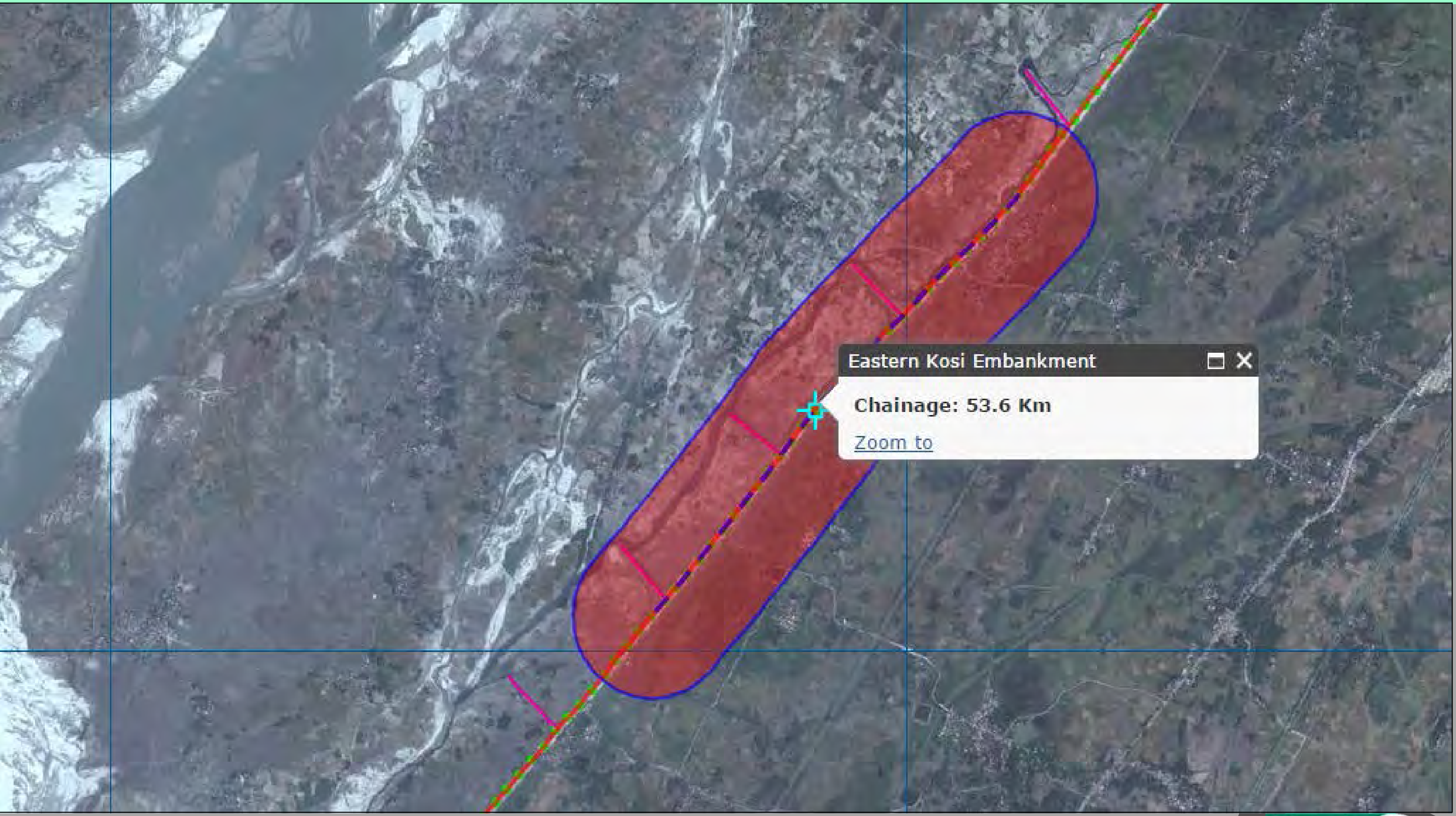
Show

Reference ID	Date of Defect Observed	Category of Defect	Detail of Defect (if any)	Name of the Asset Related to Defect	Description	Location (km stone or any landmark)	Nearest Village	View Photo	Detail of User Reported	Remark of Officer Concerned (whether information correct / incorrect)	Grade	Remarks	Status (Open / Closed)	Updated By	Updation TimeStam
GUS/24	06-May-2015	Earthwork Compaction	test	Barrage	Kosi Main Barrage	test	Aadharpur		Name : xyz Mob: 0000 E-mail: x@y.z	Correct	Emergency	test	Open	dsingh	03-06-201 14:02:09
GUS/23	19-Apr-2015	Slope stability & slope profile	Embankment Slope is collapsing	Embankment		at km 1.2 to 1.4	Adabari		Name : M U Ghani Mob: 9999999999 E-mail: xy@gmail.com	Correct	Emergency	dsdfsdff	Closed	Priya	22-04-201 12:00:12
GUS/12	11-Feb-2015	Cracking	Embankment problrm	Embankment		Eastern Em 9.6 km	Achran		Name : Rajesh Mob: 9910062107 E-mail: rk3107@gmail.com	Correct		DFFDDF	Closed	Priya	22-04-201 11:57:02
GUS/10	05-Feb-2015	Distance of river from toe	River is approaching toe at km 8.6 on Eastern Embankment	Embankment		8.6 to 9.0 km	Abhaipur		Name : Rajesh Kumar Mob: 9910062107 E-mail: rk3107@gmail.com	Correct		to be attended	Closed	Priya	22-04-201 11:51:41

Risk Assessment – Swapping Tool



Risk Assessment – Buffer Tool



Home Page For Administrative Use

SMS | Downloads | Help | Spatial DataSet | Inspection Tool NEW | Telephone List | Gallery | Meta Data | Suggestions

Govt of Bihar

Water Resources Department

Kosi Embankment Asset Management System (KEAMS)

Select Language

superadmin

Home | Asset Info | Engineering Info | Basin Info | Store Info | Analysis,Planning & Design | Documents | Enviroment | Social | Inform to WRD | Data Control

Sri Rajiv Ranjan Singh Alias Lalan Singh Hon'ble Minister, W.R.D. Government of Bihar

Email:
Mobile:

Watch Kosi Flood Video

Updates

- Status Of Approval(SOP)
- Tender Monitoring(SOP)
- Maintenance History(Asset)

Risk Analysis and Management

Important Links

- Kosi Weather (Nepal)
- India-Wris
- Birpur Barrage Gate
- Kosi Hydro (Nepal)
- Meteorological (Nepal)
- ICIMOD (Nepal)
- FMISC
- W.R.D, Bihar
- CWC
- IMD
- ISRO
- Bihar Weather Forecast
- Mausam Bihar

Alerts : Site Inspection

E : Emergency | U : Un-acceptable | M :Minimally Acceptable | A : Acceptable

Sri Arun Kumar Singh,IAS Principal Secretary,WRD Government of Bihar

Email

Latest Updates

Real Time

Water Level of Kosi River at Barahkhetra Station on 19-Dec-2015 08 hrs is Steady [119.1 m]

Flood Forecast

Current Day

Water Level of Kosi River at

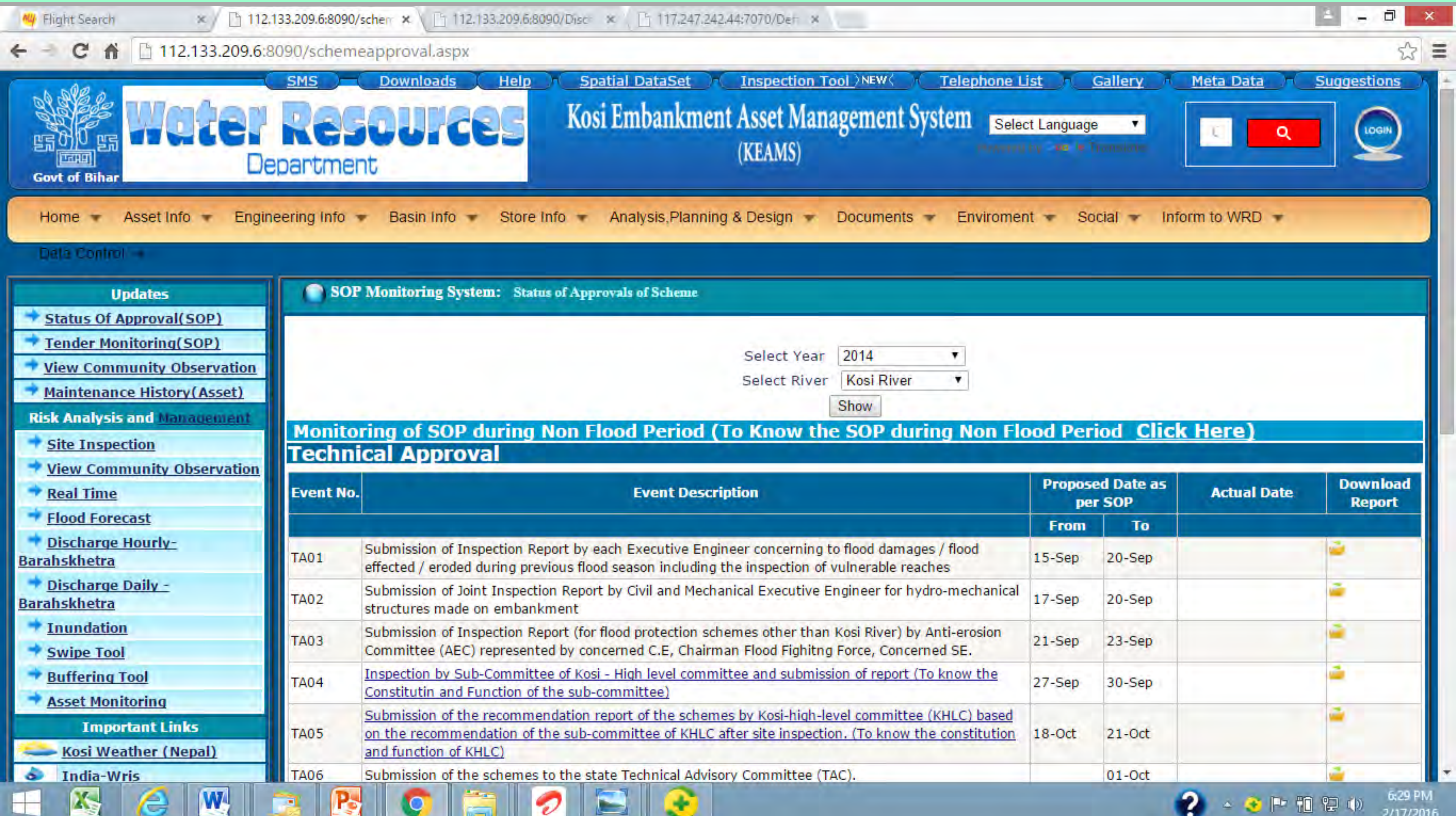
Site Inspection

Inspection Date:02/Feb/2016
Section :Section-II
Asset :Embankment

Best Viewed in Chrome Browser recommended Resoultion is 1920*1080

Consultant : LEA Associates South Asia Pvt Ltd

Status of Approval (SOP)



Event No.	Event Description	Proposed Date as per SOP From	Proposed Date as per SOP To	Actual Date	Download Report
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TA02	Submission of Joint Inspection Report by Civil and Mechanical Executive Engineer for hydro-mechanical structures made on embankment	17-Sep	20-Sep		
TA03	Submission of Inspection Report (for flood protection schemes other than Kosi River) by Anti-erosion Committee (AEC) represented by concerned C.E, Chairman Flood Fighitng Force, Concerned SE.	21-Sep	23-Sep		
TA04	Inspection by Sub-Committee of Kosi - High level committee and submission of report (To know the Constitutin and Function of the sub-committee)	27-Sep	30-Sep		
TA05	Submission of the recommendation report of the schemes by Kosi-high-level committee (KHLC) based on the recommendation of the sub-committee of KHLC after site inspection. (To know the constitution and function of KHLC)	18-Oct	21-Oct		
TA06	Submission of the schemes to the state Technical Advisory Committee (TAC).		01-Oct		

Tender Monitoring (SOP)

SMS | Downloads | Help | Spatial DataSet | Inspection Tool NEW | Telephone List | Gallery | Meta Data | Suggestions

Govt of Bihar

Water Resources Department

Kosi Embankment Asset Management System (KEAMS)

Select Language

superadmin

Home | Asset Info | Engineering Info | Basin Info | Store Info | Analysis,Planning & Design | Documents | Enviroment | Social | Inform to WRD | Data Control

Updates

- Status Of Approval(SOP)
- Tender Monitoring(SOP)
- View Community Observation
- Maintenance History(Asset)

Risk Analysis and Management

- Site Inspection
- View Community Observation
- Real Time
- Flood Forecast
- Discharge Hourly-Barahskhetra
- Discharge Daily -Barahskhetra
- Inundation
- Swipe Tool
- Buffering Tool
- Asset Monitoring

Important Links

- Kosi Weather (Nepal)
- India-Wris
- Birpur Barrage Gate
- Kosi Hydro (Nepal)
- Meteorological (Nepal)
- ICIMOD (Nepal)
- FMISC
- W.R.D, Bihar
- CWC
- IMD
- ISRO
- Bihar Weather Forecast
- Mausam Bihar

Status of Tenders View Screen

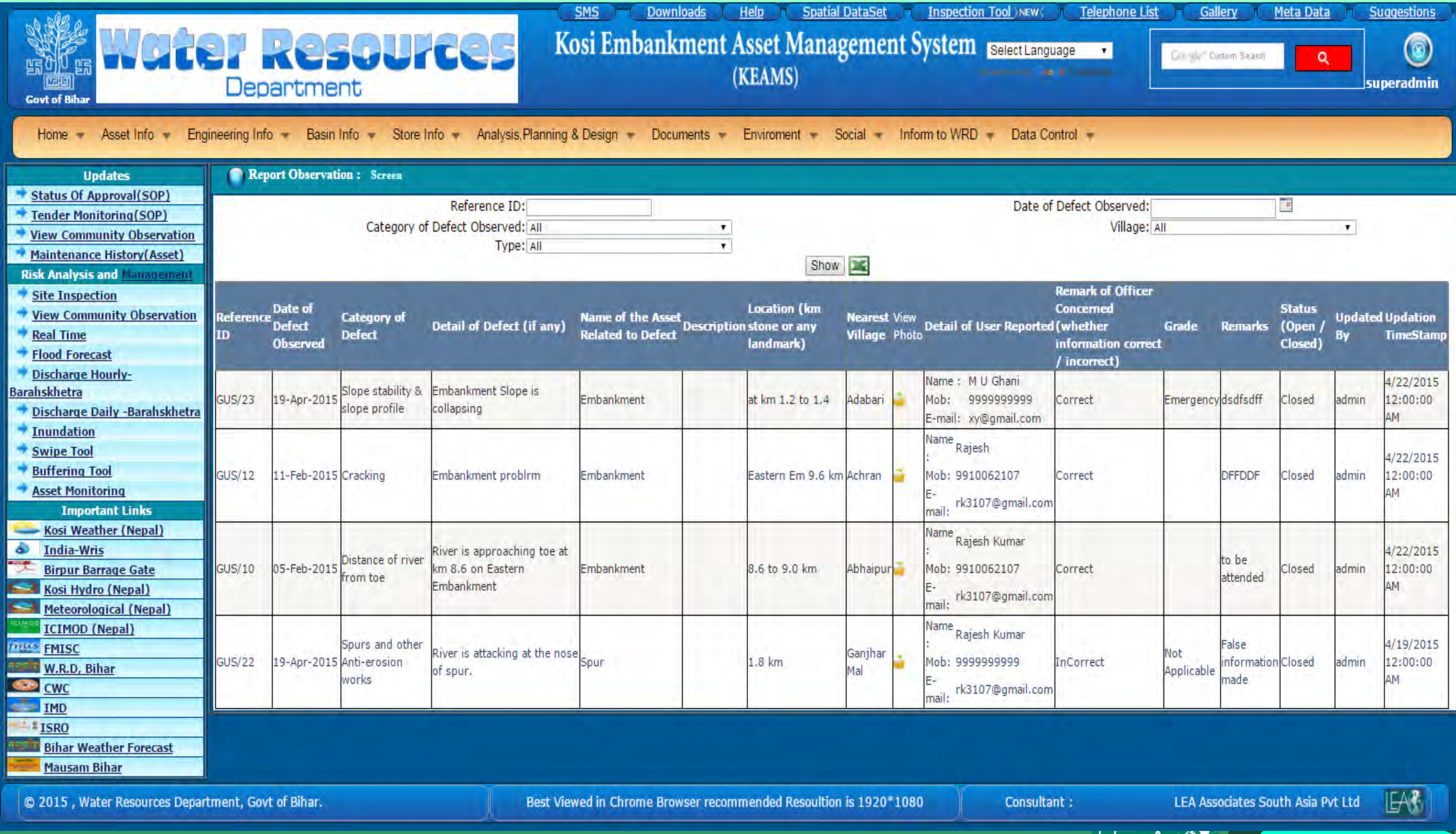
* Before Flood of Year (Tender) : 2015

* Division : All

Show

				Amount(in Rs)		Status of Tender				At Start of Work		Intermediate of Work	At Completion of Work			
Agenda No.	Name of Work	Item Name	Division	Estimated	Approved by Administration	Status of Invitation of Tender	Status of Receipt of Tender	Status of Execution of Tender	Status of Work Allocation	Status of Work Start	View Photo	Details	Status of Work Complete	View Photo	Updated By	Updation TimeStamp
EAB/H/ 07/ 2015	Anti Erosion Work between km 12.5 and km 12.80 of EAM	Anti Erosion Work	Head Works Division, Birpur	0	3735000	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View		CLICK HERE	Status - not updated View		superadmin	2/17/2016 6:10:24 PM
EAB/H/ 07/ 2015	Anti Erosion Work between km 12.5 and km 12.80 of EAM	Anti Erosion Work	Head Works Division, Birpur	0	3735000	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View		CLICK HERE	Status - not updated View		superadmin	2/17/2016 6:10:24 PM
EAB/H/ 06/ 2015	AEW	AEW	Head Works Division, Birpur	0	7983356	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View		CLICK HERE	Status - not updated View		superadmin	2/17/2016 5:53:20 PM
EAB/H/ 05/ 2015	AEW	AEW	Head Works Division, Birpur	0	71079769	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View		CLICK HERE	Status - not updated View		superadmin	2/17/2016 5:51:42 PM
WAB/H/04/ 2015	Anti Erosion Work from 0.00 km to 8.00 km of WAB	Anti Erosion Work	Head Works Division, Birpur	0	96869000	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View		CLICK HERE	Status - not updated View		superadmin	2/17/2016 5:12:27 PM
WAB/H/03/ 2015	Anti Erosion Work Spur at 11.75	Anti Erosion Work	Head Works Division, Birpur	0	6642000	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View		CLICK HERE	Status - not updated View		superadmin	2/17/2016 4:58:41 PM
WAB/H/02/ 2015	Anti Erosion Work at 7.60 km of WAB	7.60 km of WAB	Head Works Division, Birpur	0	13600000	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View		CLICK HERE	Status - not updated View		superadmin	2/17/2016 4:57:01 PM
B/H/01/2015	Anti Erosion Work at Down Stream of Kosi Barrage	Anti Erosion Work	Head Works Division, Birpur	0	18574000	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View	Status - not updated View		CLICK HERE	On Schedule View		superadmin	2/17/2016 4:42:55 PM

Community Feedback



SMS | Downloads | Help | Spatial DataSet | Inspection Tool NEW | Telephone List | Gallery | Meta Data | Suggestions

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- W.R.D, Bihar
- CWC
- IMD
- ISRO
- Bihar Weather Forecast
- Mausam Bihar

Report Observation : Screen

Reference ID:

Date of Defect Observed:

Category of Defect Observed: All

Village: All

Type: All

Show

Reference ID	Date of Defect Observed	Category of Defect	Detail of Defect (if any)	Name of the Asset Related to Defect	Description	Location (km stone or any landmark)	Nearest Village	View Photo	Detail of User Reported	Remark of Officer Concerned (whether information correct / incorrect)	Grade	Remarks	Status (Open / Closed)	Updated By	Updation TimeStamp
GUS/23	19-Apr-2015	Slope stability & slope profile	Embankment Slope is collapsing	Embankment		at km 1.2 to 1.4	Adabari		Name : M U Ghani Mob: 9999999999 E-mail: xy@gmail.com	Correct	Emergency	dsdfsdff	Closed	admin	4/22/2015 12:00:00 AM
GUS/12	11-Feb-2015	Cracking	Embankment problrm	Embankment		Eastern Em 9.6 km	Achran		Name : Rajesh Mob: 9910062107 E-mail: rk3107@gmail.com	Correct		DFFDDF	Closed	admin	4/22/2015 12:00:00 AM
GUS/10	05-Feb-2015	Distance of river from toe	River is approaching toe at km 8.6 on Eastern Embankment	Embankment		8.6 to 9.0 km	Abhaipur		Name : Rajesh Kumar Mob: 9910062107 E-mail: rk3107@gmail.com	Correct		to be attended	Closed	admin	4/22/2015 12:00:00 AM
GUS/22	19-Apr-2015	Spurs and other Anti-erosion works	River is attacking at the nose of spur.	Spur		1.8 km	Ganjhar Mal		Name : Rajesh Kumar Mob: 9999999999 E-mail: rk3107@gmail.com	InCorrect	Not Applicable	False information made	Closed	admin	4/19/2015 12:00:00 AM

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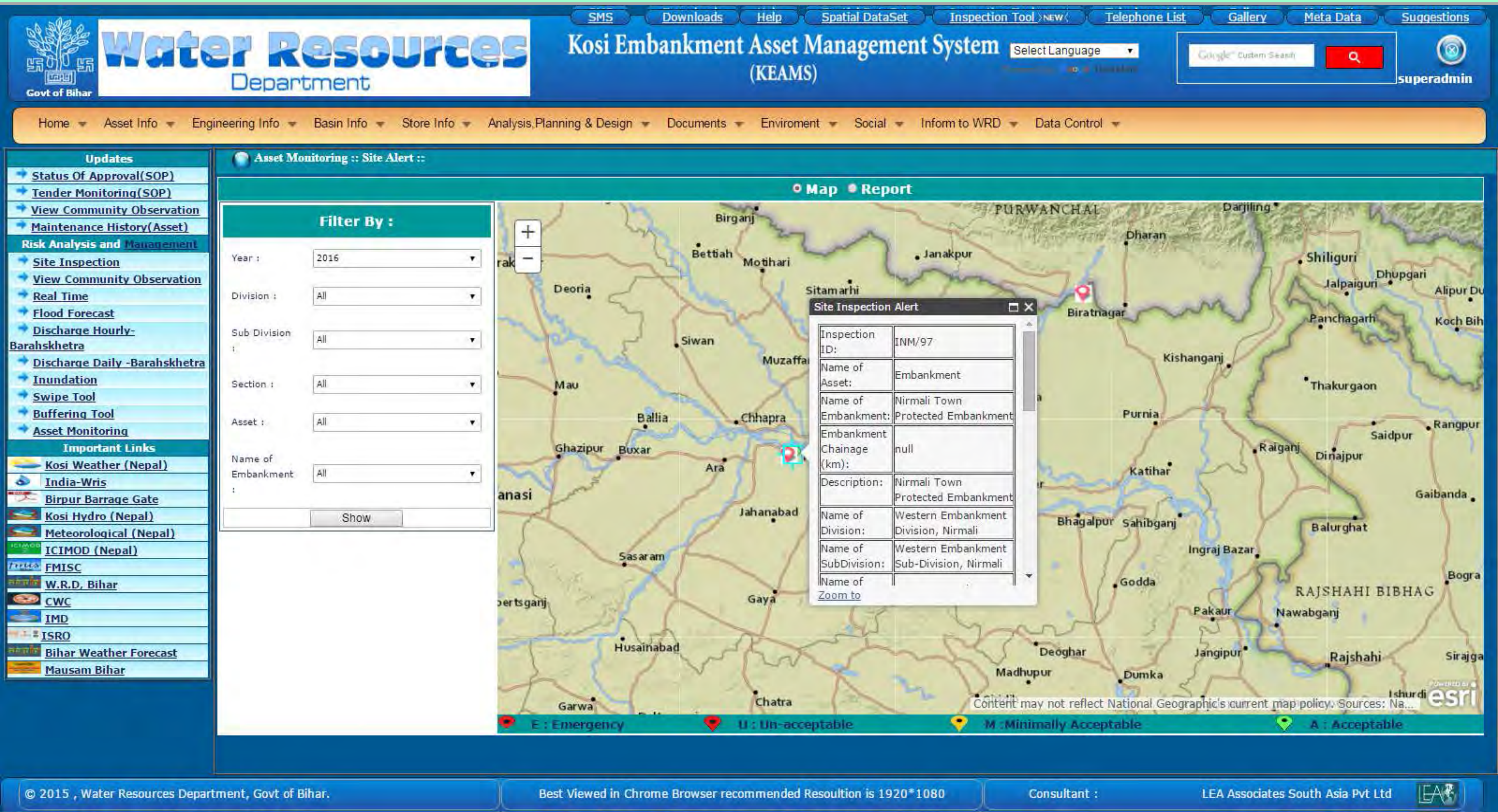
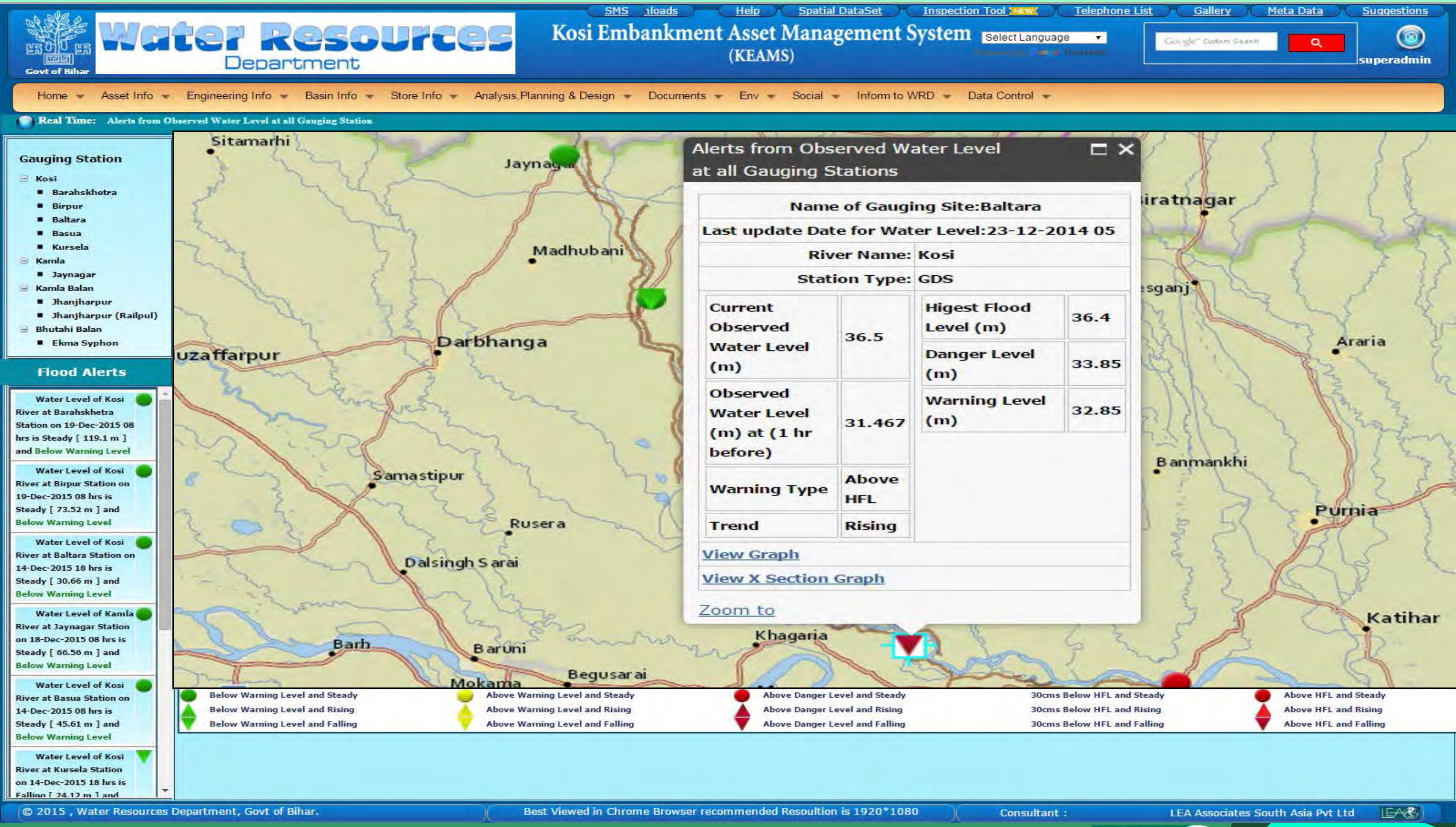
Best Viewed in Chrome Browser recommended Resoultion is 1920*1080

Consultant : LEA Associates South Asia Pvt Ltd

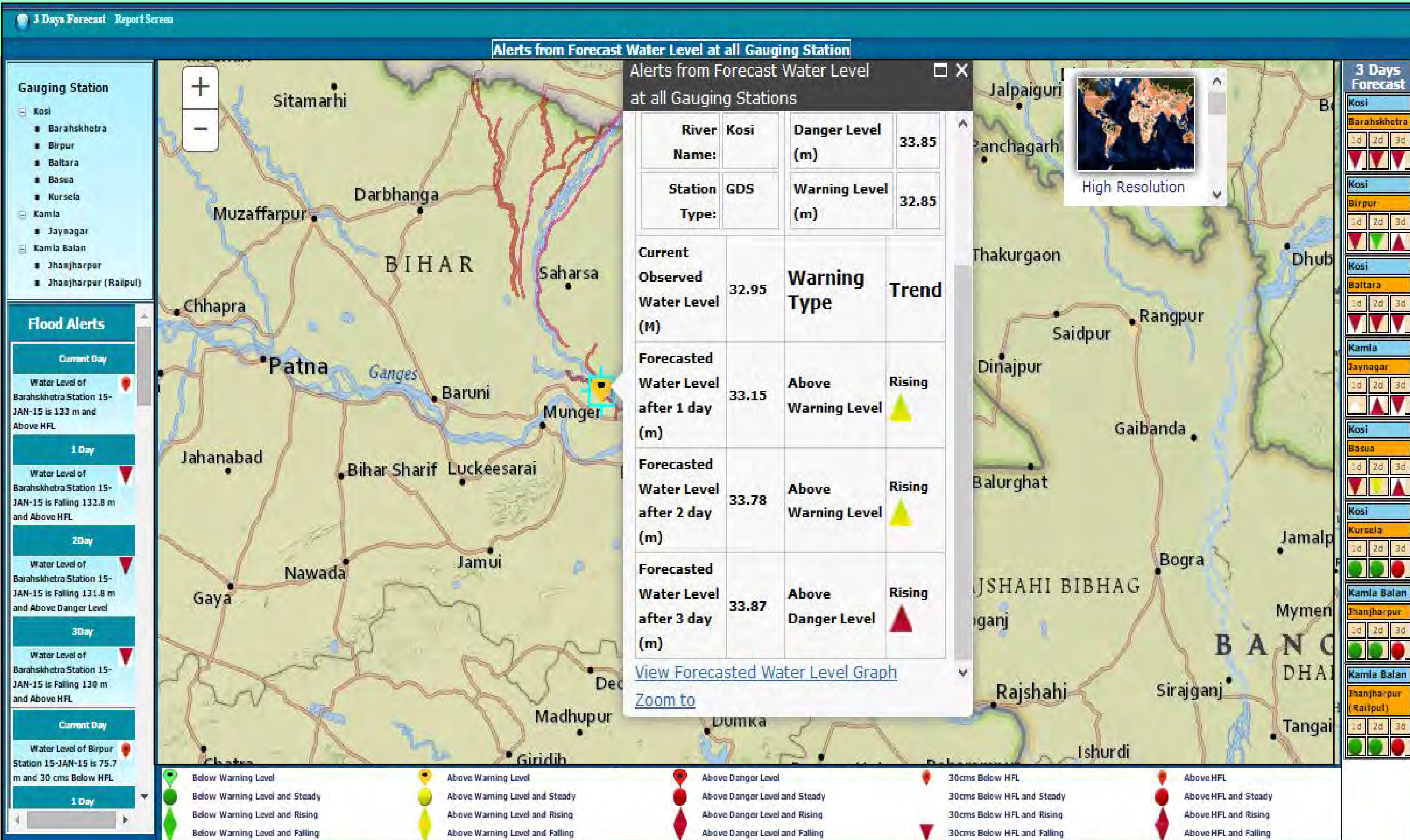
Site Inspection



Real Time (Water Level)



Flood Forecast



Roles of K-EAMS in 4 I's

Thank You

Developing Approach, Protocols and Mechanisms for community participation in embankment surveillance and piloting in select communities in Kosi River Basin

JPS Associates (P) Ltd.
Hauz Khas Enclave
New Delhi-110016

Outline of the Presentation

- Short introduction to JPS Associates
- Scope of Work under the assignment "Developing Approach , Protocols and mechanisms for community participation in Embankment Surveillance and piloting in select communities in Kosi River Basin"
- Key Activities and deliverables
- Progress on the assignment
- Approach and Protocols developed for community participation
- Action Plan for community participation along the entire basin
- Finally the mechanisms of information sharing from Community to the WRD and vice versa

BRIEF ON JPS

- JPS is an ISO 9001 2008 certified company and founded in 1979
- JPS works on development sector related projects supported by central and state governments as well as by International and bi-lateral development agencies
- Provided consultancy services in more than a 1000 assignments.
- **Clients include** :World Bank, ADB, UNDP, UNEP, ILO, Global Environment Facility (GEF), EU, USAID, DFID), JBIC, JICA, CIDA, AusAID, KfW, GIZ NORAD.
- **Government clients:** National institutions, central government, state government, local government and parastatals such as public sector undertakings and public sector banks.
- **Empanelled with**: Several Govt. Departments for conducting various monitoring and evaluation exercises such as with MoHFW , SIFPSA (UP), Ministry of MSME, NHAI, Ministry of Water Resources, MouD etc.,

Scope of work

1. To develop community participation modes for involving community/PRI bodies during normal times and during flood times to supplement institutional efforts in embankment surveillance.

2. To hold workshops in selected communities in the basin area and to reach consensus on the proposed participation modalities

3. To suggest a communication plan and a system of transmitting periodical real time feedback on different nature of embankment info such as: visual observation of river flow close to embankment , damage to river training works and embankment structures , wave action damaging the river-side slope of the embankment , Seepage of water through embankment, rat holes, rapidly rising river water level.
4. The info exchange would be from the community to WRD field offices , BAPEPS, FMISC and vice versa through integration into the EAMS.

5. To develop a plan for the annual pre-season workshops and an action plan for implementation in the whole basin for ensuring community preparedness during any eventuality.

6. Pilot the plan in a selected portion (say, one WRD Division) in Kosi Basin to finalize the strategy for reliability across the entire stretch.

7. To assess financial implications of community participation and to recommend whether the participation would be voluntary or funded. If funded what amount is required.

>>>>> Progress.................

Deliverables

Deliverable	Content	Status
First - Inception report	Review of International and National experience in ES Revised Methodology, timelines	Approved
Second	1. Survey report 2. Report containing recommendation on community participation modalities 3. Proposed approach , protocols and mechanisms of community participation for embankment surveillance	Approved
Third	1. Report on Consensus on modalities and protocols 2. Annual pre-season workshop plan and Piloting of plan Implementation in Kosi - Kamla Basin 3. Information flow mechanisms and 4. Training manual for formation of ES Committees and its functioning	Approved
Draft report	Pending submission (More of a compilation of the 3 deliverables	
Final Report	Pending submission	

KEY DELIVERABLES THAT WILL BE DISCUSSED

- Approach, Protocols and mechanisms of CP modes on which consensus was arrived at through consultative Workshops
- Pre-season Workshop plan, its needs and plan for implementing the CP mode along the entire basin
- Mechanisms of Information Communication (sms gateway and integration into the K-EAMS

Activities conducted To develop approach , protocols

Desk Review of National and International experiences in CP.

Consultation with WRD officials at field and HQ level, FMISC, BAPEPS FMC

Field survey

Outcome of desk review

- Reviewed international experiences of Bangladesh, Pakistan Srilanka, China, Netherlands , Australia, Vietnam…
- ES at the national level are few and far between - Mostly episodic
- Most CP models talk about CP involvement in Early Warning System, Flood / disaster preparedness.
- Did not find anything worthwhile on CP in ES. Nothing special for enabling a framework for institutional mechanism of CP.

Review of select CP modes

- Participatory Irrigation Management (PIM) in Bihar is thought to be a successful programme . Programme, improved the revenue collection mechanism.
- Religious leaders (Imams in Masjids) have been utilized to disseminate flood related information successfully
- Joint forest Management (JFM) is a successful model where community participation has seen a lot of forests to be protected from deforestation and the benefits of Non Timber Forest Produces (NTFP) has been shared by community in organized manner.
- Internationally Community-based Disaster Risk Management (DRM) activities are well integrated into the daily lives of most Japanese, ensuring that awareness of natural hazards is never far from their minds
- In Netherlands, local governments and communities in affected areas served as first responders, managed evacuation centers, and promptly began post disaster reconstruction

Preliminary findings (Community views)

- People living in close proximity of embankments value its importance as its provides safety, good transportation and stable livelihood.
- There is a growing tendency of exploiting the embankment for personal needs
- Embankments are under threat due to constant wear and tear, vehicular, cattle movement, rainfall impact, public cuts, uncontrolled human interference.

Existing mechanisms for ES / Flood control/ disaster mitigation

- Community interaction has given insights that embankment surveillance is currently seen as the departments responsibility
- Community is actually involved in select places for Flood and Disaster Management and had received some sort of training from NGOs and BSDMA (District units).
- Community not involved in ES currently, but are appreciative of departments efforts to involve community both in its surveillance and management
- Community participation in ES should be a group approach through committees rather through individuals and it should not be only department's initiatives. Community should be made equally responsible

SURVEY - Issues on which feedback through survey, FGDs was sought

Regarding role embankment plays in the life of Community

Condition of the embankment as perceived by Community

Risks to embankment health

Role community can play in embankment surveillance

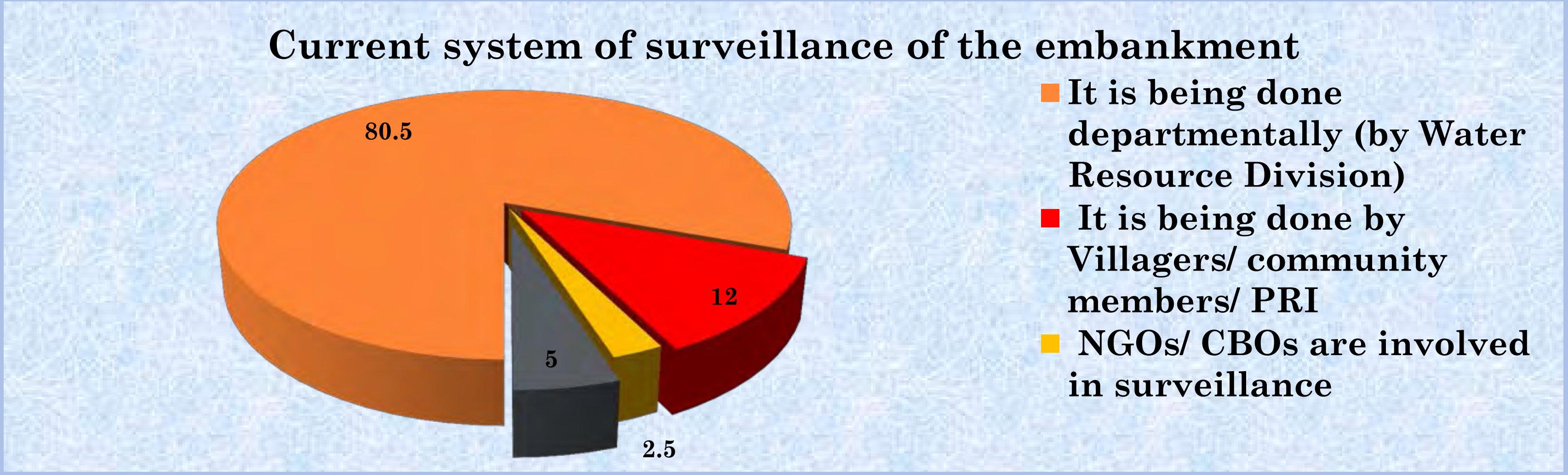
Existing information dissemination system

Probable models of community participation

OUTCOME OF SURVEY

Importance of embankment in the lives of people

- 1020 households surveyed
- (85%) perceive Embankment as their a lifeline
- For 71% presence of embankments has enabled carrying out agricultural activity in all the seasons
- for 79% it has brought prosperity in the area and increased the living standards.

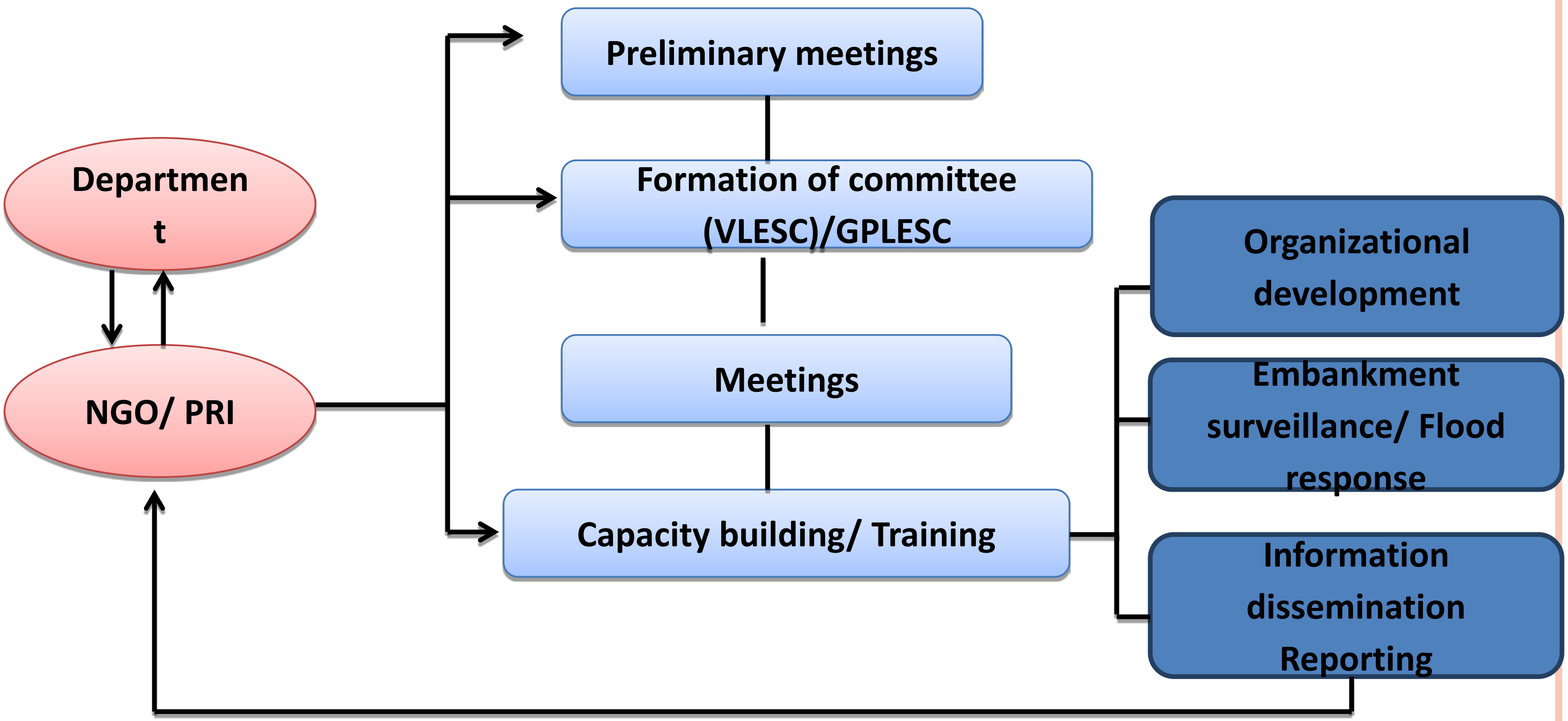


Summary of suggestions from the Community members and officials

- Attempts to strengthen embankments should not be confined just before the monsoon season but on regular basis all through the year.
- Community participation should be ensured in ES as well as all other works done on the embankments.
- Information of all the important contact numbers of Government officials must be painted at public places in the villages near embankments.
- Need for capacity building of ES Committees on technical aspects and reporting
- Help from Dept. and Govt. is sought for removing houses/shops and big trees on the embankments. Community is clueless of procedures
- Mobile application and sms gateway most appropriate mechanism for info sharing

APPROACH PROTOCOLS AND MECHANISM

- Consensus was that GPLESC would be appropriate
- VLESC only in limited areas where there is high risk
- Agreed approach and framework



PROTOCOLS

- Conducted Workshops in select communities, along with concerned field division staff, to develop consensus on community participation mode, and finalize it in stakeholders workshop in WRD Patna.
- Nearly 220 community members and 80 WRD officials participated in 4 major workshops; 3 at field level and 1 at Patna
- Department should have sensitization meetings in the community regularly
- It should take help of NGOs/ PRI members/ Aajeevika workers to form ESC
- It should comprise of 9-15 members permanently residing in the village / Panchayat
- Each committee should have women participation and also have people from vulnerable committees
- The committee should patrol the embankment on daily basis and call specific meetings on monthly basis and maintain proper proceeding registers
- Committee should take Embankment safety/ threats issues in gram sabha and resolutions be recorded
- Committees to function under special code of conducts
- The committees formed should be properly sensitized on their voluntary role.
- They should also be sensitized to respond during emergency situations, for eg. making arrangement of labour during flood fighting efforts.
- Committee should have special meeting with WRD staff (pre and post season) during May and September. This will enable AEC and TAC to include community issues.

Roles and responsibilities of Embankment Surveillance Committee (VLESC/GPLESC) during normal times and during flood situation:

Role	During Normal times	During Flood season
<u>Preparatory stage:</u> Planning for embankment surveillance	Meetings to be held during /May and September	Meetings to be held with community before TAC, AEC meetings
<u>Awareness building in the community:</u> • Create awareness on ES , EWS, flood preparedness, disaster mitigation • Create awareness on flood warning, classification of floods based on intensity and threat, safety measures (indigenous measures), creation of common resources such as tarpaulins, lantern, floating bags, grain banks, places of safety etc. Creating awareness on officials to be contacted during vulnerable periods • Involving community in activities related to reducing community irritation during execution of works during and after floods or any emergency or even at normal times	Quarterly activity Quarterly activity Quarterly activity	Daily - Intensified through loudspeaker – camp mode -do- Daily

Contd…

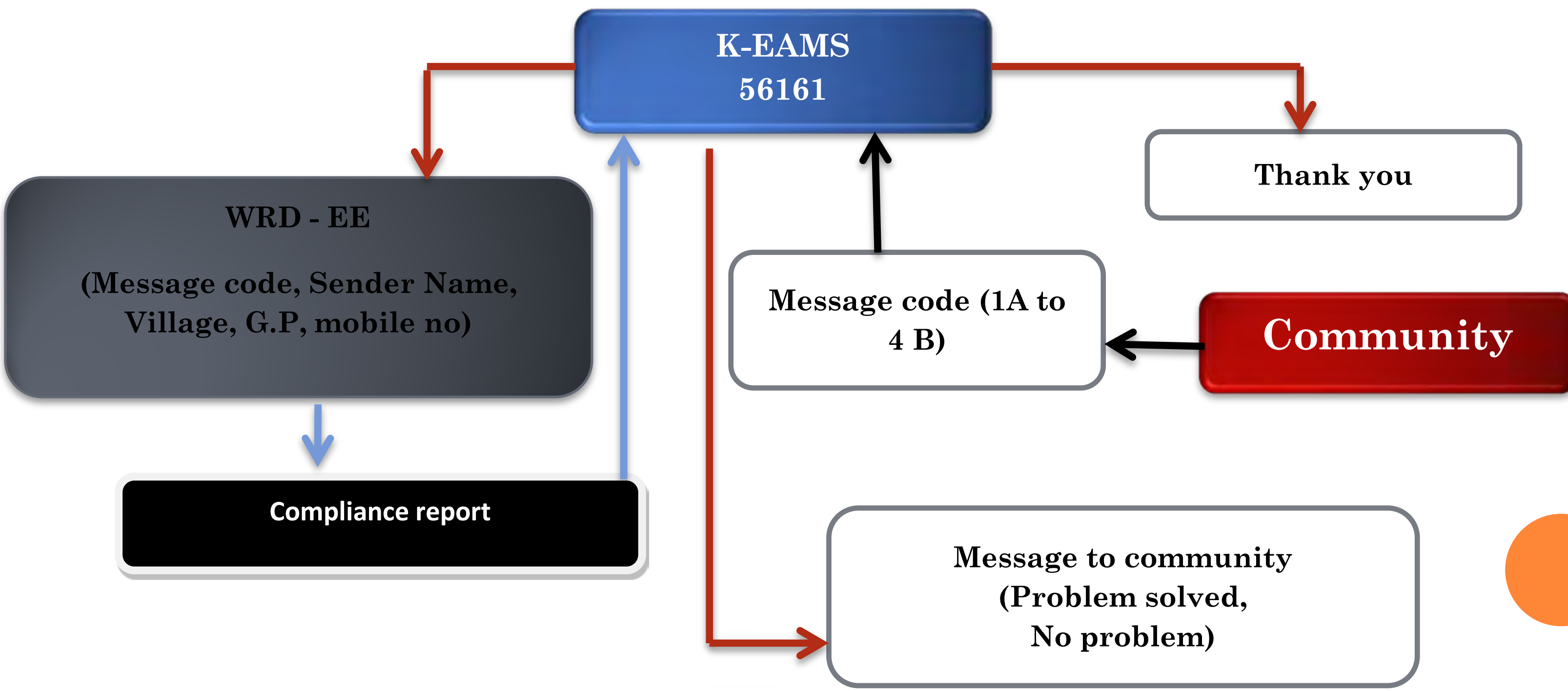
Role	During Normal times	During Flood season
Patrolling	Weekly patrolling	Daily patrolling
Updation of perceived threat situation to embankment (condition of embankment) (Identify threats to embankment health (Rat holes, cuts, breaches) with location specific information - relative distance (RD) wise	Monthly activity	Updating required daily, even hourly messages will be of importance
Communication of relevant messages: Communicate reliable information (coded/digital/ photos) needed by the Department in proper , organized manner periodically on a monthly basis during rainy season / vulnerable periods)	Fortnightly / Monthly activity	Daily activity
Arranging for local labour during execution of embankment maintenance works	As and when required	Daily activity – in emergency - immediate

WORKSHOPS ON COMMUNITY PARTICIPATION MODES

Name of Division	Date	No of community members	No. of WRD officials	Total
EKE (Birpur)	16.12.2015	77	13	90
WKE (Nirmali)	19.12.2015	62	17	79
Kamla (Jhanjharpur II)	23.12.2015	50	15	65
Patna	04.01.2016	25	23	48
Total	**4**	**214**	**68**	**282**

Mechanism for transmission of messages from community to Department

- A meeting with Kosi Embankment Asset Management System (K-EAMS) officials and the IT officials from FMISC was held on 12.01.2016 at FMISC.
- The process of message transmission was discussed in detail and it was agreed that K-EAMs will adopt the following process to integrate the messages received from VLESC and GPLESC members



सुरक्षा संदेशो की सुची

S. No.	Alerts (सुरक्षा संदेश)	प्राथमिकता	SMS कोड
1	तटबंध के किनारे नदी भाग में कटाव हो रहा है और किनारे की मिट्टी धंस रही है ।	1	1 A
2	बॉध में दरार पड़ी है ।	1	1 B
3	तटबंध पर किये गये सुरक्षात्मक कार्यों में धंसान या क्षति देखी गई है ।	1	1 C
4	नदी तटबंध के किनारे पहुँच चुकी है और बॉध के किनारे मिट्टी का कटाव या धसाव हो रहा है ।	1	1 D
5	तटबंध के ढलान पर रिसाव हो रहा है या आसपास के जमीन में बुलबुले निकल रहे हैं । रिसाव के समय गंदा पानी आ रहा है ।	1	1 E
6	तटबंध के उपर की सतह खराब स्थिति में है और इसके रख–रखाव की आवश्यकता है ।	2	2 A
7	कुछ लोगों ने तटबंध के किनारे की मिट्टी काट लिया है ।	2	2 B
8	नदी तटबंध से लगभग 100 मी0 की दूरी पर है और इसकी प्रवृति और नजदीक आने की है ।	2	2 C
9	तटबंध पर एक बित्ता (6 इंच से ज्यादा) के गढढे बन गये हैं ।	2	2 D
10	बॉध पर वर्षा के कारण नालियॉ बन गई है जिसे मिट्टी से भरने की जरूरत है ।	3	3 A
11	बॉध में जानवरों द्वारा बिल बनाये गये हैं और इस पर तुरन्त ध्यान देने की आवश्यकता है ।	3	3 B
12	बॉध पर लोगों ने मवेशी स्थल और झोपड़ी बना रखे हैं ।	4	4 A

SMS ALERTS IN ENGLISH

S. No.	Alerts	Priority	SMS Code
1	Erosion, caving on the river side slope of embankment is occurring.	1	1 A
2	Cracks have been observed on the embankment.	1	1 B
3	Damage or caving of protection work done on the river side of embankments has been observed.	1	1 C
4	The river is flowing at the edge of embankment and erosion/caving of embankment is taking place.	1	1 D
5	Seepage or sand boils have been observed on the embankment slope and in nearby areas.	1	1 E
6	Surface of the embankment is in bad shape and needs immediate attention.	2	2 A
7	Country side toe-cutting has been observed in the embankment.	2	2 B
8	The river is flowing at a distance of 100 mts. From the embankment and displays a tendency of coming nearer.	2	2 C
9	Depressions greater than 6 inches have been observed on the embankment.	2	2 D
10	Rain cut has been observed on the embankment that requires soil filling.	3	3 A
11	Several animal burrows present on the embankment that require immediate attention	3	3 B
12	Construction of hutment & animal shed is taking place on the embankment	4	4 A

Pull Service: Receiving SMS from community in Community Participation page of K-EAMS:

- K-EAMS will receive message from the community on "**Number" in the Community page** following the below mentioned procedure:
  - Code of Type of Problem
  - On receiving the message the EAMS will generate a gratitude note (Apke sahyog ke liye Dhanyavad or THANK YOU FOR YOUR COOPERATION) which the sender will immediately receive.
  - A database of contact numbers of selected persons will be registered in the CP section in EAMS that will help identify the location instantly on receiving messages from any of these.

About 1000 phone numbers along the entire stretch loaded on K-EAMS Community page

Push Service: Sending Messages to the concerned Division Executive Engineer and the Community:

- The message received from the community will be forwarded to the Executive Engineers (EE) of the respective division in the format "message code", Name of the person, Village name, G.P Name, Telephone number".

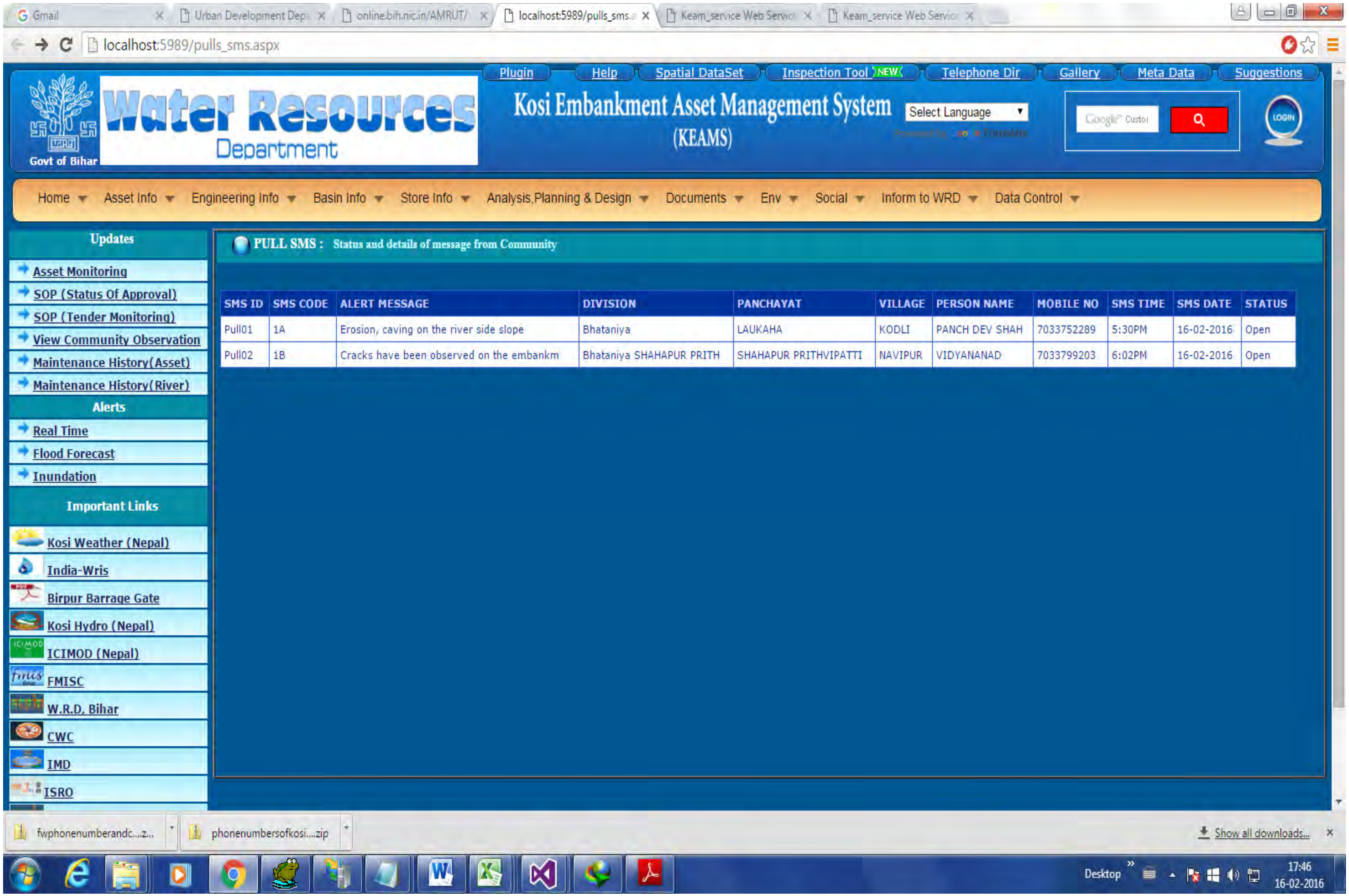
- The EE will screen messages and initiate action and once action is initiated he will update on the compliance icon (Status open) provided on the Community participation page.

- The EAMS may get back to the message sender once Action has been taken on the problem identified (Status closed).

- This Database of contact numbers will in any case be important for sending alerts to the community by EAMS.

  - The major feature of CP Page on EAMS will be:-
  - Archive of Community Messages on embankment safety for every quarter.
  - Action Taken Report on messages received from Community will be uploaded on the page
  - Community reports and remedial actions by the dept should form part of maintenance and inspection database.

SCREEN SHOT


localhost:5989/pulls_sms.aspx
Plugin
Help
Spatial DataSet
Inspection Tool
Telephone Dir
Gallery
Meta Data
Suggestions
Govt of Bihar
Water Resources Department
Kosi Embankment Asset Management System (KEAMS)
Select Language
Home
Asset Info
Engineering Info
Basin Info
Store Info
Analysis,Planning & Design
Documents
Env
Social
Inform to WRD
Data Control
Updates
Asset Monitoring
SOP (Status Of Approval)
SOP (Tender Monitoring)
View Community Observation
Maintenance History(Asset)
Maintenance History(River)
Alerts
Real Time
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Kosi Hydro (Nepal)
ICIMOD (Nepal)
FMISC
W.R.D. Bihar
CWC
IMD
ISRO
PULL SMS : Status and details of message from Community
SMS ID | SMS CODE | ALERT MESSAGE | DIVISION | PANCHAYAT | VILLAGE | PERSON NAME | MOBILE NO | SMS TIME | SMS DATE | STATUS
Pull01 | 1A | Erosion, caving on the river side slope | Bhataniya | LAUKAHA | KODLI | PANCH DEV SHAH | 7033752289 | 5:30PM | 16-02-2016 | Open
Pull02 | 1B | Cracks have been observed on the embankm | Bhataniya SHAHAPUR PRITH | SHAHAPUR PRITHVIPATTI | NAVIPUR | VIDYANANAD | 7033799203 | 6:02PM | 16-02-2016 | Open
Show all downloads...
Desktop
17:46
16-02-2016

ACTION PLAN

- Pre-season Workshops for community preparedness prepared and piloted in Birpur and Nirmali Division

Kosi Embankment	Name of Division	Workshop Dates	
		Pre-monsoon	Post-monsoon
East Flood Embankment Division (EKE)	Birpur	16th. May, 2016	16th September, 2016
	Supaul	19th. May, 2016	19th September, 2016
	Khopadia	23rd.· May, 2016	21st September 2016
	Chadrayan	27th.· May, 2016	23rd September,2016
Western Flood Embankment (WKE)	Kunauli	16th. May, 2016	16th September, 2016
	Nirmali	19th. May, 2016	19th September, 2016
	Bhagalpur	23rd.· May, 2016	21st September 2016
	Bhagalpur	27th.· May, 2016	23rd September,2016
Kamla Embankment			
	Jhanjharpur - I	16th. May, 2016	16th September, 2016
	Jhanjharpur –II	19th. May, 2016	19th September, 2016

ACTION PLAN FOR PRESEASON WORKSHOPS

Why preseason workshops are necessary:

- Creating an effective and conducive platform wherein the WRD field division staff and the community representatives can interact freely and plan together for
  - Embankment surveillance
  - Identifying potential risks points to embankment health
  - Any activity related to embankment safety or for reducing risks to the embankment
  - Any civil/engineering additional measures to be taken for embankment safety
  - Organizing labour for any physical works related to embankment management/ safety or risk reduction
  - Preparedness for flood/ Flood control activities during the onset of flood and even for post flood activities

Cost involved in conducting workshop cum orientation of GPLESCs at Division level

Sl	Particulars	Amount (INR)
1	Working lunch, tea for 70 participants @ Rs.125/-	8,750
2	Cost of miking for creation of awareness and inviting participants in the embankment stretch from where participants will come (includes vehicle and mike costs for one day prior to the workshop)	2,500
2	Logistics (Hiring of Audio visual equipment like Microphone, Projector, chair tables)	2,500
3	Honorarium to Resource persons @ 500 per person X 2 persons	1,000
4	Miscellaneous expenses (Training materials, banners etc.)	1,500
	Total	16,250
	Cost for 20 Workshops	3,25,000

How to conduct Workshops and training / orientation of committees

- **Step 1:** Formation of Village Level Embankment Surveillance Committees (VLESC) and Formation of G.P Level Embankment Surveillance Committees(GPLESC)
- **Step 2:** Orientation of the committees (To be conducted by Trained Trainers).
- Orientation and trainings to be done as per training Manual (Available both in English and Hindi…….Also Piloted)
- Orientation to be clubbed up with Workshops with GPLESCs to make it cost effective

Appropriateness of the Training materials:

- Training manual in Hindi was shared with the WRD field level Assistant Engineers and Junior Engineers of Birpur and Nirmali Divisions. Following is an abstract of remarks:

Particulars	Remarks
Language	The Manual is in Hindi and can be easily understood by the trainer
Content	
a) Understanding of the concept of embankment surveillance	The language used is simple and concepts on embankment surveillance are easily understood. Exhibits used are good.
a) Understanding the concept of community participation	Clear concept has been provided
a) Quality of exhibits and illustrations	Good, but can be improved. Some videos can be helpful
a) Explanation on how , when, where of community Organisation process	Could be easily understood
a) Messages list with codes	Messages depict actual situation and are easily understood. The trainer will need to demonstrate the messages by taking the partiicpants to the field and showing them rain cuts, erosion , holes in the embankment etc
a) Duration of training	One day training is enough
Overall utility and appropriateness of the training manual	Useful. It should be circulated to all Divisions

Action plan for implementing strategy in the entire Kosi Kamala basin

- Formation of community organizations at the Gram Panchayat levels is the agreed approach evolving from discussions at all the field level and WRD level workshops.
- As discussed earlier 65 GPLESC have to be formed in the entire stretch covering all 10 Divisions
- Of this 15 have already been formed by the consultants as a part of pilot. In addition to this 30VLESCs also formed as pilot
- A suggestive list of places where GPLESC can be formed by Department is provided in the next slide

Sr. No.	Panchayat	Name of the villages under Panchayats	R.D. Kms	Division
Eastern Kosi Embankment				
1	Ratanpur	Dhena, Piparahi, Baijnathpur	9 -11.7	Bhataniya
2	Kamalpur	Rupauli	19 kms	Bhataniya
3	Laukaha	Kodli, Nonpar, Baisa	20.7 – 25.14	Bhataniya
4	Chitthi Hanumanagar	Simri/Chitthi	22	Bhataniya
5	Sahpur Pritipatti	Nabipur	23	Bhataniya
6	Jhila Dumri	Sadanandpur, Bishunpur	28	Bhataniya
7	Baphtiyahi	Gadhiya	32.33	Bhataniya
8	Katahara Kadampura	Katahara, Khakhai, Bakurahi	53	Supaul
9	Bairiya	Malhad, Bairiya Manch	58 - 59	Supaul
10	Bashbitti	Bhajantoli, Basua	65 – 68	Supaul
11	Ramdupatti	Rampur Nobad, Nemua, Ramduttpati	66. 67 – 68.25	Supaul
12	Bakaur	Bakaur	72	Supaul
13	Hatti	Barahi	72.80	Supaul
14	Mohanpur	Misharaulia, Fakhrahi, Mohanpur	80.65 – 81.5	Chandrayan
15	Chandrain	Ekar, Chardrain, Jodi	83.40 – 85.16	Chandrayan
16	Muradpur	Darahara	84	Chandrayan
17	Sahpur	Majhaul	85.5	Chandrayan
18	Meshraho	Meshraho, Sarauni, Baluaha, Teghra	88 - 93	Chandrayan
19	Mahisi Uttari	Mahisi	95	Chandrayan
20	Mahisi Dakhsini	Bhagwatpur, Mahpura	97 – 98	Chandrayan
21	Shirwar Virwar	Gamraho, Bijwar	101 – 102	Chandrayan
22	Rajhanpur	Rajhanpur	103	Chandrayan
23	Goghsam	Tilati	104.5	Chandrayan
24	Gordar	Bagewa	122	Koparia
25	Utteshra	Utteshra	123	Koparia
26	Salakhua	Salakhua	124	Koparia
27	Sitwaha	Sitwaha	125	Koparia

Below Kosi main Embankment				
28	Sarswa	Dhamara Ghat		Khagaria
29	Hardia	Badla Ghat		Khagaria
30	Madrauni	Madrauni		Bhagalpur
31	Sahora	Sahora		Bhagalpur
Western Kosi Embankment				
32	Ghonghepur	Gonghepur	53.5 Below GGh	Nirmali
33	Telwa Paschim	Bhanti, Dumri Supaul	48 -50 Below GGh	Nirmali
34	Manovar	Jalai	49 Below GGH	Nirmali
35	Telwa	Nabada	48 Below GGh	Nirmali
36	Baghwa	Garual	46 kms	Nirmali
37	Jamalpur	Jamalpur	41 kms	Nirmali
38	Narkatia	Bhoogaul	39 kms	Nirmali
Right Kamala Balan Embankment				
39	Sukki	Sukki	9 kms	Jhanjharpur 2
40	Kanhauli	Kunhauli	14 kms	Jhanjharpur 2
Left Kamala Balan Embankment				
41	Satghara	Satghara	27 kms	Jhanjharpur 1
42	Dabhaar	Bithauni	29 kms	Jhanjharpur 1
43	Maharail	Mahrail	41 Kms	Jhanjharpur 1
44	Jhanjharpur	Partapur	42 kms	Jhanjharpur 1
45	Behat Dakshin	Pipraghat	51 Kms	Jhanjharpur 1
46	Balia	Khairi	59 Kms	Jhanjharpur 1
47	Prasad	Kahairi Mushari	62 kms	Jhanjharpur 1
48	Banki	Fataki	64 kms	Jhanjharpur 1
49	Parwalpur	Daldal	66 kms	Jhanjharpur 1
50	Rashiyari	Rashiyari Tola	73 Kms	Jhanjharpur 1

Financial implications-Cost of arranging GP level committees

Sl	Particulars	Amount (INR)
Cost of arranging one GPLESC		
1	Travel to villages for awareness building meetings at Village level (at least 3 visits) @ 500/- per visit	**1,500**
2	Cost of arranging GP level meeting (Cost of tea and snacks)	**500**
3	Cost of signage with messages (at Panchayat office), Road side and School and flex boards at various places of the Panchayat	**1,500**
4	Management costs to NGO/agency conductng meetings @ 500 per meeting for 4 meetings annually including cost of stationary materials	**2,000**
Total Cost for arranging one GPLESC		**5,500**
Cost of arranging 50 GP level committees proposed		**2,75,000**


स्थान-
दिनांक



Stone pitching on Left Kamla Embankment at Fataki 64 Rd

Khairi Mushehri 62 RD(left Kamla Embankment sand bagging)

Black topped Embankment – Mahapura (98 RD)

Partapur Left Kala embankment 42 RD

FGD with villagers at Simri 22.00 RD

Ravi Gupta from BAPEPS interacting with villagers at Mahisi 95 RD

CONCLUSION

Community participation cannot be envisioned with community as mere messengers or watch dogs.

Any mode of community participation has to strategize ways where community becomes an active stakeholder and such strategies are designed in manner that can sustain their participation for longer duration.

FINAL WORDS……………..

COMMUNITY PARTICIPATION IS BOUND TO TAKE SOME TIME … PEOPLE HAVE STARTED TO RESPOND

SUSTAINABILITY REQUIRES BCC ACTIVITIES

DEPARTMENT SHOULD BE SERIOUS TO CONTINUE TO REACH OUT TO COMMITTEES

OTHER WISE THEY WILL FADE INTO OBLIVION

THANK YOU

Ganges Basin Flood Risk Atlas

19 February 2016

Patna

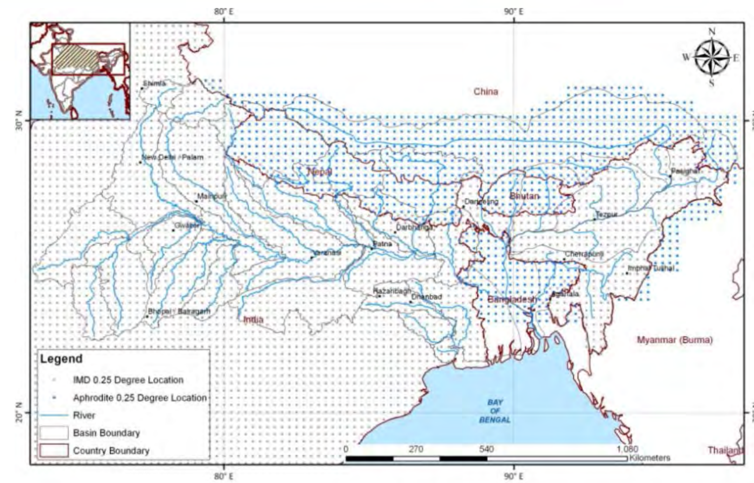
Flood Forecasting

- Flood Risk Assessment
  - Coverage: Ganges Basin (Nepal, India and Bangladesh)
  - Purpose: Evaluate areas at risk considering hazard, exposure and vulnerability; in order to guide flood forecasting priorities
  - Status: Completed

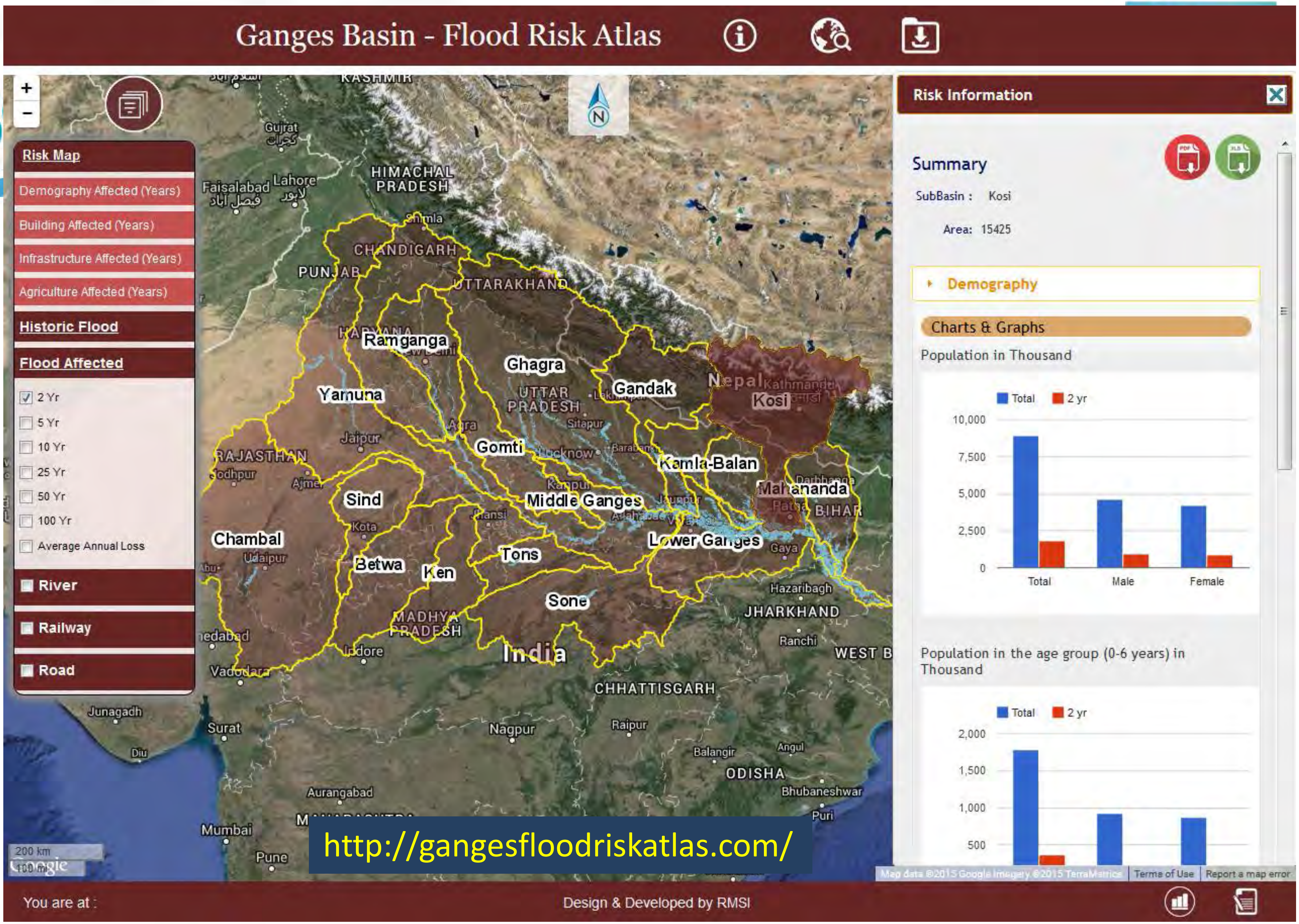
Flood Risk Assessment

<u>Purpose</u>: To support and coordinate trans boundary and intra-state (sub-basin) flood risk management

- **Operational link**: To support National Hydrology Project to overcome fragmented approach to flood forecasting prioritization
- **Coverage**: Entire Ganga Basin (Nepal, India and Bangladesh)
- **Approach**: Risk = f (H, E and V)



Area of Ganges Basin - 984,076 sq.km
India- 80%; Nepal -15%
China- 4%; Bangladesh – 1% of Basin



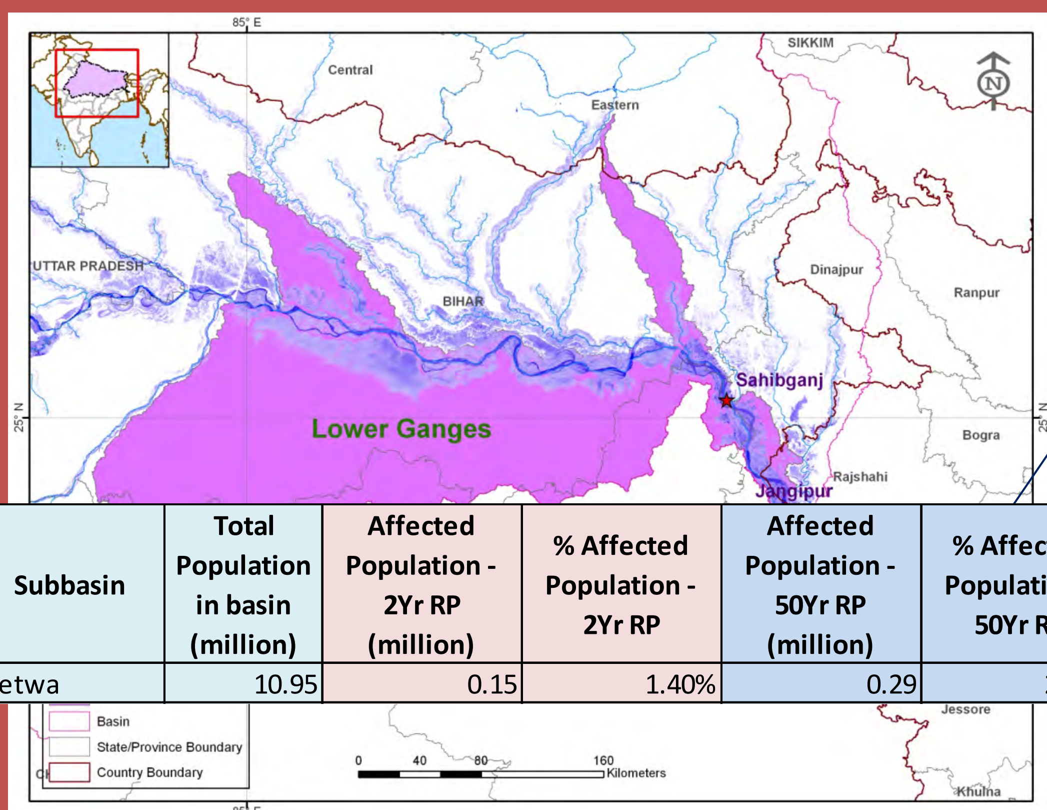
Ganges Basin - Flood Risk Atlas
Risk Map
Demography Affected (Years)
Building Affected (Years)
Infrastructure Affected (Years)
Agriculture Affected (Years)
Historic Flood
Flood Affected
2 Yr
5 Yr
10 Yr
25 Yr
50 Yr
100 Yr
Average Annual Loss
River
Railway
Road
Ramganga
Yamuna
Ghagra
Gandak
Kosi
Gomti
Kamla-Balan
Mahananda
Sind
Middle Ganges
Chambal
Lower Ganges
Betwa
Ken
Tons
Sone
India
Nepal
HIMACHAL PRADESH
CHANDIGARH
PUNJAB
UTTARAKHAND
HARYANA
UTTAR PRADESH
RAJASTHAN
MADHYA PRADESH
BIHAR
JHARKHAND
CHHATTISGARH
ODISHA
Risk Information
Summary
SubBasin : Kosi
Area: 15425
Demography
Charts & Graphs
Population in Thousand
Total
2 yr
10,000
7,500
5,000
2,500
0
Total
Male
Female
Population in the age group (0-6 years) in Thousand
Total
2 yr
2,000
1,500
1,000
500
You are at :
Design & Developed by RMSI
http://gangesfloodriskatlas.com/

Example Results 1: Population Affected

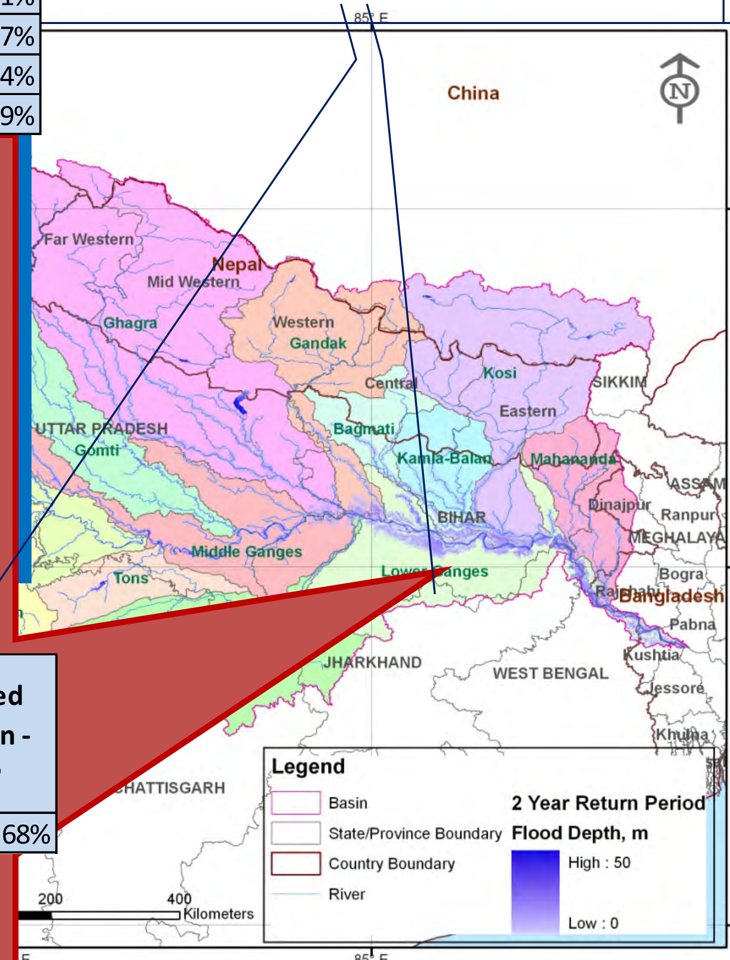
Subbasin	Total Population in basin (million)	Affected Population - 2Yr RP (million)	% Affected Population - 2Yr RP	Affected Population - 50Yr RP (million)	% Affected Population - 50Yr RP
Lower Ganges	48.68	13.11	26.93%	16.26	33.41%
India	441.47	49.89	11.30%	74.06	16.77%
Nepal	26.25	0.45	1.70%	0.67	2.54%
Total	474.09	52.87	11.15%	77.68	16.39%

Selevely Affected Sub-basin: Lower Ganges

Least Affected Sub-basin: Betwa

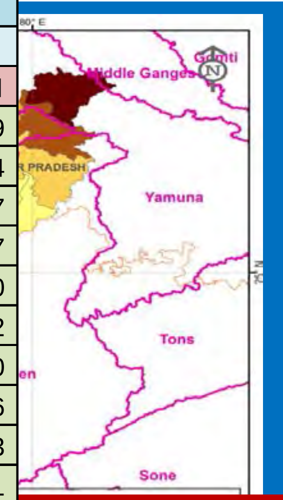


Subbasin	Total Population in basin (million)	Affected Population - 2Yr RP (million)	% Affected Population - 2Yr RP	Affected Population - 50Yr RP (million)	% Affected Population - 50Yr RP
Betwa	10.95	0.15	1.40%	0.29	2.68%

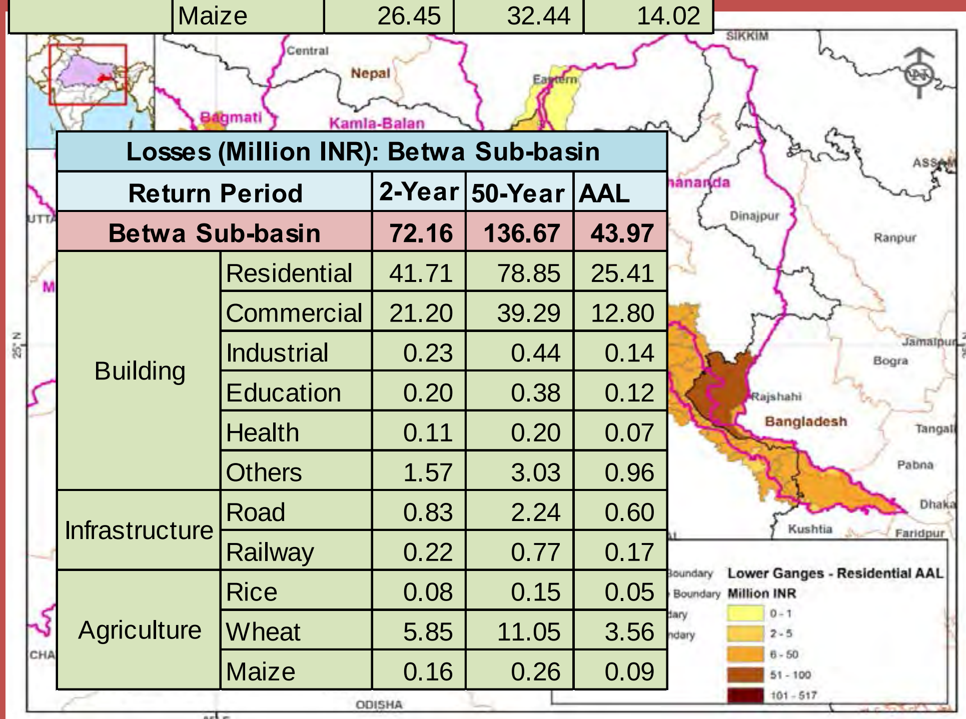


Example Results 2: Economic Losses

Losses (Million INR): Lower Ganges Sub-basin				
Return Period		2-Year	50-Year	AAL
Lower Ganges Sub-basin		**6,158.29**	**7,632.54**	**3,273.91**
Building	Residential	4,663.18	5,731.99	2,473.89
	Commercial	1,062.49	1,347.21	568.24
	Industrial	20.16	25.52	10.77
	Education	9.68	12.19	5.17
	Health	6.73	8.52	3.60
	Others	77.16	97.49	41.22
Infrastructure	Road	18.90	30.87	10.90
	Railway	21.92	32.94	12.36
Agriculture	Rice	188.96	234.01	100.23
	Wheat	62.66	79.36	33.51
	Maize	26.45	32.44	14.02

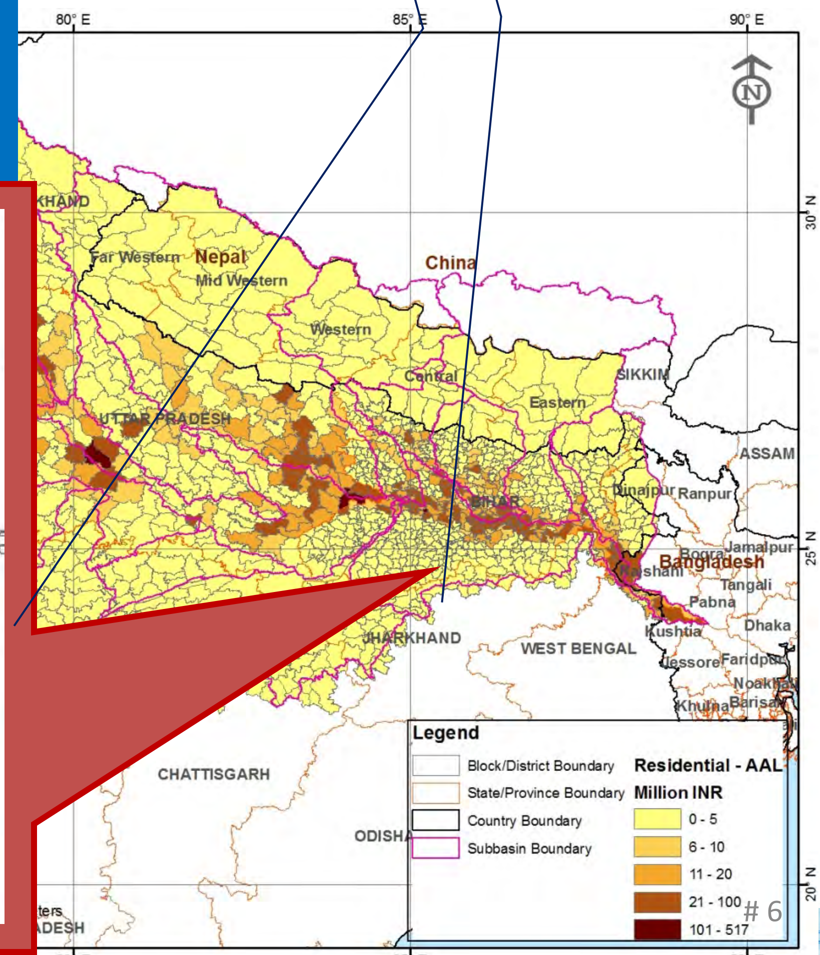


Losses (Million INR): Betwa Sub-basin				
Return Period		2-Year	50-Year	AAL
Betwa Sub-basin		**72.16**	**136.67**	**43.97**
Building	Residential	41.71	78.85	25.41
	Commercial	21.20	39.29	12.80
	Industrial	0.23	0.44	0.14
	Education	0.20	0.38	0.12
	Health	0.11	0.20	0.07
	Others	1.57	3.03	0.96
Infrastructure	Road	0.83	2.24	0.60
	Railway	0.22	0.77	0.17
Agriculture	Rice	0.08	0.15	0.05
	Wheat	5.85	11.05	3.56
	Maize	0.16	0.26	0.09



Severely Affected Sub-basin: Lower Ganges

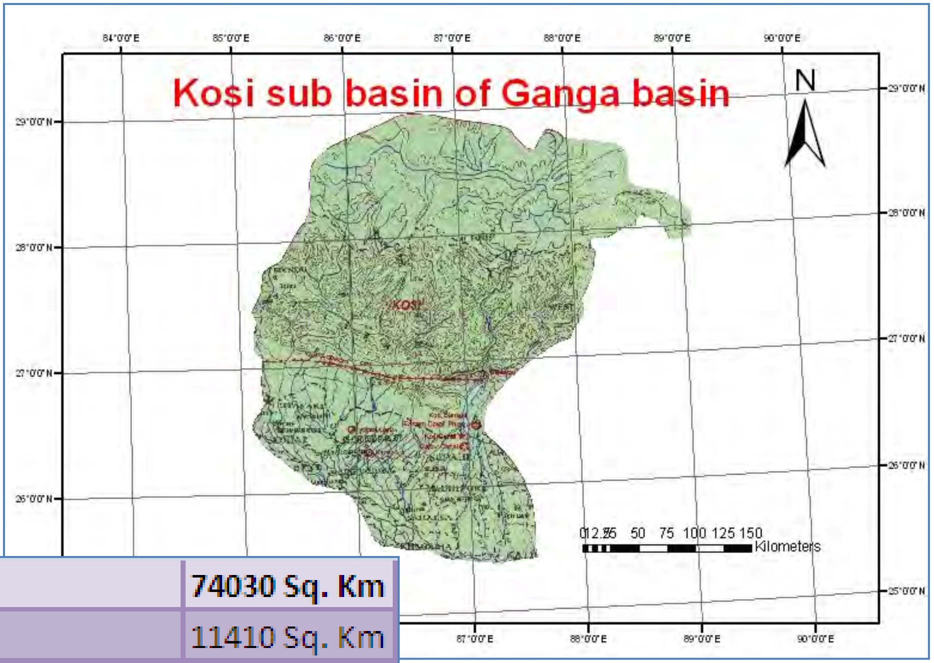
Least Affected Sub-basin: Betwa



Kosi Sub Basin: Glimpse

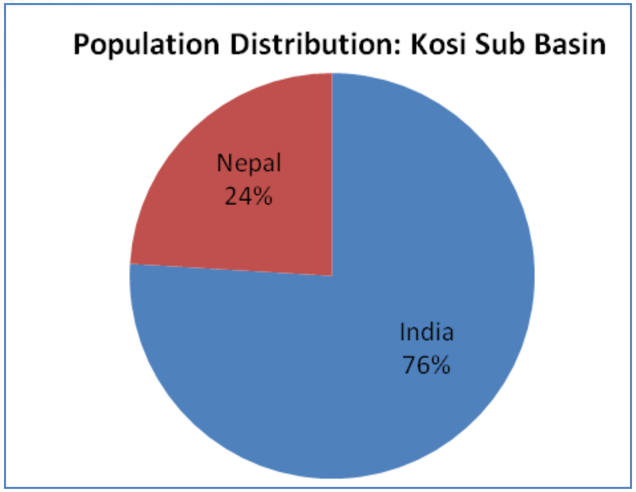
- Originates at an altitude of 7,000 m in the Himalayas

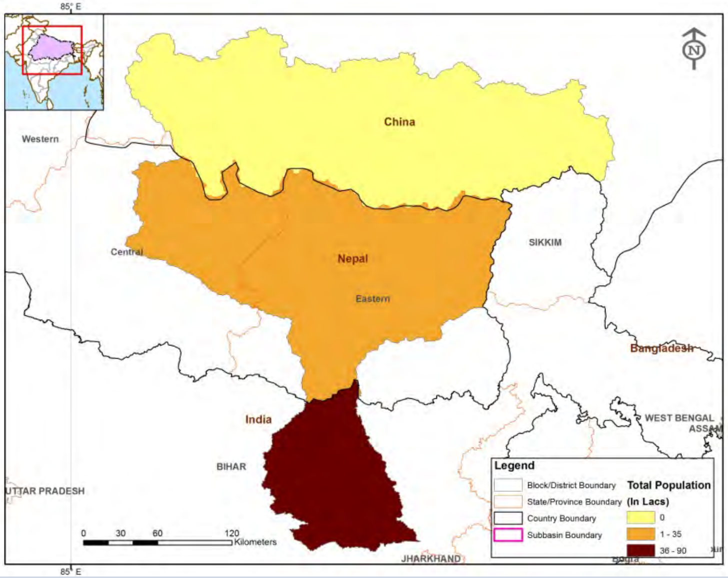
- Major tributary of the Ganga River



1	**Total Drainage Area**	**74030 Sq. Km**
2	Drainage Area in Bihar	11410 Sq. Km
3	Population in Bihar	66.55 Lakh
4	Water resources	52219 MCM
5	Average annual rainfall	1456 mm
6	Total length of main river in Bihar	260 Km
7	Cropped area in Bihar	8694 Sq.Km
8	Tributaries: Bagmati(R), Kamla Balan(R), Bhuthi Balan(R), Trijuga(R), Fariani dhar(L), Dhemama dhar(L)	

Demography and Agriculture





- 76 percent of the total population living under recurring threat of floods

Population Distribution: Kosi Sub basin							
India				Nepal			
Male	Female	0-6 year	Total	Male	Female	0-6 year	Total
4,655,844	4,249,207	1,788,028	10,693,079	1,604,514	1,780,117	-	3,384,632

Agriculture: Kosi Sub basin						
Country	Cropped Area, ha			Exposure Value, Million INR		
	Rice	Wheat	Maize	Rice	Wheat	Maize
India	351,752	190,652	128,968	9,814	5,489	5,601
Nepal	167,926	68,929	227,184	16,863	3,089	5,630

Flood Risk Assessment

- Third most severely affected sub-basin in the Ganges Basin
- Affected population due to a 2-year return period flood event is estimated at 1,822,000 and 81,000 for India and Nepal respectively
- 20.5%, and 2.4% of the total population of the area of the respective countries reside in the sub-basin

Sub-basin: Kosi						
Return Period	India			Nepal		
	Male	Female	Total	Male	Female	Total
2-Year	958	864	1,822	39	42	81
5-Year	1,170	1,057	2,227	47	51	98
10-Year	1,242	1,122	2,363	50	54	104
25-Year	1,286	1,162	2,448	53	56	109
50-Year	1,321	1,194	2,515	54	58	112
100-Year	1,343	1,214	2,557	55	59	114

Flood Risk Assessment contd.,

- Residential buildings bear the maximum losses followed by commercial buildings
- Residential buildings have a maximum AAL of INR 236 million that is 57.8% of total AAL
- Commercial buildings and rice crop are the second and third biggest contributors in total AAL with 31.6% and 3.1% contribution respectively

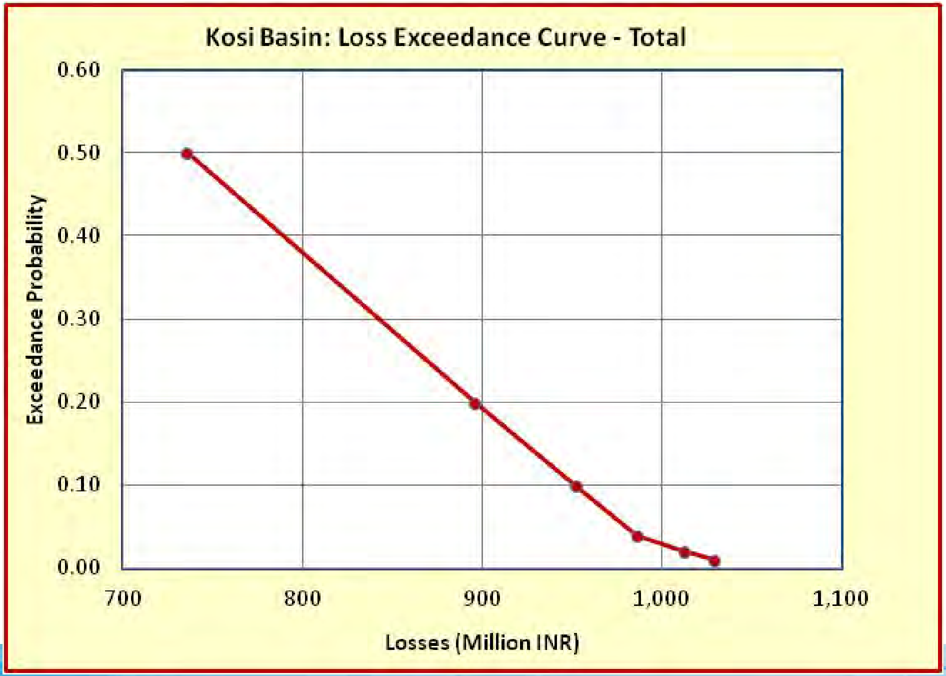
Losses (Million INR): Kosi Sub-basin								
Return Period		2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	AAL
Kosi Sub-basin		735.66	896.03	951.72	985.97	1,012.15	1,029.26	407.54
Building	Residential	428.81	514.9	544.3	562.18	576.06	584.76	235.64
	Commercial	229.6	285.58	305.57	317.87	327.12	333.5	128.74
	Industrial	2.64	3.25	3.46	3.59	3.69	3.76	1.47
	Education	0.93	1.12	1.18	1.22	1.25	1.27	0.51
	Health	0.47	0.55	0.58	0.6	0.62	0.62	0.25
	Others	12.83	15.8	16.84	17.47	17.95	18.27	7.15
Infrastructure	Road	5.14	6.67	7.2	7.64	7.98	8.25	2.96
	Railway	4.05	5.34	5.72	6.02	6.19	6.31	2.34
Agriculture	Rice	22.65	27.9	29.75	30.95	31.8	32.41	12.63
	Wheat	13.34	16.37	17.42	18.06	18.55	18.87	7.42
	Maize	15.19	18.55	19.7	20.36	20.93	21.26	8.42

Risk Assessment contd.,

State/Province wise Losses (Thousand INR): Kosi Sub-basin								
		Return Period						
Country	State/Province	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	AAL
India	Bihar	718,060	874,786	929,097	962,209	987,706	1,004,243	397,806
Nepal	Central	1,168	1,291	1,335	1,375	1,394	1,416	615
	Eastern	16,432	19,956	21,289	22,387	23,049	23,603	9,117

- Bihar State has the maximum AAL of INR 39.78 Core which is around 97.6% of sub-basin's total AAL

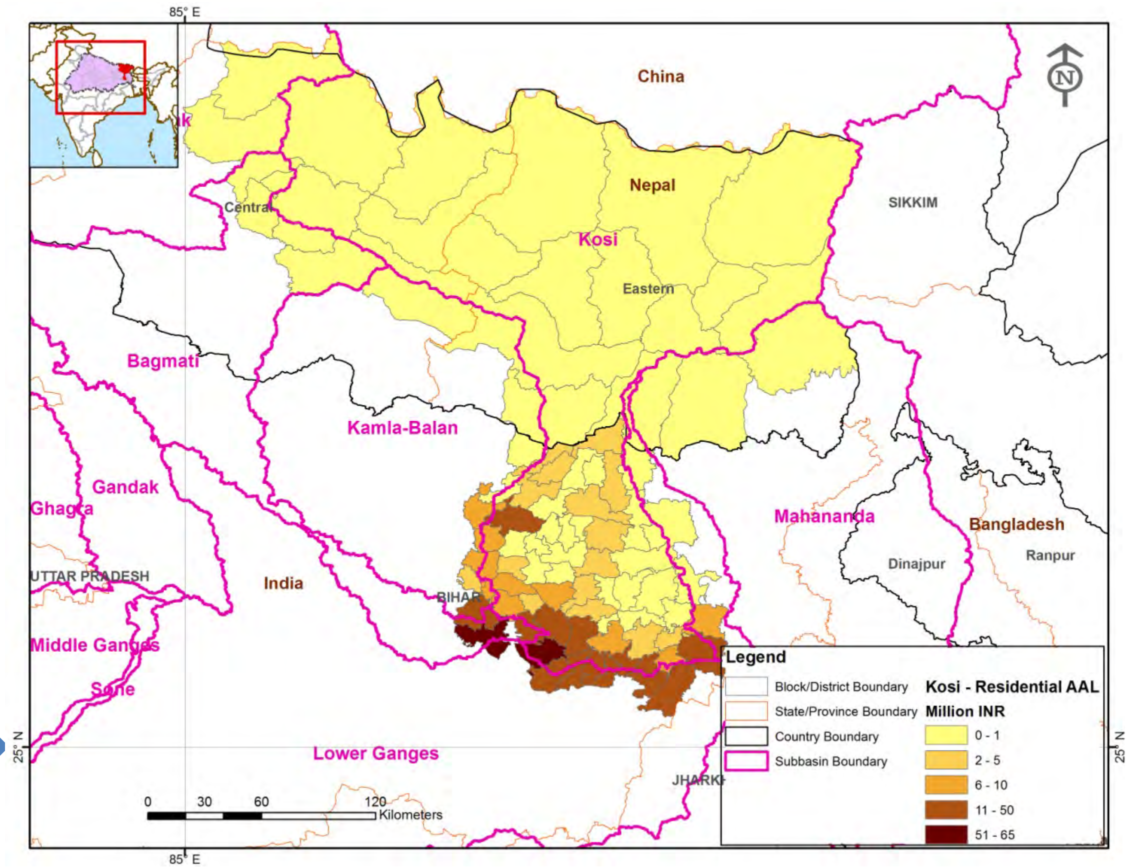
Loss Exceedance Curve: Kosi Sub basin



Risk Assessment contd.,

- Gogri, Alamnagar, Beldaur, Supaul, and Naugachhia in India are the worst affected blocks
- Maximum losses are incurred by the residential building class

AAL (million INR) due to floods for buildings: Residential



भारत सरकार
Government of India
केन्द्रीय जल आयोग
Central Water Commission
नदी आँकड़ा निदेशालय
River Data Directorate

No.4/29/2015/RDD/ 3447-53 Dated: 03.12.2015

Office Order

As desired by Chairman, Central Water Commission a committee "To finalize the modalities of taking over of Web based tools for Ganges Flood risk assessment developed by RMSI" is hereby constituted with the following members:

1. Shri M.P.Singh, Chief Engineer (P&D), CWC	Chairman
2. Shri Yogesh Paithankar, Director (RS), CWC	Member
3. Shri V.D.Roy, Director (FFM), CWC	Member
4. Shri N.K.Manglik, Director (RDD), CWC	Convener
5. Dr. Satya Priya, World Bank	Special Invittee

The terms and reference of the Committee is as under:

1. To firm up of the modalities for taking over Web based tools for Ganges Flood risk assessment developed by RMSI and hosting the same.
2. Review the data base and suggest suitable modifications before handing over.
3. Any other related issues.

(N.K.Manglik)
Director (RDD)

To conclude…

Ganges Floor Risk Assessment is aimed at - Improving flood risk information, capacity and coordination among the riparian countries in ***managing trans boundary flood risks***

- The time horizon of responses: Improvise choices for responses that have a long lead time (*ex-ante* approach)
    - Frontier science (technological intervention)
- Prioritize the schema of flood forecasting matrix at sub-basins level through ongoing diplomacy
    - Cooperation frontier (non-structural intervention)
- Move away from Central to State to Sub-basin scale operational flood forecasting options
    - Governance frontier (inter-state/ trans boundary cooperation); example: Baghmati Basin FMIS under Ganges FA
    - Strengthen operational flood forecasting agency/institution @State level

Thank you!
Spriya1@worldbank.org

http://gangesfloodriskatlas.com/

Spatial Data @ FMISC

Journey so far & the way ahead

By
Sanjay kumar
GIS Specialist
FMISC

Progress during phases

Started with borrowed layers from NRSC P-I

Updated through outsourcing P-I

More districts of flood prone North Bihar included **P-II**

Finally whole Bihar was covered **P-II**

Basic data layers- Drainage, Geomorphology, Soil, Landuse, Canal, Roads, Railway, Embankments, Administrative Boundaries,

Layers created in-house - Bridges, Sluice, Gauges ……

Spatial Data – Growing Need

More details in layers- Greater precision and details is being asked for by user, hence updating with higher resolution satellite images required

Update frequency- Normally using latest satellite images of moderate resolution e.g. LANDSAT 8 Images (15m) mostly for Rivers and ongoing constructions/ up-gradation (e.g. MDR to SH)

Data enrichment- Using departmental info as and when available, Gathering updates from peoples visiting fields

Inclusion of freeware data

Why use freeware ?

Geographical position of Bihar …

All catchments have a sizable part in neighbor's territories

Difficulty in outsourcing preparation of data for neighboring states & countries

Every modeling exercise requires wholesome information of the system, be it irrigation or flood

The way ahead.....

Introducing open source software for reaching down to field staff

Sharing among core user group for participatory mapping

Crowd sourcing of controlled kind

Going 3D

Thanks

An

Introduction to Bihar Kosi Basin Development Project (BKBDP)

by Anil Kumar, Deputy Director, *fmisc*

19 February, 2016

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1. BACKGROUND :-

❑ A National Disaster – The Kosi Breach

The Kosi River avulsed into its paleo channels on 18th August 2008 by breaching its Eastern Afflux Embankment near Kusaha village in Nepal, about 12.80 Km. upstream of Kosi Barrage.

This floods are considered the worst floods disaster in the last 50 years in India and were declared a national calamity by the Government of India.

According to the Post Disaster Needs Assessment, conducted by the World Bank and GFDRR in close cooperation with GoB more than 330,000 houses, 1,800 km of paved and unpaved roads, and 1,100 bridges and culverts were damaged. Approximately 600,000 acres of crops were ruined, impacting close to 500,000 farmers.

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- To mitigate 2008 Kosi River Flood disaster, the GoB with the assistance from the World Bank launched Bihar Kosi Flood Recovery Project (BKFRP) in first phase to address the short-term needs of the flood-affected population while in second phase as Bihar Kosi Basin Development Project (BKBDP) provides a comprehensive programme to tackle the longer-term challenges of overall disaster management, in particular for flood risk management and sustainable interventions in the area of agricultural productivity.

❑BKFRP Timeline –

March 2011

Details :
- Owner Driven Housing Reconstruction
  Target - 1,00,000 houses
- Roads and Bridges
  Roads - 290 Km rural roads
  Bridges - 74 Nos.
- Water Resources (Irrigation) Components -
  Strengthening Flood Management Capacity
  Knowledge Management and Capacity building
  Flood forecasting and Early warning
  Structural investments
- Livelihood Restoration and Enhancement (JEEVIKA) - Target 50,000 People
- Improving Emergency Response Capacity.
- Project Management Implementation Support.

- Kosi river flood management studies are being undertaken along with restoration of flood channel works and embankment road improvement works by the Implementing Agency – **WRD** and BAPEPS.

June 2016

2. INTRODUCTION – BKBDP :-

- The successor of BKFRP which provides a comprehensive programme for the State's longer term needs on overall disaster management, in particular for flood risk management and sustainable interventions in the area of agricultural productivity and road connectivity.

- Water Resources Management will be the one of prime area in that Phase.

3. OBJECTIVE:-

The project development objective is to **enhance resilience to floods, increase agricultural production** and productivity in the targeted districts in the Kosi River Basin, and to improve the Government of Bihar's capacity to respond promptly and effectively to an Eligible crisis or emergency.

4. DETAILS:-

- Loan Agreement has been signed between GoB and the World Bank on 20th January, 2016 having **total outlay of about 2250 crore INR** in which the share of **Water Resources department has ₹600 Crore** for flood management.

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4. DETAILS:-

❑ Snapshot of the Project Cost

Components (in US$ million)	Project cost	Bank contribution	GoB Contribution	Community' Contribution
Component 1: Improving Flood Risk Management	**100.0**	**66.7**	**33.3**	**0.0**
Component 2: Enhancing Agricultural Productivity and Competitiveness	82.5	50.0	25.0	7.5
Component 3: Augmenting Connectivity	173.0	115.33	57.67	0.0
Component 4: Contingent Emergency Response	0.0	0.0	0.0	0.0
Component 5: Implementation Support	27.0	18.0	9.0	0.0
Total	382.5	250.0	125.0	7.5

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4. DETAILS:-

Project Components

- Improving Flood Risk Management
- Enhancing Agricultural Productivity and Competitiveness
- Augmenting Connectivity
- Contingent Emergency Response and
- Implementation Support

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4. DETAILS:-

- **WRD** Component – Improving Flood Risk Management

4. DETAILS:-

❑ACTIVITIES – REINFORCEMENT OF FLOOD CONTROL INFRASTRUCTURE

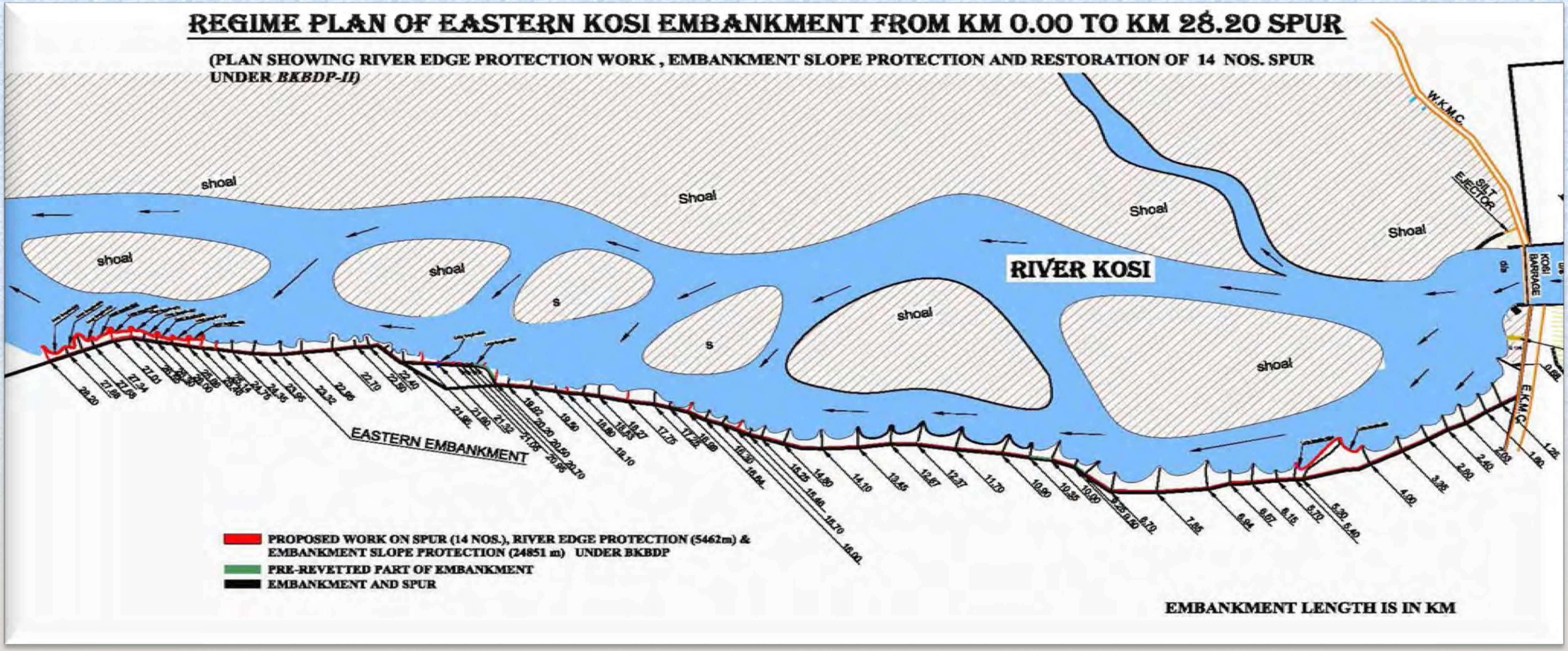
1

Protection and restoration of Spurs & Embankment between Km 0-28.20 of Eastern Kosi Embankment

2

Protection and restoration of Spurs & Embankment between Km 78.0-84.0 of Eastern Kosi Embankment

OVERVIEW OF PROTECTION WORK



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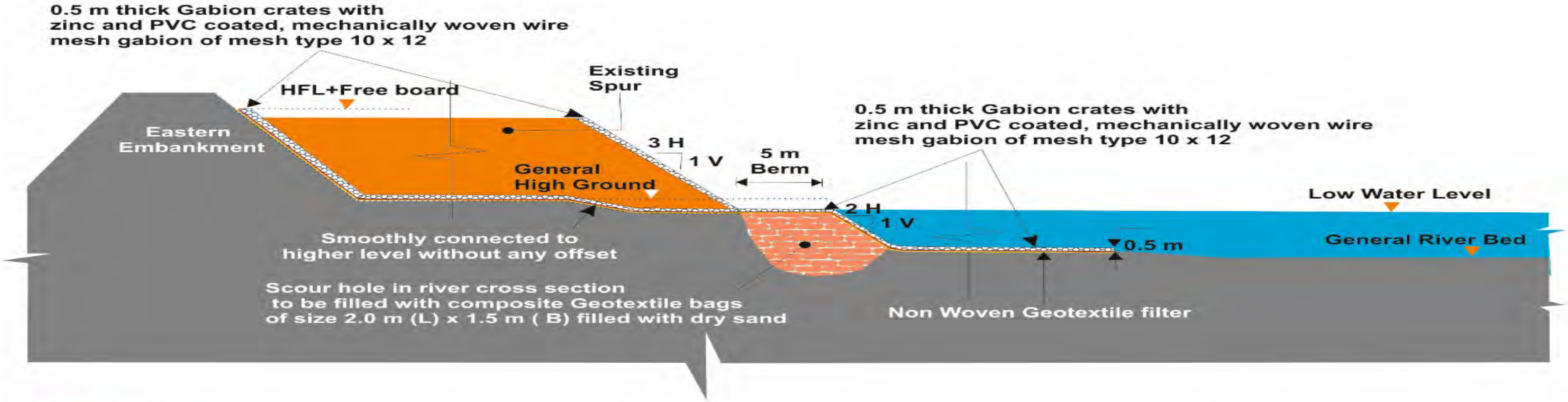
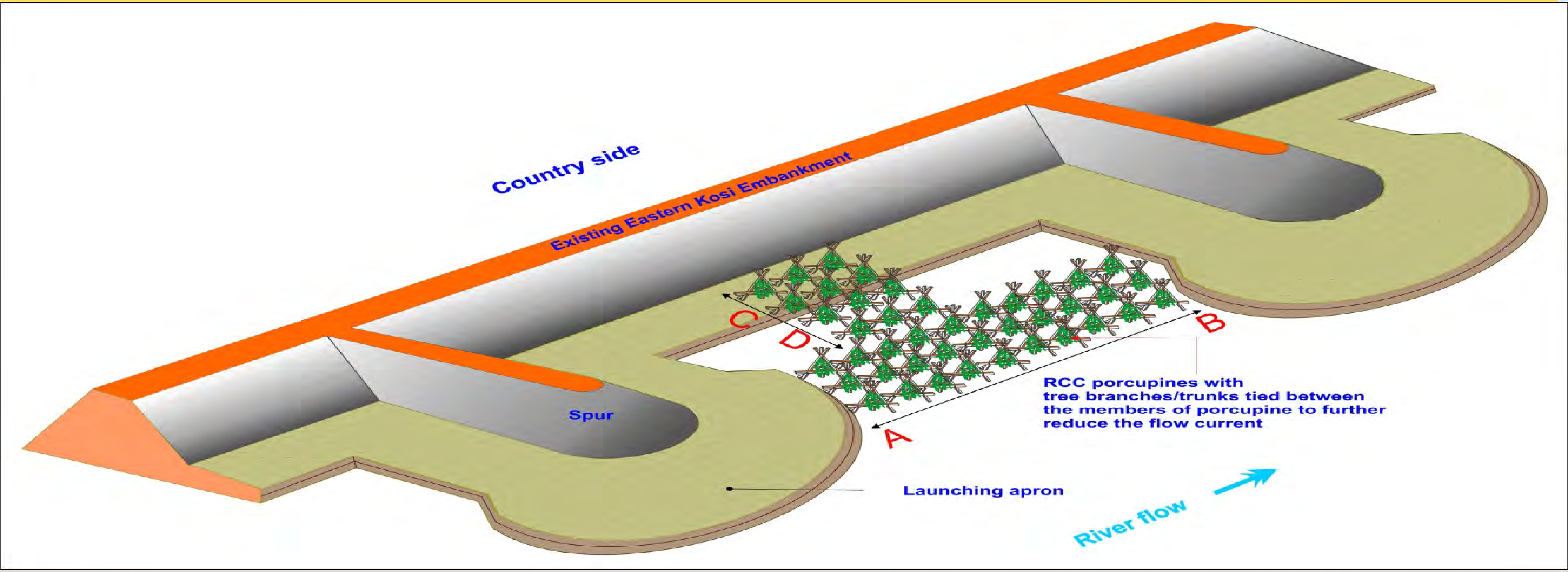
TYPICAL SECTION OF BANK PROTECTION WORKS NEAR THE SPUR AS RECOMMENDED BY CWPRS, PUNE



NOTE:

1. Sketch not to scale.
2. Geofabric filter should be continued from top of bank, bank slope and further under launching apron.
3. Length of the launching apron may be decided based on the sample computations given in the text for various reaches
4. 0.5 m thick mattress shall be mechanically woven double twisted forming hexagonal shape with Mesh wire dia. of 2.7/3.7 mm (ID/OD). Mesh shall be mechanically edged/ salvedged with galvanisation and partitions at every 1 m interval and shall have a minimum 10 numbers of mesh openings per meter of mesh perpendicular to twist.
5. Geotextile bags shall be with Woven layer on outer cover and non woven polyester layer in the inner layer filled with dry sand containing less than 15 % fines.
6. The sketch shown above is typical section of protection works. However, the site engineers are advised to assess the actual site condition, scour filling, river bed profile/level, etc., and may accordingly modify the protection works. Table 6 provides various slopes for protection works.

TYPICAL THREE DIMENSIONAL VIEW OF RCC PORCUPINE SPURS AND DAMPNERS ALONG THE LOOP BETWEEN SPURS AS RECOMMENDED BY CWPRS, PUNE



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4. DETAILS:-

❑ACTIVITIES – REINFORCEMENT OF FLOOD CONTROL INFRASTRUCTURE

3

Protection and restoration of extended Sikarhatta Manjhari low bundh between Km 6.0-13.50 and Western Kosi Embankment D/S of Ghogardiha between Km 30.10-47.40

4

Procurement of 2/3 nos. dredgers

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4. DETAILS:-

❑ACTIVITIES –SUPPORT TO STRENGTHEN INSTITUTIONAL CAPACITY TO MANAGE FLOOD RISK

1

Establishment of Centre of Excellence for Water Resources Research & Development under WRD

2

Procurement of Real Time Data Acquisition System RTDAS for Bagmati- Adhwari and Kosi Basin

4. DETAILS:-

❑ACTIVITIES –SUPPORT TO STRENGTHEN INSTITUTIONAL CAPACITY TO MANAGE FLOOD RISK

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5. Success Story of BKFRP :-

Strengthening Flood Management Capacity in Kosi Basin

- Structural activities
- Non-structural activities

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5. Success Story of BKFRP - Structural activities :- 1

Restoration of Western Kosi Embankment from 15.0 km to 23.0 km in the reach of 8.0 km with black topping on the top of Embankment.

(Completed)

5. Success Story of BKFRP - Structural activities :-

Picture Showing Black topping Work on Western Embankment (15.0-23.0 km)

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5. <u>Success Story of BKFRP</u> - Structural activities :-

Picture Showing Black topping Work on Western Embankment (15.0-23.0 km)

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5. Success Story of BKFRP - Structural activities :-

Picture Showing Restoration of spur located on Western Embankment

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5. Success Story of BKFRP - Structural activities :-

2

Restoration of three Dhar – Sanjay Dhar, Haiyya Dhar and Bochha Dhar damaged by flood.

(Completed)

5. Success Story of BKFRP - Structural activities :-

Picture Showing Protection of Dhar

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5. Success Story of BKFRP - Structural activities :-

Picture Showing Flowing of water after restoration of Sanjay Dhar

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5. Success Story of BKFRP - Structural activities :-

Picture Showing Flowing of water after restoration of Haiya Dhar

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5. <u>Success Story of BKFRP</u> - Structural activities :-

Picture Showing Flowing of water after restoration of Haiya Dhar

5. Success Story of BKFRP - Structural activities :-

3

Protection and Restoration of 18.0 nos. spurs located between 0.0 to 15.5 km of Eastern Kosi embankment D/S of Barrage.

(Tender Process)

5. <u>Success Story of BKFRP</u> - Structural activities :-

5. Success Story of BKFRP – Non-Structural activities :- 1

To develop Flood Forecasting , Inundation Mapping and Early Warning System

(under process)

5. Success Story of BKFRP – Non-Structural activities :-

2

Embankment Asset Management System (EAMS)

(completed & in maintenance phase)

5. Success Story of BKFRP – Non-Structural activities :- 3

Developing approach protocols and mechanism for community participation in Embankment Surveillance

(ongoing)

5. Success Story of BKFRP – Non-Structural activities :-

3

Developing approach protocols and mechanism for community participation in Embankment Surveillance

Continuously monitor the status and safety of embankments to rationally assess the need and nature of embankment maintenance, and anti-erosion works or flood fighting works to protect the embankment assets and the downstream habitations. It is now increasingly being realized that to supplement and complement the efforts of WRD in embankment surveillance, community participation is of vital importance.

5. Success Story of BKFRP – Non-Structural activities :-

3

Developing approach protocols and mechanism for community participation in Embankment Surveillance

The surveillance of long stretches of embankments by community members residing along the embankment stretches will not only help the department in close monitoring of the embankment condition but will also prepare the community in raising their awareness level with regard to various human activities that in the present sometime lead to damages in the embankment condition.

5. Success Story of BKFRP – Non-Structural activities :-

3

Developing approach protocols and mechanism for community participation in Embankment Surveillance

Later on, Developed protocol is added in EAMS.

5. Success Story of BKFRP – Non-Structural activities :- 4

River behavioral analysis in Kosi Basin (ongoing)

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5. Success Story of BKFRP – Non-Structural activities :-

4

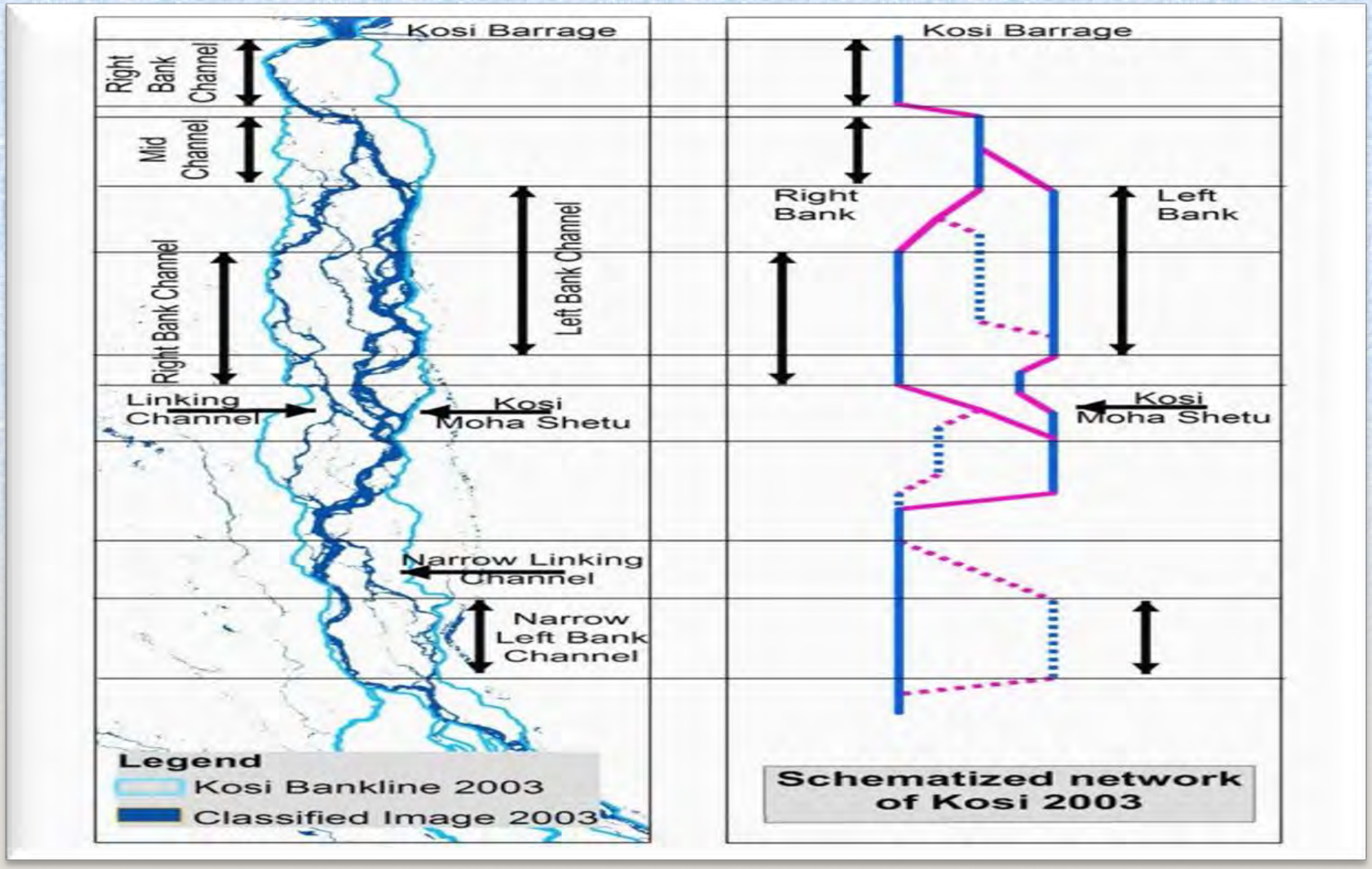
River behavioral analysis in Kosi Basin

In order to study the morphological behaviour of the Kosi River, we developed a GUI based prediction tool through channel network analysis. It is mainly done by the assessment of the existence of the channel within the river boundary. Then the channel network of different years have been imposed to identify the vulnerable zones along the river bank. The model is able to predict the vulnerable zones as well as the vulnerability of the embankment one year ahead.

5. Success Story of BKFRP – Non-Structural activities :-

4

River behavioral analysis in Kosi Basin



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5. Success Story of BKFRP – Non-Structural activities :-

4

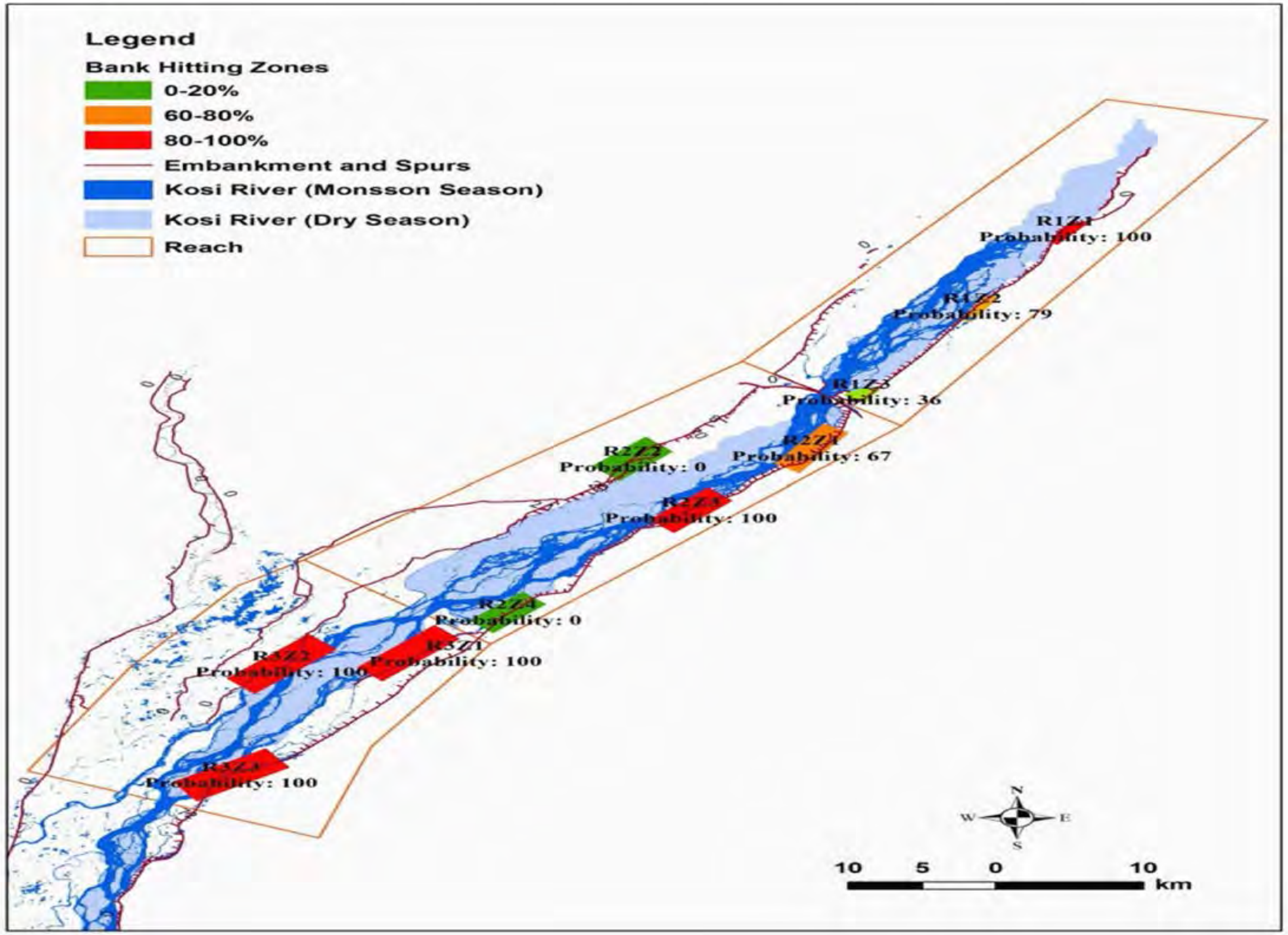
River behavioral analysis in Kosi Basin

The model is set for the reaches 1, 2 and 3. The model predicts the different bank hitting zones/ vulnerable zones along the both bank of the Kosi River.

5. Success Story of BKFRP – Non-Structural activities :-

4

River behavioral analysis in Kosi Basin



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5. Success Story of BKFRP – Non-Structural activities :-

4

River behavioral analysis in Kosi Basin

Along with the prediction of the bank hitting zones, the model is also capable of vulnerability of the embankment as well as the channel pattern within the spurs which helps to assess the vulnerability of the embankment, spurs as well as the floodplain within both banks with map as well as a tabular form.

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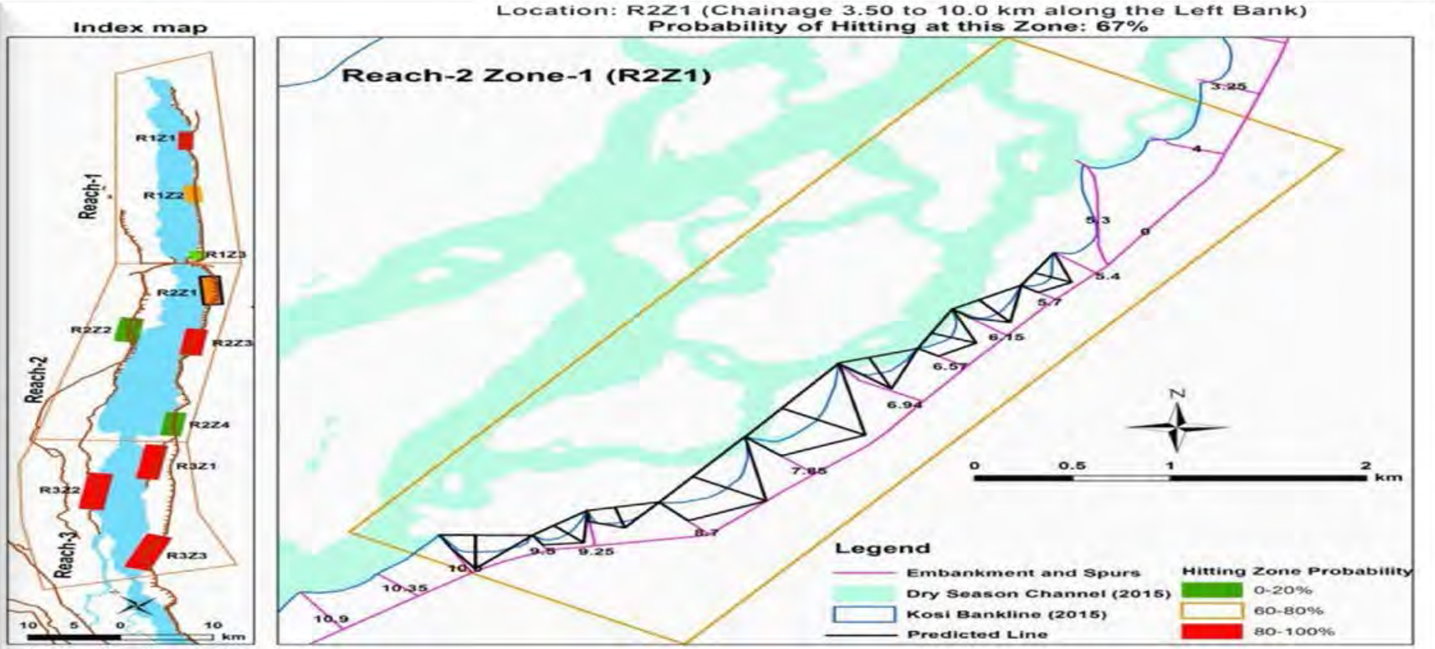
5. Success Story of BKFRP – Non-Structural activities :-

4

River behavioral analysis in Kosi Basin



Reach	Zone	Spur (Chainage-km)	Present		Predicted				Vulnerability	
			CL	ED	DSS	PL	D	ED	Floodplain Vulnerability	Embankment Vulnerability
Reach 2	Zone 1A	5.4 - 5.7	375	98	146	112	255	217	Yes	
Reach 2	Zone 1A	5.7 - 6.15	428	172	167	128	306	248	Yes	
Reach 2	Zone 1A	6.15 - 6.57	437	67	170	131	348	253	Yes	
Reach 2	Zone 1A	6.57 - 6.94	435	136	170	130	444	252	Yes	
Reach 2	Zone 1A	6.94 - 7.85	887	196	346	266	548	514	Yes	Yes
Reach 2	Zone 1A	7.85 - 8.7	794	211	310	238	469	461	Yes	Yes
Reach 2	Zone 1A	8.7 - 9.25	378	160	147	113	372	219	Yes	
Reach 2	Zone 1A	9.25 - 9.5	376	111	146	112	263	218	Yes	
Reach 2	Zone 1A	9.5 - 10	472	171	184	141	296	273	Yes	Yes

Condition for Vulnerability:

1. If Predicted ED< Present ED, Less Vulnerable
2. If Present ED<Predicted ED<0.9D, Vulnerable to Floodplain
3. IF Predicted ED> 0.9D, Vulnerable to Floodplain and Embankment

Note:

ED = Maximum Embayment Depth
CL = Cord Length
PL = Protrusion Length
DDS = Distance from downstream spur to the position of maximum embayment depth on Cord

5. Success Story of BKFRP – Non-Structural activities :-

5

Master Plan for flood and Sediment Management (ongoing)

5. Success Story of BKFRP – Non-Structural activities :-

5

Master Plan for flood and Sediment Management

Objective

Prepare a comprehensive Master Plan for flood and sediment management, and determine a set of priority structural and non-structural measures that will provide sustainable flood and sediment management up to safety level, which are environment friendly, socially acceptable and techno-economic viable.

5. Success Story of BKFRP – Non-Structural activities :-

5

Master Plan for flood and Sediment Management

Existing Problems

 # Excessive generation of sediment in upper catchments in Nepal.

 # Heavy siltation at u/s of Kosi Barrage.

 # Problem of shifting of course due to aggradation, degradation, braiding and meandering characteristics of the Kosi River.

 # Erosion and overtopping leading to breaches of Kosi Embankments.

5. Success Story of BKFRP – Non-Structural activities :-

5

Master Plan for flood and Sediment Management

Existing Problems

 # Inundation due to annual flooding of 395 villages located between the two embankments.

 # Flooding (450 sq. km) and drainage congestion of the area east of the Eastern Embankment.

 # Water logging and drainage congestion in the command of eastern Kosi canal.

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5. Success Story of BKFRP – Non-Structural activities :-

5

Master Plan for flood and Sediment Management

Management Unit

1) The catchment area upstream of Chatra (Outside India) in Kosi river system.

2) Barrage and appurtenant works.

3) The Kosi River Course (From Chatra to Kursela):

a. From Chatra to Kosi Barrage;

b. From Kosi Barrage to Koparia;

c. From Koparia to Kursela.

5. Success Story of BKFRP – Non-Structural activities :-

5

Master Plan for flood and Sediment Management

Management Unit

4) Embankments:

a. Upstream of Kosi Barrage;

b. Downstream of Kosi Barrage – Eastern Embankment

c. Downstream of Kosi Barrage – Western Embankments

5) Area between embankments (between Barrage & Koparia)

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5. Success Story of BKFRP – Non-Structural activities :-

5

Master Plan for flood and Sediment Management

Management Unit

6) Area east of the eastern embankment

a. Area suffering from drainage congestion;

b. Area suffering from flood problem.

7) Area west of western embankment suffering from drainage problem.

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5. Success Story of BKFRP – Non-Structural activities :-

5

Master Plan for flood and Sediment Management

Provide base/support for selection of appropriate measures for the Master Plan, the following model studies have been under taken:

Morphological Study

Sediment Yield.

1D Hydrodynamic Model.

1D Sediment Transport Model.

2D Hydrodynamic Model.

Identification of Vulnerable Reaches based on Imageries.

5. Success Story of BKFRP – Non-Structural activities :-

5

Master Plan for flood and Sediment Management

Current Status

For most critical management units: Management Unit No. 1 – Upper Catchments and Management Unit No. 5 – The Area between two embankments, the draft Master Plan have been finalized and the rest are also under advanced stage of finalization.

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5. Success Story of BKFRP – Non-Structural activities :-

6

Preparation of (DPR) for establishment of Centre of Excellence for Water Resources Research & Development under Water Resources Department, Bihar

(ongoing)

6. Conclusion

That's all. Our learning and creating best ideas are still in process.

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HYDROLOGY PROJECT
CRUCIAL FOR INDIA

National Hydrology Project

RELIABLE, TIMELY, QUALITY, CONSISTENT, PUBLIC DATA

Dr. Saroj Kumar Verma
Deputy Director, FMISC, WRD, Bihar

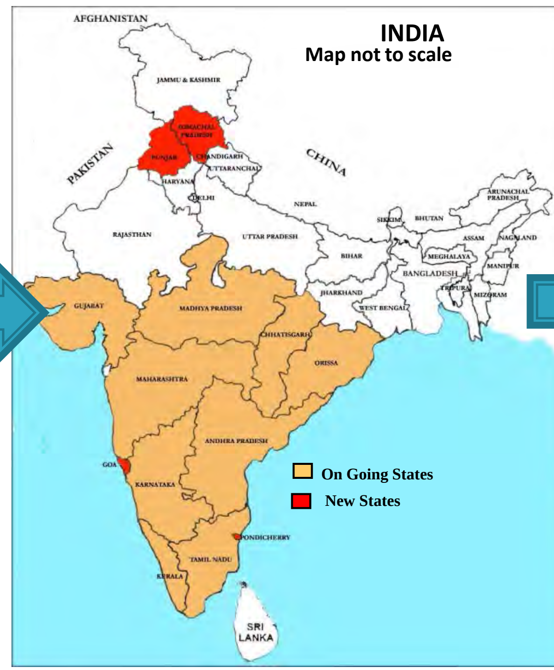
HYDROLOGY PROJECT – Journey Ahead

India Water Resources Management Program – Hydrology Project

HP-I

- 9 States
- 6 Central Agencies

HP-II



- 13 States
- 8 Central Agencies

NHP

Across All Indian States and UTs

National Perspective

State Perspective (WRD, Bihar) : Surface Water Components

- There are total 47 Implementing Agencies including 8 Central Agencies, 37 State level agencies and UTs and 2 River Basin Organisations.
- Central Agencies involved are : MoWR, RD&GR; CWC, CGWB, NIH, CPCB, SoI, NRSC and CWPRS.
- Total Project Cost : INR 3640 Crore
- WRD, Bihar is Implementing Agency for Surface Water Components in Bihar,
- Minor WRD, Bihar is IA for Ground Water Components.

Project Design
Objectives and Key Indicators

Part of a long-term program/series of projects

Development Objective: Modernize nation-wide the data, information and knowledge support for water resources management, planning and operation in India

Key Indicators to monitor:

- Functioning National and regional Water Resources Information and Knowledge Centers
- Functioning WRIS monitoring networks and India-WRIS data base up-to-date
- Key Water Resources data, information and knowledge products available in the public-domain
- Hydrologic, Flood Forecasting, WRM and Decision Support System tools and products in use in all major river basins for operational, design and planning purposes

Proposed Components

A. Modernizing Water Resources Monitoring system (WRMS)
B. Modernizing Water Resources Information Systems (WRIS)
C. Water Resources Management Tools and Applications (WRMTA)
D. Modernizing Institutions and Capacity Building

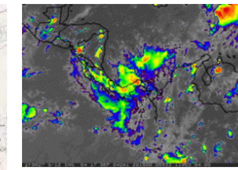
Component A
Modernizing Water Resources Monitoring System

A1. Water resources monitoring systems

- Modernize and expand water resources monitoring (*including real time*) systems including:
  - Weather: Automatic Weather Stations , rainfall and Snow gauges.
  - Rivers: Stage/discharge of Rivers, water quality, rating curve updating
  - Groundwater levels and GW quality
  - Reservoirs/tanks: Water levels, gate positions, outflows and spillways, update rating curves
  - Water uses: main canal water levels, intakes, return flows (drainage)
  - Sediment transport and load monitoring
  - Coastal monitoring
- Introduce Community based and mobile based monitoring in particular for small streams, groundwater and water bodies, floods, embankment status.

Component A
Modernizing Water Resources Monitoring System

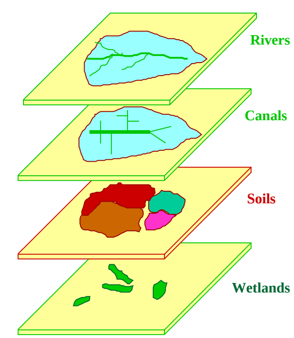
A2. Data rescue and processing

- Digitization, categorization and integration of paper data and documents (e.g. documents, books, maps) across agencies
- WQ Laboratories
- Computerized data entry systems for modernizing priority manual systems
- Upgrade centralized and web-based data storage management and dissemination systems including mobile applications for data entry.
- Data sharing and data validation across agencies

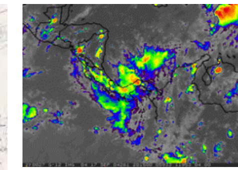




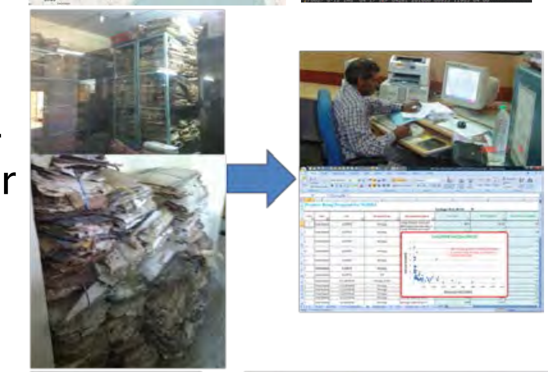


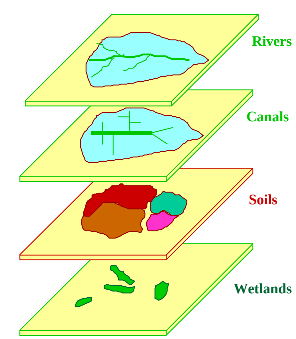
Component A
Modernizing Water Resources Monitoring System

A3. Targeted Surveys in selected areas



- Development of DEM for the entire country for improved flood mapping and other planning purposes:
  - High resolution surveys such as LIDAR for flood prone areas and for purpose of flood risk mapping (40 Mha)
  - High resolution remote sensing imageries and other supplementary information to develop DEM for other areas (much available NRSC)
- Develop spatial River Basin information system based on historical data, maps and satellite imageries including:
  - Existing water bodies and their usage.
  - Canal system networks
  - Land use and performance of irrigation systems
  - Inventories of water pollution.
- Reservoir Sedimentation surveys
- Bathymetric river surveys in critical areas
- Groundwater/aquifer mapping
- Water quality/waste loads
- Other environment (e.g. wetlands, erosion, e-flows, etc.)





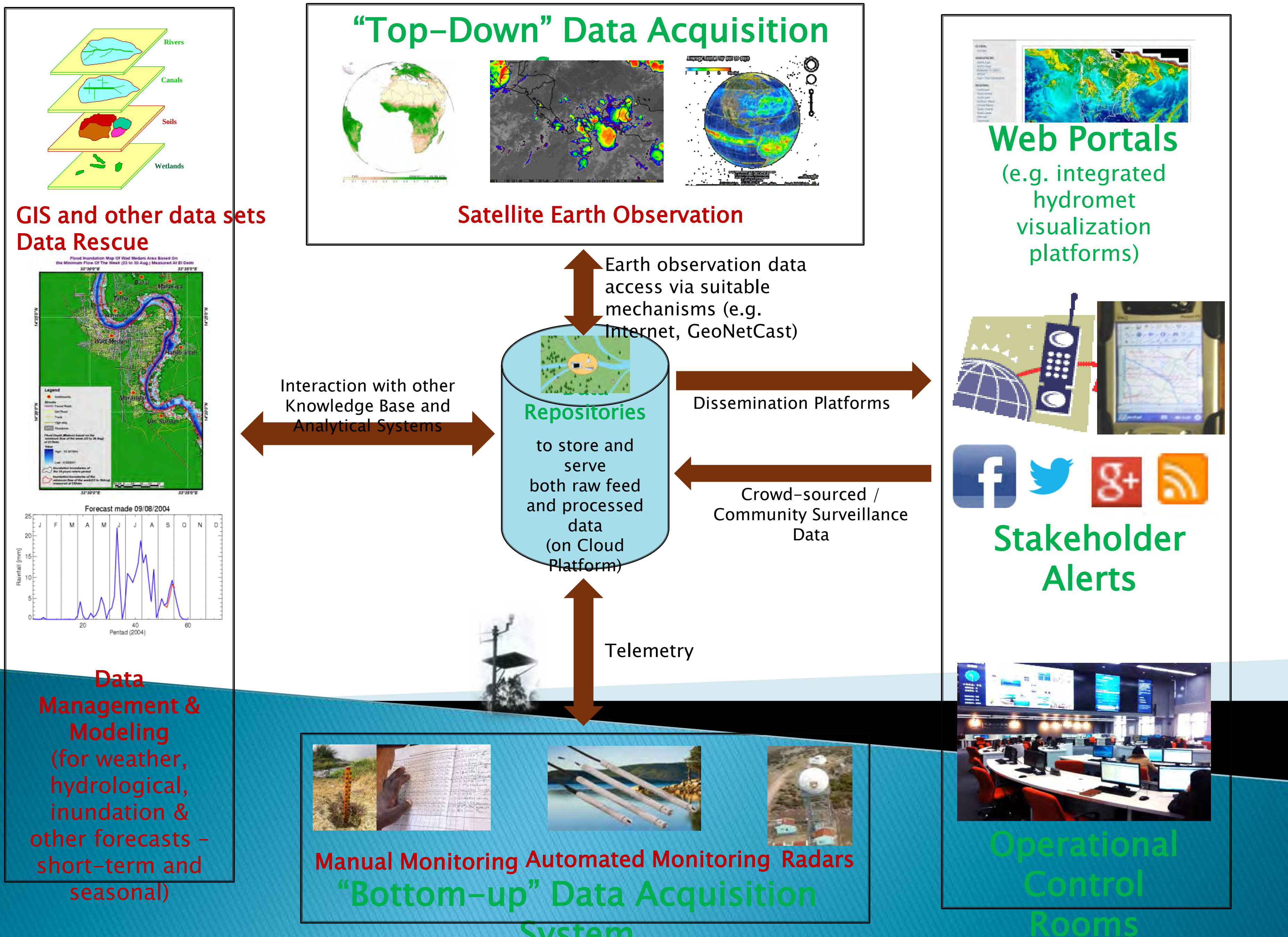
Component B

Modernizing Water Resources Information Systems

B1: Spatial Information and Knowledge Services and Products

- Temporal Earth Observation products for the entire country (including upper catchments in Himalayas) for regular updating of:
  - Estimation of precipitation, snow cover and snow melt, soil moisture, land use and actual evapotranspiration (ET)
  - Runoff estimates as the basis for flood forecasting and reservoir operations
  - Monitoring of cropping patterns, crop conditions, droughts and water supply conditions in irrigation systems
  - Monitoring of water logging, water storage in tanks and other water bodies
- Development of a web-based hydrological modelling system for the entire country (Hydro-India)
- Provide access to multiple short- and medium range weather forecasting products, to improve flow/flood forecasting, reservoir operations, cropping planning, drought management, etc.
- Provide easy access to climate change projections for Climate Risk Assessments.

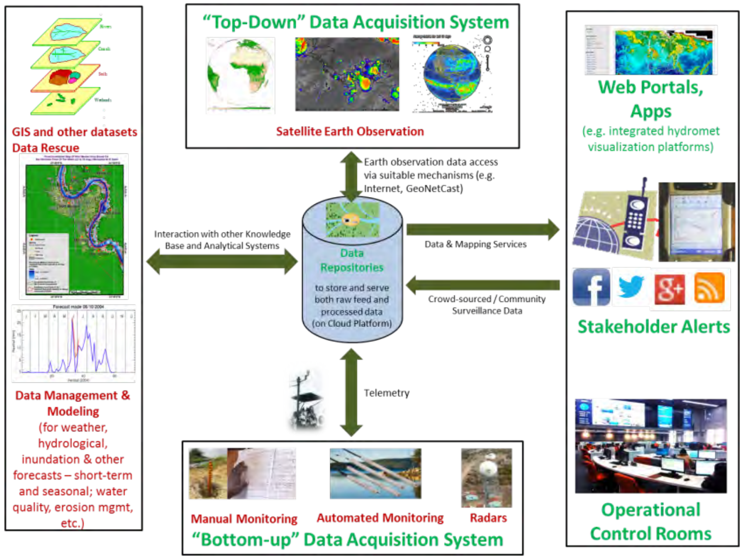
Vision for National Water Informatics Cente



Component B
Modernizing Water Resources Information Systems

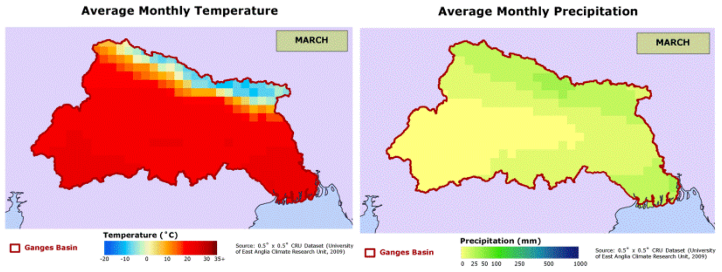
B2. Water Resources Information System

- Develop web-based integrated portal for water resources information (incl. e.g. “bottom-up” monitoring data from gauges/radars and “top-down” satellite products; curated spatial information from legacy data and surveys, etc.)
- Data quality management and statistics



B3. Public-Domain Services

- Provide public-domain information services (incl. online open data and map services, digital-online libraries)
- Provide information products (e.g. online yearbooks, online interactive atlases, customizable interactive visualization dashboards, benchmarking products)

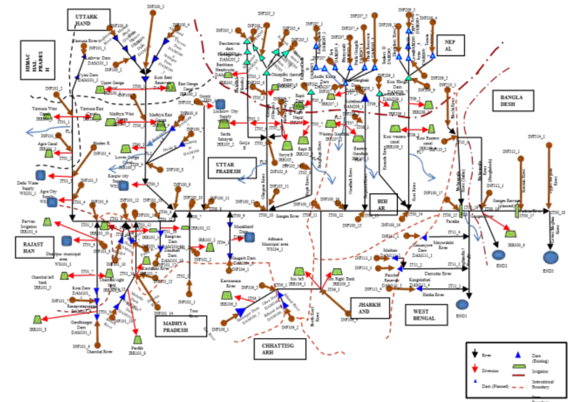


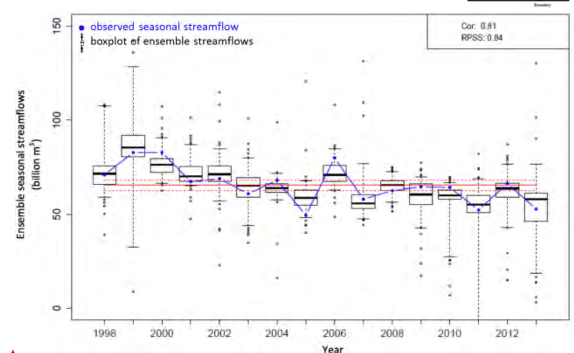
Component C

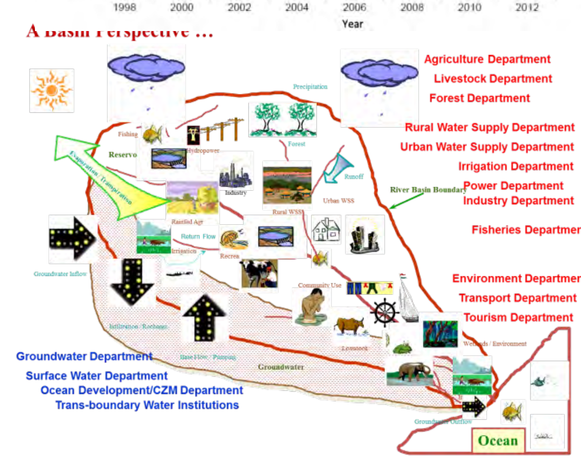
Water Resources Management Tools and Applications

C1. Water Resources Management Tools

- Planning and Decision Support Systems (e.g. for river basin planning, introduction of community based groundwater management, climate risk assessment, water quality management, watershed planning, scenario analysis for investment planning
- Design Tools: Modernizing design tools such as hydrologic design aids to improve design practices of WR infrastructure
- Flow/Flood Forecasting Tools (e.g. short-term and seasonal forecasts for floods, flows, inundation, droughts)
- Operational Management Tools (e.g. for reservoirs, irrigation systems and other water infrastructure operations, flood and drought management – incl. flood and drought preparedness, abstractions, and spill management)





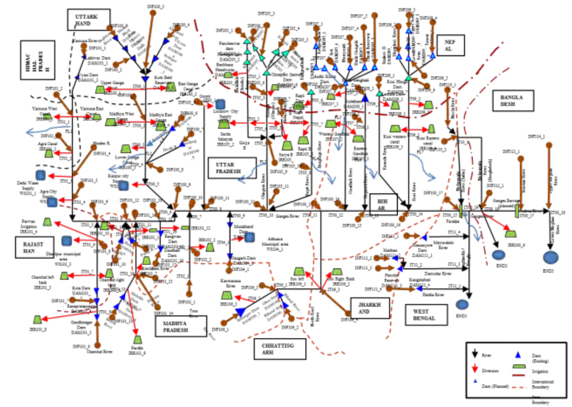


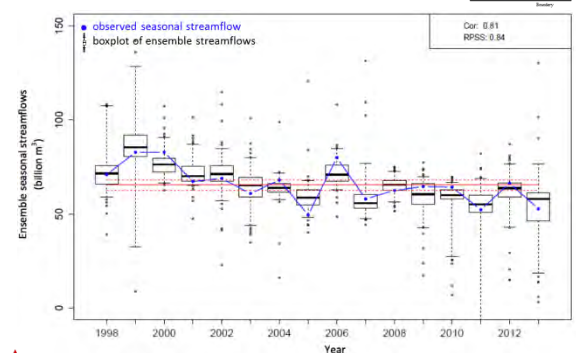
Component C

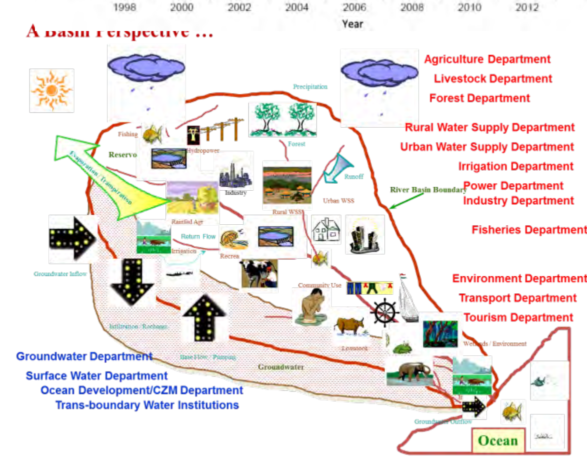
Water Resources Management Tools and Applications

C2. Water Knowledge Products

- Pilot River Basin Management Plans (with stakeholder involvement)
- Customizable knowledge portals and mobile Apps; Bulletins (e.g. flood forecasting)
- Special Issue based Studies (e.g. on climate change and basin performance)
- Flagship Knowledge Products (e.g. State of India’s Water Resources)







Component D – Modernizing Institutions and Capacity Building

D1. Integrated Water Resources Knowledge Centers

- Establishment of the **National Water Informatics Center** (integrated Center of Excellence for water resources knowledge and analysis, including use of modern modeling tools; provision of national helpdesk services) – with deputed experts from various Departments
- **Sub-National Level** (similar downscaled centers at basin, regional or state levels based on requirements)

D2. Water Resources capacity-building

- Policy Support (e.g. data pooling, data quality management, enhancing public-domain information)
- Institutional Modernization Support (e.g. processes, manuals, information systems design)
- Modernizing offices (including laboratory and information management tools
- Strengthened Partnerships (e.g. with earth observation data and other knowledge providers, Open Data Initiatives, Academia, Schools, etc. Internships/Visiting Experts/Development Assignments, international exchange programs.




Component D – Modernizing Institutions and capacity building

D3. Training & Outreach

- Annual Water Resources Knowledge Forum (showcasing the best of what India has to offer and facilitate knowledge exchange)
- Training (incl. curriculum development, technical courses, refresher courses
- Multi-media: Distance Learning (e.g. using videoconferencing), e-learning (incl. self-paced courses, webinars), Vendor Fairs; Regular Video & Audio Podcasts; Documentaries
- Competitions

D4. Project Management and Technical Assistance

- *Establishment of a permanent WRIS Coordination Secretariat*
- Project Implementation Facilitation (e.g. technical assistance and support for procurement, financial management, safeguards, training and sustainability)
- Project Monitoring (M&E, reporting)

Expected Benefits

- Standardized countrywide water resources database and country under one water resources information framework
- Creating centers of excellence to provide modern water resources knowledge services and partnerships
- Focus on use of water resources information for addressing critical water challenges in the country
- Improved output/outcome focus due to performance-based financing for a broad range of organizations
- Modernizing learning and knowledge exchange
- Improved access to information in the public-domain

CONCEPT NOTE

for

NATIONAL HYDROLOGY PROJECT

in

BIHAR

WATER RESOURCES DEPARTMENT, GOVT. OF BIHAR

Bihar : an Overview
Why National Hydrology Project is needed in Bihar

- Bihar accounts for about 17% of the flood-prone area and 22% of the flood-prone population in India.
- As much as three-fourths of Bihar's area is flood-prone and three-fourths of north Bihar's population lives under the threat of recurrent floods.
- Bihar's vulnerability to floods is due to
  - its very flat topography just downstream of the Himalayas,
  - intense monsoonal rains (more than 2,500mm/yr in the upstream areas and about 1,200 mm/yr in the State,
  - high sediment loads,
  - high population density (1102 per km^2),
  - low-socio-economic development,
  - inadequate water infrastructure to regulate flows (e.g. storage upstream in Nepal or designated detention areas).

- The rivers that cause much of the flooding include the Ganges and its tributaries (Burhi Gandak, Gandak, Adhwara Group, Kamla, and Kosi from the Himalayas on its left bank and the lower reaches of the Sone and Punpun rivers on its right bank).
- The Himalayan tributaries and local rainfall are responsible for most of the flooding.
- Most of these tributaries have a substantial portion of their basins in Nepal and China and hydro-climatic data collection and sharing are major problems.
- Travel times for the tributaries are short, river discharge data is suspect due to lack of routinely updated rating curves in highly silt-laden rivers
- No climate-based forecasts are available currently, and data sharing remains a serious issue. Even when short-lead warnings on river stages are received, “last mile” issues remain on connectivity, dissemination, and community and institutional preparedness.

- The Government of Bihar (GoB) thus far has focused on structural interventions, such as constructing, raising, and strengthening embankments (levees), river training, river bank and town/village protection measures.
- More than 3,700 kms of embankments has been constructed over the years, which remain a major and important component of the flood risk management system in the State.
- It is thus necessary to continuously monitor the status and safety of embankment to rationally assess the need and nature of embankment maintenance, anti-erosion works or flood fighting works to protect the embankment and the downstream habitations.
- In order to achieve this, the response of the river system to various modeled flood discharges has to be studied so that appropriate flood stage information can be derived for different locations along these embankments.
- An accurate information base has to be developed containing river cross sections, longitudinal gradients in the river, current information on the cross-section of the embankments, current freeboards available for various discharges and the status of structures located on these embankments.
- This information has to be updated periodically to ensure the migration as well as the sedimentation patterns of the river are recorded and used in the various flood management models.

- Traditional efforts at flood management have so far focused on hardware systems, such as the building of a system of embankment.
- Despite the largely structural solutions that have been the focus of flood management in the past decades, the threat of floods remains as high as ever to the detriment of economy & livelihoods in Bihar.
- Thus it is obvious that flood management is a vital element to be addressed in the overall comprehensive plan for optimum development of Water Resources of Bihar.
- Non-structural measures for flood management are equally necessary. Bihar is working on non-structural measures.

Vision and Expectations from National Hydrology Project :

- Sound hydrological data base in the context of a paradigm shift towards comprehensive planning, development and management of water resources is necessary. Therefore, data base covering all aspects of Hydrologic Cycle is essential.

- The focus must be on
  - Real time monitoring,
  - Data processing,
  - Reservoir management,
  - Flood and drought management.

- Real Time Data Acquisition System (RTDAS) and Real Time Decision Support System (RTDSS) are very important for improved flood forecasting, reservoir management, flood control etc. WRD, Bihar is currently taking up improved flood forecast and inundation modelling in Bagmati- Adhwara and Kosi basin where RTDAS and RTDSS will be immensely useful.

- Water quality parameters monitoring is also essential in the present scenario when all the fresh water resources are getting progressively polluted. To achieve this objective of procuring reliable data base RTDAS Network has to be designed and established in the focus area.
- Decision Support Systems Planning (DSS-P) will be very helpful for Water Resources Department, Bihar as they include Surface Water Planning, Integrated Operations of Reservoirs, Conjunctive Use Planning, Drought Monitoring, Assessment and Management of both Surface and Ground Water Quality.
- web based e-GEMS (e-Ground Water Estimation and Management System) and e-SWIS (e-Surface Water Information System) will provide easy access and use and must be taken up under NHP in Bihar also.

FUNDING ARRANGEMENT :

- Total project 3640 Crores;
- 50% of amount would be World Bank loan and remaining 50% would be central assistance from the budgetary support.
- The EFC (Ministry of Finance, GoI) has recommended that NHP may be taken as 100% Central Sector Scheme, without seeking any budgetary support from the States/Organization to facilitate smoother implementation of the Project.
- Clearances from Planning Commission and Finance Department, Govt. of India already done, hence clearance from MoWR/Planning Commission not required by State.
- State budgets will be need-based and demand-driven; Implementation capacity is crucial.
- State has to create a separate budget head for NHP.
- Retroactive financing of preparatory works for NHP will be re-imbursed if agreement signed between MoWR, GoI and World Bank within one year.

Fund Flow Arrangement

The World Bank will finance 50% of the project cost under IBRD loan terms and funds will be released into the Consolidated Fund of GoI. The fund flow arrangements for the project will be through established country systems of GoI. All releases from GoI will be done electronically. The fund flow will be as follows :

Fund flow to states:

- MoWR, RD & GR will release funds into the State treasury in form of Grant in Aid. The prerequisite for releasing this amount to the state is the state providing budget for the project and approved work plan.
- The releases from MoWR, RD & GR will be made in two installments. The first release will be made at the beginning of each financial year soon after the annual budget is approved by GoI. The second installment will be released based on the demand from State (usually six months after the first release) in a similar manner. The second installment would be released only when states submit the Utilization Certificate (UC) and request for demand of funds. This release will take into account the expenditure incurred and forecast of cash requirement for the rest of financial year.
- The states would submit an UC along with the fund request for claiming the second tranche. In case if any state, requires fund earlier than six months they can submit the requisite documents along with UC and claim the second installment.

Fund flow to Departments:

The state will provide the budget at the beginning of the financial year, for the departments to spend the amount. The Departments will allocate the Central plus State matching share to Drawing and Disbursal Officers (DDOs) of implementing departments who will exercise powers to disburse payments for approved project activities. All payments would be made through the state treasury. The departments would liaise with the state finance department for budget and fund flow related issues.

READINESS CRITERIA :

- Project management/implementation units at each agency must be strengthened in line with project requirements.
- 30 percent (by value) of civil works bid documents (or hydromet) should be ready to be awarded.
- Major consultancies should be awarded prior to effectiveness.

WRD, Bihar has proposed following activities to be included in NHP –

- Construction of **'Water Knowledge Centre, Bihar'** as Hydrology Project Centre
- Institutional Modernization Support
- Installation of Hydro-met Stations in four River Basins (Gandak, Mahananda, Kiul-Harohar and Sone) and at seven (Chandan, Badua, Durgawati, Kohira, Kharagpur Lake, Upper Kiul and Phulwaria)
- Dam/Reservoir sites for RTDAS.
- Creating State Chapter of WRIS
- Hiring of Professional Specialists

Consultancy Services for :-

- Reservoir Sedimentation Surveys for Chandan and Badua Reservoir.
- Surface Water Assessment and Water Balance Studies in Mahananda and Kiul-Harohar Basin.
- River Cross section survey for Gandak river
- Inflow forecasting at Indrapuri Barrage
- Reservoir regulation and Operation and Maintenance for Chandan and Badua reservoirs
- Development of Embankment Asset Managment System for Gandak river basin.
- Digitization for Sone Canal System and its CCA
- Monitoring of Irrigation at Distributaries level
- Dam Break Analysis for Chandan Dam.

The total work has been planned to be implemented by following five organizations as per the decision of High Level Committee :-

Implementing Organizations :

- Flood Management Improvement Support Centre, Patna
- Hydrology Directorate, Patna
- Dam Safety Cell, Patna
- Irrigation Monitoring Circle, Patna, and
- Chief Engineer, WRD, Patna

Works Assigned to Different Organizations within Water Resources Department have been proposed as follows –

FMISC

- As a NODAL OFFICE – To co-ordinate among different Implementing Agencies
- Institutional strengthening & capacity building – Procurement of software, Training of engineers within country and abroad, Hiring of Professional Consultants
- Consultancy works for flood Embankment Asset Management System of Gandak Basin
- Create STATE CHAPTER of India-WRIS (Water Resources Information System)
- Creating a platform for development of mechanism for DATA SHARING among NHP family.

Dam Safety Cell

- Procurement of Real Time data acquisition system for seven (Chandan, Badua, Upper Kiul, Phulwaria, Kharagpur Lake, Durgawati and Kohira) reservoirs.
- Reservoir Sedimentation Surveys for Chandan and Badua Reservoir.
- Reservoir regulation and Operation and Maintenance for Chandan and Badua eservoirs
- Hydrographic and Sedimentation Study of reservoirs.
- Dam Break Analysis for Chandan Dam.

Irrigation Monitoring Circle

- Digitization of Sone Canal Systems and its CCA (including khata, khesra and area) as per distributaries.
- Monitoring of Irrigation at Distributaries' levels.
- Inflow forecasting at Indrapuri Barrage

Hydrology Directorate :

- Design of HIS and Procurement of Real Time data acquisition system for 4 Basins (Gandak, Mahanada, Sone and Kiul-Harohar).
- Surface Water Assessment and Water Balance Studies in Mahananda and Kiul-Harohar Basin.
- River Cross section survey for Gandak river
- Sediment studies in Five River Basins

- **Chief Engineer, WRD, Patna**

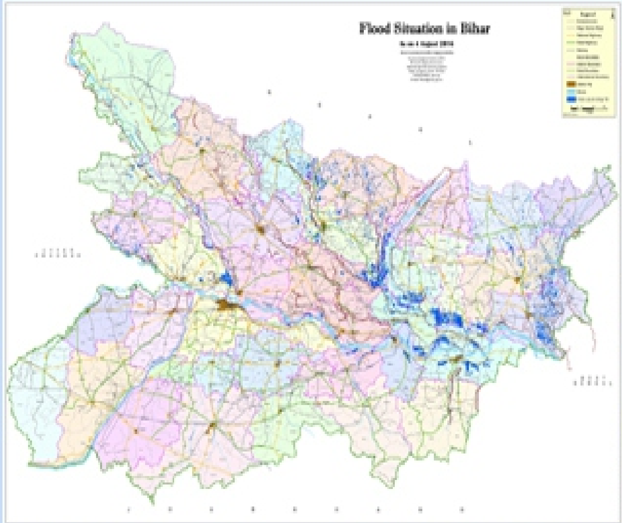
    - Construction of Water Knowledge Centre, Patna as Hydrology Project Centre.

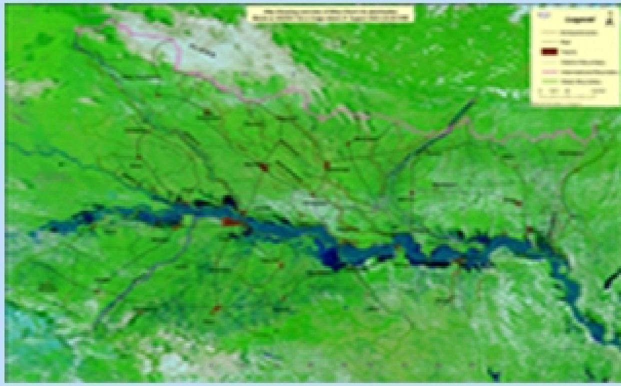
STATUS AS ON DATE :

- *A Dream Project Implementation Plan (PIP) for INR 273.9512 Crore was submitted to World Bank and MoWR, GoI in December, 2014.*
- *A Priority PIP for INR 169.055 Crore was submitted to World Bank and MoWR, GoI in February 2015.*
- *In view of the fund constraint and as per direction of MoWR, GoI and World Bank, Final PIP for INR 105.1652 Crore has ben submitted in Sept. 2015.*

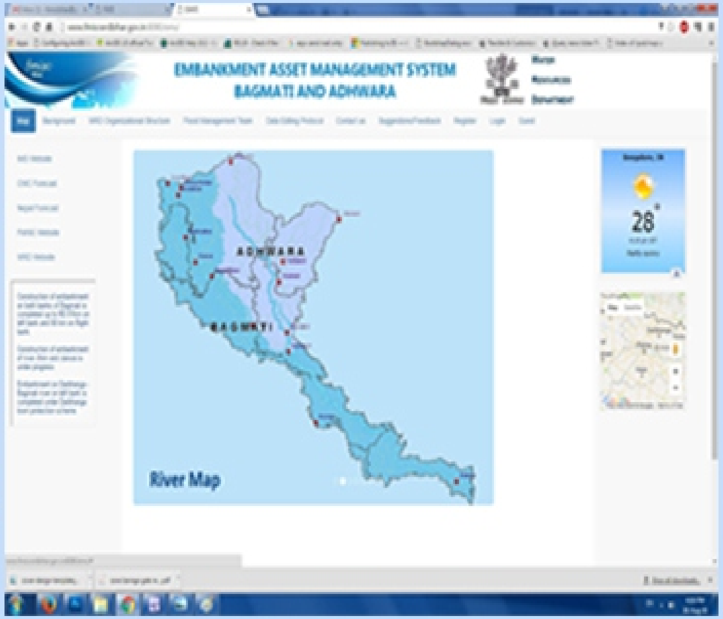
- Work Plan and Procurement Plan for 1st 18 months have been submitted to World Bank and MoWR, GoI on 12.09.2015.
- State Project Management Unit (SPMU) – The structure of SPMU has been approved by WRD, Bihar and has been communicated to World Bank and MoWR, GoI.
- Preparation of Terms of References (ToR) and Bid Documents for different activities outlined in first 18 months by different Implementing Agencies are in progress.
- A separate State budget head for NHP has been opened by Finance Department, GoB.

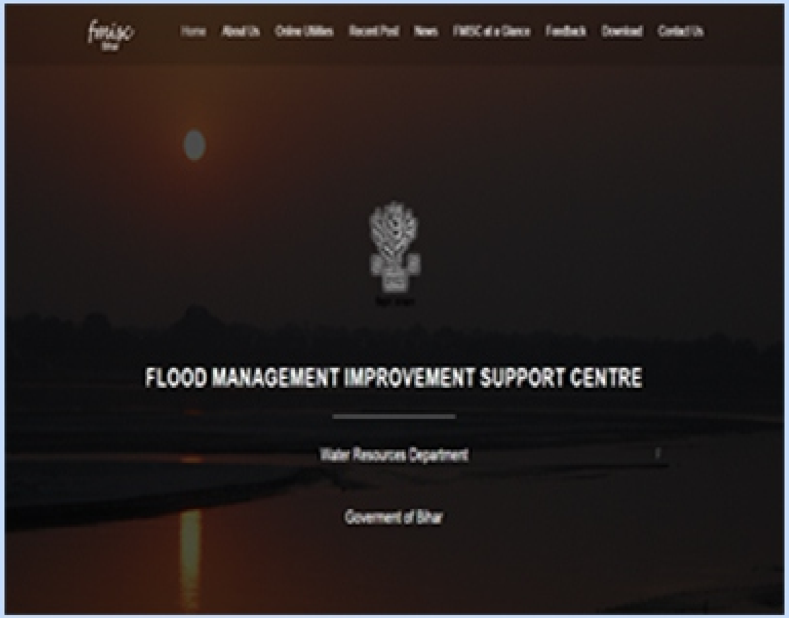
THANK YOU FOR KIND ATTENTION


Flood Situation in Bihar


Legend


Water Resources Department
Kosi Embankment Asset Management System
(KEAMS)
BIHAR


EMBANKMENT ASSET MANAGEMENT SYSTEM
BAGMATI AND ADHWARA
ADHWARA
BAGMATI
River Map
28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on
Improving Flood Risk Management in Bihar


on
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and


on
Water Resources Department, Government of Bihar
and
The World Bank