18 Industrial Water Demand in India

Challenges and Implications for Water Pricing

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Introduction

In India, industry is the second highest consumer of water. The main sources of water for the industrial sector are groundwater and surface water. Groundwater has emerged as an important source to meet the water requirements of industries. Choice of source of water depends on the availability of sufficient and regular supply of water and the cost of water from the source. While the running cost of surface water is mainly the price paid to the supplier—the municipal bodies; the cost of groundwater is the extraction cost—energy used (electricity/diesel). Since the prices of all the inputs, water, electricity, and diesel are administered or regulated by the government, the inefficient use of water remains a normal practice. Since the surface water supply from municipal sources is not sufficiently guaranteed, industrial units tend to depend on groundwater.

Industrial water demand has been increasing with the pace of industrial development. The growth in some of the water intensive industries has been quite significant, putting further pressure on the industrial demand for water. While the annual growth in the chemical industry and construction has been around 9 per cent, it has been around 6 per cent in textile and food since the 1990s and 5 per cent in paper and paper products industry.

Quantity Dimension

In India, there are no accurate estimates of water consumption by the industrial sector. Different agencies report different figures of water use by the industrial sector. For example, according to the Ministry of Water Resources, the industrial sector accounts for about six per cent of the total freshwater abstraction at the beginning of this century, and the Central Pollution Control Board (CPCB) reports that the figure may be eight per cent. The allocation of freshwater resources is given in Table 18.1. However, the World Bank estimates that the current industrial water use in India is about 13 per cent of the total freshwater withdrawal in the country and the water demand for industrial uses and energy production will grow at a rate of 4.2 per cent per year, rising from 67 billion cubic metres in 1999 to 228 billion cubic metres by 2025. All these estimates reveal that the industrial water demand is not negligible in India and that it is bound to grow in the coming years.

Quality Dimension

Industries not only consume water but also pollute it. According to the *World Development Report* (WDR) of 2003, in developing countries, 70 per cent of industrial wastes are dumped without treatment, thereby polluting the usable water supply. Note that industrial water

Table 18.1 Estimates of Sectoral Water Demand in India

Category	*1990 billion cubic metres (per cent)*	*2010 billion cubic metres (per cent)*	*2025 billion cubic metres (per cent)*	*2050 billion cubic metres (per cent)*
Irrigation	460 (88.6)	536 (77.3)	688 (73)	1008 (70.9)
Industries + Energy	34 (6.6)	41.4 (6)	80 (8.5)	143 (10.1)
Total (including others)	519	693	942	1422

Source: National Commission for Integrated Water Resources Development Plan, Ministry of Water Resources, 1999, as cited in Centre for Science and Environment [CSE] (2004).

demand is not the demand for water as in other sectors, as a large part of the water withdrawn for industrial use is discharged as polluted water by the industries. According to CSE (2004), on an average, each litre of wastewater discharged further pollutes about 5–8 litres of water which raises the share of industrial water use to somewhere between 35–50 per cent of the total water used in the country, and not the 7–8 per cent that is considered as the industrial water use. Polluted water is very rarely used by industries. Table 18.2 provides estimates of water consumption and wastewater generated by different industries in India.

There is rampant increase in water use and wastewater disposal due to a lack of clear environmental policies as well as fragmented responsibility and control over water used for industrial purposes (CSE 2004). The future demand will inevitably put pressure on the available freshwater resources, both due to water consumption and water pollution. To add to this, India scores poorly in terms of industrial water productivity which at US$ 3.42 m^3, is among the lowest in the world (Table 18.3). Current effluent standards use concentration as the measure of contamination, encouraging the practice among industries to dilute polluted water until acceptable norms are met, rather than controlling pollution at the source and limiting the total load discharged in water bodies. Relatively clean or reusable water polluted by industrial effluents renders this unfit for irrigation or other consumption and effectively represents a consumptive loss.

Table 18.2 Wastewater Generation and Water Use by Different Industries in India, 2004

Industrial Sector	*Annual wastewater discharge (million cubic metres)*	*Annual consumption (million cubic metres)*	*Proportion of total water consumed in industry (per cent)*
Thermal power plants	27,000.9	35,157.4	87.87
Engineering	1551.3	2019.9	5.05
Pulp and paper	695.7	905.8	2.26
Textiles	637.3	829.8	2.07
Steel	396.8	516.6	1.29
Sugar	149.7	194.9	0.49
Fertilizer	56.4	73.5	0.18
Others	241.3	314.2	0.78
Total	30,729.2	40,012.0	100.0

Source: CSE (2004).

Table 18.3 Industrial Water Use Productivity for a Group of Select Countries, 2000

Country	*Industrial value added (IVA), 2001 (in billion constant 1995 US$)*	*Industrial water use, 2000 (km³/year)*	*Industrial water productivity (IWP), 2000 (US$ IVA m³)*
Japan	1890	16	119.62
Korea, Republic of	286	3	93.66
UK	340	7	47.28
The Netherlands	120	5	25.17
Germany	748	32	23.43
USA	2148	221	9.73
China	594	162	3.67
India	120	35	3.42

Source: United Nations Educational Scientific and Cultural Organization (UNESCO) and World Water Assessment Programme (WWAP) (2006) as cited in Van-Rooijen et al. (2008).

Industrial Water Pricing and Price Elasticity of Demand

Price Elasticity of Demand for Water in India

Water is used by many industries as an input, like all other inputs during the process of production. Therefore, the demand for water depends, among other factors, on the demand for the final products and hence is a derived demand. The relationship between inputs and the final products is explained by the economic theory of production. It provides a useful framework for examining industrial water use and its sensitivity to the prices that is, its elasticity[1] (Spulber and Sabbaghi 1994; Renzetti 2002; and Kumar 2006) Moreover, the industrial sector may have substantially more choice over some aspects of water use than typical households, and may have ready availability of different qualities of water, including intake water, water recycling, treatment of water prior to use, and water discharge. However, the price of water that a firm pays for its use determines the demand for it to a large extent.

Poor water pricing is one of the main reasons for its inefficient use by the industrial sector. In India the cost of water has three components: Water Cess paid to the pollution control boards, cost of buying water from the suppliers such as municipalities, and cost of extracting water from the sources such as rivers or groundwater (CSE 2004). According to the Water Cess Act, 1977 (Prevention and Control of Pollution) which has been revised a couple of times, the industrial sector is required to pay a price for the use of water. However, the rate of cess is very low and the purpose of the cess is not to encourage efficient use of water but to collect resources for financing state pollution control boards. Even from the point of view of the total production cost, the water cess is insignificant. For instance, in two major water consuming industries, pulp and paper and iron and steel, even with at new rates the water cess will constitute only about 0.1–0.2 per cent and 0.02–0.05 per cent of the total value turnover, respectively (CSE 2004).

Similarly, the water supplying agencies such as municipalities do not charge according to the marginal cost of supplying water, and charges at most follow the simple average cost pricing rule which ignores the opportunity cost of water. The extent of implicit subsidy

[1] This sensitivity of demand for water to these factors is described as elasticity of demand of water. Own price elasticity provides the response of quantity demanded to its own price while cross price elasticity gives the response with respect to the price change across products. Generally all own price elasticities have a negative sign, implying an inverse relationship between the price of an input and its quantity demanded. The cross elasticity may be negative (for substitutes) or positive (for complements) depending on the substitutability of inputs.

becomes apparent when we compare the price charged by these public water supplying agencies to the price paid by industries in water-scarce regions to commercial water suppliers. In water-scarce areas of Gujarat and Tamil Nadu some firms are already paying Rs 25–60 per kilolitre (CSE 2004). Similarly, the cost of negative externalities arising from the damages caused by industries in polluting surface water and groundwater are ignored in determining water tariffs. Instruments that charge negative externalities such as pollution taxes and/or effluent charges do not exist. As a result, from an economic viewpoint, excessive quantities of water are used, and excessive pollution is caused. Goldar (2003) finds that on average industry pays just Rs 1.94 per kilolitre.

To find the opportunity value of water, Kumar (2006) estimates the shadow price of water for industrial use in India for major water polluting industries.[2] A shadow price is the maximum price that a firm is willing to pay for an extra unit of a given limited resource, that is, water. The value of the shadow price can provide a powerful insight into the gap between the price of water which is actually being paid by the firms and the price which the firms may be willing to pay to meet the demand. He estimates the average shadow price of water to be Rs 7.21 per kilolitre. It is also found that there is a wide variation in price across firms and industries (see Table 18.4). The variation may be due to the difference in water intensity, as measured by the ratio of water consumption to sale value, among the industries. The correlation coefficient between the shadow price of water and water intensity is 0.32. While the correlation is 0.68 for firms in which the intensity of water is more than one kilolitre/unit of output (million Rs), it is 0.14 for firms in which the water intensity is less than one kilolitre/unit of output (million Rs). This implies that higher the water intensity, higher would be the shadow price. The difference between the actual price paid and its opportunity value, therefore, indicates the existence of ample scope for introducing a higher water price for the industrial use. This also implies that water shortage in industries would constitute a significant cost in terms of lost industrial output.[3]

Table 18.4 Shadow Price of Water

Name of Industry	*Number of observations*	*Shadow Price of Water (Rs/Kl)*
Leather	09	1.161
Distillery	18	6.752
Chemicals	48	3.164
Sugar	114	4.862
Paper and Paper Products	33	30.535
Fertilizers	18	2.465
Drug and Pharmaceuticals	06	3.919
Petrochemicals	09	1.396
Misc.	21	3.026
All	276	7.209

Source: Kumar (2006).

Kumar (2006) also estimates the cross elasticity and own price elasticity for industrial use of water. Since firms use different inputs such as labour, capital, materials, and water, for each of these inputs, both own price elasticity and cross price elasticity have been calsculated. Table 18.5 presents these elasticities at their mean values. All own price elasticities have the expected negative sign, implying an inverse relationship between the price of an input and its quantity demanded. It should be noted that the own price elasticity of industrial water use, contrary to the domestic sector, is quite high, –1.11 at the sample mean. This result suggests that demand for water is very sensitive to its own price and hence a suitable pricing policy can be a potential instrument for water conservation.

Elasticity of Demand for Water—An International Comparison

The estimated elasticity of water in the present analysis is close to that obtained by Wang and Lall (2002) for the Chinese economy, at approximately -1.0 and by Feres and Reynaud (2003) for the Brazilian economy

[2] Kumar (2006) uses the data collected for a sample of water polluting industries by the Institute of Economic Growth. For details, see Murty and Kumar (2004).

[3] The serious adverse effect that water shortage has on industrial production has been analysed by Bhatia et al. (1994) in the context of India and some other developing countries.

Table 18.5 Mean of Cross and Own Indirect Price Elasticity of Input Demands

	Materials	*Wage bill*	*Capital stock*	*Water*
Materials	–3.73	6.94	8.55	125.00
Wage bill	3.42	–1.92	4.55	142.86
Capital stock	3.70	3.05	–1.70	–111.11
Water	1.27	0.81	–3.19	–1.11

Source: Kumar (2006).

(see Table 18.6). However, since Wang and Lall (2002) adopt a marginal productivity approach and Feres and Reynaud (2003) adopt a cost function approach to derive elasticity estimates, any comparison between the two has to be made with caution.

The estimates of own price elasticity of industrial water for India (Kumar 2006), China, and Brazil are higher than those obtained by Onjala (2001) for India. These differences are largely due to methodological differences between the studies. The water price used by Kumar (2006) corresponds to the marginal cost whereas the prices paid by Indian firms are far below this level. This may have led to an upward bias in his estimates. The same upward bias could be present in Wang and Lall (2002) and Feres and Reynaud (2003). Moreover, the three studies of India, China, and Brazil are related by and large to medium and large plants, which tend to have higher water price elasticity than small ones. Since large firms withdraw high volumes of water, they face high incentives to invest in water-recycling/conservation activities if the pricing of water is efficient. Water recirculation being a substitute to water withdrawal, these firms would have higher water withdrawal price elasticity (Reynaud 2003). In developing countries, it should be noticed that water is not a scarce resource in the sense that firms do not face any stringent water resource constraint. Water is often an under-priced or un-priced intermediate input in these countries. In such a context, firms are likely to overuse water resources and the marginal productivity of water tends to be low, as reported by Wang and Lall (2002). This may result in high responsiveness to water prices, since any increase in water prices would lead to substantial cut in water withdrawals.

Table 18.6 Price Elasticity of Demand for Water in Selected Countries

Name of the Country (Source)	*Price Elasticity*
India (Kumar 2006)	–1.1
China (Wang and Lall 2002)	–1.0
Brazil (Feres and Reynaud 2003)	–1.08
Kenya (Onjala 2001)	–0.60 to 0.37
India (Goldar 2003)	–0.64 to –0.4
US manufacturing (Grebenstein and Field 1979)	–0.80 to –0.33
Canadian Manufacturing (Babin, Willis, and Allen 1982)	0.59 to –0.15
French Manufacturing (Reynaud 2003)	–0.29

The cross price elasticities as shown in Table 18.5 (off-diagonal cells) indicate that water is found to be a substitute for capital and a complement to materials and labour. Substitution between capital and water was also observed by Dupont and Renzetti (2001) and Feres and Reynaud (2003), in contrast to previous results from Grebenstein and Field (1979) and Babin, Willis, and Allen (1982), where water was found to be a substitute for labour and a complement to capital.

The substitutability between water and capital implies that as the price of water increases the industry employs more of capital. As the price of water increases the industry may try to reduce water consumption by investing in water conserving/recirculation technologies. Water conservation/recirculation is generally accompanied by reduction in energy costs, recapturing valuable raw materials and reduction in effluent stream (Dupont and Renzetti 2001). Therefore, the complementarity between water and materials found by Kumar (2006) is in conformity with Dupont and Renzetti.

The estimated price elasticities of water point to the fact that despite different estimates, demand for water in India is not only highly sensitive to its own price but also to the prices of other inputs such as capital, labour, and materials. While own price elasticities of water in India are higher than those in developed countries, they are comparable to other similarly placed developing countries. A suitable water pricing policy and incentive structure for efficient use of water may go a far way in rationalizing the use of water by the industrial sector in India.

Industrial Water Regulations

The problem of industrial water (mis)management is fairly obvious. First, there is a lack of effective regulations and coordination between regulatory bodies. Second, there are few incentives provided to industry for efficient water use. Water tariffs, where they exist, are very low and otherwise ignored. As a result, conflicts between industry and local communities are on the rise over water allocation and water pollution. Depletion of groundwater by industries, diversion of water meant for irrigation to industries, and preferential treatment given to industries by the government are some of the major reasons for the conflict between industry and community over water use (CSE 2004). Protests and public interest litigations have become quite common on this issue. In India, where every segment of the economy is growing rapidly, and domestic, agricultural, and industrial water needs are pitted against each other, the conflict will become unmanageable if it is not addressed now.

In India there is a multiplicity of authorities/ministries with different mandates which are often vaguely defined and overlapping, for example, the Ministry of Water Resource (MoWR) is the principle agency responsible for water in India but water pollution does not fall under its purview, nor does the industrial use of water. Similarly, the Ministry of Industry (MoI) is concerned with the planning and development of water resources for industrial use. It has no mandate to control or regulate water use by industries. The Central Groundwater Board (CGWB) is meant to regulate the groundwater quality and quantity in the country. Though they have mandate to do what they can with groundwater, they have so far only mapped the groundwater status. They have no mandate to charge for industrial groundwater use. While the CPCB and state pollution control boards (SPCBs) regulate industrial water pollution and charge water cess based on the amount of wastewater discharged by the companies, they have no mandate to control sourcing of water from various sources. As a result, water conservation and pollution control measures have not shown any significant success.

Groundwater Regulations

In India, as of now, there is no law determining the exact amount of water meant for consumption by the various industrial sectors. Though CPCB has prescribed water consumption levels for some industrial sectors, they are mere recommendations and cannot be enforced by laws. Laws related to groundwater extraction are also obsolete. As per the law, the person who owns the land also owns the groundwater below. Though this law has some relevance as far as the domestic groundwater use is concerned, it is illogical for industrial and commercial use. The consequence of such laws is that industries withdraw groundwater that remains unregulated and un-priced.

The Scheme on Artificial Recharge of Groundwater through dug wells in hard rock areas in seven states is facing problems due to the overexploitation of groundwater. Pursuant to the announcement made by the Honourable Minister of Finance in his Budget Speech, 2007, a State Sector Scheme on 'Artificial Recharge to Groundwater through dug wells' during the Eleventh Plan is under implementation in 1180 over-exploited, critical, and semi-critical blocks in the seven states namely, Andhra Pradesh, Maharashtra, Karnataka, Rajasthan, Tamil Nadu, Gujarat, and Madhya Pradesh at an estimated cost of Rs 1798.71 crores. The scheme aims to facilitate improvement in the groundwater situation in the affected areas, increase the sustainability of wells during lean period, improve quality of groundwater, and involve the community in water resource management in the affected areas.

Industrial Water Recycling

The effluent discharged by industries in rivers leads to many health related problems and causes loss of agricultural production to the villagers who live downstream. Industries must be made to invest in the up-gradation of their pollution control equipment for effluent treatment. They should be motivated to reduce their water consumption through regulation or incentives. However, water use and water pollution in industries can be reduced only if water pricing is such that it encourages industries to conserve water. There are instances which clearly prove that proper pricing of natural resources is essential for proper management of natural resources and this, in turn, has a direct bearing on efficient water management.

Industrial Wastewater Management

The wastewater treatment system by most of the industries are essentially installed to meet the wastewater discharge norms, which are concentration based, that is, they measure the concentration of pollution in a given quantity of water. The result is that an industry can meet the required standard merely by diluting the effluent with clean water. Since the cost of water is low, it makes more economic sense for an industry to dilute the effluent than to treat it to meet the standards.

The industries do not have the incentives to recycle and reuse the wastewater. Water once used is generally thrown without any further use, even if it can be reused. Segregation of wastewater from various processes into clean wastewater (that can be reused), and contaminated water, is not commonly done. The result is that even the uncontaminated water gets contaminated after mixing and is discharged as effluent.

Conclusion

Industrial water demand in India is on the rise. Also water use in Indian industry is very high due to a combination of factors including obsolete process technology, poor recycling and reuse practices and poor wastewater treatment. There is very low level of awareness about the problem and needs for wastewater treatment by industry.

Efficiency of utilization in all the industrial uses of water should be optimized and an awareness of water as a scarce resource should be fostered. The water resources should be conserved and its availability increased by maximizing retention, eliminating pollution and minimizing losses. Conservation consciousness should be promoted through education, regulation, incentives and disincentives. Though some of the issues related to the industrial water have been addressed in National Water Policy (NWP) 2002 but no clear vision for regulating and controlling industrial water use has been given.

The key to the problem lies in effective management of water resources. Suitable measures including improved process technology; effluent treatment; reuse of process water for more than once; re-circulating of process water in the same use for a number of times; rainwater harvesting; waste-minimization must be adopted. Coordination among different authorities/ Ministries is a must if the future water conflicts are to be avoided.

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