

Global Best Practices in Flood:

Examples from Bihar & Bangladesh for Actionable & Measurable Flood Warning and Management for Pakistan



Stakeholder's Workshop: Flood Forecasting & Management
Organized by the Government of Pakistan and World Bank

Islamabad, 14 February 2013

102 Years Ago...

“Hitherto the long range forecaster has been denied a seat in the banquet hall of science; ...the general scientist has denounced him; the professional weather man has treated him with supercilious scorn” (Ricard 1911).

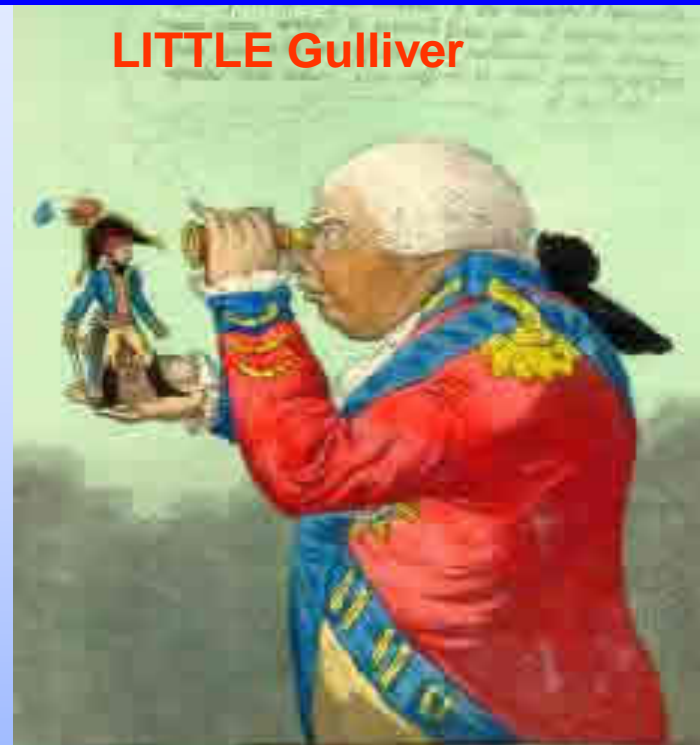
100 years later...

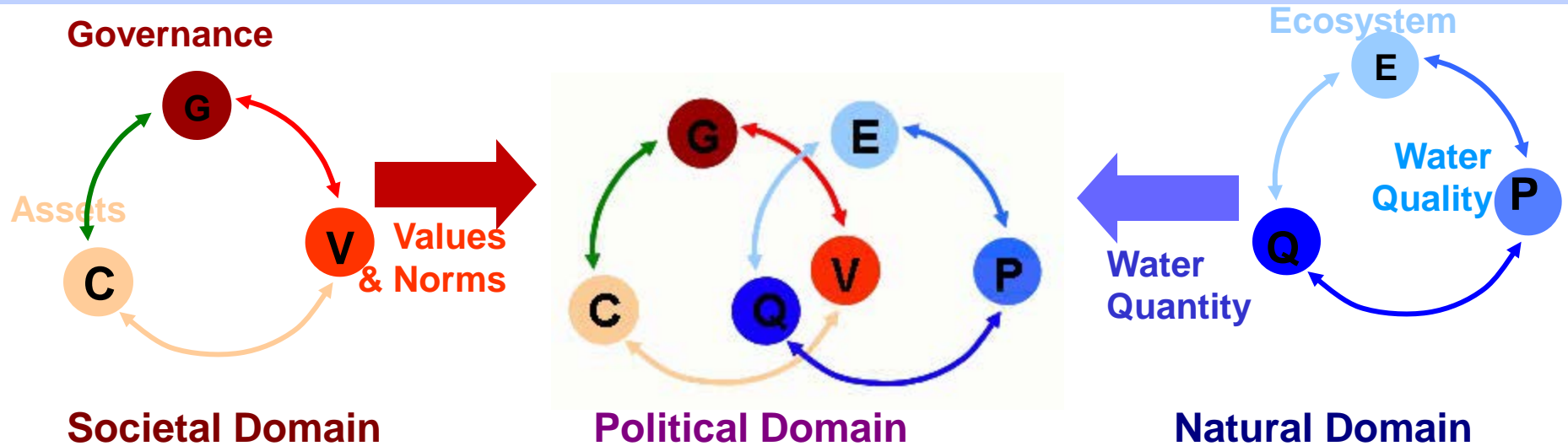
2010 Pakistan Flood: >20M people; >\$40B Economic Impact

2011 Thailand Flood: >13M people; >\$46B Economic Impact

Floods in Asia: Lessons to be Learned

“...as Thailand begins its rehabilitation effort, it should not only include reconstruction of infrastructure but also restoration of the trust and confidence of the people. We need to continuously learn from mistakes and prepare for a better future.” Irandoust and Biswas (2012)





Coupled Natural, Societal and Political Domain (**NSPD**)

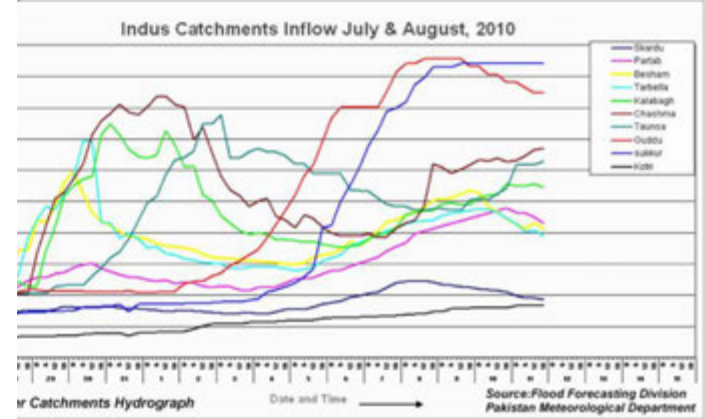
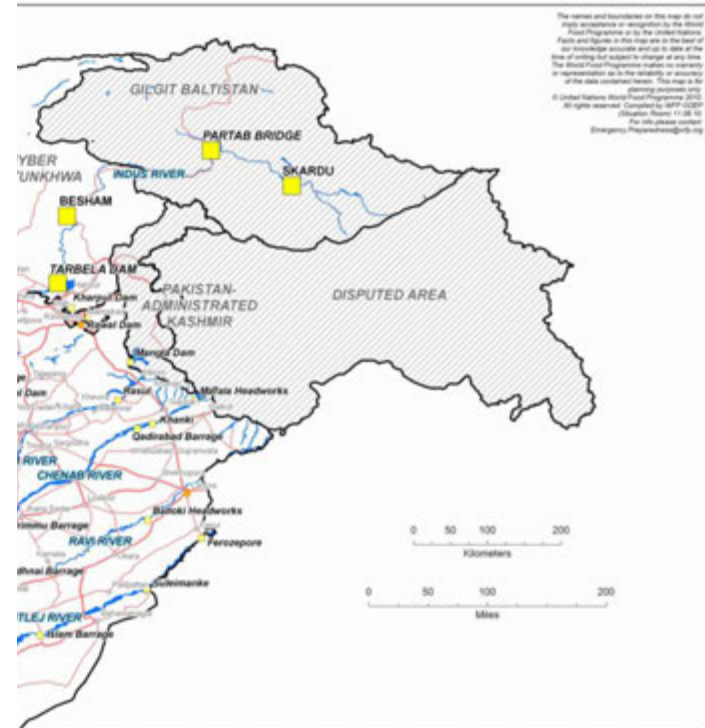
Indus River System

A Boundary Crossing Coupled Natural and Human System

Domains
Scales
Levels

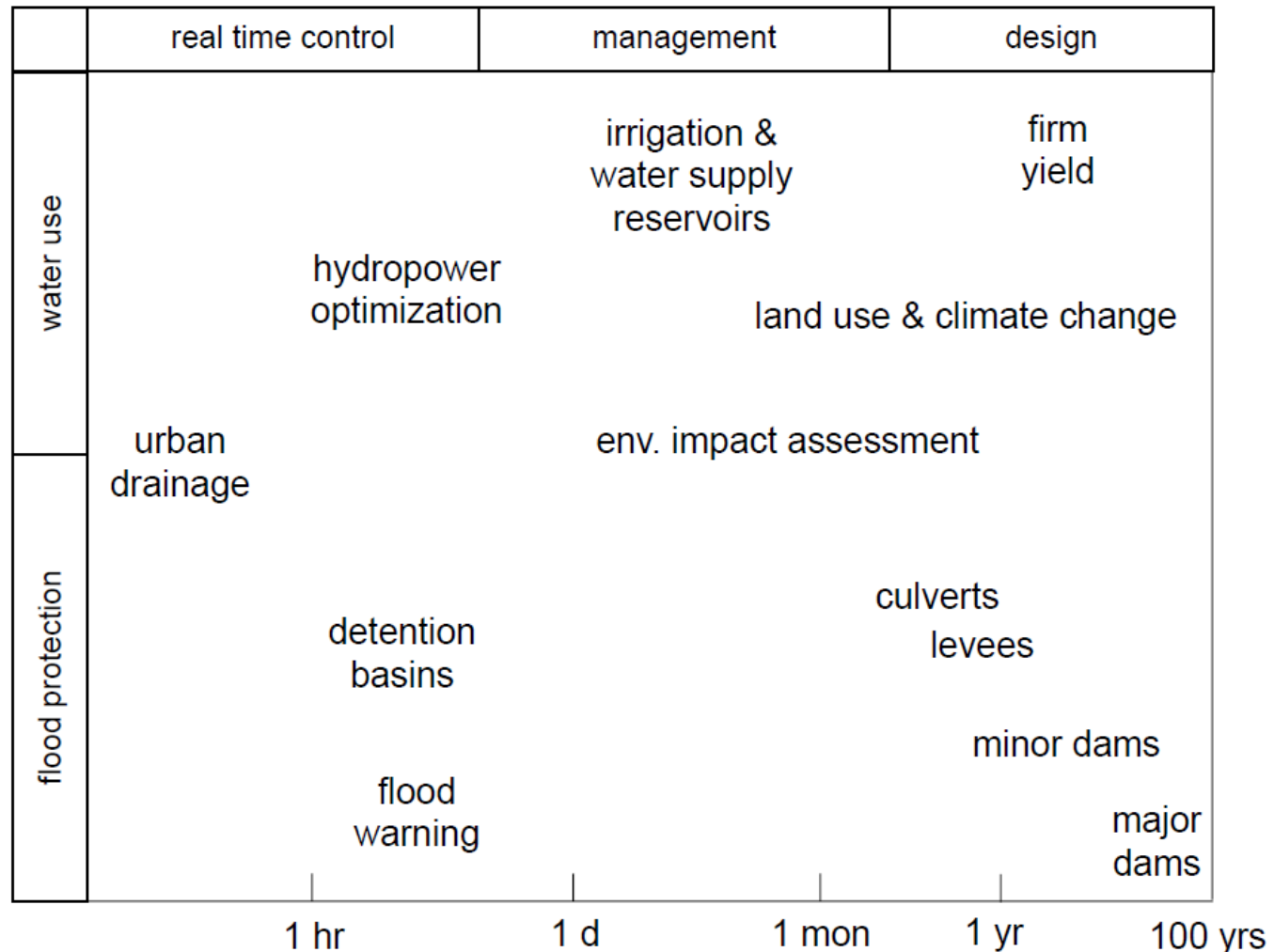
Watershed
Problem-shed
Policy-shed





Domains, Scales and Levels

Scale Challenges: Combination of cross-scale and cross-level interactions



Flood Forecasting

Macro
Micro

Large
Small

Climate
Weather

Economic
Utility

Water
Quality

Governance &
Institutions

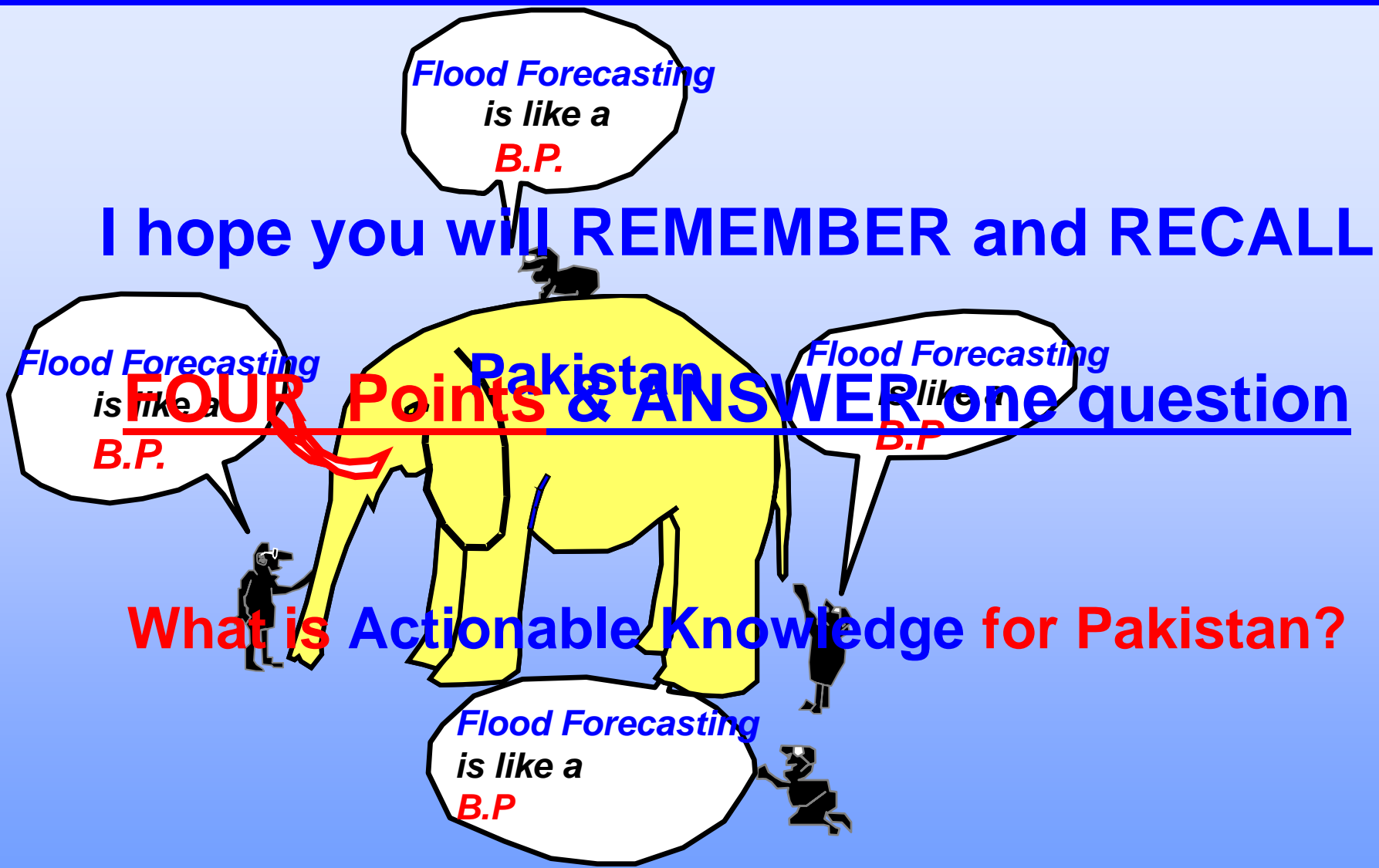
Ecological
Economics

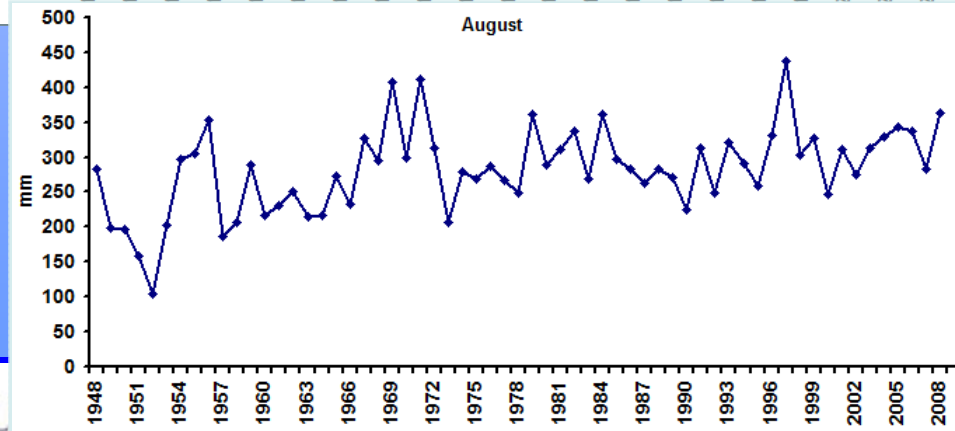
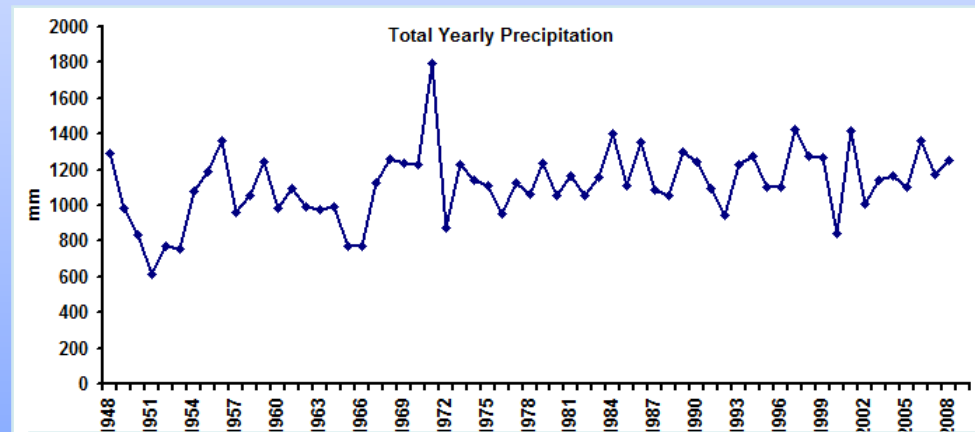
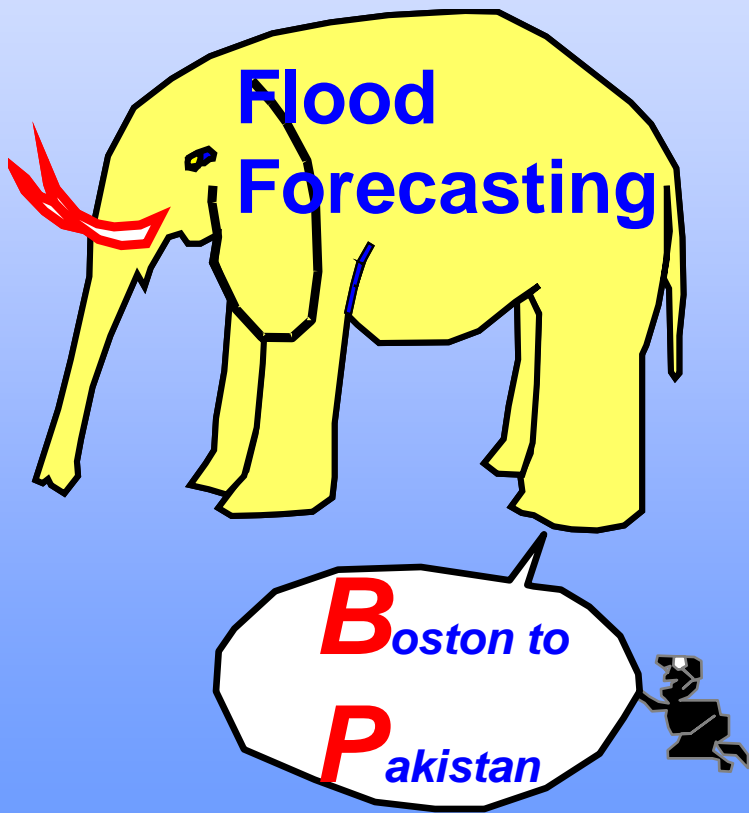
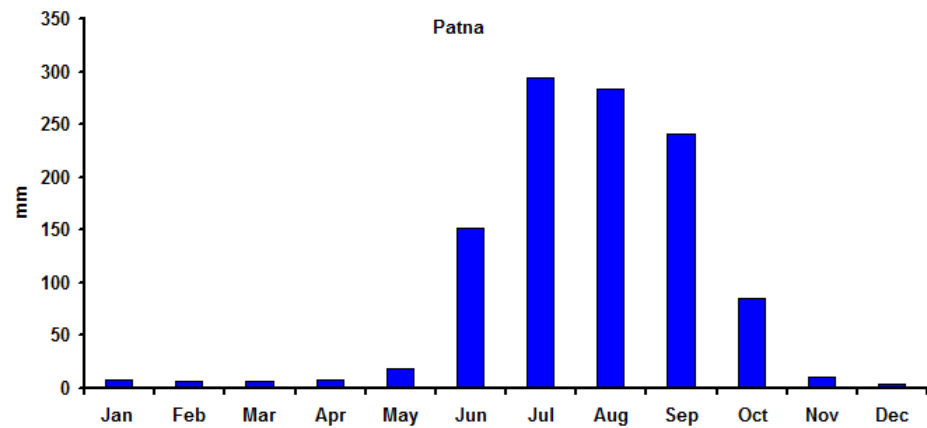
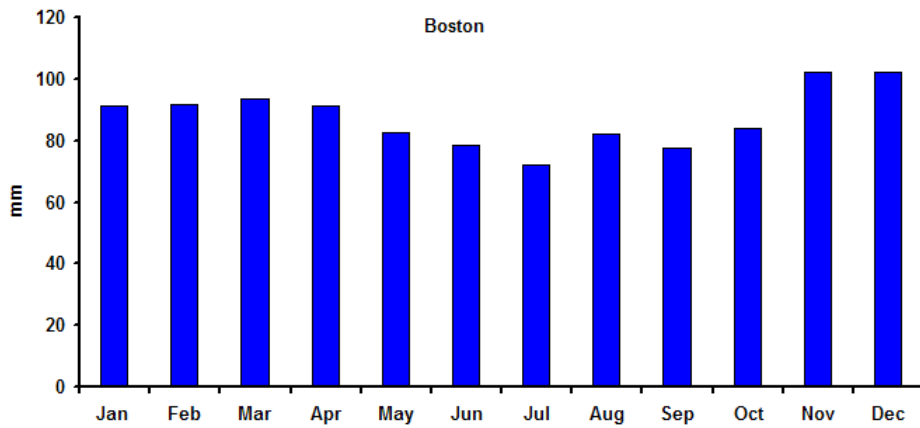
Culture &
Values

Water
Quantity



Water Management





Flood Forecasting

Macro
Micro

Large
Small

Climate
Weather

Precipitation

Vegetation

Soil Moisture

Topography

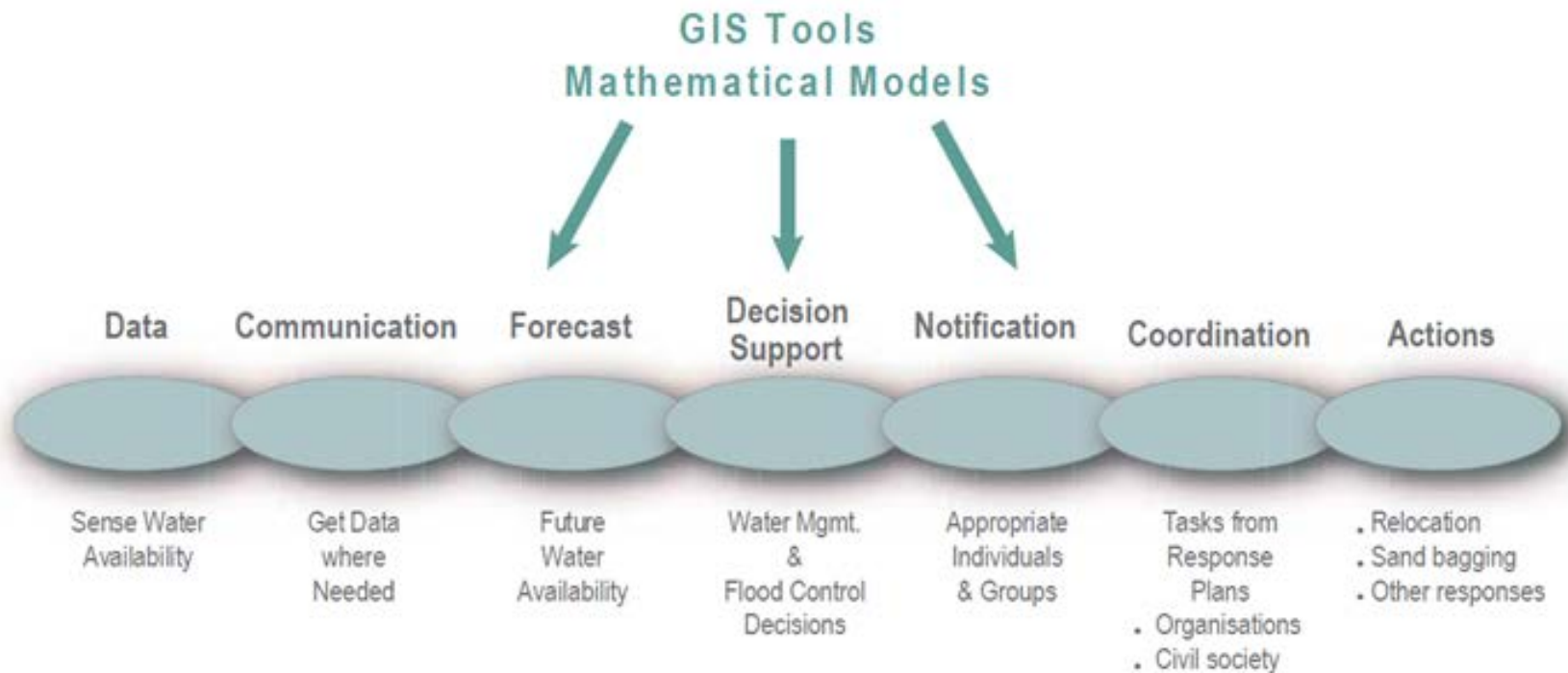
Surface Runoff

Evaporation



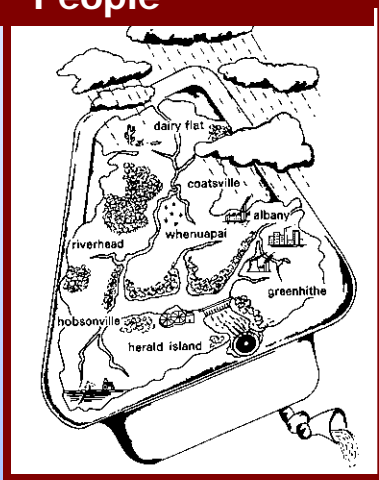
Water Management

Flood and Water Resources Management: a Critical Chain of Events and Actions

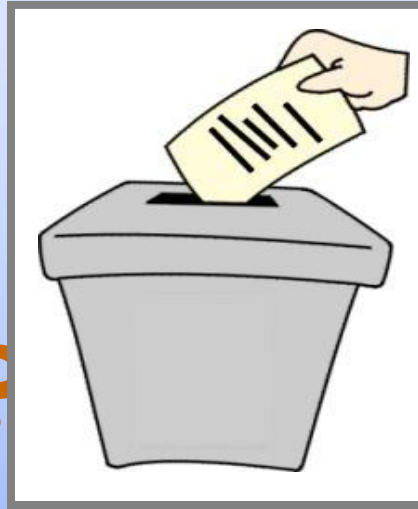


Perception of water resources systems

"People"



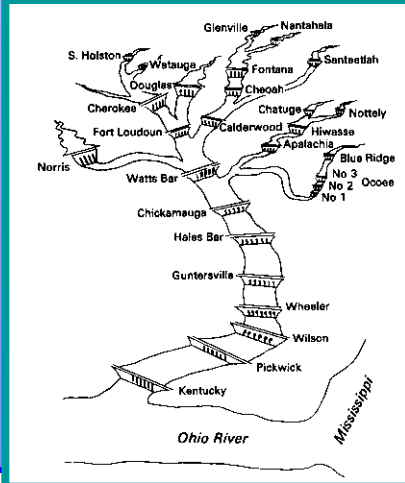
Politicians



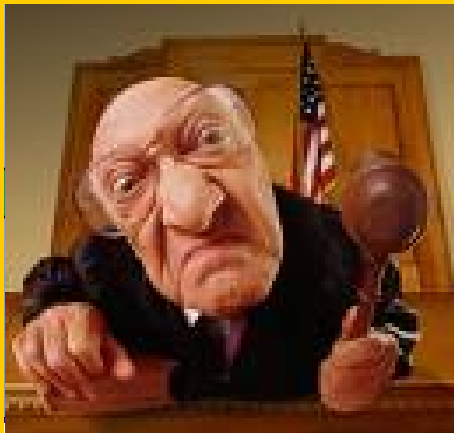
Engineers



"Practitioners"



Justice



Scientists



Connect **THEORY** and **PRACTICE**: Create Actionable Knowledge in WATER

MANAGING THE SCIENCE, POLICY, AND POLITICS OF WATER NETWORKS THROUGH NEGOTIATION



DOCTORAL PROGRAM WORKSHOP R.C.N. AQUAPEDIA FORUMS PRESS



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WATER PROFESSIONALS

WATER DIPLOMACY

FORUMS

Complex Problems Require Negotiated Solutions

Water issues create contentious arguments over its availability, access and allocation for human needs, agricultural use, industrial development and ecosystem services. Science or policymaking alone is not sufficient. Sustainable solutions can only come from diplomacy that takes science, policy, and politics into account.



1 2 3 4



IGERT PhD: Preparing the Next Generation of Water Scholars

The Water Diplomacy Graduate Program at Tufts University educates doctoral students who will become the next generation of teachers and scholars of water diplomacy. Supported by the Integrated Graduate Education and Research Traineeship (IGERT) of the National Science Foundation, this degree teaches interdisciplinary water professionals to think across boundaries, integrate explicit and tacit knowledge, and link knowledge and action from multiple perspectives to help resolve water issues through mutual-gains negotiations.



WDW: Building the Capacity of Reflective Water Professionals

The Water Diplomacy Workshop (WDW) is an annual "train-the-trainer" event that builds the capacity of senior water managers. Through highly interactive presentations and exercises, it helps participants master important water network management tools, and gain the skills needed to teach these tools to others. The 2013 WDW is scheduled for June 24-28 in Boston, Massachusetts, USA. [Read about it or apply.](#)



RCN: Bringing Together Research and Practitioner Communities

The Research Coordination Network (RCN) is a group of researchers and practitioners who will synthesize theory and practice to address complex water problems where natural, societal, and political elements cross multiple boundaries. Supported by the National Science Foundation, this global Water Diplomacy RCN explores ways to incorporate recent developments in complexity theory and negotiations, as well as advances in social networking technology, to generate actionable knowledge for adaptive water management.



Aquapedia: Gathering and Sharing Case Studies About Water

Aquapedia is a managed wiki that gathers case studies of water management and water conflict. It is meant to provide reliable, relevant, and readily available water information and wisdom from users and producers of explicit and tacit water knowledge. The potentially transformative and collaborative power of *AquaPedia* will, we hope, make water a flexible and expandable resource.



Water Diplomacy Workshop (WDW) in 2011 and participants master theory and practice

...of water network management tools and teach these tools to others.

Indus River System

An Example from AquaPedia: What Can We Learn Together?

Tools for Editors

Learn More

Help
Policies
About AquaPedia

Contents (hide)

- Summary
- Natural, Historic, Economic, Regional, and Political Framework
 - Conflicting Claims for Water by India and Pakistan
 - Attempts at Conflict Management
 - Outcome
 - Issues and Stakeholders
- Analysis, Synthesis, and Insight
 - Conflict Management in the Indus Basin: Insights from the Transboundary Freshwater Dispute Database
- Key Questions
- External Links

Summary

The Indus River Basin lies mostly within Pakistan and India with smaller portions of the basin of the basin within the latter waters and to date, major Indus and its tributaries have been

Case Description



Geolocation: $31^{\circ}32'45''\text{N}$, $74^{\circ}20'22''\text{E}$

Total Watershed: 178,483,470 million
Population:
Total Watershed: 1,138,800 km²
Area:

Most tropical (Köppen A-type), Semi-arid/steppe (Köppen B-type), Humid Descriptors: mid-latitude Köppen C-type, Continental (Köppen D-type), Moist, Monsoon

Predominant posture, industrial use, Land Use: forest land, urban-high Descriptors: density, religious/cultural sites

Important: Agriculture or Irrigation, Uses of Water: Domestic/Urban Supply, Hydropower Generation

Water: Indus River
Features:
Riparians: India, Pakistan
Water: Permanent Indus
Projects: Commission
Agreements: Indus Water Treaty
More facts

Facts about Conflict Management Strategies Among Riparians Within the Indus River Basin

RDF feed

Agreement	Indus Water Treaty +
Area	1,138,800 km ² (439,693.138 mi ²) +
Climate	Moist tropical (Köppen A-type) + , Semi-arid/steppe (Köppen B-type) + , Humid mid-latitude (Köppen C-type) + , Continental (Köppen D-type) + , Moist + and Monsoon +
Geolocation	$31^{\circ}32'45''\text{N}$, $74^{\circ}20'22''\text{E}$ +
Issue	Negotiating an equitable allocation of the flow of the Indus River and its tributaries between the riparian states; developing a rational plan for integrated watershed development, and financing for development plans. +
Key Question	What mechanisms beyond simple allocation can be incorporated into transboundary water agreements to add value and facilitate resolution? + , To what extent can international actors and movements from civil society influence water management? How and when is this beneficial/detrimental and how can these effects be supported/mitigated? + and How does asymmetry of power influence water negotiations and how can the negative effects be mitigated? +
Land Use	agricultural- cropland and pasture + , industrial use + , forest land + , urban- high density + and religious/cultural sites +
NSPD	Water Quantity + , Water Quality + , Governance + , Assets + and Values and Norms +
Population	178,483,470 million +
Riparian	India + and Pakistan +
Stakeholder Type	Sovereign state/national/federal government + , Local Government + and Non-legislative governmental agency +
Water Feature	Indus River +
Water Project	Permanent Indus Commission +
Water Use	Agriculture or Irrigation + , Domestic/Urban Supply + and Hydropower Generation +

posed problems between the states or partition, though, and the they only exacerbated the issue. Injuries, now found the water sources relations were increasing in ad from 1947 through 1960, yet none ed up until the Indus Waters:

ember 19, 1960 and government

The Indus Waters Treaty was trical and financial concerns of y also established the Permanent as Waters from each country.

of the conflicting claims of up- admitted under the provisions for been submitted at all. Other ys. One controversy surrounding d through bilateral negotiations new hydroelectric projects and the t the Baglihar dam on the Chenab ditional negotiations proved less Pakistan's concerns with the negotiated between India and Pakistan.

and

posed became increased the for her ing in sic case of he conflict or delivery inter- a agreed uld not is position id agreed Pakistan at they India were these igned, later if Pakistan



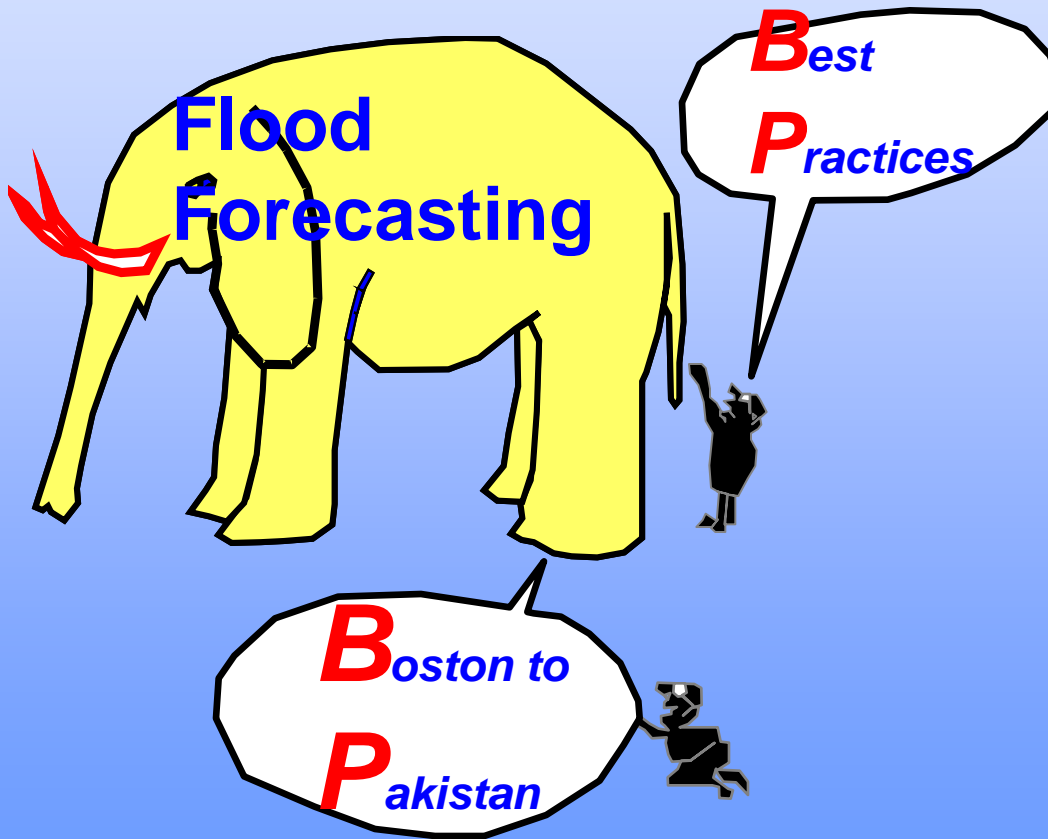
Figure 1. Map of the Indus River Basin [1]

ing time for Pakistan to develop alternate sources. Pakistan later expressed s 1948, calling for the "equitable apportionment of all common waters," and id Court. India suggested rather that a commission of judges from each tem over to a third party. This stalemate lasted through 1950.

Attempts at Conflict Management

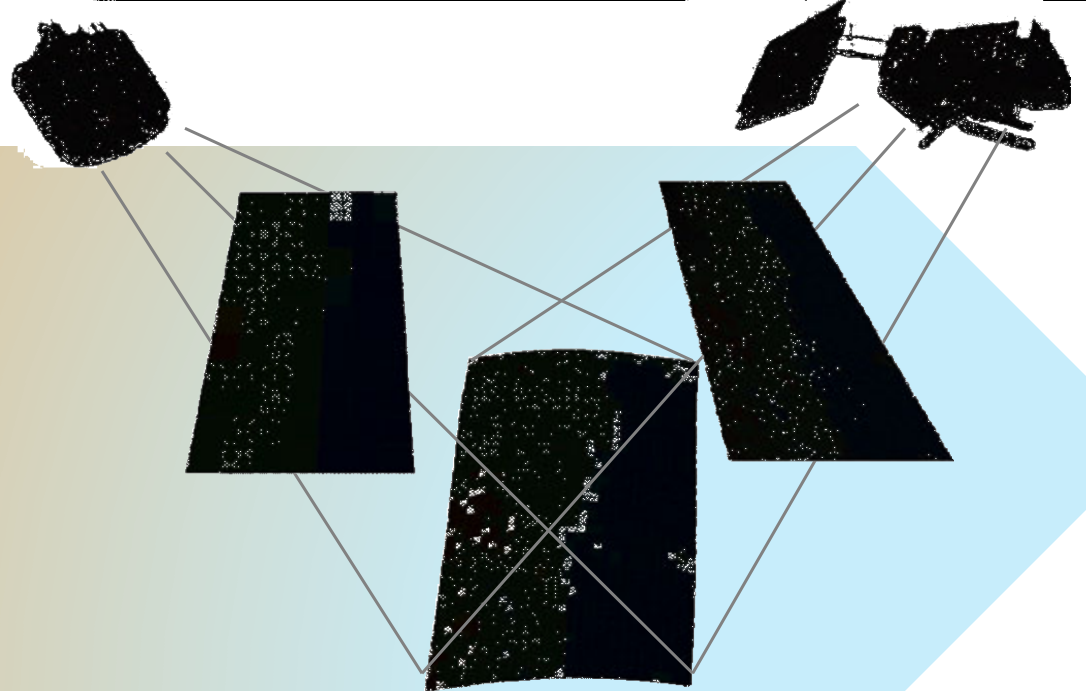
In 1951, Indian Prime Minister Nehru, whose interest in integrated river management along the lines of the Tennessee Valley Authority had been piqued, invited David Lilienthal, former chairman of the TVA, to visit India. Lilienthal also visited Pakistan and, on his return to the US, wrote an article outlining his impressions and recommendations (the trip had been commissioned by Columbia University's International Rivers Commission). These included stream flow measurement, and to allow Pakistani

- Numerical Weather Prediction Model
- Rainfall-Runoff Model
- Flood Inundation Models





Before 1970s



2000s

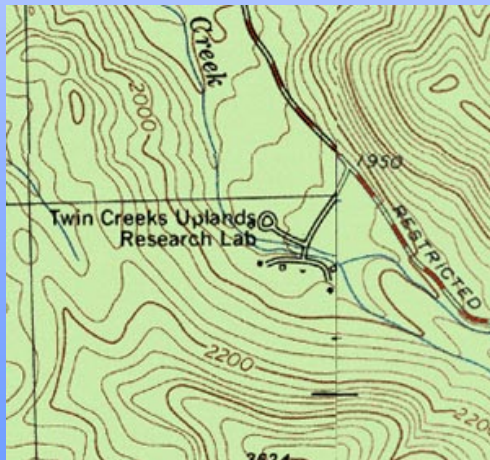
Transformative changes in measurement technologies.

Transformative developments for hydrometeorological science and understanding of hydrologic and climatic processes?

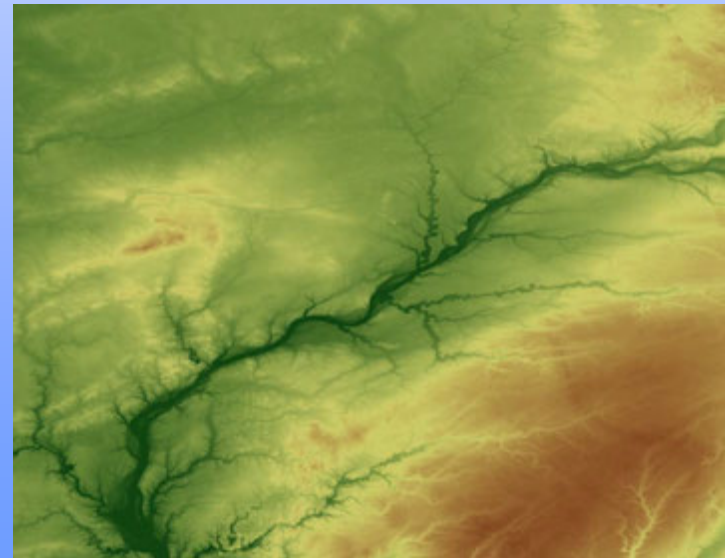
Digital Elevation

What They Made Possible.

- Enabled Spatial Hydrologic Modeling
- Linked Continental Hydrology and Oceans
- First Tool in Characterizing a Problem



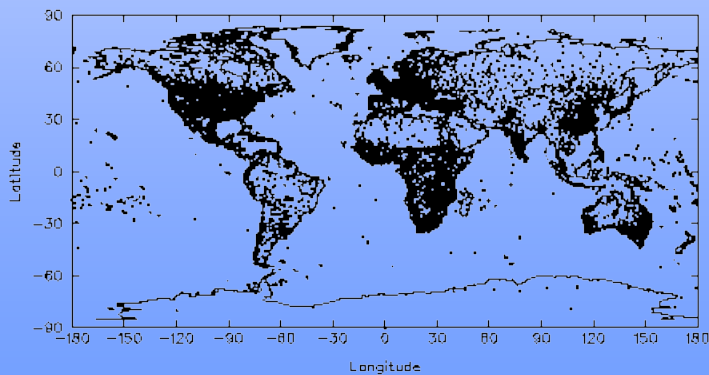
USGS Quad



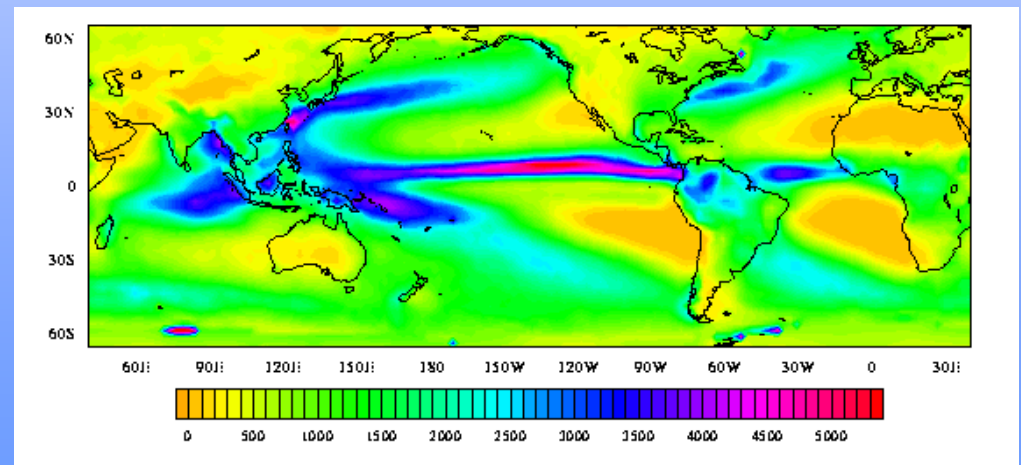
SRTM

Precipitation

- See Rainfall as Structured Fields That Move and Transform
- Catalyst in Understanding Macro-Scale Processes

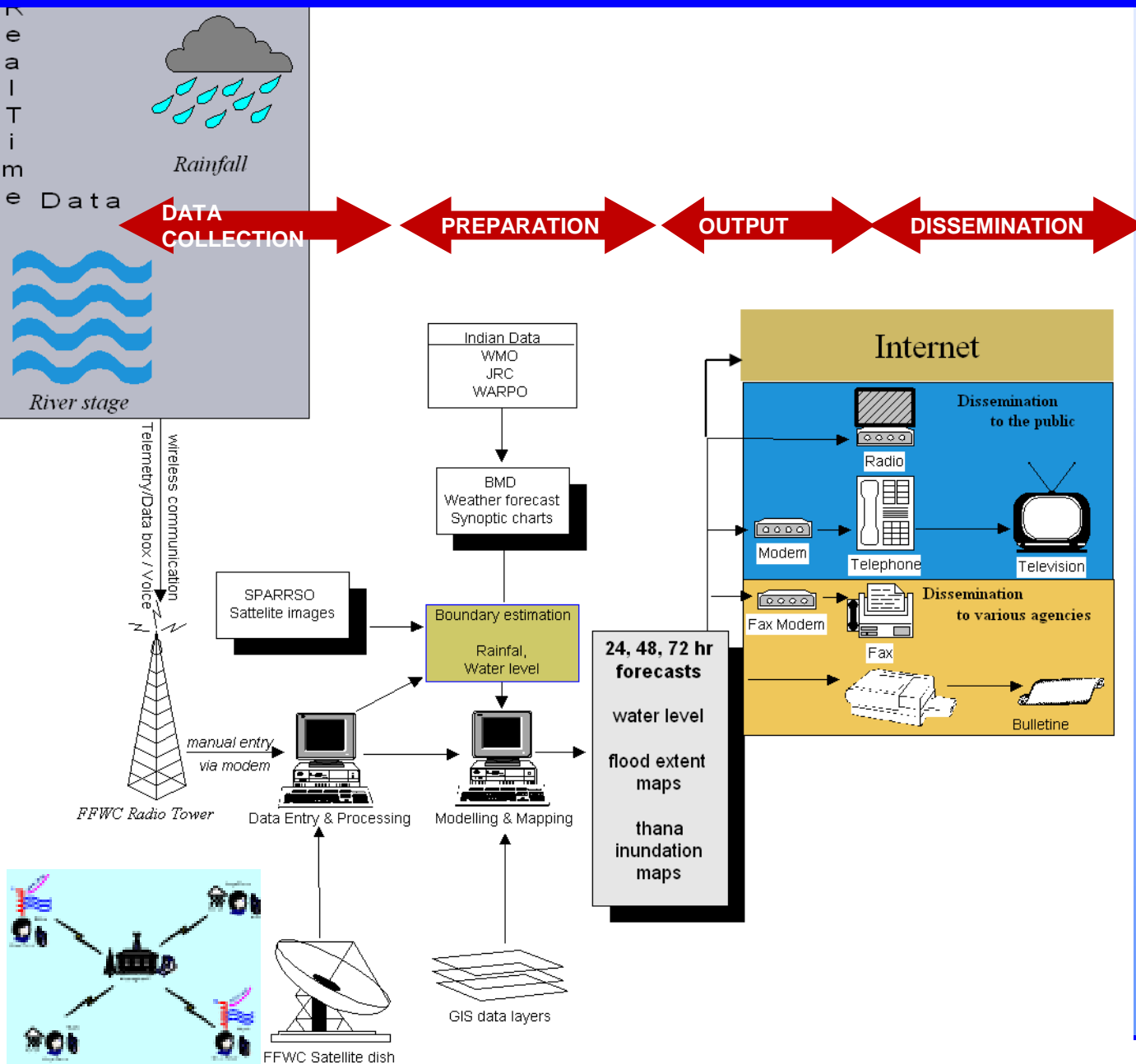


Precipitation Gauges



Regional to Global Linkages

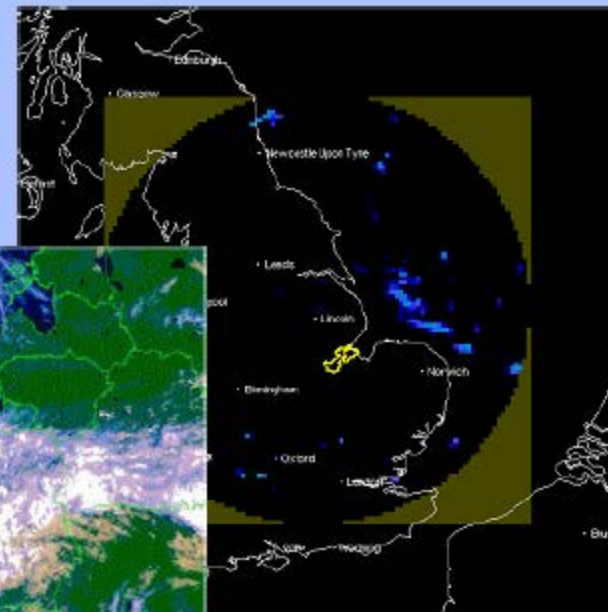
Flood Forecasting: What do we need?



- Data Collection
- Preparation
- Output
- Dissemination

FLOODRELIEF

REAL-time Flood Decision Support System Integrating Hydrological, Meteorological and Radar Technologies



Application and quantitative assessment of new technologies for the study catchments

P-8: Case study in Poland

P-9: Case study in UK

WP-8: Case study - Poland

WP-9: Case study - UK

Various tools depending on anticipation



10 days 5 days 3 days 1 days 12 hours

CEP probabilities

Expertised values

8x3h model data

Rainfall



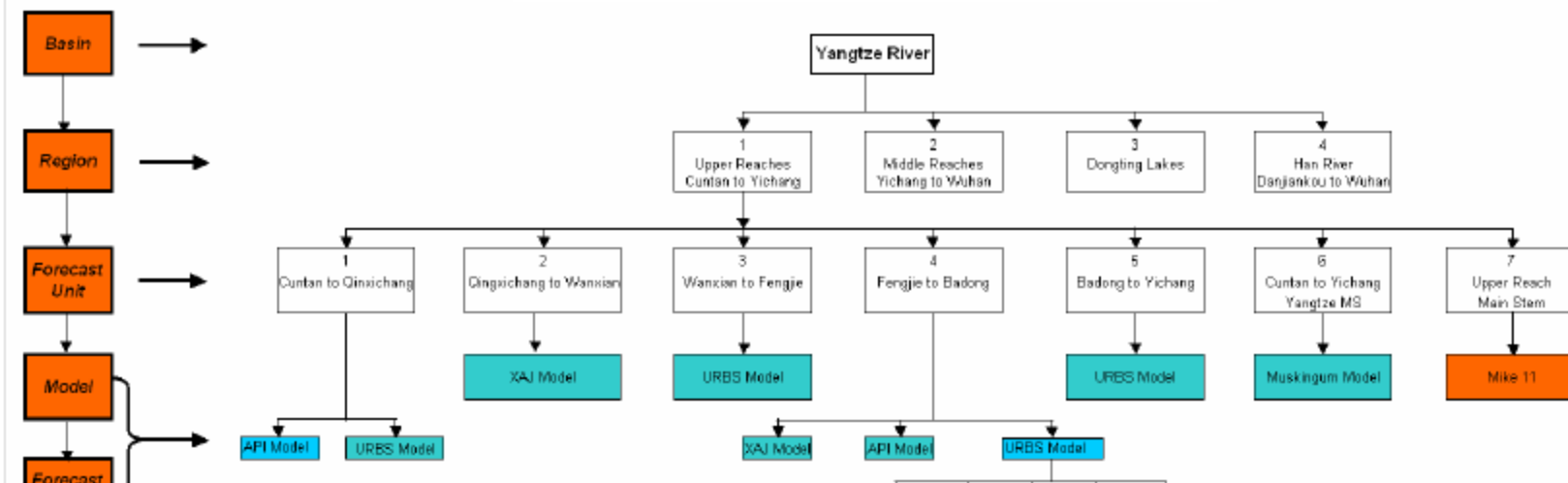
Short-term real-time Flood Forecasting System

Quantitative Precipitation Forecasting

(QPF)



Hydrological & Hydraulic models



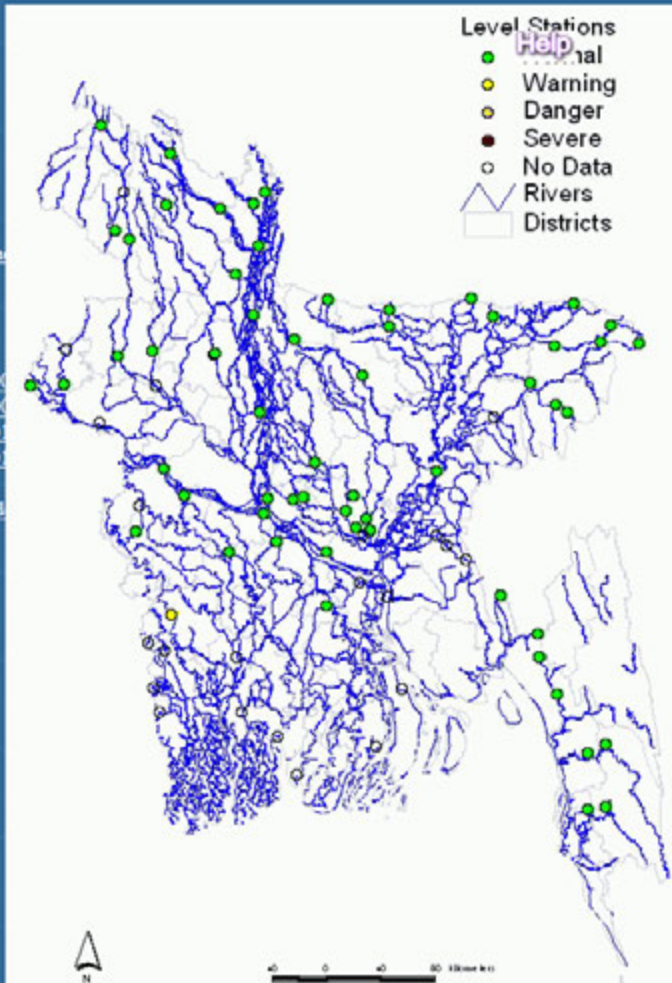
Operational Flood Forecasting in Bangladesh

Flood Forecasting and Warning Centre, Bangladesh



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- Annual Flood Report 20
- Annual Flood Report 20
- Web Mail
- Download Acrobat Read
- Important Links



★ Daily Flood Summary

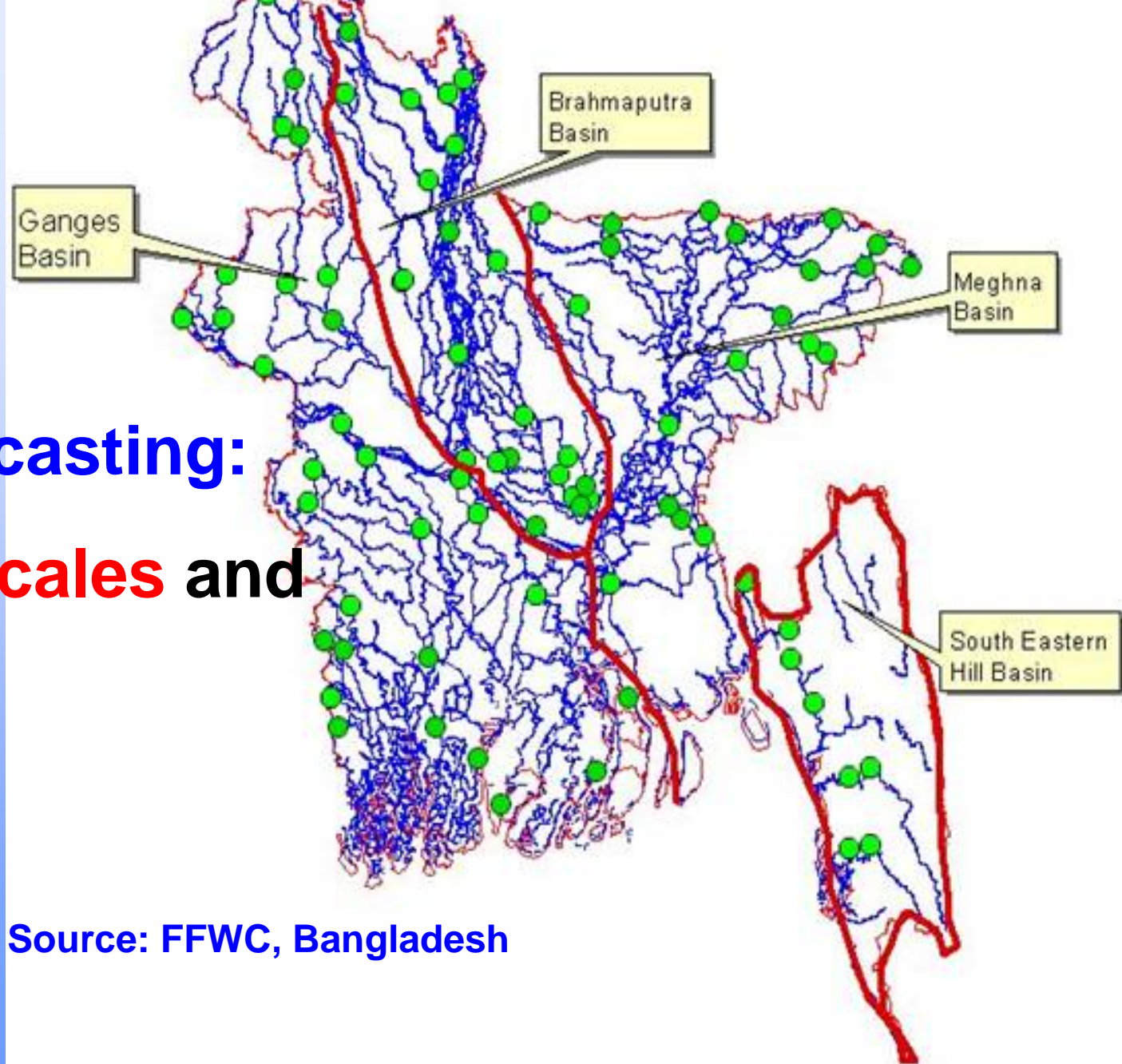
FIG (Flood Information Cell) will resume from next year monsoon (3rd week of May/2013)

Amalshil	Hakiani	Narayanasri
Arsha	Hachinop Bridge	Nayabai
Atai	Hacharpara	Noonshara
Badiadacani	Hacholia	Panchasahi
Bahadurshah	Jalit	Panchobutia
Baidar Bazar	Jamalpur	Pancha
Bandarban	Jaraijanail	Panchuram
Bhagyabul	Jhikarashaha	Pathachata
Bhairab Bazar	Jibampur	Phulbari
Bhusidbandar	Kalagachia	Porabai
Boora	Kalica	Raibahi
Chakarshampur	Kaliganjia	Ramach
Chandpur	Kamanibali	Ravanta
Chapai-Newabani	Kanaiqhat	Robanpur
Chitmai	Kanchanagar	Sarobai
Chinoga	Kaunia	Senoram
Chudafasa	Kazipur	Serisani
Comilla	Khulna	Shaha
Dalia	Kusiram	Shela
Dalmucia	Lathur	Shemur
Daulatkhan	Lama	Sinara
Demra	Loonsoth	Sucansani
Dhaka	Madanpur	Sureshwar
Dighalpur	Manu Rty. Br.	Syhat
Dohazari	Mawa	Talbaria
Duckapur	Methuracera	Terashai
Fardpur	Methua Br.	Toa
Gaibandha	Mirpur	Tongi
Gibai(Sana)	Mohadepur	
Gokarna	Mohammediar	
Gorei Rty. Bridge	Moraba	
	Moulyi Bazar	
	Mymensingh	
	Nabuwason	
	Nesabon	
	Narayach Hat	

Source: FFWC, Bangladesh

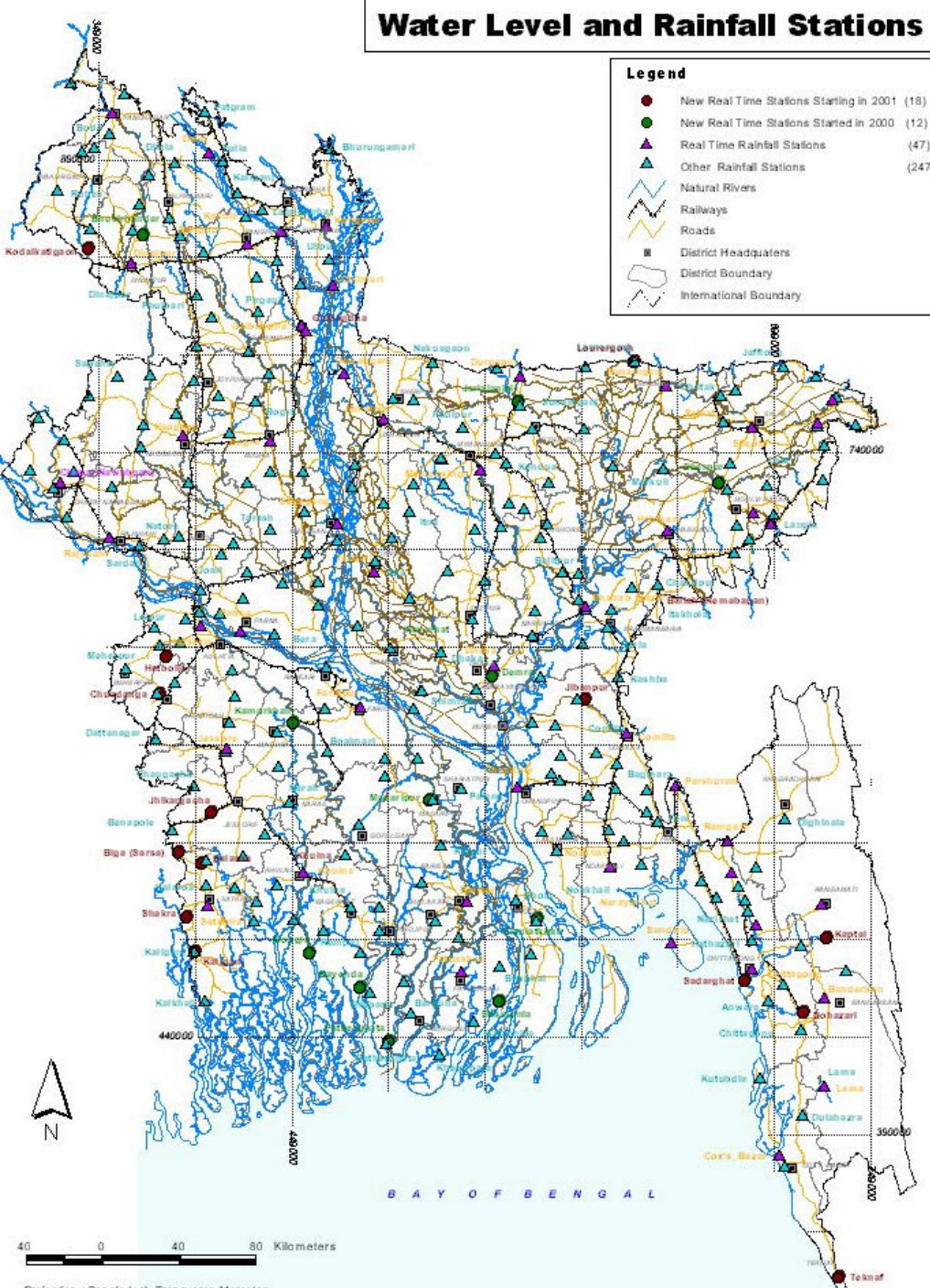
- Special flood situation report
- Thana inundation status map
- Flood forecast maps
- Monthly flood report
- Dry season bulletin (weekly)
- Annual Flood Report

Flood Forecasting: Issues of Scales and Domains



Source: FFWC, Bangladesh

Water Level and Rainfall Stations

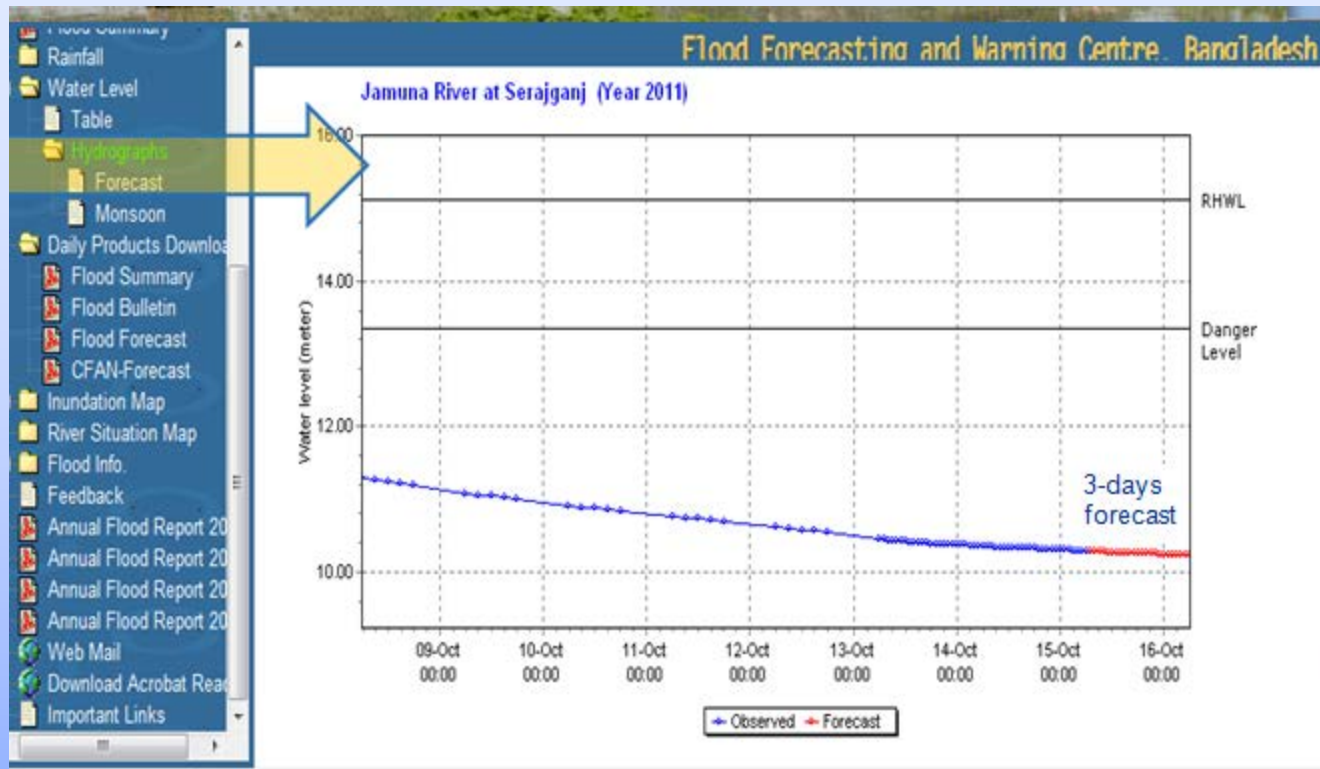


Real Time Data Collection:
Rainfall : 55
Water Level : 73

Flood Forecasting: 38 Stations

Source: FFWC, Bangladesh

Flood Forecasting in Bangladesh: 40 Years of Experience and Wisdom



Source: FFWC, Bangladesh

**1972-90: 3-day
Forecast by Gauge to
Gauge Correlation**

**1990 up till now : 3-day
Forecast: Deterministic
Modeling (Operational)**

**Future: 1~10 day Forecast
by Probabilistic Modeling
(Experimental)**

FFWC Qualitative Forecasting: An Example of Actionable Knowledge

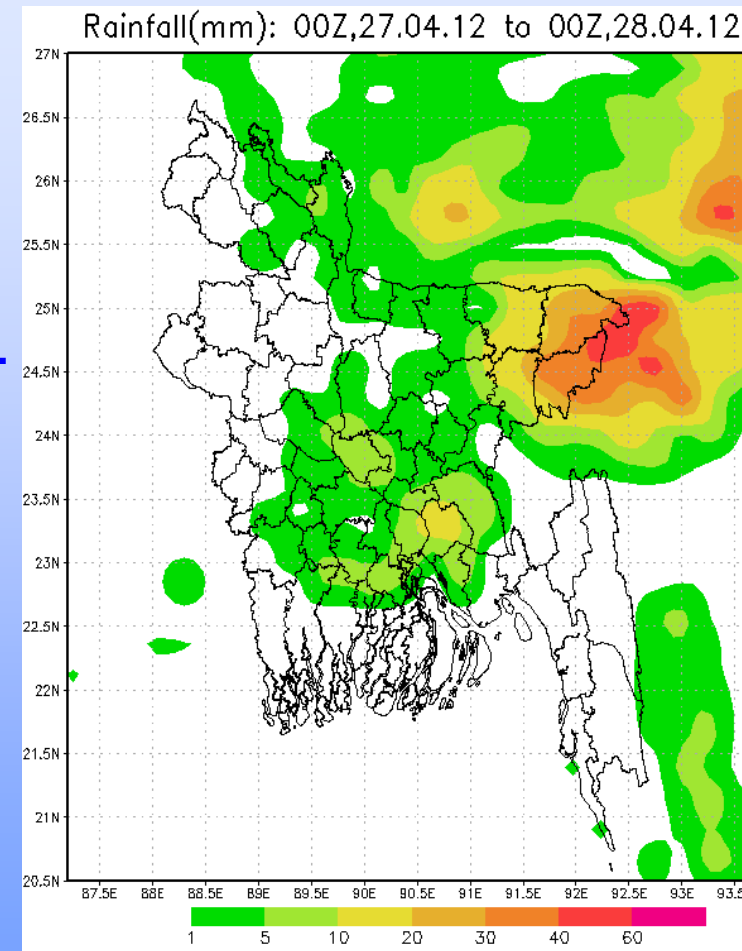
Special Outlook, FFWC, BWDB 25 April 2012

As per the Numerical Weather Prediction (NWP) of Bangladesh Meteorological Department (BMD), there is possibility of rainfall in the north east region of Bangladesh for next three days (from 26 to 28 April 2012). This may contribute to further rise of river water level in the Meghna Basin, in the north East region, specially in the Sylhet, Sunamgonj and Moulvibazar Districts.

How was this Qualitative Forecast Done?

- Bangladesh Meteorological Dept, 25 April 2012 Chart
- Indian Meteorological Department (IMD) forecast
- NOAA rainfall estimates from the web
- No Hydrological or Inundation model was used
- Dissemination to BWDB Field Offices

For further detail visit <http://www.bmd.gov.bd/nwp.php>



Source: FFWC, Bangladesh

ECMWF: Verification of Precipitation Forecast Skills



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Lead time of 1-SEEPS of precipitation reaching a threshold

Related products
Lead time of anomaly correlation reaching a threshold

Lead time of 1-SEEPS of precipitation reaching a threshold
Lead time of the continuous ranked probability skill score of 24-h precipitation reaching a threshold
Lead time of the continuous ranked probability skill score of 850hPa temperature reaching a threshold

Area
Extratropics
Europe

Download...
PDF (5.1 Kbytes)
Postscript (12.5 bytes)

24-01-2013
20-09-2012

ECMWF deterministic 12UTC forecast skill

Total precipitation
1-SEEPS
Extratropics (lat -90 to -30.0 and 30.0 to 90, lon -180.0 to 180.0)



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Lead time of the continuous ranked probability skill score of 24-h precipitation reaching a threshold

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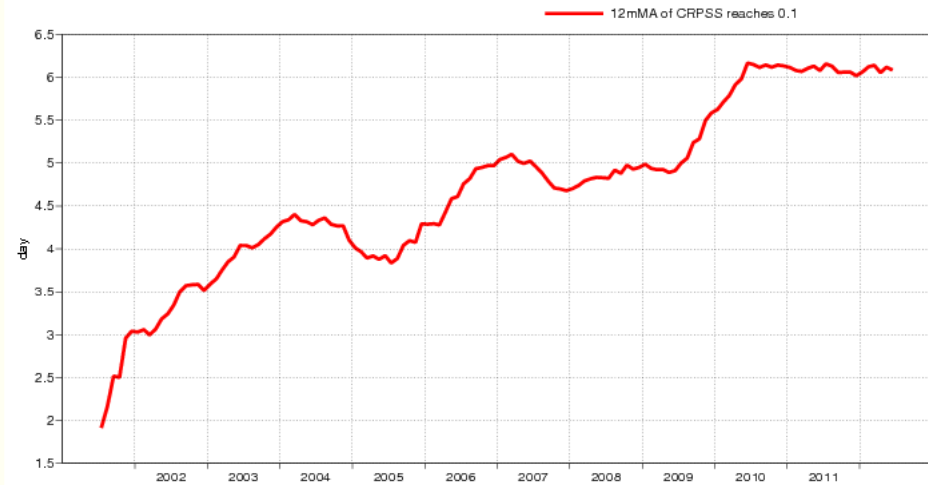
Area
Extratropics
Europe

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24-01-2013

ECMWF EPS 12UTC forecast skill

Total precipitation
Continuous ranked probability skill score
Extratropics (lat -90 to -30.0 and 30.0 to 90, lon -180.0 to 180.0)



© ECMWF

2724

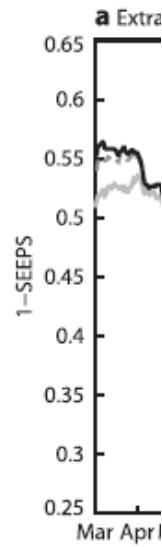


FIG. 3. Tir on forecast (only from 1)

compared to those of m from the contingency ta scores, but are small e ascribed to the varying quite pronounced. SEF tropics. It is found that issue of observation r suggest that just under the fact that gridbox ve

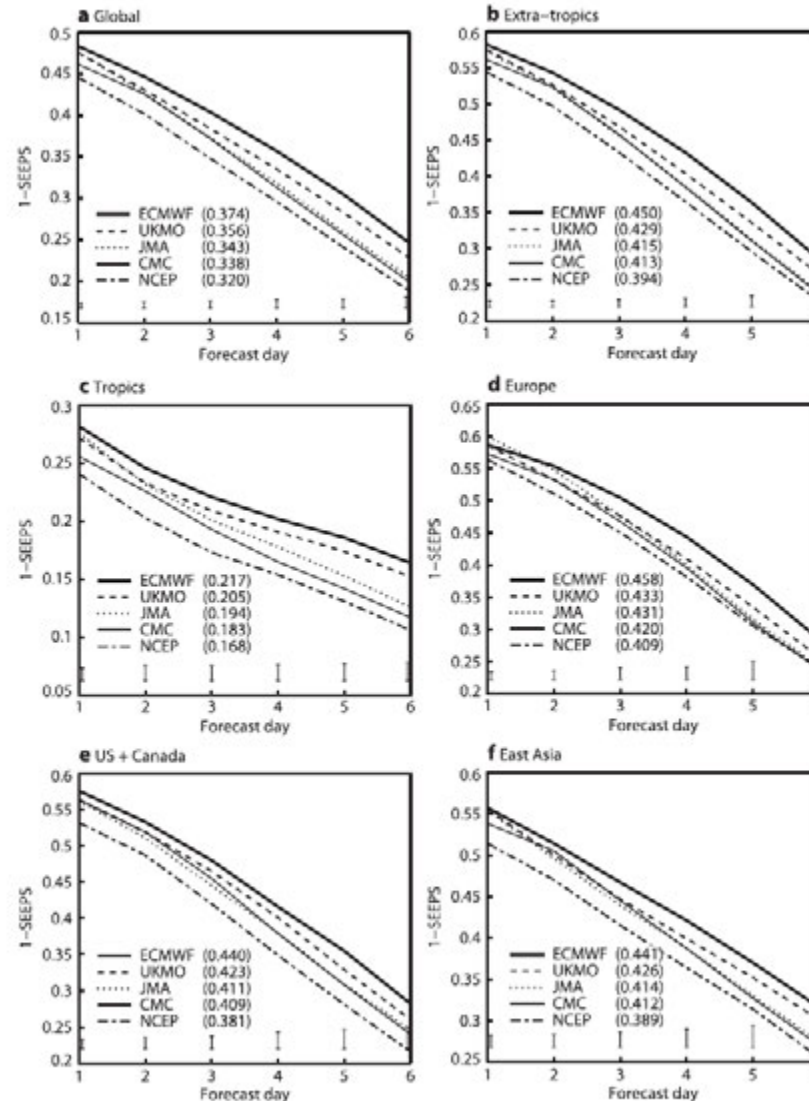
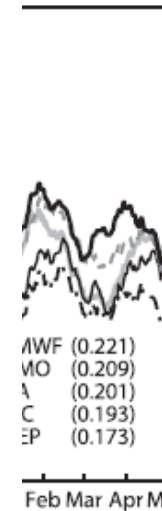


FIG. 4. Values of 1 - SEEPS for the CMC, JMA, NCEP, UKMO, and ECMWF models in different regions, averaged over the period 1 Jun 2010–30 Apr 2011, as a function of lead time. Mean values are given in parentheses. Error bars show width of 95% confidence intervals for model differences, derived from resampling of daily scores (see text for details).

VOLUME 140



nd (b) tropics were available -30 Apr 2011.

Forecasting of Water Levels from Satellites: Example from Bangladesh

L11401

BIANCAMARIA ET. AL.: RIVER WATER HEIGHT FORECAST FROM SPACE

L11401

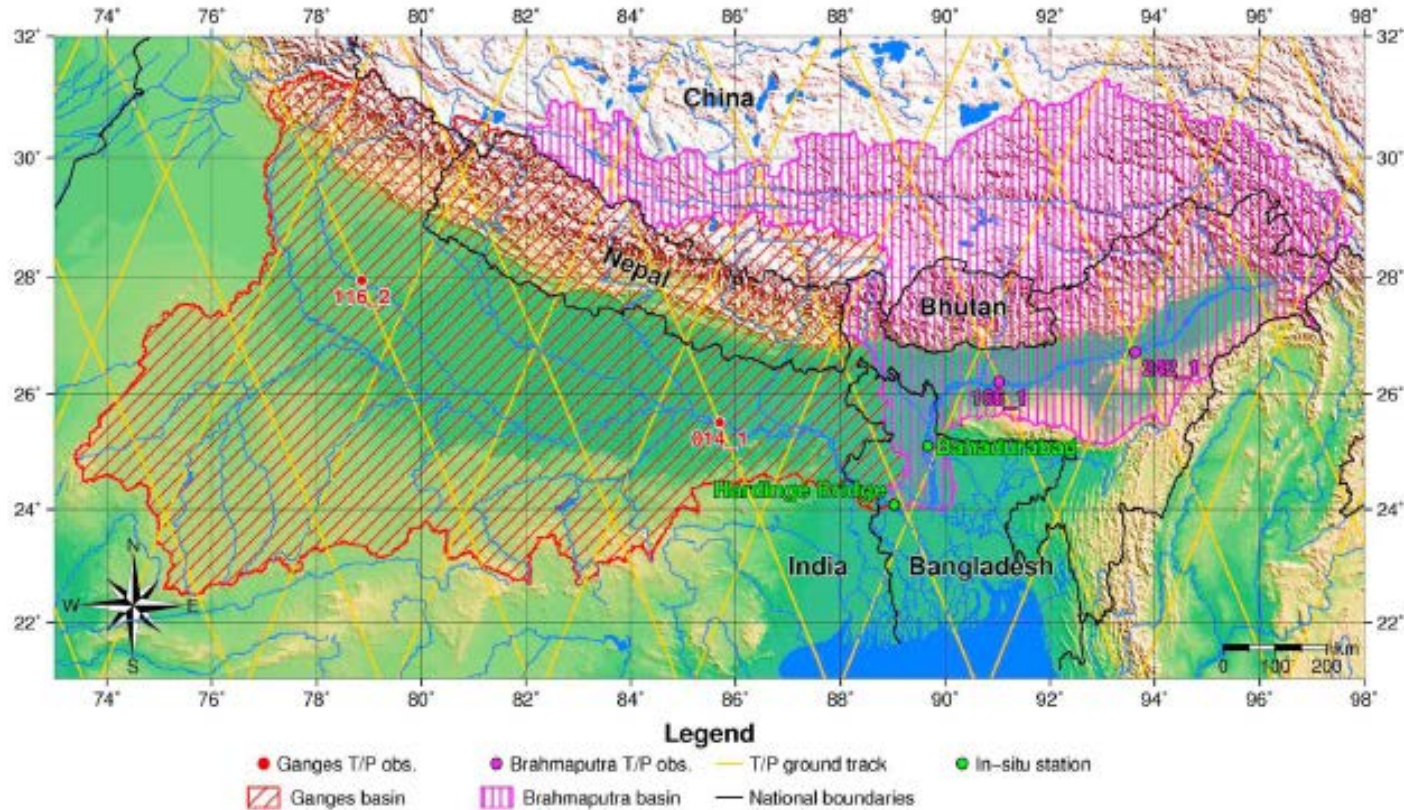


Figure 1. Map of the study domain. Ganges basin (red hatched area) and Brahmaputra basin (magenta hatched area) boundaries come from HYDRO1k. Locations of measurements from the satellite nadir altimeter Topex/Poseidon on the Ganges and the Brahmaputra rivers (available on HydroWeb) are represented, respectively, by red and purple dots (yellow lines correspond to the satellite ground tracks). Green dots correspond to the furthest upstream in-situ gauges in Bangladesh. The background topography used in this map is the ETOPO1 topography dataset. Lakes, rivers and political boundaries come from the CIA World Data Bank II.

Flood Inundation Map: 48-hour Forecast

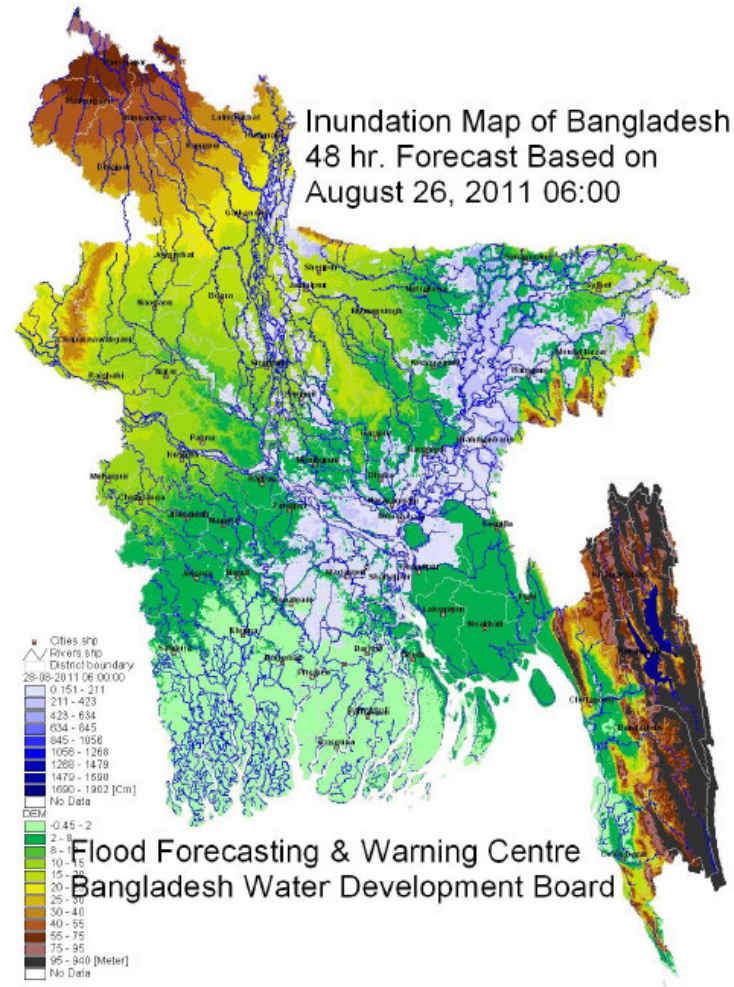


Figure 5.2 : Flood Inundation Map of Bangladesh (48hr Forecast Based on 26 August 2011)

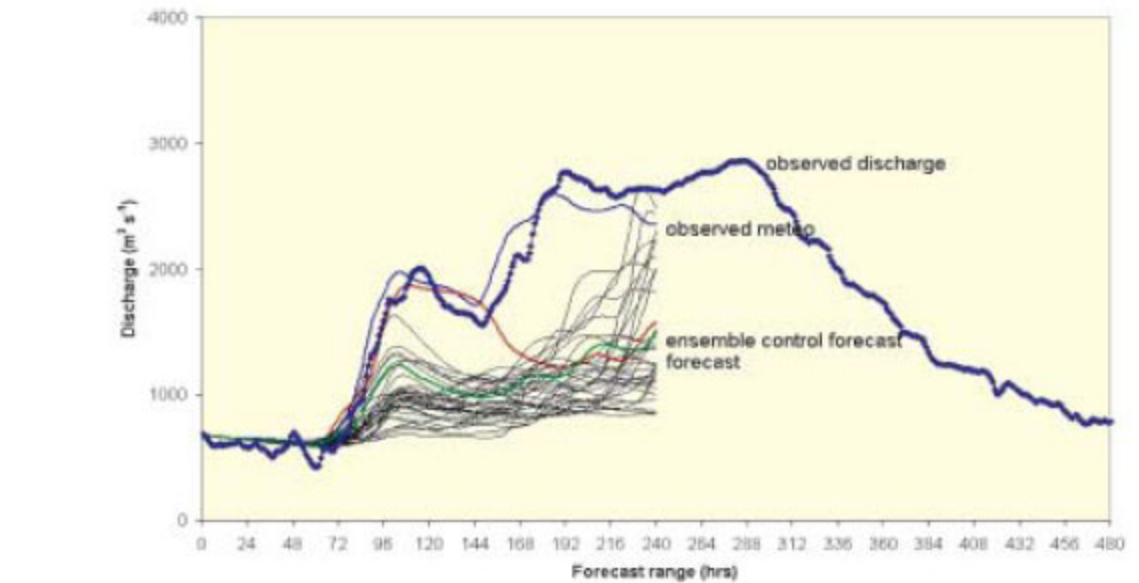
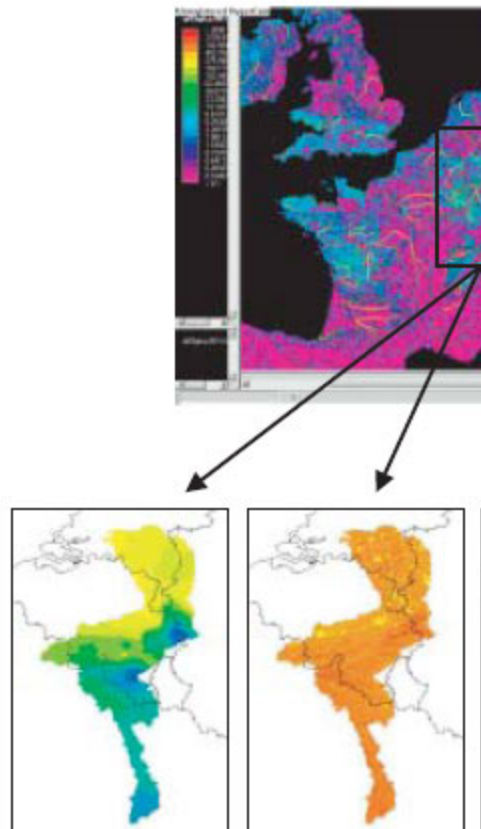


Figure 6 10-day discharge forecasts from the LISFLOOD-FF model for 0000 UTC on 19th January 1995 (hour 0) for the Borgharen gauging station on the River Meuse, The Netherlands. The observed discharge is shown as a thick blue line, the simulation driven by observed meteorologic data is shown as a thin blue line, the simulation driven by the ECMWF TL511L60 deterministic forecast is shown in red, the simulation driven by the ECMWF TL255L40 ensemble control forecast is shown in green and the simulations driven by the 50 ECMWF TL255L40 ensemble forecast members are shown in black.

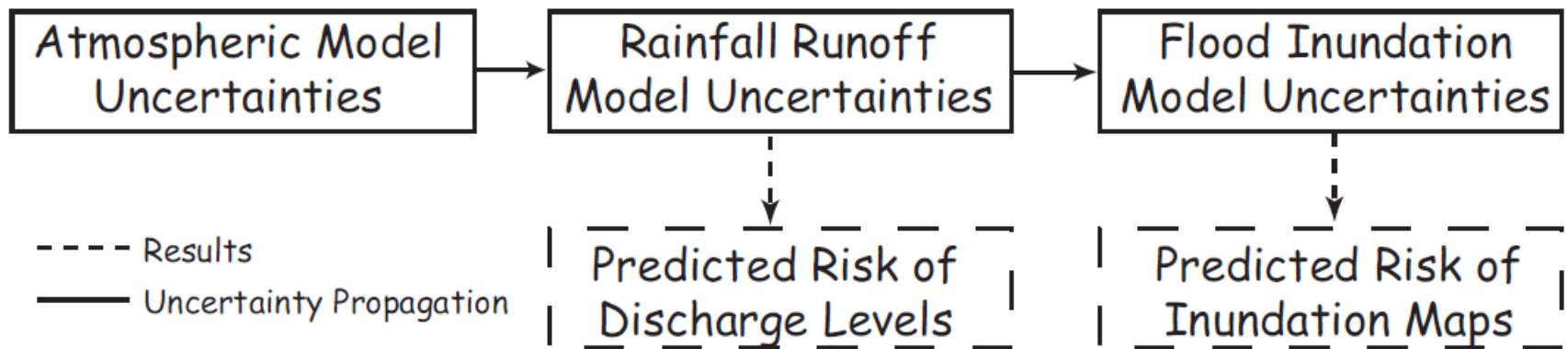
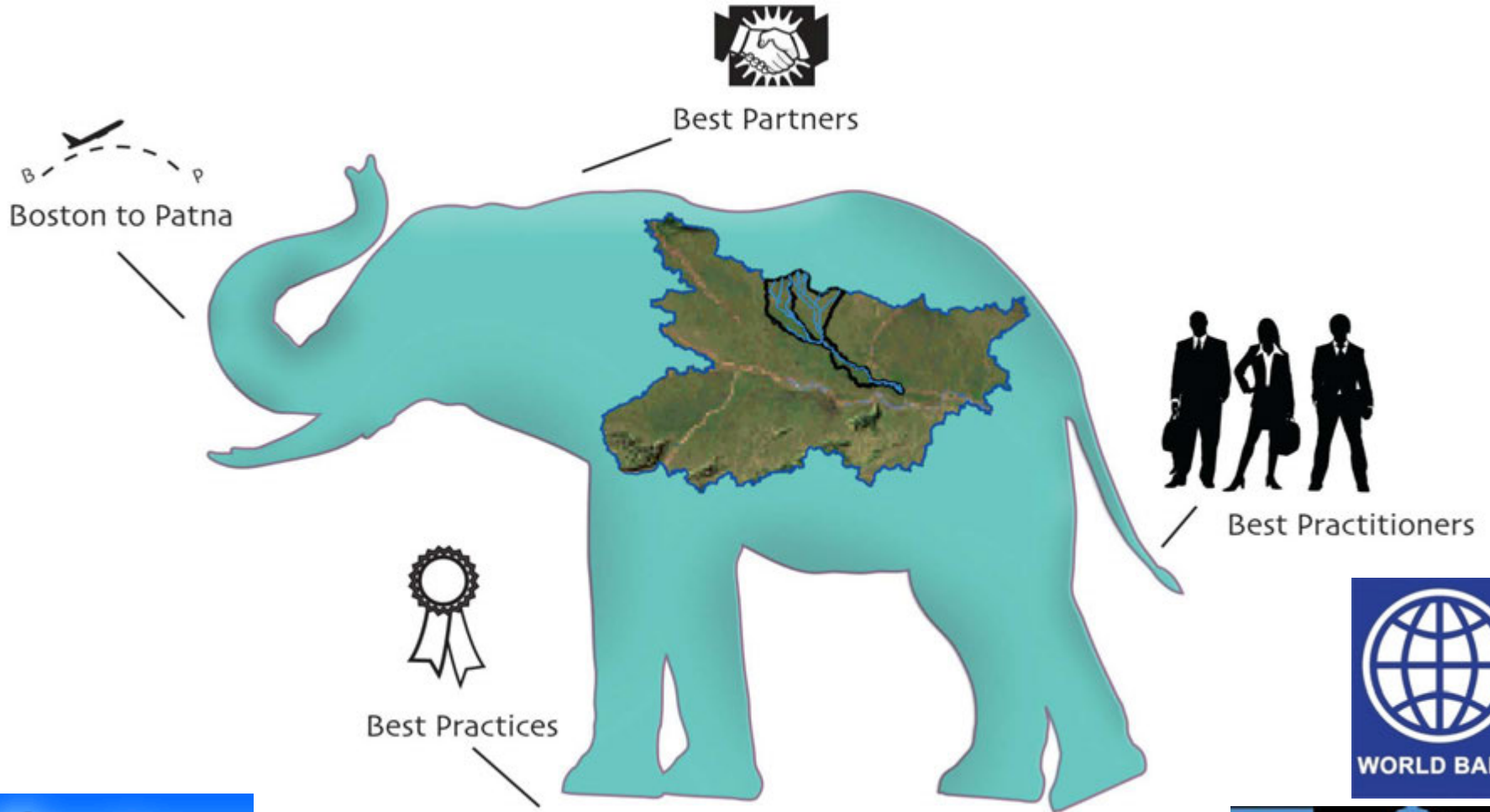


Fig. 1. Sketch of the uncertainty cascade

Four B.P.s for Actionable Water Knowledge in Bihar



Day 4: Review and HEC HMS for BA Basin

- **Comparison of IMD Forecasted and Observed Rainfall**
 - Available rainfall, water level and streamflow data
 - **ZERO order model for Forecasting Hyaghat Flow**
 - **Review HEC-HMS implementation**
 - **Customize HEC-HMS for the BA Basin**
- **Calibration and Validation of HEC-HMS for the BA basin**

World Bank-Tufts Partnership in Bihar, India

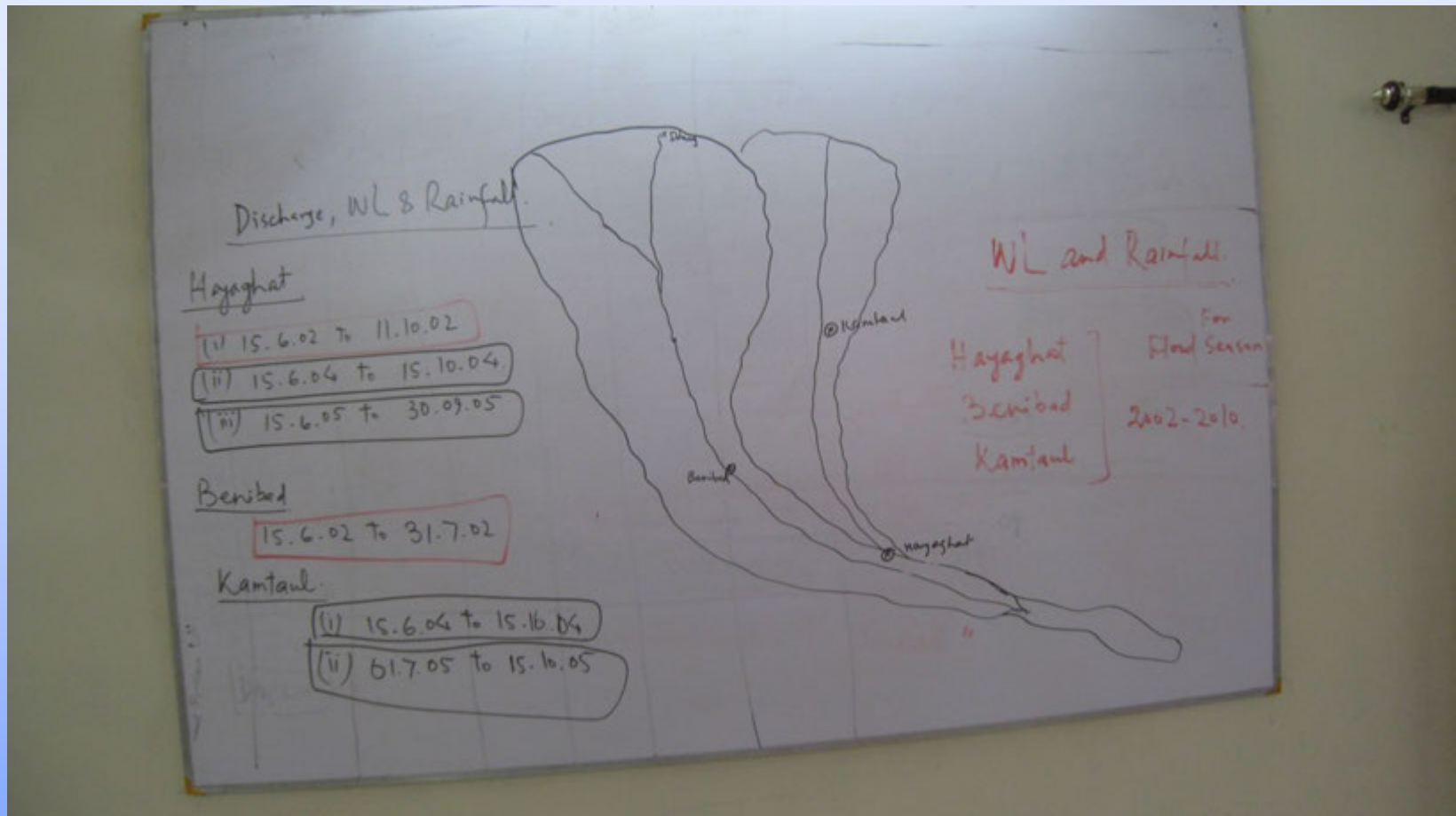
	Forecasted mean	Obs mean	(Obs-Forecasted) mean	R	Std dev Forecasted	Std dev Obs	
10/10	11.91	6.74	-3.17	0.14			
1 day	10.58 / 12.28	9.36 / 42.61	-2.21 / 30.41	0.14 / -0.27	8.26	16.10	
Benibad	10.78	5.42	-5.41	0.26	14.97	13.62	
10/10	10.69	8.34	-2.35	0.26			
Katamdu	10.27	8.34	-1.93	0.20	8.52	16.11	
2 day	15.18	4.31	-8.32	0.16	13.03	22.01	
	9.35	5.93	-3.90	0.26	15.35	13.61	
10/10	11.07	8.39	-2.73	0.10			
Katamdu	9.52 / 11.22	8.34 / 43.62	-1.18 / 32.30	0.20 / 0.45	7.22 / 6.65	16.16 / 22.38	
3 day	7.43	5.38	-2.04	0.24	11.26	13.65	

$\frac{24}{246} = 0.097$
 10%

2009 and 2010 flood seasons: Comparison of IMD forecasted rainfall And raingauge observations from Benibad and Kathmundu suggests

- **Very Low Correlation**
- **Forecasted rainfall is OVERESTIMATED**
- **When observed rainfall is greater than a threshold (mean + ONE standard deviation), forecasted rainfall is significantly UNDERESTIMATED.**

World Bank-Tufts Partnership in Bihar, India



Available rainfall, water level and stream flow data
Hourly Rainfall: Benibad, Kamtaul, Hayaghat,
Jhanjharpur: 2000-2005 selected storms

World Bank-Tufts Partnership in Bihar, India

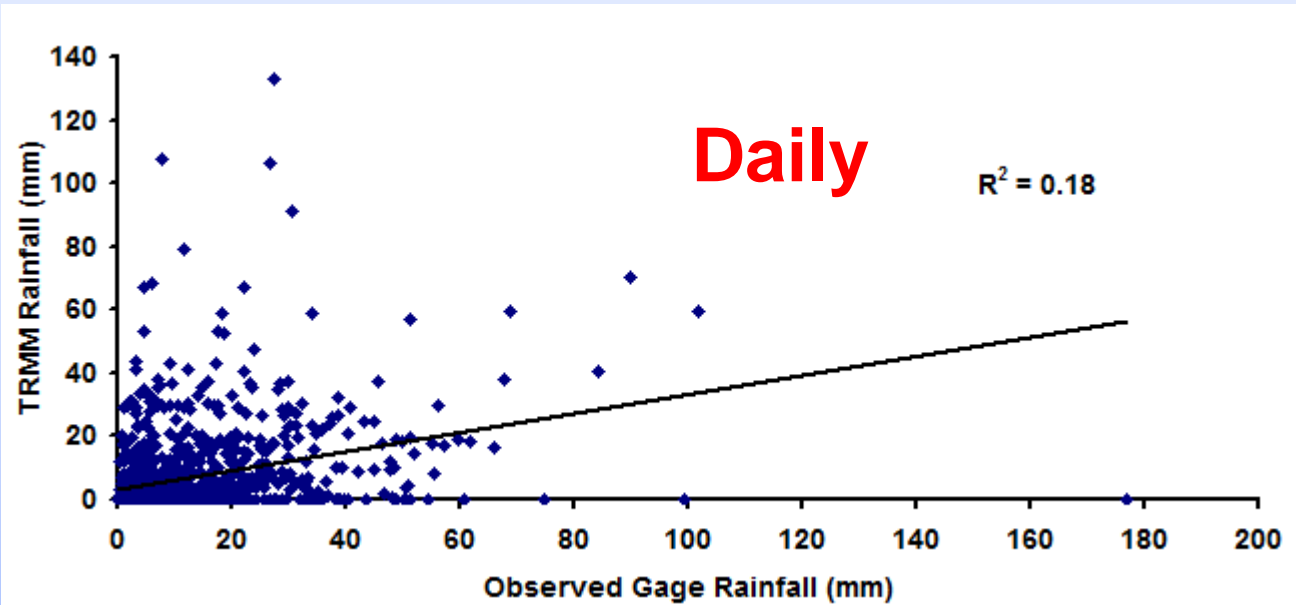
	Rainfall Hayaghat	Rainfall Bamide	WL	Rainfall Kartimukh	Rainfall Nagayach		
10 July	24.8	5.4	39.73	12	32.2	2002	0.99 1-day 0.97 2-day
11 July	29.4	20.6	39.52	12	32.2	2010	0.99 1-day 0.97 2-day 0.93 3-day
12 July	129.6	110.4	39.45	10.6	20.0	2002 Hayaghat	Streamflow 51
13 July	12.6	8.6	37.88	3.2	5.6		0.99 1-day 0.96 2-day 0.91 3-day
14 July	4.0	0	40.77	7.6	1.5	2004 Hayaghat	0.98 1-day 0.93 2-day 0.88 3-day
15 July	3.0	6.4	41.82	0	2.5	2005 Hayaghat	0.90 0.98 0.94
16 July			42.42	0.70	49.0		
17 July			42.54				

Hayaghat Water Level and Discharge Forecasting: ZERO Order Model

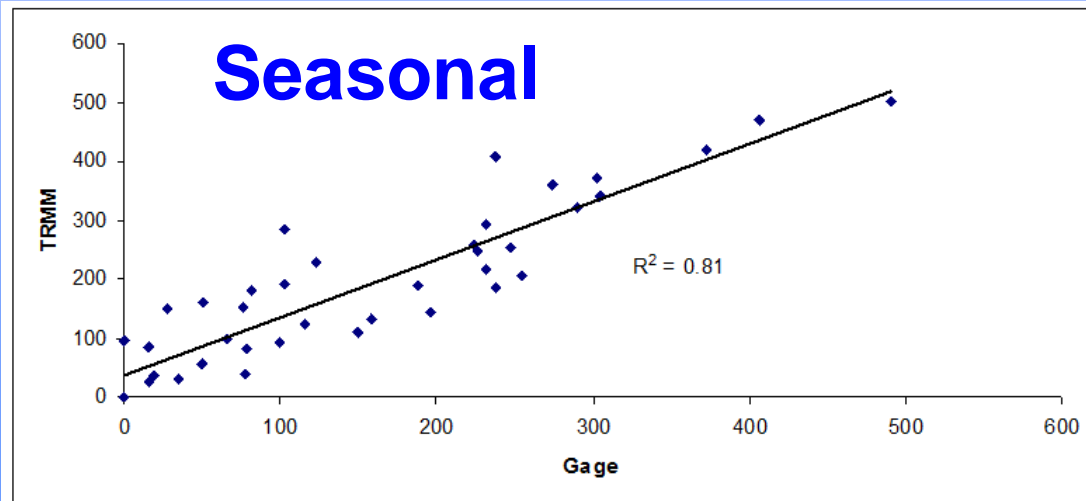
Flow/Water Level tomorrow = Flow/Water Level Today; This is 1-Day Forecast
 Flow/Water Level Day after tomorrow = Flow/Water Level Today; 2-Day Forecast

•Correlation between Forecasted and Observed Values are VERY HIGH

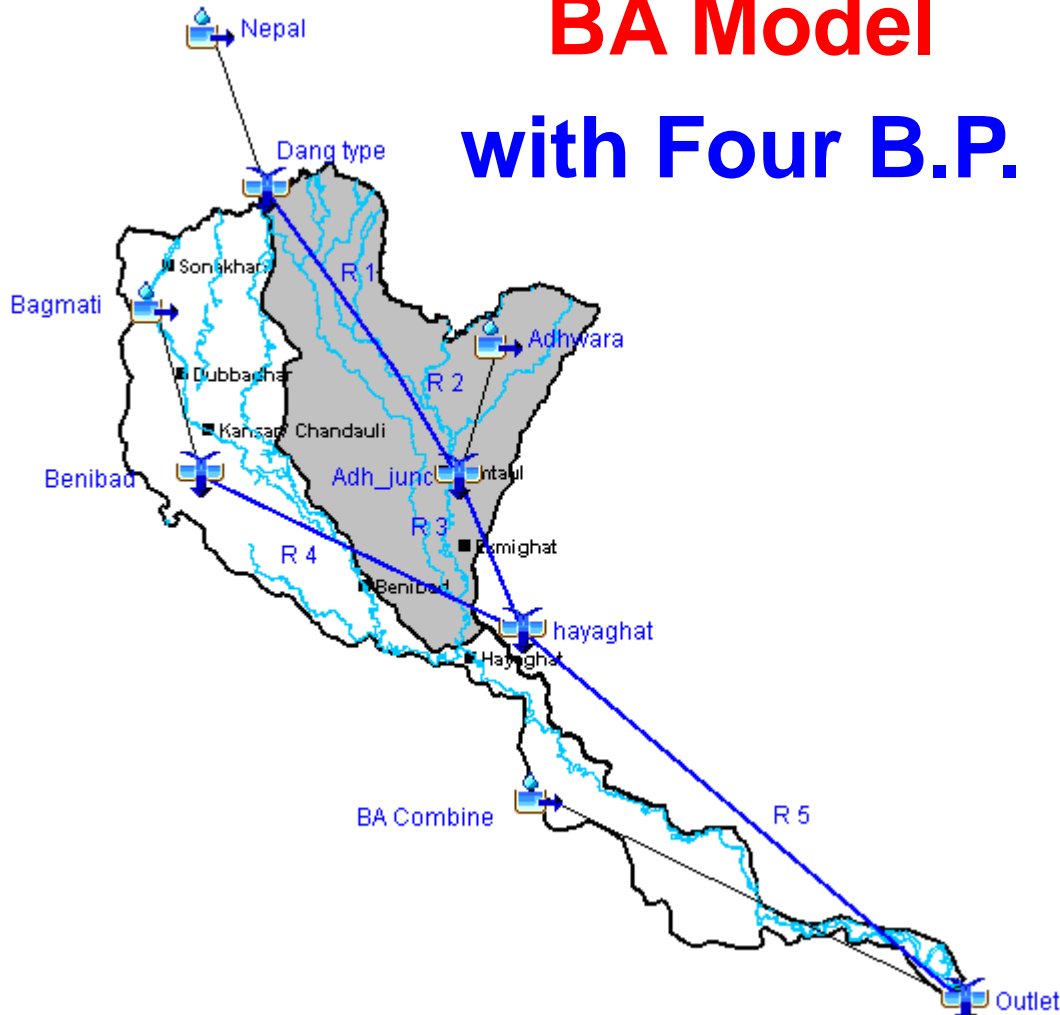
World Bank-Tufts Partnership in Bihar, India



Rainfall from
Satellite: TRMM



BA Model with Four B.P.



Modeling is a Synthesis of
Science and Art

One Year:

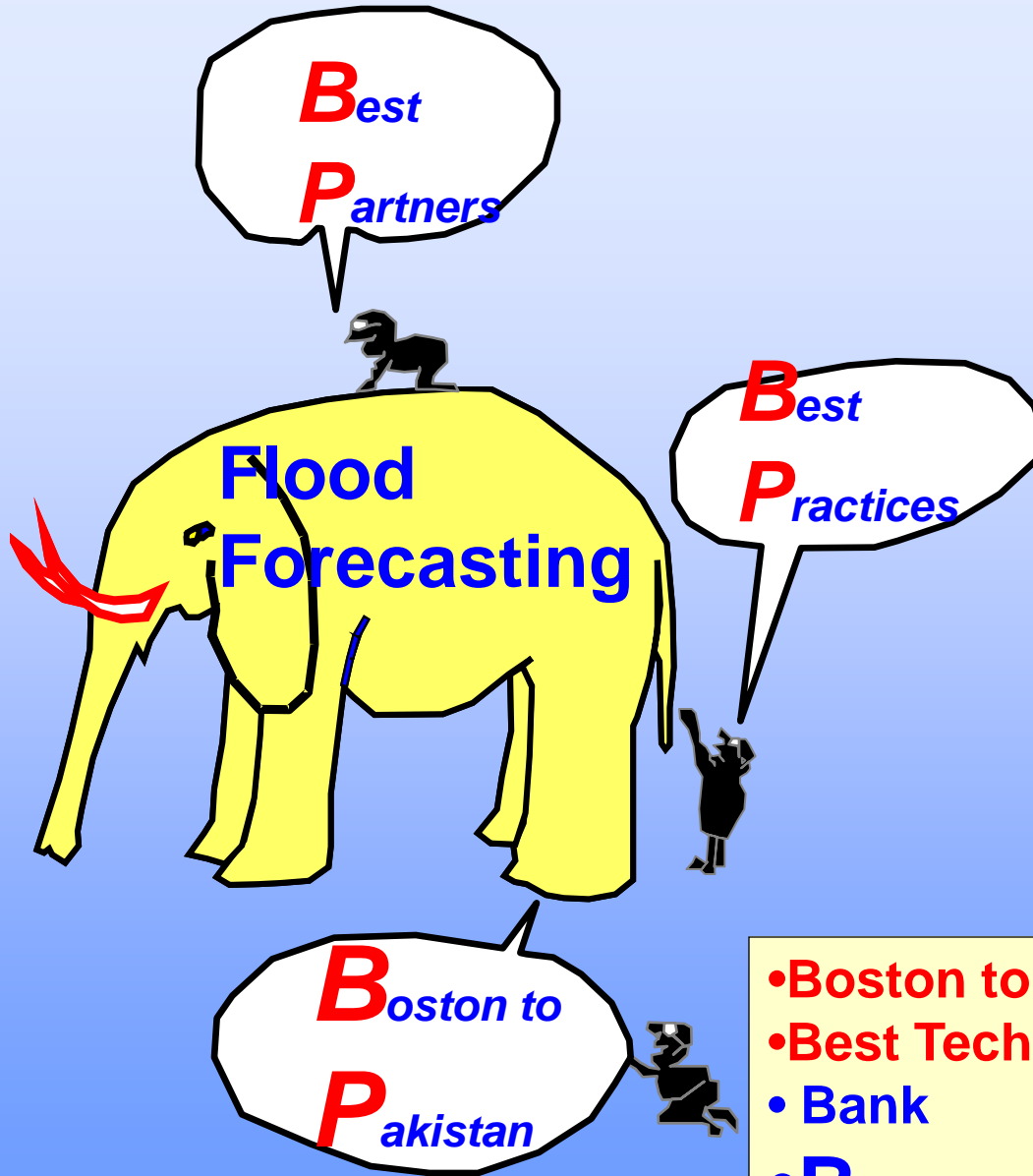
- How to set up the Model?
- What Data do we Need?
- What Forecasting Lead Time?

Three Years:

- An Operational Flood Forecasting Model
- Data Needs Identified?
- 72 Hours Lead Time

Five Years:

- An Operational and Validated Flood Forecasting Model
- Data integrated in modeling
- 3-6 Days Lead Time



- **Boston to Patna**
- **Best Technology and Know How**
- **Bank**
- **Be Adaptive to Patna**

Flood Forecasting & Water Management: Actionable Knowledge for Pakistan

“How to prevent Hazard to become Disaster”

- Improve **RESILIENCE** to water hazards in Pakistan
 - **Non-Structural** (e.g. forecasting & warning systems)/
Structural (e.g. embankment, barrage, dams)
 - **Local/Provincial/National/International**
 - **Short/Medium/Long-term**
- Improve water **PRODUCTIVITY** in Pakistan
 - Improved basin planning and investment prioritization
 - Improved irrigated agriculture
 - Improved agricultural services

Primary Challenges for Pakistan: I³

Problems and **Conditions** TO Solutions and **Management**

- **Information**

- Models (Flood Forecasting; Water Management... Numerical Weather Prediction Models, Rainfall Runoff Models, Flood Inundation Models)
- Data (Topographic Data; Rating Curves; Weather and Climate Data)
- Lack of real-time LOCAL and BOUNDARY data

- **Institutions**

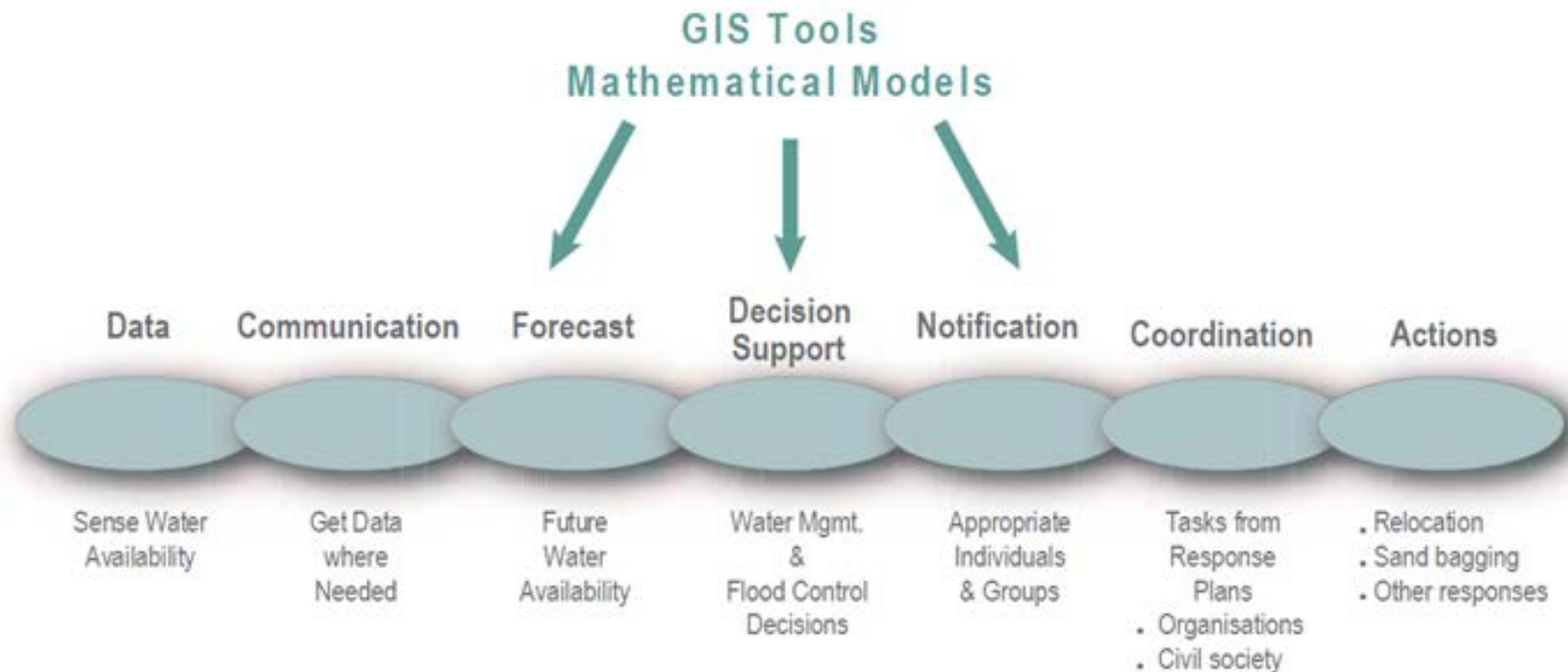
- Build and Strengthen Institutions to address PROBLEMS and CONDITIONS
- Integrate SHORT-term and LONG-term goals to CREATE ACTIONABLE KNOWLEDGE through strategic policy and MEASURABLE METRICS

- **Infrastructure**

- Physical infrastructure
- Build Capacity (Brilliant Practitioners from Pakistan who understand the “context” and current “know-how”)

From Data and Models to Action and Implementation

Flood and Water Resources Management: a Critical Chain of Events and Actions



1. Introduction

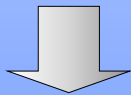
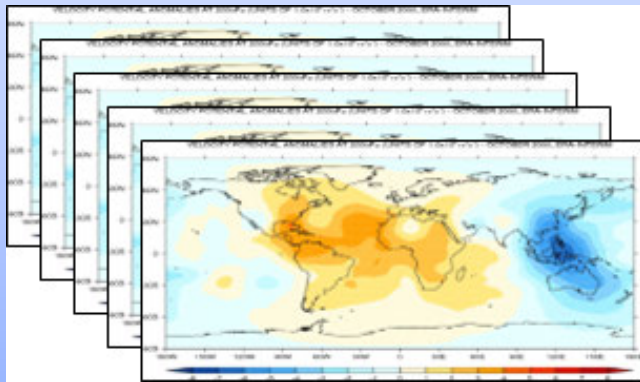
An increasing number of disasters caused by natural hazards throughout Europe have been recorded in the past decades, affecting millions (Fig. 1; CRED, 2011; European Environment Agency, 2010) and causing an increase in economic losses (e.g., Barredo, 2009). The increase in losses up to now has mostly been associated with societal changes, rather than human-induced climatic changes (Barredo, 2009). Yet, it can be expected that extreme weather events, causing most of the natural disasters, will increase with changing climate (Easterling et al., 2000; Morse et al., 2011). Rising human and economic impacts of natural hazards have triggered the European Commission to develop legal

frameworks such as the Water Framework Directive 2000/60/EC (2000) and the Floods Directive 2007/60/EC (2007), to increase prevention, preparedness, protection and response to such events and to promote research and acceptance of risk prevention measures within the society. An important part of a holistic approach to risk management of natural hazards is the set up of early warning systems. Early warning can be defined as 'the provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response' (ISDR, 2004). Recent studies have illustrated that early warning systems can have significant benefits exceeding their development and maintenance cost (e.g., Rogers and Tsirkunov, 2011; Teisberg and Weiher, 2009).

What is Global Flood Awareness System (GloFAS)?

GloFAS is a **Joint collaboration between the EC Joint Research Centre and the European Centre for Medium-Range Weather Forecast**

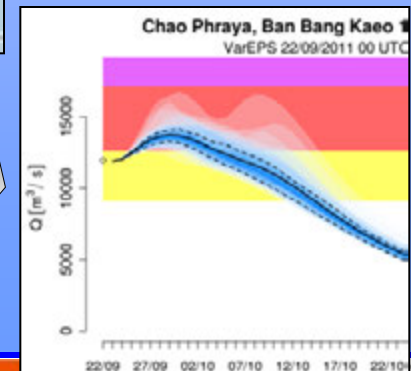
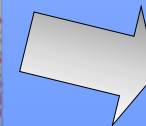
Global probabilistic weather forecast

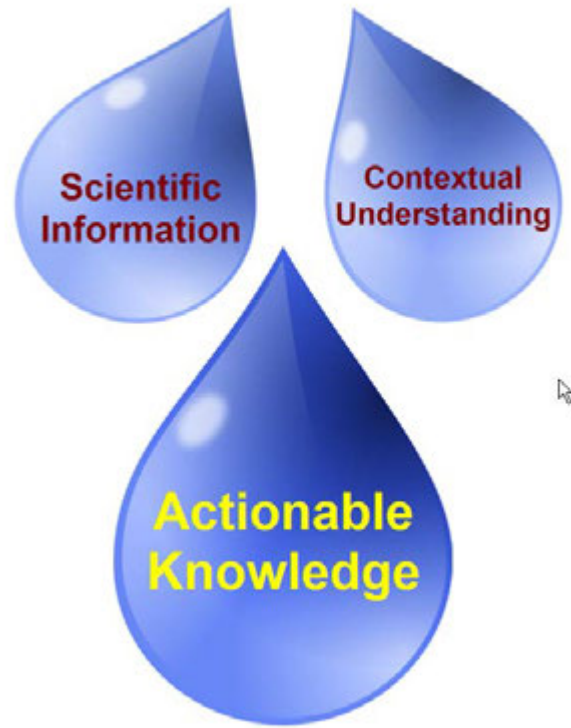
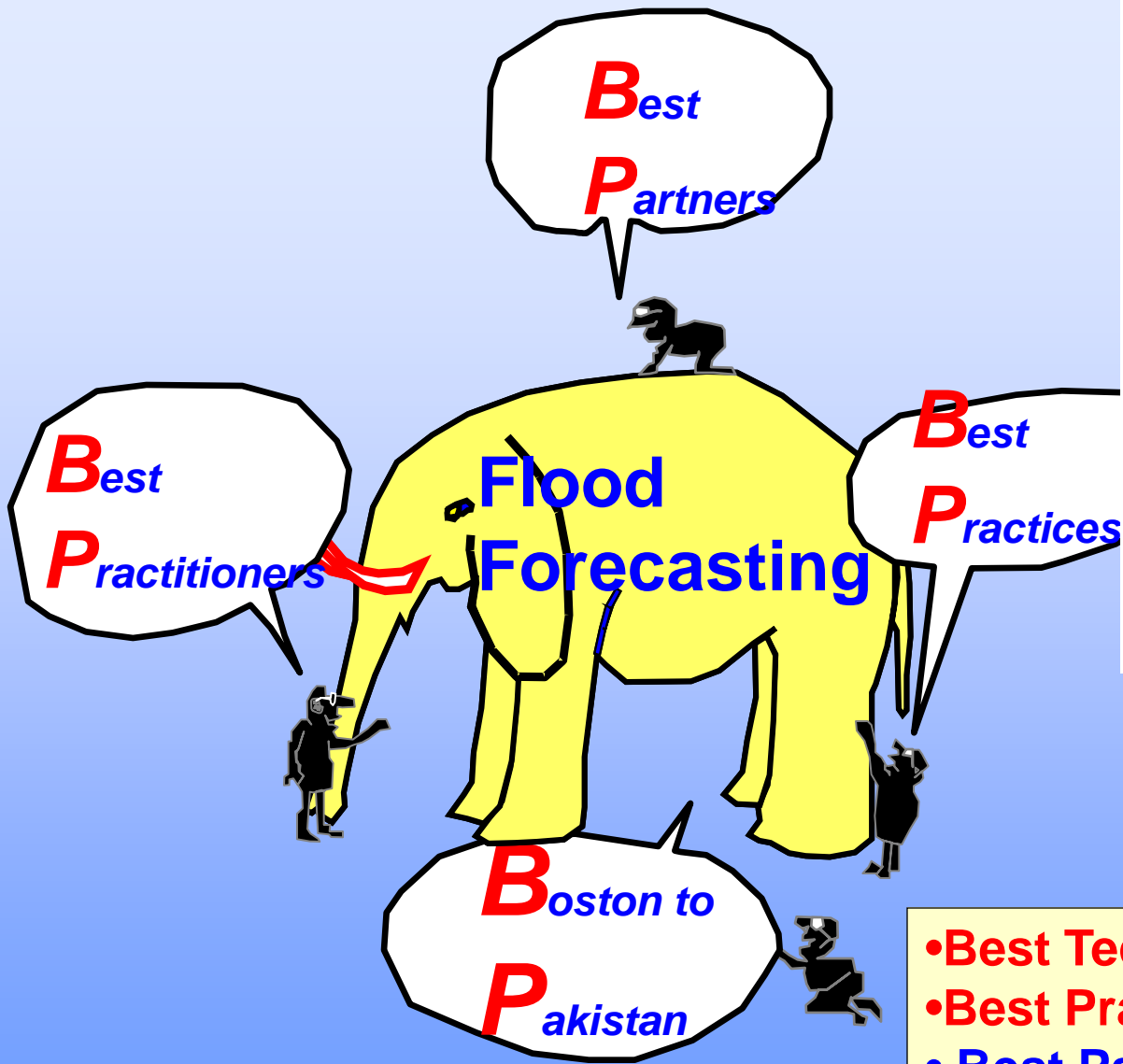


Hydrological model



Decision support information





- **Best Technology**
- **Best Practices**
- **Best Partners**
- **Best Practitioners for Pakistan**