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The Water Paradox: Is there a sharing crisis?

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ABSTRACT

Water resources management has undergone significant change since the beginning of human civilization. This study investigates water sharing and in particular the impact of the Farakka Barrage in the Ganges River Basin area. This dam has led to conflict between the Ganges states since 1951. A review of the literature shows that one of the best institutional framework solutions is the bilateral agreement between Bangladesh and India. This is encapsulated in the 1977, 1982 and 1985 Memoranda of Understanding (MOU), and also in the historical 1996 treaty. The 1996 water sharing treaty adopted Article IV of the 1966 Helsinki Rules and granted 35,000 cusecs in water releases to Bangladesh. The analysis presented in this paper suggests that availability of flows is crucial during the period March 1 to May 31. Moreover, the average flow availability at Farakka has been gradually declining during the period 1997 to 2007. For 2005 and 2006, we found that the average flow availability had declined by 12% and 25% respectively. We strongly recommend market-based water transfers from Nepal for both Bangladesh and India. We demonstrate that this would provide a better solution to sustainable water resources management in the Ganges River Basin.

Key words: Water sharing, institutional framework.

1 INTRODUCTION

Water is the hub of life and an indispensable part of all terrestrial ecosystems (Vo, 2007). The distribution of these water resources throughout the earth is as follows: Surface water is 0.02%, subsurface water is 0.62%, icecaps and glaciers are 2.15%, and seawater is 97.20% (Bras, 1990). This illustrates the limited availability of fresh water. The quantity issue arising from water sharing is particularly critical. It depends on bilateral agreements among co-riparian states and therefore, water sharing issues often become controversial in water resources management (Haftendorn, 2000). Water sharing is not confined within specific countries, but it has become a transboundary issue as well. Sharing issues between riparian nations may arise through economic development, infrastructural capacity, or political orientation. Indeed, there is already clear evidence of escalating conflicts in different parts of the world concentred on water quantity and quality issues.

In Bangladesh, water flows in the Ganges River impact on human activities in both rural and urban areas. The flow of the Ganges River in Bangladesh is influenced largely by the actions of its neighbouring countries, India and Nepal. The research work presented in this paper aims to quantify how and why the sharing of water resources became a paradox in Bangladesh. This paper analyses the sharing of water in the Ganges River Basin in terms of matching supply and demand.

2 WATER SHARING IN THE GANGES RIVER BASIN

Bangladesh's water resources derive from three main rivers - the Ganges, the Brahmaputra and the Meghna, and their tributaries and distributors. The three river catchments cover approximately 1.75 millions square kilometre areas, only 8% of which lies within Bangladesh (Abbas, 1992). However, these river systems all discharge into the Bay of Bengal through Bangladesh. In general, the problems arise from upstream countries such as India. In particular, in the absence of a treaty, upstream riparian states have a hydrological advantage in a river. In the absence of political constraints, over a number of years these upstream states have occasionally abused this advantage. This is the root of the paradox of water sharing between India and Bangladesh. Bangladesh emerged as a country independent from Pakistan in 1971. After that Bangladesh proposed to build storage facilities in the Ganges River Basin to augment the flow during the dry season (Haftendorn, 2000). As this would involve Nepal, India rejected the plan because of it not being simply a bilateral issue (Khan, 1996). On the other hand, India's proposal of diverting water from the Brahmaputra River to the Ganges River by a link canal was opposed by Bangladesh (Haftendorn, 2000) because diversion of water from the Brahmaputra River during the dry period would cause adverse effects on its downstream reaches.

In 1974, the Indo-Bangladesh Joint River Commission estimated that during the dry season the average minimum flow discharged below the Farakka Barrage was 55,000 cusecs (Adel, 2001). Of this, India claimed 40,000 cusecs to flush the Hooghly River leaving the rest for Bangladesh, which on the other hand demanded the entire 55,000 cusecs for the dry season. Hence a deadlock arose between these two countries (Hossain, 1998). To break the deadlock, the Bangladesh government proposed an interim agreement based around diversions at the Farakka Barrage. The agreement was signed on 18 April 1975 (Hossain, 1998). After the agreement expiry on only 31 May 1975, India unilaterally continued the withdrawal of water at Farakka, adversely affecting a vast area of Bangladesh. Consequently, Bangladesh raised the issue at the thirty-first session of the United Nations General Assembly in September 1976 (Khan, 1996). However, its attempts to internationalize the issue failed and a bilateral solution with India had to be sought.

As the expiry date of the 1977 treaty was looming, Bangladesh urgently needed to find another agreement for the sharing of water in the Ganges River Basin. Then two MOUs were signed on 7 October 1982 and 18 October 1985 for the next two dry seasons and three years respectively following the terms of the original 1977 agreement. After expiration of the second MOU, there was no further agreement until 12 December 1996 (Rahman, 2006), when a thirty year accord was signed by Bangladesh and India (Salman *et al.*, 1999). This will be referred to in this paper as the 1996 Treaty.

3. TREATY OF 1996

The water sharing treaty of 1996 covered a 10-day period in each of the five months from January to May. The water sharing formula presented below (Table 1) granted at least 35,000 cusecs of water to both Bangladesh and India.

Table 1: 1996 Water sharing arrangement between Bangladesh and India for the Ganges River

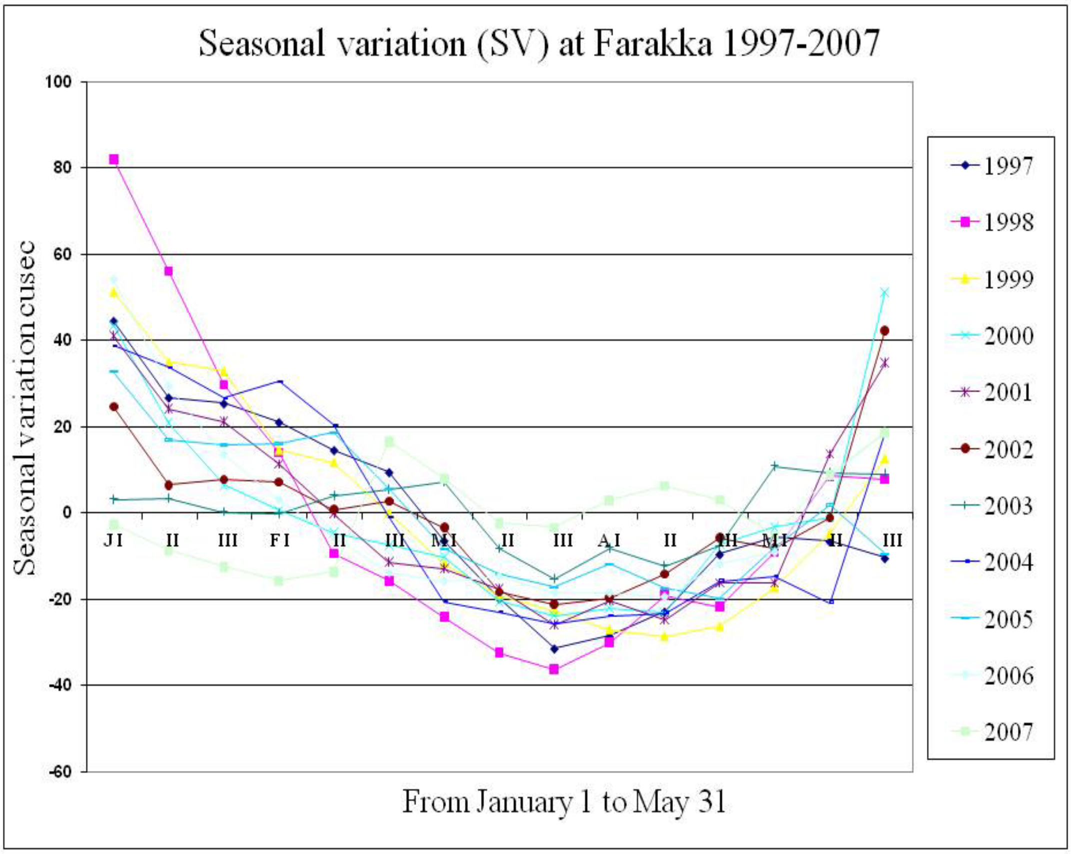
Availability at Farakka	Share for India	Share for Bangladesh
70,000 cusecs or less	50%	50%
70,000 - 75,000 cusecs	Balance of flow	35,000 cusecs
75,000 cusecs or more	40,000 cusecs	Balance of flow

Table1 shows that accurate estimation of flow availability at the Farakka Barrage in the Ganges River is essential but that it is subject to natural variability. To assess flow variability from 1997 to 2007, we used the median range estimator of standard deviation because it is relatively insensitive to occasional large shifts in the process. The estimated standard deviation ($\tilde{\sigma}$) is calculated from the median of the range multiplied by 1.047. The factor of 1.047 is based on an assumption of a random sample from a normal distribution, although it is irrelevant for calculating the statistical significance. The average flow availability and shifts in the process are shown in Table 2.

Table 2: Assessing the flow variability in the Ganges River Basin from 1997 to 2007 (flow rates in cusecs)

Year	Mean	Median	Standard deviation	Estimator of Std. deviation	Inter-quartile ranges (IQR)
1997	70911	66449	15427	69572	20488
1998	113630	102022	37293	106817	41705
1999	89821	87236	21960	91336	29505
2000	91393	87201	20186	91299	13541
2001	74128	69837	16063	73119	23798
2002	86646	85233	14530	89239	15644
2003	82290	84627	7717	88604	11600
2004	85524	78569	20496	82262	36838
2005	72699	68749	11601	71980	20602
2006	62225	57618	12829	60326	15393
2007	78675	78015	9782	81681	13046

The values of the median range estimator of standard deviation are substantially larger than the standard deviation. Therefore, there is reason to suspect occasional shifts in the mean. Moreover, the interquartile range shifts under the mean process. Figure 1 shows the clear flow variability that occurred from 1997 to 2007. Figure 1 also shows how the seasonal availability of flow at Farakka in the non-monsoonal season continuously declined from 1997 to 2006. Eventually, in 2007, seasonal variation was reduced but the average flow availability in 2007 still only remained close to the 11-year average.



J=January, F=February, M=March or May, A=April, I=1-10,II=11-20,III=21-30

Figure 1: Average seasonal variation (percentage) at Farakka 1997-2007

We may summarise that indeed, flow availability at Farakka is a crucial factor to resolve the water sharing constraints between Bangladesh and India. In order to implement the water sharing formula shown in Table 1, there is a need for flow augmentation of the Ganges River by water transfer from a third upstream country, Nepal.

4. OPTIMISATION OF WATER DIVERSIONS

The strategy is based on water transfer from Nepal to India then for water diversion from India to Bangladesh. Initially, we will consider India's situation without water augmentation. We will presume the additional amount of water transferred by Nepal will affect India's welfare, and we will compare this to the situation without water flow augmentation.

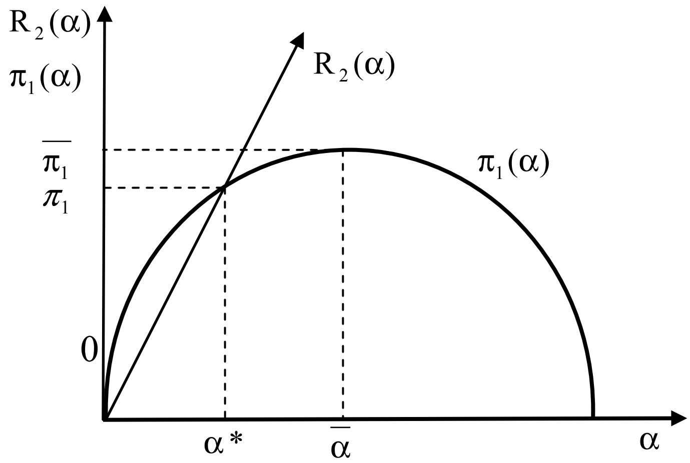


Figure 2: Optimal level of water diversion by India

We will also assume that India's water scarcity is not extreme. It follows that India's profit function is concave in diverting an amount α. We also consider it justified to diminish the marginal productivity of water utilization and to assume a negative second order profit condition, as shown in Figure 2. From Figure 2, the producers in India could maximize their profit up to the net marginal benefit of increasing sharing diversion upstream equal to the marginal cost. Secondly, we will assume that there is no provision for additional water supply from Nepal and there no longer exists a credible threat from Bangladesh in response to India increasing the diversion, α. Then India has a unilateral option to divert water, and the efficient rate of water utilization corresponds to the optimal level of water diverted, α. We define the function, $\omega_1 = f(\alpha)$ to ensure that the net benefit or profit will be at an optimal level $\bar{\pi}_1$ in Figure 2 and profit through choice of α is $\pi_1 = (p-c)p_1(\omega_1, v_1)$. Therefore, the first order condition maximizing the profit is $(p-c)\frac{\partial(p_1)}{\partial(\omega_1)}\frac{\partial(\omega_1)}{\partial(\alpha)} = 0$ which shows that the profit to India will be maximized when the marginal benefit of water diversion equals zero. Since the function $\omega_1 = f(\alpha)$ is convex, the slope of the profit function with respect to the share of water diversion will be positive when $\alpha < \bar{\alpha}$ and conversely is negative when $\alpha > \bar{\alpha}$, where $\bar{\alpha}$ is the optimum level of diversion.

In the above situation we assume that usage of water is a fixed proportion of the availability of water and is a function of α. A lower rate of water utilization would require a lower value of α. This lower value represents an under-utilization condition which generates lower profit for the producer. Similarly, from Figure 2, over-utilization of water will ensure a lower profit $\pi < \bar{\pi}$, because of the diminishing marginal productivity of water and a negative second-order profit condition. If there is no credible threat from Bangladesh, India could maximize its profit $\bar{\pi}$ by diverting a share $\bar{\alpha}$ of water upstream and allocating the rest to flow downstream to Bangladesh. In Figure 2, we can compare the results and see that water transfers from Nepal will reduce the profit to India. When water transfers from Nepal take place, it forces India to face an additional cost to increase the diversion, α. Therefore, if Bangladesh buys water from Nepal then India's optimal share of water diverted upstream, α*, will be less than the optimal level of water diverted by India in the unconstrained case, α. In such a case, India would be better off without a water augmentation treaty. This perhaps better explains why in the past India has strongly resisted efforts by Bangladesh to couple any agreement on water sharing with proposals for augmenting the Ganges' dry season flow with water transfers from Nepal.

5. CONCLUSIONS

Our analysis suggests that India would be strongly motivated to ignore the provisions of the treaty and to decide how much water to divert, as indicated in Figure 2. However, a water augmentation treaty between Bangladesh, India and Nepal not only provides additional water to both downstream countries in times of chronic scarcity but also gives Bangladesh a mechanism for deterring India from violating the Ganges River Treaty and deciding unilaterally to divert more water at the Farakka Barrage. In this regard, a water augmentation treaty is likely to reinforce the existing Ganges River Treaty.

6. ACKNOWLEDGEMENTS

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