A Water Risk Model to Inform India's Development

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An economic context for water risk?

- What is at risk if reliable water supply is not available for specific economic activities in a district/state/nation?
- How often and how severe are water shortages likely to be given the current use pattern?
- In India's highly variable climate, what are the water storage needs to meet specified demands?
- What are the costs of conservation vs storage vs shortage at the district or farm or plant level?

Scenario

- District Level Analysis
- Consider **local renewable water supply**
  - Daily Rainfall on district
    - % of rain that can be utilized for each purpose
- Daily Demand for each purpose
  - Domestic: Based on population
  - Industry: Based on type and size
  - Agriculture: Based on cropping pattern and crop model
    - Historical or stochastic or projected climate variables
- **Risk measure**
  - **Storage needed to meet district demand at specified reliability** (% of time need met)
    - Can be groundwater, RWH or transfer

Normalized Deficit Index

- **Risk**

=probability of cumulative deficit of certain size

Assessing chronic and climate-induced water risk through spatially distributed cumulative deficit measures: A new picture of water sustainability in India

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Water Risk Analysis:

- Deficit $deficit_t^i = Demand_t^i - Supply_t^i$

- Potential Storage Index (max cumulative deficit)

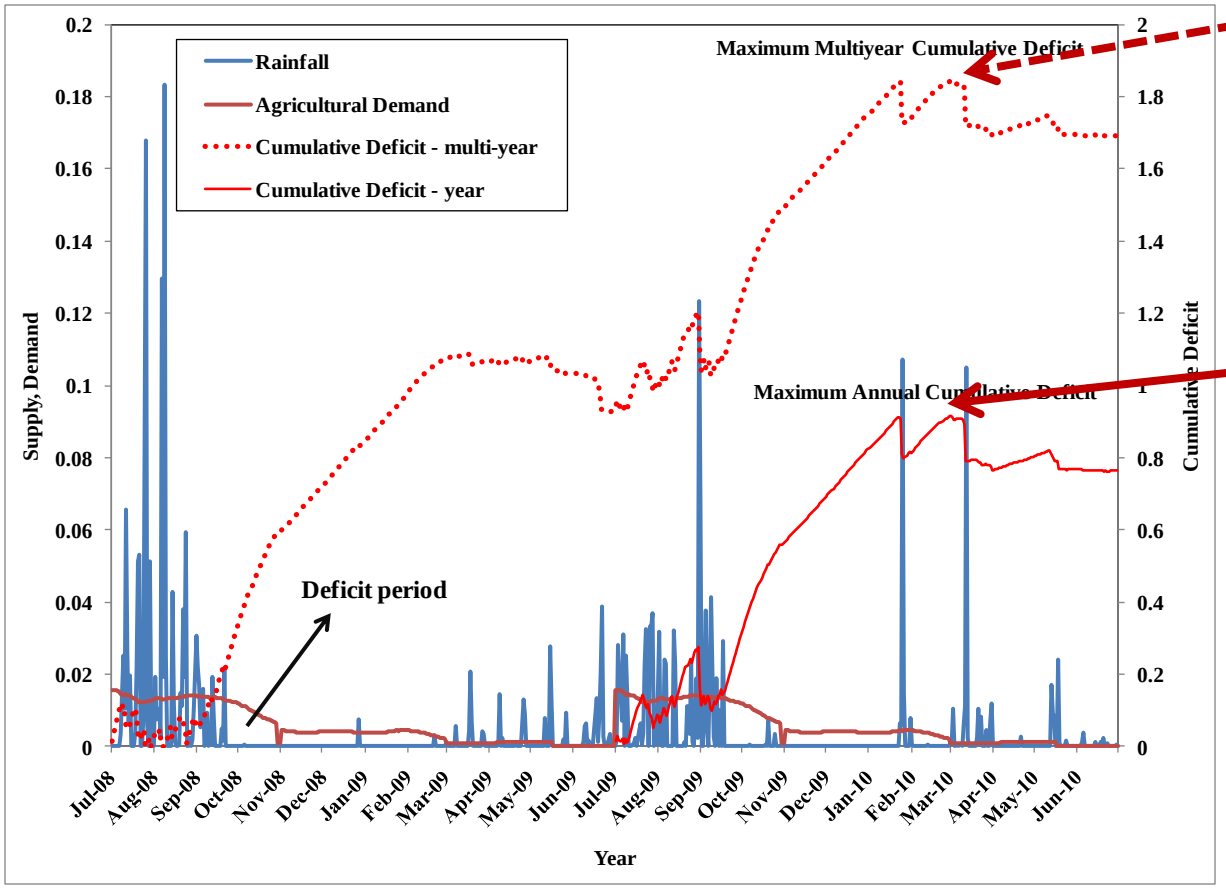
$$PSI^i = \max\left\{\max(0, deficit_{t-1}^i + deficit_t^i)\right\}$$

NDI = Annual PSI/Av. Annual Rainfall

NDC= max PSI/Av Annual Rainfall

How many years worth of average annual rainfall needs to be stored to make it through the dry period?

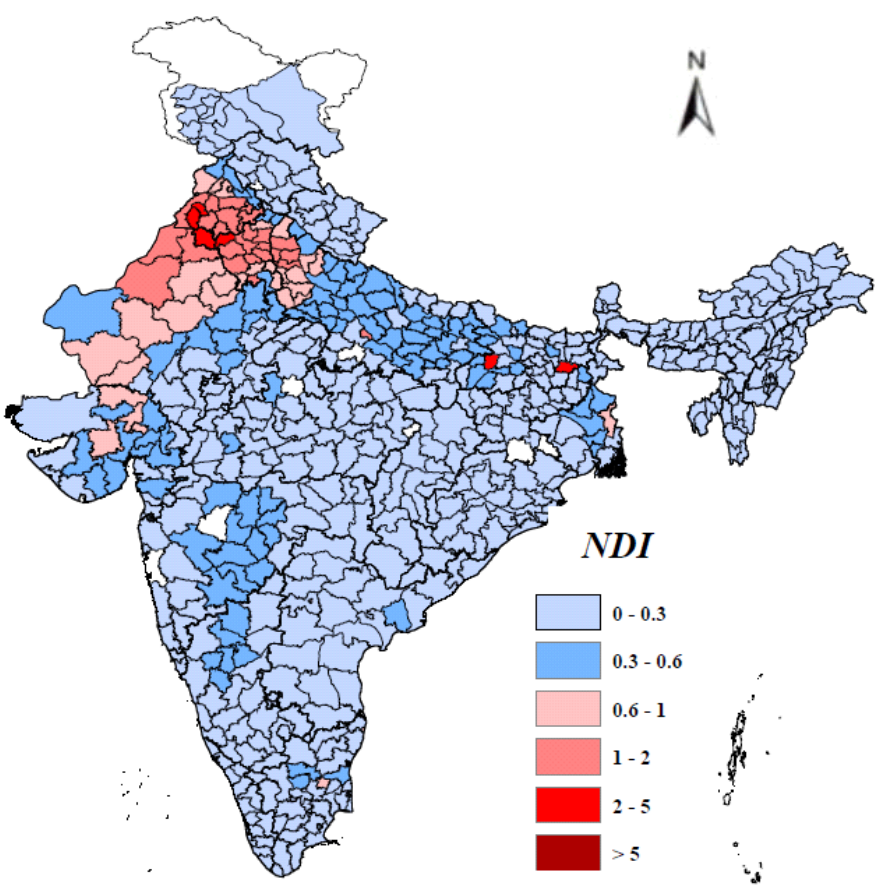
Conceptual representation of the (potential storage requirement = drought stress) based on the sequent peak algorithm



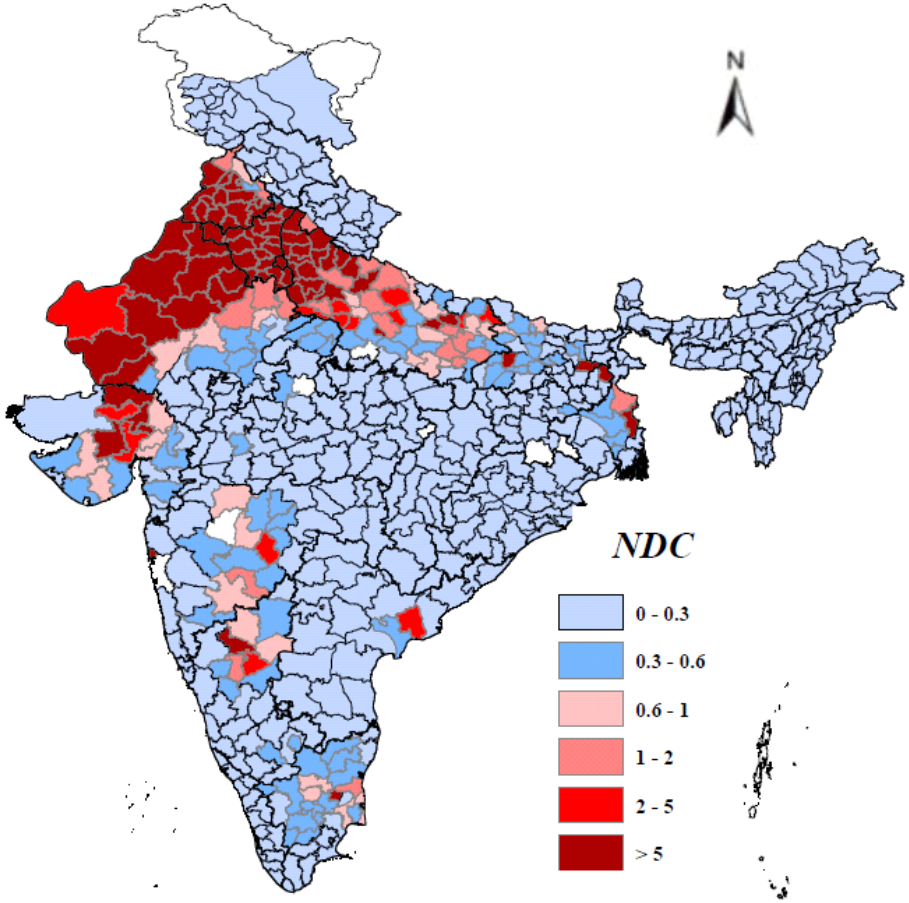
NDC: Continuous simulation across all years to account for multi-year deficit

NDI: Calculated separately for each of the 109 years to get a probability distribution of individual year outcomes

MAX (NDI)



NDC

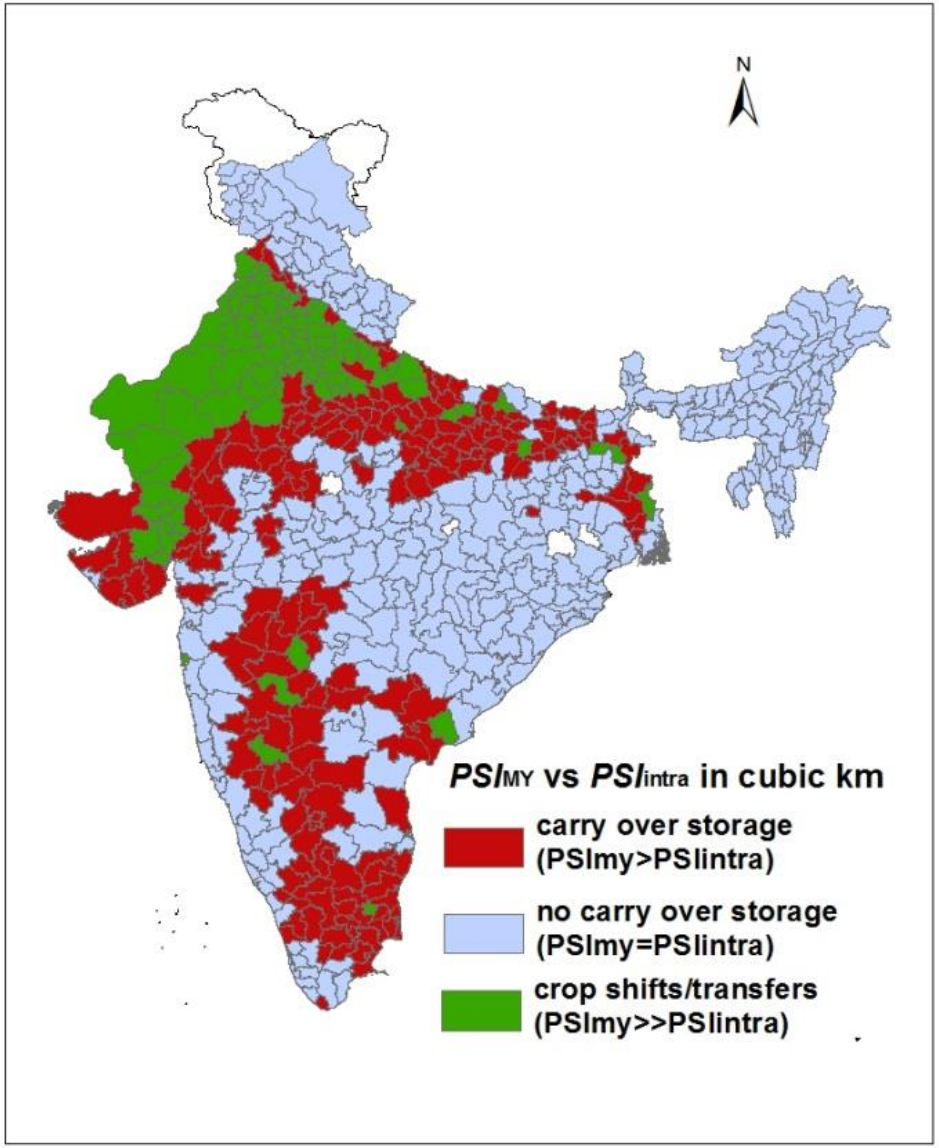


Mapping the deficits – need for storage

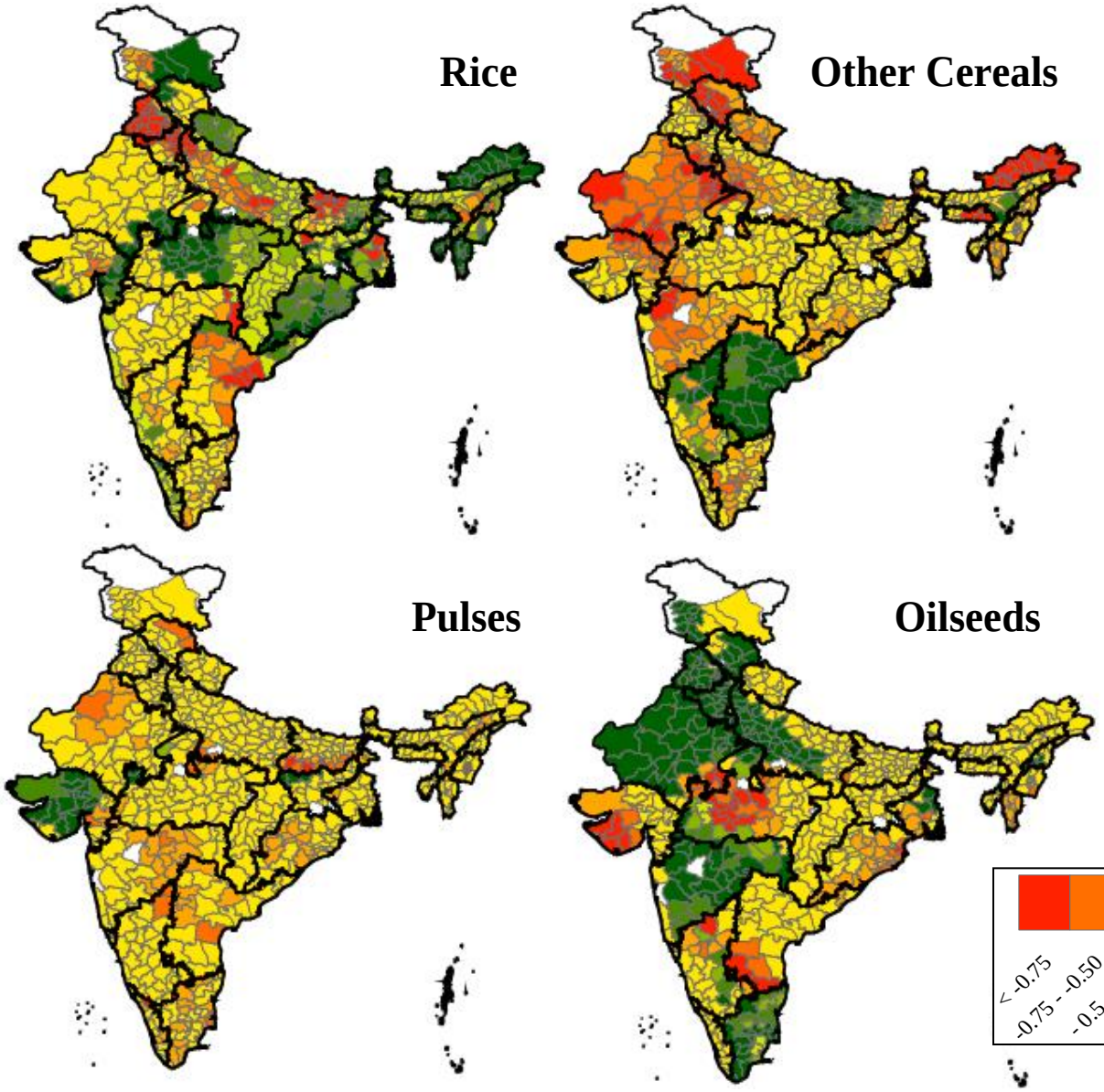
(**blue**)
If multi-year stress = max yearly stress

(**red**)
If multi-year stress > max yearly stress => carry over storage required/prone to droughts

(**green**)
If CD → ∞ => demand management
excess GW depletion



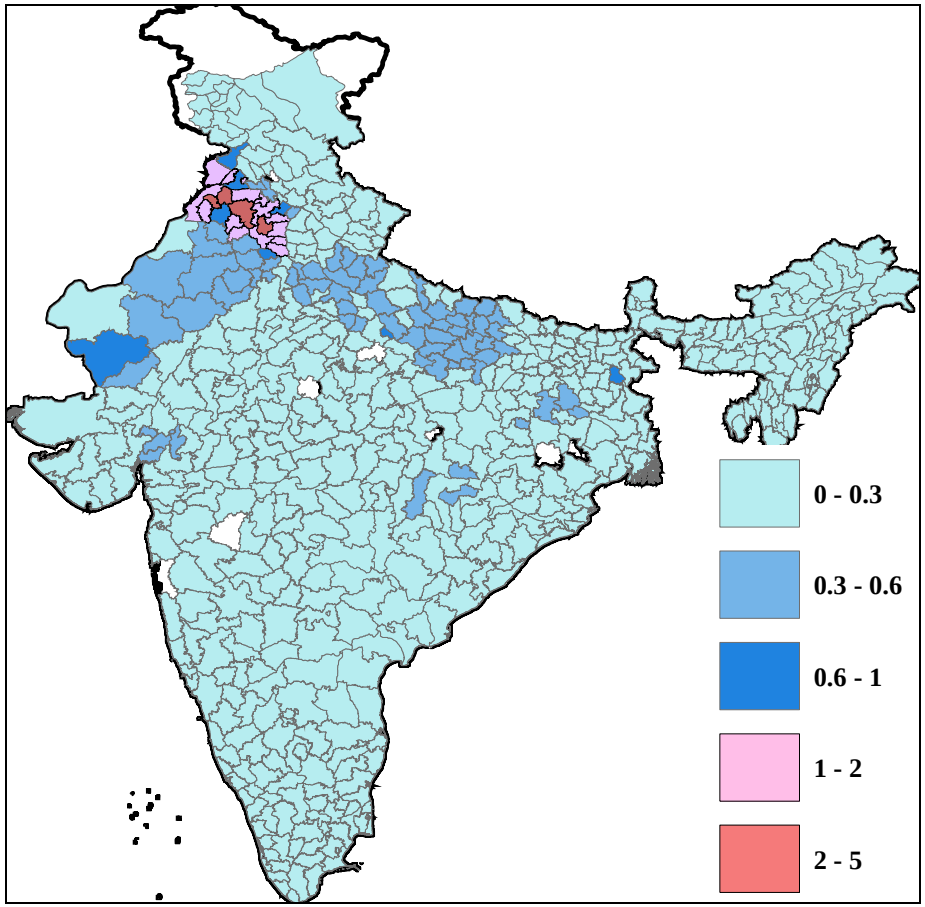
Optimal Cropping Pattern Shift



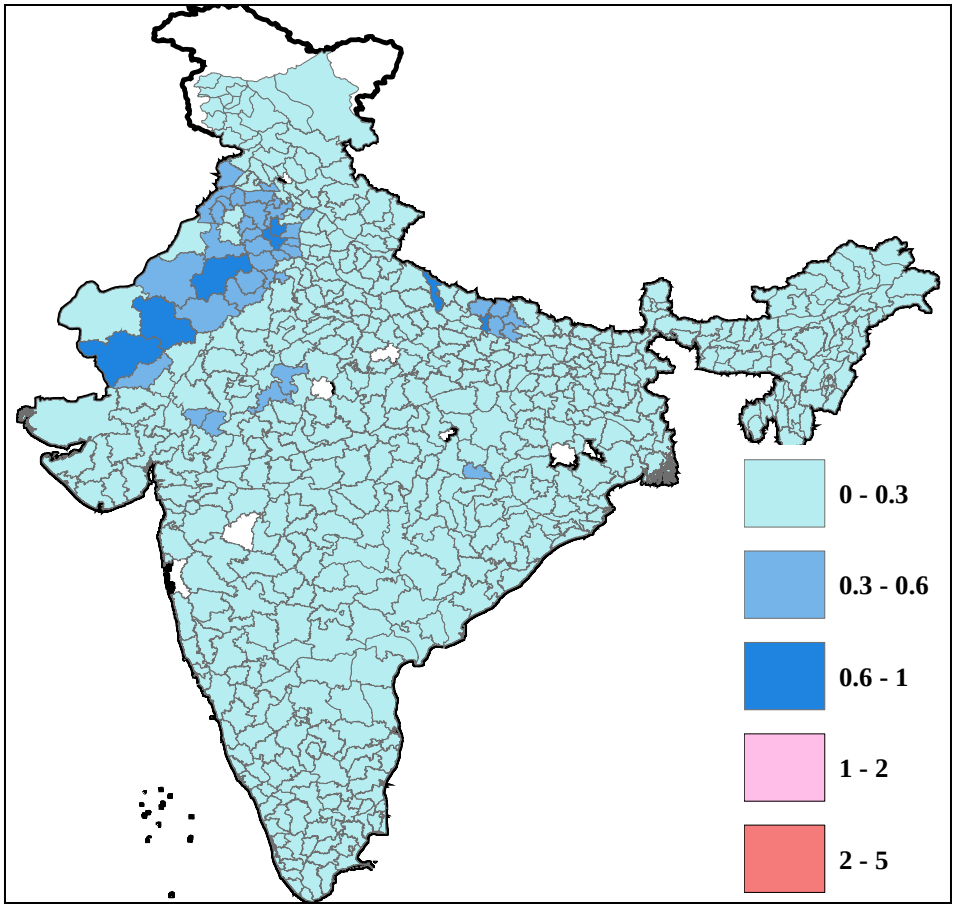
PPP Opportunity
corporate and government participation to address market price risk and technology innovation in the agricultural supply chain

Change in Water stress for rainfed scenario that meets food production goals

NDI_{max} for existing cropping pattern



NDI_{max} with crop diversification



Analysis in support of **national** food procurement system reform

Summary

- Focus Analysis at User –Decision Maker Level
  - Basin Level Analysis provides a check
- Risk Measure translates into estimates of storage needed
  - Storage = groundwater or RWH or Dams or basin transfer
  - Also measures externality imposed on others downstream of location
  - Considers renewable supply only
- Planning and economic analysis framework
  - Demand management at user level informed by costs and risks
  - Opportunity for effective water use and efficiency credits and trading