Data for Drinking Water

Centre for Technology Alternatives for Rural Areas
GISE Lab, CSE
IIT-Bombay

www.ctara.iitb.ac.in
www.gise.cse.iitb.ac.in
Centre for Technology Alternatives for Rural Areas

- An academic center of IIT-Bombay, started in 1985
- Development as an intellectual pursuit—challenges, solutions.

Recent focus:

- **Energy** – household, domestic and rural
- **Agriculture/Livelihoods** – post-harvest, foods
- **Water sector** – drinking water, policy.
- **Environmental planning** – development plans, urban and rural appraisal
- and others...

**Academic Initiatives**

- **2010**: TDSL - with other departments and UGs.
The T&D core values

- **Concrete beneficiary/stake-holder** - the bottom 80%, households, hamlets, gram-panchayats, villages, towns and cities
- **Basic areas** - soil, water, energy, livelihoods, public health
  - end-user defined or demand-driven
- **Towards change** - as close to implementation as possible
  - deliver solutions - technology, policy
  - deliver knowledge - consultancy, capacity-building, debate.

Objectives of the M.Tech. program

To produce the developmentalist/development practioner

- Analyse "development" situations and design solutions
- Work with implementation agencies and see them to completion
- Rising demand for such professionals
Drinking water for Boriwali

or for that matter, a savings and micro-lending analysis for Boriwali.
Or saving drudgery for women
Our students (and our faculty) in the field
Typology!

- **Data Gathering**: fidelity and intensity-expensive
- **Use and Cost/Benefit**: Other than research, smaller loops of delivery.
- **actionable—even at the taluka and GP level**

<table>
<thead>
<tr>
<th>Use</th>
<th>Stake-holders</th>
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<tbody>
<tr>
<td>Research</td>
<td>University, Policy-Makers, CSO</td>
</tr>
<tr>
<td>Pedagogy</td>
<td>University</td>
</tr>
<tr>
<td>Action-Research</td>
<td>University, Local Administration, NGO</td>
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<td>University, Local Administration, NGO</td>
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<td>Planning</td>
<td>University, Local Administration</td>
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</tbody>
</table>
Our Datasets

- **Census Part I and II**: basic socio-economic back-gronder, land-use
- **MRSAC**: Remote sensing, planning, roads, watersheds, drainage, District Resource Maps
- **DDWS, PWS**: habitation-wise (believed) coverage, sources and schemes
- **Groundwater Data**: Observation wells, watershed labelling, prediction and modelling of GW.
- **Local Administrative Data**: tanker-fed lists, scheme case-files, yield tests
- **IMD, bhuvan**: station-wise daily rainfall and other parameters, 90m DEM
- **Our concoctions**: contours from DEMs, GP atlas, scheme simulation models, planning GIS and so on
Pedagogy

Village statistics-ST fraction vs. female literacy
Pedagogy

ST fraction vs. population under 6
Pedagogy
more decisive - female literacy vs. population under 6
Analysis of tanker-fed wadis in Thane/Raigad
Analysis of tanker-fed wadis in Thane/Raigad
What have we done-I

Construct a planning and representation tool

- data from MRSAC, CGWB, our own analysis, local admin.
- enable visualization, analysis and planning
### Fraction of ST population.

<table>
<thead>
<tr>
<th></th>
<th>Jawhar</th>
<th>Mokhada</th>
<th>Murbad</th>
<th>Shahpur</th>
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<tbody>
<tr>
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<td>0.97</td>
<td>0.93</td>
<td>0.74</td>
<td>0.62</td>
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<tr>
<td>Neighbors</td>
<td>0.99</td>
<td>0.97</td>
<td>0.32</td>
<td>0.42</td>
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<td>Taluka</td>
<td>0.97</td>
<td>0.91</td>
<td>0.24</td>
<td>0.35</td>
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### Mean elevation:

<table>
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<th>Shahpur</th>
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</thead>
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<tr>
<td>Tankerfed</td>
<td>344</td>
<td>361</td>
<td>123</td>
<td>197</td>
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<tr>
<td>Taluka</td>
<td>320</td>
<td>350</td>
<td>126</td>
<td>132</td>
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</table>
What have we done-II

Visited tens of GPs to understand problem

- Dhamni, Dalkhan, Vihigaon, Washala, Dhakne, Mograj
- certain observations about schemes, terrain, surface vs. ground
What have we done-II

Visited tens of GPs to understand problem
- Dhamni, Dalkhan, Vihigaon, Washala, Dhakne, Mograj
- certain observations about schemes, terrain, surface vs. ground
Mograj GP - according to DDWS and actual!

<table>
<thead>
<tr>
<th>VillageName</th>
<th>HabitationName</th>
<th>SchemeNameDP</th>
<th>SanctionYear</th>
<th>SchemeType</th>
<th>Estimated Cost</th>
<th>DateOfCommencement</th>
<th>sourceTypeCategory</th>
<th>TypeOfSource</th>
<th>LocationWaterSource</th>
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<td>AMBIWADI</td>
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<td>25.00000</td>
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<td>DHAMINI</td>
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<td>Chowdhariwarri handpump</td>
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<td>near field</td>
<td>Functional</td>
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<td>DHAMANI DUGWELL</td>
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<td>Openwell</td>
<td>in village</td>
<td>Functional</td>
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<td>DHAMANI DUGWELL</td>
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<td>01/09/2005</td>
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<td>near village</td>
<td>No data</td>
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<td>MALEGAN T</td>
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<td>20/04/2005</td>
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<td>in village</td>
<td>Functional</td>
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<td>Failed</td>
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<td>MOGRAJ WELL</td>
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<td>near village</td>
<td>Seasonal</td>
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<td>31/03/2008</td>
<td>Ground Water</td>
<td>Openwell</td>
<td>Failed</td>
<td>No data</td>
</tr>
</tbody>
</table>

Source: http://indiawater.gov.in
Mograj GP and habitations
GP and sub-GP GIS
The policy change

- PWS
- Protocol 1
- Protocol 2
- Scarcity List
- Tanker
- GW−Advice
- Gram Sabha
- Maps
- PWS+
- Gram−Sewak
- Maps+Contacts
- Wadi Sabha
- Protocol 1
- Protocol 2
- Less?
- GW−Advice

January 21, 2013 21 / 34
Multi-village and regional schemes

Simulation: of existing poorly performing rural DWS

Schematic of infrastructure currently used for seasonal supply

Not to scale; Not all valve positions are shown
Also Karjat town (pop. 29,000)
And a feasibility study-70 hamlet
Feasible! 40 lpcd at Rs. 2100 capital costs.
**Groundwater**

**Question**: What would be the ground-water at position \( x \) at time \( t \)? Useful to predict scarcity (GSDA), its use for drinking water security.

- Towards regional groundwater advise, budgets
- Location specific advise
Stationary models

Polynomial Model: Bhatkheda_Dug_Well_18.65

- **Degree** | **Fit Quality**
  - 2 | 0.181494
  - 3 | 0.184356
  - 4 | 0.187787

Water Depth (meters) vs. Months

- JUNE JUNE
- JULY AUG
- SEPT OCT
- NOV DEC
- JAN
- FEB MAR
- APR MAY
- END

Original Points
Rainfall models-Thane

![Graph showing water depth over time in Mandvi Dug Well 9.1]

- Water Depth (meters)
- Months: June, July, Aug, Sept, Oct, Nov, Dec, Jan, Feb, Mar, Apr, May, End
- Data points for each year from 1991 to 2005

Years and their respective water depth values:
- 1991: 2108
- 1992: 2759
- 1993: 2748
- 1994: 2844
- 1995: 1765
- 1996: 2095
- 1997: 2282
- 1998: 2913
- 1999: 1859
- 2000: 1985
- 2001: 2116
- 2002: 1792
- 2003: 2565
- 2004: 4740
- 2005: 3051
Rainfall models-Thane
Rainfall models-Latur

Ambulga_Dug_Well_10.5

Water Depth (meters)

Months

-4
-2
0
2
4
6
8
10
12

JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY END

1989:872
1990:976
1991:481
1992:481
1993:542
1994:441
1995:677
1996:795
1997:474
1998:1061
1999:579
2000:790
2001:578
2002:527
2003:530
2004:612
2005:759
Rainfall models-Latur

![Graph showing water depth over months for different years.](Image)
Summary

$R^2$-values

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Latur</td>
<td>0.4508</td>
<td>0.5610</td>
</tr>
<tr>
<td>Thane</td>
<td>0.6730</td>
<td>0.6988</td>
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</table>

- Nearby extraction, long-term effects, shallow/deep aquifers make a difference
- Great predictability from first reading of the year
- For Thane, scarcity more episodic.
How good are our predictions?
<table>
<thead>
<tr>
<th>Name</th>
<th>Date</th>
<th>Location</th>
<th>Temperature</th>
<th>Weather</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>John</td>
<td>Jan 2</td>
<td>Los Angeles</td>
<td>72°F</td>
<td>Sunny</td>
<td>None</td>
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<tr>
<td>Jane</td>
<td>Jan 3</td>
<td>New York</td>
<td>54°F</td>
<td>Cloudy</td>
<td>None</td>
</tr>
<tr>
<td>Jack</td>
<td>Jan 4</td>
<td>Miami</td>
<td>88°F</td>
<td>Rainy</td>
<td>None</td>
</tr>
<tr>
<td>Jill</td>
<td>Jan 5</td>
<td>Boston</td>
<td>68°F</td>
<td>Snowy</td>
<td>None</td>
</tr>
<tr>
<td>Joe</td>
<td>Jan 6</td>
<td>Philadelphia</td>
<td>78°F</td>
<td>Partly Cloudy</td>
<td>None</td>
</tr>
<tr>
<td>Mary</td>
<td>Jan 7</td>
<td>Chicago</td>
<td>45°F</td>
<td>Windy</td>
<td>None</td>
</tr>
<tr>
<td>Mark</td>
<td>Jan 8</td>
<td>Denver</td>
<td>65°F</td>
<td>Sunny</td>
<td>None</td>
</tr>
<tr>
<td>Mike</td>
<td>Jan 9</td>
<td>Houston</td>
<td>85°F</td>
<td>Hot</td>
<td>None</td>
</tr>
<tr>
<td>Leslie</td>
<td>Jan 10</td>
<td>Las Vegas</td>
<td>70°F</td>
<td>Clear</td>
<td>None</td>
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<tr>
<td>Linda</td>
<td>Jan 11</td>
<td>Detroit</td>
<td>50°F</td>
<td>Overcast</td>
<td>None</td>
</tr>
<tr>
<td>Sarah</td>
<td>Jan 12</td>
<td>Dallas</td>
<td>75°F</td>
<td>Humid</td>
<td>None</td>
</tr>
<tr>
<td>David</td>
<td>Jan 13</td>
<td>Kansas City</td>
<td>55°F</td>
<td>Cloudy</td>
<td>None</td>
</tr>
<tr>
<td>Emma</td>
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<td>Seattle</td>
<td>40°F</td>
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<tr>
<td>Alex</td>
<td>Jan 15</td>
<td>Austin</td>
<td>80°F</td>
<td>Sunny</td>
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<tr>
<td>Megan</td>
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<td>San Diego</td>
<td>72°F</td>
<td>Partly Cloudy</td>
<td>None</td>
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<td>Sarah</td>
<td>Jan 17</td>
<td>Nashville</td>
<td>65°F</td>
<td>Dry</td>
<td>None</td>
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<tr>
<td>Tom</td>
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<td>New Orleans</td>
<td>78°F</td>
<td>Hot</td>
<td>None</td>
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<tr>
<td>Rachel</td>
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<td>Miami</td>
<td>85°F</td>
<td>Rainy</td>
<td>None</td>
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<td>Boston</td>
<td>60°F</td>
<td>Overcast</td>
<td>None</td>
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<tr>
<td>Lisa</td>
<td>Jan 21</td>
<td>Cleveland</td>
<td>50°F</td>
<td>Windy</td>
<td>None</td>
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</tbody>
</table>

Good-Year/Bad-Year-Latur
1998-Thane watersheds
2002-Thane watersheds
The Future

- **Watershed Improvement Program** - data-centric approach
  - Maybe, the only solution to expensive bulk water transfer
  - Must improve predictability

- Better geological modelling
  - District resource maps, better models for ground water

- District Planning tools
  - get CEO/collector on board
  - monitoring other resources (roads etc.)

- Taluka-level atlas for drinking water
  - already indicated in DDWS
  - needs OK from collector and needs local implementation agency

- A valuable local capacity - **The Taluka College**
Highlight the Analysis and its use in Decision-making!

- local-stake holders, local knowledge loops - easier to justify
- capacity-building - BDOs, engineering, GPs, colleges and IITs
- enhances transparency, participation and accountability
Thanks

1

Joint work with Vikram, Om, Puru, Pooja, Abhishek, Lalit, Ravi, Rahul, Anuja, Janhvi, hemant, Vishal, and about 10 others