DEVELOPMENT, MANAGEMENT AND IMPACT OF CLIMATE CHANGE ON TRANSBOUNDARY AQUIFERS OF INDUS BASIN

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Introduction

Indian continent, bounded by the Himalayas to the North, stretches southwards and at the Tropic of Cancer, tapers off in the Indian Ocean between the Bay of Bengal on the east and Arabian Sea to the west. The transboundary aquifers thus originate from Himalayas and pertain to the Indus and Ganges basins which share transboundary aquifers with China, Pakistan & Afghanistan and Nepal, Bangladesh & Myanmar respectively. The Ganges basin is mainly confined to India and therefore is less critical from transboundary point of view as compared to the Indus basin (Figure 1).

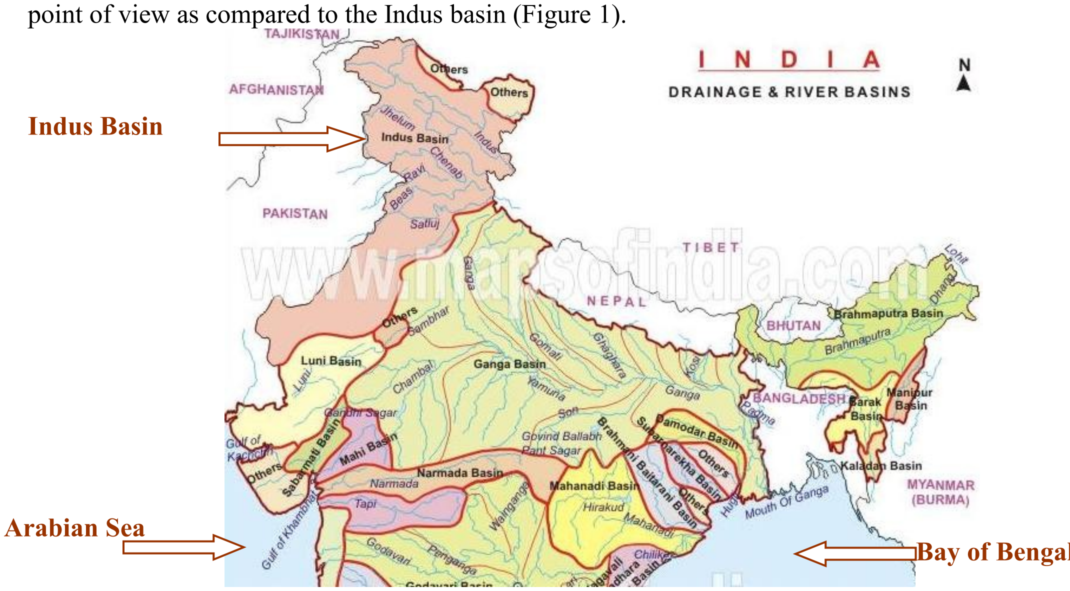

Figure 1: Location map of Indus Basin

Indus basin

Indus basin has a geographical area of 1.16 million sq.km., out of which 0.32 million sq.km. i.e. 28% falls in India and more than 50 % in Pakistan. In the Indian part of the Indus Basin, the high mountain ranges cover 85 % (i.e.2,72,280 sq km) and only 15% is covered by the foothills and plain areas. The rainfall varies from 2400mm in the northeast to the lowest of 200mm in the southwest and the average monsoon runoff is estimated as 58640 MCM. The Indus plains have a close network of canal system, the net area irrigated is 5.80 million hectare and net area sown 9.59 million hectare. The ground water potential for irrigation is estimated as 5428 MCM/Year. The sharing of the Indus river water between India and Pakistan is based on Indus water treaty but in case of ground water, it was neither found necessary nor visualized as the ground water development was very less during 1950. Now, that the ground water development has increased manifold with operation of more than 0.15 million structures and exploiting 70% of the dynamic potential and also the deep aquifer zones, the cumulative pumpage of which not quantified; it has, therefore, now become imperative to study transboundary aquifers in detail and share the information for their better management practices and utilization.

Ground Water Potential and Development

The geological formations range in age from pre-Cambrian to Quaternary deposits (recent) and thus constitute different aquifer systems with different potentialities. The ground water potential of the mountain areas (about 85% of the basin area) has not been estimated but in the 15% of the foot hills and plain areas, the dynamic (annual replenishment) and in-storage of fresh ground water potential is 26.5 BCM and 1338 BCM respectively. The saline aquifers cover an area of about 25,100 sq.km. with an estimated potential of 1.07 BCM (Table 1).

Table 1: Ground water assessment and development status for Indus Basin, India

S. No.	State/District	Geographical Area Falling In Indus basin (sq.km.)	Annual Gross Recharge (MCM)	Net Draft (MCM)	Area covered (sq.km.)	Potential (MCM)	Water logged 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	16101.95	2980	4162	5525
4	HARYANA	14679	3645.83	2067.85	3750	5430	4350
5	RAJASTHAN	14624	603.96	210.09	18347	1158	1171
6	CHANDIGARH(UT)	114	0.023	0.018	NIL	NIL	NIL

Aquifer System

The Indus basin encompasses multi-aquifer system having different aquifers ranging in age from pre-Cambrian to recent deposits. The limited ground water exploration in different parts of the basin has revealed the presence of different aquifers belonging to different rock types and their structural relationship. The synthesis of test drillings and tube wells data of the Punjab Indus plains show that the Quaternary aquifer system has 10 to 15 thick aquifer zones separated by thin intercalated impervious clay horizons (Figure 2a). The whole aquifer system up to 650 m bgl is unconfined with locally semi-confined conditions. The cumulative sand thickness is 70 to 85% of the depth explored up to 350m, so the tube wells constructed are high yielding wells. The sub-surface lithological sections show the disposition of pervious and impervious zones which are laterally and vertically extensive. The ground water flow direction shows the discharge of the ground water towards the transboundary country (i.e. Pakistan) but this has not been quantified for want of data on aquifer parameters (Figure2b).

Ground Water Management

The ground water development being a necessity to meet the irrigation demand using 90% of the resource, the resultant decline in water levels is being restored through the practices of MAR and regulatory measures. The saline ground water resources are developed on limited scale as conjunctive use with surface canal water. It is estimated that feasible ground water storage based on the surface water availability and sub-surface storage is 29,800 MCM. The non-committed run-off of about 2,100 MCM has been planned for MAR for creating sub-surface storages to check the declining trends of water levels and reducing the energy cost. A number of recharge structures have already been constructed.

Impact of Climate Change

The initial studies on impact of climate change on water availability in India covering a part of Indus basin show an increase in the water stressed conditions in the arid areas falling in the south-west whereas the melting of glaciers in the Himalayas, at the origin point of Indus River and other major tributaries, will increase the flooding. This anomalous situation will impact the food-security as the lower Indus basin is the food basket for both India and Pakistan. It is thus evident that the Indus basin is vulnerable to climate change and this will adversely affect the socio-economic conditions of the region.

Problems related to Transboundary Aquifers

India has a long border with Pakistan and the Transboundary aquifers are of different geological ages, variable ground water quality and hydrogeological conditions. In the Indus basin, the most of the precipitation is on the Indian side, ground water flow direction is towards Pakistan, both sides have close network of canal system for irrigation, areas are marked with water logged condition and inland salinity, etc.

PAKISTAN SIDE

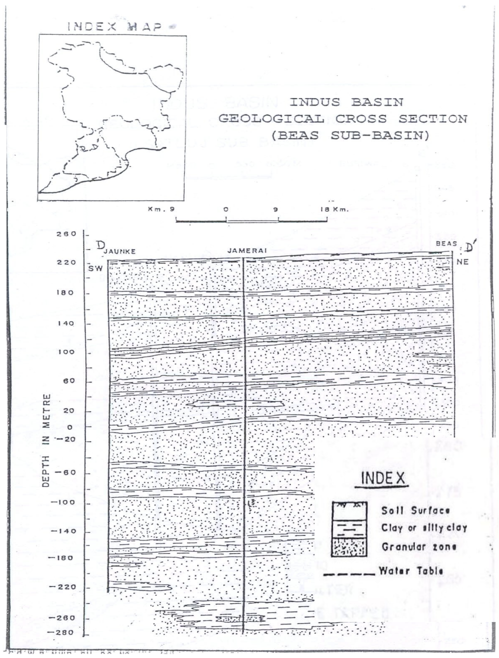

Figure 2a: Sub-surface lithological cross section, Upper Bari Doab (Beas-Ravi sub-basin)

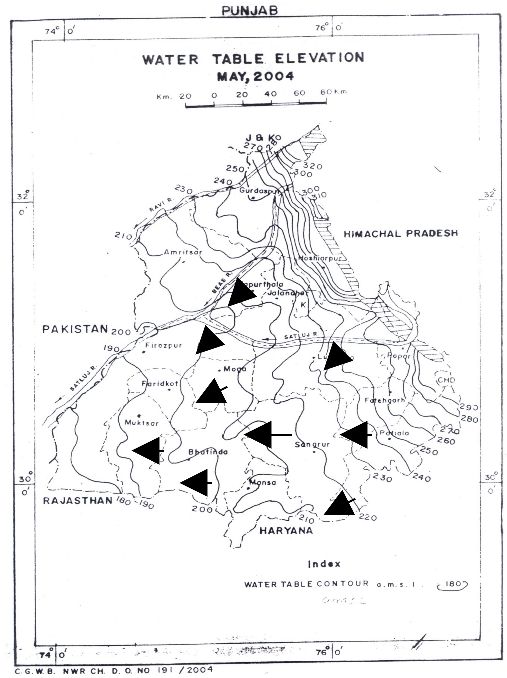

Figure 2b: Water table contour map with ground water flow direction (Unconfined aquifer-lower Indus basin)

It is opined that any future study of the Transboundary aquifers may not be restricted to the fresh aquifers but should also include saline aquifers and should deal with the problems like pollution and water logging. Moreover India has embarked upon implementation of large MAR schemes and made it mandatory for industries and urban developers /infrastructure and constituted an authority to regulate the development of ground water resources but such actions are not being envisaged in the transboundary countries. It is suggested that the guidelines to such problems/issues may be incorporated in the Draft Articles on the Law of Transboundary Aquifers (Eckstein, 2007). Moreover it is important to spell out the extent (i.e. distance from the international boundary) to which the aquifers are reckon as Transboundary and the depth for their development. Presently, there is no regional agreement between the countries sharing transboundary aquifers for sharing of data, co-operation or any identified conflict issues. However, with the increased demand of water for food security and domestic requirements, the development of deep fresh aquifers will impose new problems which would demand detailed study and sharing of data besides regional agreement for aquifers which are transboundary.

Conclusions

The Indus basin serves as food basket for both the Transboundary countries and plays an important role in mitigating poverty alleviation and social economic development, therefore, any suggestion for considering the entire basin for any agreement may not be viable and acceptable to the concerned countries. The study should be confined to a maximum of 5 km from the international boundary to have a definite idea about the continuity of the different aquifer system and their development needs. It is opined that if any breakthrough is to be achieved for bringing the Transboundary countries on a common platform, it is important to consider education and training including economics & ethics of ground water utilization backed up by proven case studies showing benefit accrued out of the management of transboundary aquifers elsewhere.

References:

Central Ground Water Board (2001). Hydrogeology of Indus Basin, Government of India.
Gabriel E. Eckstein (2007). Commentary on the UN International Law Commission Draft Articles on the Law of Transboundary Aquifers.