Water Resources of the Ganga under a Changing Climate: interaction between Glaciers and Monsoon in the Himalaya

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Interactions and changes

- Glacier melt
- Changing monsoon patterns
Recent findings glacier melt

- Western Himalaya: annual ice thickness loss of about 0.8 m w.e. per year (1999 – 2004).
  (Berthier et al., 2007 Remote Sensing of Environment)

- Global Glacier Changes: Facts and Figures
  (UNEP/WGMS, 2008)

- Mass loss on Himalayan glacier endangers water resources
  (Kehrwald et al, 2008. GRL)

- Climatic warming, glacier recession and runoff from Alpine basins after the Little Ice Age maximum
Climate models disagree on future rainfall changes.

- ECHAM4 projects an increase of 13 percent in summer (kharif season) rainfall;
- HadCM2 projects a decline of 6 percent.
Impact

Climate change impact?

Cumulative Indian rainfall
Compared with normal
Jun 1st-Aug 12th, 2009

Source: India Meteorological Department

September 9, Hyderabad
Number of drought weeks in Sub-basins of Ganga for Current (1981-2000) & GHG scenarios (HadRm2 2041-2060)

Gosain et al., 2006
Expected changes in discharge Ganges

- Trends
  - Glaciers retreating (e.g. Gangotri glacier 20-22 m per year)
  - Projected change in flow of Ganges

(e.g. Hasnain May 2004 New Scientist & Rees, June 2004. New scientist)
Challenges

*To support adaptation measures for different sectors:*

- There is a need for time and space specific CC predictions.

*To achieve this we need to:*

- Improve climate forecast skills at the regional scale by improving process knowledge and down-scaling techniques;

- Integrate socio-economic drivers in our studies to enable the assessment of other drivers than climate change and possible feedback mechanisms between them.
HighNoon approach: Adaptation strategy

- Improved boundary conditions (CC & socio-economic)
- Consideration and integration of relevant dimensions in the development of adaptation measures
- Transdisciplinary approach – combining tacit knowledge with scientific discovery

Multi sector measures
- Water supply
- Agriculture
- Hydropower
- Health
- Ecosystem

Multi parametric impact
- Water Quantity
- Water Quality
- Socio Economy
- Adaptive Capacity

Multiple scales
- Basin scale
- Subbasin scale
- Field/Farm scale
Different scales

Exposure to CC impact

Location of case study sites

(TERI, 2003)
## Socio-economic dynamics

- Make consistent scenarios for socio-economic changes in the region (large scale model)
  - Population and GDP
  - Food and water demand
  - Land use changes

- Explore physical boundary conditions for adaptation options in these scenarios.

- Refinement of geographical and management detail to local level scenarios

- Evaluate impacts of adaptation measures
Use of a nested approach to assure consistency amongst scales.

- **Scenario in global context** (Scenario model)
  - Simulation of impact of the selected adaptation measures at larger scale
  - Regional projections in global context, Potential boundaries for infrastructure measures tuned between spatial scales

- **Scenario at district level** (Statistical method)
  - Set of selected adaptation measures
  - District scale projections on population, economy, water use; Boundary conditions for adaptation

- **Set of adaptation measures** (stakeholder process)
Expected outcomes:

*Improved knowledge of:*
- Glacier melt, lake formation and glacier lake outburst floods;
- CC affecting monsoon patterns
- Impacts on water resources

*Products:*
- Improved ice/snow feedbacks routine for RCM’s (PRECIS & REMO)
- Consistent modeling results of ice/snow between RCM’s and hydrological models
- Assessment of water resources for consistent scenario’s at different scales
- Set of tools to facilitate prioritization of adaptation measures
- Extension of indicator framework to assess impact of adaptation measures
- Adaptation strategies over multiple scales and sectors