Advances in Tools for Water Resources Management

Anju Gaur and C.R. Singh
The World Bank, agaur@worldbank.org
### Water Availability by Basin

<table>
<thead>
<tr>
<th>Basin</th>
<th>SW Resource (BCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indus</td>
<td>73</td>
</tr>
<tr>
<td>Ganga</td>
<td>525</td>
</tr>
<tr>
<td>Brahmaputra/Barak</td>
<td>585</td>
</tr>
<tr>
<td>Godavari</td>
<td>110</td>
</tr>
<tr>
<td>Krishna</td>
<td>78</td>
</tr>
<tr>
<td>Mahanadi</td>
<td>67</td>
</tr>
<tr>
<td>Narmada</td>
<td>46</td>
</tr>
<tr>
<td>Brahmani/Baitarni</td>
<td>28</td>
</tr>
<tr>
<td>Cauvery</td>
<td>21</td>
</tr>
<tr>
<td>Others</td>
<td>336</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1869</strong></td>
</tr>
</tbody>
</table>

From: IWMI – Spatial Variation in Water Supply and Demand
Source: [http://www.history.upenn.edu/coursepages/hist086/material/IndiaRiverBasins.gif](http://www.history.upenn.edu/coursepages/hist086/material/IndiaRiverBasins.gif)
Climate extremes

• **Drought Prone**: 68 percent area

• **Flood affected**: 12 percent (USD 1 Billion loss and affecting more than 30 million people)
PMKSY (central irrigation scheme) targets to develop and manage irrigation

Out of Net Sown area of 141 M Ha, Irrigated area is 55.1 M Ha (16 M Ha Canal irrigated) and Rainfed area is > 60%
Water Resources Development Potential is Spatio-temporal Sensitive

Major Basins in South excepting Godavari are closed

In Southern basins, further development will be at the cost of downstream

In east, potential for substantial development excepting some hotspots

storage: the number of days of average flow

http://www.indiawaterportal.org/articles/images-and-facts-ground-water-situation-india, IWMI
India Water Resources Projects (>5 Billion USD)

National Projects
• National Hydrology Project (NHP)
• Watershed Project

State Projects
- Dam rehabilitation: 5
- Tank /Irrigation: 4
- Water Sector Restructuring Project: 3
- Watershed/Agriculture: 3

World Bank projects in IWRM

- River basin Management
- Irrigation Management
- Dam Safety
Proposed National Hydrology Project (USD 350 million)

- Real time Hydromet system with access to the users
- Standardizing Water Resources Data and Information System for the country (India-WRIS)
- Setup River basin planning tools for improved planning and real time flood forecasting (Dynamic water availability and forecast)
- Institutional Capacity enhancement
IndiaWRIS: Web enabled information system

http://www.india-wris.nrsc.gov.in/wris.html
Flood Management: Linking with climate forecast

Bhakra and Krishna Basins
- Regulated basin
- First time streamflow forecast linked with the weather forecast and real time data acquisition systems

* Existing forecast system in CWC is based on upstream water level in the streams

Floods are minimized and saved lives and damages
Flood Management: Ensemble

NCAR: Ensemble forecast

Brahmaputra Discharge Forecast Ensembles

- 7 day forecast
- 8 day forecast
- 9 day forecast
- 10 day forecast

Forecast Trigger:
- ECMWF forecast files

Updated TRMM-CMORPH-CPC precipitation estimates

Updated distributed model parameters

Updated outlet discharge estimates

Above-critical-level forecast probabilities transferred to Bangladesh

Calibrate AR error model

Convolute multi-model forecast PDF with model error PDF

Generate model error PDF

Discharge Forecast PDF Generation

Generate forecasts

Generate hindcasts

Generate forecasts

Generate hindcasts

Generate forecasts

Generate hindcasts

Generate forecasts

Generate hindcasts

Lumped Model Hindcast/Forecast Discharge Generation

Generate forecasts

Generate hindcasts

Multi-Model Hindcast/Forecast Discharge Generation

Calibrate multi-model

Generate forecasts

Generate hindcasts

Generate forecasts

Generate hindcasts

Generate forecasts

Generate hindcasts

Generate forecasts

Generate hindcasts

Distributed Model Hindcast/Forecast Discharge Generation

Update soil moisture states and in-stream flows

Generate forecasts

Generate hindcasts

Generate forecasts

Generate hindcasts
Flood Management: Satellite based

Hydrological forecast: Role of time and space

Ganga-Brahmaputra
- Flood management in unregulated and data scarce basins
- Priority of area assessed with flood damage

GLOFs & Flash Floods
Medium Rivers Large River Basin Flooding
Spatial Scale (geographical area affected or contributing)
Hydrological forecasts: Role of time and space in Ganga and Brahmaputra basin

Spatial:
- 28 Catchments
- 4696 Catchments

Temporal:
- Isochrones for water travel time through the G-B Basins
- The contour shows the approximate number of days that water takes to travel
Yamuna
Manas
Ghagra
Middle Ganges
Chambal
Sone
Meghna
Middle Brahmaputra

--- ECMWF
--- NCEP
--- CMC
--- UKMET
--- OBS
Dam Break Analysis: Inundation Mapping

[Maps showing inundation mapping for Aliyar Dam, Tamil Nadu]
Remote Sensing Technology for targeting Irrigation Investment

Brining transparency and accountability in selection of area for irrigation development and management using remote sensing based land use in West Bengal (www.wbadmip.org)

Prioritize watersheds (Green/Yellow watersheds are comparatively water scarce)

Focus on rainfed area
Watershed based Water Budgeting and Planning for irrigation development
GIS based Project Monitoring through Mapping of Project Impacts

Cropping intensity improved from 30% to 100%, Paddy Production increased by 250%

<table>
<thead>
<tr>
<th>Paddy production (t)</th>
<th>Pre project 2013-14</th>
<th>Post project 2014-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop stages</td>
<td>Area (Ha)</td>
<td>Yield (t/ Ha)</td>
</tr>
<tr>
<td>Post monsoon (Rabi)</td>
<td>10</td>
<td>5.20</td>
</tr>
</tbody>
</table>
Farmer entrepreneurs
Summary

• Spatio-temporal system has crucial role in
  – flood management with real time and ensemble forecast in the river basins.
  – Identification of the “right” beneficiaries for irrigation development and management.
  – Evidence based Impact assessment.
  – Finally contributing to transparency and governance in the system.

“Accessibility, capacity building in analytical solutions”

http://www.appslutelydigital.com/SpatialAgent/
Some Resources

1. India Snapshots: www.worldbank.org;
2. Spatial agent: http://www.appslutelydigital.com/SpatialAgent/
5. West Bengal Accelerated Development Project: www.wbadmip.org

Contact: Anju Gaur (agaur@worldbank.org)

Please note, maps used in this presentation are not to scale