INNOVATIVE ENERGY TECHNOLOGY SYSTEMS AND ENVIRONMENTAL CONCERNS: A SUSTAINABLE APPROACH
ISBN: 978-93-84144-81-4

Relevance of Indus Water Treaty–A Key for Sustainable Bilateral Relation between India and Pakistan

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Abstract

The Indus Waters Treaty is a water-sharing treaty between the Republic of India and Islamic Republic of Pakistan, brokered by the World Bank (then the International Bank for Reconstruction and Development). The Indus System of Rivers comprises three Western Rivers (166 BCM) the Indus, the Jhelum and Chenab and three Eastern Rivers (41 BCM) the Sutlej, the Beas and the Ravi; and with minor exceptions, the treaty gives India exclusive use of all of the waters of the Eastern Rivers and their tributaries before the point where the rivers enter Pakistan. Similarly, Pakistan has exclusive use of the Western Rivers. Pakistan also received one-time financial compensation for the loss of water from the Eastern Rivers. Indus Waters Treaty has been successful for over forty years; the increasing needs for water and power in India and Pakistan are beginning to subject the Treaty to tensions. But treaty defused a major source of potential conflict and allowed each country to develop its share of the basin's waters.

Keywords: Indus water treaty, Permanent Indus Commission, Western rivers, Eastern rivers.

1. Introduction

Population growth and expanding urbanization and industrialization has resulted in the ever increasing imbalance between water availability and water demand in most developing countries in general but India and Pakistan in particular. The Indus River Basin, with 212 million people, faces severe water scarcity during eight months of the year. In the northwestern Indian provinces of Punjab, Rajasthan and Haryana, each one of which lies fully or partly in the Indus River Basin, groundwater is steadily being depleted. South Asia, which has the lowest level of water resources per capita, water availability per capita has already decreased by almost 70 % since 1950. The India and Pakistan experience water shortages despite good rainfall because of the lack of appropriate investment and technology for water storage. Climate change is a factor that will affect water availability in the region. Whether water stress can be mitigated in the future depends on how efficiently water is used and conserved.

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Reconstruction and Development). The treaty was signed in Karachi on September 19, 1960 by Indian Prime Minister Shri. Jawaharlal Nehru and President of Pakistan Mr. Mohammad Ayub Khan. The Indus System of Rivers comprises three Western Rivers (166 BCM) the Indus, the Jhelum and Chenab and three Eastern Rivers (41 BCM) the Sutlej, the Beas and the Ravi; and with minor exceptions, the treaty gives India exclusive use of all of the waters of the Eastern Rivers and their tributaries before the point where the rivers enter Pakistan. Similarly, Pakistan has exclusive use of the Western Rivers. Pakistan also received one-time financial compensation for the loss of water from the Eastern Rivers. The countries agree to exchange data and co-operate in matters related to the treaty. For this purpose, treaty creates the Permanent Indus Commission, with a commissioner appointed by each country. Since, India has not built any conservation storage on Western Rivers, India can develop irrigation by withdrawals from river flow only within the restricted area of 108000 ha over and above the area as on effective date.

2. Resources and liabilities of India

India is located in southern Asia and has a total area of almost 3.3 million km^2, bordered in the northwest by Pakistan. India has an annual average precipitation of 1,170 mm and about 80 % of the total area of the country experiences annual rainfall of 750 mm or more. It was mentioned that more than 50 % of water resources of India are located in various tributaries of Indus river systems [1]. Indeed, about 80 % of the river flow occurs during the four to five months of the southwest monsoon season. Population projections for India anticipate that it will reach 1.5 to 1.8 billion by 2050. In India per capita surface water availability in the years 1991 and 2001 were 2309 and 1902 cubic meter and these are projected to reduce to 1401 and 1191 cubic meter by the years 2025 and 2050, respectively. Hence, there is a need for proper planning, development and management of the greatest assets of the country, viz. water and land resources for raising the standards of living of the millions of people, particularly in the rural areas. In addition to devastating the agricultural sector of India's economy, the water crisis will have a big effect on India's industrial sector, possibly stagnating many industries.

India needs to make water supply a national priority the way it has made food security and economic growth priorities in the past. India's need for a comprehensive management program is so severe because of its rapidly depleting water supply, environmental problems, and growing population. If the country continues with a business as usual mentality the consequences will be drastic. All India projected water demand by different sectors in different years is given in the Table 1.

Table 1: All-India projected water demand in India by different uses (2010, 2025 and 2050)

Different use	**Water demand in BCM**								
	Standing Sub-committee of Ministry of Water Resources			**National Commission on Integrated Water Resources Development**					
	2010	**2025**	**2050**	**2010**		**2025**		**2050**	
				Low	**High**	**Low**	**High**	**Low**	**High**
Irrigation	688	910	1,072	543	557	561	611	628	807
Drinking water	56	73	102	42	43	55	62	90	111
Industry	12	23	63	37	37	67	67	81	81

ISBN: 978-93-84144-81-4

Energy	5	15	130	18	19	31	33	63	70
Other	52	72	80	54	54	70	70	111	111
Total	813	1,093	1,447	694	710	784	843	973	1,180
Source: Compendium of Environment Statistics India, 2011, Central Statistical Office, Ministry of Statistics and Programme Implementation, Government of India.									

The projected food demand as estimated by different researchers is given in the Table 2.

Table 2: Projected food demand for India by different studies (million tons)

Source	Year	Rice	Wheat	Total cereals	Pulses	Food grains
Rosegrant et. al. (1995)	2020	-	-	237.3	-	-
Kumar (1998)	2010	103.6	85.8	223.7	23.0	246.7
	2020	122.1	102.8	265.7	30.9	296.6
Planning commission (2006)	-	-	-	224.0	20.0	244.0
Chand (2007)	2011	-	-	218.9	16.1	235.0
	2021	-	-	261.5	19.1	280.6
Mittal (2008)	2011	94.4	59.0	188.5	24.1	212.6
	2021	96.8	64.3	245.1	42.5	287.6
	2026	102.1	65.9	277.2	57.7	334.9
Kumar et. al. (2009)	2011	101.1	81.1	211.6	15.5	227.1
	2016	106.8	86.9	223.6	17.5	241.2
	2021	113.3	89.5	233.6	19.5	253.2

3. Resources and liabilities of Pakistan

Pakistan is a South Asian country situated between Latitude 24° and 37° N and Longitude 61° and 75°E. The area is about 796,095 km^2. Current population of Pakistan is 180 million and projected to reach 260 millions by 2025 [2]. Average annual rainfall varies from 125 mm in South East to over 750 mm in North West of Pakistan. It contributes 32 billion cubic meters of water [3]. Pakistan has experienced one of the worst droughts in its history during 1998-2003 due to extremely low rainfall [4]. Rainfalls are erratic and are received in two rainy seasons; about two thirds of annual rains are received during the monsoon season (July to mid-September) and the remaining one third in the winter season (January to March). The mean annual rainfall is 778 mm [5]. There exists high variability in rainfall distribution in different locations of the country. Over the fifty years period (1950-2000), per capita water availability reduced by 77 %. Food grain demand needs to be increased by 100 % in 2050 since 2010 by increasing the area in the tune of 84.8 % (Table 4).

Table 3: Pakistan water demand (BCM).

Sectors	Year					
	2008	2010	2015	2020	2025	2030
Irrigation	204.7	206	206.6	207	207.7	208.7
Livestock	1.08	1.14	1.32	1.49	1.66	1.84
Agriculture	205	207	207.7	208.4	209.5	210.5

Source: Pakistan Development Forum, 2003

ISBN: 978-93-84144-81-4

Table 4: Projected food grain demands and irrigated crop area.

Projections	Years			Percentage increase from 2010	
	2010	**2025**	**2050**	**2025**	**2050**
Food grain demand, million tons	247	320	494	29.9	100
Net cultivated area, million ha	143	144	145	0.7	1.4
Total cropped area, million ha	193	204	232	5.7	20.2
Total irrigated crop area, million ha	79	98	146	24.1	84.8

Source: Asian irrigation Forum, 2012

IWMI's general conclusion is that the Pakistan will face physical water scarcity by 2025 - that is, primary water supply more than 60 % of the potential utilizable water resource. Consequently, Pakistan will require 102 % of its potential utilizable water resource to feed its population. This means it will experience absolute scarcity of internal water resources irrespective of the financial or management means available. Given this forecast and the fact that opportunities to increase total water supply are severely limited, it is clear that to meet future demands for food production, Pakistan will have to invest significantly in increasing water efficiency in existing irrigated areas. Water allocations in the Indus Basin will also need to take account of the fact that people in the lower part of the basin rely on sufficient water being left in the river for their food security (e.g. maintenance of fisheries). Food requirements not met through improvements to Pakistan s agriculture will have to be provided through imports of grain, with consequent socio-economic implications, particularly for poorer sections of the population (Table 5).

Table 5: Water demand forecast for cereal crops in Pakistan.

Particulars	Year		
	1995	**2025**	**Increase (%)**
Irrigated cereal area (million ha)	10.30	12.17	18
Primary water supply (km^3)	177.67	203.35	14
Rainfed cereal area (million ha)	0	0	0
Potential utilizable water resources (km^3)	199		

Source: WWF, 2003

4. Perspective from India and Pakistan on IWT

The Indus waters dispute surfaced with the partitioning of undivided India. This arbitrarily vivisected an integrated and intricate system of barrages, head works and link canals diverting 73 million acre-feet of water to irrigate 1.02 million hectares of land, essentially in Punjab and Sind and developed over the preceding century. With most crown lands under the Raj being located in what was known as British India, the bulk of the irrigation developed was in areas that fell to Pakistan. The princely states of Punjab and what is now Haryana, that became a part of India, received relatively little benefit. An interruption in canal water supplies to Pakistan in 1948, following the termination of an inter-Dominion standstill agreement in this

ISBN: 978-93-84144-81-4

regard, triggered a serious crisis the final resolution of which was embodied in the Indus Waters Treaty.

The treaty divided the waters of the Indus and the hitherto integrated irrigation network into two, the waters of the three eastern rivers going to India and those of the three western rivers plus the Kabul, a major right bank tributary of the Indus, going to Pakistan. In the final reckoning, of the 168 MAF discharge of the Indus, 81 % of the waters were allocated to Pakistan and 19 % to India. Further, India and the international community funded Pakistan for the development of replace works to render it totally independent of any canals, links or structures located in India. These transitional arrangements were completed in a decade, by 1970.

Both sides constructed storages on their rivers and further developed their respective commands. In India, the Bhakra and Pong dams on the Sutlej and Beas and the power generated from them, laid the basis for the green revolution to follow and energized a vast network of tube wells drawing on irrigation recharge and providing vertical drainage. The Mangla and Tarbela dams did the same for Pakistan. With the completion of the Thein dam on the Ravi, the third major storage on the eastern rivers is in position. The Pong and Thein dams divert eight million acre-feet of water to Rajasthan. This has transformed the Thar desert, with a swathe of green running north-south along the Pakistan border.

Increases in domestic water stress would also bring more potential for conflicts among countries. On the other hand, such competition for water also provides opportunities for cooperation on allocation and sharing of water resources (Table 6).

Table 6: Millennium Development Goals (MDG) water indicator by countries.

Country	**Freshwater withdrawal (million m^3)**	**Total actual renewable freshwater resources (million m^3)**	**MDG Water Indicator (%)**
	Total	Total Actual Renewable Water Resources (TARWR)	Total freshwater withdrawal as percentage of TARWR
India	760999	1911370	39.8
Pakistan	183421	230770	79.5

Source: Aquastat survey, 2011

Socio economic indicators and projected water demand/availability in Bangladesh, India and Pakistan is given in Table 7.

Table 7: Socio economic indicators and projected water demand / availability in India and Pakistan

Country	**Population density per km^2 (at 2001)**	**Projected water (in BMC)**		
		Demand up to 2025	**Availability**	**Surplus deficit**
India	348	1060	1086	(+) 26
Pakistan	183	335	236	(-) 102

Source: world Bank, 2003

ISBN: 978-93-84144-81-4

Table 8 presents the distribution of water withdrawal by country for the three large water-consuming sectors: agriculture (irrigation, livestock watering and aquaculture), municipalities (domestic/municipal) and industry (including water for cooling of thermoelectric plants). Figures for agricultural water withdrawal expressed in m^3 per hectare of irrigated land show large discrepancies between countries, which cannot be explained solely by differences in climatic conditions. Rather, their difference is to be found in computation methods. Indeed, with a major regional emphasis on flooded rice irrigation, it is particularly difficult to assess agricultural water withdrawal. The annual water withdrawal per hectare of agricultural area is more compared to municipalities and industries uses. The total volume of water withdrawal per inhabitant is higher in Pakistan (1096 m^3/inhabitant) than in India (630 m^3/inhabitant).

Table 8: Annual water withdrawal by sector in India and Pakistan/

Country	Year	Agriculture		Municipalities		Industries		Total	
		Volume (Mm^3)	% of Total	Volume (Mm^3)	% of Total	Volume (Mm^3)	% of Total	Volume (Mm^3)	Per inhabitant (m^3/inhab)
India	2010	688000	90	56000	7	17000	2	761000	630
Pakistan	2008	172371	94	9650	5	1400	1	183421	1096

Source: Aquastat survey, 2011

5. Current disputes between India and Pakistan

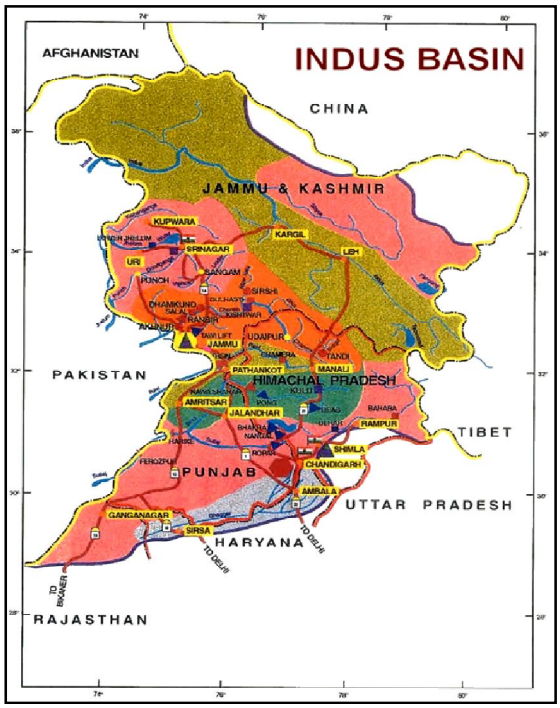
India and Pakistan have been at odds since the partition of British India in 1947. Disputes over water only serve to compound existing tensions between these regional rivals, who continue to contest control of the Jammu and Kashmir region. The map of Pakistan illustrates the geographical ambiguity inherent in the Indo-Pakistani borders. Indeed, limited freshwater resources, which are critical to irrigated agriculture and industrial development, remain an ongoing area of conflict between India and Pakistan. While a longstanding treaty has governed their shared river resources, India and Pakistan continue to feud over interpretation of the agreement, with dam projects often serving as a flashpoint for tensions.

The discrepancy between political borders and the natural course of rivers, coupled with the structure of the Indus Water Treaty, creates multiple areas of potential conflict between India and Pakistan. The greatest issue under dispute is India's construction of dams and other projects that divert water that would otherwise reach Pakistan. The most important current disputes involve the Baglihar Dam, the Tulbul Navigation/ Wular Barrage, the Kishenganga Dam and Indian retention of water from the Beas, Ravi and Sutlej rivers. In most cases, Pakistan believes it has been the victim of Indian strong-arm tactics. Indus river basin map is given in Fig. 1.

Domestic and irrigation water requirements are essential for sustenance of life, these requirement bear the top priority of any country. The industrial, energy and other requirements may then be met/ planned out of the balance water available. Water deficiency will be felt in the Indus river systems (Table 9). The overall picture in the country in 2050 may be grim as the total water requirement for various uses would not be adequate to meet the demands of the sectors other than irrigation and domestic with the balance available water of 136 BCM through conventional means. The situation can only be managed by different methods of

ISBN: 978-93-84144-81-4

conservation of water and adopting all measures for exploring / tapping the remaining water resources in the identified proposals to be given propriety so that additional water is available to meet the demand of all sectors by 2050.



Source:http://www.cwc.nic.in/regional/chandigarh/images/basin.jpg

Fig. 1: Indus river basin

Table 9: Basin wise demand of water.

S. N.	Basin	Total surface and ground water resources	Estimated demand of water				Net for irrigation and domestic	Balance available for industry and other uses
			Irrigation	Domestic	Total	Return flow		
		Year 2010						
1.	Indus	72.5	102.9	2.83	104.9	12.47	92.45	-19.95
2.	Gang-Brahmaputra-Megna							
a.	Ganga	421	311.9	22.2	334.2	48.9	285.2	135.7
b.	Brahmaputra	50.5	12.9	1.3	14.2	2.3	11.8	38.7
c.	Barak &other	8.5	1.6	1.4	3.0	1.3	1.7	6.7
Year 2025								
1.	Indus	72.5	134.9	4.0	139.0	16.7	122	-49.7
2.	Gang-Brahmaputra-Megna							
a.	Ganga	421	412.4	29.6	441.9	64.8	377.1	43.9
b.	Brahmaputra	50.5	17.1	1.6	18.6	2.9	15.7	34.8

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c.	Barak & other	8.5	2.1	0.8	3.0	0.9	2.1	6.4
Year 2050								
1.	Indus	72.5	159.1	5.9	164.9	20.6	144.3	-71.8
2.	Gang-Brahmaputra-Megna							
a.	Ganga	421	486.1	38.9	525	79.8	445.3	-24.2
b.	Brahmaputra	50.5	20.1	1.8	22	3.5	18.5	32.1
c.	Barak & other	8.5	2.5	3.1	5.6	2.7	2.8	5.6

Source: FAO 2003. Water report # 23

6. Water balance details of Indus basin

The water balance of the Indus basin has been carefully studied, which is not the case for the other basins. Therefore most of the results found refer only to the Indus basin. The mean annual inflow into the Pakistan through the western rivers (the Indus, including the Kabul tributary, the Jhelum and the Chenab) amounted to 170.27 km^3 (Table 10). The mean annual natural inflow into the country through the eastern rivers (the Ravi, the Beas and the Sutlej) is estimated at 11.1 km^3, but this is reserved for India, according to the 1960 Indus Water Treaty.

Table 10: Water balance sheet.

Internal Renewable water resources (IRWR)	
Precipitation (mm/year)	494
Area of the country (000 ha)	79610
Precipitation (km^3/year)	393.3
Surface water produced internally	47.4
Ground water produced internally	55
Overlap between surface water and ground water	47.4
Total internal renewable water resources	55

Source: Aquastat, 2010

7. Conclusion

The Indus Treaty allows India limited existing and new water uses from the western rivers in Jammu & Kashmir as well as restricted non-consumptive uses on the Chenab and the tributaries of the Jhelum for hydropower. The potential has yet to be fully exploited and has partly been delayed as a result of Pakistani objections on what it has insisted were and are technical cum strategic considerations. The Tulbul of Wulur barrage project, essentially to maintain navigation along the Jhelum, remains a casualty. The Indus Treaty does not permit optimal harnessing of the full water and energy potential of the Indus system. It had a narrower objective. Even within those parameters it ranks among the triumphs of the United Nations System. There is still considerable scope for improving the benefits to both countries. The increase in water demand in all sectors is expected to create conflicts among sectors and within each sector over water allocation. In Asia, many countries share international river basins as sources of water.

Water management is a heterogeneous area with linkages to different sectors of national economy including the agricultural, industrial, domestic and household, power, environment, fisheries and transportation arenas. There are various key issues related to conservation of

depleting ground water resources, soil conservation, flood control and availability of drinking water. Because water is a shared and community resource, it has often led to disputes between different states and also with the neighboring countries and that adds to the problems of water resource management in countries.

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