WATER MANAGEMENT FOR FOOD SECURITY

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Challenges

- Soil sampling and analysis
- Soil health knowledge dissemination
- Need to change recommendation
- Restructuring of incentives on fertilizers
Importance of Rainfed Agriculture
Rainfed areas in India generate 60% of agriculture produce, 75% of pulses and more than 90% of sorghum, millet, and groundnut although these areas are the hot spots of poverty, water scarcity, droughts, land degradation, and low rainwater use efficiency. Rainfed agriculture productivity is even crucial for food security and economy of Karnataka as it has the second largest rainfed area in India.

Yield Gaps in Major Crops of Karnataka
An ICRISAT study reveals that the farmers’ current crop yields are two to five times less than the achievable yields (Fig.1), with a huge scope to boost the yields through integrated and improved management practices.

Objectives
- To identify and scale-up best options (soil, crop and water management), including improved cultivars.
- Train DoA staff members to perform stratified soil sampling, analyze micronutrients, and prepare GIS-based soil maps.
- Improve skills of farmers and consortium partners in sustainable use of natural resources for enhancing crop productivity.

Strategies: Mission Mode Approach
- Adopt Integrated Genetic and Natural Resource Management (IGNRM) approach to boost rainfed crop yields on fields of small holder farmers fields in Karnataka.
- Establish farmers’ participatory research and development (PR & D) approach to evaluate productivity enhancement technologies, “Seeing is believing”.
- Build capacity of stakeholders at all levels including Farm Facilitators (FFs), and Lead Farmers, and provide exposure to technologies through field days and mass media.
- Assess the soil health in 30 districts, and provide taluk-wise nutrient recommendations, and ensure timely availability of quality inputs in villages.
- Scaling-up strategy to cover millions of smallholder farmers.
Scaling-up of Technologies for Impact: Bhoochetana

- Increased crop yield by 20–66%
- Covered 5.0 m ha and benefitted 4.75 m farmers
- Contributed to rise in agriculture growth annually above 5% since 2009
- Benefit cost ratio for the farmers 3-14:1
- Net benefits accrued in 5 years Rs. 1963 Crores (US$ 353 million)
Benefits of Soil Health Mapping

- Estimated benefits of ₹4.33 trillion (US$ 68.73 billion) in 10 years with an investment of ₹0.254 trillion (US$ 4.03 billion)
- B:C ratio 17:1
- Environment benefits
- Employment generation
- Trigger agro-processing industries’ growth
Direct Benefit Transfer on Soil-test based Nutrient Subsidy

- Identification of beneficiaries
- DBT delivery mechanism
- Fertilizer supply chain
- Promotion of organic manure
Soil Fertility Atlas for Karnataka, India

Department of Agriculture
Government of Karnataka
International Crops Research Institute for the Semi-Arid Tropics
Objectives of Soil Health Mission are as follows:

1. To issue soil health cards to all farmers of the Karnataka in a span of three years, so as to provide a basis to include nutrient deficiencies in fertilization practices.

2. To diagnose soil fertility related constraints with standardized procedures for sampling and analysis and design taluqa/block level fertilizer recommendations in targeted districts.

3. To develop crops specific nutrient management in the districts for enhancing nutrient use efficiency.

4. To promote soil test based balancing of nutrients to manage fertility related risks for higher production.

5. To conduct demonstrations with diversified crops to quantify benefits of improved nutrient management practices in terms of increased crop yields and economic viability of farmers.
In situ soil moisture and nutrient measurements
The Fertilizer Technology Challenge

- Biotechnology
- BNF
- Nanotechnology
Rainfall is Erratic in Time and Space
**Potential impacts of climate change**

Current SAT:
- Area: 12,643,378 km²

Future SAT in 2050 under 5°C, -10% rainfall:
- Area loss: 1,901,315 km² (15%)
- Area gain: 3,322,187 km² (26%)

Net expansion of extended SAT area by 11%
Short term seasonal rainfall variations often attributed to climate change.

*Bulawayo, Zimbabwe*
Global Irrigated and Rainfed Cropland Statistics

- 1,500 million ha of global cropland
- 275 m ha irrigated (17%)
- Irrigated lands produce 40% of world’s food
- 1,250 m ha of rainfed lands producing 60% of the world’s food
### World Irrigated Area by Region 2004

<table>
<thead>
<tr>
<th>Region</th>
<th>Irrigated Area (Million ha)</th>
<th>Share of World Total* (Per cent)</th>
<th>Share of Cropland That is Irrigated (Per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia +</td>
<td>193.9</td>
<td>70</td>
<td>33</td>
</tr>
<tr>
<td>North and Central America</td>
<td>31.4</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Europe</td>
<td>25.2</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Africa +</td>
<td>12.9</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>South America +</td>
<td>10.5</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Oceania</td>
<td>2.8</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td><strong>World</strong></td>
<td><strong>276.7</strong></td>
<td><strong>100</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

+ Scope for irrigation expansion.

FAOSTAT, 2004
Proportion of total water withdrawal withdrawn for agriculture

Agricultural water withdrawal as percentage of total water withdrawal for agricultural, domestic and industrial purposes (around 2006)

Legend
- No Data
- < 25
- 25 - 50
- 50 - 75
- 75 - 90
- > 90 %

FAO - AQUASTAT, 2013
Source: AQUASTAT
Geographic Projection

Disclaimer
The designations employed and the presentation of material in the map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal or constitutional status of any country, territory or sea area, or concerning the delimitation of frontiers.
Storage Mitigates Against Crop Failure and Stabilizes Crop Yield Year Round
Figure 14.7 Water Reservoir Storage per Capita in Selected Countries, 2003

<table>
<thead>
<tr>
<th>Country</th>
<th>Cubic Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td>38</td>
</tr>
<tr>
<td>South Africa</td>
<td>687</td>
</tr>
<tr>
<td>Mexico</td>
<td>1,104</td>
</tr>
<tr>
<td>Thailand</td>
<td>1,277</td>
</tr>
<tr>
<td>China</td>
<td>2,486</td>
</tr>
<tr>
<td>Brazil</td>
<td>3,386</td>
</tr>
<tr>
<td>Australia</td>
<td>4,717</td>
</tr>
<tr>
<td>North America</td>
<td>5,961</td>
</tr>
</tbody>
</table>

Source: Grey and Sadoff 2006a.
NUMBER OF DAMS IN THE WORLD

Source: ICOLD

- AFRICA (5%)
- ASIA (35.38%)
- EUROPE (25.35%)
- N. AMERICA (31.61%)
- S. AMERICA (2.66%)
- AUSTRAL-ASIA (2%)
Figure 1.7: Dams constructed over time by region (1900-2000)

Multi Functional Purposes of Dams

- Energy
- Irrigation/food production
- Flood control
- Fisheries
- Navigation
- Water supply
Water use by sector, 2000

- Agriculture: 71%
- Industry: 20%
- Domestic: 9%
RISING WATER DEMAND FROM OTHER SECTORS (Source: FAO, 2009)
Managing the resource: Surface water – Ground water interactions
Ground Water Exploitation

- Has expanded irrigation
- Boosted local food production
- Increased small holder production systems
- Contributed to inadequate management of the resource
Evolution of irrigation in India (Bhatia, 2005)
• Global irrigated area is approximately 300 Mha
• 38% equipped for groundwater irrigation
• Total irrigation water consumptive use is 1277 km3/a
• 43% or 545 km3/a is consumptive ground water use

Groundwater irrigated areas:
• India – 39 Mha
• China – 19 Mha
• US – 17Mha

Siebert et al., 2010 – Groundwater use for irrigation – a global inventory
<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of groundwater as part of water resource used</th>
<th>Total Irrigation water use (million m³/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Arabia</td>
<td>96</td>
<td>15,310</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>69</td>
<td>12,600</td>
</tr>
<tr>
<td>Tunisia</td>
<td>61</td>
<td>2,730</td>
</tr>
<tr>
<td>Jordan</td>
<td>55</td>
<td>740</td>
</tr>
<tr>
<td>India</td>
<td>53</td>
<td>4,600,000</td>
</tr>
<tr>
<td>Iran</td>
<td>50</td>
<td>64,160</td>
</tr>
<tr>
<td>Pakistan</td>
<td>34</td>
<td>150,600</td>
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<tr>
<td>Morocco</td>
<td>31</td>
<td>10,180</td>
</tr>
<tr>
<td>Mexico</td>
<td>27</td>
<td>61,200</td>
</tr>
<tr>
<td>China</td>
<td>18</td>
<td>407,800</td>
</tr>
<tr>
<td>South Africa</td>
<td>18</td>
<td>9,580</td>
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<tr>
<td>Nepal</td>
<td>12</td>
<td>28,700</td>
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<tr>
<td>Peru</td>
<td>11</td>
<td>16,300</td>
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<tr>
<td>Malaysia</td>
<td>8</td>
<td>9,700</td>
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<td>Egypt</td>
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<td>45,400</td>
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<tr>
<td>Mali</td>
<td>3</td>
<td>1,320</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1</td>
<td>69,200</td>
</tr>
</tbody>
</table>
Ground water irrigation:
• on demand
• individual use and not constrained by institutional management and variability in supply
• user flexibility in irrigation scheduling and water management
• overcomes temporal variability in soil moisture in order to stabilize crop production
• drought proofing in times of climate change

An invisible and diminishing resource
• when abstraction exceeds recharge
• depletion
• multiple pumping points – difficult to manage without legal framework
• lack of monitoring and permits
• energy costs – used to be cheap/subsidized
Simulated groundwater depletion, mm/a

Global depletion of groundwater resources (Wada et al, 2010)
Global depletion of groundwater resources (Wada et al, 2010)
Can we learn lessons from the Ogallala Aquifer project?

- Monitoring
- Management
- Mitigation
Ogallala Aquifer

- Covers 450,000 km²
- Covers 27% of US irrigated land
- Withdrawals for irrigation - 26 km³
- Total withdrawals since development – 312 km³
- 9% decline in storage since development
• If spread across the U.S. the aquifer would cover all 50 states with 45 cm of water;
• If drained, it would take more than 6,000 years to refill naturally;
• More than 90% of the water pumped is used to irrigate crops;
• $20 billion a year in food and fiber depend on the aquifer;
Establishing a Framework for Groundwater Management and Protection

- Protection of ecosystem viability
- Proper governance systems to reduce depletion and pollution
- Establish institutional, monitoring, permitting and pricing mechanisms
- Assessment of the resource
- Enhancing recharge
- Use of surface water control systems to replenish ground water
- Sustainable management to achieve economic and social well being