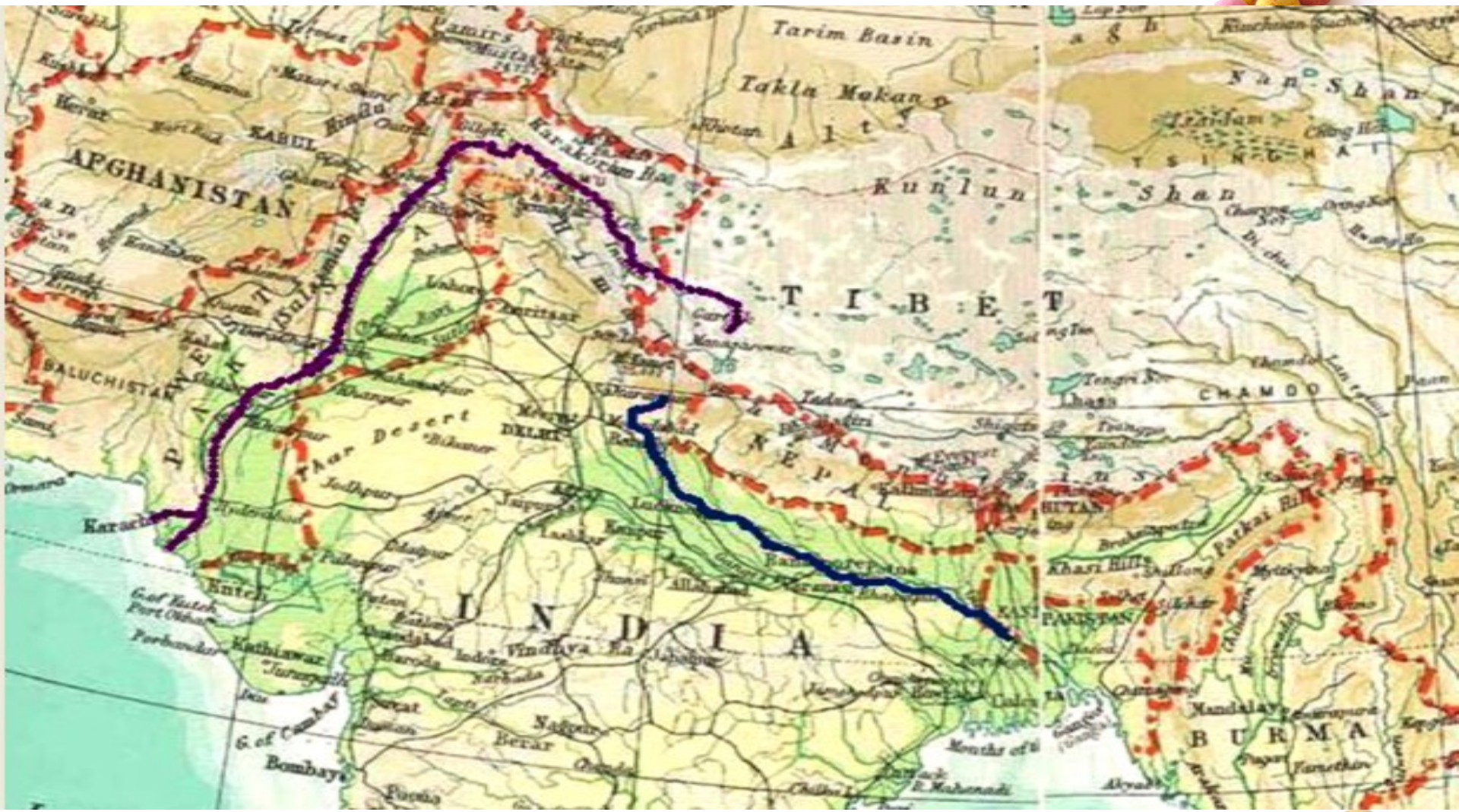
Thessaloniki, Greece IV International Symposium on Transboundary Waters Management 15th-18th October 2008

Development, Management & Impact of Climate Change on Quaternary Transboundary Aquifers of Indus Basin, India

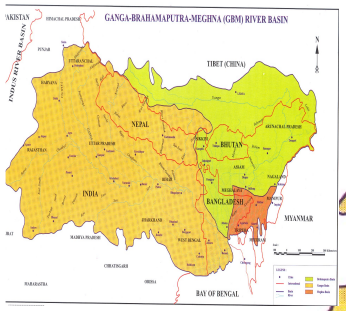
DR. D.K.CHADHA
(FORMER CHAIRMAN, CENTRAL GROUND WATER BOARD)
PRESIDENT
GLOBAL HYDROGEOLOGICAL SOLUTIONS

International Transboundary Countries



LEGEND
Indus Basin
Ganga Basin

INDUS BASIN



Kabul
Peshawar
Islamabad
Srinagar
Leh
Jammu
Lahore
Amritsar
Ludhiyana
Chandigarh
Ganga Nagar
Jind
Churu
Quetta
Jaisalmer
Indus
Kabul
Shyok
Indus
Jhelum
Chenab
Ravi
Beas
Sutlej
Zhob
Chenab
Ravi
Sutlej
Indus
PAKISTAN
INDIA
ARABIAN SEA
N

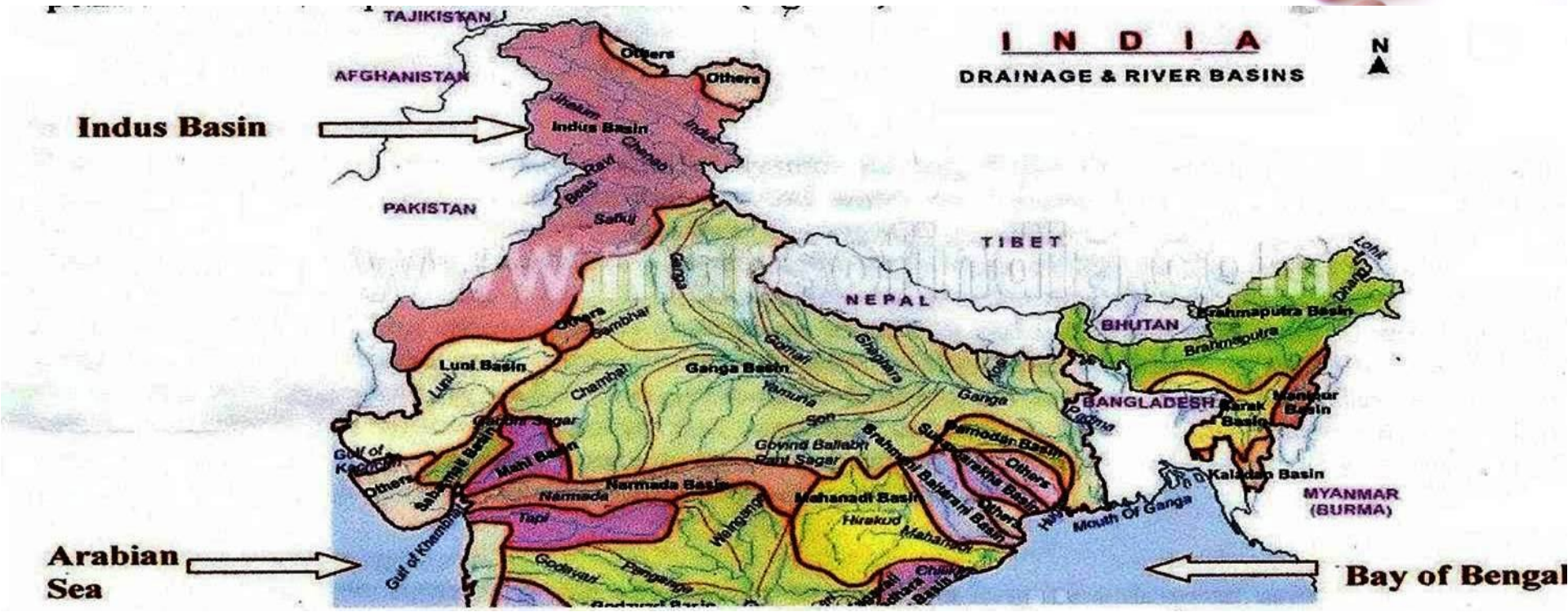
Total Length : 2880 km
Mean Annual Discharge: 207.5 x 109 m3

Indus river originates from lake Mansarover and flows in China, India, Pakistan and Afghanistan

Major River basins of India

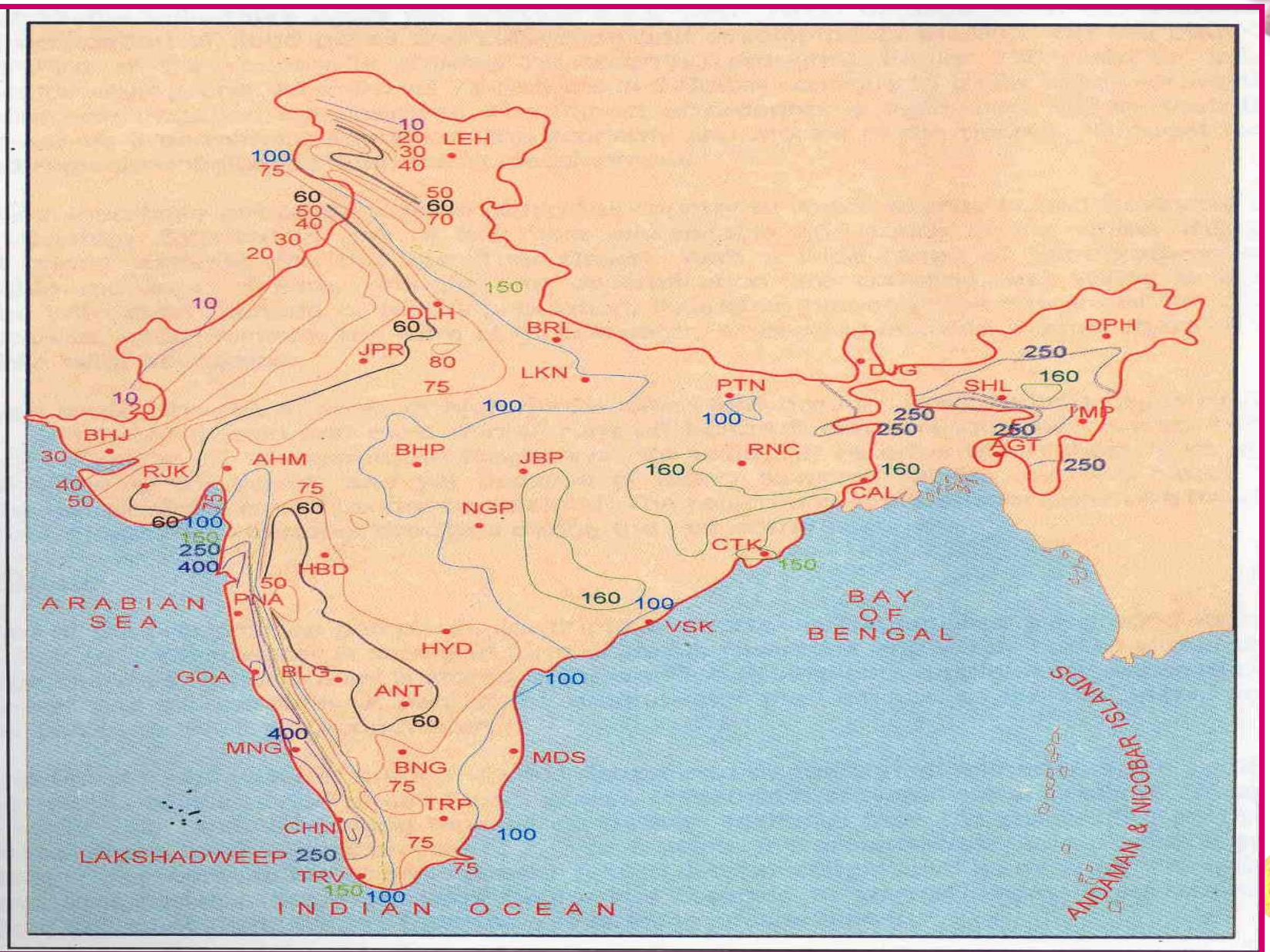
- Transboundary Aquifers originate from Himalayas and thus belong to Indus and Ganga Basins.
- Indus Basin Aquifers are shared with China, Pakistan and Afghanistan.
- Ganga Basin Aquifers are shared with Nepal, Bangladesh and Myanmar.

Map of Indus and Ganga Basin



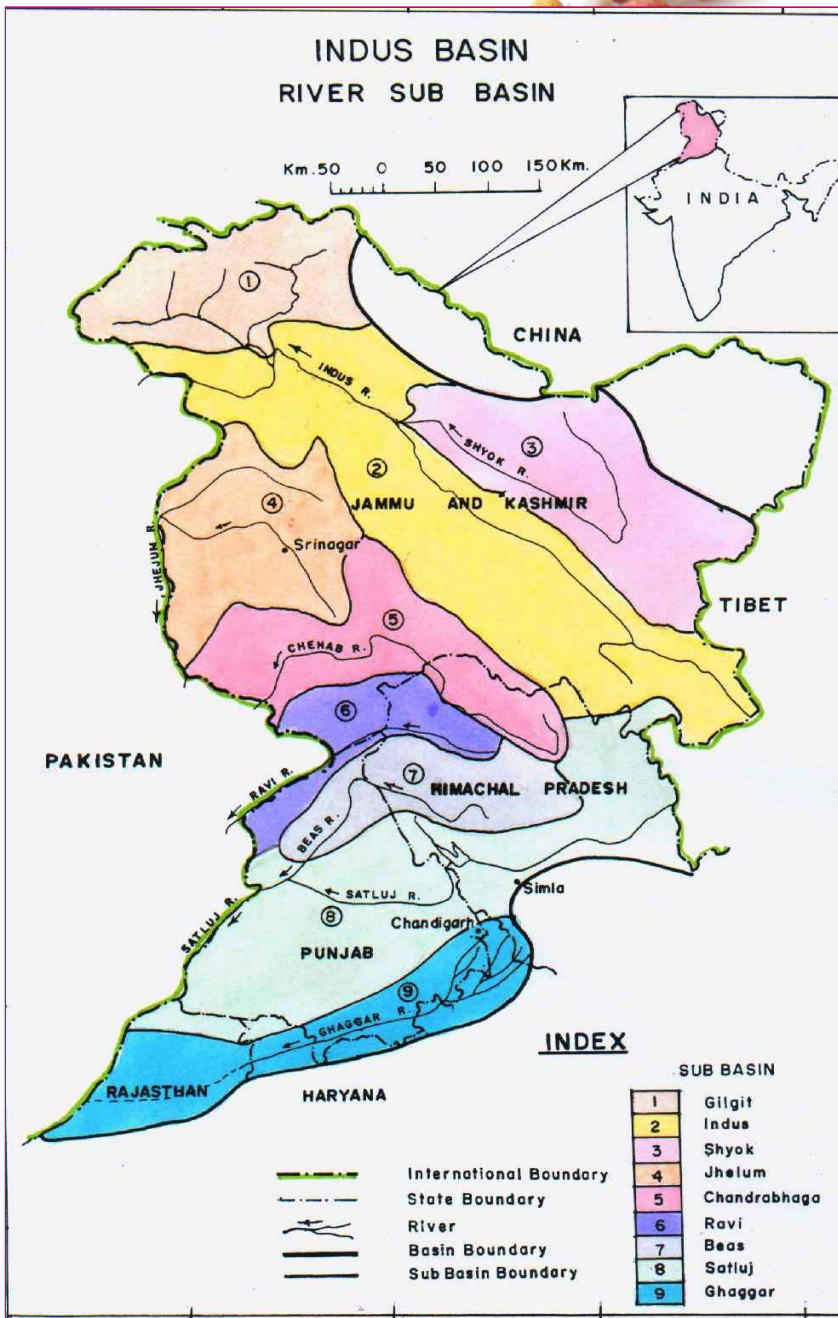
- Geographical area: 1.6 million sq.km.
- India occupies 0.32 million sq.km.(28%) and more than 50% is in Pakistan.
- In India this basin has more than 85% hilly terrain,15% plain area.
- Total Storage Capacity km3 =16.28
- Dynamic Potential (Ground Water) = 26.5 km3/yr
- In storage fresh ground water Potential = 1338.2 Km3

Normal Annual Rainfall Isohyets



Details of Indus sub-basins

S N	Sub-basins	Area in sq km	Administrative Unit
1.	Gilgit	24,250	Jammu & Kashmir
2.	Indus	71,250	Jammu & Kashmir
3.	Shyok	40,000	Jammu & Kashmir
4.	Jhehlum	28,600	Jammu & Kashmir
5.	Chenab(Chandrabhaga)	27,500	J&K and Himachal
6.	Ravi	12,500	J&K, Himachal Pradesh and Punjab
7.	Beas	22,500	Punjab & Himachal Pradesh
8.	Satluj	61,939	Punjab, Himachal Pradesh & Rajasthan
9.	Ghaggar	32,750	Punjab,Chd.(U.T.) Haryana & Rajasthan
	Total	3,21,289	



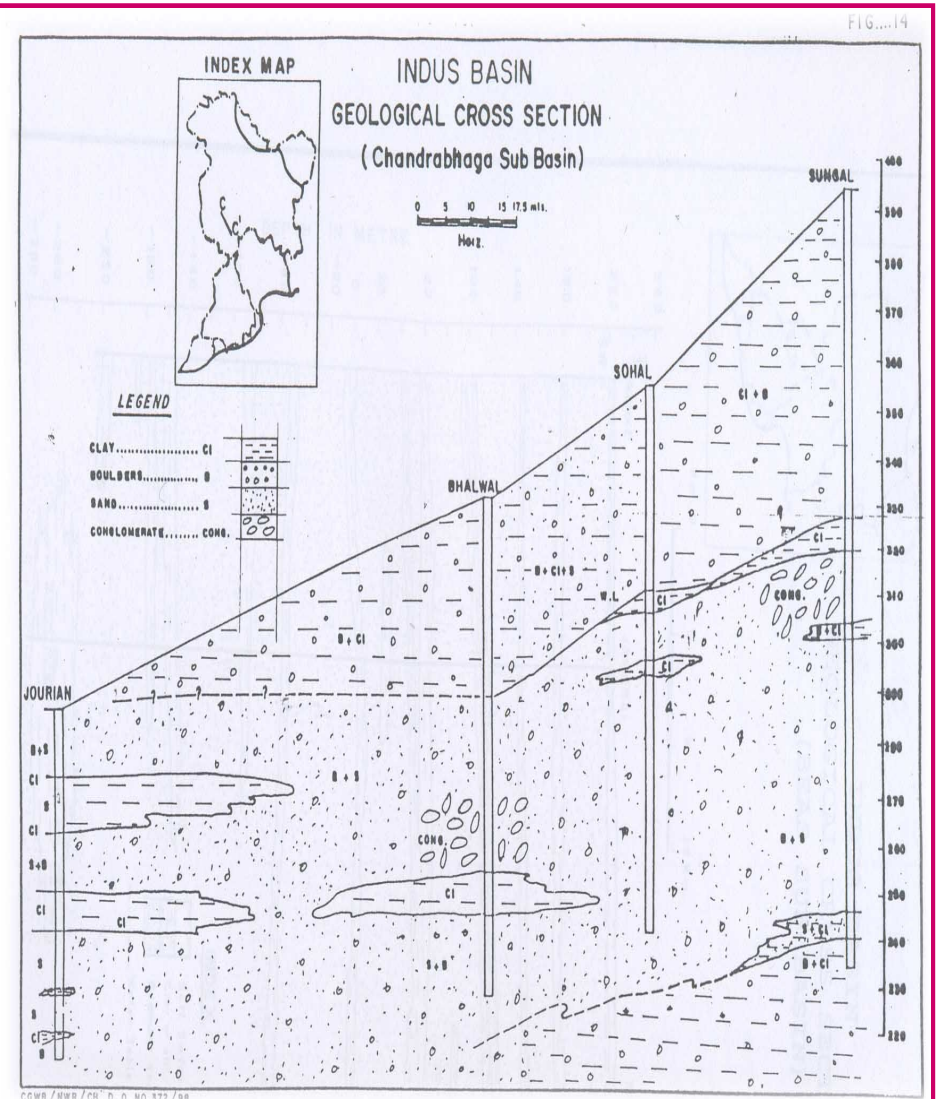
Geological succession in Indus basin

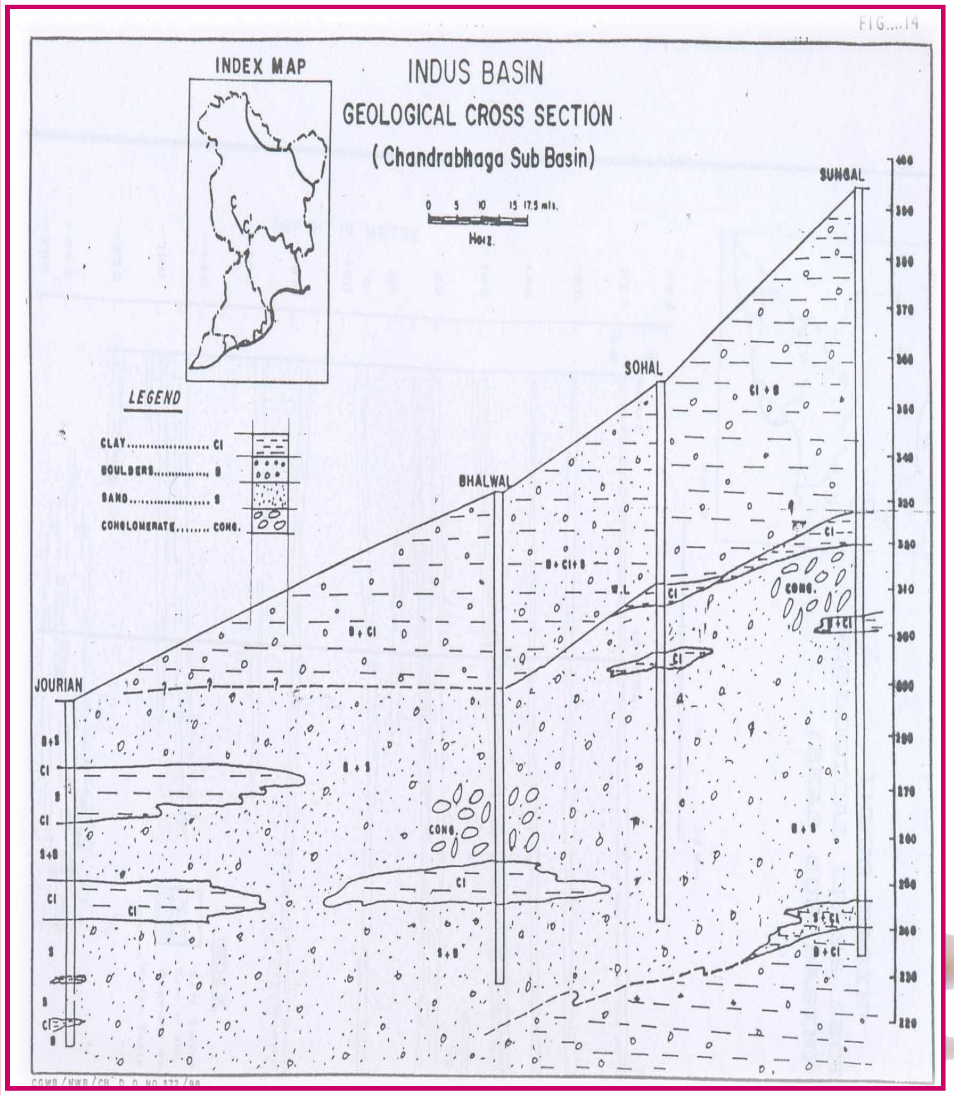
Era	Period	Formation (Thickness)
RAJASTHAN		
Quaternary	Recent, Sub-recent to Pleistocene.	Desert sands, sand dunes and Alluvium Summer formation.
Tertiary	U. Paleocene to Lower Eocene.	Bandah Limestone (75 m) Khuiala Limestone (100 m) Sanu Sandstone (75 m)
Mesozoic	Lower Cretaceous Jurassic	Abur Limestone (66 m) Parihar sandstone (300 m) Badesar sandstone (65 m) Baisaki shales (165) Jaisalmer limestone (150 m) Lathi sandstone (450 m)
Paleozoic	Cambrian	Jodhpur group (240 m)
Proterozoic	Pre-Cambrian	Malani Ingneous suite (Granites and Rhyolites)

AQUIFER GEOMETRY

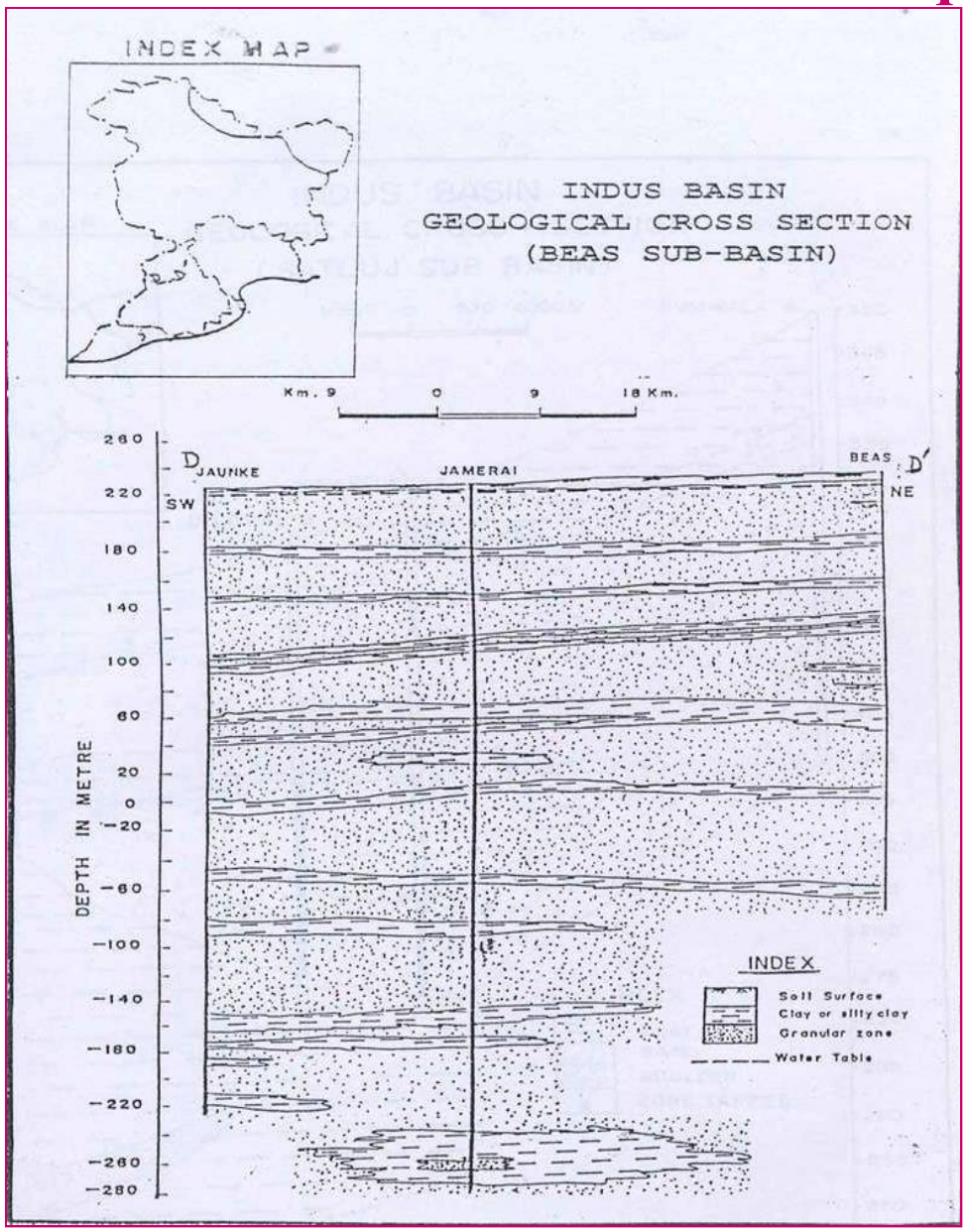
Lithological cross section of Chenab (Chandrabhaga) Sub Basin&

Jhelum Sub basin



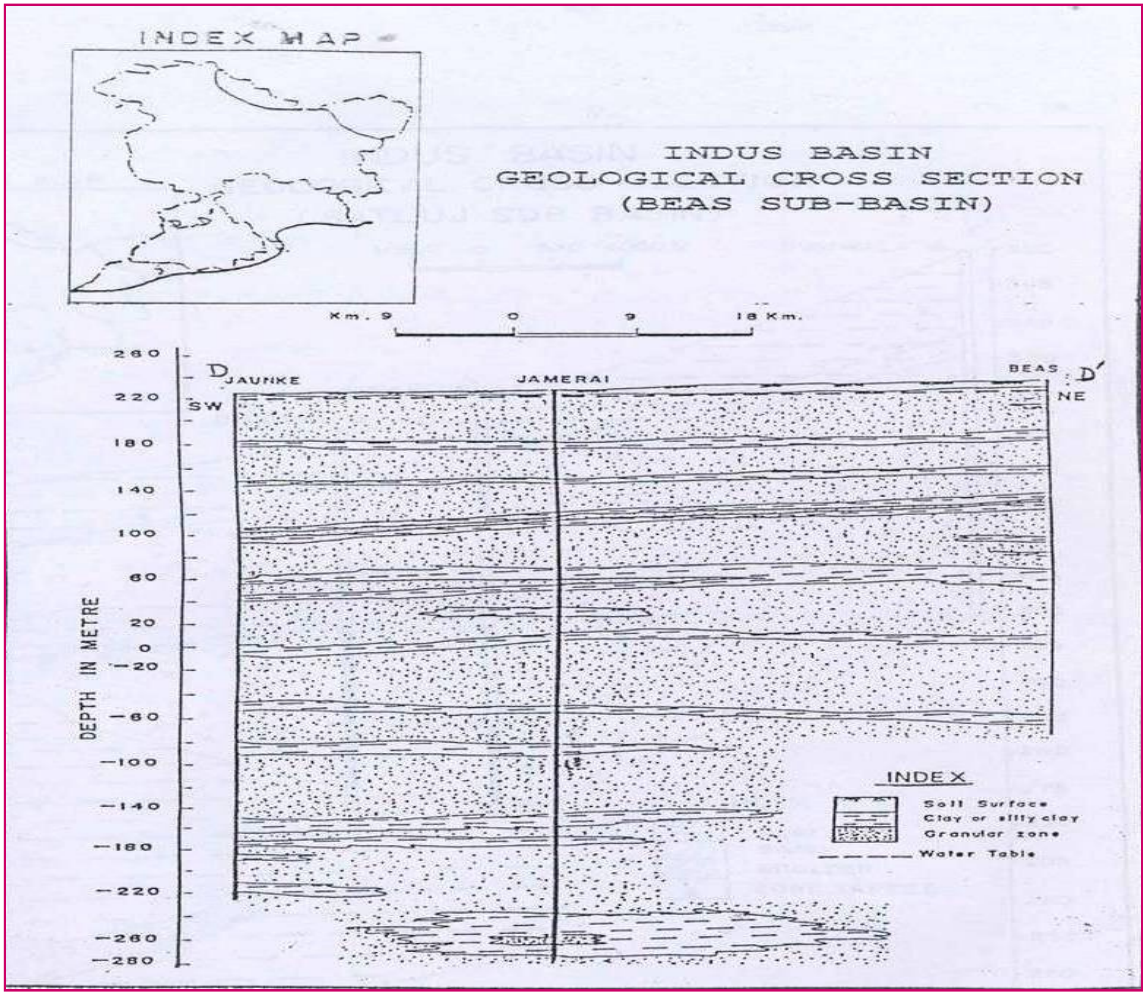


AQUIFER GEOMETRY
Indus Basin Aquifer System



- Encompasses multi- aquifer system having different aquifers ranging in age from pre-cambrian to recent deposits.
- Punjab Indus plains indicate quarternary aquifer system has 10-15 thick aquifer zones separated by thin intrecalated impervious clay conditions.
- Whole aquifer system up to 650m bgl is unconfined with locally semi-confined conditions.
- Cumulative sand thickness is 70 -85% of the depth explored up to 350m.
- The ground water is fresh but in the south-western part of Punjab, the groundwater is brackish to saline.
- The area is water logged because of seepage from network of canal system.

AQUIFER GEOMETRY
Indus Basin Punjab Hydrogeology



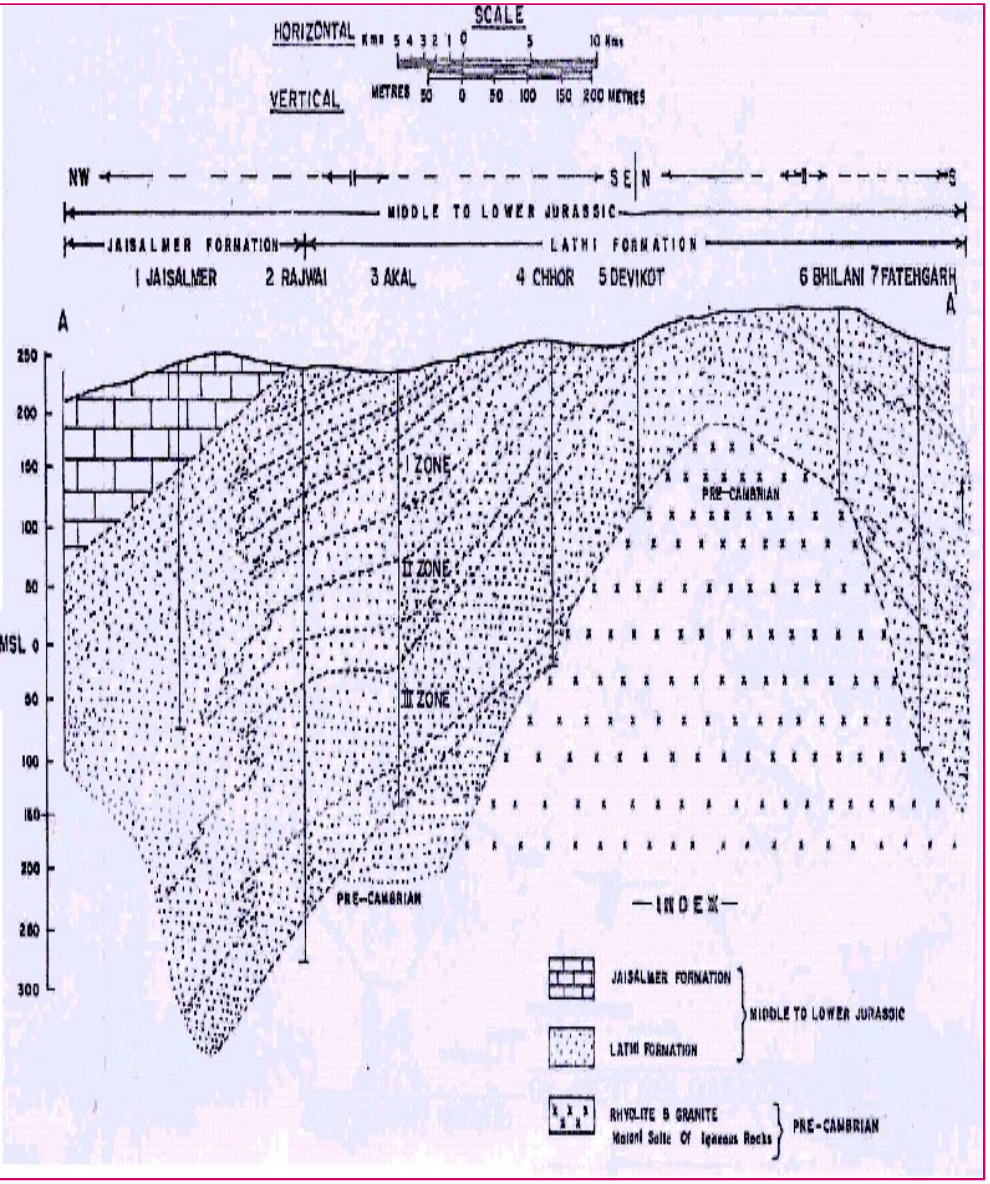
- The ground water is fresh but in the south-western part of Punjab, the groundwater is brackish to saline and the area is water logged because of seepage from network of canal system.

D. K. Chadha, D. S. Saini

Sub surface lithological section – Mullowali – Dhakoa (Scale 1 cm= km)

AQUIFER GEOMETRY

Geological Map of Indus Basin



The Indus basin is a multi aquifer system:

- Alluvial aquifers-recent to Quarternary.
- Sandstone, Limestone-Cenozoic Mesozoic
- Aravalli, Quartzite – Pre-Cambrian

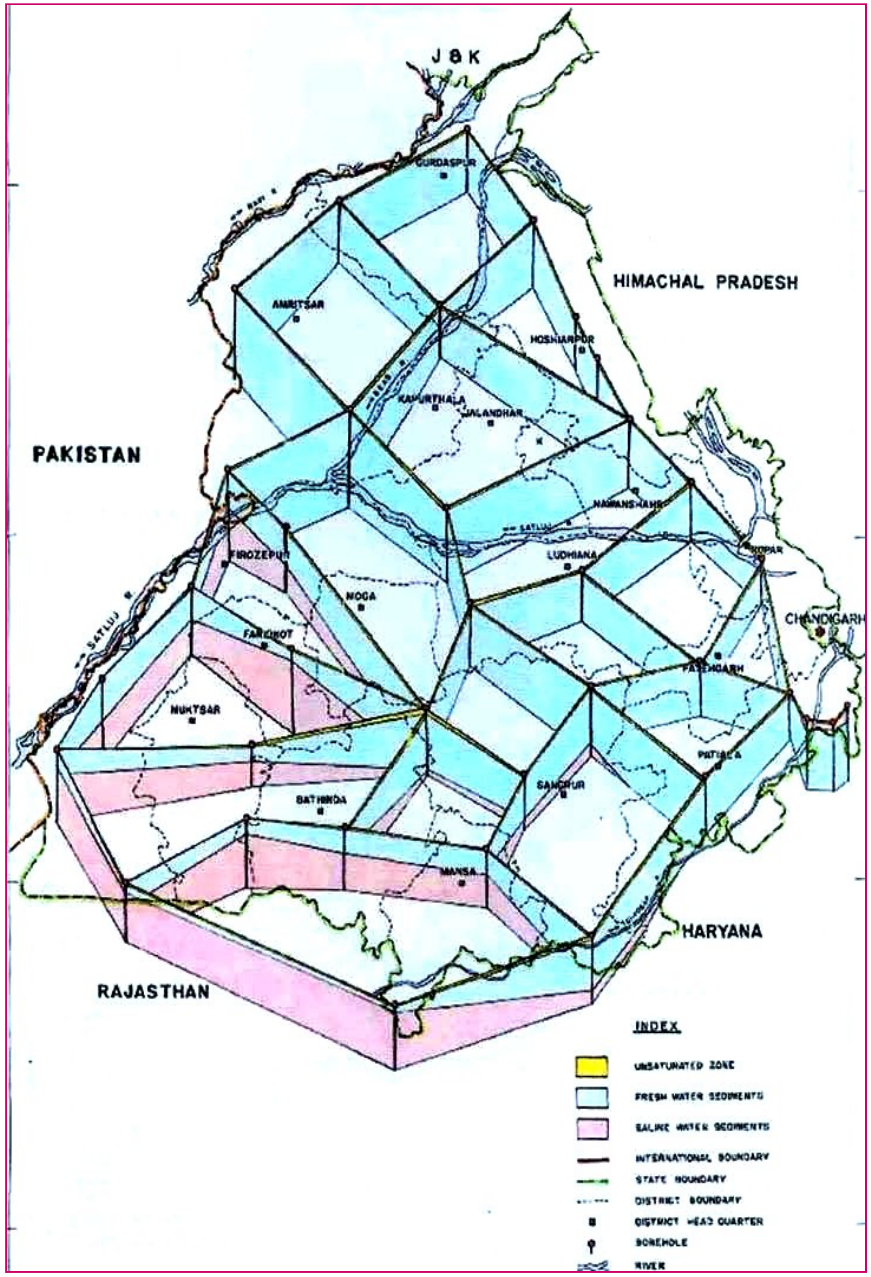
The deep aquifers of the Indus basin are of the tertiary to Mesozoic period but their contribution across the Pakistan is not deciphered.

#

GROUND WATER DEVELOPMENT – STATE WISE DATA

S.No	State/Districts	Geographical Area Falling In Indus Basin (Sq Km)	Annual gross rech arge (MC M)	Net Draft (MC M)	Area Cove red (Sq Km)	Potentia l (MC M)	Water Logg ed area (Sq Km)
			Fresh Ground Water		Saline Ground Water		
1	Jammu Kashmir	117683	4425.6	40.3	NIL	NIL	NIL
2	Himachal Pradesh	47436	247.72	49.3	NIL	NIL	321
3	Punjab	50362	18192.27	16101.9	2980	4162	5525
4	Haryana	14679	3645.83	2067.8	3750	5430	4350
5	Rajasthan	14624	603.96	210	18347	1158	1171
6	Chandigarh (UT)	114	0.023	0.018	NIL	NIL	NIL

INDUS BASIN PUNJAB-TRANSBOUNDARY STATE



- The transboundary aquifer system is a pile of alluvial sediments mostly of different grades of sand with intervening layers of silt and clay.

Area irrigated in Punjab

Year	Canal	Well and Tube well	Other sources	Total irrigated	Net area irrigated (%)
1960-61	1180 (58.4)	829 (41.0)	11 (0.2)	2020 (100.0)	54
1990-91	1669 (42.7)	2233 (57.1)	7 (0.2)	3909 (100.0)	93
2001-02	987 (24.9)	3017 (75.0)	2 (0.1)	4021 (100.0)	95 #

Irrigation Potential from Projects in Indian States (million ha)

Sno.	State	Total Irrigation Potential
1	Haryana	4.51
2	Himachal Pradesh	0.36
3	Jammu & Kashmir	1.36
4	Punjab	5.97
5	Rajasthan	5.13
	Total	17.33

Table 1. Area under different food grains (in thousand hectares),Punjab

Year	Rice	Jawar	Bajra	Maize	Wheat	Barley	Other Cereals	Total Cereals	Gram	Other Pulses	Total Pulses	Total Food Grains
1970-71	390	5	207	555	2296	57	1	3515	358	56	414	3928
2001-02	2489	<0.5	7	165	3422	23	-	6107	7	42	49	6155

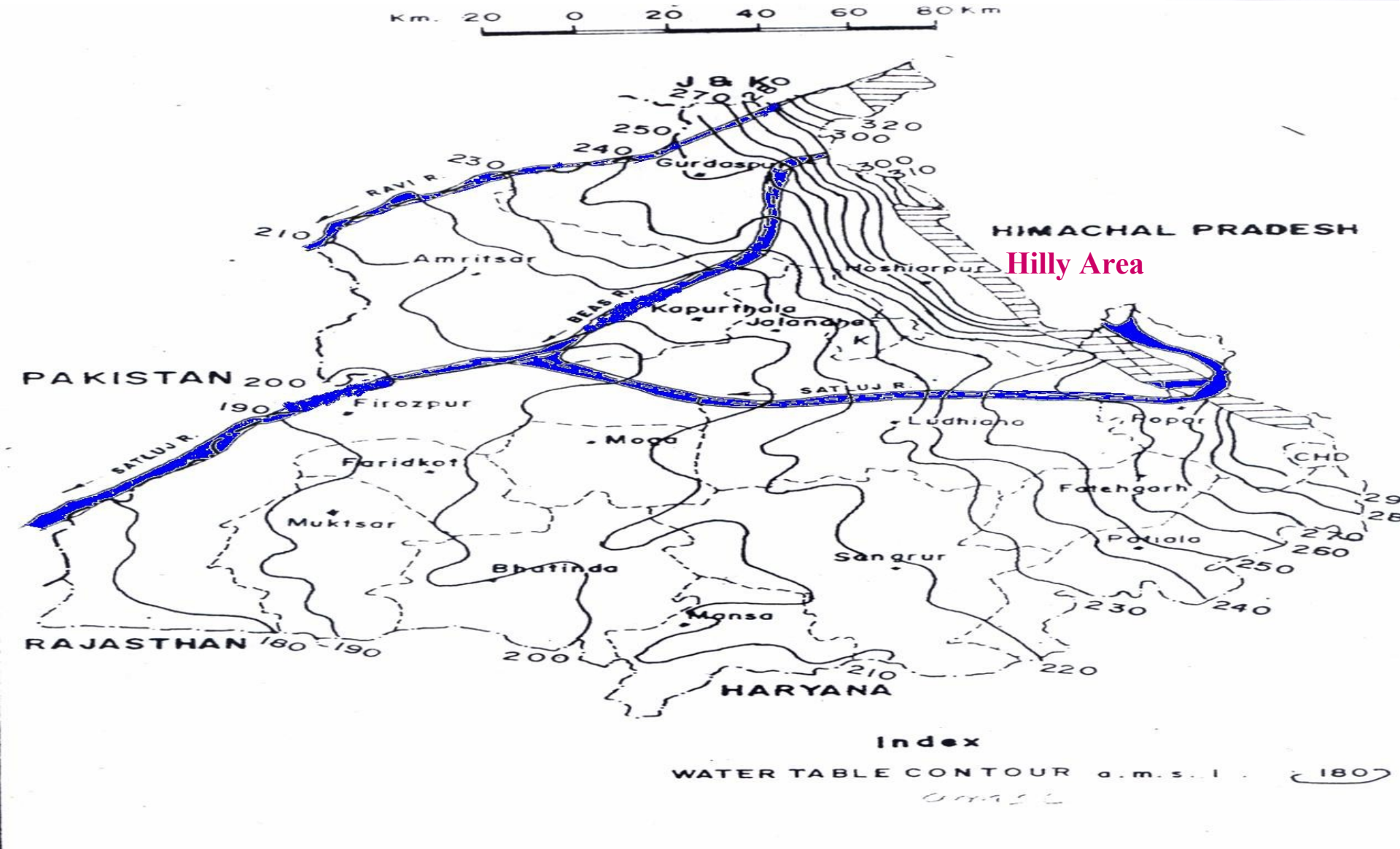
Source: Statical Abstract, Punjab, 2002

Table 2. Food grains productions (in thousand metric tones)

1970-71	688	3	243	861	5145	57	<0.5	6997	284	24	308	7305
2001-02	8824	<0.5	7	449	15509	78	-	24867	6	25	21	24898

Source: Statical Abstract, Punjab, 2002

Water Table Contour Map with Ground Water Flow Direction (Unconfined aquifer-lower Indus basin)



Artificial Recharge Potential of Indus Basin

- Recharge structures used-Recharge shaft, lateral trench with injection wells and trenches, check dams, Gabbion structures, Nala-bunds, Roof top rain water harvesting.

Monsoon run-off and available surplus water	Indus MCM
Average monsoon run-off	58640
Committed storage of surface water projects	16992
Monsoon surplus water	41648
Available water for recharge (75 percent of 3)	31236
Sub-surface storage potential for recharge	143813
Feasible groundwater storage	31236
Retrievable groundwater storage	21665
Water availability to meet requirements of groundwater storage Excess	-
Deficit	113050

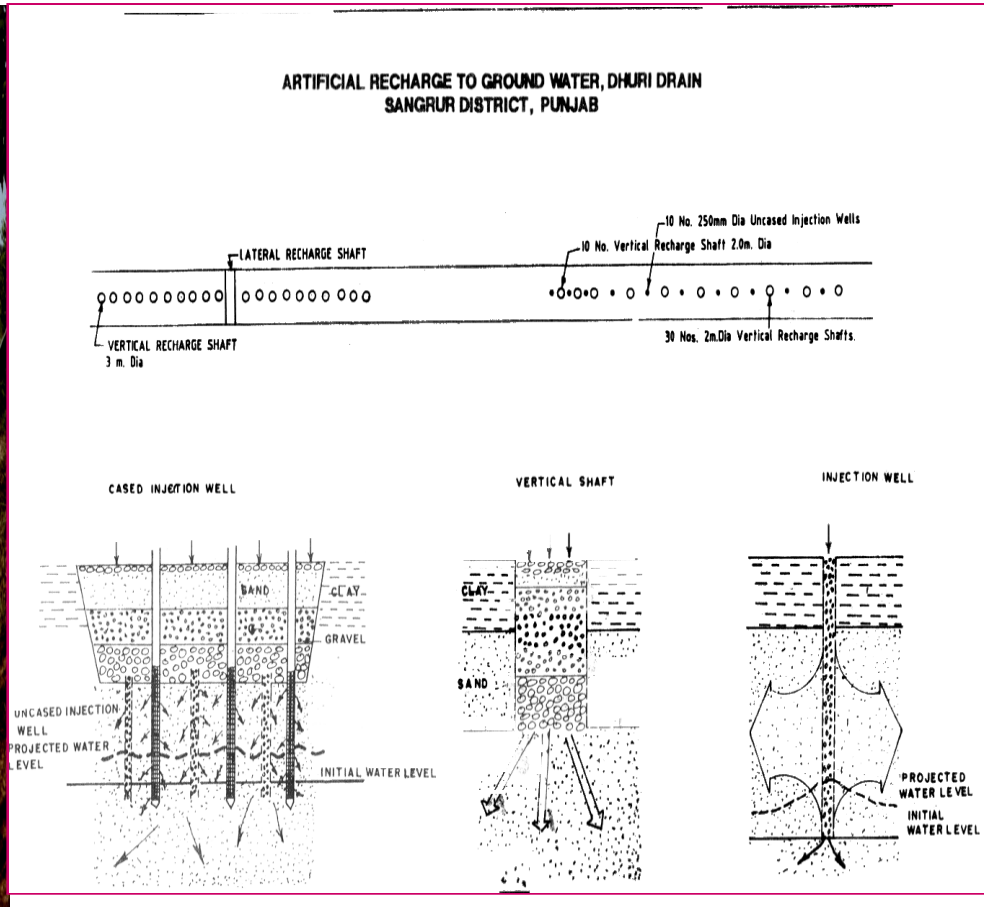
Artificial Recharge Study - Haryana & Punjab

State	Sub basin	Area for artificial Recharge	Aquifer saturation requirement	Sub-Surface storage potential	Surface water for Artificial recharge	No. of structures required
Haryana	3 (Yamuna, Ghaggar, Internal sub basin)	16120k m^2	3mbgl.	16310 MCM	684.50 MCM	15928(Recharge Shaft)
Punjab	4 (Ravi, Sutlej, Beas, Ghaggar)	22,750 km^2	3m bgl	18,863.5 MCM	1200 MCM	40030 (Recharge shaft) 12800 Roof top Harvesting

AQUIFER GEOMETRY

SUB SURFACE DYKE IN PATIALA NADI, PUNJAB

- Total catchment area: 300 sq. km.
- Average rainfall: 870 mm/year
- Total water available for recharge: 64.58 MCM/year
- Trench with recharge well
- Rectangular weir cum gabion structure



Canal System in Punjab & Haryana

PUNJAB

- Total length of network = 14500km. (main canal/ distributaries/minors)

1. Water Courses = 100000Km.
2. Area Irrigated = 15.6 lac hectares
3. Major Canal Systems
   - Bhakra
   - Sirhind
   - Bist Doab
   - Sirhind Feeder
   - Upper Bari Doab
   - Shah Nehar
   - Kandi
   - Eastern

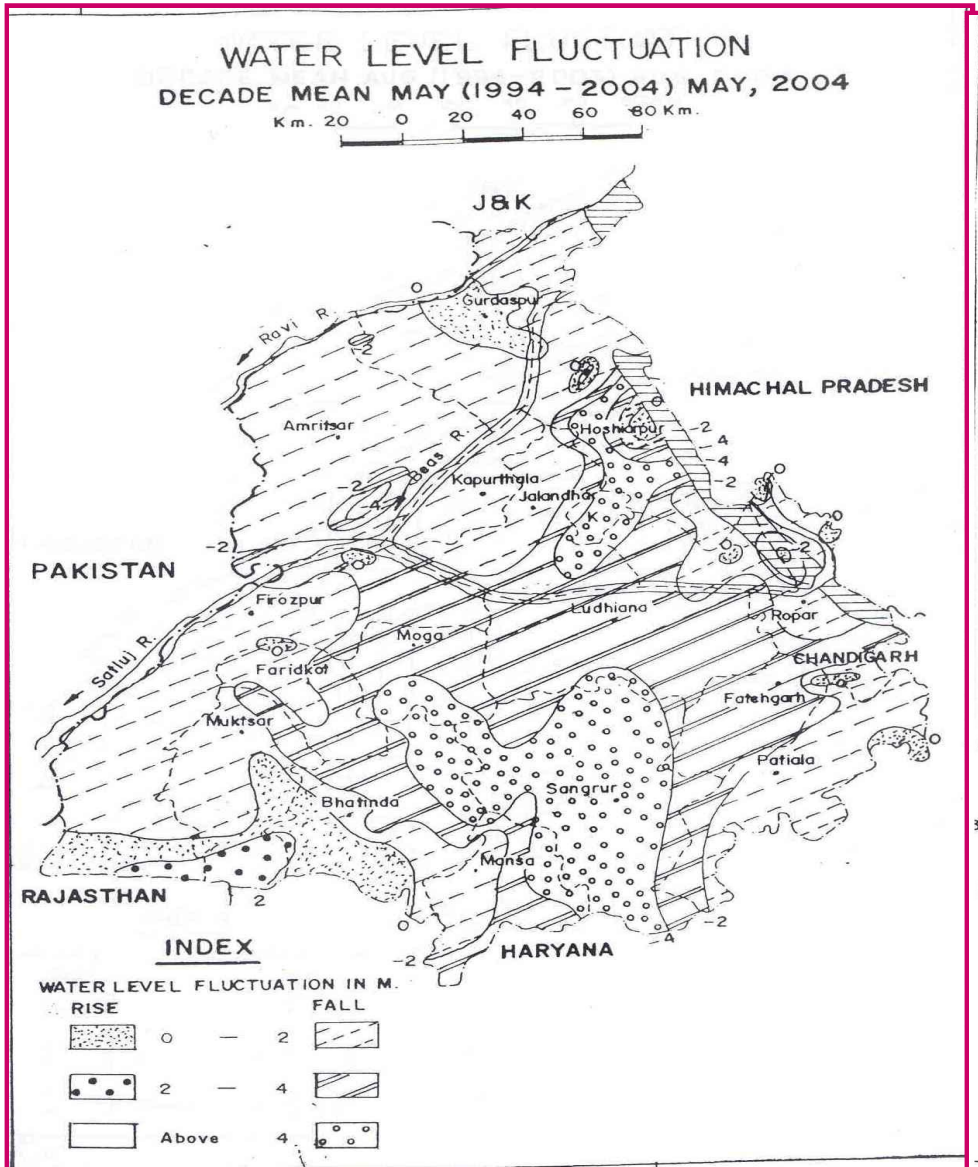
- HARYANA

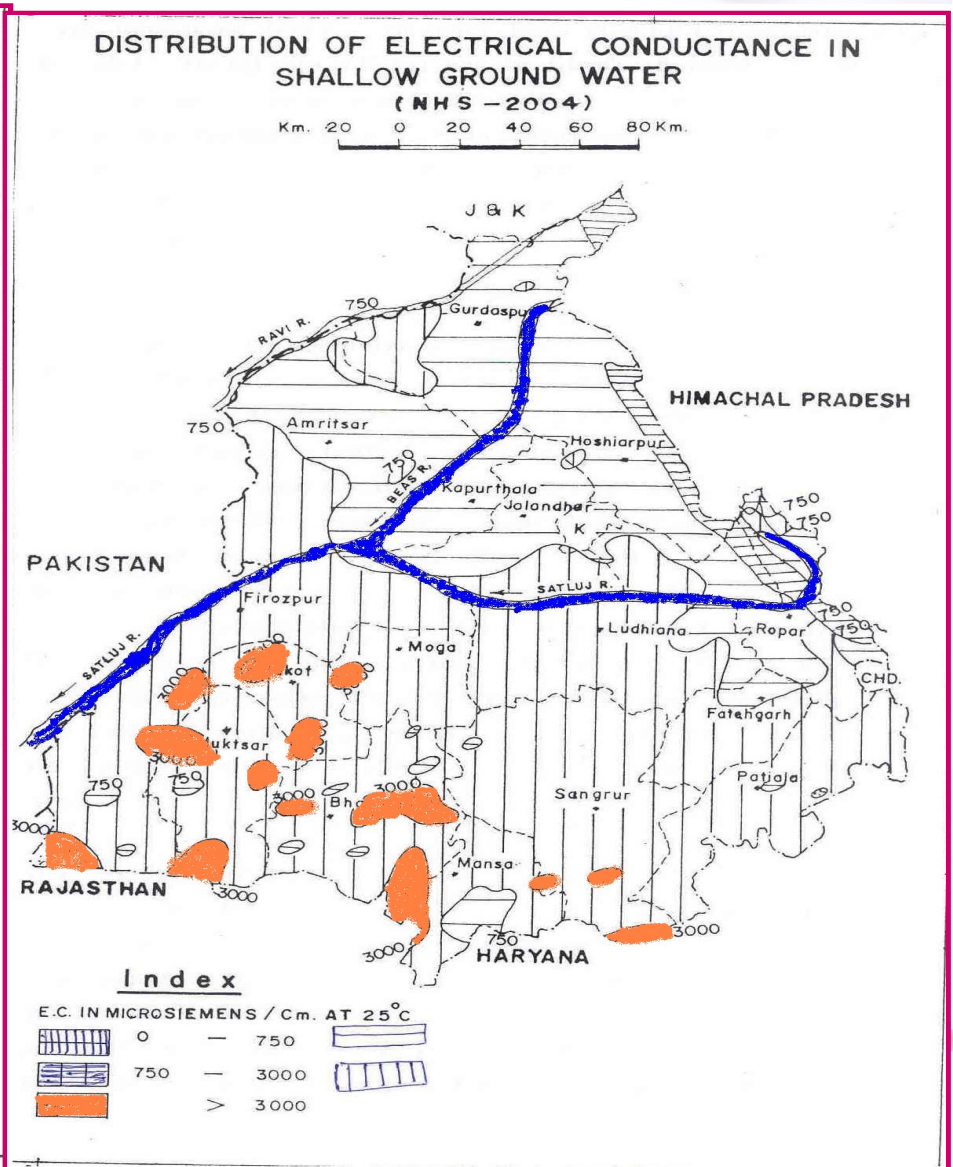
1. Bhakra Canal

Indus Basin Status of Water Logging and Inland Salinity

S No	States	Water Logged Area (0-2m)	Area under salinity (>3.46 dS/m)in Sq.km
1	Haryana	794	9166
2	Rajastha n	880	141036
3	Punjab	2350	3509
	Total	4024	153711

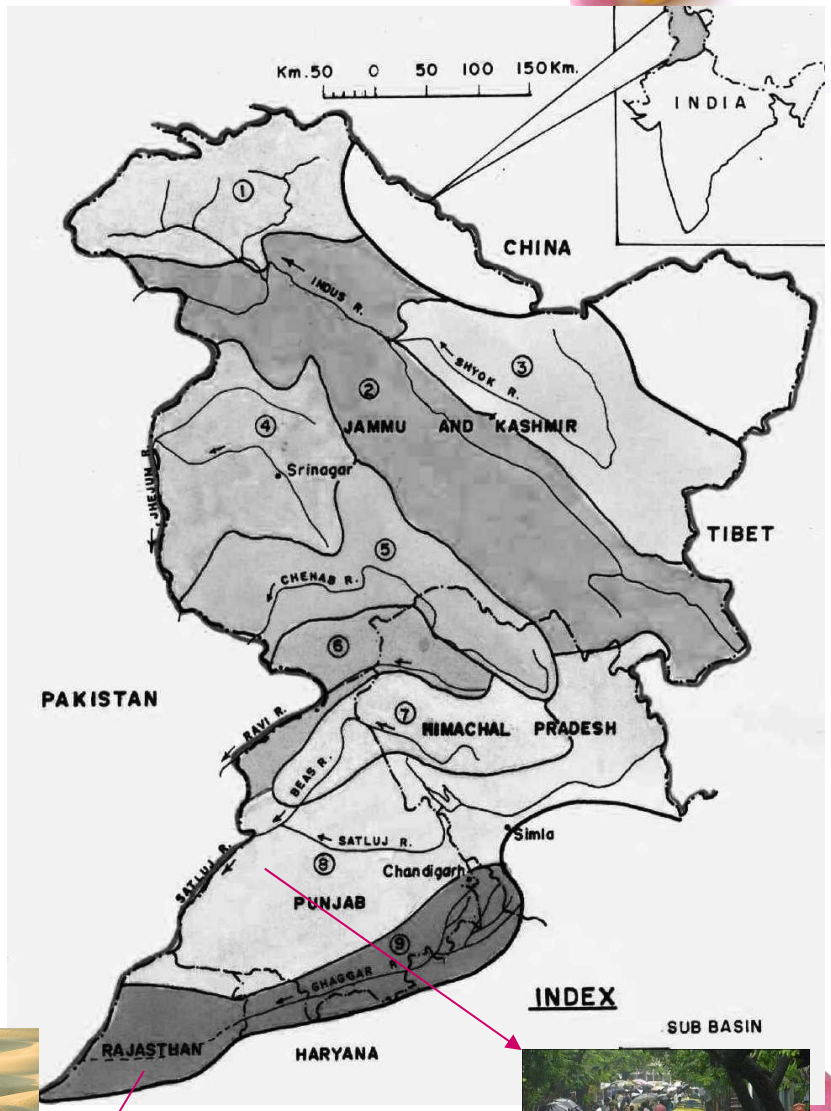
Water Level Fluctuation & Electrical conductivity

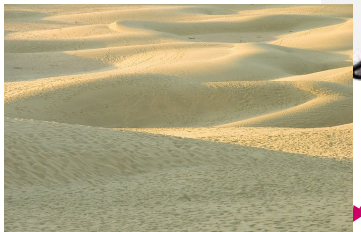




Impacts On climate Change

- Increase in water stressed conditions in arid areas in South West basin.
- Increase in flooding due to melting of glaciers in the Himalayas at the origin point of Indus river & other major tributaries.
- Impact on food security as lower basin is food basket for both India & Pakistan.
- Adversely affect the socio-economic conditions.





Summary Of Results

- The increasing water scarcity and continuous increase in demand particularly in the semi-arid and arid areas, southwest part of the basin adjoining the international boundary will increase conflicts in such areas.
- India has a long border with Pakistan with different aquifer system.
- Transboundary aquifers of different geological periods with variable potentialities and quality.
- Most of the precipitation on the Indian side whereas ground water flow is towards Pakistan, quantification of sub-surface flow for sharing can be debatable.
- Both sides have close network of canal system in the Indus plains for irrigation, contributing to recharge unconfined aquifer but leading to water salinity and water logging.
- Increased agriculture demand putting stress on deep Transboundary aquifers, the impact of which is difficult to ascertain but the hydraulic gradient is being reversed.
- Transboundary aquifers, both unconfined and confined, are exploited more than the estimated annual replenishment on both sides.
- India has initiated implementation of MAR schemes as mandatory and constituted regulatory authority to regulate the development of ground water resources but such actions are not being envisaged in the trans boundary countries.
- Climate change will bring floods in the alluvial plains of Punjab & drought conditions in the southwest arid area.

Points For Consideration

- Extent to which aquifer should be considered as transboundary-5Km from the international boundary on either side; max extent of influence of cumulative pumping.
- Depth of the aquifer- 300m or up to the depth of basement rock.
- Multi Aquifer System-Which of the aquifers to be considered as Transboundary-Unconfined aquifer and or deep aquifers (Development status is not known; quality is mostly saline).
- Saline aquifers- quality of same aquifer changes Transboundary-Can the saline aquifers be a part of TB
- MAR-India has Planned for large scale MAR but correspondingly efforts are not in the transboundary countries-How to account for this additional potential
- Groundwater regulation is exercised in India but not in transboundary Countries.
- The impact of canal irrigation near to the Transboundary aquifers.

Recommended Studies For Indus Basin

- First approximation of the ground water resource potential available and utilized within 20kms from the international border
- Status of ground water development and future demand.
- Data collection from different organizations, its synthesis and creating GIS database.
- To study impact of climate change on rainfall distribution and development of trans-boundary aquifer.
- Capacity building & training (under APN)
- International conference on successful case studies of transboundary aquifers
- Organization of several regional consultations to ensure consensus & participation at regional level.

GLOBAL HYDROGEOLOGICAL SOLUTIONS

Thank You !

Total Solutions for Groundwater and Environment

Ground floor -66, Vikaspuri,
New Delhi – 110018
Email : ghs_india@hotmail.com