IWMI'S FLOOD RISK ASSESSMENT AND MODELING RESEARCH IN ASIA AND AFRICA

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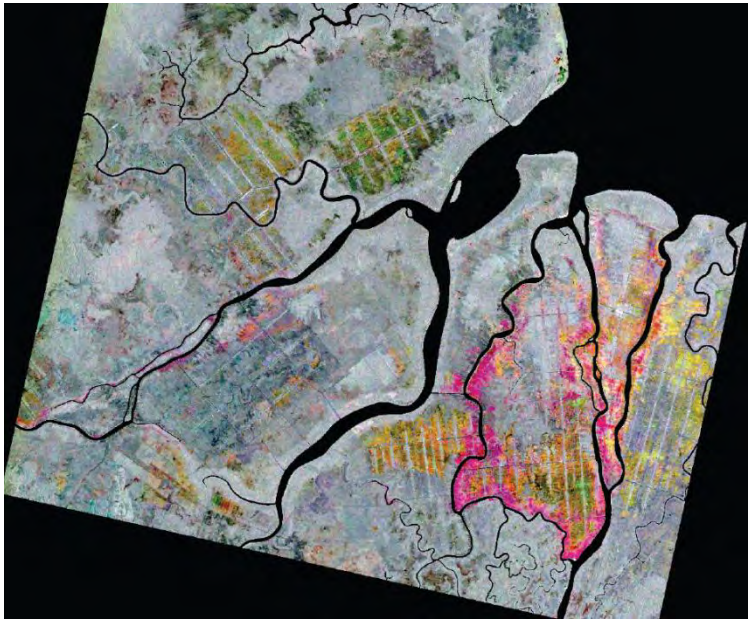
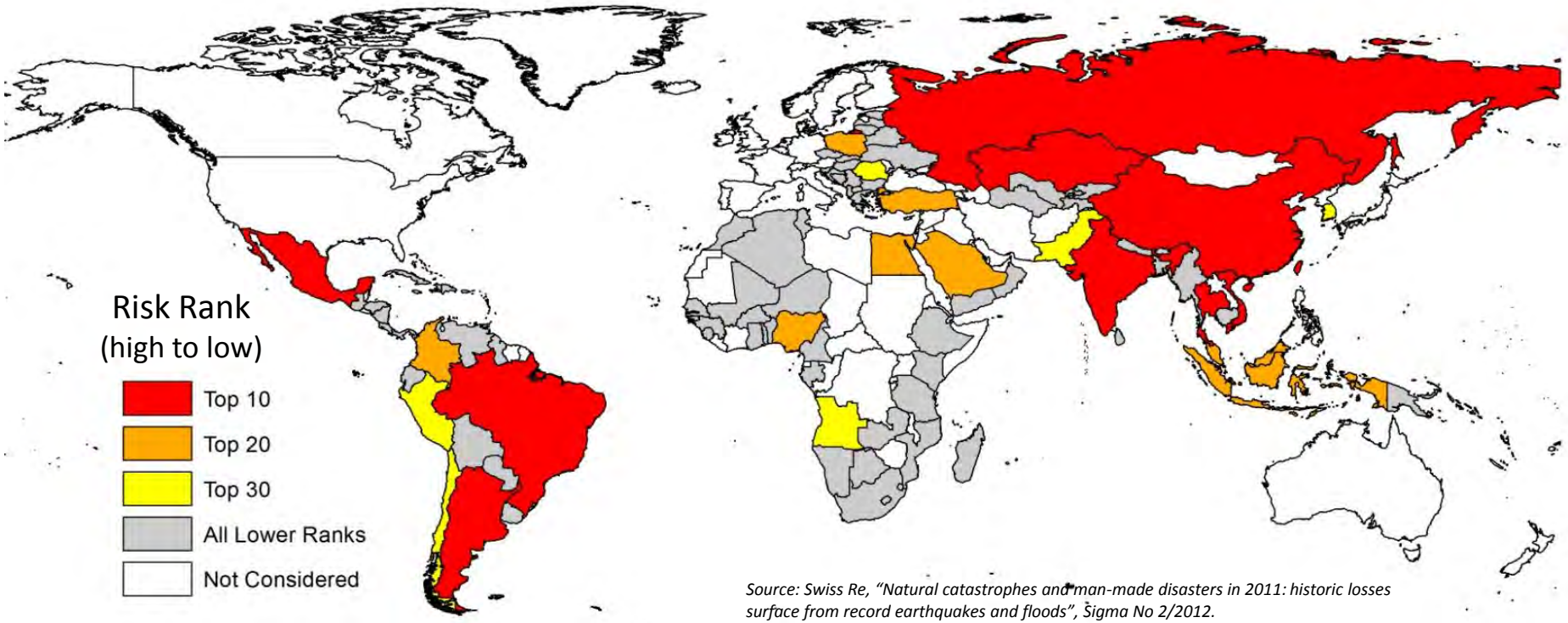


THE PROBLEM

- **Floods – primary natural disasters**
- **Precipitation intensity and variability is projected to increase – increasing risks of flooding globally and in Asia**
- **Global flood losses in 2011 >$100 Billion**
  - **Largest global losses:**
    - **Thailand (Jun-Nov) $40-50B**
    - **Australia (Jan-Feb) $20-30B**
    - **Hurricane Irene (Aug) $5-10B**
- **May rise to over $450B by 2030**

GLOBAL FLOOD RISK RANKING

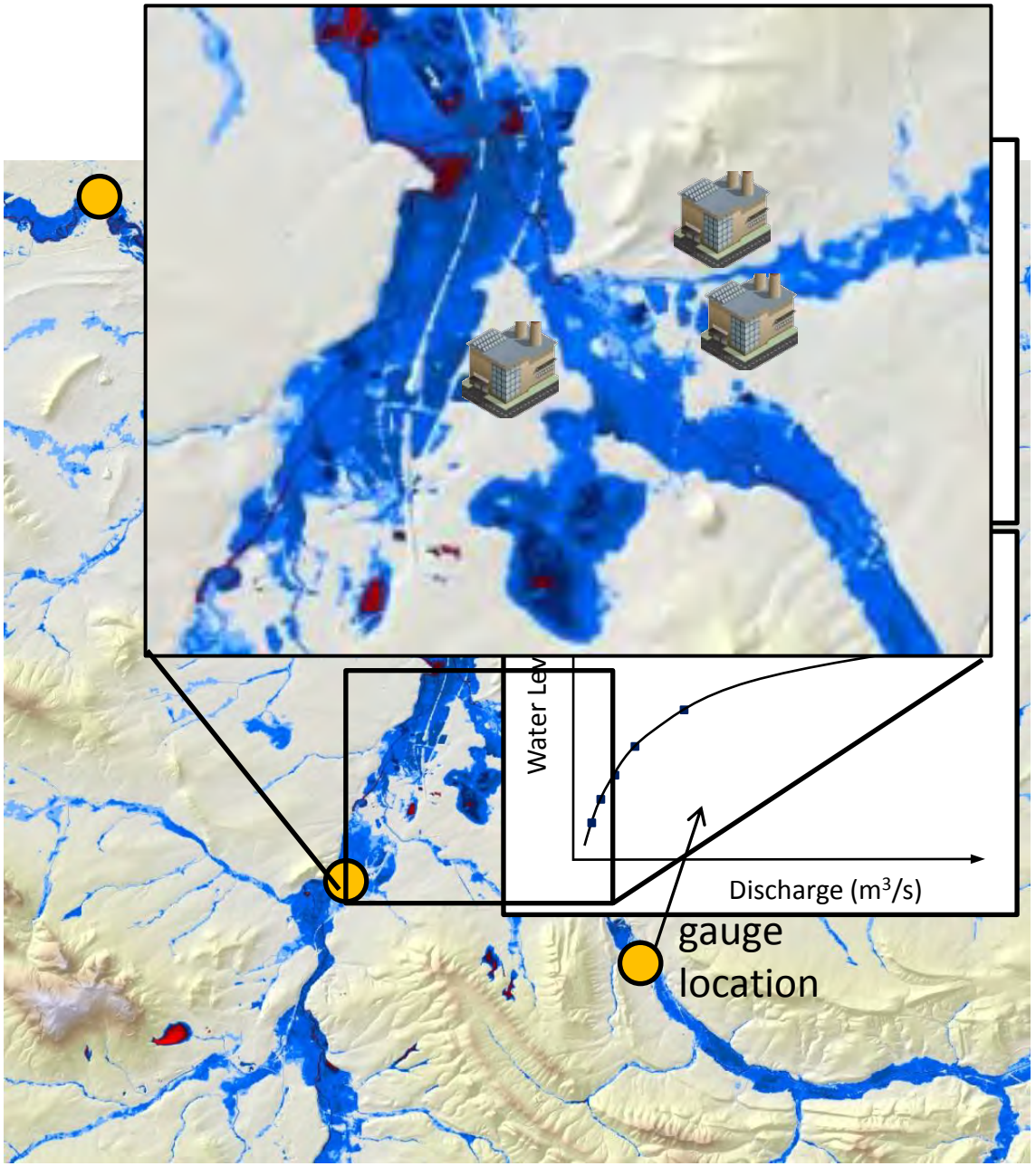
- Flooding major concern in many emerging markets
  - Risks based on flood exposure and economic growth
  - Thailand (2011 flood losses of $40-50B) only ranks 7th
  - Highest risk regions where streamflow data are limited



Source: Swiss Re, "Natural catastrophes and man-made disasters in 2011: historic losses surface from record earthquakes and floods", Sigma No 2/2012.

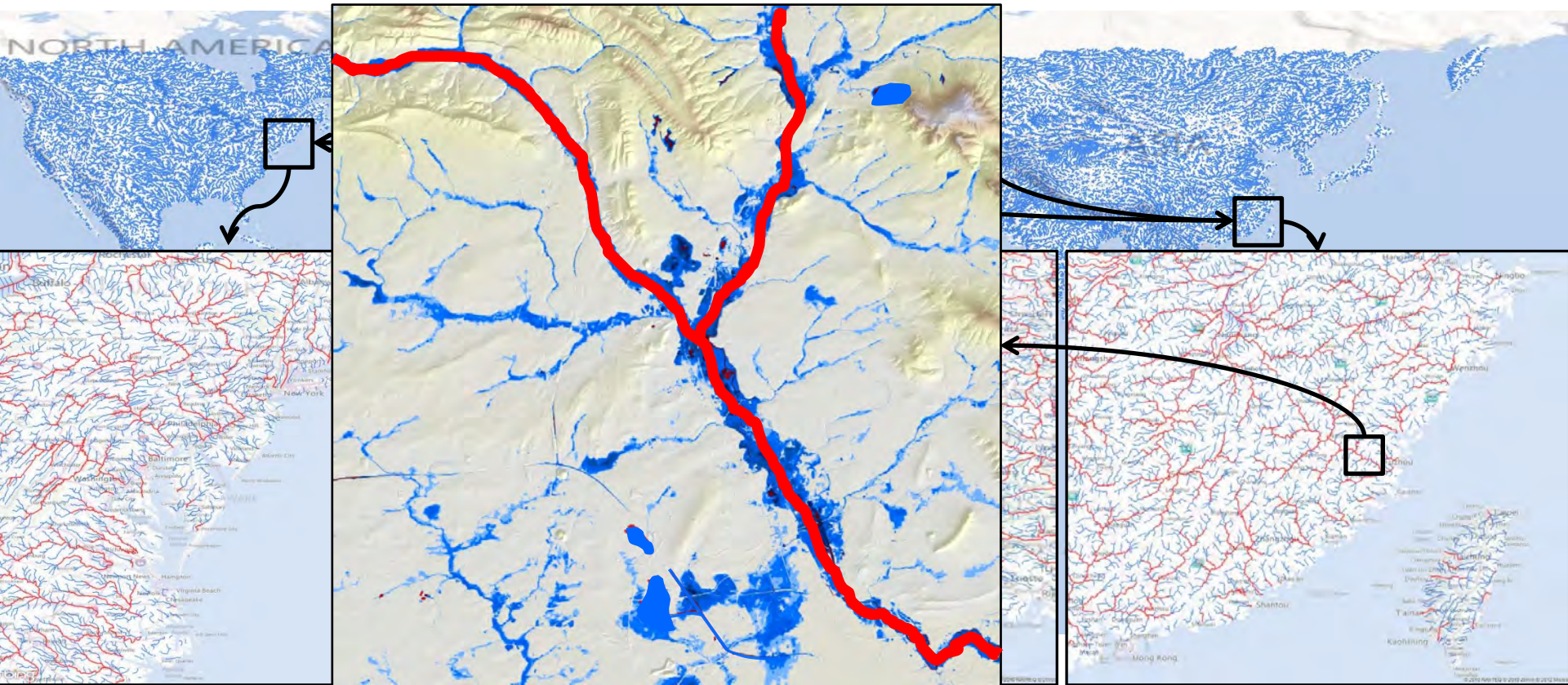
UNDERSTANDING FLOOD RISK – "AT A SITE"

- Sample X-yr flood map; shaded by water depth (shallow-blue to deep-red)
- Challenge to validate hydraulic model producing continuous water surface w/ point measurements
- Will these locations flood?



UNDERSTANDING FLOOD RISK – "GLOBAL TO LOCAL "

- Satellites/Models provide consistent data for ??? km of river reaches, of which many (???%) river reaches are needed for Engineering and Insurance Applications
- Can lead to X-yr flood hazard meaning same everywhere
- Help in aggregate analyses at **Global**, **Regional** & **Local** **scales**

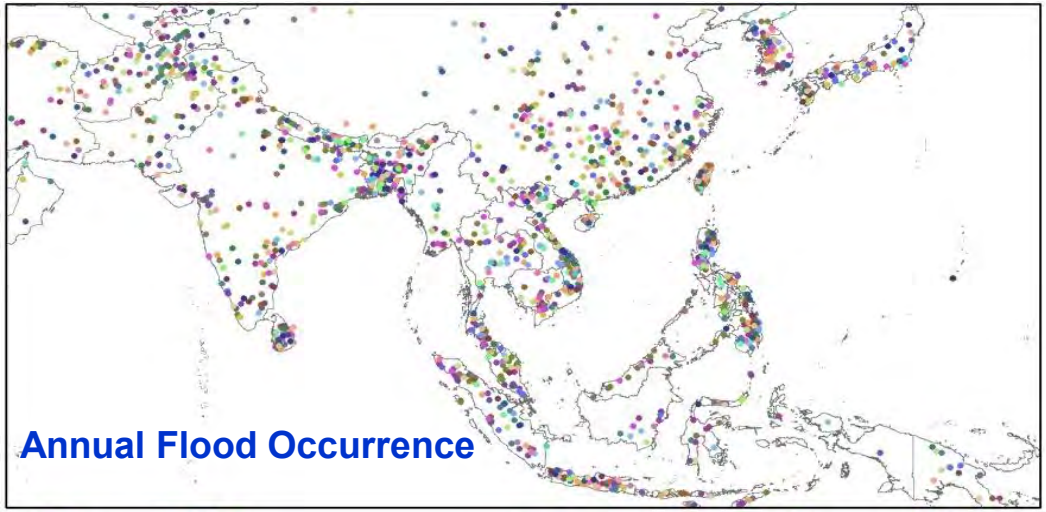


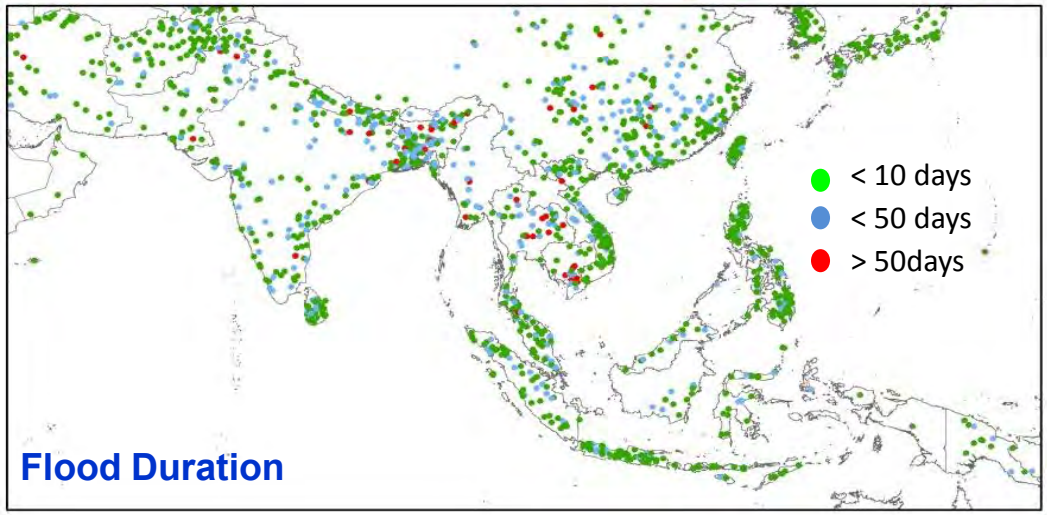
Mapping Flood Hotspots for Climatic Change

CATASTROPHIC FLOODS IN ASIA: 1900-2011

- Collated from 6 global sources
- >4000 floods globally
- Around 35% - in Asia

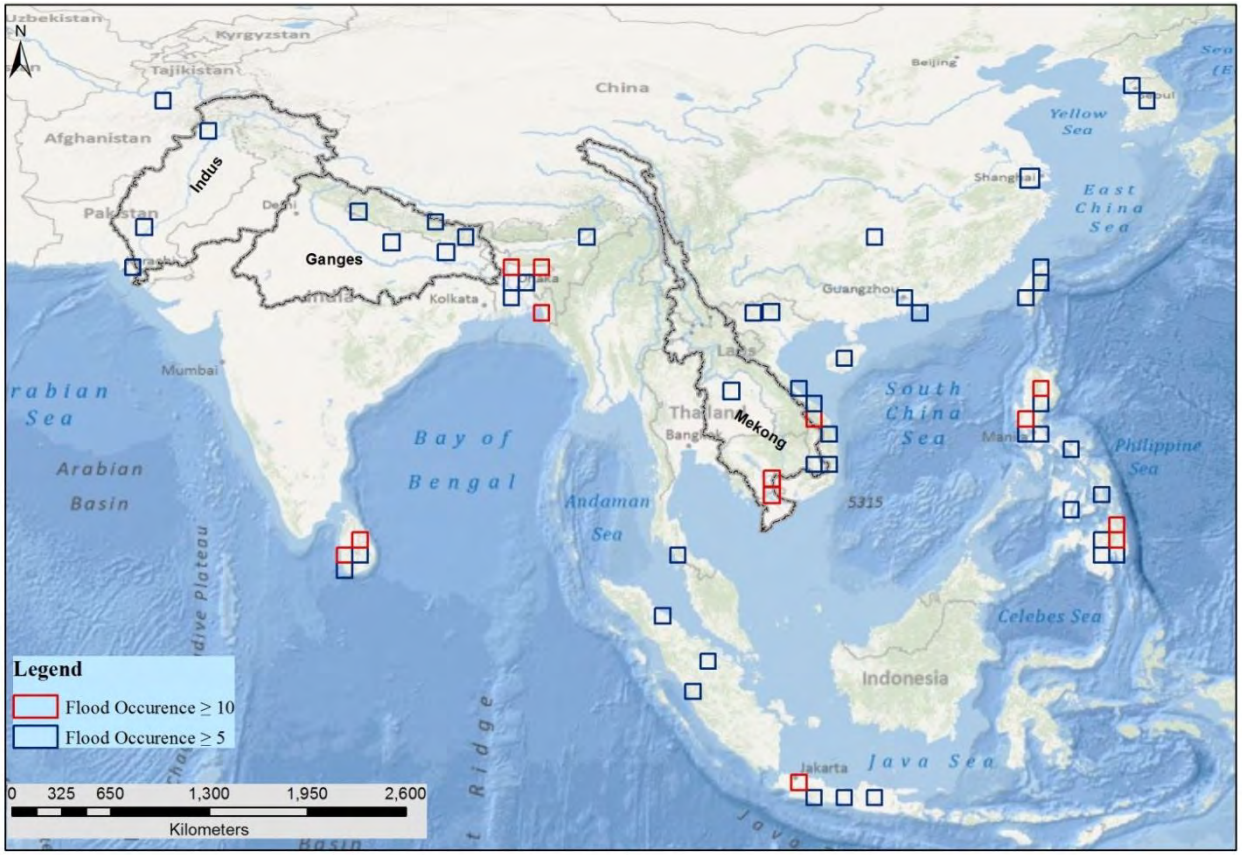
Country	Flood Occurrence
India	237
China P Rep	209
United States	155
Indonesia	142
Philippines	116
Brazil	112
Bangladesh	83
Iran Islam Rep	72
Pakistan	72
Vietnam	67



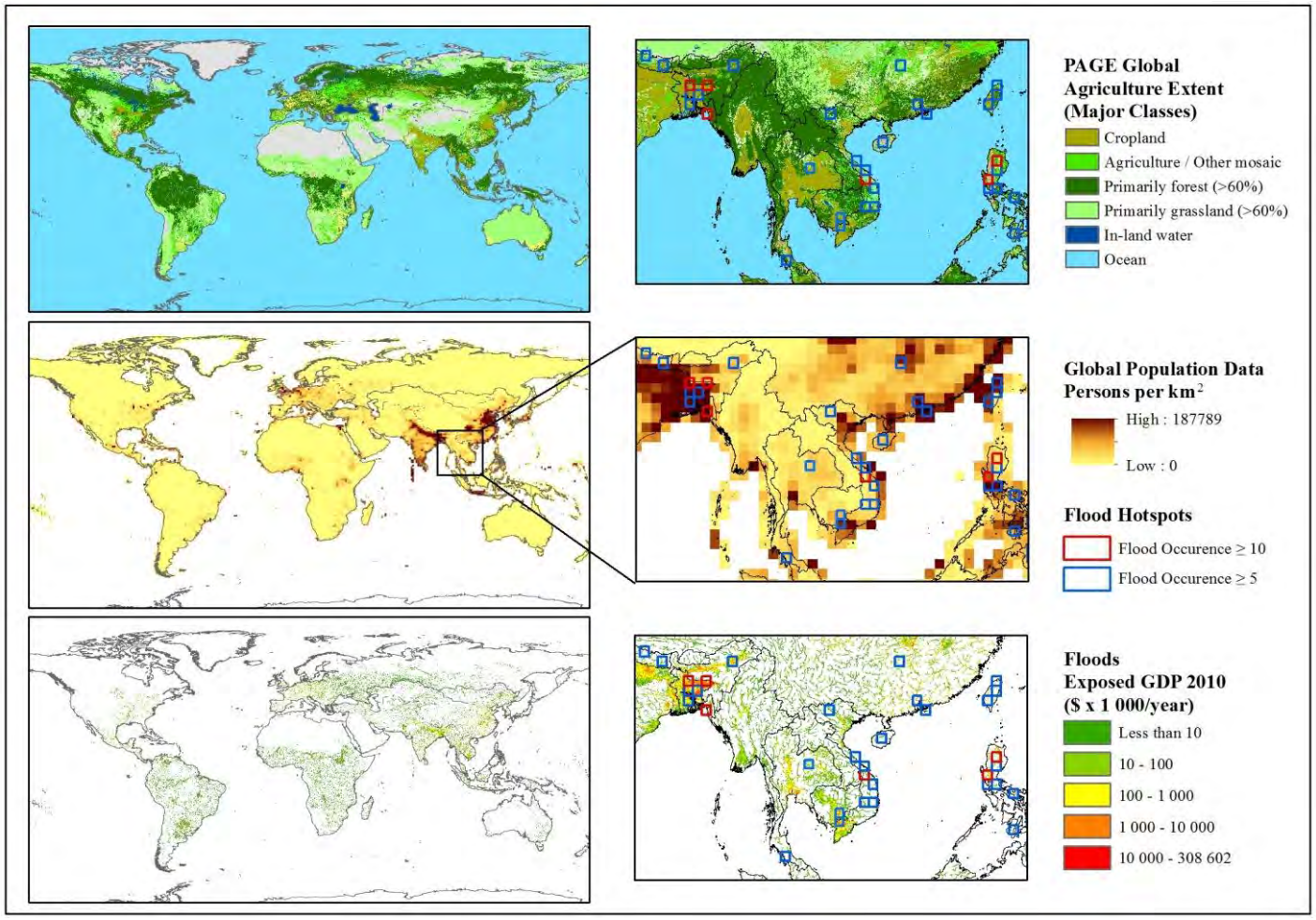


IDENTIFYING FLOOD HOTSPOTS

- 100 km grid over the globe;
- numbers of floods in each cell over 1900-2011



CHARACTERISING FLOOD HOTSPOTS



AGRICULTURE;
PAGE (2005)

POPULATION
CIESIN - 2010

FLOOD EXPOSED GDP
WB, 2010

CHARACHERIZING FLOOD HOTSPOTS

- Globally - 90 grid cells with catastrophic flood occurrence ≥ 5;
- 60% of these cells -in Asia

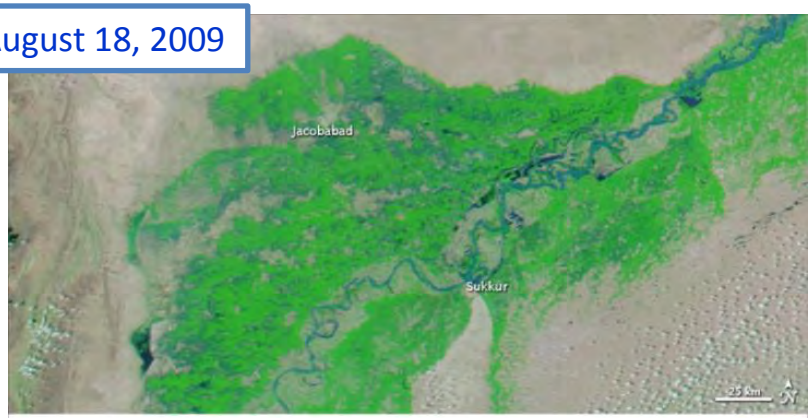
- Estimated total over these hotspots:
  - annual economic loss due to floods - $20bn
  - 30 million affected people
  - 500,000 km^2 of affected croplands

SUB-CONTINENTAL SCALE FLOOD MAPPING

Examples from SA and SEA – MODIS images

Indus

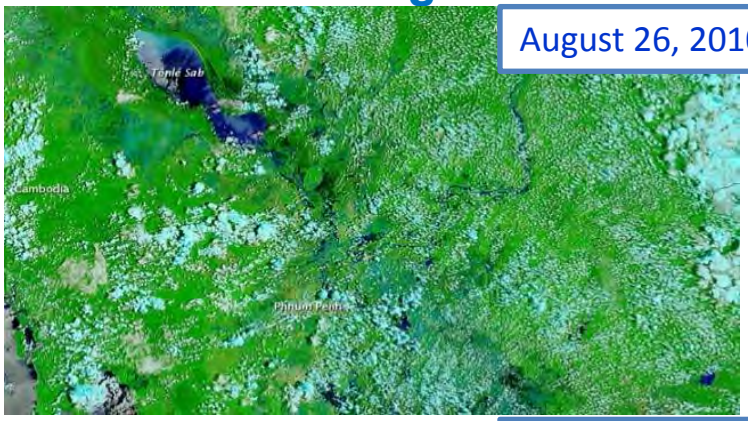
August 18, 2009



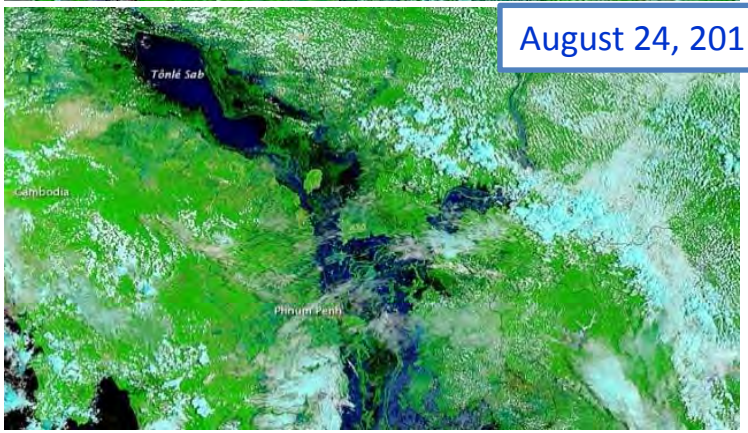
August 17, 2010

Mekong

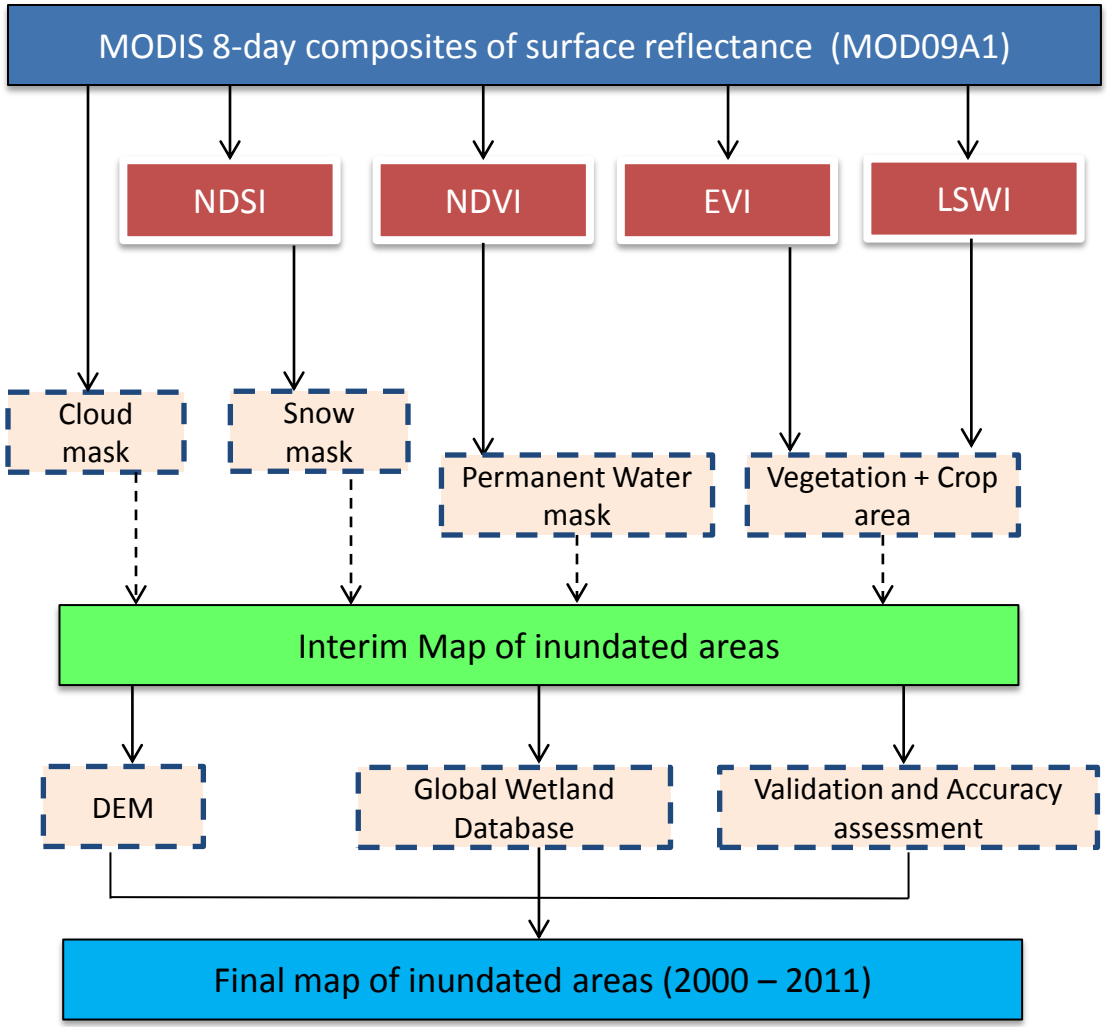
August 26, 2010



August 24, 2011



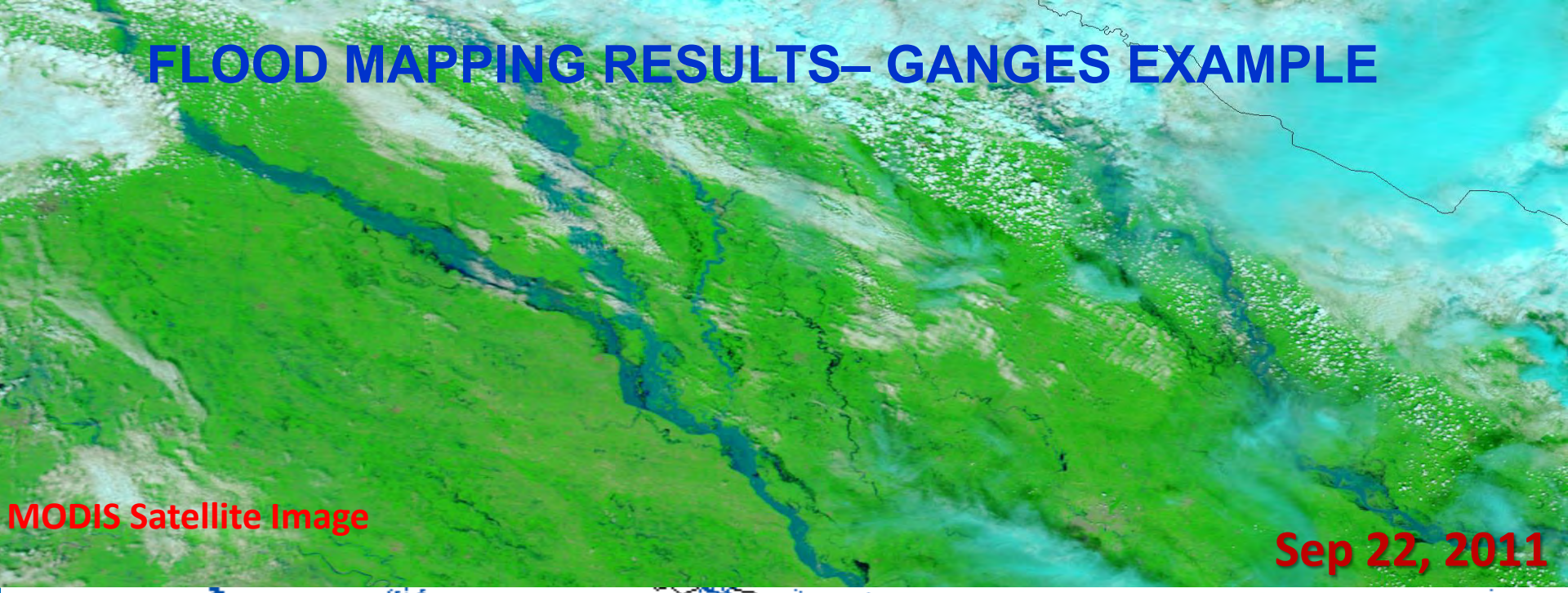
FLOOD INUNDATION MAPPING ALGORITHM

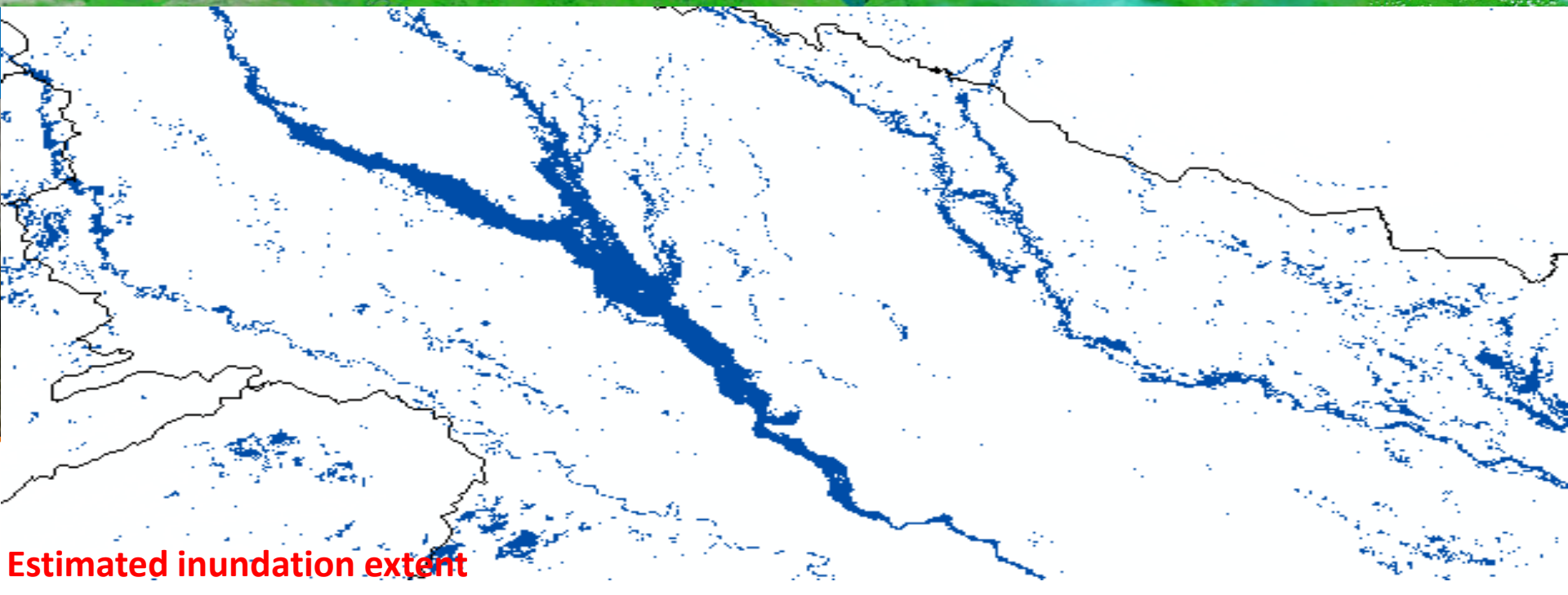


- MODIS surface reflectance
- Global
- Temporal resolution : 8 days
- Spatial resolution – 500 m
- Period : 2000 – 2011
- Indices : EVI, NDWI, LSWI, NDSI
- DVEL (EVI-LSWI) was used to discriminate between *Water* pixels and *Non–water* pixels. If the smoothed DVEL is less than 0.05 pixel is assumed to be a *Water* pixel;
- Several procedure further differentiate between permanent water bodies and temporary *Flood pixels*

- Applied in South Asia
- Being applied in South East Asia

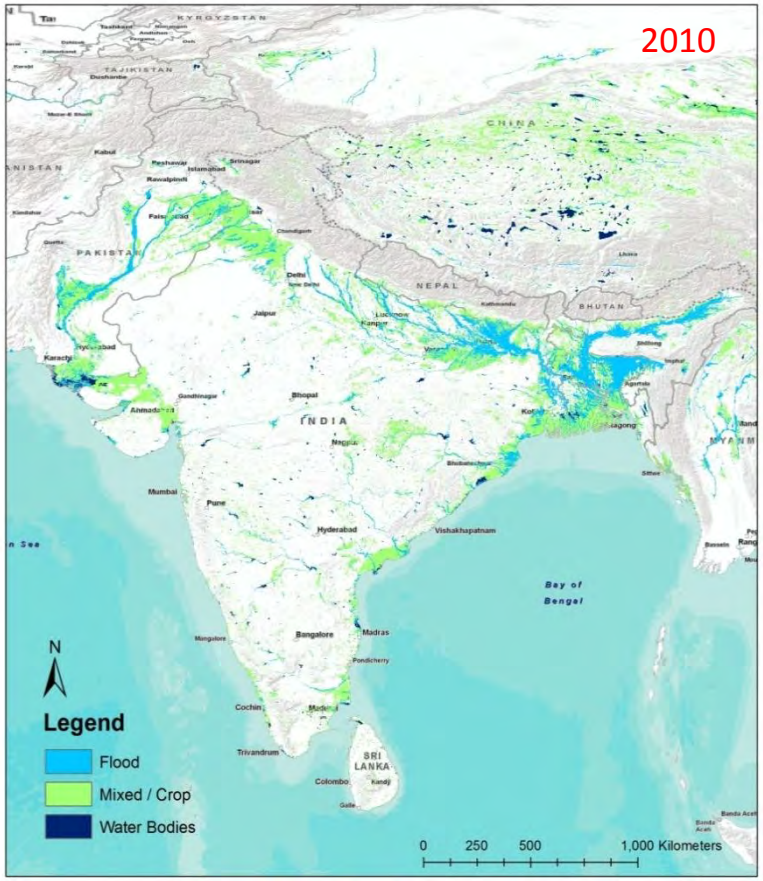
FLOOD MAPPING RESULTS– GANGES EXAMPLE



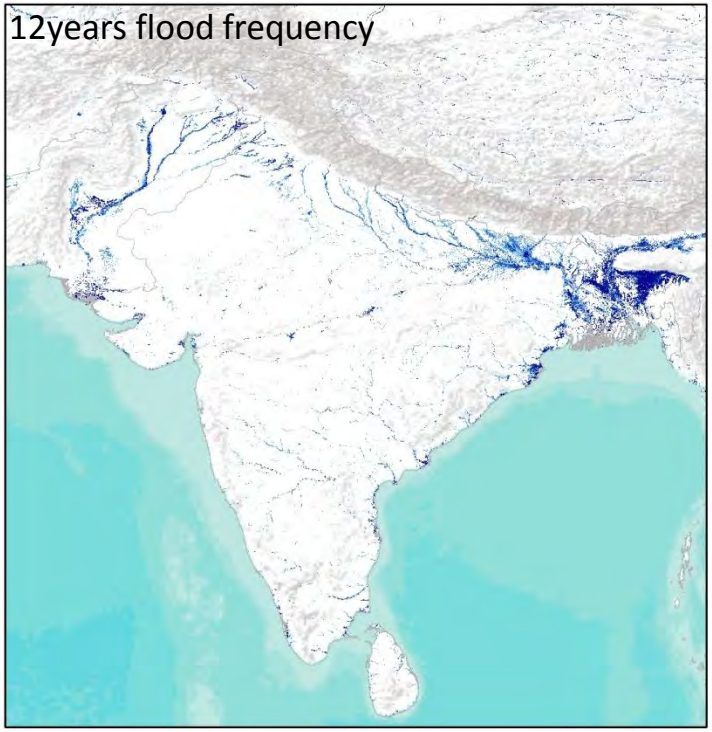


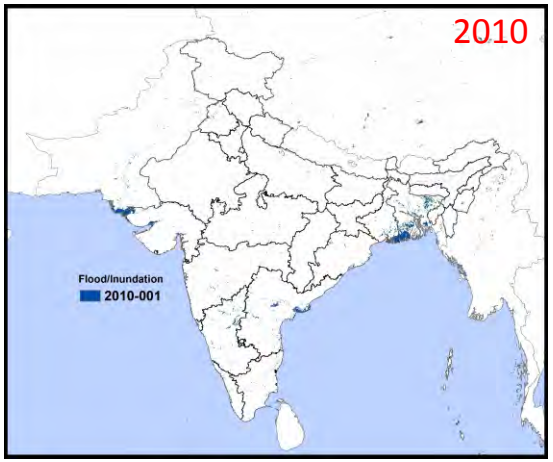
SOUTH ASIA FLOOD MAPPING PRODUCTS

- 8-days maps of inundation extent
- Annual maps of maximum inundation
- Inter-annual variation of regional flooding extent
- Spatial distribution of start – end dates, and duration of inundation cycle
- Basin level flood risk assessment



SOUTH ASIA PRODUCTS





Country	Flood Affected Area	Area (sqkm)	Percent Area
Bangladesh	69,025.93	147,570	46.78
India	135,568.18	3,287,240	4.12
Nepal	1,442.34	147,181	0.98
Pakistan	97,057.15	796,095	12.19
SriLanka	838.27	65,610	1.28

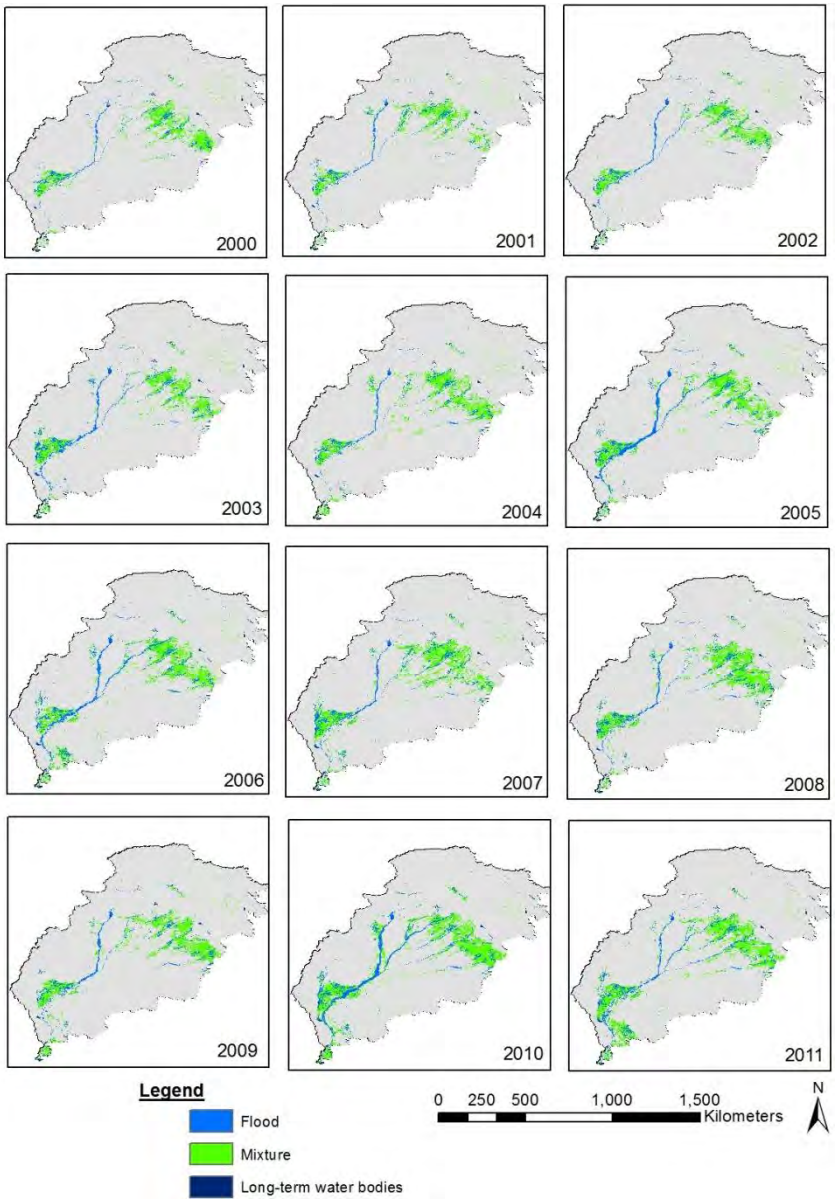
Big Facts on Floods and Crops

Flooding affects ~10 million hectares of rice fields

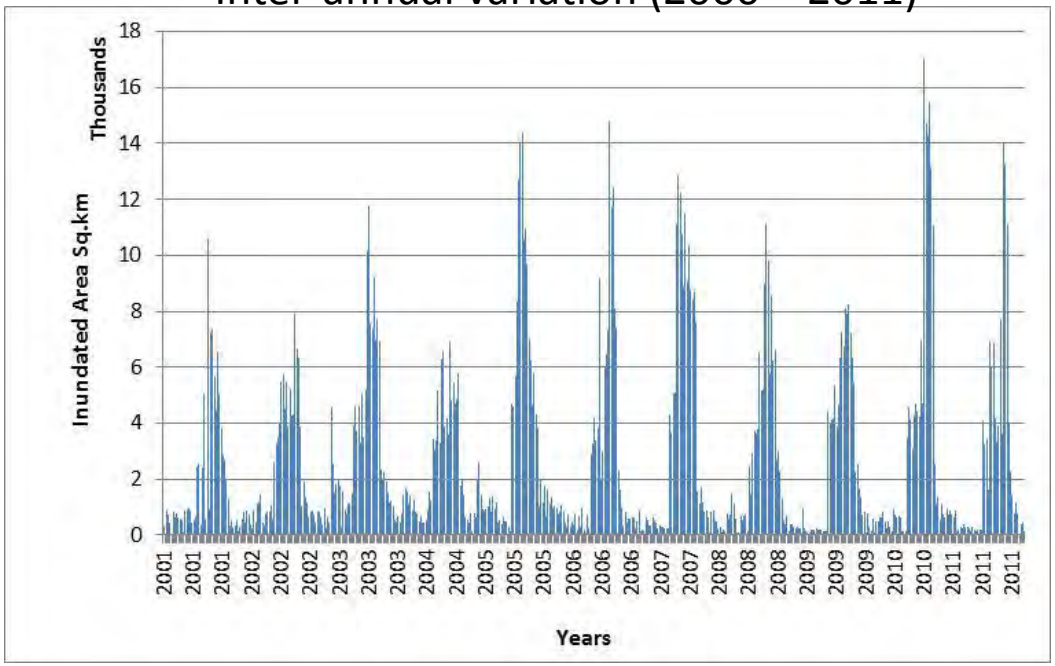
Estimated $1 billion USD in yield losses per year

EXAMPLE PRODUCTS : INDUS BASIN

Annual floods maps



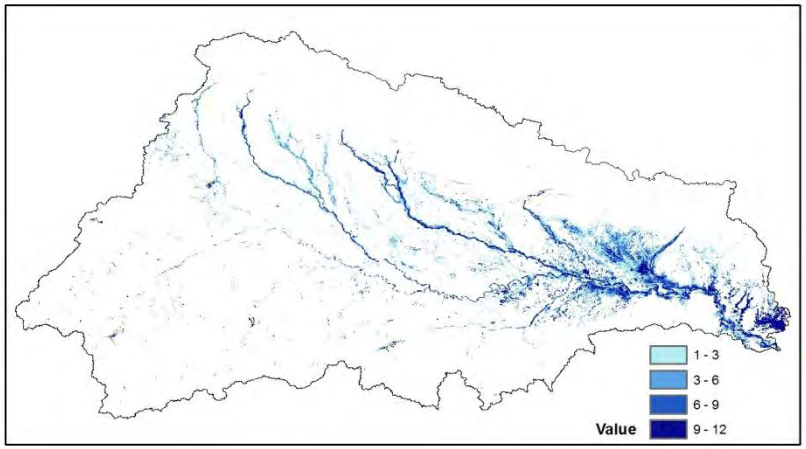
Inter-annual variation (2000 – 2011)

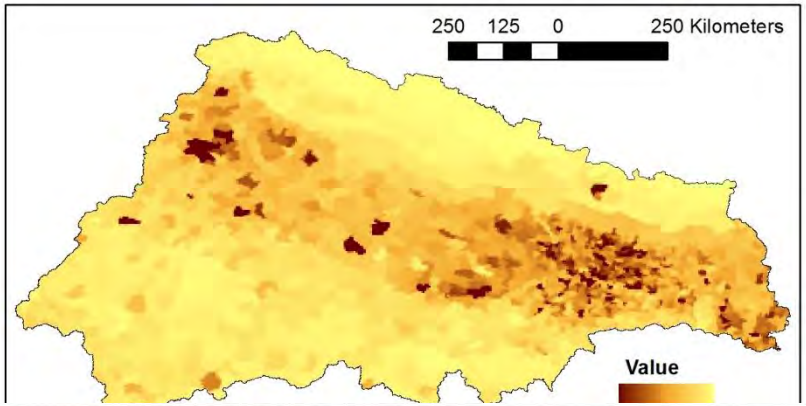


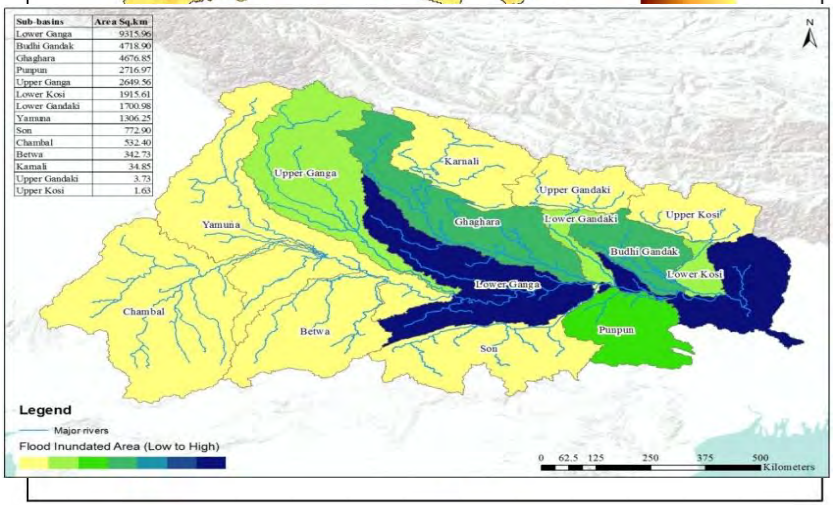
RIVER BASIN : FLOOD INUNDATION

- ~ 76 million population are exposed to floods
- ~ 80,000 sq.km of cropland are impacted by flooding
- Avg. annual flooding in lower ganga ~9,300sq.km followed by Gandak and Ghaghara basins

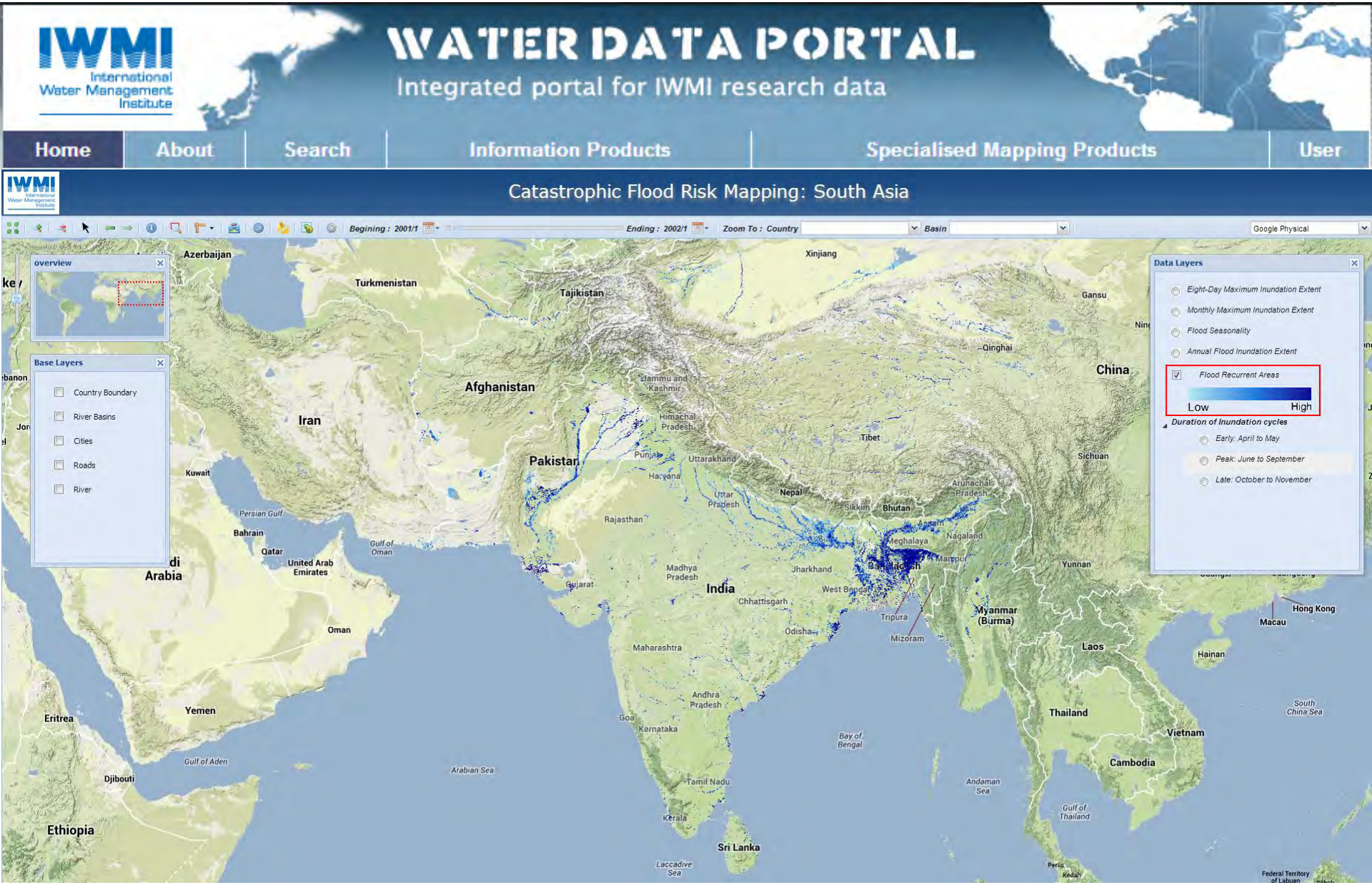
		Affected Population
Recurrent Floods (12yrs)	Low	29,824,380
	Moderate	18,429,050
	High	12,822,060
	Very high	15,080,070
Total Pop. Affected		**76,155,560**







Flood Data Web Services !!



RAPID EMERGENCY RESPONSE MAPPING

Journal of
Flood Risk Management

http://dx.doi.org/10.1111/jfr3.12045

2013

An algorithm for rapid flood inundation mapping from optical data using a reflectance differencing technique

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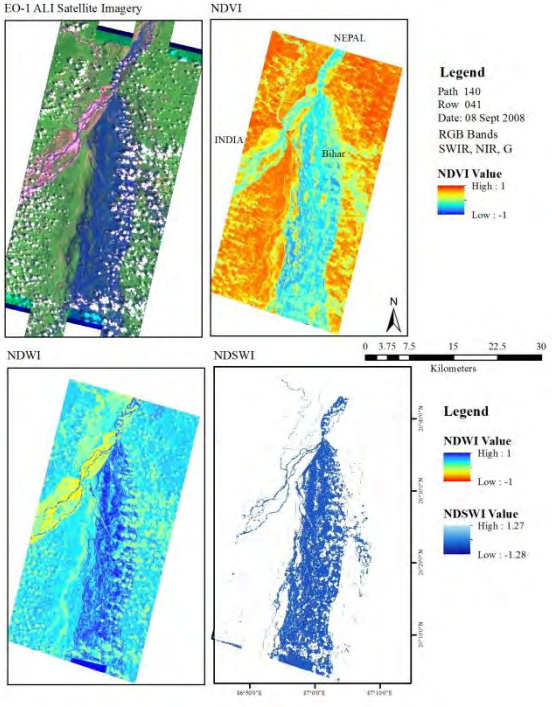
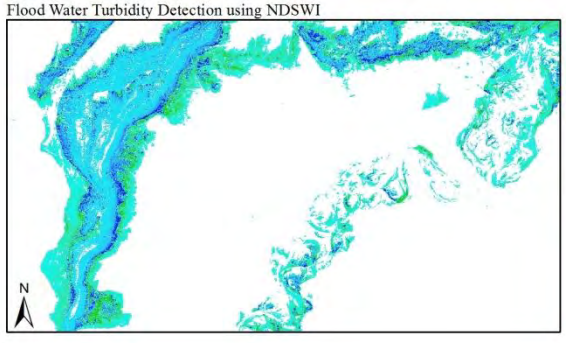
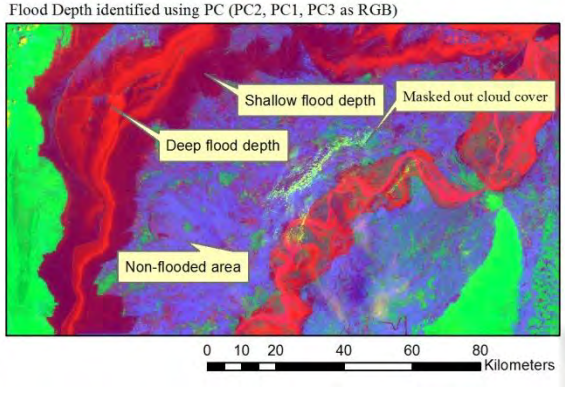
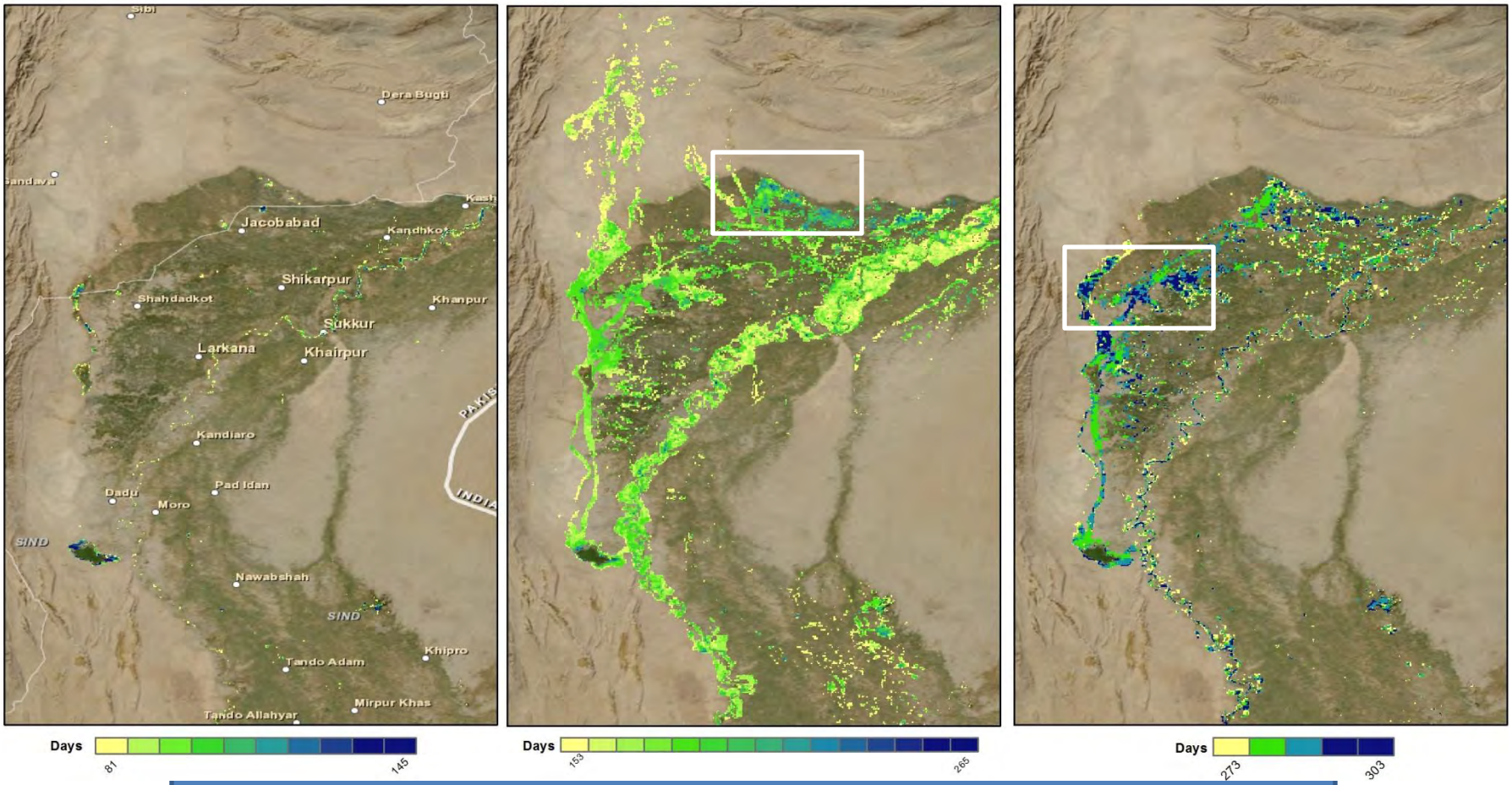




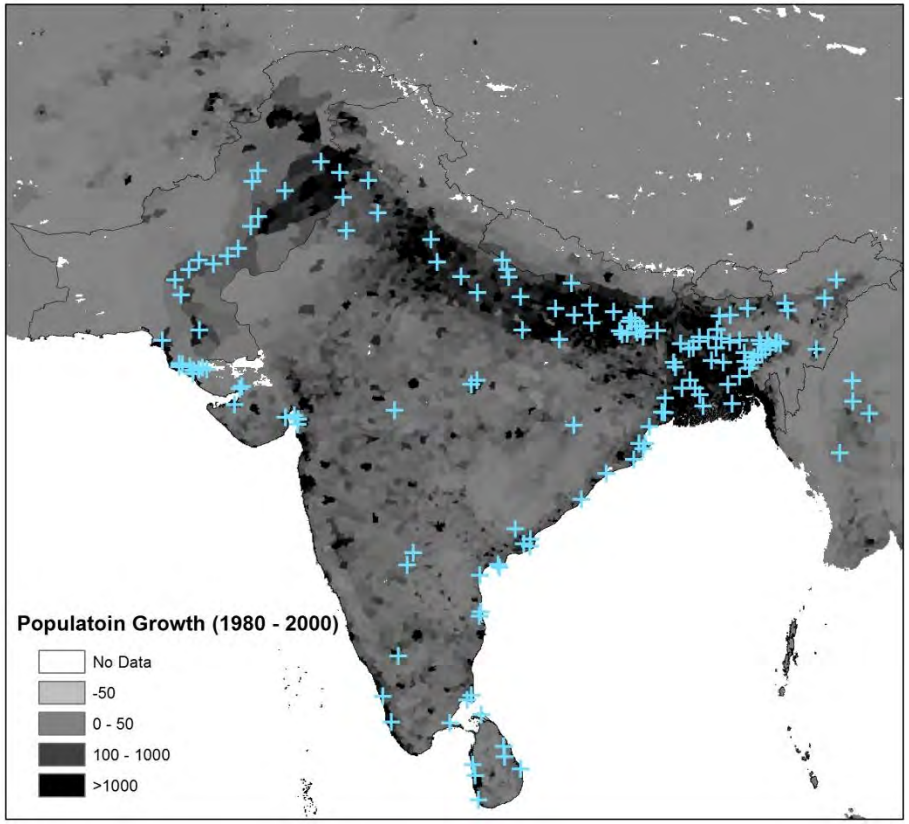


Flood Duration : Indus Basin, Pakistan



- Duration of annual flood inundation is defined from the start and end dates of annual flood inundation
- Longer flood duration significantly increase the flood risk damage

Spatial Distribution of population growth (1980 – 2000) and location of the recent floods mapped using RS data

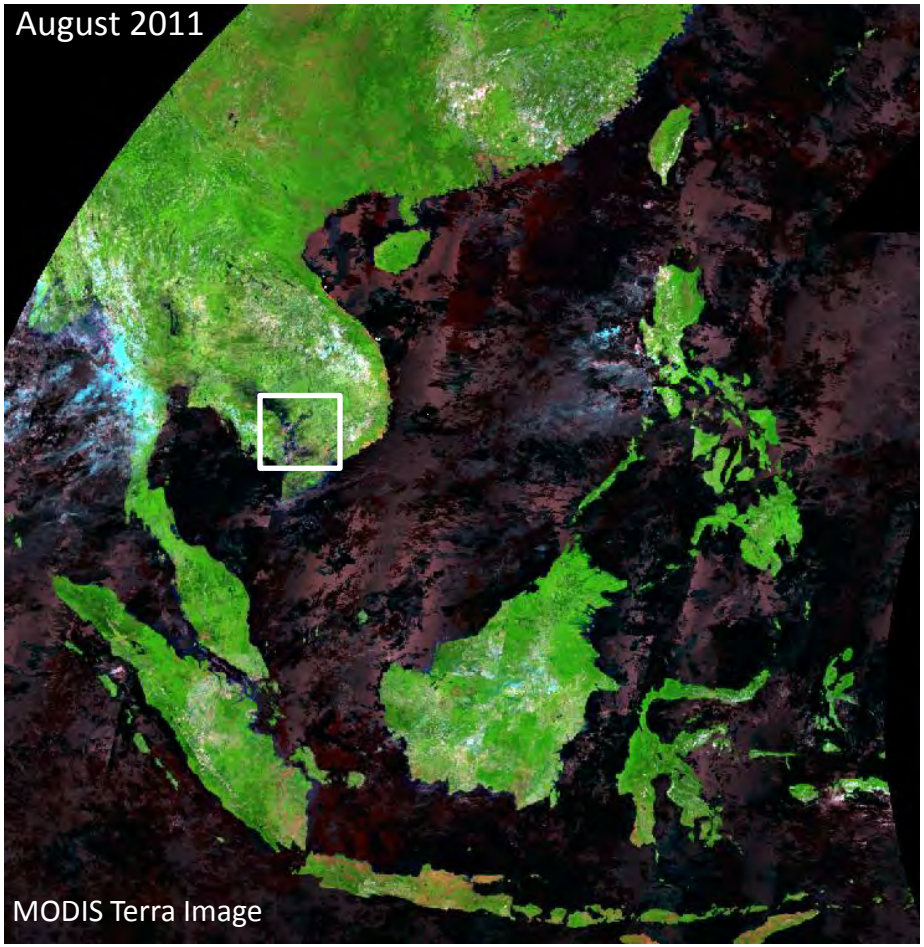


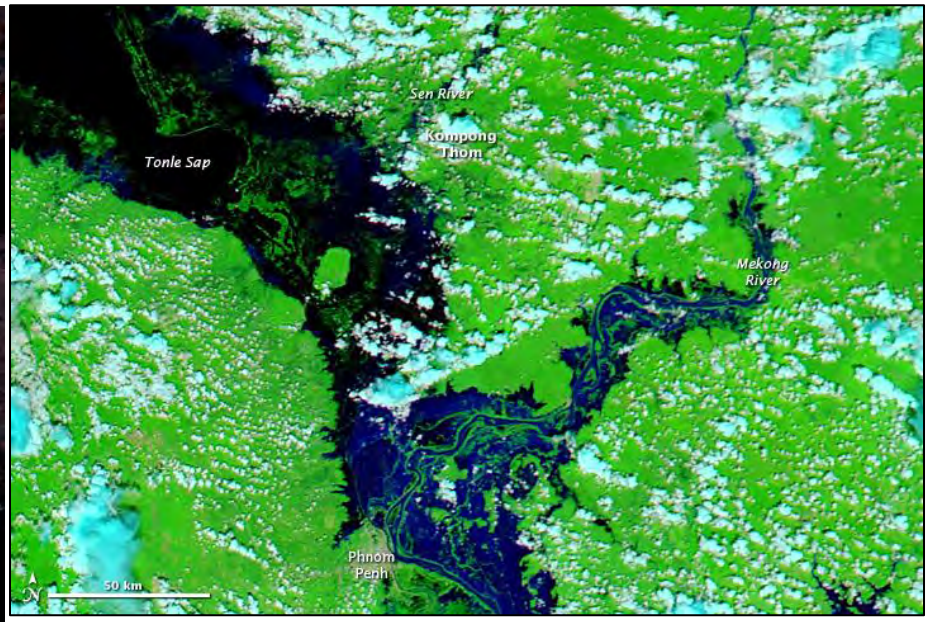
	Total Population	Affected Population	%
Bangladesh	152,518,015	99,412,500	65.18
India	1,210,193,422	131,107,100	10.83
Nepal	26,620,080	323,995	1.22
Pakistan	180,440,000	18,933,730	10.49
Sri Lanka	20,277,597	901,151	4.44

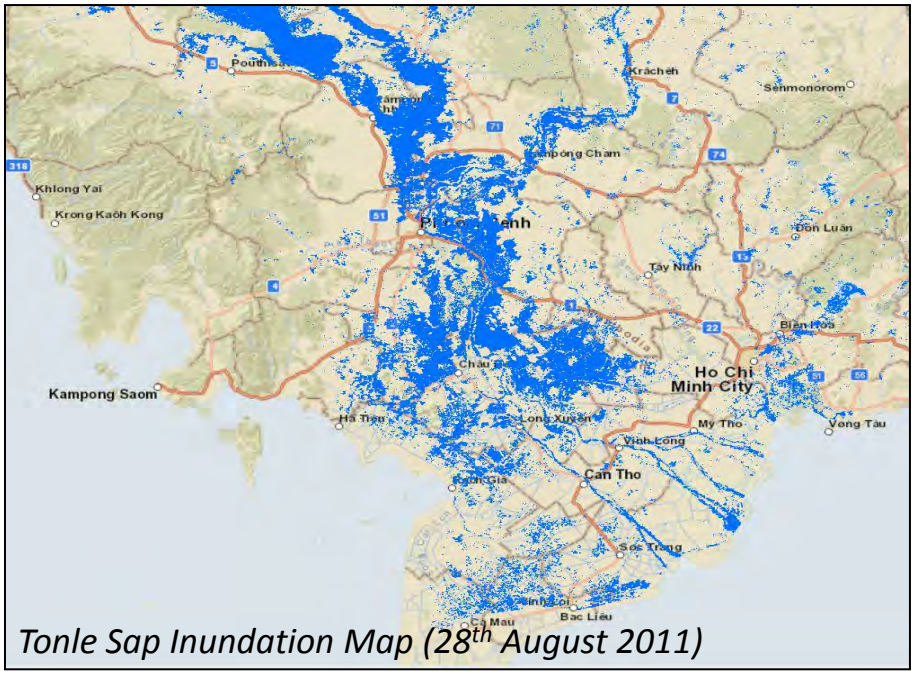
Flooding in SA has affected total population = 250million

- Sub-continental scale, the dynamics of human settlements (i.e. population growth between 1980 and 2000) and the location of latest floods in SA using RS data.
- Highlights that most of the recent floods (i.e. period 2000 – 2011) have occurred where the population has increased more.
- Intensive and unplanned urbanization of flood-prone areas, played a major role in increasing the potential adverse consequences of floods

SOUTH EAST ASIA^{++} Flood Mapping







Tonle Sap Inundation Map (28th August 2011)

MODIS 15 tiles covering SE Asia^{++}
Total Images (2000 – 2011) = 7590

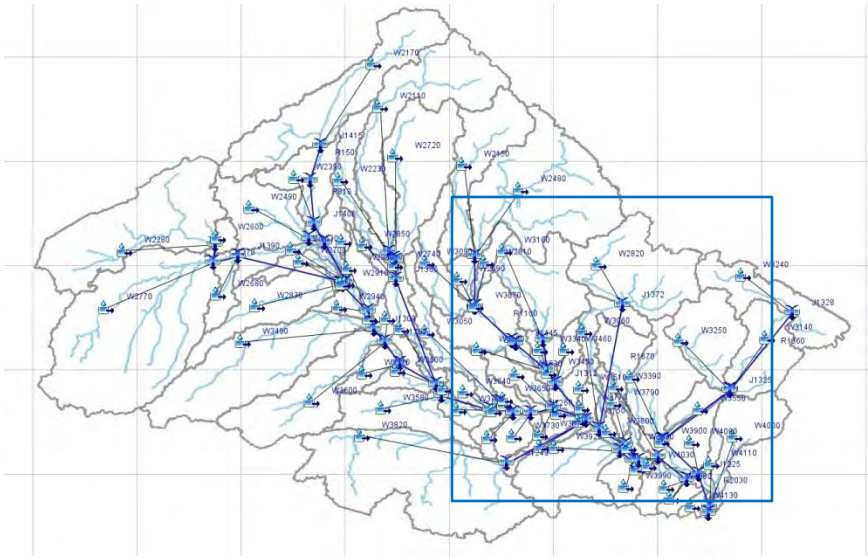
MODIS Flood Maps 2011 completed.
Validation ongoing

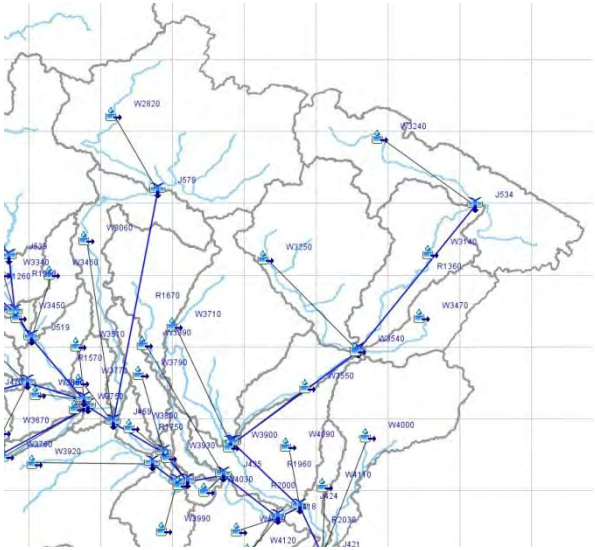
Modeling Inundation Extent and Flood Forecasting System

Modeling Flood Inundation Extent using HEC-HMS (Hydrological Modeling Scheme)

Main inputs to the model includes:

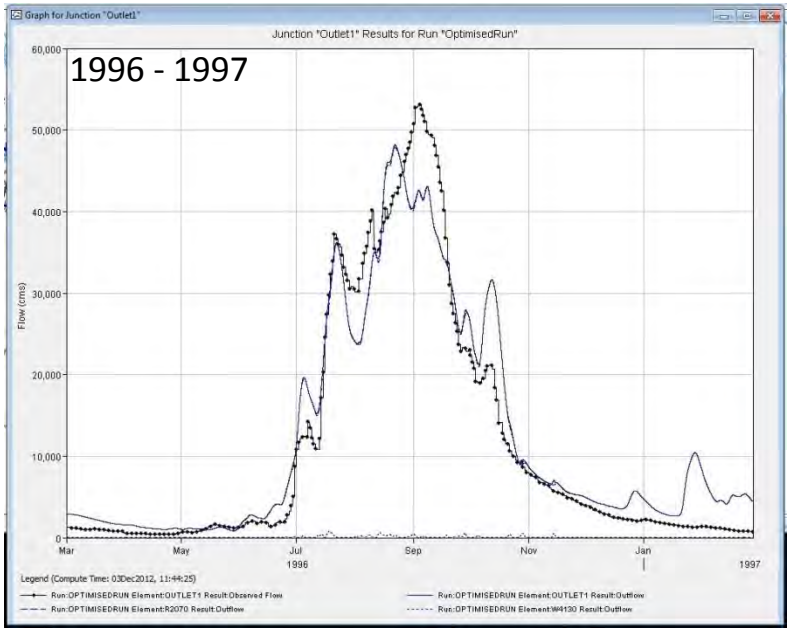
- Watershed stream network and size : 79 sub-basins and 53 river reaches,
- *Infiltration loss method* : SCS Curve Number
- *Transform method (excess precipitation to runoff)* : SCS
- *Baseflow method*: Exponential recession
- *Routing method*: Muskingum
- *Meteorological data*: 86 rainfall stations
- *Time Span* : 1947 – 2005 (most data 1980 – 1999)
- Calibrated and validated for 1987-1999 where daily discharge data fro *Farakka* is available
- Used 4 discharge stations and 1 remotely sensed data for calibration

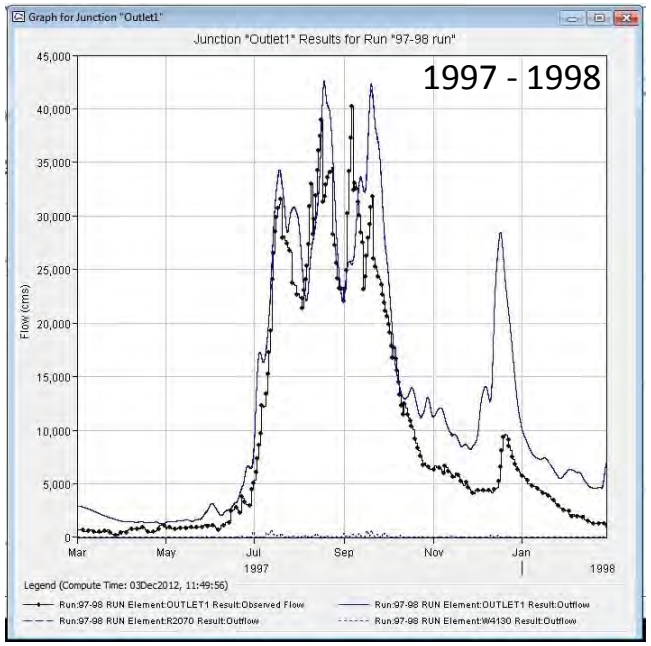




Modeling Flood Inundation Extent using HEC-HMS (Hydrological Modeling Scheme)

Hydrograph
Simulated vs. Observed





Farakka Station

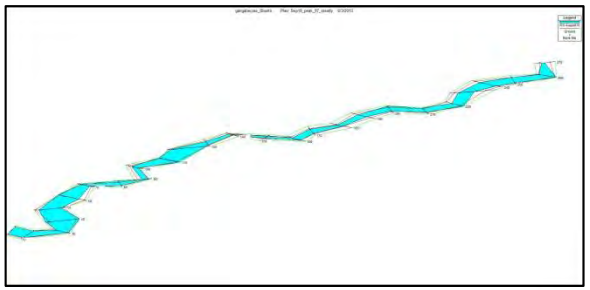
Flow, Time of Peak and Volume for some HMS calibration events

For 96-97: Peak observed discharge: 53125 m^3/s peak date: September 4
Peak Simulated discharge: 48332 m^3/s peak date: August 22

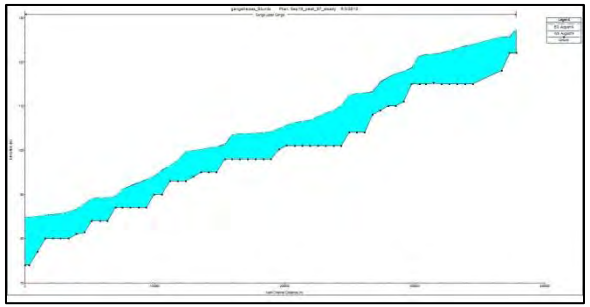
For 97-98: Peak observed: 40210 m^3/s peak date: September 7
Peak Simulated: 43694 m^3/s peak date: September 19

Average absolute residual error: 5-9% of the peak flow

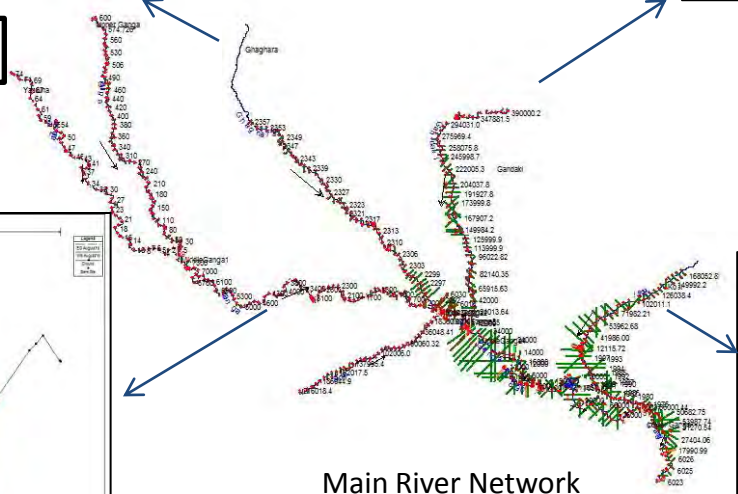
Modeling Flood Inundation Extent using HEC-RAS (River Analysis System)



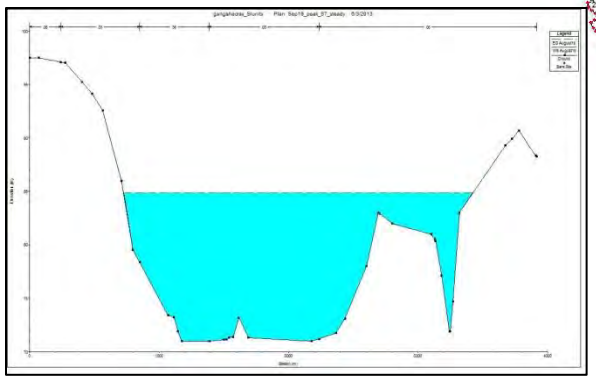
3D-Plot



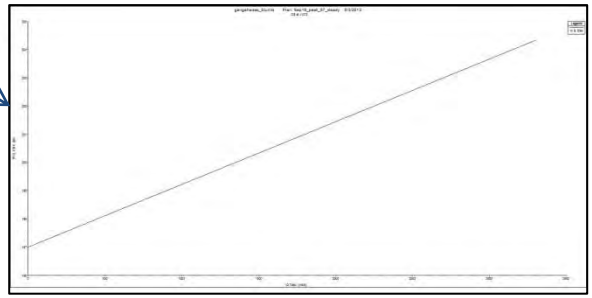
Water Surface Profile



Main River Network



Cross Sections



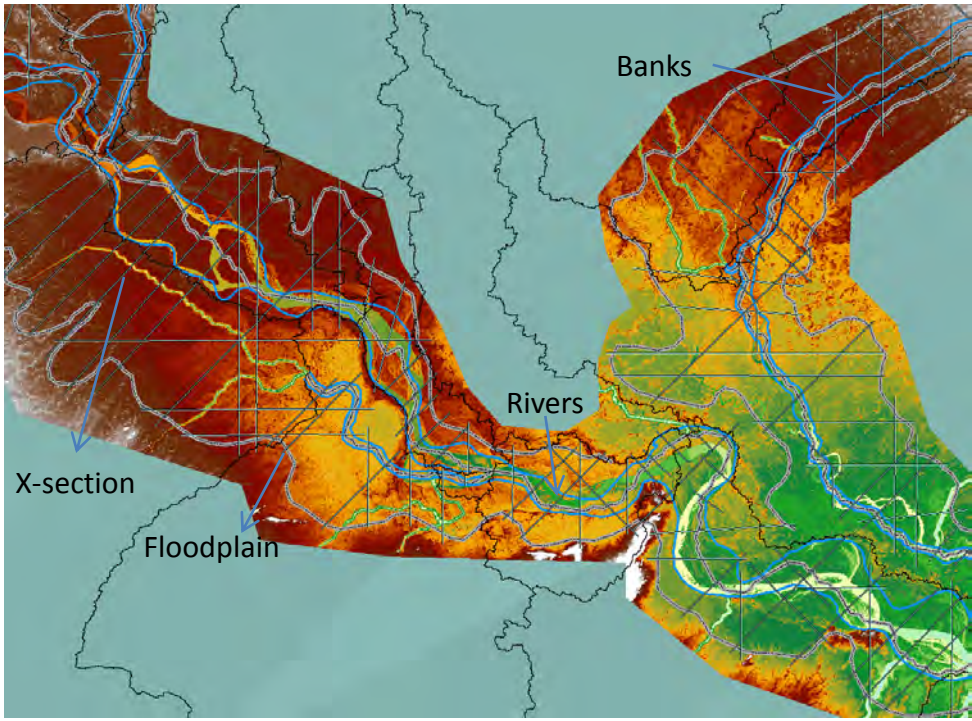
Rating Curves

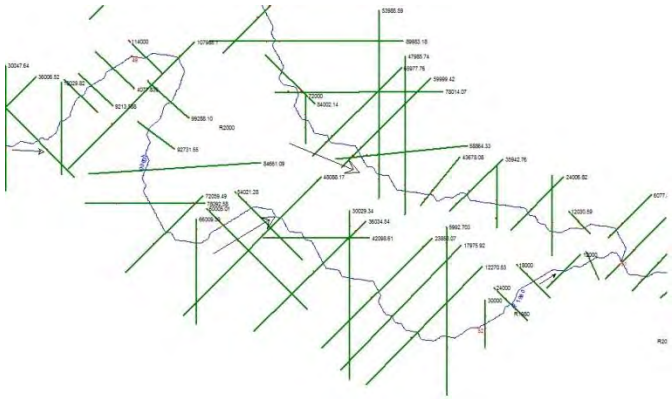
Outputs produced by HEC-RAS – Trial run for 97-98 flood

Modeling Flood Inundation Extent using HEC-RAS (River Analysis System)

Main inputs to the model includes:

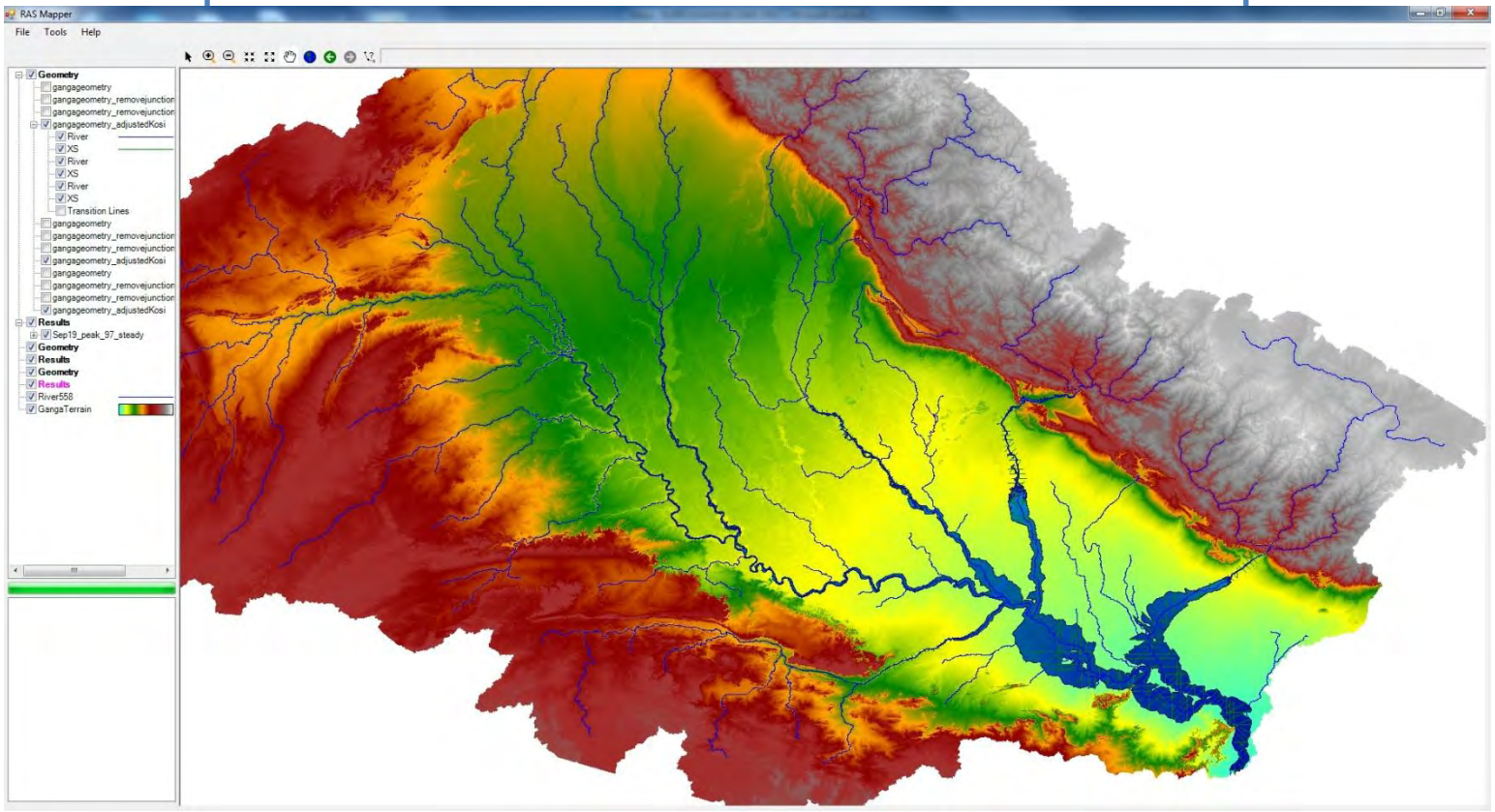
- River geometry including Stream Centerline, Flow Path Centerline, Floodplain extent, Main Channel Banks, and Cross Sections
- Mannings n values of cross-sections (range 0.03-0.36)
- *Inflow hydrographs (or peak flows) at key locations along the main river network*
- *The parameters that can be adjusted are the Mannings n value and the boundary conditions like normal or critical depth. The observed water elevations are compared to the simulated ones (Ongoing)*
- *Validate the model for other events based on the calibrated parameters (Ongoing)*





Modeling Flood Inundation Extent using HEC-RAS (River Analysis System)

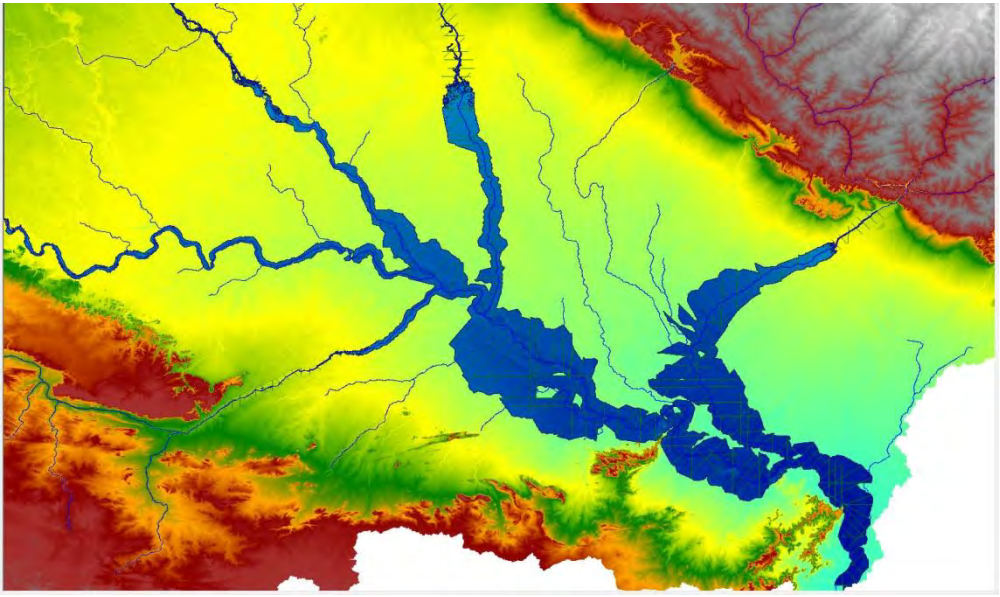
Outputs produced by HEC-RAS – Trial run for 97-98 flood



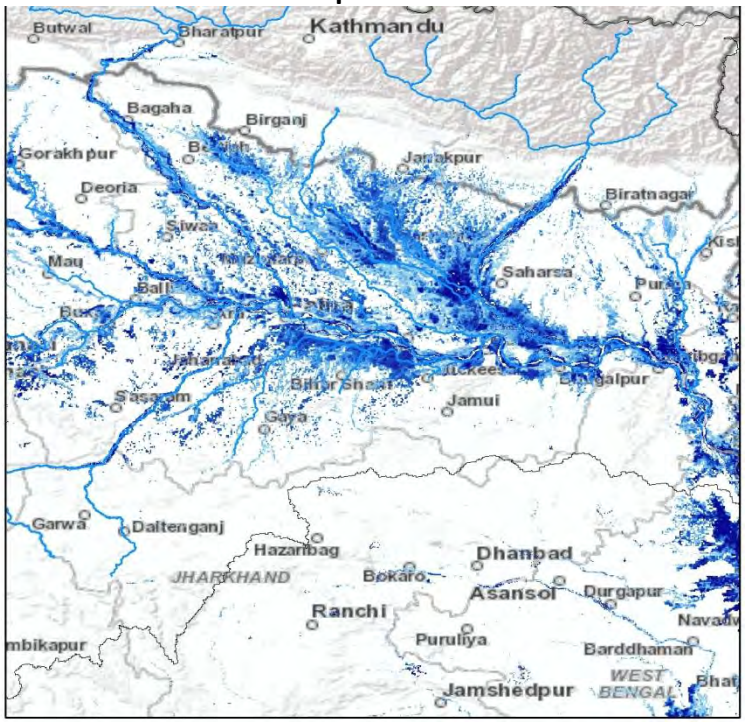
Flooding Extent and Depth

Flood Inundation Extent – Ganga Basin

HEC-RAS Model



MODIS Flood Maps



- Flood extent maps derived from RS data are essential calibration data to evaluate inundation models
- Other outputs such as water depth, flow velocity are available

Ganga FloodPlain Inundation Model (GFIM)

Extent of floodplain inundation in GIS format which can be analyzed and overlaid on other spatial datasets such as riparian vegetation, transport and water infrastructure to address impacts

Identifying vulnerable areas for better flood management

DEVELOPMENT OF FLOOD FORECASTING SYSTEM HEC HMS+RAS

Basin Characteristics

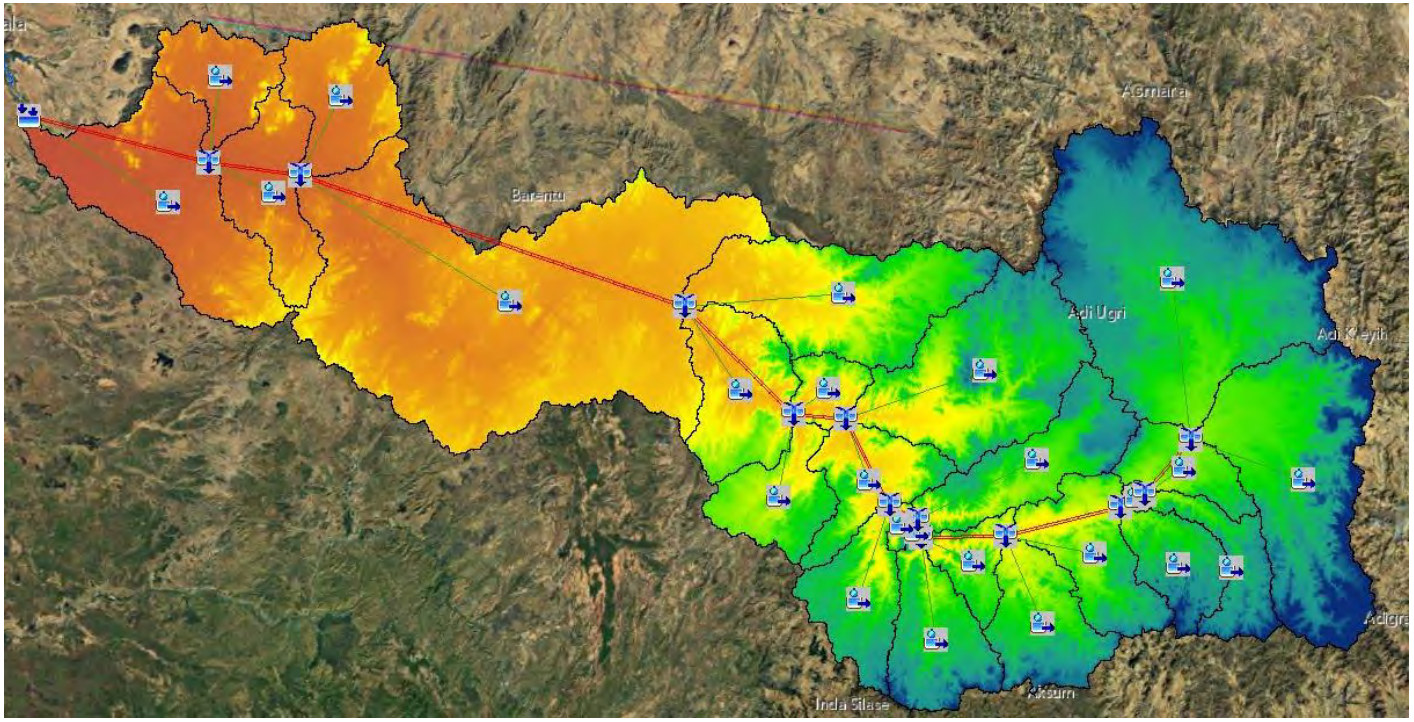
25 sub-basin
Watershed ~20,000km^2
12 river segments

Model Inputs

5 raingauges (Ethiopia)
El Gera flow data (GRTU)
TRMM, RFE, CMORPH SRE Data
DEM, LULC, FAO Soil Data

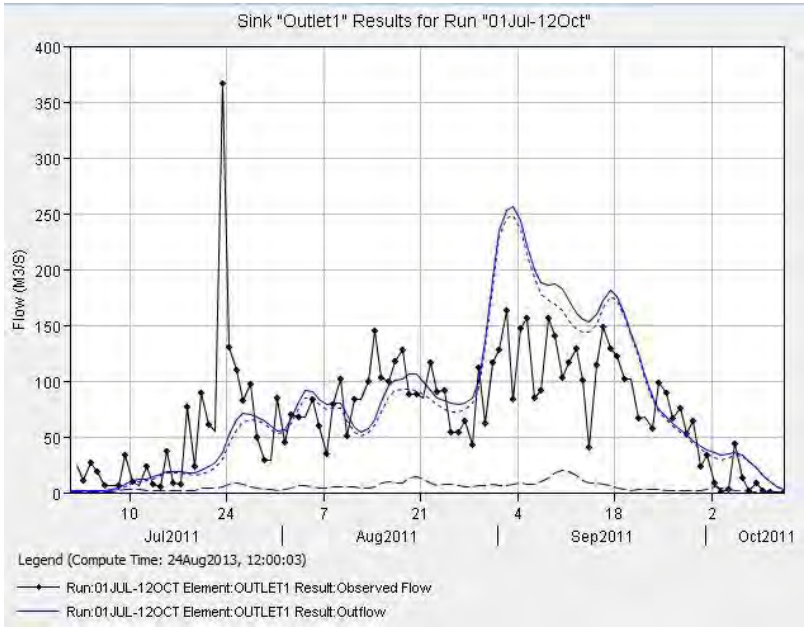
HMS Parameters

Loss (SCS Curve Number)
Transform (SCS Unit Hydrograph)
Baseflow (Constant Monthly)
Routing (Muskingum)

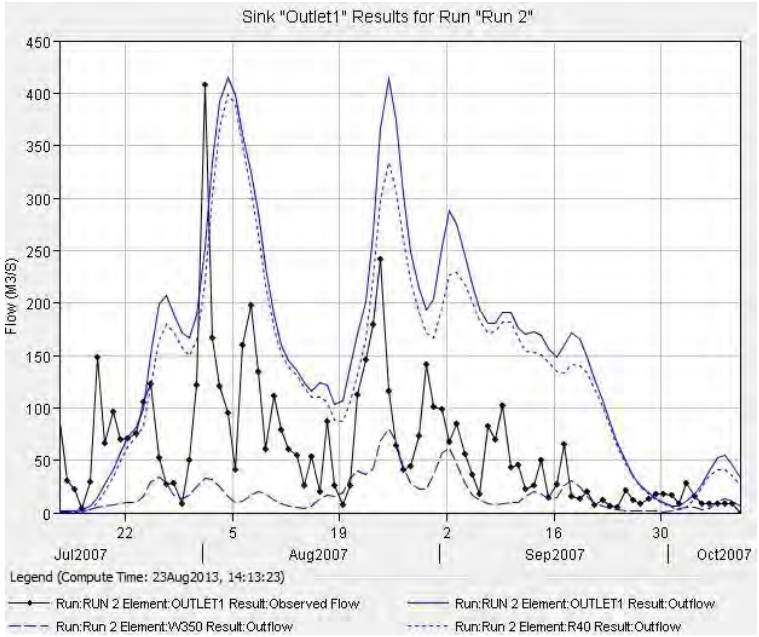


DEVELOPMENT OF FLOOD FORECASTING SYSTEM USING HEC-HMS

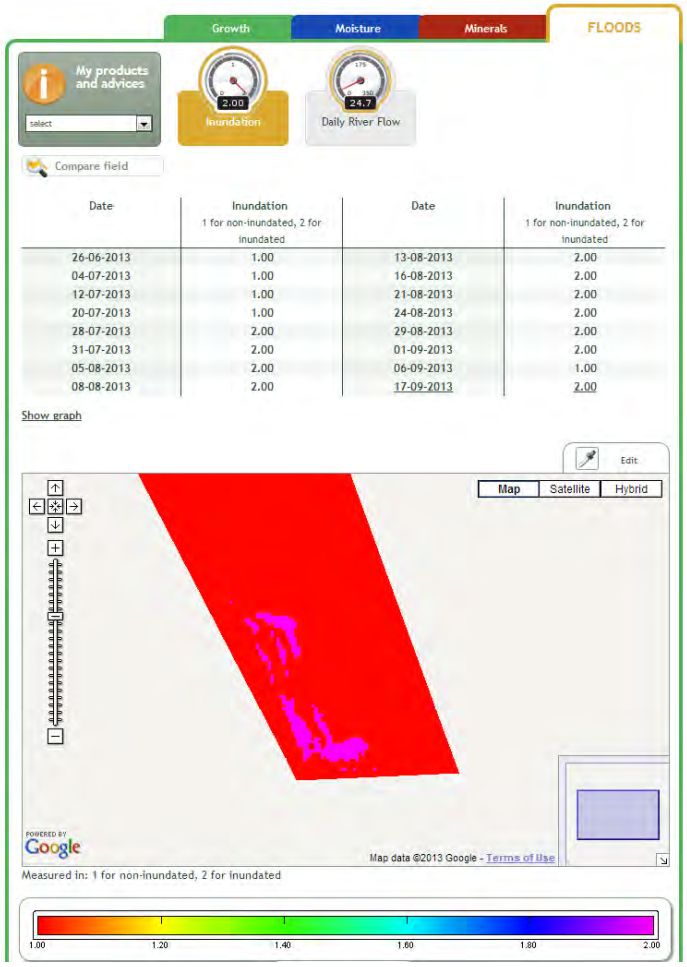
Observed vs. Simulated flow data “2011 flood season”

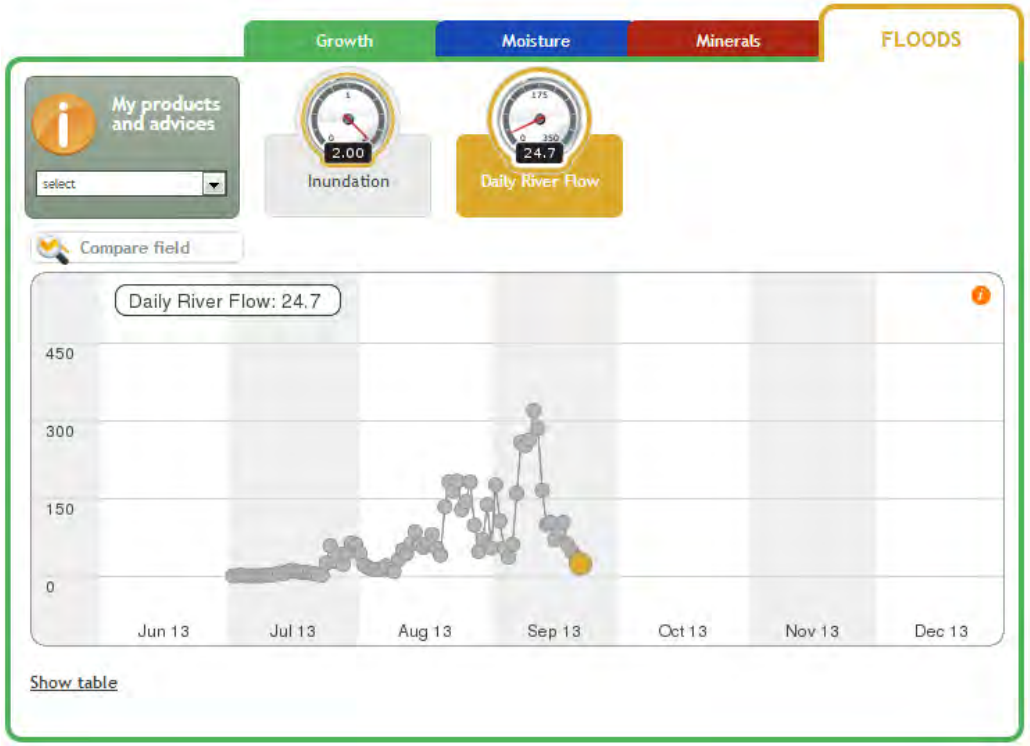


Observed vs. Simulated flow data “2007 flood season”



From pixels….to information….to simple action messages





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SUMMARY

- Global flood hot spots identified and characterized in terms of economic and human losses
- Several spatial products quantifying flood inundation pattern in South Asia with a resolution of 500 m and 8 days available
- Demonstrated how remote sensing data and Smart-ICT can help farmers for effective management of land and water resources in Gash Delta
- Modeling Inundation Extent and Flood Forecasting are important sources for flood mitigation measures and flood management

Email contact: a.giriraj@cgiar.org

" Let not a single drop of water received from rains go waste into the sea without benefiting the man and the beast "

King Parakramabahu (1153-1186 AD)