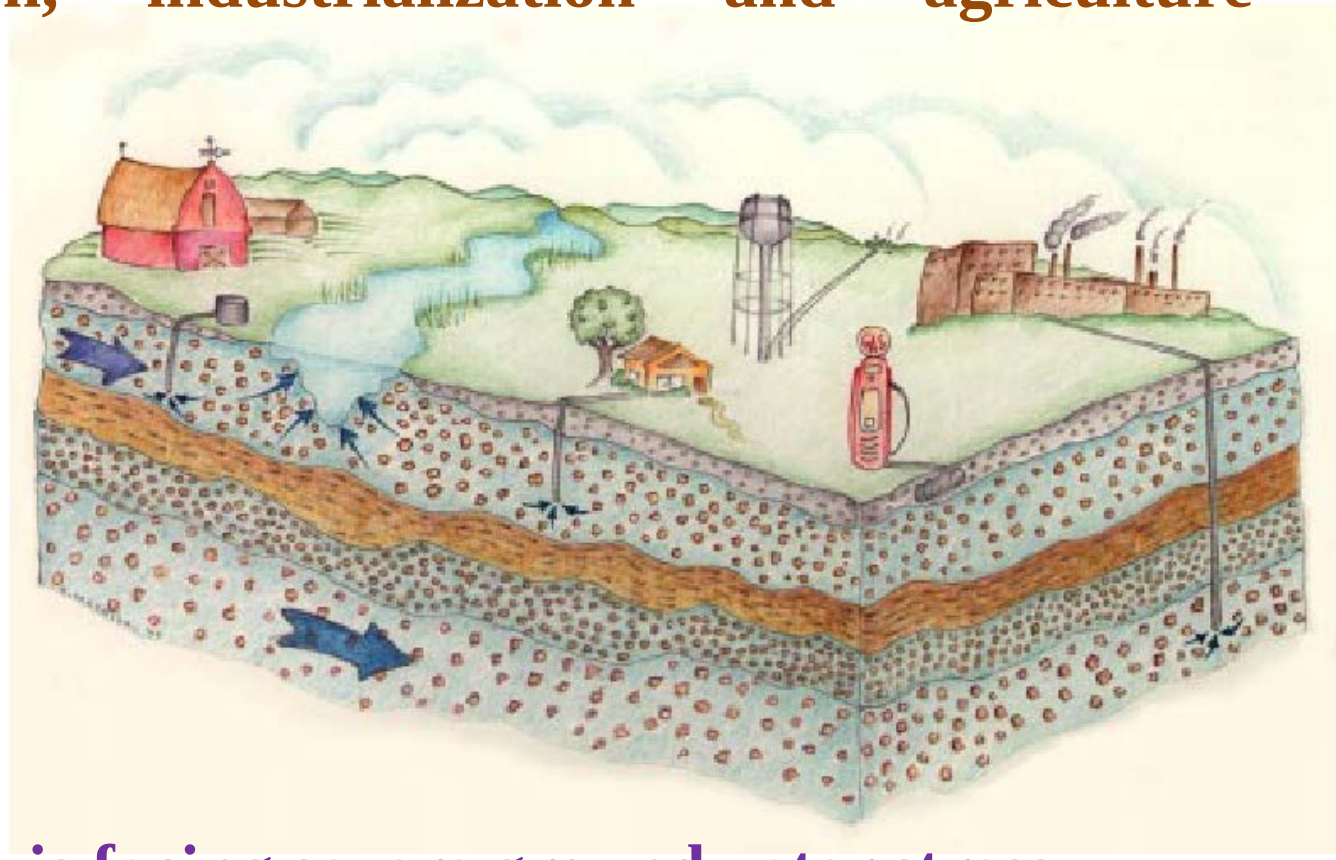
ASSESSMENT OF GROUNDWATER RESOURCES AND QUALITY IN BIST DOAB REGION, PUNJAB, INDIA

Anju Pant, M S Rao, Y S Rawat, P Purushothaman & Gopal Krishan

Hydrological Investigation Division,
National Institute of Hydrology, Roorkee

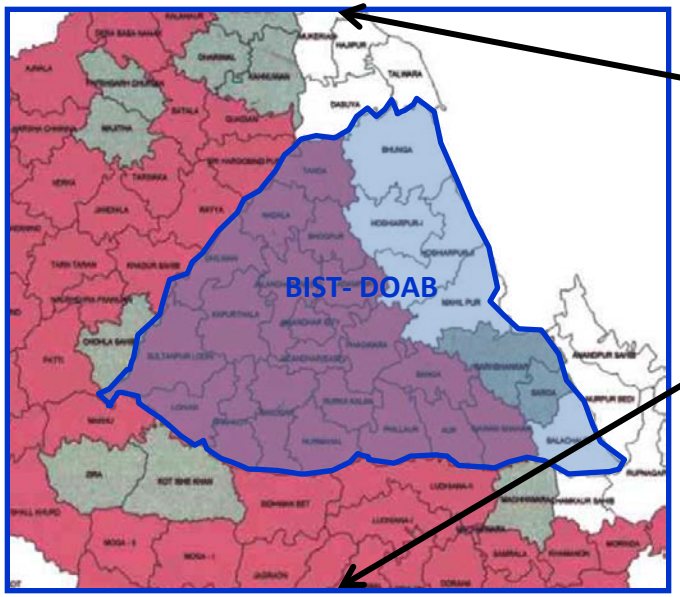
INTRODUCTION

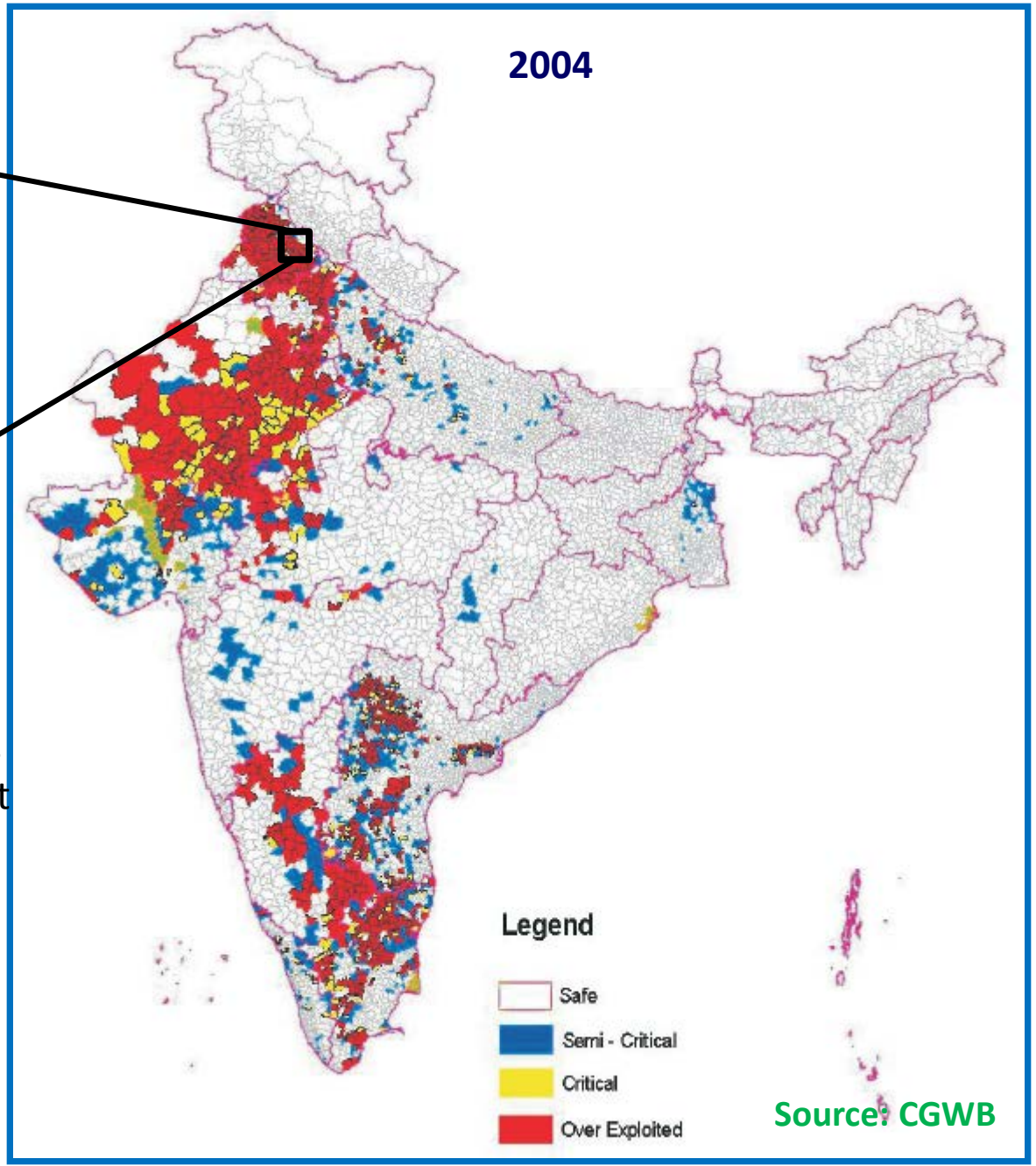
- Groundwater is an essential resource for drinking, irrigation and industrial purposes
- It is under stress due to rapid population growth, urbanization, industrialization and agriculture activities



- Punjab State is facing severe groundwater stress

INDIA's GROUNDWATER RESOURCE SCENARIO

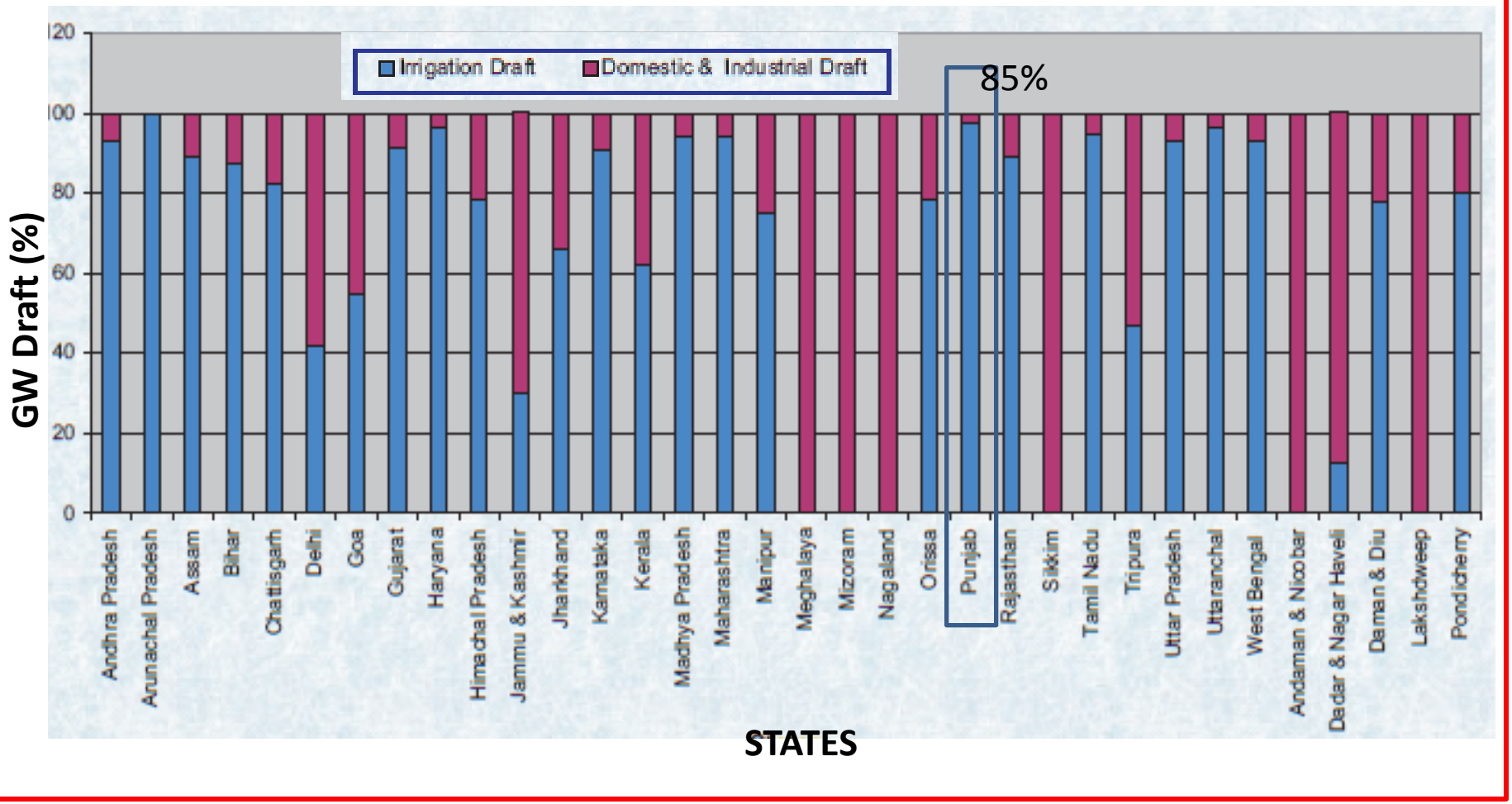




Punj.: The most stunning exmpl of GR
70% of peple are engaged in agrocult.
Food deficit to food surplus, slf-relient

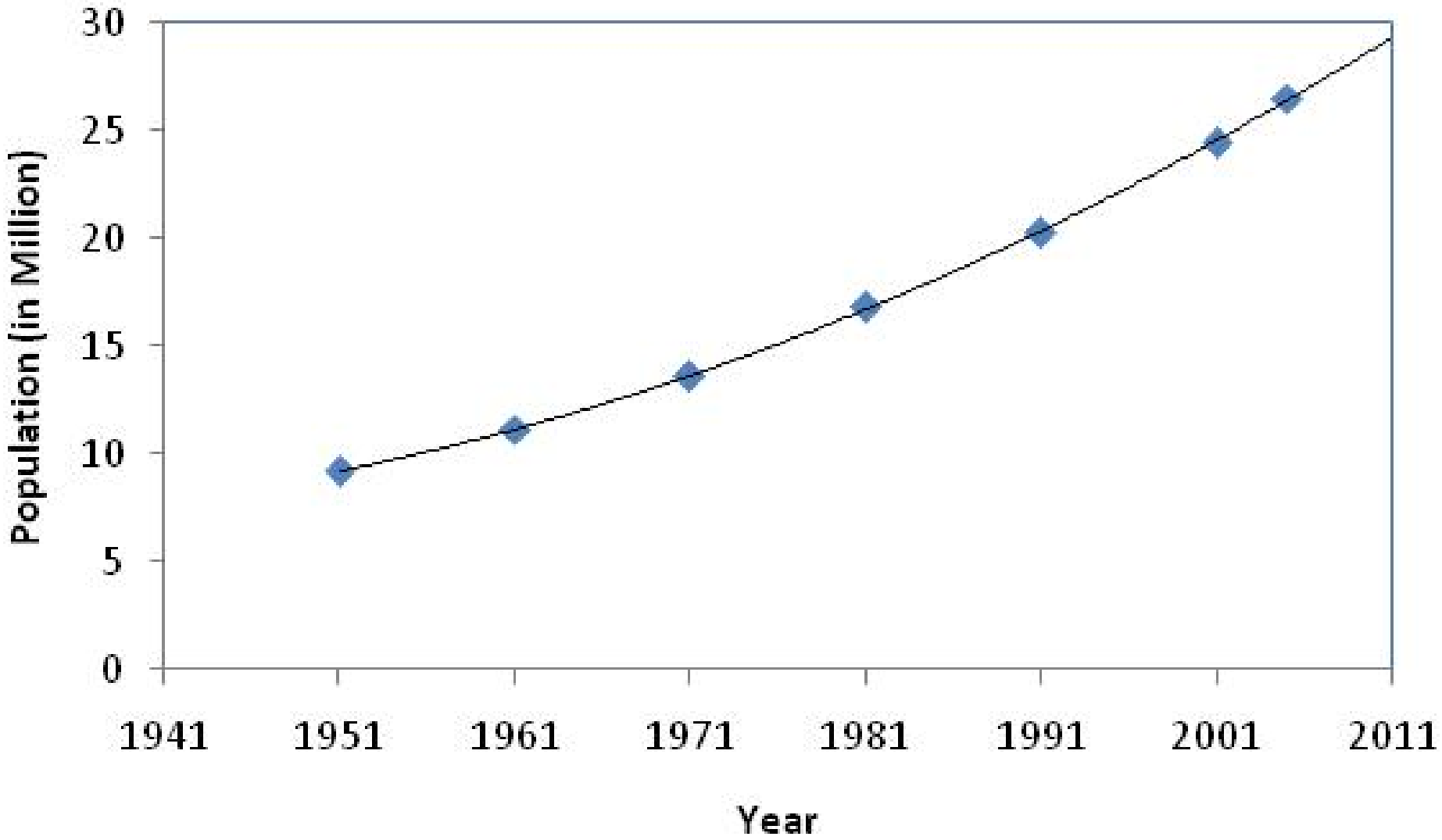
Annual Replenishable GW:	**11.56 bcm**
Annual GW Draft	: **12.99 bcm**
Stage of GW development:	**125 %**
Assessed blocks	: **237**
over-exploited	:**140 (59%)**
safe	: **32 (13.5%)**

IRRIGATION DRAFT VIS-A-VIS DOMESTIC & INDUSTRIAL DRAFT



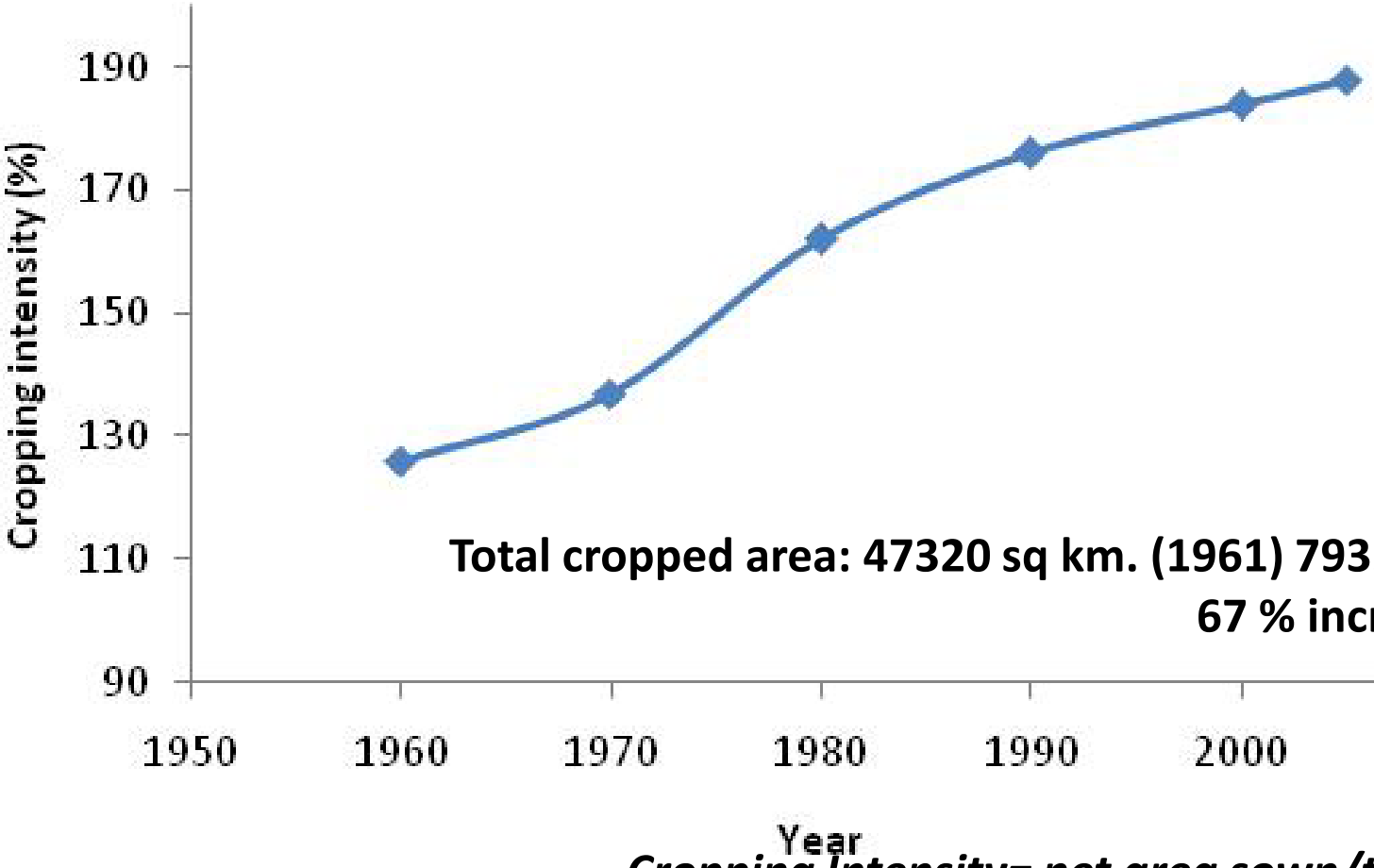
Land use:87% agri. (including hort., agroforsetry plantation) 2004 (PSRC)

Source: State of Environment, 2005



(~21% decadal growth rate)

About 85% of geographical area of Punjab is under agriculture of which 97% area is irrigated

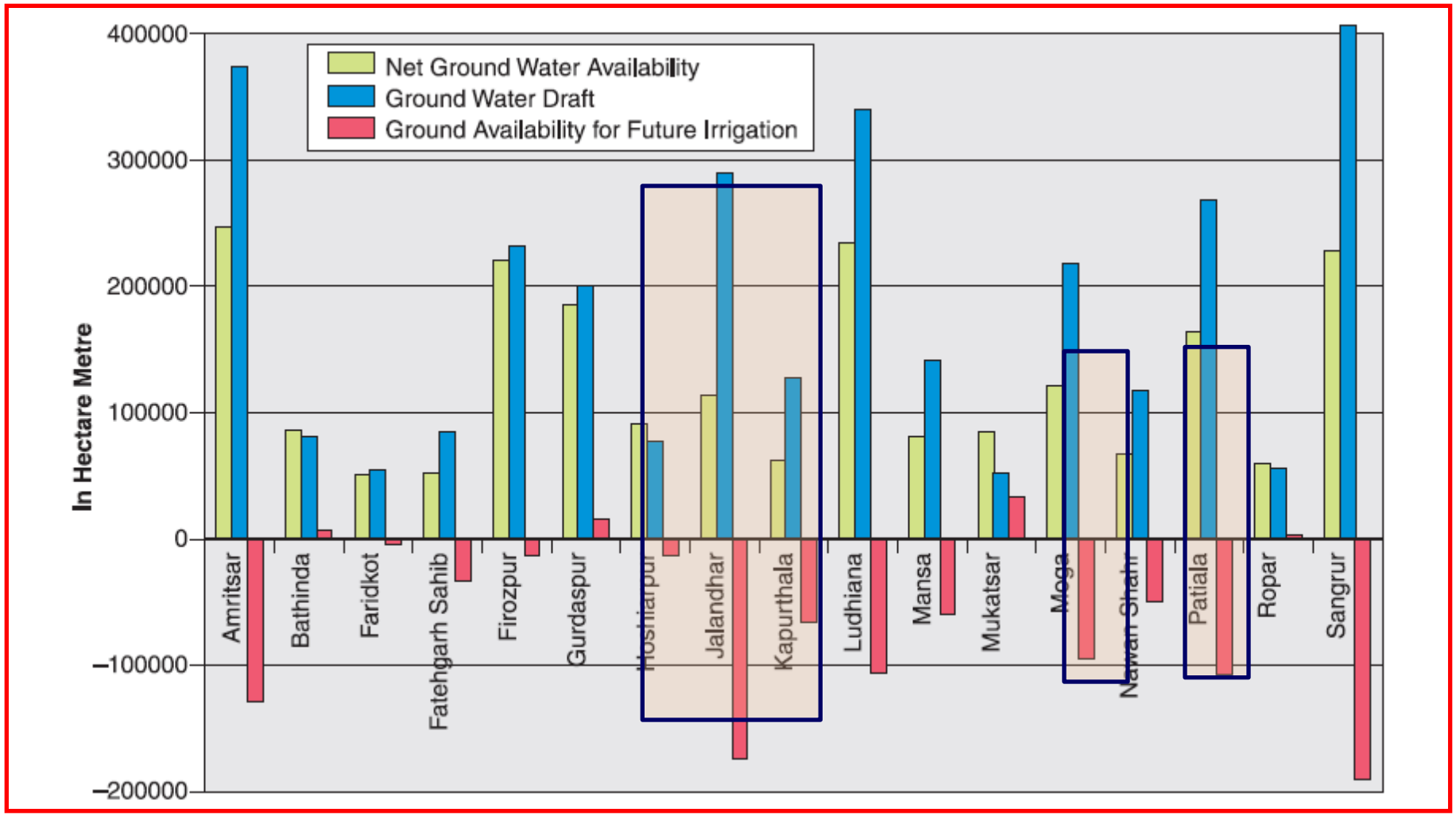


Total cropped area: 47320 sq km. (1961) 79320 sq. km. (2005)
67 % increase.

Cropping Intensity= net area sown/total cropped area

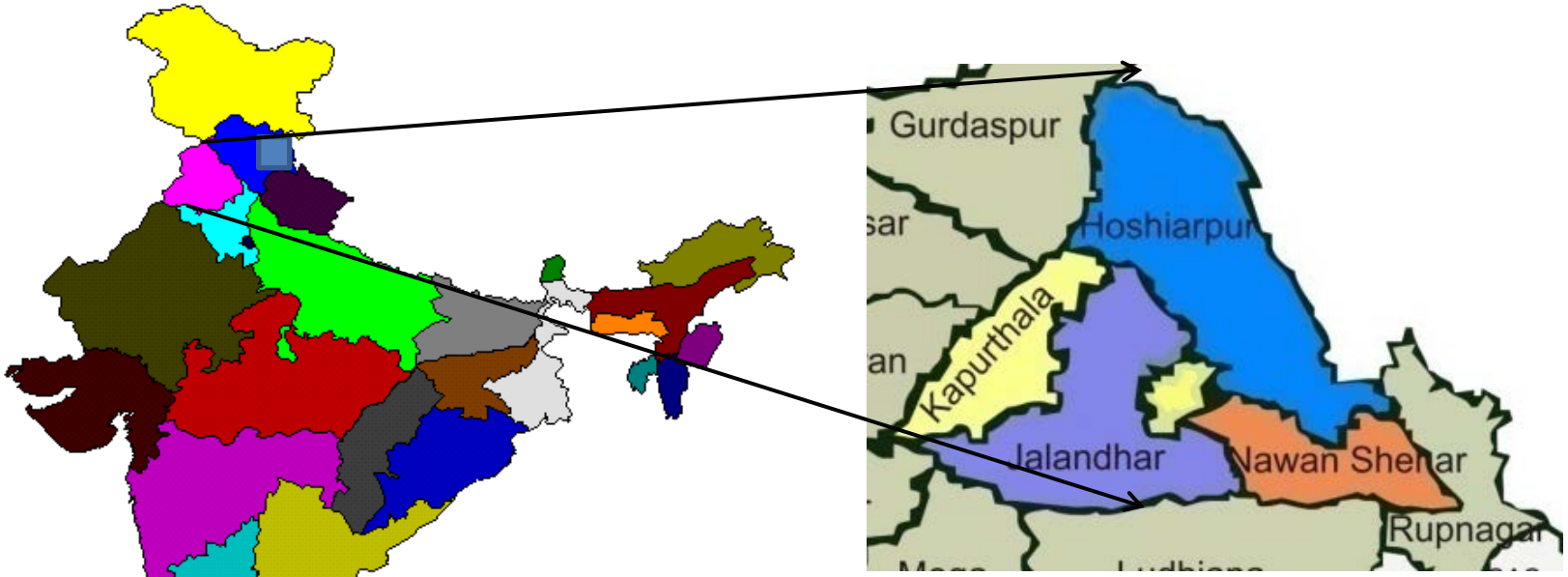
Demand of water for Agriculture (4.38 Mham) = Canal Water (1.45)+ Dynamic GW (recharge from rains &Canal seepage = 1.68) + Over exploitation of Deep GW (1.25)

DISTRICT WISE GROUND WATER AVAILABILTY, DRAFT AND NET AVAILABILTY IN PUNJAB

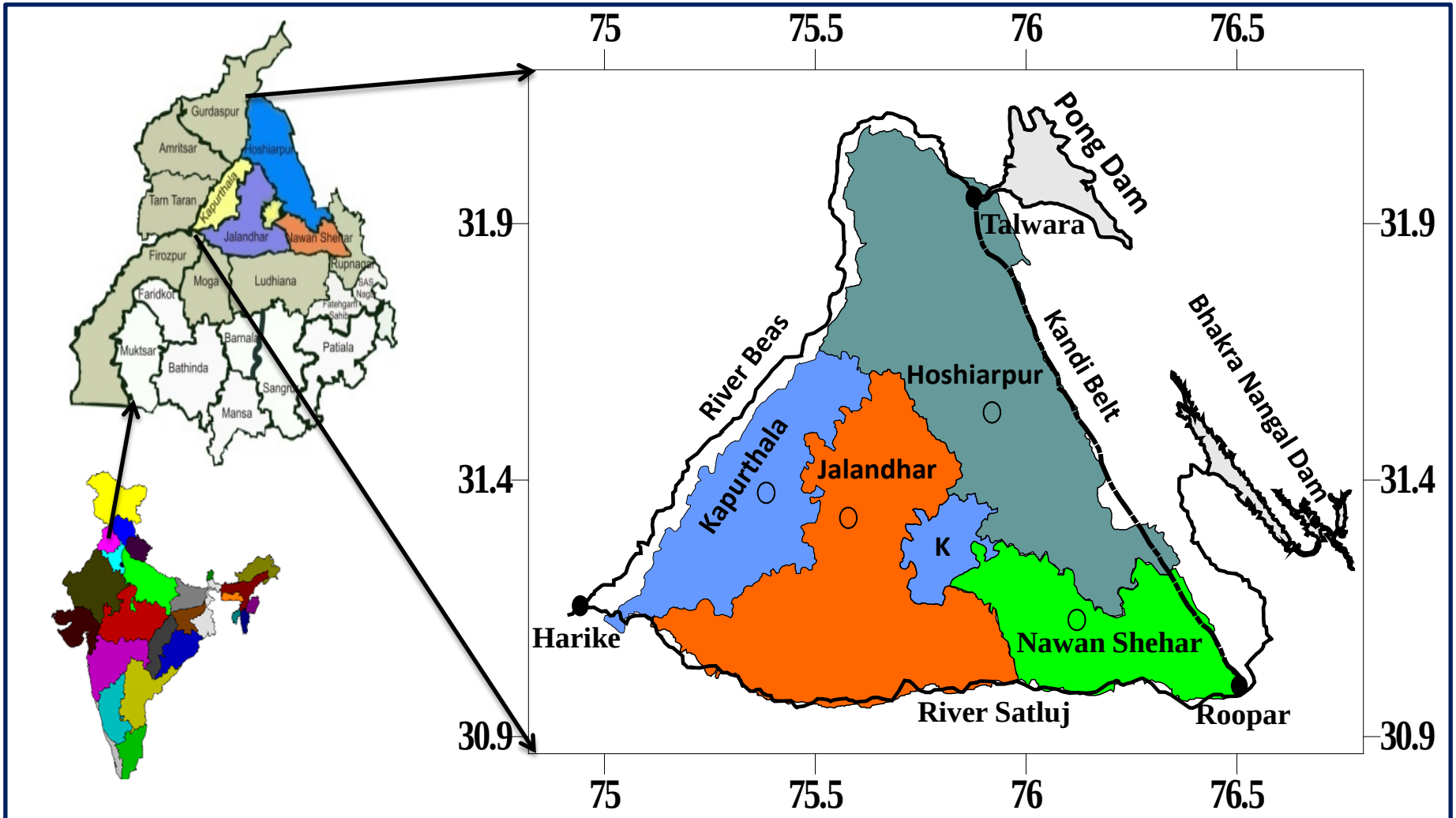


Source: CGWB & Deptt. Of Irrigation, Punjab, 2005

STUDY AREA: BIST- DOAB



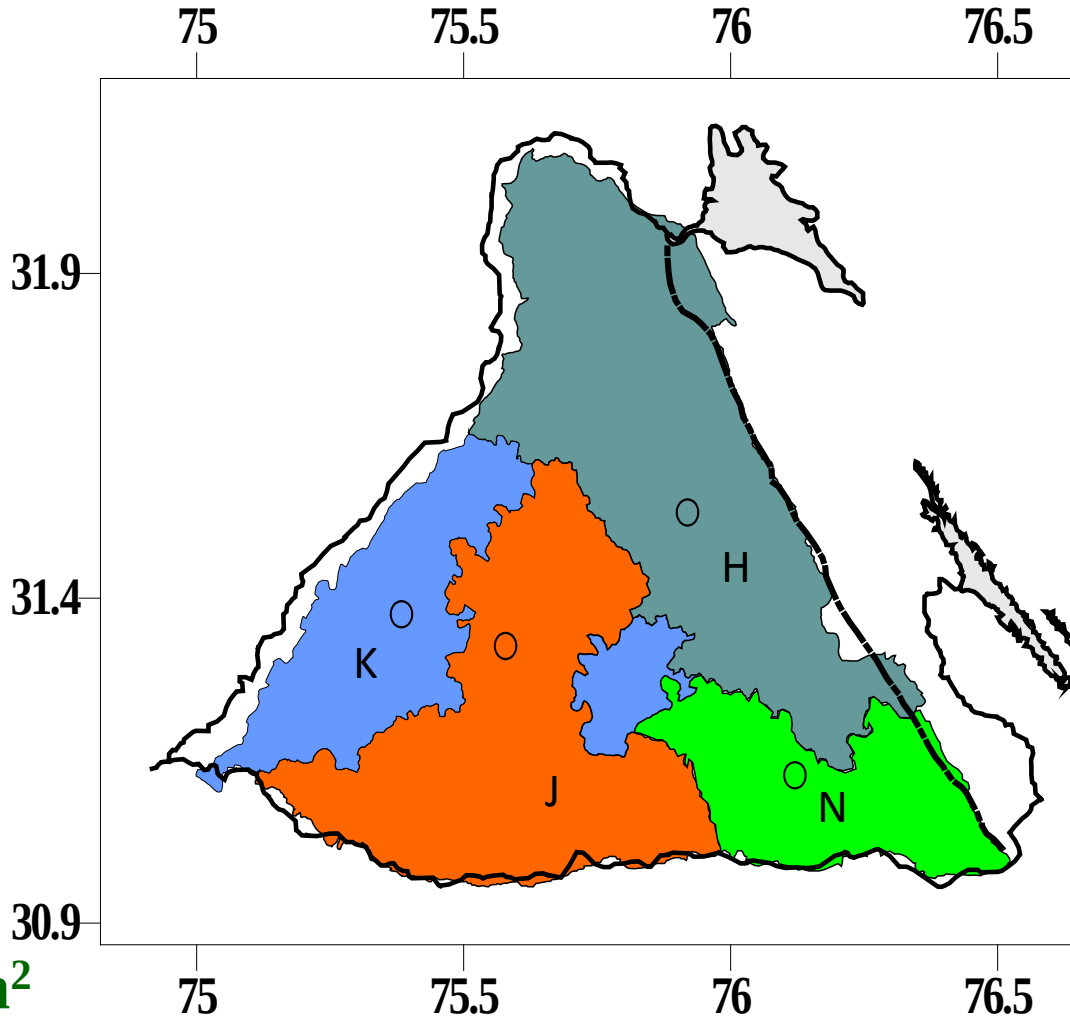
STUDY AREA



Area (km^2): 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

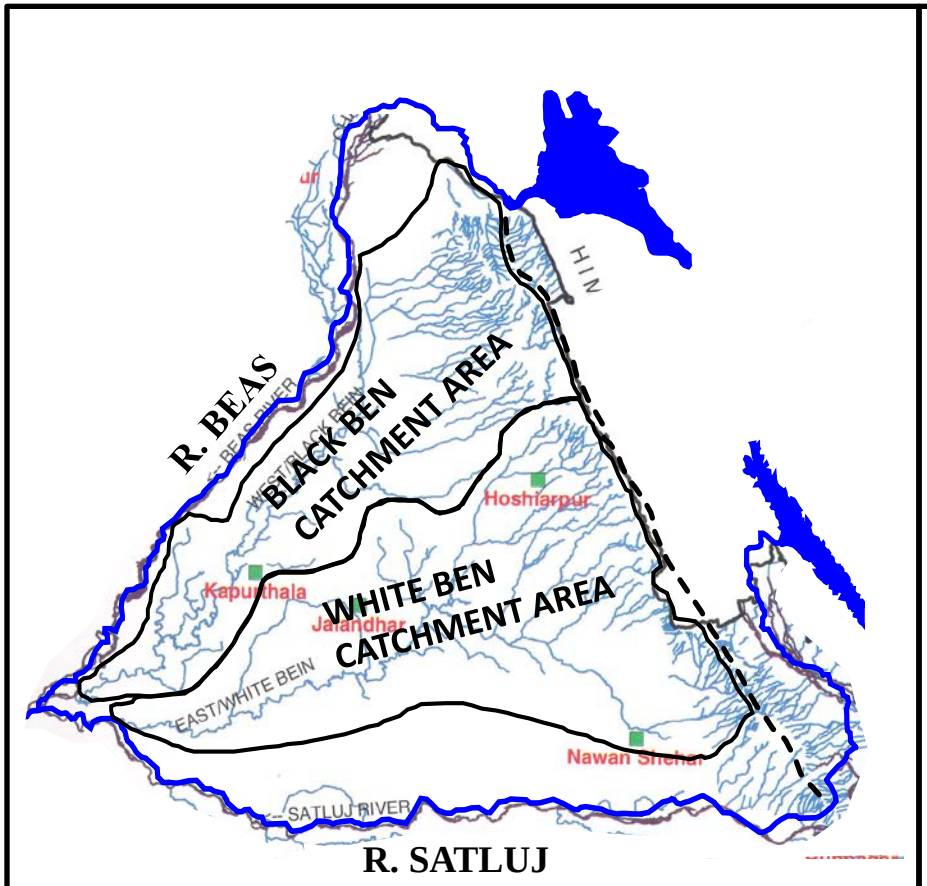


- Interfluves,
- Triangular region
- Area: 9060 km^2
- 4 Districts
- Bounded by Siwaliks, rivers Beas & Satluj
- Population density 529/ km^2 (Census, 2011)
- Temperature
  - Summers: 30 to 32 °C ; Winters: 10 to 15 °C
- The average rainfall of the region is 543.3mm

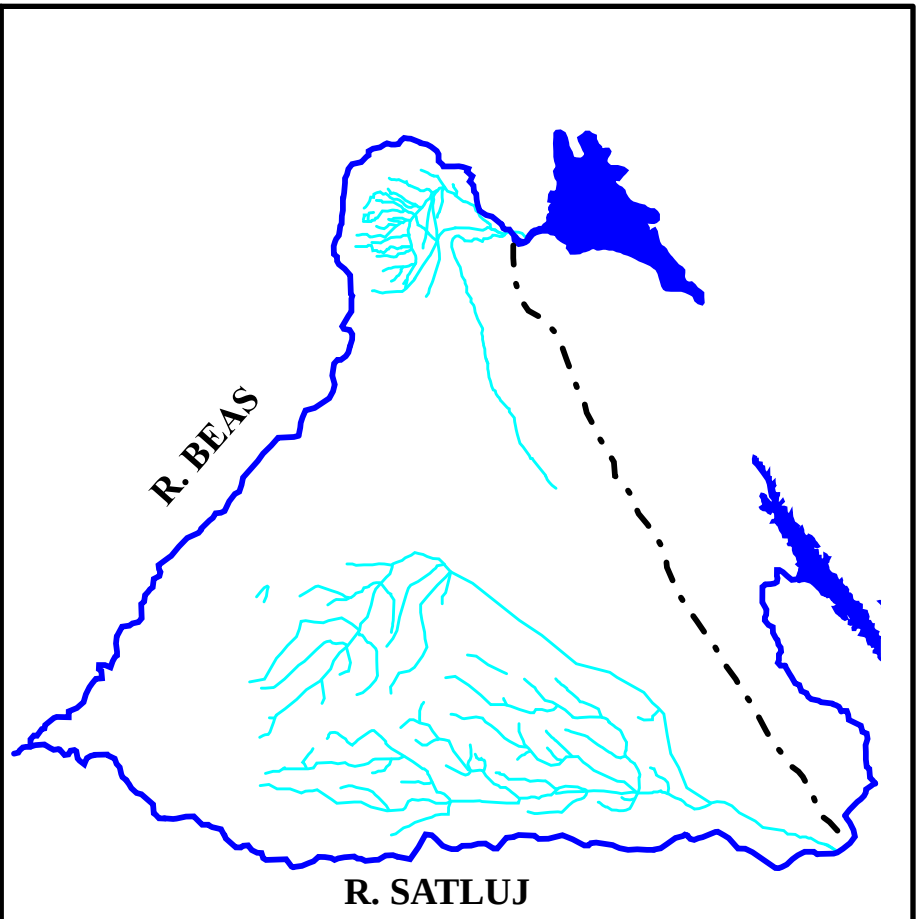
OBJECTIVES

- **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



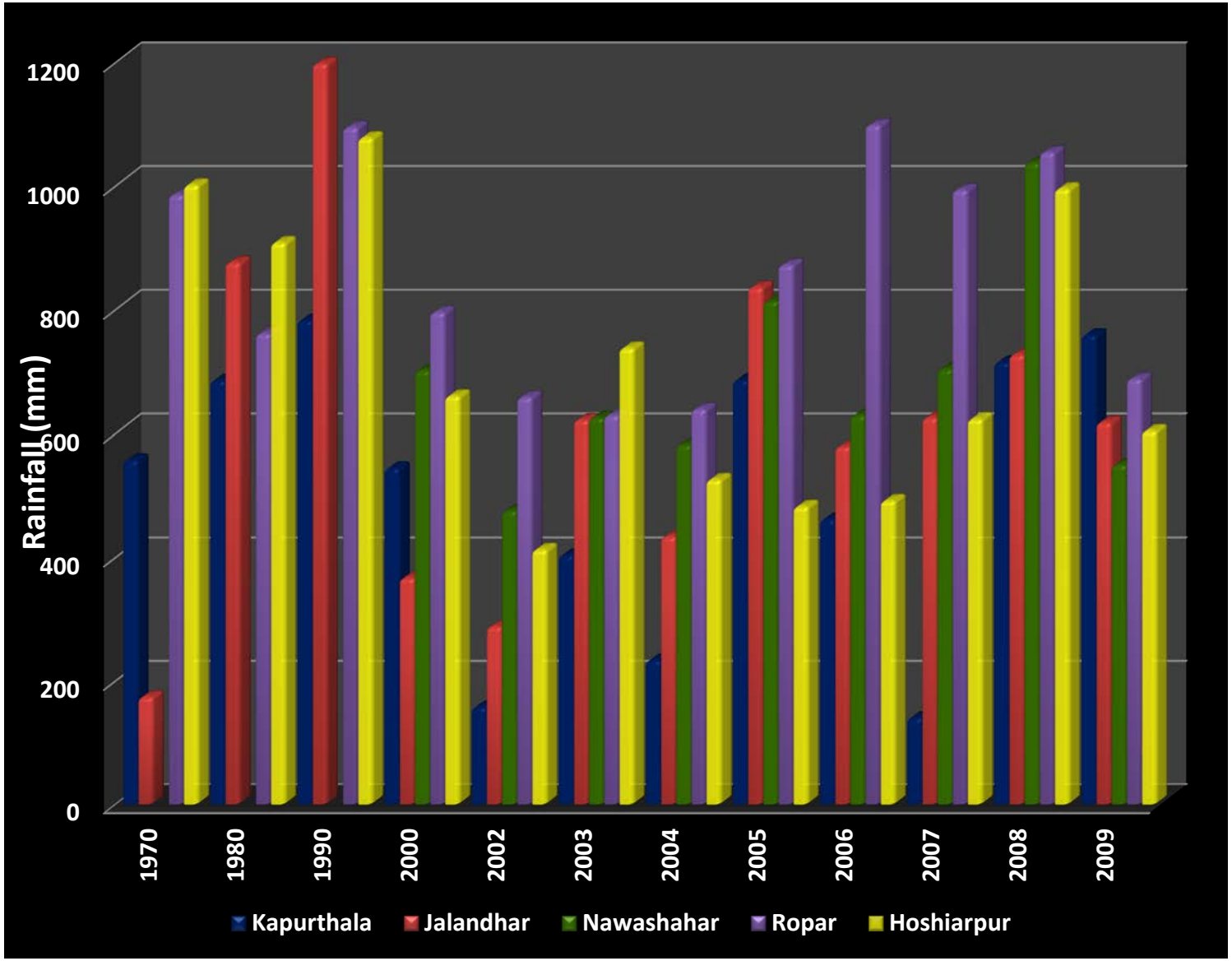
DRAINAGE SYSTEM



CANAL SYSTEM

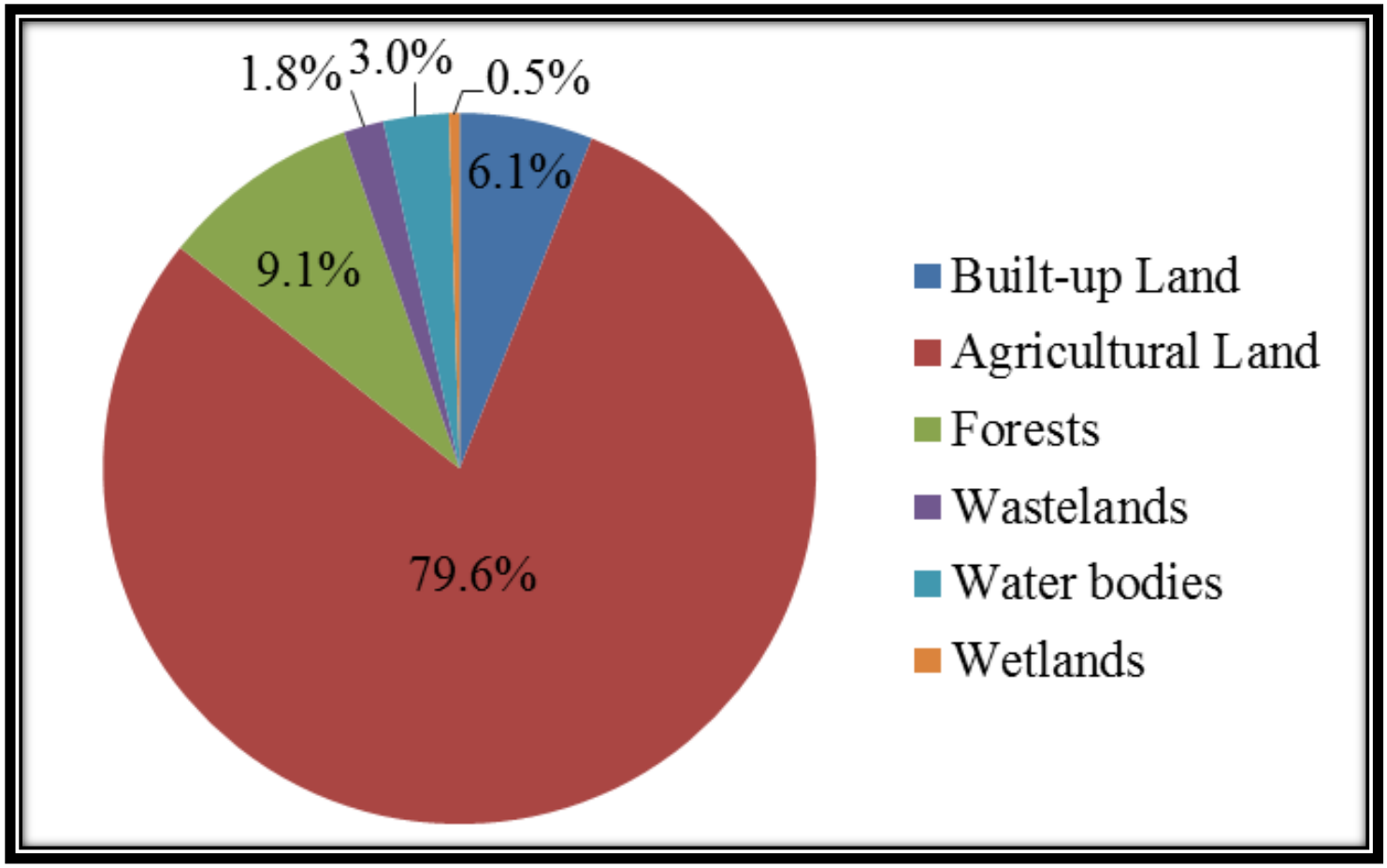
VARIABILITY IN INPUT & DRAFT

AVERAGE ANNUAL RAINFALL IN THE BIST- DOAB REGION

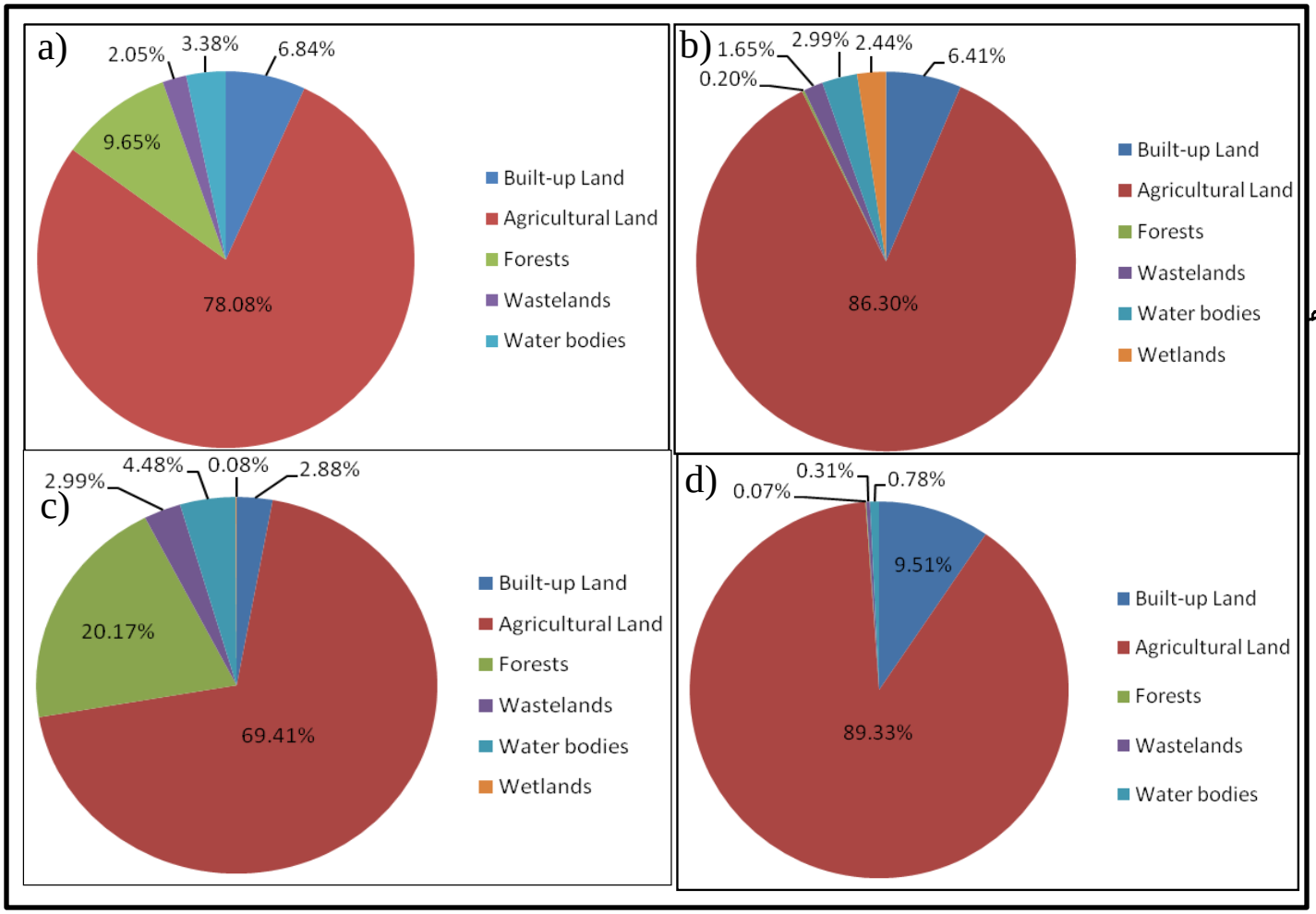


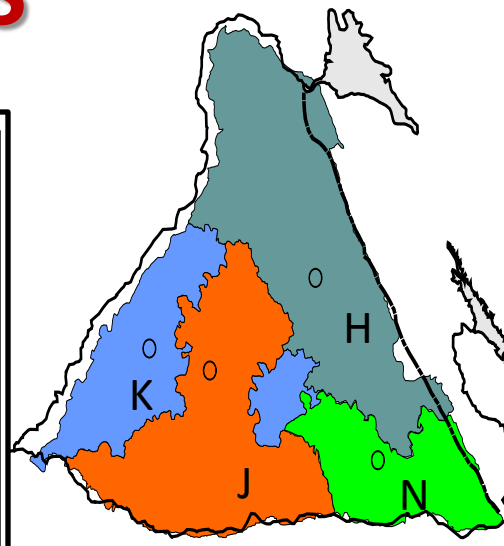
(Source: IMD)

LAND USE IN BIST DOAB REGION



LAND USE IN DISTRICTS





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

Area: 1190km^2; 1633km^2; 3365km^2; 2622km^2

(Source: Punjab Remote Sensing Centre, Ludhiana, 2008)

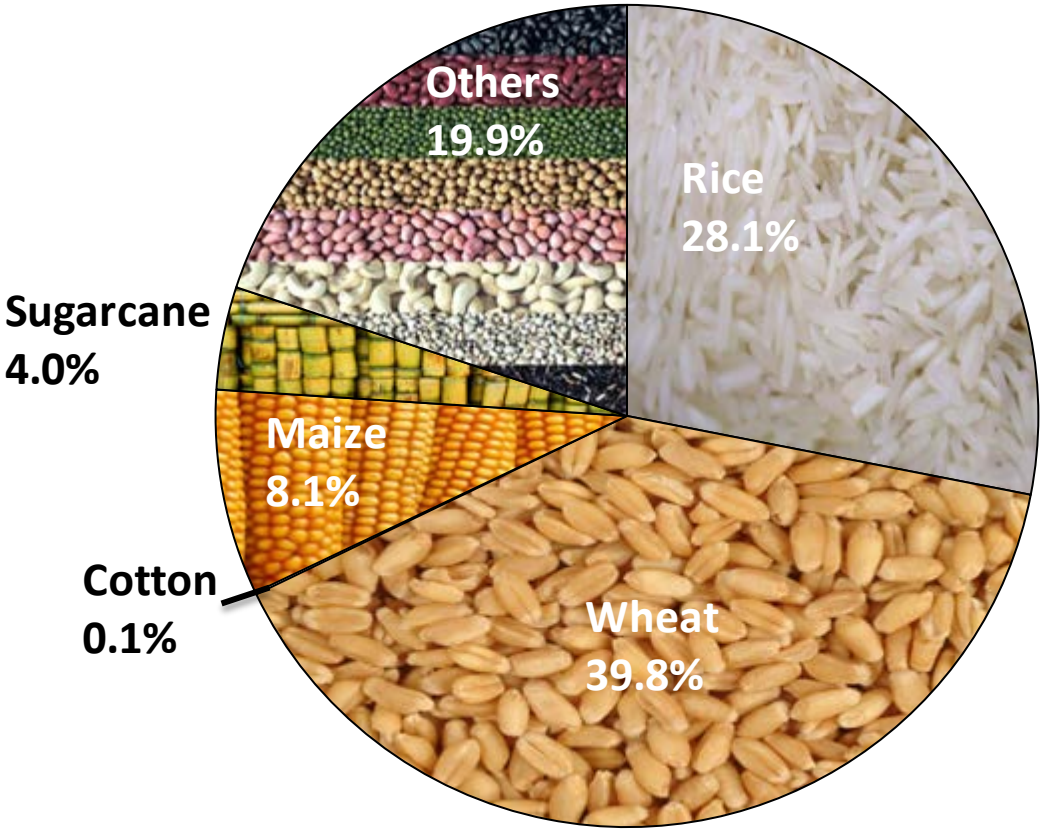
VIRTUAL WATER CONTENT OF CROPS

S. No.	Product	Virtual Water (m^3/ton)
1	Cotton	8264
2	Rice	2850
3	Maize	1937
4	Wheat	1654
5	Sugar Cane Sugar (Raw/Refined)	159 1301/1391

Source: Kumar, V & Jain, S.K. 2007. *Curr. Sci.* (93) 1093- 1099

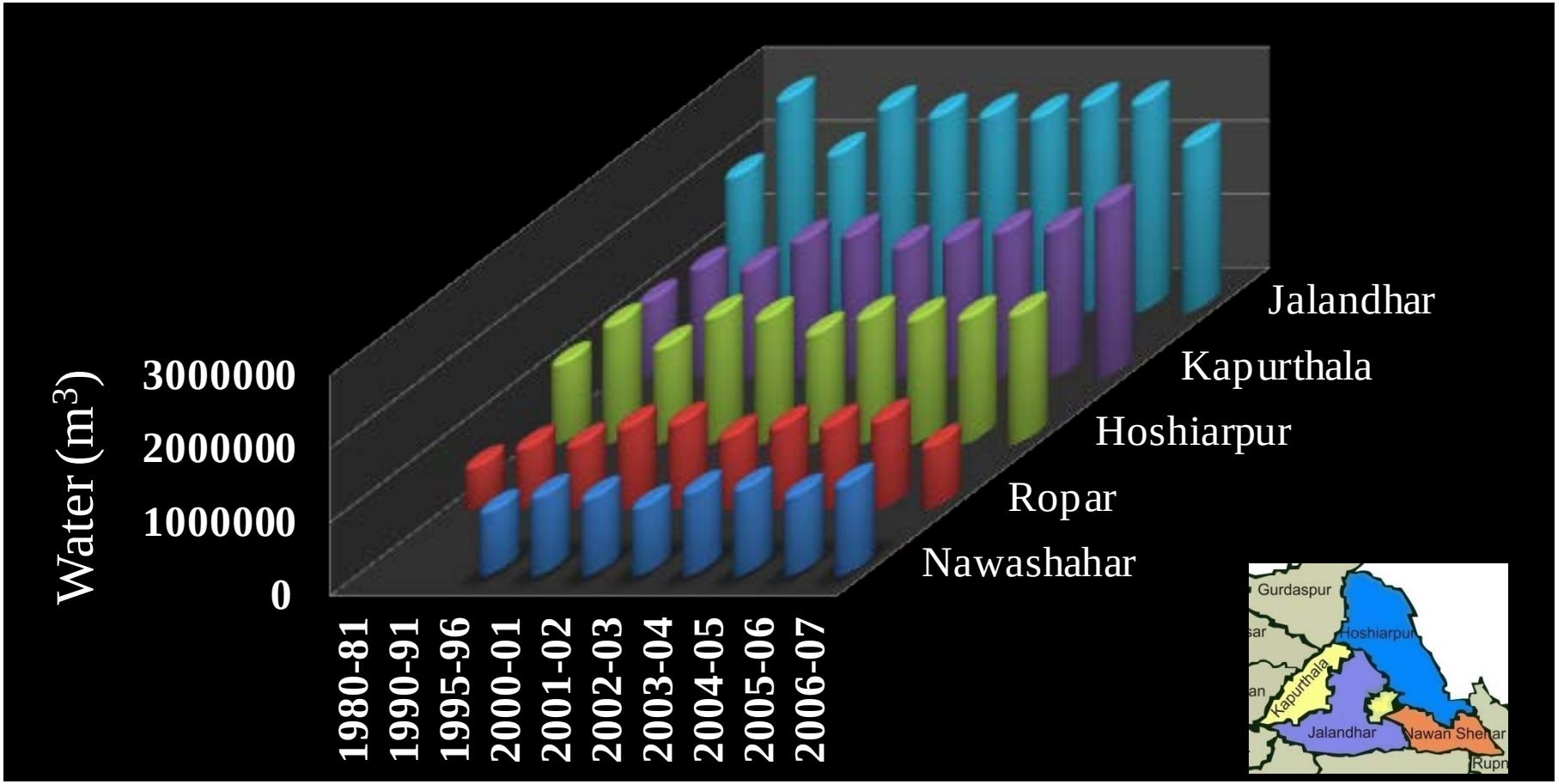
CROP DISTRIBUTION & VIRTUAL WATER REQUIREMENT IN BIST-DOAB REGION

Crop	Total Area		VWR
	(km^2)	(%)	(m^3)
Rice	3495	28.1	3461325
Wheat	4953	39.8	3367820
Maize	1007	8.1	544297
Sugarcane	503	4.0	45289
Cotton	10	0.1	2755
Others	2482	19.9	



(Source: Deptt. Agriculture, Punjab- 2006)

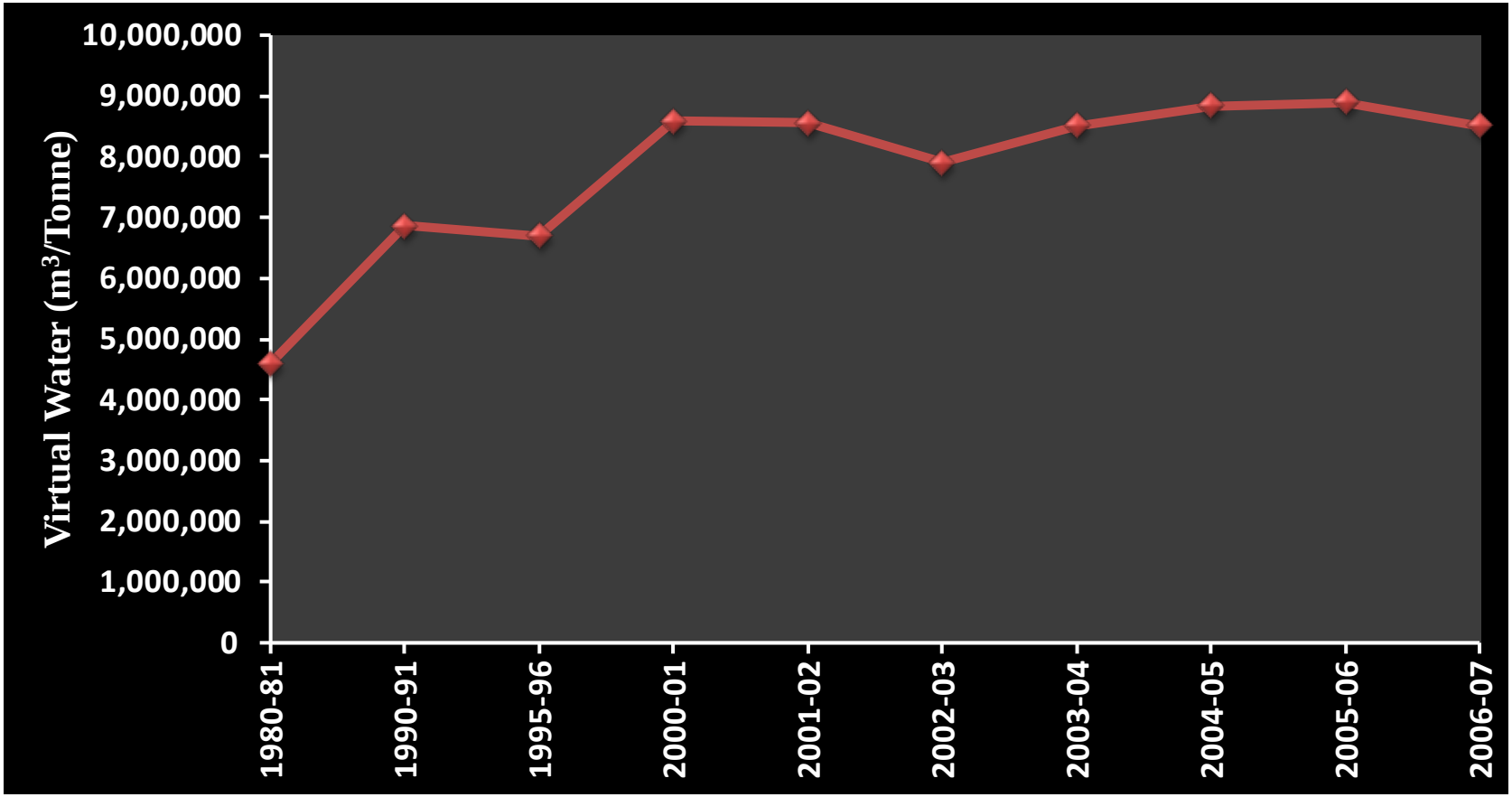
WATER UTILIZED IN BIST- DOAB REGION FOR IRRIGATION (m^3)



Production Equivalent to Water

(Source: Deptt. Agriculture, Punjab- 2006)

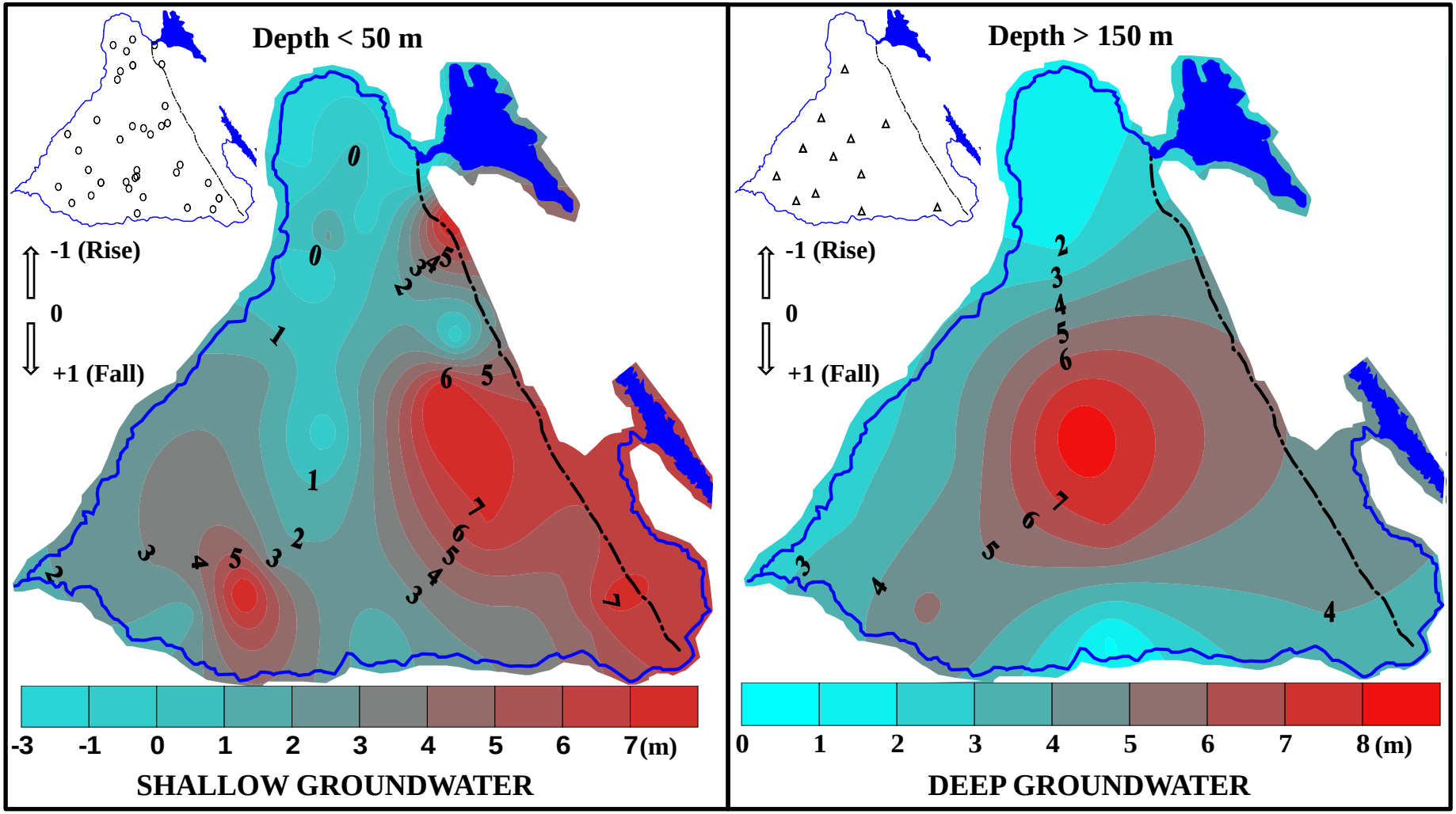
TOTAL WATER CONSUMPTION FOR IRRIGATION IN BIST DOAB REGION



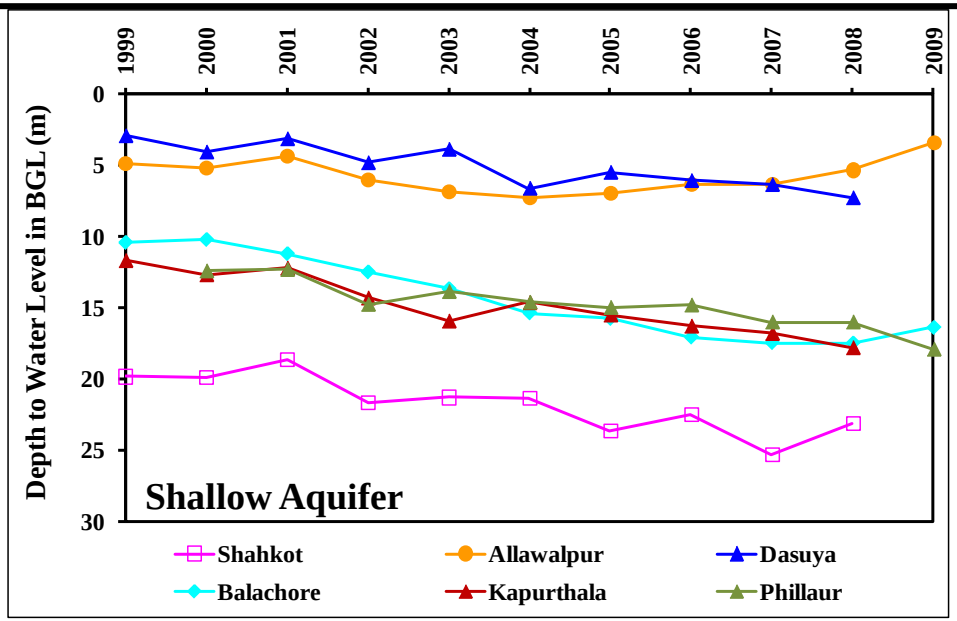
(Source: Deptt. Agriculture, Punjab- 2006)

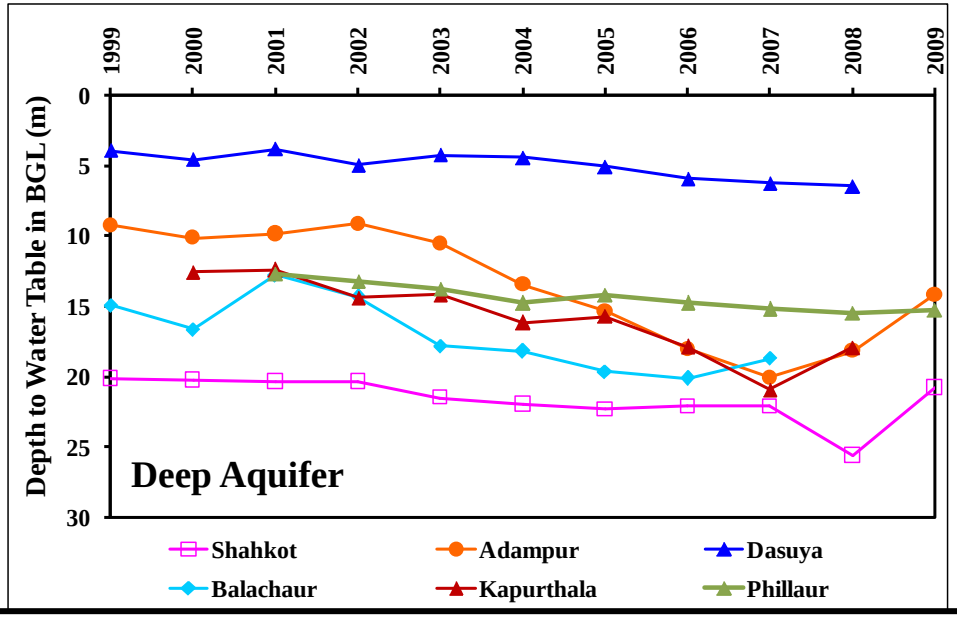
GROUNDWATER DYNAMICS & WATER BALANCE

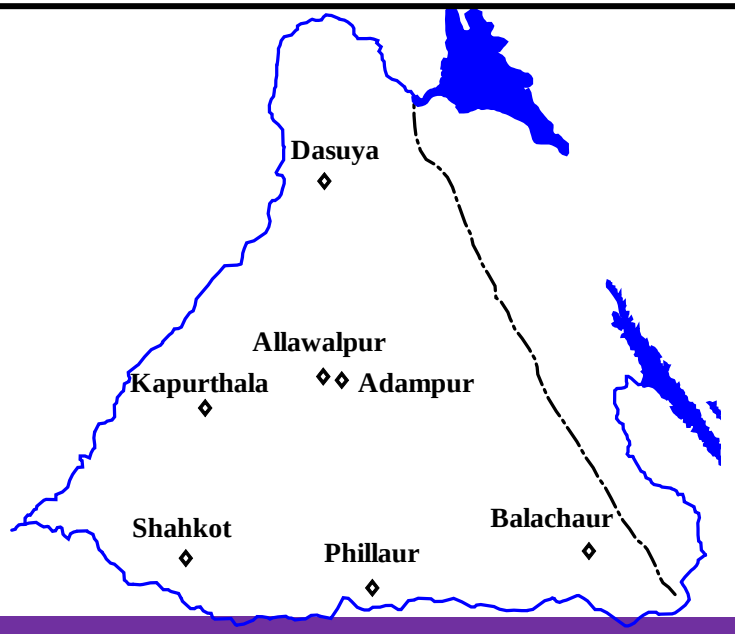
GROUNDWATER FLUCTUATION IN BIST-DOAB REGION (2002-08)



VARIATION IN DEPTH TO WATER TABLE IN BIST DOAB

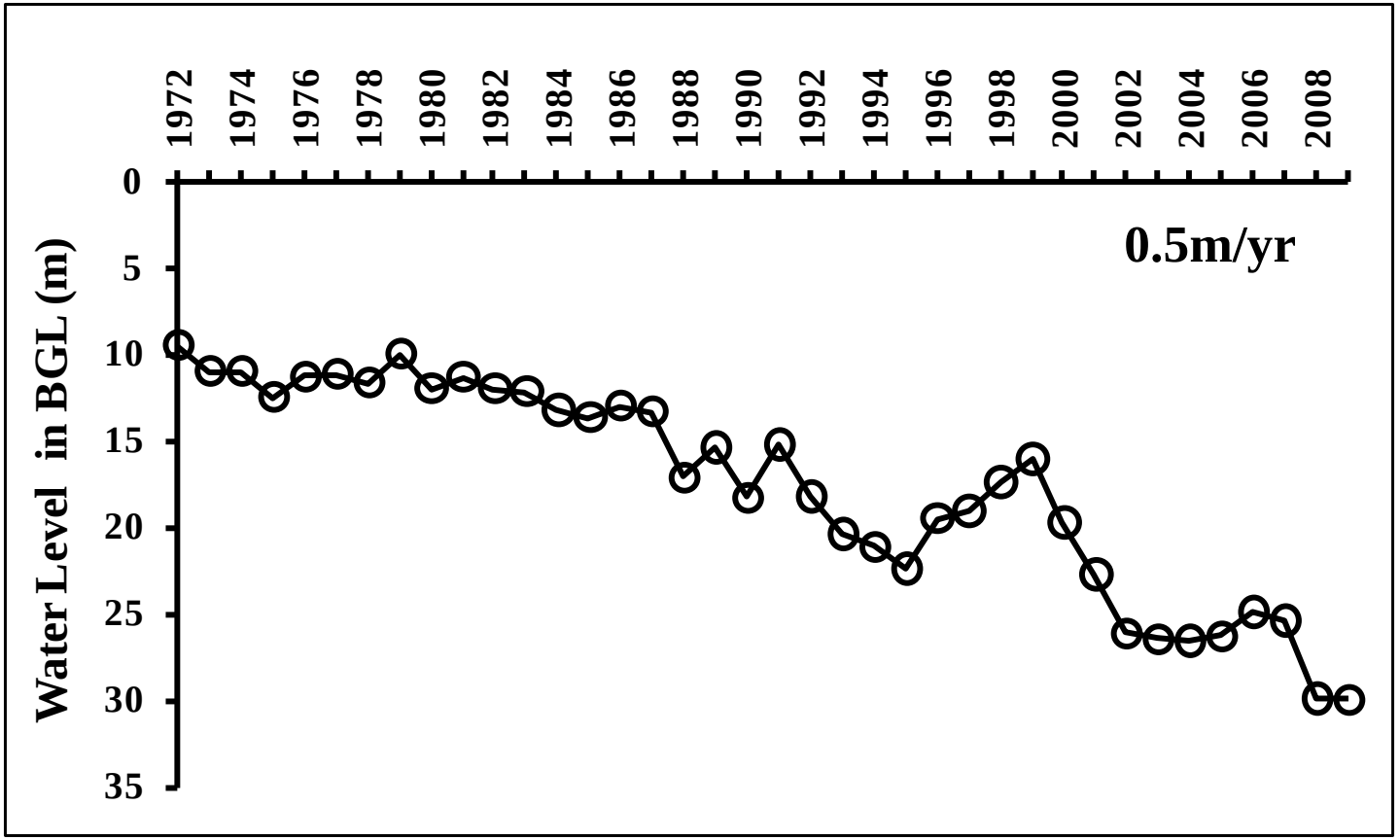






Location	Water Level Fall/ Rise (m/yr)	
	Shallow	Deep
Dasuya	0.35	0.21
Allwalpur	-0.10	-
Adampur	-	1.9
Kapurthala	0.50	0.51
Shahkot	0.21	0.75
Phillaur	0.18	0.32
Balachaur	0.72	0.73

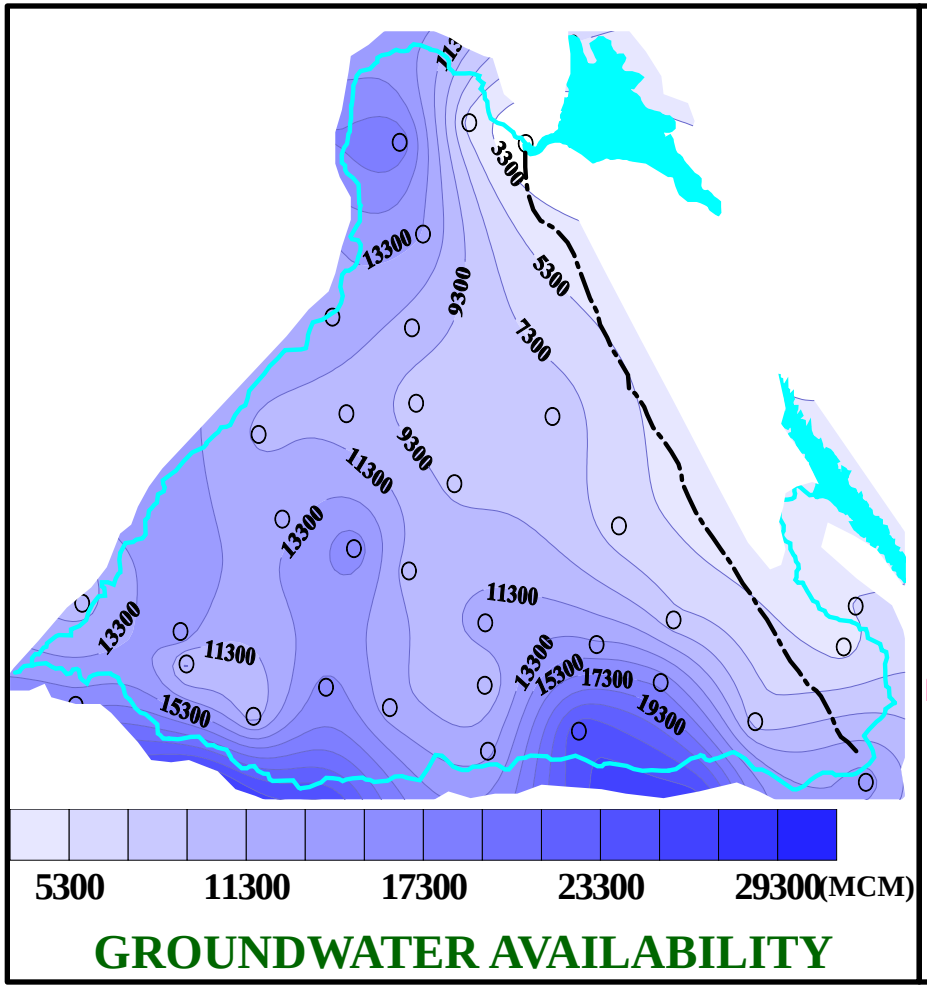
LONG TERM VARIATION OF PRE-MONSOON (JUNE) WATER TABLE



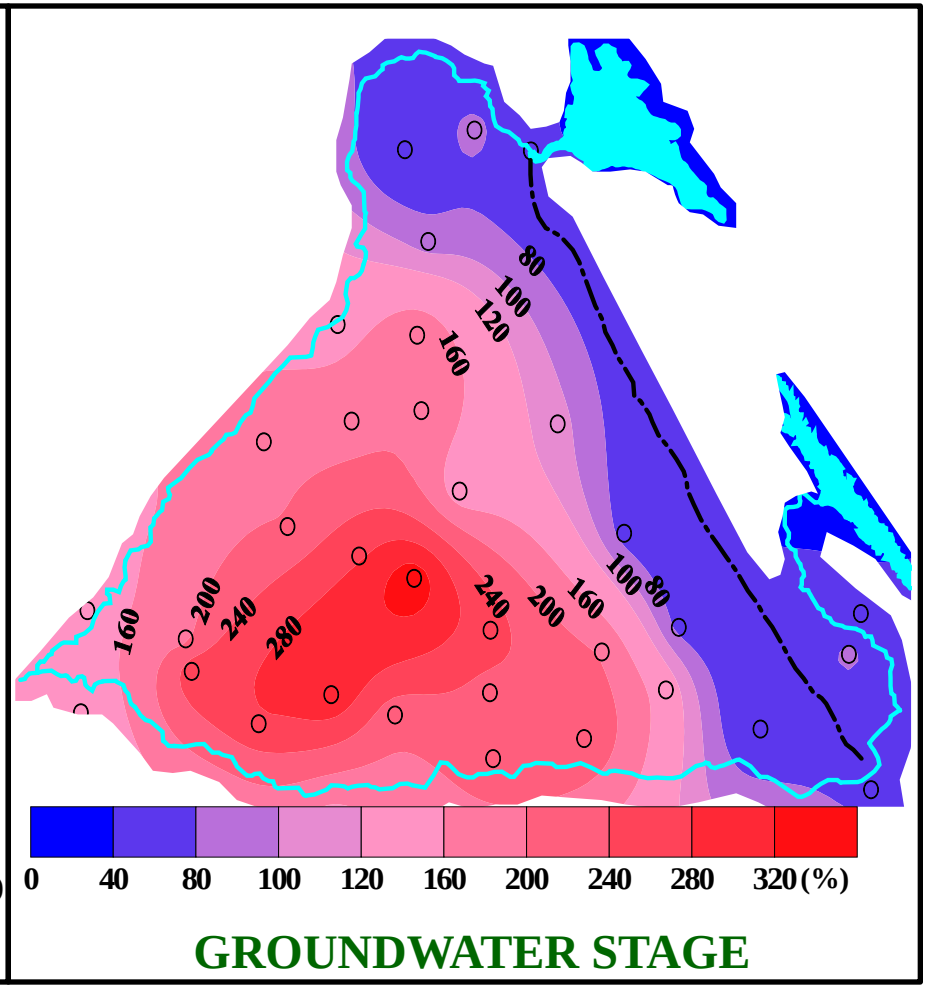
VILLAGE SHANKAR, BLOCK NAKODAR, DISTRICT JALANDHAR

- **Water levels are declining in region on a long term basis**

GROUNDWATER AVAILABILITY & STAGE (2004) IN BIST-DOAB REGION



GROUNDWATER AVAILABILITY

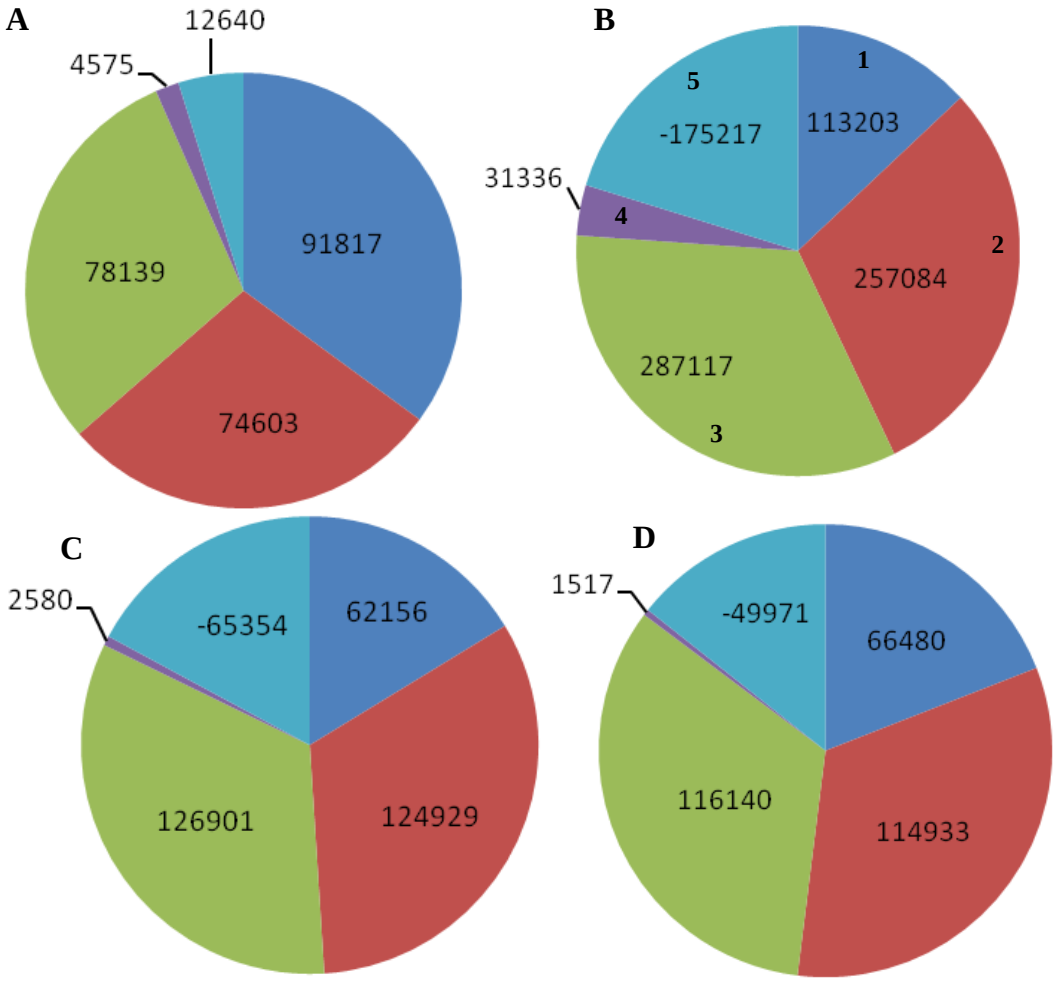


GROUNDWATER STAGE

CATEGORIZATION OF BLOCKS IN BIST-DOAB REGION

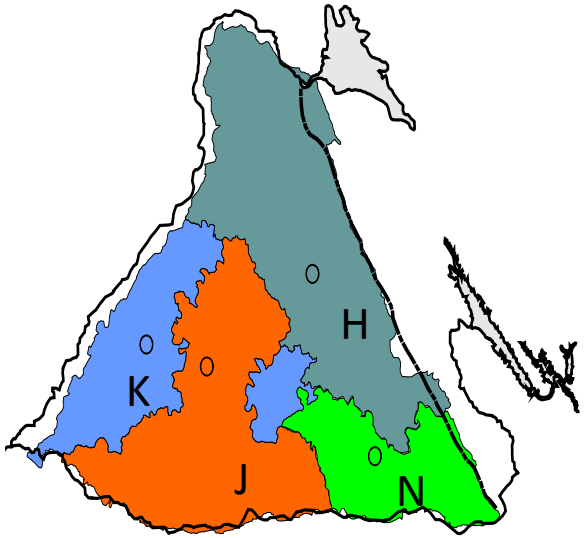
S. No.	District	Semi-Critical	Critical	Over-Exploited
1.	Hoshiarpur	1 Garh Shankar 2 Hazipur	- -	1 Hoshiarpur-I 2 Tanda
2.	Jalandhar			1 Adampur 2 Bhogpur 3 Goraya 4 Jal-east 5 Jal-west 6 Lohian 7 Nakodar 8 Nurmahal 9 Phillaur 10 Shahkot
3.	Kapurthala			1 Bholath 2 Dhilwan 3 Kapurthala 4 Phagwara 5 Sultanpur
4	Nawan shahar			1 Aur 2 Banga 3 Nawanshahar

GROUND WATER RESOURCES IN VARIOUS DISTRICTS OF BIST- DOAB REGION



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 upto next 25 years
5. Net Groundwater Availability for future Irrigation Development

(All units in: ham)



A: Hoshiarpur

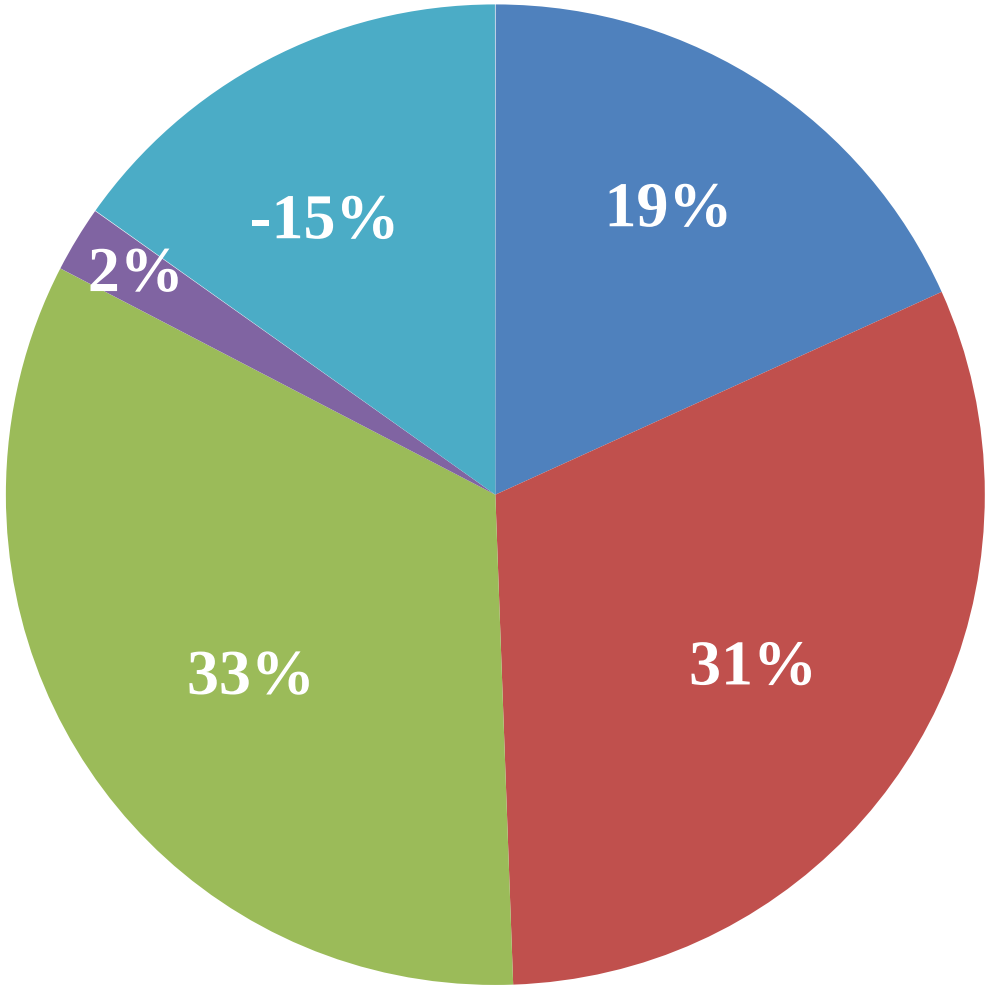
B: Jalandhar

C: Kapurthala

D: Nawanshahar

CGWB, 2007

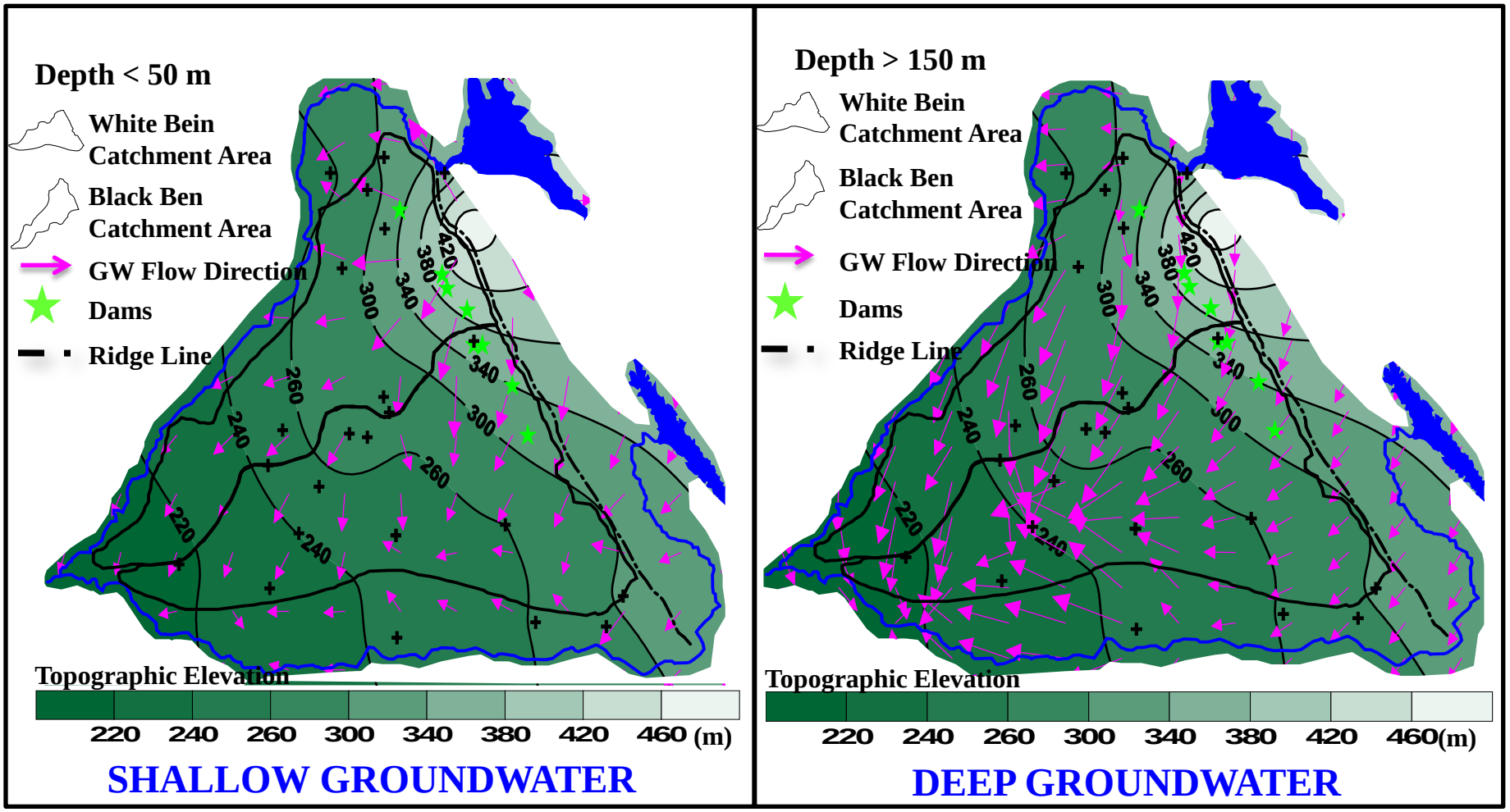
GROUND WATER RESOURCES OF BIST- DOAB REGION



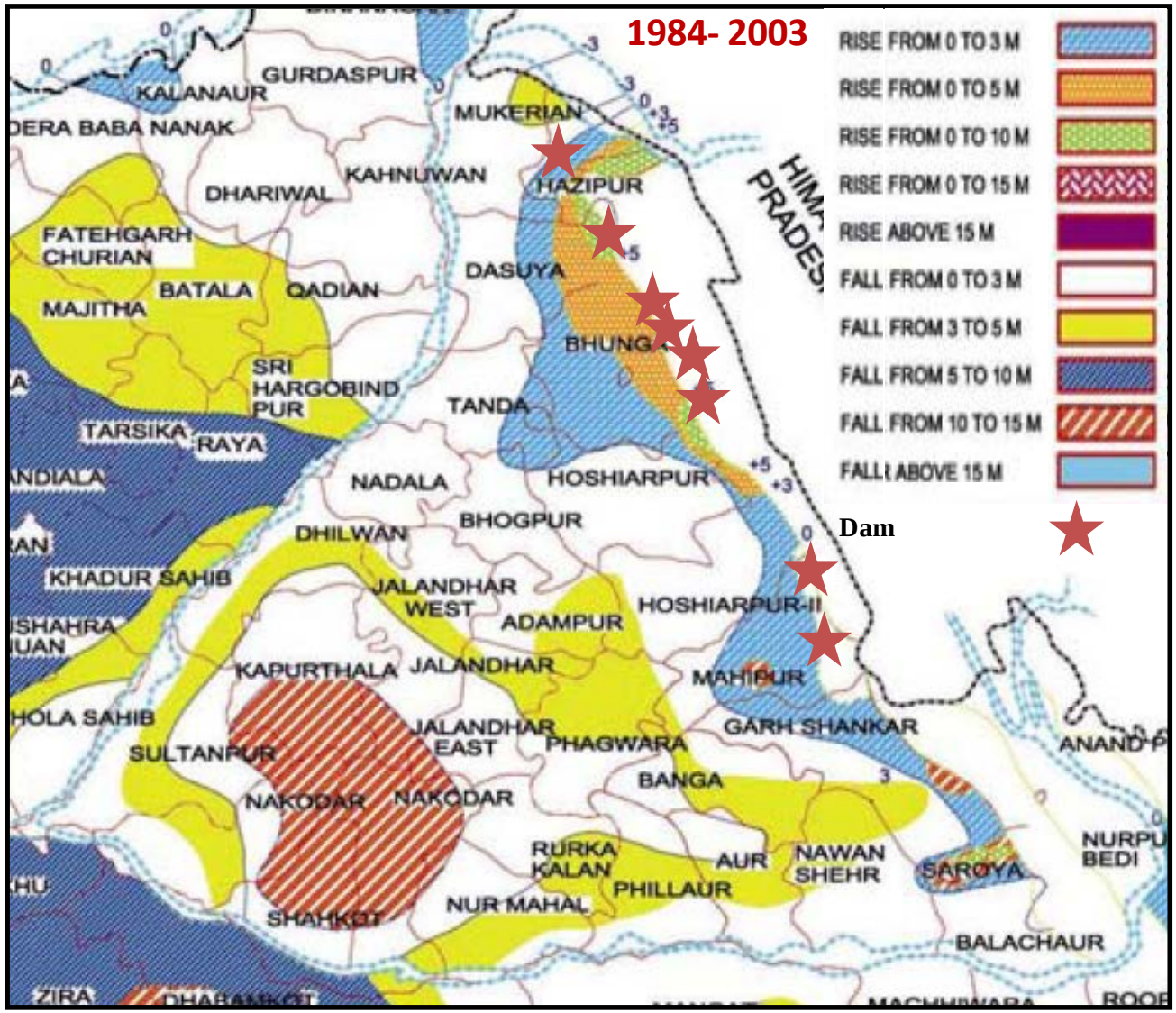
- Net Annual Groundwater Availability
- Existing Gross Groundwater Availability
- Existing Gross Groundwater Draft for all users
- Allocation for Domestic & Industrial Requirement Supply for next 25yrs
- Net Groundwater Availability for Future Irrigation Development

MANAGEMENT MEASURES

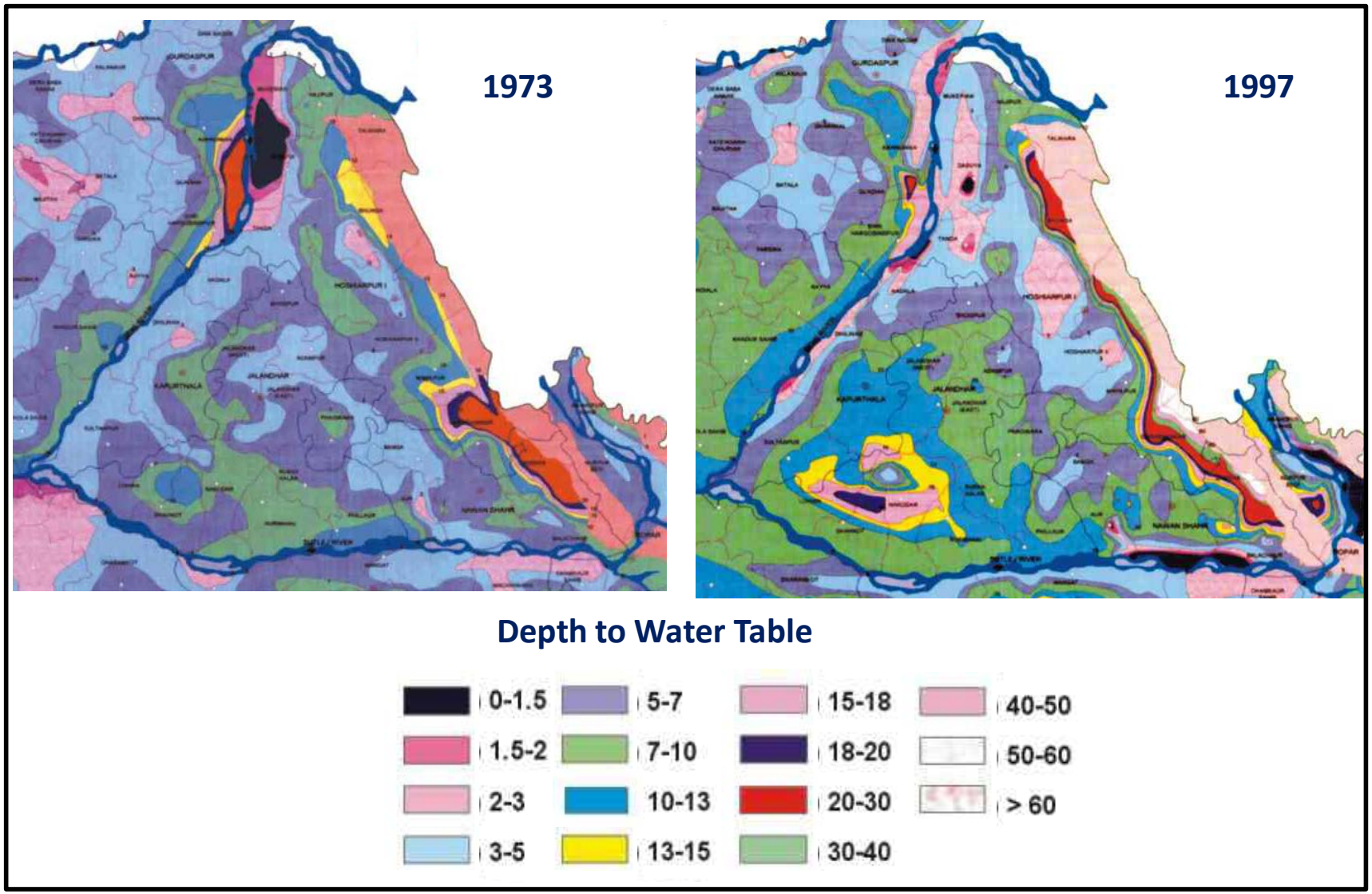
GROUNDWATER FLOW IN BIST-DOAB REGION (2008)



GROUNDWATER RISE/FALL IN BIST-DOAB REGION

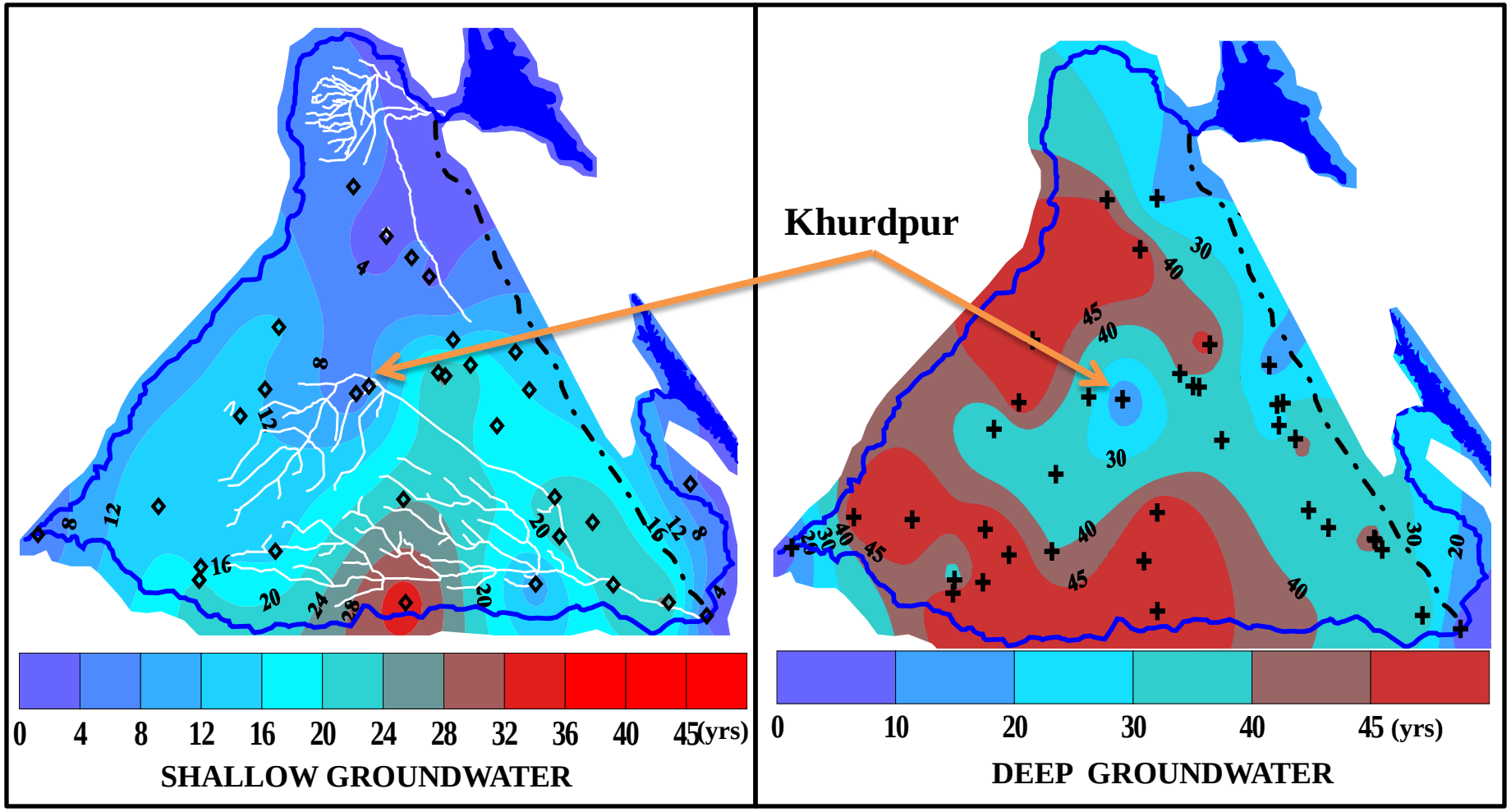


GROUNDWATER DEPTH IN BIST- DOAB REGION



APPLICATION OF NEW TECHNIQUES

GROUNDWATER AGE USING ENVIRONMENTAL TRITIUM ACTIVITY



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

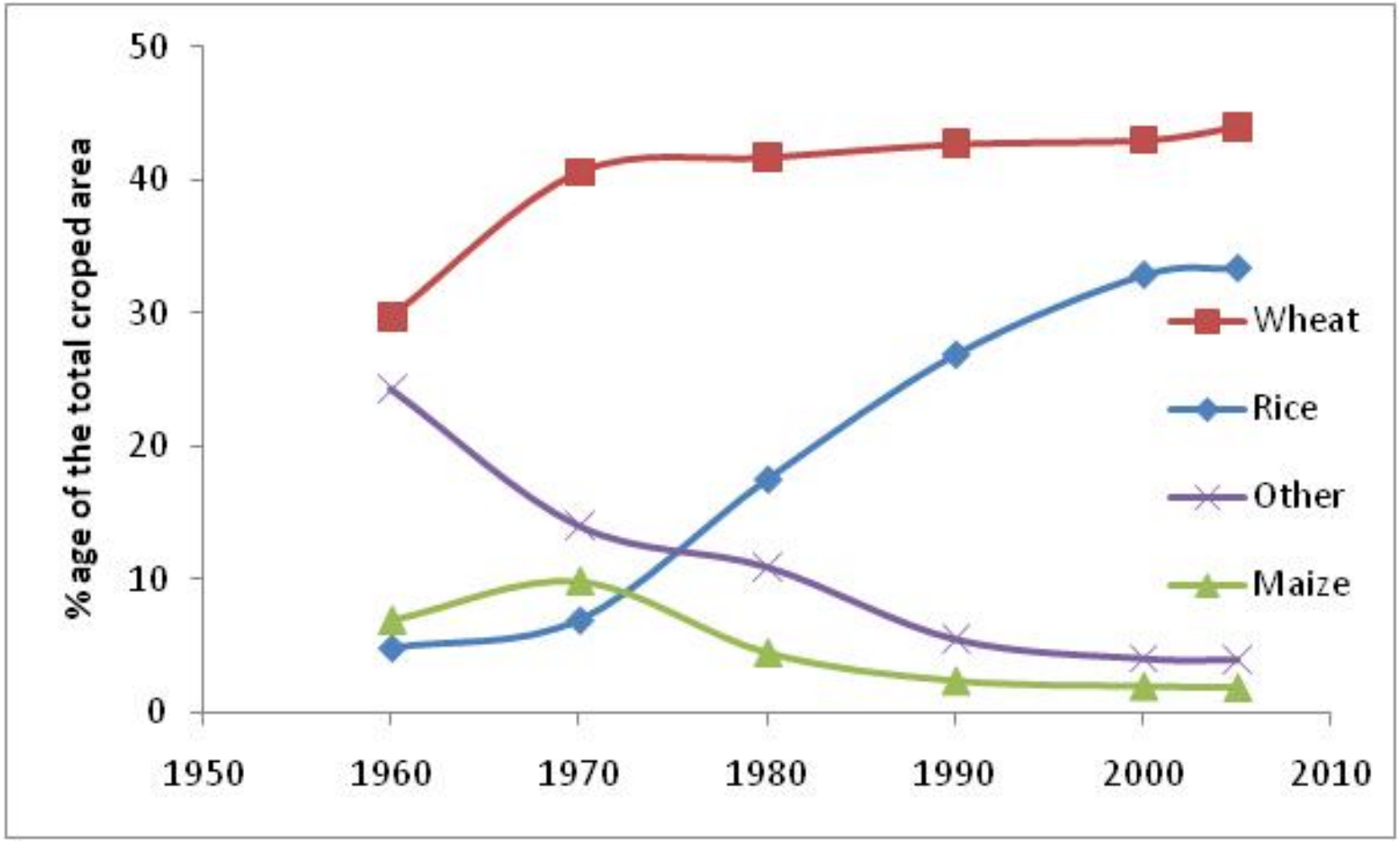
- Groundwater has reached to critical condition in Bist Doab region
  - Out of 22 blocks, 20 blocks are overexploited in the BIST-DOAB Region
- Rainfall pattern shows an increasing trend since 2002 the water table displays falling trend especially in the central and south central region
- Increasing 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.**

THANKS



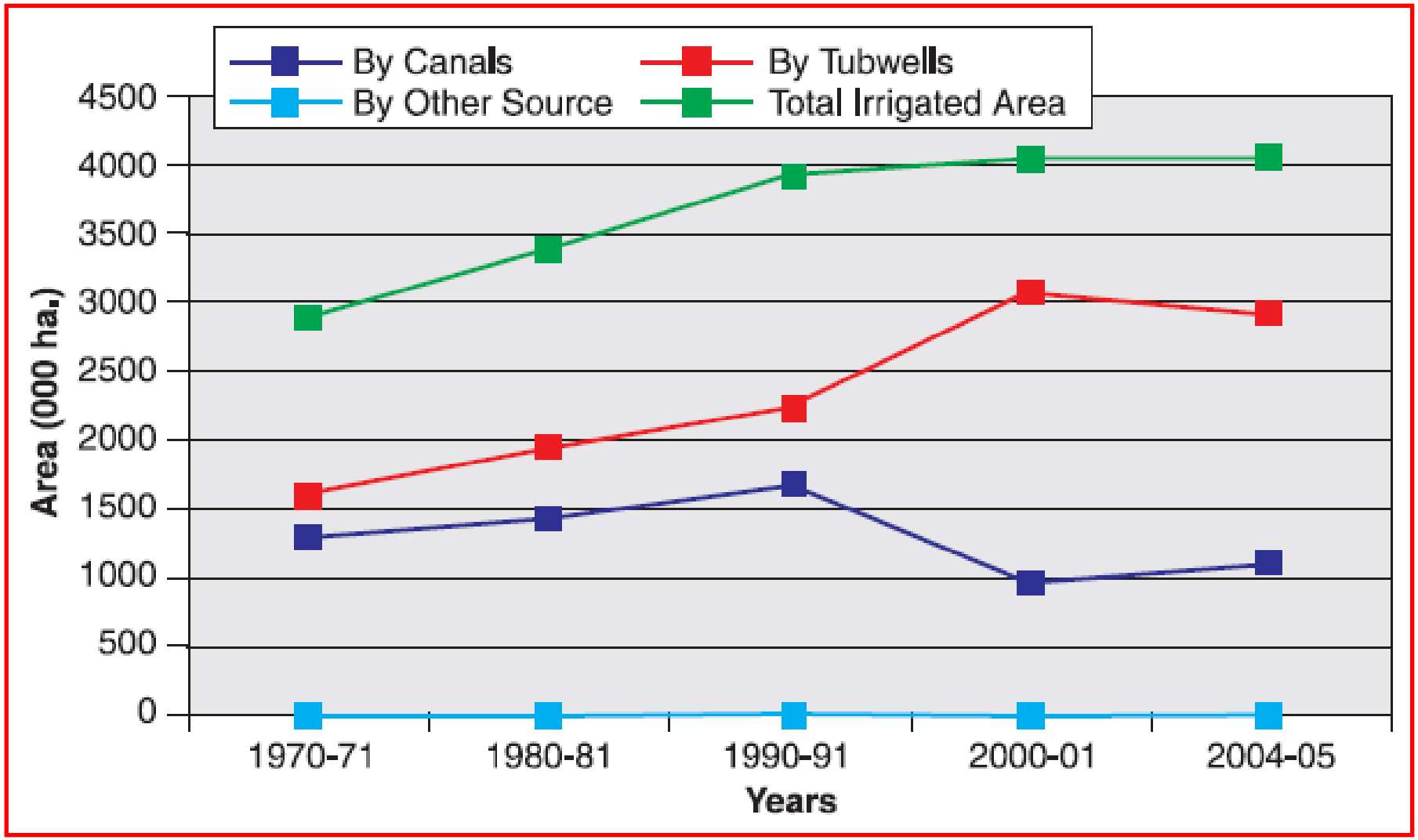
Other: Total oil seeds+total pulses+Barley+Total Vegetables+ Fruits

Only 21% of the paddy area is canal irrigated.

HYV: Wheat (Maxico), Paddy (Manila)

Over-intensification of agriculture -→ GW depletion, reduced soil fertility, μ-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
= 0.24% per yr.

Irrigation water requirement

Total Agri. Area	:	4.2 M ha
Canal Irrigated area	:	1.6 M ha (38%)
Irrigation from other sources	:	2.35 M ha (56%)
Total irrigated area	:	3.95 M ha (94%)

Demand of water for Agriculture (4.38 Mham)

Supply

Canal Water	:	1.45Mham.
GW recharge (rains +Canal seapage):		1.68 Mham
Over exploitation of Deep GW	:	1.25 M ham

Tubewells as on 2004-05 (1.17 million)

≥ 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**