ASSESSMENT OF GROUNDWATER RESOURCES AND QUALITY IN BIST DOAB REGION, PUNJAB, INDIA

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INTRODUCTION

- Groundwater is an essential resource for drinking, irrigation and industrial purposes.
- It is under stress due to rapid population growth, urbanization, industrialization and agriculture activities.
- Punjab State is facing severe groundwater stress.
INDIA’s GROUNDWATER RESOURCE SCENARIO

Annual Replenishable GW: 11.56 bcm
Annual GW Draft: 12.99 bcm
Stage of GW development: 125%
Assessed blocks: 237
  - over-exploited: 140 (59%)
  - safe: 32 (13.5%)

Punj.: The most stunning exmpl of GR
70% of people are engaged in agrocult.
Food deficit to food surplus, slf-relient

Source: CGWB
IRRIGATION DRAFT VIS-A-VIS DOMESTIC & INDUSTRIAL DRAFT

Land use: 87% agri. (including hort., agroforestry plantation)
2004 (PSRC)

Source: State of Environment, 2005
Population (in Million)

Year


(~21% decadal growth rate)
About 85% of geographical area of Punjab is under agriculture of which 97% area is irrigated.

**Cropping Intensity** = \( \frac{\text{net area sown}}{\text{total cropped area}} \)


**Demand of water for Agriculture** (4.38 Mham) = Canal Water (1.45) + Dynamic GW (recharge from rains & Canal seepage = 1.68) + Over exploitation of Deep GW (1.25)
DISTRICT WISE GROUND WATER AVAILABILITY, DRAFT AND NET AVAILABILITY IN PUNJAB

Source: CGWB & Deptt. Of Irrigation, Punjab, 2005
STUDY AREA: BIST- DOAB
Area (km²): **9060** *(Kandi: 1060+ ; Plains: 8000)*

1. Ropar to Harike: 155 km; 2. Talwara to Harike: 125 km; 3. Ropar to Talwara: 118 km
BIST DOAB REGION

- Interfluves,
- Triangular region
- Area: 9060 km²
- 4 Districts
- Bounded by Siwaliks, rivers Beas & Satluj
- Population density 529/ km² (Census, 2011)
- Temperature
  - Summers: 30 to 32 °C ; Winters: 10 to 15 °C
- The average rainfall of the region is 543.3mm
OBJECTIVES

- To Assess Variability in Input & Draft
  - Input of groundwater: Rainfall Variable (Decadal Scale)
  - Groundwater Requirement for various crops

- To assess the groundwater balance & availability for future use
  - Groundwater Fluctuation; Availability & Stage
  - Groundwater Resources for future

- Groundwater Management Measures
  - Flow Pattern;
  - Development of surface water sources
  - Artificial Groundwater Recharge
  - Optimization of irrigation applications
CANAL & DRAINAGE SYSTEM

DRAINAGE SYSTEM

CANAL SYSTEM
VARIABILITY IN INPUT & DRAFT
AVERAGE ANNUAL RAINFALL IN THE BIST-DOAB REGION

(Source: IMD)
LAND USE IN BIST DOAB REGION

- Built-up Land: 1.8%
- Agricultural Land: 79.6%
- Forests: 9.1%
- Wastelands: 3.0%
- Wetlands: 0.5%
- Water bodies: 6.1%
LAND USE IN DISTRICTS

a) Nawansahar b) Kapurthala c) Hoshiarpur d) Jalandhar

Area: 1190km²; 1633km²; 3365km²; 2622km²

(Source: Punjab Remote Sensing Centre, Ludhiana, 2008)
# Virtual Water Content of Crops

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Product</th>
<th>Virtual Water (m³/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cotton</td>
<td>8264</td>
</tr>
<tr>
<td>2</td>
<td>Rice</td>
<td>2850</td>
</tr>
<tr>
<td>3</td>
<td>Maize</td>
<td>1937</td>
</tr>
<tr>
<td>4</td>
<td>Wheat</td>
<td>1654</td>
</tr>
</tbody>
</table>
| 5      | Sugar Cane Sugar (Raw/Refined) | 159  
|        |                          | 1301/1391              |

# CROP DISTRIBUTION & VIRTUAL WATER REQUIREMENT IN BIST-DOAB REGION

(Source: Deptt. Agriculture, Punjab- 2006)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Total Area (km²)</th>
<th>VWR (%)</th>
<th>VWR (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>3495</td>
<td>28.1</td>
<td>3461325</td>
</tr>
<tr>
<td>Wheat</td>
<td>4953</td>
<td>39.8</td>
<td>3367820</td>
</tr>
<tr>
<td>Maize</td>
<td>1007</td>
<td>8.1</td>
<td>544297</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>503</td>
<td>4.0</td>
<td>45289</td>
</tr>
<tr>
<td>Cotton</td>
<td>10</td>
<td>0.1</td>
<td>2755</td>
</tr>
<tr>
<td>Others</td>
<td>2482</td>
<td>19.9</td>
<td></td>
</tr>
</tbody>
</table>

- **Others**: 19.9%
- **Rice**: 28.1%
- **Wheat**: 39.8%
- **Maize**: 8.1%
- **Sugarcane**: 4.0%
- **Cotton**: 0.1%
WATER UTILIZED IN BIST- DOAB REGION FOR IRRIGATION (m³)

Production Equivalent to Water

(Source: Deptt. Agriculture, Punjab- 2006)
TOTAL WATER CONSUMPTION FOR IRRIGATION IN BIST DOAB REGION

(Source: Deptt. Agriculture, Punjab- 2006)
GROUNDWATER DYNAMICS & WATER BALANCE
GROUNDWATER FLUCTUATION IN BIST-DOAB REGION (2002-08)
VARIATION IN DEPTH TO WATER TABLE IN BIST DOAB

**Location**

<table>
<thead>
<tr>
<th>Location</th>
<th>Shallow</th>
<th>Deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dasuya</td>
<td>0.35</td>
<td>0.21</td>
</tr>
<tr>
<td>Allwalpur</td>
<td>-0.10</td>
<td>-</td>
</tr>
<tr>
<td>Adampur</td>
<td>-</td>
<td>1.9</td>
</tr>
<tr>
<td>Kapurthala</td>
<td>0.50</td>
<td>0.51</td>
</tr>
<tr>
<td>Shahkot</td>
<td>0.21</td>
<td>0.75</td>
</tr>
<tr>
<td>Phillaur</td>
<td>0.18</td>
<td>0.32</td>
</tr>
<tr>
<td>Balachaur</td>
<td>0.72</td>
<td>0.73</td>
</tr>
</tbody>
</table>

**Shallow Aquifer**

**Deep Aquifer**
LONG TERM VARIATION OF PRE-MONSOON (JUNE) WATER TABLE

Water levels are declining in region on a long term basis.
GROUNDWATER AVAILABILITY & STAGE (2004) IN BIST-DOAB REGION
## CATEGORIZATION OF BLOCKS IN BIST-DOAB REGION

<table>
<thead>
<tr>
<th>S. No.</th>
<th>District</th>
<th>Semi-Critical</th>
<th>Critical</th>
<th>Over-Exploited</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Hoshiarpur</td>
<td>1 Garh Shankar</td>
<td>-</td>
<td>1 Hoshiarpur-I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 Hazipur</td>
<td>-</td>
<td>2 Tanda</td>
</tr>
<tr>
<td>2.</td>
<td>Jalandhar</td>
<td></td>
<td></td>
<td>1 Adampur</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 Bhogpur</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 Goraya</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 Jal-east</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 Jal-west</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6 Lohian</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7 Nakodar</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8 Nurmahal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9 Phillaur</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10 Shahkot</td>
</tr>
<tr>
<td>3.</td>
<td>Kapurthala</td>
<td></td>
<td></td>
<td>1 Bholath</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 Dhilwan</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 Kapurthala</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 Phagwara</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 Sultanpur</td>
</tr>
<tr>
<td>4</td>
<td>Nawan shahar</td>
<td></td>
<td></td>
<td>1 Aur</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 Banga</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 Nawanshahar</td>
</tr>
</tbody>
</table>
GROUND WATER RESOURCES IN VARIOUS DISTRICTS OF BIST-DOAB REGION

A: Hoshiarpur
B: Jalandhar
C: Kapurthala
D: Nawanshahar

1. Net Annual Groundwater Availability
2. Existing Gross Groundwater Availability
3. Existing Gross Groundwater Draft for all Users
4. Allocation for Domestic and Industrial Requirement Supply up to next 25 years
5. Net Groundwater Availability for future Irrigation Development

(All units in: ham)

CGWB, 2007
GROUND WATER RESOURCES OF BIST- DOAB REGION

-15% 19%

2% 31%

33%

Net Annual Groundwater Availability

Existing Gross Groundwater Availability

Existing Gross Groundwater Draft for all users

Allocation for Domestic & Industrial Requirement Supply for next 25yrs

Net Groundwater Availability for Future Irrigation Development

GROUND WATER RESOURCES OF BIST- DOAB REGION

-15% 19%

2% 31%

33%
MANAGEMENT MEASURES
GROUNDWATER FLOW IN BIST-DOAB REGION (2008)

Depth < 50 m
- White Bein Catchment Area
- Black Ben Catchment Area
- GW Flow Direction
- Dams
- Ridge Line

Depth > 150 m
- White Bein Catchment Area
- Black Ben Catchment Area
- GW Flow Direction
- Dams
- Ridge Line

Topographic Elevation

SHALLOW GROUNDWATER

DEEP GROUNDWATER
GROUNDWATER RISE/FALL IN BIST-DOAB REGION

1984-2003

[Map showing groundwater rise/fall with various regions indicated by color codes and stars marking specific areas of interest.]
GROUNDWATER DEPTH IN BIST- DOAB REGION

1973

1997

Depth to Water Table

0-1.5
1.5-2
2-3
3-5
5-7
7-10
10-13
13-15
15-18
18-20
20-30
30-40
40-50
50-60
> 60
APPLICATION OF NEW TECHNIQUES
The groundwater shows interaction between deep aquifer and shallow aquifer at few locations in the south eastern part and at Khurdpur in the central part.
INFERENCES

- Groundwater has reached to critical condition in Bist Doab region
- Out of 22 blocks, 20 blocks are overexploited in the BIST-DOAB Region
- Rainfall pattern shows an increasing trend since 2002 the water table displays falling trend especially in the central and south central region
- Increasing use of water demanding crops is one of the principal reason for the observed decline in groundwater table in the region
- Minor Dams distributed over a wider region in addition to supporting the surface water requirement helps in recouping the groundwater resources
- The accelerated groundwater recharge needs an integrated use of modern techniques
WATER MANAGEMENT & DEVELOPMENT STRATEGIES

- Use of soil water management techniques to save water without loss of crop yields
- Change in cropping pattern (use of less water demanding crops)
- Conjunctive use of surface water and groundwater system & use of water blending technique at required areas
- Construction of multiple water storage

- Artificial Recharge to Groundwater
  - Use of surface water drains for artificial recharge
  - The check dams may be constructed across the drains
  - Recharge through east & west Bain flood plain
  - Use of tube wells and abandoned dug wells
The case study can be extended in other parts of India where such problem exists.
Other: Total oil seeds+total pulses+Barley+Total Vegetables+ Fruits

Only 21% of the paddy area is canal irrigated.

HYV: Wheat (Maxico), Paddy (Manila)

Over-intensification of agriculture  $\rightarrow$ GW depletion, reduced soil fertility, $\mu$-nutrient deficiency, reduced genetic diversity, water pollution
NET IRRIGATED AREA BY DIFFERENT SOURCE IN PUNJAB

Source: Statistical Abstract of Punjab, 1990 & 2005

(Canal: Reduction in capacity due to siltation; TW: CF, Submerc., )
INTRODUCTION

- Groundwater is an essential resource for drinking, irrigation and industrial purposes.
- It is under stress due to rapid population growth, urbanization, industrialization and agriculture activities.
- Punjab State is also facing severe groundwater stress due to its intensive use in agriculture and other activities.
- About 85% of geographical area of Punjab is under agriculture of which 97% area is irrigated.
Based on cropping pattern and practices, the total demand of water for agriculture is 4.38 mham against the total availability of 3.13 mham

The shortage of 1.25 mham is met through groundwater reserves

The dynamic groundwater reserve is limited to 2.38 mham

Resulting in rapid decline of water table

The area under irrigation by groundwater through tube wells had increased from 55 to 72 percent during 1970-2006 with the corresponding decrease in the area under irrigation by canals

The annual average rainfall has also decreased from 739.1 mm in 1980 to 529.2 mm in 2008
Groundwater Sustainability,
PDS(MSR) Annual Meeting Delhi,
AOGS PDS
## PUNJAB: AGRICULTURE STATUS

### Total Land: Land under agriculture activity
- 75% in 1960-61
- 80% in 1970-71
- 84.4% in 2000-01
- \(\frac{84.4-75}{75} \times 100 = 0.24\%\) per yr.

### Irrigation water requirement

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Agri. Area</td>
<td>4.2 M ha</td>
</tr>
<tr>
<td>Canal Irrigated area</td>
<td>1.6 M ha (38%)</td>
</tr>
<tr>
<td>Irrigation from other sources</td>
<td>2.35 M ha (56%)</td>
</tr>
<tr>
<td>Total irrigated area</td>
<td>3.95 M ha (94%)</td>
</tr>
</tbody>
</table>

### Demand of water for Agriculture (4.38 Mham)

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply</td>
<td></td>
</tr>
<tr>
<td>Canal Water</td>
<td>1.45 Mham.</td>
</tr>
<tr>
<td>GW recharge (rains +Canal seepage)</td>
<td>1.68 Mham</td>
</tr>
<tr>
<td>Over exploitation of Deep GW</td>
<td>1.25 M ham</td>
</tr>
</tbody>
</table>

### Tubewells as on 2004-05 (1.17 million)

\[\geq 1\, TW\, per\, 0.5\, ha\, in\, non-canal\, irrigated\, area\]

(Source: Tiwana et al., 2005)
- Long term trend for water utilization for agriculture in the region shows that the water utilized per unit area is highest in Jalandhar district followed by Kapurthala district.

- Water is the major limitation for crop productivity in Kandi area.