Rainwater Harvesting in India: Some Critical Issues for Basin Planning and Research

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Plan of Presentation

- Introduction to the basic premise
- Supply side issues in RWH
- Demand side Issues
- Economic issues
- Issues relating to improving basin water economy
- Major findings
- Ways to make RWH more effective
- Conclusions
Objectives
- Improve runoff collection and storage efficiency
- Equitable distribution of water
- Resource management

Underlying value
- Local water self-sufficiency; demands are small

Assumption
- More structures mean more benefit
- Structures are cost-effective

Planning & action are community-based & decentralized
Supply-Demand Issues in Rainwater Harvesting

- Low rainfall in water scarce areas
- Variability in rainfall is high in water scarce regions
- Fewer rainy days in semi-arid and arid, water scarce areas
- Evaporation rates are high in water scarce regions
- Large part of India has hard rock geology
Supply-demand issues in rainwater harvesting

- High inter-annual variability in runoff
- Poor infiltration capacities of soils in hard rock areas
- High water demand in water scarce areas
  - Demand far irrigation exceeds the locally harvestable renewable resources
Economic Issues in Water Harvesting

- **Very High Cost of Production of Water**

  The gross returns range from Rs. 1.9/m$^3$ to Rs. 17/m$^3$ (based on data from 450 farmers in 9 agro climatic sub-regions)

- **Scale considerations are important in economic evaluation of small WHS**

- **Trade off between economics and hydrological benefits**
Issues related to improving basin water economy

- Demands higher in lower plains of river basins; supply potential is high in upper basin areas
- Economic value of water is high in scarce areas
- Lack of integrated approach to planning
  - Groundwater contributing to surface flows in hilly areas
Issues related to improving basin water economy

- Poor storage in hard rock aquifers
- Many basins are physically water-scarce
- Downstream Impacts in closed basins
  - Many basins in water-scarce regions are “closed”
  - Downstream negative impacts in Ghelo river basin, Saurashtra
- Lack of water use planning for the harvested water
Findings

- Limited potential of RWH in water-scarce areas
  - Low mean annual rainfalls, high inter-annual variability, high PET & E
  - Inefficient recharging in hard rocks

- Many water-scarce regions have water demands, far exceed the supplies

- Unit cost of water harvesting is prohibitively high for many known techniques

- Scale considerations can further reduce the economic prospects of water harvesting
Findings

- Lower catchments of basins are more naturally water-scarce
- Economic value of water is high in water-scarce areas
- Maximizing hydrological benefits reduces cost effectiveness
- U/S diversions reduce prospects of D/S areas in closed basins of water-scarce areas
How to make water harvesting more effective?

- Understand catchment hydrology better
  - Use of hydrological simulation models for un-gauged basins
  - Use of remote sensing and GIS to generate geomorphological data for simulation models

- Analyze cost implications of harvesting/recharge for different physical environments and with different systems

- Focus on green water, harvested in RWHS
  - Collection efficiency
  - Use efficiency
How to make water harvesting more effective? Cont...

- Study basin water accounts and water balance
  - How much water is used up as beneficial ET, non-beneficial Evaporation
  - How much surplus flows available for harnessing

- Improve wet water-saving in water harvesting structures and large water resource systems
  - Develop proper water use plans for WHS as well
Conclusions

- Water harvesting/watershed programmes to be supported by proper understanding of basin water accounts and balance.

- Further, indulging in large-scale water harvesting projects calls for a careful consideration of costs and benefits with due consideration to hydrological regimes, and cost of different techniques.

- Developing proper water use planning before harvesting initiatives is important.
Coefficient of variation in rainfall

Average Coefficient of Variation in Rainfall: India

Legend:
- Rainfall CV range (%)
  - < 25
  - 26 - 30
  - 31 - 40
  - 41 - 50
  - > 50
Mean Annual Rainy Days

Average Rainy Days : India

Legend
Average Rainy Days
- < 20
- 21 - 30
- 31 - 40
- 41 - 50
- 51 - 75
- > 75
Infiltration Rate in Sandy Loam and Silty clay Soil at the bottom of dug well
Average Annual Potential Evaporation

Legend

Average Annual Evaporation (mm)
- < 1500
- 1500 - 2500
- 2500 - 3500
- > 3500
Aquifer System in India
Runoff Variability Higher than Rainfall Variability
Upstream Vs Downstream Water Demands in Agriculture

Figure 7: Upstream Vs Downstream Water Demands in 6 Basins
Water has Higher economic value in scarce areas

<table>
<thead>
<tr>
<th>Region</th>
<th>Economic Value (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern UP</td>
<td>11.007</td>
</tr>
<tr>
<td>Western Punjab</td>
<td>14.852</td>
</tr>
</tbody>
</table>
### Estimated Unit Cost of Artificial Recharge Structures Built under Pilot Scheme of CGWB

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Type of Recharge Structure (Life in years)</th>
<th>Expected Active Life of the System</th>
<th>Estimated Recharge Benefit (TCM)</th>
<th>Capital Cost of the Structure (in Lac Rs.)</th>
<th>Cost of the Structure per m$^3$ of water (Rs/m$^3$)</th>
<th>Annualized Cost* (Rs/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Percolation Tank</td>
<td>10</td>
<td>2.0-225.0</td>
<td>71.00</td>
<td>20.0-193.0</td>
<td>2.00-19.30</td>
</tr>
<tr>
<td>2</td>
<td>Check Dam</td>
<td>5</td>
<td>1.0-2100.0</td>
<td>1050.0</td>
<td>73.0-290.0</td>
<td>14.60-58.0</td>
</tr>
<tr>
<td>3</td>
<td>Recharge Trench/Shaft/3</td>
<td>5</td>
<td>1.0-1550.0</td>
<td>15.00</td>
<td>2.50-80.0</td>
<td>0.83-26.33</td>
</tr>
<tr>
<td>4</td>
<td>Sub-surface Dyke</td>
<td>5</td>
<td>2.0-11.5</td>
<td>7.30-17.70</td>
<td>158-455.0</td>
<td>31.60-91.00</td>
</tr>
</tbody>
</table>

Water harvesting interventions to replace a SSP (9 MAF of water) would cost us somewhere near two times the rough cost of NRLP.

GOI, 2007
Wells are overflowing!

Figure X: Water Level Fluctuation in Wells in Fulzar, Ghelo River Basin

- Rainfall, mm
- Nr-Median
- Far-Median
### Average Reference Evapo-transpiration Against Mean Annual Rainfall in Selected River Basins in Water-Scarce Region

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Name of the Basin</th>
<th>Mean Annual Rainfall (mm)</th>
<th>Average Annual Water Resources(^1)(mm)</th>
<th>Effective Annual Water Resource(^2) (mm)</th>
<th>Reference Evapo-transpiration(^3) (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Upper</td>
<td>Lower</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Narmada basin</td>
<td>1352.00</td>
<td>792.00</td>
<td>444.70</td>
<td>937.60</td>
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<tr>
<td>2</td>
<td>Sabarmati basin</td>
<td>643.00</td>
<td>821.00</td>
<td>222.84</td>
<td>309.61</td>
</tr>
<tr>
<td>3</td>
<td>Cauvery basin</td>
<td>3283.00</td>
<td>1337.00</td>
<td>316.15</td>
<td>682.80</td>
</tr>
<tr>
<td>4</td>
<td>Pennar basin</td>
<td>900.00</td>
<td>567.00</td>
<td>193.90</td>
<td>467.80</td>
</tr>
<tr>
<td>5</td>
<td>Krishna basin</td>
<td>2100.00</td>
<td>1029.00</td>
<td>249.16</td>
<td>489.15</td>
</tr>
</tbody>
</table>
Effect of Watershed Interventions on Run-Off

G-S Rainfall-Runoff, Cms

Total Rainfall, Cms  Total Runoff, Cms

Year
Marginal cost & benefits of water harvesting with different stages of basin development

Degree of Water Development

Marginal benefit (Social, Environmental and Economic)
Increasing unit cost for higher runoff collection

Trade off between Economics and Hydrological Opportunity