Assessing Net Economic Gains from Domestic and Industrial Water Supply: Cases from NRLP Schemes

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Summary

This paper attempts to identify and evolve a method for valuing and estimating the net gains from domestic and industrial water supply from the interbasin transfer schemes contemplated in the National River Link Project (NRLP). An existing interbasin transfer (IBT) scheme, namely Indira Gandhi Nahar Project (IGNP) and a proposed IBT scheme namely Polavaram-Vijaywada (PV) Link Canal were chosen for detailed analyses. Secondary data were used for identifying the region and the populations that benefited from the schemes. Economic gains arising out of water supply to the actual or potentially benefited areas were estimated. The estimation involved assessment of current costs incurred by the people in the area, in terms of both paid-out costs and time spent in fetching water. The saving in time was valued at market wage rates prevalent in the area and paid-out costs were assessed in terms of current market prices, ignoring the administered prices involved. The gains to urban populations were assessed by estimating the reduction in energy costs incurred by municipal authorities in undertaking the supply. Amortized capital costs for putting necessary hardware for distributing water from the IBT schemes as well as operation and maintenance (O&M) costs of running these schemes were netted from the gains to obtain the figures for net economic gains. More indirect benefits such as reduced drudgery or improved educational performance as well as reduced health expenditure were recognized but were all ignored to ensure greater robustness in the estimates. Only net gains to the society were considered and hence gains arising out of creation of industrial estates within the commands were ignored since similar gains could also be obtained by locating these estates elsewhere. The net economic gains are seen to depend on both demographic features of the region and its ecology. Desert-like conditions of the IGNP-benefited areas tend to make the gains from domestic water supply schemes large, while similar gains in the Polavaram-Vijaywada areas are smaller. The net economic gains are of a significant order and would seem to indicate that, at least insofar as the dry areas of the country are concerned, these can perhaps exceed the gains due to increased agricultural production and hence could perhaps justify the creation of the schemes by themselves.

Introduction

The proposed project to build 37 links between the Himalayan and peninsular rivers in the country, together called the National River Link Project (NRLP), is a huge program, which would change the face of the countryside. It envisages transferring of some 178 billion cubic meters (Bm^3) of water through these links and making large quantities of water available for irrigation and other uses. The project does envisage benefits on three fronts: bringing additional areas under irrigation for producing the food that would be required to feed an estimated population of 1,580 million in the country; producing a huge amount of electricity by installing hydropower projects on the Himalayan rivers; building infrastructures useful for accomplishing water transfer, and delivering the supply of water for domestic and industrial uses in water-starved southern and western peninsular regions. Much discourse about the project revolves around the appropriateness of providing such extra irrigation through the link schemes while significant attention has also been given to aspects of environmental impacts and seismic stability of the structures on the Himalayan rivers. We believe that huge benefits of the project are in the supply of drinking water to literally millions of households and also in enabling industrial activity to take place in areas starved of water. We suggest that the economic benefits accruing from these end uses are likely to be far more significant than the irrigation benefits, particularly as there may be few alternatives to large-scale IBTs for supporting dozens of thickly populated and growing urban centers.

According to recent experience from several large dams in the country (e.g., Narmada Dam, Jayakwadi Dam on the Godavari and scores of smaller projects elsewhere), they may be economically justified by looking at agricultural production they have enabled and the electricity produced on these structures. Their contribution is most striking in enabling the concerned state governments to augment and stabilize water supply for domestic purposes to cities, towns and villages and in supplying water to industrial estates. The Jayakwadi, for instance, not only sustains cities of Aurangabad and Jalna and several smaller townships by supplying drinking water but has enabled the Walunj and other industrial estates to flourish. The case of the Narmada Dam is even more pertinent. The project has not started irrigating more than a fraction of its proposed command but already the project has enabled the state government to augment and strengthen the water supply in over 200 cities and towns and in a few thousand villages. In fact, the Government of Gujarat has been proud in proclaiming its achievements in solving the drinking water crisis facing the difficult Saurashtra and Kutch areas. The case of many other projects originally designed as irrigation schemes is similar: the Pench project has turned out to be a boon in supporting the 3 million strong Najaur City; but for the Upper Wardha project, the neighboring Amravati District would have continued to face tough problems; the Nagarjuna-Sagar Dam gives water through the Telugu Ganga canal to Chennai City; Ujani supports Solapur and soon Godavari water will be taken to support Hyderbad-Secunderabad.

The premise of this exercise is that irrespective of the planning objectives of the projects and the economic rationale on which they are justified, the various projects in the NRLP will, in fact, be used, whether directly or indirectly (through the substitution route), to a significant extent to address the question of supplying drinking water to populations facing the threat of unreliable water supply and to augment water supply to industrial estates and units which would find it difficult to carry out their industrial activities without water supply. The exercise looks at one existing instance of interbasin transfer of water (namely the IGNP, from the Indus to the Luni and other basins) and one proposed Polavaram-Vijaywada (PV) Link which would be one of the elements of the NRLP design.[1]

The exercise is aimed at arriving at a broadly acceptable estimate of the (actual in case of IGNP or likely in the second case) net economic gain resulting from the use of water from these projects for domestic and industrial purposes. The tasks involved in the exercise include identifying the benefits in the industrial and domestic water supply that can be attributed to these projects, estimating the quantum of these gains and valuing them.

The Study Area

The tasks of identifying attributive gains relate to identifying geographic areas covering cities, towns, villages and industrial estates to which the water from these projects actually flows or will actually flow. For this purpose, the use of maps and other secondary materials from concerned government offices is resorted to. The task of estimating the volume of gain consists of identifying the current and potential water needs of geographic areas where the gains due to water can be attributed to these schemes. This is an exercise in the projection of demographic changes and possibly industrial growth. The former is relatively simple and in conjunction with the work done under NRLP on demographic changes last year, it can be accomplished without much effort. The latter is speculative since the industrial growth in a region is a determinant of several factors, one of which is uninterrupted and adequate supply of water. Valuation remains an issue and will be discussed later.

Indira Gandhi Nahar Pariyojana

The Indira Gandhi Nahar Pariyojana (IGNP) with a command area of 1.543 million hectares (Mha) is the largest irrigation and drinking water project in northwestern Rajasthan. The project was taken up in three stages. The first stage has already been completed, the second was recently completed and the third is under execution. Stage II area of IGNP starts from Pugal and comprises the main canal from 620 RD to 1458 RD. The main canal gets water from the Sutlej River in Punjab through a feeder canal.

The climate of the region is arid with an average annual rainfall of about 200-250 mm. The temperature ranges from freezing point in winter to above 50^{o} C in summer. The area covered by the IGNP consists of sandy undulating plains with various types of low-to-medium sand dunes. The thickness of sand cover varies from a few centimeters to 200 meters (m). The top aeolian soils have high permeability but the underlying sediments, comprising silty clay and *kankar*, have low permeability. Prior to introduction of the canal irrigation, only rain-fed agriculture was practiced. But the introduction of canal irrigation has changed the cultural practices. Groundwater was also not generally available before the introduction of this canal system. Barring a few sweet water locations along buried channels, groundwater where present, was deep and saline. The main cause of the rise in water tables in IGNP Stage-

[1]The Government of Andhra Pradesh (GoAP) has proposed the Pollavaram Dam and the link canal to Vijaywada irrespective of the realization of the NRLP design. However, the same dam would be a link between the Mahanadi-Godavari scheme on the one hand and Godavari-Krishna (Pollavaram-Vijaywada) Link on the other.

II command is the presence of a hard pan at shallow depths. This pan restricts the downward movement of the groundwater, resulting in the formation of perched water tables.

The main soil types of the study area are deep and calcareous flood plain soils and sand dunes. The geology of the area is marked by aeolian sand and alluvium of quaternary age forming extensive sandy plains. Alluvium is mostly fluvial in origin and comprises unconsolidated to loosely consolidated sediments, consisting of an alternate sequence of sand, silt and clay with frequent lens of silty clays and kankar with occasional gravel horizons. Groundwater occurs in these alluvial sediments under water-table conditions. Groundwater is generally saline in most parts of the study area. The important components of groundwater recharge in the area are the IGNP canal system and their distributaries, Ghaggar Diversion Channel (constructed to divert the floodwater of Ghaggar River to inter-dunal depressions) and inter-dunal depressions south of Suratgarh. A substantial part of recharge is contributed by return flow of irrigation water and some by annual precipitation. The groundwater level in the area has been rising since the commencement of canal irrigation leading to waterlogging in the area. This high rise in groundwater levels has led to systematic monitoring of groundwater levels from the year 1981-82.

Polavaram-Vijaywada Link Canal Area

Andhra Pradesh is bestowed with 108 Bm^3 of water from groundwater, local and interstate rivers out of which only 78 Bm^3 are usable (GoAP 2003 b) . The present total use is about 62.3 Bm^3 which are expected to reach 113 Bm^3 by 2025 assuming that 3.5, 108, 1.4 and 0.1 Bm^3 are required for drinking water, irrigation, industries and for power generation, respectively, Hence, by 2025, the total water demand would have crossed the total availability.

Besides, about 36% of rural habitations and 72% of urban bodies still do not have adequate drinking water facilities. The key water challenge in the state is increasing demand for industrial and domestic water, which will have to be met from the present allocation to the agriculture sector.

Long-distance interbasin transfer of water from water-surplus basins to water-deficit basins has been mooted in India in order to reduce the imbalance in the water availability among various regions. A National Perspective Plan (NPP) was formulated in 1980 by the Union Ministry of Irrigation (now Ministry of Water Resources) and the Central Water Commission, identifying a number of interbasin water transfer links in respect of both the peninsular and the Himalayan rivers of the country. The Peninsular Rivers Development and the Himalayan Rivers Development components put together were expected to create an additional irrigation potential of 35 Mha besides hydropower potential and other benefits.

The interlinking of Mahanadi–Godavari-Krishna-Pennar-Cauvery is one of the four parts of the Peninsular Rivers Development Component of the NPP. Amongst the peninsular rivers, the Mahanadi and the Godavari have sizeable surpluses after meeting the existing and projected requirements within the basins. It is, therefore, proposed to divert the surplus water of the Mahanadi and the Godavari to the water-short river basins: the Krishna, the Pennar and the Cauvery. Three water transfer links have been proposed, connecting Godavari to Krishna, forming part of the interlinking. They are: (i) Inchampalli-Nagarjunasagar, (ii) Inchampalli-Pulichintala, and (iii) Polavaram-Vijayawada. This report deals with the feasibility of the third link, i.e., diversion of a part of the surplus Godavari water from the proposed Polavaram Reservoir to the Prakasam Barrage on the Krishna River through the Godavari (Polavaram).

The National Water Development Agency (NWDA) has been carrying out water balance and other studies on a scientific and realistic basis for optimum utilization of water resources for preparing feasibility reports and thus to give concrete shape to the proposals of the NPP. The objective of preparing the feasibility report is mainly to facilitate firming up of the proposals and for discussions among the concerned states to arrive at broad agreements on the quantum of diversions and utilizations of water, sharing of cost and benefits, etc. This report has been prepared keeping in view the various comments offered by the governments of Andhra Pradesh, Madhya Pradesh and Karnataka on the topo-sheet study and pre-feasibility study of the Godavari (Polavaram)-Krishna (Vijayawada) Link project.

The Godavari Water Disputes Tribunal (GWDT) award stipulates, among other provisions, transfer of 2,265 Mm^3 of water from Godavari at Polavaram to Krishna above the Prakasam Barrage at Vijayawada, thereby displacing the discharges from Nagarjunasagar project for the Krishna Delta, and thus enabling the use of the above quantity for projects upstream of Nagarjunasagar. However, considering the possible full development of irrigation in the basin and projected in-basin uses for domestic and industrial requirements up to the year 2025 and also considering the proposed transfer of 6,500 Mm^3 from Mahanadi to Godavari through the Mahanadi (Manibhadra)-Godavari (Dowlaiswaram) Link, NWDA by simulation studies, has assessed that it is possible to transfer an additional quantity of 1,236 Mm^3 through the proposed Polavaram-Vijayawada Link Canal from Godavari to Krishna. An equal quantity of water can be made available for possible use in the water-short upper regions of the Krishna Basin by way of substitution. The Polavaram project has been formulated by the Government of Andhra Pradesh for the utilization of Godavari water for irrigation and other benefits by creating a reservoir and canal systems at Polavaram about 42 km upstream of the existing Godavari Barrage at Dowlaiswaram near Rajamundry. The Polavaram project will also cater to the transfer of 2,265 Mm^3 of Godavari water to Krishna as agreed to by the states concerned and reflected in the GWDT award. A detailed project report on the Polavaram project has been prepared by the Government of Andhra Pradesh. The project proposals include the construction of an earth-cum-rockfill dam across Godavari at Polavaram for creating a reservoir of 2,130 Mm^3 live storage capacity; a Left Main Canal with a capacity of 250 m^3/sec. for providing irrigation to a culturable command area (CCA) of 1,74,978 ha and supplying 664 Mm^3 to the steel plant and other industries of Visakhapatnam; and a Right Main Canal with a capacity of 453 m^3/sec. for providing irrigation to a CCA of 139,740 ha besides transferring 2,265 Mm^3 of Godavari water to Krishna. The project also includes a hydropower component for generating 60 MW of firm power with an installed capacity of 720 MW.

The Polavaram-Vijayawada Link Canal now proposed by NWDA and detailed in this feasibility report will be incorporated in the Polavaram project of Andhra Pradesh. The link canal will replace the Right Main Canal of the Polavaram project. In fact, the alignment of the link canal has been proposed to be the same as that of the Right Main Canal as proposed by the State Government.

The Godavari (Polavaram)-Krishna (Vijayawada) Link Canal takes off from the right bank of Godavari at the proposed Polavaram Reservoir. The canal, after traversing 174 km, falls into the Budameru River (which drains into the Kolleru Lake) at a point upstream of the Velagaleru regulator. From the regulator, the canal water is let into the existing Budameru Diversion Channel that, after traversing 12 km, joins the Krishna River at about 8 km upstream of the existing Prakasam Barrage at Vijayawada. Diversion of 5,325 Mm^3 of water is envisaged through the canal. This will cater to (i) a transfer of 2,265 Mm^3 to the Krishna Delta as committed under the GWDT award, (ii) an en-route irrigation requirement of 1,402 Mm^3, (iii) en-route domestic and industrial requirements of 162 Mm^3, and (iv) transmission losses of 260 Mm^3. The remaining 1,236 Mm^3 of water will be utilized for stabilizing the existing ayacut under the Krishna Delta. With 1,402 Mm^3 of water available for en-route irrigation, an area of 139,740 ha (CCA) will be benefited with 150% intensity of irrigation. The entire canal and the command areas lie in Andhra Pradesh.

The total length of the link canal from Polavaram to Budameru will be 174 km. The canal will pass through West Godavari and Krishna districts of Andhra Pradesh. The design discharge at the head of the canal is 405.12 m^3/sec. The canal will be trapezoidal and lined throughout its length. The bed width will be 68.5 m and full supply depth 4.9 m. The bed slope will be 1: 20,000. The link canal is proposed to be operated throughout the year.

The total cost of the Polavaram-Vijayawada Link project including the cost of command area development, but excluding the apportioned cost of head works, i.e., Polavaram Dam and appurtenant works, is estimated to be Rs 14,839.1 million at the 1994-95 price level. The net value of annual benefits from irrigation in the en-route command due to the project works out to Rs 2,011 million against the annual cost of Rs 1,646.274 million. Thus, the benefit:cost ratio works out to 1.22.

The structures including the main link canal pass through the districts of East and West Godavari and Krishna. These two districts have coastal alluvial soils in the east of the canal and lateritic soils on the western parts of the canal. The western parts tend to be on a higher elevation and water from the canal will not flow to them under gravity. The deltaic regions are agriculturally very rich with crops such as sugarcane, paddy, banana and oil palm. Tobacco is grown extensively on both the eastern and the western land masses of the canal. The Koleru Lake widely known for its fish production lies to the east of the canal. The region has a tropical humid climate.

Drinking Water Supply

Situation of Drinking Water in IGNP

There is widespread scarcity of potable water in the northwestern part of the state, which is the area under IGNP. In the first place, groundwater is generally saline and unfit for human consumption. Second, the existing surface water resources are not adequate or dependable. The canal has become in its true sense a "life line" for this area. When the first revised estimates for Stage-II of IGNP were sanctioned in May 1972, the available quantity of water was to be used for agricultural purposes besides meeting the drinking water requirements of the villages and *abadis* located in the command areas. Subsequently, requirements for water for drinking and industrial purposes went on increasing. A provision of 1,073 Mm^3 was kept for nonagricultural purposes in the 1984 revised estimate of the project. The Public Health Engineering Department (PHED), vested with the task of provision of drinking water, asked for more reservation of water for drinking and industrial activities in the command area on the basis of expected population rise in the following two decades.

The PHED supplies, on average, 1,344 million liters of water a day. Surface water contributes 604 million liters (45% of the total), and groundwater the remaining 740 million liters for Rajasthan (Tables 1 and 2).

Table 1. Population with drinking water facilities in Rajasthan.

District	FC	FC (%)	NC	NC (%)	PC	PC (%)	Grand total
Barmer	106,478	5.9	1,711,762	94.1	168	0.0	1,818,408
Bikaner	568,995	31.3	356,354	19.6	336,705	18.5	1,262,054
Churu	508,046	27.9	404,239	22.2	294,065	16.2	1,206,350
Ganganagar	1,077,473	59.3	127,223	7.0	140,490	7.7	1,345,186
Hanumangadh	747,088	41.1	35,583	2.0	428,425	23.6	1,211,096
Jaisalmer	50,334	2.8	355,074	19.5	26,448	1.5	431,856
Jhunjhanu	721,333	39.7	547,232	30.1	256,328	14.1	1,524,893
Jodhpur	41,567	2.3	1,640,413	90.2	231,718	12.7	1,913,698
Najaur	118,436	6.5	2,116,865	116.4	58,816	3.2	2,294,117
Sikar	519,198	28.6	786,928	43.3	509,124	28.0	1,815,250

Notes: FC=fully covered; NC= not covered; PC=partially covered.
Source: National Habitation Survey 2003, (GoI 2004).

Table 2. Sources of drinking water supply for the urban population.

Source of supply	No. of towns and cities	Quantity supplied	
		Million liters/day	Mm^3/yr
Surface water	40	604	220.5
Groundwater	151	740	270.1
Surface water and groundwater	31		
Total	222	1,344	490.5

Source: Report of the Expert Committee on Integrated Development of Water Resources, June 2005 (GoR 2005)

It is being proposed to provide water from IGNP not only for the project area but also for cities and villages located outside the command area. At present, IGNP water is being supplied to villages and towns partly or fully in eight districts. Two more districts will be added. Ultimately, a population of about 20 million located in 24 cities/towns and 5,300 villages/settlements would draw drinking water supplies form this canal by the year 2045 (GoR 2002).

Drinking Water Situation in the Polavaram-Vijayawada (PV) Link Canal

Sources of drinking water in the areas of PV Link canal are the main groundwater-based. Vishakhapattanam City slated to be among the main beneficiaries of the link in terms of supply of water for domestic and industrial applications (Table 3). At present, out of a total 65.12 Bm^3 water use, drinking water supply is 0.59 and industrial water use is 0.28 Bm^3, while irrigation receives the lion's share of 64.21 Bm^3 (GoAP 2003 b). There are several issues such as inequality in distribution of water supply in rural as well as urban areas, deterioration of water quality due to municipal/domestic, industrial and agricultural pollution, pricing of water, competing interests in the use and management of water and more efficient use of water in all the sectors.

Table 3. Drinking water in the PV Link canal area.

District	Mandalam	FC	FC (%)	NC	NC (%)	PC	PC (%)	Grand total
East Godavari	Amalapuram	36	26	1	1	102	73	139
	Biccavolu	3	17		0	15	83	18
	Peddapuram	7	28		0	18	72	25
	Seethanagaram	22	92		0	2	8	24
Krishna	Nuzvid	28	56	2	4	20	40	50
Vizag	Anakapalle	49	46	5	5	52	49	106
	Narsipatnam	8	17	4	9	35	74	47
West Godavari	Pedavegi		0		0	55	100	55
	Tadepalligudem	23	61	1	3	14	37	38

Notes: FC=fully covered; NC= not covered; PC=partially covered.
Source: National Habitation Survey 2003, Status of Drinking Water Supply, GoI 2004.

According to the Public Health and Municipal Engineering Department of the Government of Andhra Pradesh, only 33 out of 117 municipal bodies are being supplied with adequate water. An average supply of only 48 liters per capita per day (lpcd) could be achieved against the standards of 140 lpcd. Out of the 69,732 rural population in the state-protected area, water supply has been provided to only 44,951, and the remaining population is yet to be supplied with water. Nearly 75% of the rural drinking water requirement is met using groundwater, which is around 800 Mm^3 and likely to be 876 Mm^3 by the year 2020 (Table 4). Already, a population of more than 21,000 is affected with poor-quality groundwater (Panchayati Raj Rural Development Department RWS).

Table 4. Water requirement estimates of different sectors (Bm^3).

Year	Drinking water	Balance left for irrigation	Water for industries	Water for power	Total development
Present	0.59	64.21	0.28	0.03	65.12
2020	3.45	67.00	1.00	0.05	71.50
2025	3.45	107.98	1.44	0.06	112.94

Source: Andhra Pradesh Water Vision 2003 (GoAP 2003 a).

According to the Public Health and Municipal Engineering Department of the Government of Andhra Pradesh, the cost of water supply from groundwater sources (bore wells and subsurface water) is Rs 5 per kiloliter while that from surface water sources is Rs 10 per kiloliter; at the same time, the cost recovery is only Rs 2.25 per kiloliter. At present, diversion of surface water for drinking water schemes is 5 mld, 14 mld million liters per day and 10 mld from Godavari, Krishna and Pennar river basins, respectively. In the future, the quantity of water diverted will have to be increased to 414, 378 and 90 mld from Godavari, Krishna and Pennar river basins, respectively (GoAP 2003b).

Industrial Water

Industrial Water in IGNP Area

Except for some village-level wool manufacturing and leather and carpentry works, there were hardly any industries in the project area before IGNP. In 1951, there were 17 registered factories in Sri Ganganagar District, which rose to 85 in 1961. By 1980, the figure went up to 828, with 14,500 employees. The major contribution in the rapid growth of industries between 1961 and 1981 is due to IGNP, after the project commenced in this region in 1961. Now there are many agro-based industries flourishing in the project area.

Industrial Water in PV Link Canal Area

Andhra Pradesh ranks sixth in industrial production in India. Major industries cover information technology, bulk drugs and pharmaceuticals, basin chemicals, agro-processing, mineral-based industries, metal industries, engineering, textiles, leather, cement, sugar, power, fertilizers, gems, jewelry, papers, petrochemicals, etc. There are 242 industrial estates in the states, 3,055 medium- and large-scale units, 16,000 registered factories and 140,000 registered small-scale industries. A considerable concentration of industries can be found around the Hyderabad and Vishakhapatanam urban conglomeration. Employment in the industries increased from 0.4% in 1961 to 1.5% in 2000. By 2025, the industrial sector is expected to grow 13-fold at a growth rate of 11% per annum (GoAP 2003b). Industrial water requirement is likely to increase to 1.44 Bm^3 by 2025 from the present 0.28 Bm^3.

Issue of Water Quality

In the IGNP areas, water quality issues are connected with high levels of total dissolved solids (TDS) in groundwater. Fluoride contamination is known to occur in several patches in the area. The problem caused by high TDS and fluoride is exacerbating over time, and one of the chief advantages of the domestic water supply from IGNP is seen as the reduction in health syndromes arising out of poor water quality. In fact, the areas severely affected with these issues will be given priority in the supply of domestic water from the IGNP and the task of establishing relevant structures is expected to be completed by 2010.

The issues of water quality in the PV Link Canal areas are somewhat muted at this point in time. Coastal salinity ingress in the East Godavari District has been reported to be rising. Also, chemicals used in coastal aquaculture are said to be causing groundwater pollution which is on the rise in the Krishna District. The supply of drinking water to these areas is thus likely to have positive though somewhat less-prominent effects.

Review of Literature and Methods

This review mainly relates to literature pertaining to valuation of domestic and industrial water gains. Possible methods of valuation include the Techniques of Valuation (*source:*

www.ecosystemvaluation.org accessed on 5 October 2006). Historically, there are four major techniques that have been used to estimate economic value of ecosystem services. In this study we used the economic value of IBT water for domestic and industrial purposes.

Technique 1: Productivity Method or Production Function Approach

This approach is used to estimate the economic value of ecosystem services or products (in this study, IBT water), which contribute to the production of a market good (textile in the case of the textile manufacturing unit in Jodhpur). The production function approach can then be used to find out how changes in the quantity or quality of water supply through transfer of IBT water affect the quality or quantity of water in terms of price change (Consumer Surplus[2]) or cost changes (Producer Surplus[3]). This method is applicable when the particular resource in question is a perfect substitute for other substitutes for other inputs (e.g., import of fresh IBT water results in less usage of treatment chemicals of hitherto polluted groundwater). However, the method suffers from a critical problem of attribution where the particular resource may not be related clearly or solely to the production of marketed goods (that provision of IBT water may not be the sole reason why production will rise or, in other cases, may not be related to production of marketed goods as in the case of provision for drinking purposes).

Technique 2: Travel Cost Method (TCM)

The TCM is used to estimate the economic value of ecosystem services used for recreational purposes. The value of a new water body used for recreational purposes having both *use* and *nonuse* values (use value as boating and fishing and nonuse value as mere enjoyment of watching good scenery) is analyzed using TCM. The crux of this method is based on the Revealed Preference Approach where actual spending of a visitor in terms of Actual Travel Cost and Opportunity Cost of time spent in travel which are combined together and plotted against the rate of visits to derive a demand function that surrogates the *number of visits **purchased*** at *different prices*. The Consumer Surplus from this demand function is then used to calculate the economic value of this resource. Since we do not consider any recreational component in our study we opt not to use this technique.

Technique 3: Contingent Valuation Method (CVM)

The CVM is used to estimate the economic value of environments and ecosystem services and can be used for both use and nonuse values. This technique aims to compute individuals' *willingness to pay* ***contingent*** on certain hypothetical scenarios. Thus, the crux of this technique is based on the *stated preference* approach. This technique is particularly used where the value of an ecosystem service is mostly nonuse in nature and does not involve any market purchase. In this context, the import of fresh IBT water in a high TDS area will actually recharge

[2]Consumer Surplus is defined as the area between the demand curve and the price that resembles the difference between what the consumer wants to pay for a unit of good and what he actually has to pay.

[3]Producers Surplus is defined as the area between the supply curve and the market price that resembles the price at which the producer wants to supply a commodity and the price he actually gets. It can also be interpreted in terms of cost of supply where a reduction in the cost of production will actually increase the producer surplus if not reflected in the changes in the prices.

groundwater and dilute the TDS content. But this *passive use* of IBT water remains outside the market, which can be captured through this method. Although flexible, the methodology of asking people questions rather than observing their behavior has made the technique very controversial and the economic value computed using this technique is generally taken with a pinch of salt!

Technique 4: Cost-Based Method Including Damage Control, Replacement and Substitute Cost

The cost-based approach of valuation is often used to estimate the economic value of ecosystem services in terms of Damage Cost Avoided, Replacement Cost and Substitute Cost. The approach is based on the theoretical assumption that if the people incur costs to avoid damages or provision for substitute services in the absence of the service in question then the services must be worth at least what is paid to avoid, replace or substitute those services. *Damage Cost Avoided Method* uses either the value of property protected or the cost of actions taken to avoid damages as a measure of economic value of that service. In the context of this study, the cost incurred in setting up a filtration plant or reverse osmosis (RO) plant in the case of industrial use or fuel cost in boiling water in the case of domestic use would be an appropriate surrogate of value of supply of fresh IBT water for domestic and industrial purposes.

The *Replacement Cost Method* uses the cost of replacing an ecosystem or its services as an estimate of the value of those services. In the context of our study, if high TDS content of groundwater causes erosion of boilers in the chilling plant of URMUL Dairy and thus compels the industry to frequently replace the boiler or if a textile unit located in Jodhpur plans to shift its entire production unit to another place because the contaminated groundwater in Jodhpur actually affects their production then the cost of this replacement or relocation can act as a surrogate value of supplying fresh IBT water to industrial units.

The *Substitute Cost Method* uses the cost of providing substitute services as an estimate of the economic value of the ecosystem service. In the case of our study, the value of supplying fresh IBT water could be the extra cost that the people (or units) incur while extracting groundwater (which may include both pumping cost and quality impacts) or opportunity cost in the case of an alternate source (in the case of purchase of tanker water or walking long distances to a canal source or another village source to collect freshwater).

Method Adopted

For Domestic Water Supply

Humans and cattle, among others, have to obtain a minimum supply of water for survival. The costs involved in obtaining the water are direct, indirect as well as in the nature of opportunity gain/loss.

- Direct costs are those costs the consumers pay.
- Indirect costs are those imposed upon the users due to aspects of reliability and water quality.

- Opportunity gains or losses arise out of saving or increase in drudgery, labor, investment (saving) of time and the consequential effects such as reduction in dropping in school attendance, effect on health, etc.

Direct costs paid out for obtaining water supply from alternative sources are the easiest to justify save for the fact that in a majority of the cases there is a significant element of subsidy given by state agencies to the actual users. Thus, the costs paid out by actual user households are not economic costs.[4] The economic costs are absorbed by the water supply agencies and the decisions on water levies to users are taken on the basis of parameters only one of which is these direct paid-out costs. Thus, wherever households use water supplied by public agencies, we need to look at costs incurred by these agencies and not by the households themselves except so far as the households have to resort to self-provisioning when the public institutions perform inadequately or unreliably. An assessment of the reliability and adequacy of the water supply by public agencies and the costs paid out by users when the water from these sources is not available is therefore necessary. The costs paid out by these agencies would be in the nature of revenue expenditure on staff salaries, maintenance and power consumption, etc., as well as amortized components of the capital costs in installing water extraction, storage, and purification and distribution systems. Some of these systems are/would be used by these agencies even if the IBT water replaces current sources. Further, the use of IBT water would perhaps entail installation of devices for conveying water from canal heads to cities, etc. The gain to the system is therefore the difference between the existing paid-out costs and the new costs.

Indirect costs arise due to effects of water quality. Wherever groundwater has high TDS or has contaminants such as fluorine, treatment costs as well as costs in terms of lost wages are imposed on users. Efforts have been exerted elsewhere to quantify these costs. There is a wide diversity in situations concerning occurrence of contaminants and dissolved salts across the region where IBT water is expected to flow in both the regions. Second, the assessment of treatment costs and lost wages is a somewhat speculative exercise. In view of this, although we propose to recognize these costs exist we choose to ignore them.

Householders who had to fetch water from far-off sources previously get opportunity gains. Since fetching water is a task most often left to women and children of the households, the task imposes severe drudgery on women and also leads to reduced attendance in schools and health effects on young children. Easier and smoother supply of water using IBT water coming into the village reduces this drudgery and investment of time and also contributes to enhanced health and school attendance. Among these costs, the most directly measurable are the “equivalent lost wage costs” for the time an adult woman has to spend on fetching water, assuming, of course, that she has wage opportunities available on all the days of the year. The gains due to health effects or increased attendance in schools, etc., are real but pose much difficulty in valuation as they involve speculative assessment. Hence, we will consider only the reduction in lost wage opportunity as the net gain due to IBT water.

Industrial Water Supply

Often, industrial activity in a location in India fails to come up only for want of a reliable water supply. It is only when the entire value-addition in the industries which progress in a location

[4]Actual cost incurred for water supply varies from Rs 15 to 20 per 1,000 liters, while it is charged only Rs 1-5 per 1,000 liters.

after IBT water reaches it that it can be directly attributed to the water supply. However, it can be argued that industries which fail to progress in place A do so in place B within the country. As one is looking at costs and benefits at the national level and so long as one does not explicitly place a value on a specific location of industries this is not a material consideration. To argue that a certain industrial activity arises solely because water has become available from IBT is untenable unless one can demonstrate that water at a specific place has a particular contribution which another place would not have. In view of this, we do not choose to value industrial activity made possible by the arrival of water from IBT at the full value-added level.

The other advantage of water supply from IBT water comes in two forms. The first is in avoidance of costs (both, amortized capital costs and revenue costs of electricity consumed, etc.) incurred in obtaining water from alternative sources. Thus, if an industrial unit obtains water from groundwater sources and subsequently starts obtaining water from IBT sources, then the net consideration is the savings made by the industrial unit in terms of electricity consumed, etc. The second benefit arises from the fact that the treatment costs on freshwater supply from canals in the IBT schemes may possibly be lower than the treatment costs for water obtained from alternative sources. It is tenable to argue that costs in demineralizing water obtained from IBT sources would be smaller compared to those in demineralizing water from groundwater sources (Kumar et al. 2002). The third benefit that arises in certain cases is because use of better-quality water may enhance the quality of the product and hence fetch a better price. We propose to consider these three benefits.

Sources of Data

Secondary data were collected from Bikaner, Hanumangarh, Jaipur and Jaisalmer offices of the Indira Gandhi Nahar Board; all district offices, websites, annual reports, Census 2001 and District Statistical Handbooks of the Public Health Engineering Department (PHED); District Industrial Centre (DIC) and Rajasthan Industrial Investment Corporation (RIICO) offices in various districts; and from State's Economic and Statistical Department and its publications. Primary data collection was carried out with the help of Urmul Trust, Bikaner. Data for the exercise were obtained from three sources.

a. Secondary data sources were used for gathering information on the reach of the domestic water supply schemes based on the two canals. These included the departments connected with drinking water supply in Rajasthan and Andhra Pradesh.
b. Primary data at the level of households and villages were obtained by conducting a primary survey as outlined below.

The survey was conducted in 10 districts of Rajasthan. In eight districts IGNP water is being supplied for drinking and industrial purposes. These are Hanumangarh, Sri Ganganagar, Bikaner, Churu, Jhunjhanu, Jaisalmer, Jodhpur and Barmer. Sikar and Najaur will receive IGNP water very shortly. By and large, the study covered 497 households from 50 villages of 10 districts. The data represent the population of more than 225,000.

Identification of Samples for Drinking Water

The sample villages were identified based on three criteria: villages depending upon canal water, villages depending solely on groundwater and villages with a combination of these two. Cities were identified based on the urban classifications, i.e., Class-I to Class-VI. Representative towns/cities from all the urban classes were identified for the sample survey. Altogether, 17 towns/cities were identified. Lists of the sample villages and towns/cities are given in Tables 10 and 15. Households in these villages were identified randomly. In most of the villages, one household from each *vaas* (hamlet) was identified and the householders interviewed with the help of a questionnaire. The household survey form comprised information related to family members, age, income, primary and alternative sources of drinking water during normal and scarcity periods, direct cost paid out to obtain the water, time spent to collect from sources, etc.

Apart from the household survey, village-level information was collected using the village-level survey form, which mainly covered data pertaining to water supply, its source, head works, methods of water supply, number of connections, tariff structure and recovery, type of treatment given, etc. Similarly, town- and city-level survey forms were filled out. These forms were filled out by the survey team as per the information given by the administrative personnel. The survey was conducted by a team of five persons from December 2006 to February 2007. This team had conducted surveys in all the 10 districts in around 10 weeks' time. To reduce sample biases, the same survey team had covered all the sample villages and households.

A similar procedure was followed in Andhra Pradesh. The survey work was done in Vishakhapattanam, East Godavari, West Godavari and Krishna districts. In these districts, 359 households in 36 villages were covered. The survey instruments for the two regions of IGNP canal command area and PV Link were the same. These were translated into the local language and administered with the help of the partners: URMUL Trust in the case of IGNP and a consultant, Nikhil Mathur, in the case of AP. Prior to a full-fledged survey, the instruments were tested in Anand and the two respective areas.

Data from urban centers were obtained through personal interviews with the appropriate municipal authorities as well as selected key informants as outlined below. In urban centers, information from the secondary sources was collected to determine the cost paid out by the households. Survey of tanker water suppliers, interviews of water supply department engineers, and several indirect methods were used to estimate the economic costs of urban water scarcity. These include using alternative costs of shortages paid out by the households and the average number of days of water scarcity.

Sample Characterization

Sample Characteristics of Rural Drinking Water, IGNP

In the IGNP areas, 497 households were surveyed. In the sample, the average age of the respondents was 47 years, while the average family size was 7.3 persons per household, with the lowest, 5.9, in Barmer and the highest, 9.5, in Bikaner. A family's average monthly income was found to be Rs 3,643. The highest monthly income (Rs 5,909) was found in the Sikar District and the lowest (Rs 2,481) in Churu. Mean monthly income was found to be Rs 3,646 (Table 5).

Table 5. Average family size and income of the respondents.

District	Average age of respondents	Average family size	Average income (Rs)
Barmer	44	5.9	3,080
Bikaner	45	9.5	2,624
Churu	46	7.7	2,481
Jaisalmer	52	8.0	4,175
Hanumangarh	51	6.9	3,240
Ganganagar	50	6.1	2,860
Najaur	44	7.2	2,945
Sikar	51	7.7	5,909
Jodhpur	45	7.0	3,613
Jhunjhanu	46	6.8	5,506
Mean	47	7.3	3,643

The occupations of the heads of the households are given in Table 6. As can be determined, 35% of the households were agriculturists, 43% engaged in other diverse occupations and the rest primarily wage earners, mostly in agriculture.

Households discussed problems of fetching domestic water in "normal" months and "months of scarcity." The durations of the normal and scarcity periods across the sampled villages are given in Annex 1, and for districts are in Table 7.

Table 6. Primary occupation of the heads of the sample families.

Primary occupation	Labor	Agriculture	Others	Total
Barmer	22	10	18	50
Bikaner	9	23	18	50
Churu		32	18	50
Jaisalmer	8	18	24	50
Hanumangarh	14	9	25	48
Ganganagar	10	17	23	50
Najaur	16	17	17	50
Sikar	9	21	19	49
Jodhpur	9	9	32	50
Jhunjhanu	9	20	21	50
Total	106	176	215	497

Table 7. Duration of normal and scarcity months.

District	Duration of "normal" period (months)	Duration of "scarcity" period (months)
Barmer	7.34	4.66
Bikaner	9.64	2.36
Churu	11.38	0.62
Hanumangarh	10.98	1.02
Jhunjhanu	11.62	0.38
Jaisalmer	11.46	0.54
Jodhpur	10.70	1.30
Najaur	10.56	1.43
Sikar	11.90	0.10
Ganganagar	10.16	1.84

The average water consumption (liters per capita per day, lpcd) by households as well as the storage capacity (in number of days of supply) created by the households at the home level are given in Table 8. The average water consumption in the study area is 47.1 lpcd and mean storage capacity is about a week. It may be noted that a few households had in-house sanitation facilities and, hence, that this suppresses the daily water consumption.

Table 8. District-wise water consumption and household storage capacity.

District	Average water use (lpcd)	Average storage capacity (no. of days)
Barmer	52.18	9.79
Bikaner	48.67	7.28
Churu	46.89	3.12
Hanumangarh	48.20	1.90
Jaisalmer	54.94	8.68
Jhunjhanu	38.80	4.31
Jodhpur	54.30	16.70
Najaur	38.33	15.07
Sikar	45.20	1.00
Sri Ganganagar	43.50	4.35
Mean	47.10	7.20

The data on consumption and storage were related to reported household incomes. The difference in consumption levels as well as storage capacity across income levels is insignificant (Table 9).

Table 9. Group-wise income, water consumption and household storage capacity

Income group (Rs)	Average water use (lpcd)	Average storage capacity (no. of days)
Up to 2000	46.96	7.37
2,000-6,000	48.34	7.16
Above 6,000	48.61	5.31
Mean	47.97	6.61

Note: Average water use and storage capacity in number of days may not be the same in Tables 8 and 9, as around 10% of samples did not give information about the monthly income.

Table 10 shows the main source of domestic water for the households. There are three groups of villages: those adjacent to the canal as they get their water from the canal without the creation of any new systems; those which are primarily dependent on the groundwater and will eventually be brought under the schemes and the third group where both sources are currently in use. The data show that 307 households depended on groundwater for their domestic water requirements (Table 10).

Table 10. Sample villages and main sources of water.

Village	Block	District	Source of water supply	No. of samples
Ashotra	Balatra	Barmer	GW	10
Badi khuri	Sikar	Sikar	GW	10
Bhakra	Jhunjhanu	Jhunjhanu	GW	10
Banad	Jodhpur	Jodhpur	GW	10
Bandhrau	Sardarsahar	Churu	SW	10
Basanpeer	Jaisalmar	Jaisalmar	GW	10
Bhadana	Najaur	Najaur	GW	10
Bhadhadar	Sikar	Sikar	GW	10
Bhairupura	Sikar	Sikar	GW	10
Bhamatsar	Nokha	Bikaner	GW	10
Budana	Jhunjhanu	Jhunjhanu	GW	10
Chandan	Jaisalmar	Jaisalmar	GW	10
Chudela	Malsisar	Jhunjhanu	GW	10
Daizar	Jodhpur	Jodhpur	GW and SW	10
Dangiyabas	Jodhpur	Jodhpur	GW and SW	10
Dantiwara	Jodhpur	Jodhpur	SW	10
Desusar	Jhunjhanu	Jhunjhanu	GW	10
Devliya	Jodhpur	Jodhpur	SW	10
Dhassu Ka Bass	Laxmangarh	Sikar	GW	10
Dholipal	Hanumangarh	Hanumangarh	SW	10
Didiya Kala	Jayal	Najaur	GW	10

Ganeshgarh	Ganganagar	Ganganagar	SW	10
Hameera	Jaisalmar	Jaisalmar	GW	9
Jasol	Panchpadra	Barmer	GW	10
Junjala	Jayal	Najaur	GW	10
Kikasar	Sardarsahar	Churu	SW	10
Kuship	Siwana	Barmer	GW	10
Mahiyawali	Ganganagar	Ganganagar	SW	10
Malkasar	Sardarsahar	Churu	SW	10
Malsar	Sardarsahar	Churu	SW	10
Manaksar	Hanumangarh	Hanumangarh	SW	10
Manjhu Bass	Padampur	Ganganagar	SW	10
Mevanagar	Panchpadra	Barmer	GW	10
Naradhana	Jayal	Najaur	GW	9
Nayana	Hanumangarh	Hanumangarh	GW and SW	10
Nokha	Nokha	Bikaner	GW	10
Padardi	Siwana	Barmer	GW	10
Parwa	Nokha	Bikaner	GW	10
Patamdesar	Sardarsahar	Churu	SW	10
Rashid pura	Sikar	Sikar	GW	10
Rasisar	Nokha	Bikaner	GW	10
Ratewala	Padampur	Ganganagar	SW	10
Rijani	Alsisar	Jhunjhanu	GW	10
Rodawali	Hanumangarh	Hanumangarh	GW and SW	10
Roll	Jayal	Najaur	GW	10
Sanwatsar	Padampur	S.ganganagar	SW	10
Satipura	Hanumangarh	Hanumangarh	GW and SW	10
Sodakor	Jaisalmar	Jaisalmar	GW	9
Somalsar	Nokha	Bikaner	GW	10
Thaieyat	Jaisalmar	Jaisalmar	GW	10
Total samples				497

Note: GW = groundwater; SW = surface water.
Source: Primary data.

Table 11 shows the distance of the main sources of water from the household.

Table 11. Average distance (km) of source of water.

District	Normal time primary source	Scarcity time primary source	Normal time alternative source	Scarcity time alternative source
Barmer	0.27	3.27	0.00	3.35
Bikaner	0.43	0.89	0.00	0.95
Churu	0.05	0.49	0.00	0.84
Hanumangarh	0.07	0.49	0.01	0.60
Jaisalmer	0.37	0.37	0.01	0.36
Jhunjhanu	0.20	0.03	0.00	0.05
Jodhpur	0.81	3.25	0.00	4.47
Najaur	0.62	1.57	0.05	1.62
Sikar	0.05	0.02	0.00	0.01
Sri Ganganagar	0.36	0.53	0.00	0.68
Mean	0.3	1.1	0.0	1.3

Source: Primary data.

The average travel distance to fetch water as per the main source of village is given in Table 12. This is given for the normal period and the scarcity time. Not many people rely on alternative sources during normal time and similarly not many people rely on primary sources during scarcity time. Very interestingly, it was found that villagers depending only on groundwater sources were traveling longer distances than those depending on canal water sources.

Table 12. Average travel distance in villages for fetching water based on main source of water.

	During normal periods (km)			During scarcity time (km)		
District	Ground-water	Surface water	Both groundwater and surface water	Ground-water	Surface water	Both groundwater and surface water
Barmer	0.27			3.43		
Bikaner	0.43			0.95		
Churu		0.05			0.84	
Hanumangarh		0.05	0.08		0.74	0.37
Jaisalmer	0.37			0.36		
Jhunjhanu	0.20			0.05		
Jodhpur	0.61	0.45	1.28	8.20	5.65	2.49
Najaur	0.62			1.66		
Sikar	0.05			0.03		
Sri Ganganagar		0.36			0.68	
Mean	0.36	0.23	0.68	2.10	1.98	1.43

The fees were paid not only to owners of water sources including the Panchayats, but also to tanker suppliers and other individuals or institutions. The data show that households paid, on average, Rs 6.50 per month for fetching their water during normal periods and around Rs 24 per month during scarcity periods (Table 13). Many people did not pay any fee for water including Panchayats (188 of 497 respondents). Similarly, it can be seen from the Table that the cost paid by the people residing in canal water supplied villages was lesser than that paid by villagers depending on groundwater.

Table 13. Average paid out cost per month per household (Rs).

District	All samples		Canal water villages		Groundwater villages	
	Normal period	Scarcity period	Normal period	Scarcity period	Normal period	Scarcity period
Barmer	10.80	404.00			10.80	404.00
Bikaner	61.70	242.80			61.70	242.80
Churu	47.94	48.00	47.94	48.00		
Hanumangarh	22.72	53.00	19.05	52.50		
Jhunjhanu	45.48	40.83			45.48	40.83
Jaisalmer	69.45	46.00			69.45	46.00
Jodhpur	44.02	346.00	30.05	340.00	0.00	480.00
Najaur	67.41	213.88			67.41	213.88
Sikar	36.15	1.20			36.15	1.20
Sri Ganganagar	22.14	59.60	22.14	59.60		
Mean	42.78	145.53	29.80	125.03	41.57	204.10

It was found in the samples that the average paid-out cost for water was 4% of the income though it varied from 0% to 40%

The time spent by the households in fetching their water each day as well as the breakup of this time across the category of individuals engaged in the task are given in Table 14. It was found that average time taken to fetch water was higher during a normal period than in a scarcity period.

Table 14. Average of daily hours spent in collecting water.

District	Normal period				Scarcity period			
	Others	Child	Female	Male	Others	Child	Female	Male
Barmer		3.00	1.24	3.00	2.38	0.00	1.03	0.00
Bikaner			1.18	1.94			0.83	0.22
Churu			1.20				0.43	
Hanumangarh			0.68	0.50			1.12	0.00
Jaisalmer	0.95		1.71	1.21	0.20		0.15	0.14
Jhunjhanu	0.90		0.78		0.00		0.30	
Jodhpur	1.17	2.00	1.98	3.00	0.83	2.00	0.53	0.00
Najaur			1.88	0.83			0.53	0.67
Sikar			0.91				0.04	
Sri Ganganagar	0.00		0.67		1.00		0.68	
Mean	0.60	2.50	1.22	1.75	0.88	1.00	0.56	0.17

Urban Drinking Water

Of the 16 urban centers studied, four obtained their domestic water purely from surface water sources, another four from both surface water and groundwater sources while the remaining eight depended entirely on groundwater. The mean water supply given to these centers by the municipal authorities ranged between 70 and 191 lpcd (Table 15).

Table 15. Urban water supply standards, actual supply and electricity consumption for groundwater pumping.

Town	Source	Water supply norm	Supply (lpcd)	Electricity consumption, (kWh/day)[5]
Pokaran	Groundwater	70	117	na
Najaur	Groundwater	100	70	248
Nokha	Groundwater	100	111	373
Churu	Surface water and groundwater	70		na
Hanumangarh	Surface water	90		
Ravatsar	Surface water	100	109	
Jaisalmer	Surface water and groundwater	70	87	na
Barmer	Surface water and groundwater	135	85	na
Jhunjhanu		100	88	
Bagar	Groundwater	100	116	9
Sadulsahar	Surface water	100	99	
Suratgarh	Surface water	135	120	
Fatehpur	Groundwater	100	89	77
Pilibanga	Groundwater	70	191	na
Bikaner	Surface water and groundwater	130	107	na

Sample Characterization of Industrial Water Use

There are no major industries in the ten districts where the survey was undertaken except for a few thermal- or lignite-based power projects (the information for the same is given in the report in the subsequent section). Altogether, 25 industries were surveyed, which covered cotton ginning mills, textiles, agro-based industries, food processing units and others. All the samples were from small-scale industries. We found that almost all the industries depended on the Rajasthan Industrial Investment Corporation (RIICO, Government of Rajasthan) for water supply for daily needs. The water supply by RIICO is often not enough; hence, undersupplied water was managed from private bore wells. Now, very few industrial estates are supplied with IGNP water by RIICO.

[5]Authors' estimate based on data available on groundwater levels.

EI = (P X 100,000) / (Q X hs X 3600), where, EI = Energy Index (assumed 50%); P = power consumption, kWh; Q = discharge rate, liters per second (assumed 18 hours of pumping per day); hs = static head in meters.

Industrial estates in Hanumangadh and two industrial estates in Bikaner are currently supplied with IGNP canal water. Quality requirement of water varies across industries. Industrial water requirement is mainly for process and waste disposal (chemical, pulp and paper, petroleum refining and primary metal) and cooling (thermal power plants). Except for most of the small-scale industries (SSI), water is mainly required for drinking, sprinkling, gardening and other housekeeping activities. A modicum of water is needed for these purposes. Among the SSI, only textile units (bleaching and dying units) need water preferably potable. If the desirable quality and quantity of water are supplied or undersupplied to these industries, the latter manage to get the water from private tanker owners, who normally get water from groundwater from nearby sources. For example, in the Balotara industrial estate of Pachpadra block of Barmer District, textile units for bleaching are flourishing because of the rich groundwater aquifer. But the quality of water is still not good enough for dying the bleached cloths. Jodhpur enjoys a great advantage because of its good-quality (less-saline) canal water (IGNP) and its proximity to Balotara; all the dying work is carried out in the textile units of the Jodhpur industrial estates.

Polavaram-Vijaywada Link Canal Areas

Sample Characterization of Rural Drinking Water

The average age of the respondents in the Vijaywada project was 39 years while the average family size was five. The district-wise details are given in Table 16.

Table 16. The average age of respondents and family size.

District	Average age of respondent	Family size
East Godavari	40.28	5.0
Krishna	41.43	4.7
Vishakapatnam	38.49	5.1
West Godavari	35.56	5.1
Mean	38.96	5.0

Almost half the population was associated with agriculture, either in direct farming or as agricultural laborers (Table 17).

Table 17. Primary occupation of the head of the sample families in some districts.

District	Agriculture	Laborer	Others	Total
East Godavari	38	37	84	159
Krishna	9	10	11	30
Vishakapatnam	14	22	64	100
West Godavari	16	16	38	70
Total	77	85	197	359

It was seen that water supply in the region is quite reliable. A very few days in a year were felt to be water-scarce compared to the IGNP area in Rajasthan (Table 18).

Table 18. Duration of normal and scarcity periods for water supply (in months).

District	Duration of normal period	Duration of scarcity period
East Godavari	11.80	0.20
Krishna	12.00	0.00
Vishakapatnam	11.72	0.26
West Godavari	11.89	0.25

The average water consumption was found to be 72 liters per person per day. Because of an ensured water source (groundwater or surface water) the need for household storage was very low. On average, the storage for only half the daily water requirement was created at the household level (Table 19).

Table 19. The average water consumption and household storage capacity.

District	Average water use (lpcd)	Average household storage (days)	Average household daily water use (liters)
East Godavari	73	0.4	351
Krishna	69	0.5	321
Vishakapatnam	73	0.4	363
West Godavari	72	0.6	361
Mean	72	0.5	349

The average distances of sources of water for villagers are given in Table 20. The average distance traveled was 1.6 km during the normal period and 2.3 km during the scarcity period.

Table 20. Average distance of source of water (km).

District	Normal time primary source	Scarcity time primary source	Normal time alternative source	Scarcity time alternative source
East Godavari	1.29	2.14	1.41	2.50
Krishna	0.97		2.63	
Vishakapatnam	1.42	1.29	1.15	1.83
West Godavari	3.16	1.67	2.75	4.00
Mean	1.66	1.83	1.69	2.37

The total number of samples surveyed in the Polavaram-Vijaywada project are given in Table 21. Around 300 samples were taken from villages depending on groundwater and 50 samples were taken from villages depending on surface water. Ten samples were identified from a village having both surface water and groundwater as a source of domestic water use.

Table 21. Number of samples based on source of water.

District	Groundwater	Surface water	Both surface water and groundwater	Total
East Godavari	129	20	10	159
Krishna	30			30
Vishakapatnam	80	20		100
West Godavari	60	10		70
Total	299	50	10	359

Table 22 shows the average paid-out cost for water to private suppliers and also to the Panchayat. On average, Rs 7 was spent by families, with a maximum of Rs 1 in the Krishna District and around Rs 15 in the West Godavari District.

Table 22. Average paid-out cost per month per household (Rs).

District	Normal time primary source	Scarcity time primary source	Normal time alternative source	Scarcity time alternative source
East Godavari	7.93	0.00	0.48	0.00
Krishna	1.04	0.00	0.44	0.00
Vishakapatnam	2.95	0.00	3.50	0.00
West Godavari	14.63	0.00	2.69	0.00
Mean	7.27	0.00	1.74	0.00

The data show the time spent by household members for each category, i.e., male, female and child during normal and scarcity periods. On average, an hour was spent by each category to fetch water during normal periods. The time taken during the scarcity period was 2-4 hours, spent by adult female or male members of the household. Child labor for fetching water was used only in the West Godavari District (Tables 23 and 24).

Table 23. Time spent in collecting water during normal periods (in hours).

District	Male	Female	Child	Total
East Godavari	1.09	1.11		1.11
Krishna	0.50	0.67		0.66
Vishakapatnam		0.91		0.91
West Godavari	1.33	0.87	1.00	0.89
Mean	1.10	0.97	1.00	0.97

Table 24. Time spent in collecting water during scarcity times.

District	Male	Female	Child	Total
East Godavari	2.0	1.3		1.4
Krishna				
Vishakapatnam		2.2		2.2
West Godavari	2.0	23.0		16.0
Mean	2.0	3.7		3.5

Characterization of Urban Drinking Water

Table 25. Source of water, water supply standards and actual water supply.

Town	Source	Water supply norm	Supply (lpcd)	Electricity consumption, (kWh/day**)
Narsipatnam	Groundwater	na	17.0	8
Baligattam	Surface water	na	54.6	na
Vemulapudi	Groundwater	na	12.8	2
Anakapalli	Surface water	135	56.5	na
Kundram	Groundwater	na	7.1	2
Pudimadaka	Groundwater	na	30.6	7
Kondakarla	Groundwater	na	na	na
Nuzvid	Groundwater	100	70.3	270
Garlamudugu	Groundwater	na	21.2	5
Kunchimpudi	Groundwater	50	54.5	9
Tadepalli Gudem	Surface water	70	92.0	na
Sita Nagaram	Groundwater	na	57.1	5
Cinakondepudi	Groundwater	na	43.8	4
Peddapuram	Surface water and groundwater	na	44.4	102
Edurapalli	Surface water	80	40.7	na
Bandarulanka	Groundwater	na	34.3	2
Amalapuram	Surface water	100	187.6	na
Kondaduru	Groundwater	na	na	0
Bikkavolu	Groundwater	na	25.5	14

** Authors' estimate based on data available.

Industrial Water in Polavaram-Vijaywada (PV) Project

One of the most important duties of the PV project are to fulfill the needs of the industrial sector, flourishing in Vishakhapatnam, East Godavari and West Godavari districts. Vishakhapatnam is an especially important industrial and port city. There are large and water-intensive industries around Vishakhapatnam, such as the Vizag Steel Plant, NTPC, BHPV, HPCL, Hindustan Zinc, etc. In 2004, the Vishakhapatnam Industrial Water Supply Project (VIWSP)[6] was conceived to

[6]The Vishakapatnam Industrial Water Supply Project (VIWSP) envisages capacity augmentation of the existing 153 km long Yeleru Left Bank Canal (YLBC) system in the East Godavari District of Andhra Pradesh, on a Build Own Operate Transfer (BOOT) basis. The YLBC presently delivers about 180 million liters per day (mld) of water from the Yeleru Reservoir to the Visakhapatnam Steel Plant (VSP). The demand in the immediate future 260 mld, would in the long run, increase to 600 mld.. The other beneficiaries will include the NTPC Power Plant, Parvada Industrial Development Area, the Vishakapatnam Municipal Corporation, the proposed Special Economic Zone and the proposed Gangavaram Port near Vishakapatnam and other upcoming industries in the Vishakapatnam-Kakinada belt.

fulfill the industrial sector's water requirement around Vishakhapatnam. Initially, a 388 mld water supply project from the Yeleru Reservoir through the 153 km long Yeleru Canal and another 388 mld water supply project from the Godavari River through a 56 km long MS (mild steel) pipeline were commissioned. It was envisaged that supply provision would double once the Polavaram project is completed.

Methodology of Estimating Net Gains

The basic premise, on which our methodology is based, is to find out the cost paid for the NEXT BEST option for the water. The difference of the cost between IGNP benefited villages/towns/cities and non-benefited areas (depending solely on groundwater) would be the direct benefit accrued. This will be calculated based on the following formula:

$V_1 = (P_1 - P_2) \times Q_1$

where, P_1 = price in non-benefited area

P_2 = price in benefited area

Q_1 = quantity of water used in non-benefited area.

In addition to this, there is a value in the time saved each day in fetching water because people may now use that time for work or other activities.

$V_2 = [(T_1 / Q_1) - (T_2 / Q_2)] \times W \times Q_1$

where, T1 = time spent water hauling in non-benefited area

Q_1 = quantity of water used in non-benefited area

T_2 = time spent water hauling in benefited area

Q_2 = quantity of water used in benefited area

W = wage rate for time spent on water hauling (daily or hourly as appropriate)

While the above difference gives the gross benefit, the net gain due to IBT would be obtained by removing the amortized capital costs of the hardware necessary for bringing the IBT scheme water to villages/cities and the O&M costs on these schemes. Thus, an estimate of these two would have to be deducted from the gross benefit.

Second, for the urban centers, we have data from the municipal authorities. The rate at which urban consumers are charged for water is an administrative decision of the concerned authority and need not enter our calculation. The actual cost incurred is the cost of accessing water as of now and the gain is likely to accrue from reduction in this access cost. For the eight cities dependent on groundwater alone this access cost is essentially the cost of pumping the water from underground aquifers. This is assessed by considering the volume and fixing a standard rate for power consumption per unit of water as well as a standard power rate of Rs 4 per kWh. The pumping cost would vary by the depth of the aquifer in the concerned city and the age of equipment. While refinement in these numbers is possible, we have taken representative numbers for illustrating the gain.

Industrial Water Supply

The northwestern part of Rajasthan does not have major or large-scale industries. Most of the districts except Jodhpur are industrially backward. Jodhpur has many medium- to large-scale industries. The reason for poor industrial development relates to inadequate development of transportation and communication facilities, lack of investment and, above all, acute water shortages. Recently, the State Government took a few policy initiatives to attract entrepreneurs from outside to set up industrial units in this area. It is envisaged and hoped that many industries will come up in this area in the near future. Almost all the industries surveyed in Rajasthan were small-scale. On average, these industries paid Rs 52.47 per m^3 of water, with a minimum of Rs 16 to a maximum of Rs 100 per m^3. Similarly, out-of-pocket cost paid for alternative sources of water supply by the industries varied from Rs 500 to nearly Rs 500,000 per year.

Power Projects

Lignite-based as well as thermal power plants are getting IGNP water or will get it in the near future (Table 26).

Table 26. Power projects in the IGNP area.

Project	District	Capacity (megawatt)
Projects already conceived		
Suratgarh Thermal Power Plant	Sriganganagar	1,250
Barsingsar	Bikaner	240
Ramgarh gas power plant	Jaisalmer	160
Projects under consideration		
Palana lignite	Bikaner	120
Guja lignite	Bikaner	240
Kapoordi lignite	Bikaner	500
Jalipa lignite	Bikaner	915
Kasnana-Igyar lignite	Najaur	100
Mathania solar thermal	Jodhpur	30
Projects for future		
Thermal plant	Najaur	500
Bishnok lignite	Bikaner	80
Giral lignite	Bikaner	100
Mertha road lignite	Najaur	125
Mokala lignite	Najaur	60
Grand total		4,170

Water is or will be supplied to these power plants from IGNP. Needless to say, without IGNP water, these plants would not have even been conceived. There are incremental benefits from the energy units generated. Here too the net gain is estimated on the cost side: the current cost of accessing water is compared with the cost of fetching water from the canal and the difference is attributed to the IBT scheme.

Apni Yojana of Rajasthan

Under the Apni Yojana scheme, the cost of establishing water supply infrastructure to the urban and rural people in the study areas has been estimated at Rs 4 billion. The estimated life of the scheme is 30 years. We have assumed this to be the gross capital cost in creating infrastructure for reaching the IGNP water for domestic purposes. The O&M costs currently average 15% of the capital costs. We have used these values and have also done sensitivity analyses on the economic life of the scheme as well as on the level of O&M costs.

Similar data for industrial water supply are not available. Water infrastructure along with other infrastructure are created by RIICO, and the industrial unit located in an estate charges for it in accordance with the industrial policy in the state. We have assumed that the cost of accessing water is paid out by RIICO at the same level as the above cost of the Apni Yojana.

Similarly, the cost of water supply from the canal was calculated as Rs 10 per m^3 for Andhra Pradesh (GoAP 2003 b)

Estimation of Gains: IGNP

Economic Benefits of Rural Water Supply

Current paid-out costs per household and hence per m^3 for non-benefited areas are given in Table 27.

Table 27. Net economic gain of rural drinking water in the IGNP area.

District	Areas benefiting from groundwater				Areas benefiting from canal water				
	Direct cost (Rs billion /yr)	Potential wage loss cost (Rs billion / yr)	Total cost		Direct cost (Rs billion /yr)	Potential wage loss (Rs billion / yr)	Total cost		Cost of canal water supply Rs/ m^3
			Rs billion	Rs/ m^3			Total cost (Rs billion /yr)	Rs/ m^3	
Barmer	0.58	1.26	1.85	53.31					3.68
Bikaner	0.23	0.38	0.61	31.83					
Churu					0.12	0.47	0.60	25.07	
Hanumangarh					0.11	0.12	0.23	12.34	
Jaisalmer	0.04	0.28	0.32	10.50					
Jhunjhanu	0.20	0.59	0.79	128.9					
Jodhpur		0.24	0.24						
Najaur	0.43	1.15	1.58	49.75					
Sikar	0.12	0.90	1.01	33.76					
Sri Ganganagar					0.08	0.44	0.53	24.79	
Average				51.35				20.73	3.68

Gw - Cc = Rs (51.35-20.73)/m^3 = Rs 30.62/m^3

Gw - (Cc + CWs) = Rs (30.62 – 3.68) = Rs 26.94/m^3.

where, Gw = Cost paid out in groundwater supplied villages.

Cc = Cost paid out in Canal water supplied villages .

CWs = Cost of canal water supply.[7]

[7]Cost of canal water supply has been calculated from a piped drinking water supply project in Churu and Jhunjhunu districts of Rajasthan called *Apni Yojna*. Total cost was Rs 4 billion and catering to the population of 900,000 (approximately 700,000 rural and 200,000 urban). There are several assumptions taken; [1] life of the project would be 50 years, [2] urban population growth rate 2% and rural growth rate at 1.2% per annum [3] O&M 20% of capital cost and inflation 5%, [5] rural water supply at 70 lpcd and urban at 200 lpcd.

It is estimated that a rural population of 5 million is being supplied by IGNP water. The total rural population in these 10 districts is around 15 million. Hence, a population of around 10 million is still depending on groundwater. Two scenarios are given here. One is as per the present level of consumption of water, which, in average, is 47 lpcd and less than the standard norms. Scenario 2 has been calculated as per the standard norms of 70 lpcd (Table 28).

Table 28. Total net economic gain of rural drinking water in the IGNP area.

Scenario 1, GW-Cc, Rs billion	Scenario 1, GW - (Cc+Cws), Rs billion	Scenario 2, GW-Cc, Rs billion @ 70 lpcd	Scenario 2, GW - (Cc+Cws), Rs billion, @ 70 lpcd
5.289	4.653	7.822	6.882

Hence, economic benefits at the present water consumption level of 47 lpcd would be around Rs 4.7-5.3 billion per annum (Table 28). Similarly, water supply as per the standard would be Rs 6.9-7.8 billion per annum.

Economic Benefits of Urban Water Supply in IGNP

The urban population of Hanumangarh, Ganganagar District, and a part of the population of Bikaner City, Churu Town are being supplied IGNP water. According to an estimate based on the data available from IGNP only 1.2 million of the total urban population of around 5 million in these 10 districts are supplied with IGNP water. Another 3.8 million of urban population needs to be supplied with IGNP water (Table 29).

Table 29. Net economic gain of urban drinking water in IGNP area.

Average population depending on groundwater	3,800,000
Water supply standard (liters/capita/day)	200
Total water supply, (m^3)	760,000
Average kWh/m^3	0.05
Total water (m^3)	38,000
Unit rate Rs/kWh	4.00
Total (Rs/day)	152,000
Annual cost (Rs)	55,480,000

The average present water supply in the urban area is 112 lpcd. If the same supply level is maintained then the net economic gain would be Rs 31 million per annum. If we consider a supply standard of 200 lpcd, then the economic benefits would be Rs 55.5 million per annum. The total net economic gain in the domestic sector in the IGNP area is Rs 4.681 billion and on the conservative side it is Rs 7.875 billion.

Current Water Use in Industries Sampled

The total electricity generation by the power projects in the region is, on average, 3,200 million units annually. The average water needed to produce this quantity of electricity would be 496 million liters (Ml) (GoI 1999): wastewater generation rate for the thermal power plant is 155 X 10^3 liters/hour/megawatt. We assume no consumptive use to be on a higher side. The total electricity required to withdraw 496 Ml of groundwater (assuming the alternative source is groundwater) at 0.05 kWh per m^3 would be 24.8 million units. If we attribute these units at the rate of Rs 4.00 per unit, the total attributable cost would be Rs 99.2 million.

Net Gains from Polavaram-Vijaywada Project

Net Benefits from Rural Drinking Water Supply

The net benefits from drinking water supply may be seen in Table 30.

Table 30. Net economic gain of rural drinking water in the PV area.

District	Groundwater benefited areas				Canal water benefited areas				Cost of canal water supply, (Rs/ m^3)
	Direct cost (Rs billion /yr)	Potential wage loss cost (Rs billion/ yr)	Total cost (Rs billion /yr)	Cost in Rs/ m^3	Direct cost (Rs billion /yr)	Potential wage loss (Rs billion / yr)	Total cost (Rs billion /yr)	Annual cost (Rs/ m^3)	
East Godavari	0.09	4.18	4.28	2.03	0.25	1.32	1.57	14.83	3.68
Krishna	0.02	1.57	1.58	5.11		-			
Vishakapatnam	0.03	1.77	1.80	7.46		0.89	1.13	10.84	
West Godavari	0.17	3.24	3.41	3.67	0.32	2.86	.17	33.22	
Total			11.07	24.57			5.88	19.63	3.68

Gw–Cc= Rs 4.94 per m^3.
Gw – (Cc + CWs) = Rs 1.26/ m^3.
where, Gw = cost paid out in groundwater supplied villages
Cc = cost paid out in canal water supplied villages
CWs = cost of canal water supply (same as IGNP)

It is estimated that presently, out of a total rural population of 17 million, 9 million are still using groundwater. Two scenarios are given here (Table 31). One is as per the present level of consumption of water that, in average, is 72 lpcd. Hence, scenario 2 will not be different from it.

Table 31. Total net economic gain of rural drinking water, PV area.

Scenario 1, gw-Cc, Rs billion	Scenario 1, gw - (Cc+Cws), Rs billion
1.167	0.298

Economic Benefits of Urban Water Supply in the Polavaram Project

A few of the urban pockets in the West Godavari and East Godavari districts are being supplied by the Eluru canal network. The estimated population based on the data available would be 3.5 million, which can be catered to from the Polavaram project (Table 32).

Table 32. Net economic gain of urban drinking water in the PV area.

Average population depending on groundwater	3,500,000
Water supply standard (pcd)	200
Total water supply, m^3	700,000
Average kWh/ m^3	0.035
Total water, m^3	24,500
Unit rate Rs/kWh	4
Total Rs/day	98,000
Annual cost, Rs	35,770,000

The present level of water supply in the urban area is quite low. Its average is 50 lpcd. The net economic gain at the present level of water supply would be around Rs 9 million while at 200 lpcd of water supply the net economic gain would be Rs 35.7 million. The total net gain in the domestic sector in the Polavaram project would be Rs 0.307 billion at the lower side and Rs 1.203 billion at the higher side.

Net Economic Gain in the Industrial Sector in the Polavaram Project

As mentioned in the previous sections, industries around Vishakhapatnam and Gangavaram port are withdrawing water from the Godavari River. Eventually, after the completion of the Polavaram project the water supply capacity would be doubled. Hence, we do not attribute additional net gains due to a future Polavaram project (Table 33).

Summary of Net Economic Gains

Table 33. Summary of net economic gains.

Item		IGNP		PV	
		Population served (million)	NEG (Rs billion)	Population served (million)	NEG (Rs billion)
Rural drinking	Lower	10.0	4.6 – 5.2	9.0	0.298
	Upper		6.9 – 7.8		1.167
Urban drinking	Lower	3.8	0.031	3.5	0.009
	Upper		0.056		0.036
Industrial		na	0.099	na	0.0
Total	Lower	13.8	4.73	12.5	0.307
	Upper		7.056		1.203
	Expected gains		6.9		0.75

Note: NEG = Net economic gains.

Discussions and Conclusion

An attempt has been made here to estimate the net economic gains from water supply from IBT schemes to domestic and industrial sectors. The exercise is important for the chief reason that seldom does an exercise that aims for economic gains from schemes for creating large water structures explicitly consider the economic gains accruing from the use of water for domestic and industrial purposes per se. Investments in these schemes are sought to be justified by estimating the net contribution these schemes make in terms of increased production in the agriculture sector and, in the case of multipurpose schemes, in terms of value of electricity produced. Benefits such as domestic and industrial supply are mentioned but their values are not computed. We have adopted what we consider the most defensible method. The schemes are expected to supply water to domestic and industrial users. These users currently draw their supplies from some existing sources, such as groundwater. In doing so, they have to incur expenditure on energy for pumping water; and also spend hours trudging to the source of water. We have basically captured the benefits in terms of reduced energy costs and time spent on fetching water. These two benefits accrue to the economy via the agents who are directly benefited. We have valued energy at the market rate and the time saved at the going wage rate. There is a likelihood of a dispute about valuing time as it involves the tacit assumptions that there is abundant demand for labor and that time saved from daily chores of collecting water would be automatically sold in the market. Both these can be questioned on the grounds of their relevance to reality.

Yet we submit that what we have obtained is a conservative estimate of the value to these people. We have not really valued the negative utilities of drudgery, much of it regarding women. Nor have we attributed any specific gains to the salutary impacts, thus saving of children's time on improved school attendance and on health. There is little dispute that these benefits, in fact, do accrue, but there are issues about quantifying, valuing and estimating the quantum of these benefits. We have perhaps erred on the conservative side in an obvious manner in ignoring the salutary impacts on reduced health expenditure in the face of fairly known consequences of negative health impacts of groundwater with high TDS as well as contaminants such as fluorine. We have chosen to do so since the data on the extent of prevalence of health syndromes arising out of contaminated groundwater and pertaining to the cost of treatment as well as in terms of lost wages were not collected in these areas. Since we have not measured the impacts in terms of reduced drudgery, improved educational performance and avoided health impacts, we believe the above estimates to be conservative.

Demographic as well as ecological factors determine the size of these benefits. In the case of IGNP, the benefited areas are dry, with a small population. In fact, the absence of the canal may well have caused a situation that would require depopulating the region. Clearly, the scheme has high benefits in this situation. On the other hand, the benefited areas of the PV scheme, barring highland areas of Vizag, are in the delataic regions with abundant groundwater. Here the benefits are more muted. The chief advantage of the supply of PV scheme water to the Vizag industrial estate is said to be making industrial growth possible in that region. However, we have not attributed any gains from such industrial growth to the scheme since it is possible to argue that the same projects could easily come up in other regions where water is currently available without any net gains to the economy. This argument does not hold for domestic water supply in the case of IGNP as the people already exist out there and face a crunch.

An interesting question is how the benefits compare with the cost of creating the structures. The current estimate of creating the whole PV scheme, including the dam on the Godavari River at Pollavaram as well as the rehabilitation and resettlement is about Rs 13,000 crore, or Rs 130 billion. Against this, net economic gains from the industrial and domestic water supply from the canals are estimated by us here at about Rs 0.75 billion per year. This is about half a percent rate of return on an annual basis. It is, of course, a moot point whether one should consider the entire investment for this comparison, or the investment on just the canals, etc. The total package of benefits from the PV Link scheme includes enhanced industrial production, incremental irrigation and revival of irrigation in the Krishna Delta currently facing a water crisis. When viewed in their totality, the gains are not insignificant even for the PV case. The size of these benefits is much more significant in the case of the IGNP project. Here, the IGNP itself is expected to cost around Rs 20 billion and on that the gains from domestic and industrial water supply as estimated by us come to about Rs 6.9 billion. This is quite a sizeable gain and it would appear in retrospect that the scheme should be seen as making sense even if it were not to provide any irrigation benefits! The dominance of gains from domestic and industrial water supply would be a common feature in all regions which face massive distress on account of paucity of drinking water as in the case of Gujarat, Marathwada, Karnataka, etc. An argument can broached that the chief advantage of the IBT schemes proposed under the NRLP lies in reducing the distress for domestic water faced by millions of people living in western and southern India. The question whether this benefit necessarily involves the proposed configuration of irrigation hardware needs to be thought over. In conclusion, we believe that the contribution of this paper lies in its attempt at demonstrating a way of attributing, valuing and estimating benefits which have hitherto been simply written as being incidental advantages of water structures.

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Annex 1. Details of time and cost of fetching water and potential wage loss in the sampled villages.

Groundwater in IGNP

District	Name of habitat	Out-of-pocket cost to household for normal, Rs/month	Out-of-pocket cost to household for scarcity, Rs/month	Total out-of-pocket cost of household Rs/month	lpcd	Normal month	Scarcity month	Time spent-normal period-primary source	Time spent-normal period-alternative source	Time spent during normal period, hours/yr	Time spent-scarcity period-primary source	Time spent-scarcity period-alternative source	Time spent during scarcity period, hours/yr	Prevailing wage rate, Rs	Potential wage loss during normal time @ 8 hours/day	Potential wage loss during scarcity time @ 8 hours/day
Barmer	Asotara	16.40	480	151.62	50.4	8.5	3.5	1.6	0.0	408.0	1.0	1.0	210.0	82.00	4,182	2,153
	Jasol	19.40	220	36.12	66.9	11.0	1.0	1.2	0.0	379.5	0.8	0.8	48.0	92.00	4,364	552
	Kuship	18.20	43	320.19	43.6	3.2	8.8	0.9	0.0	86.4	1.5	1.6	818.4	34.00	367	3,478
	Mevanagar	0.00	590	191.75	60.7	8.1	3.9	1.0	0.0	243.0	0.5	0.6	122.9	82.00	2,491	1,259
	Padardi	0.00	300	152.50	39.3	5.9	6.1	1.4	0.0	247.8	1.6	1.6	567.3	33.00	1,022	2,340
		11	404	170	52	7	5	1.2	0.0					65	2,485	1,956
Bikaner	Bhamatsar	23.40	0.	23.40	52.8	12.0	0.0	0.9	0.0	324.0	0.0	0.0	0.0	57.00	2,309	0
	Nokha	91.00	110	95.28	43.0	9.3	2.7	1.7	0.0	460.4	0.4	0.6	81.0	45.00	2,589	456
	Parwa	50.00	164	73.75	50.2	9.5	2.5	1.8	0.0	513.0	0.7	0.8	112.5	35.00	2,244	492
	Rasisar	43.50	180	61.70	50.4	10.4	1.6	0.9	0.0	280.8	0.4	0.6	48.0	65.00	2,282	390
	Somalsar	100.60	760	375.35	46.9	7.0	5.0	1.4	0.0	283.5	1.6	1.6	480.0	16.00	567	960
		62	243	126	49	10	2	1.3	0.0					44	1,998	460
Churu	Bandhrau													29.00	0	0
	Kikasar													77.00	0	0
	Malkasarq													16.00	0	0
	Malsar													50.00	0	0
	Patamdesar													36.00	0	0
														42	0	0
Hanumangarh	Dholipal													27.00	0	0
	Manaksar													64.00	0	0
	Nayana														0	0

	Rodawali														0	0
	Satipura														0	0
														46	0	0
Jaisalmer	Basanpeer	40.00	90	44.17	67.3	11.0	1.0	1.7	0.0	544.5	0.3	0.3	15.0	27.00	1,838	51
	Chandan	86.30	46	84.96	60.3	11.6	0.4	0.9	0.0	295.8	0.1	0.1	2.4	117.00	4,326	35
	Hameera	35.56	66.67	37.28	63.3	11.3	0.7	1.6	0.0	528.9	0.1	0.1	4.4	70.00	4,628	39
	Sodakor	33.33	0	31.48	41.1	11.3	0.7	1.6	0.0	528.9	0.2	0.3	11.1	32.22	2,130	45
	Thaieyat	30.00	0	30.00	39.2	12.0	0.0	1.8	0.0	648.0	0.0	0.0	0.0	81.00	6,561	0
		45	41	46	54									65	3,897	34
Jhunjhanu	Bakra	38.20	0	36.93	42.9	11.6	0.4	0.7	0.0	243.6	0.2	0.0	1.8	111.00	3,380	25
	Budana	26.00	0	25.35	38.0	11.7	0.3	0.8	0.0	263.3	0.0	0.2	1.8	78.00	2,567	18
	Chudela	156.67	130	154.44	40.6	11.0	1.0	0.8	0.0	264.0	0.2	0.6	24.0	57.00	1,881	171
	Desusar	23.40	0	23.01	35.8	11.8	0.2	0.6	0.0	212.4	0.2	0.2	2.4	90.50	2,403	27
	Rijani	103.00	100	103.00	36.7	12.0	0.0	1.2	0.0	414.0	0.0	0.2	0.0	34.00	1,760	0
		69	46	69	39									74	2,398	48
Jodhpur	Banad	0.00	480	0.00	59.8	12.0	0.0	1.6	0.0	576.0	0.0	1.4	0.0	113.00	8,136	0
	Daizar														0	0
	Dangiyabas														0	0
	Dantiwara													21.00	0	0
	Devliya													57.00	0	0
		0	240		60									64	1,627	0
Najaur	Bhadana	208.50	360	224.91	27.7	10.7	1.3	1.4	0.0	449.4	0.9	1.0	74.1	31.00	1,741	287
	Didiya kala	27.00	238	74.48	59.2	9.3	2.7	1.9	0.0	530.1	0.7	0.7	105.3	36.00	2,385	474
	Junjala	77.00	0	75.08	26.6	11.7	0.3	1.3	0.0	438.8	0.4	0.4	7.2	33.00	1,810	30
	Naradhana	11.11	500	124.28	39.9	9.2	2.8	1.6	0.0	430.4	1.0	0.8	148.1	40.00	2,152	741
	Roll	7.80	0	7.80	36.4	12.0	0.0	2.0	0.0	720.0	0.0	0.0	0.0	75.00	6,750	0
		66	220	101	38									43	2,968	306
Sikar	Badi khuri	40.67	0	40.67	43.3	12.0	0.0	0.9	0.0	324.0	0.0	0.0	0.0	129.57	5,247	0
	Bhadhadar	24.26	0	24.06	37.9	11.9	0.1	1.1	0.0	374.9	0.0	0.1	0.3	47.00	2,202	2

	Bhairupura	40.05	6	38.92	57.4	11.6	0.4	1.1	0.0	382.8	0.1	0.1	2.4	77.00	3,684	23
	Dhassu ka bass	34.33	0	34.33	46.0	12.0	0.0	0.8	0.0	270.0	0.0	0.0	0.0	106.30	3,588	0
	Rashid pura	41.42	0	41.42	41.5	12.0	0.0	0.8	0.0	270.0	0.0	0.0	0.0	59.00	1,991	0
		36	1	36	45									84	3,343	5
Ganganagar	Ganeshgarh													46.00	0	0
	Mahiyawali													67.00	0	0
	Manjhu bass													51.50	0	0
	Ratewala													63.00	0	0
	Sanwatsar													48.80	0	0
														55	0	0

Canal Water

Barmer	Asotara												82.00	0	0
	Jasol												92.00	0	0
	Kuship												34.00	0	0
	Mevanagar												82.00	0	0
	Padardi												33.00	0	0
														0	0
Bikaner	Bhamatsar												57.00	0	0
	Nokha												45.00	0	0
	Parwa												35.00	0	0
	Rasisar												65.00	0	0
	Somalsar												16.00	0	0
														0	0
Churu	Bandhrau	45.00	52	45.70	43.2	10.8	1.2	0.8	260.2	0.4	0.7	37.8	29.00	943	137
	Kikasar	43.20	85	44.25	54.6	11.7	0.3	1.3	456.3	0.0	0.2	1.8	77.00	4,392	17
	Malkasarq	54.00	103	58.90	42.9	10.8	1.2	1.5	486.0	0.8	1.0	63.0	16.00	972	126

	Malsar	31.50	0	30.45	37.4	11.6	0.4	1.2	400.2	0.1	0.3	4.2	50.00	2,501	26
	Patamdesar	66.00	0	66.00	56.4	12.0	0.0	1.3	450.0	0.0	0.0	0.0	36.00	2,025	0
		47.94	48	49	47				0.0			0.0		2,167	61
Hanumangarh	Dholipal	21.00	65	25.03	44.1	10.9	1.1	0.7	220.7	0.2	0.5	23.1	27.00	745	78
	Manaksar	17.10	40	19.58	38.7	10.7	1.3	0.6	200.6	1.0	1.1	81.9	64.00	1,605	655
	Nayana													0	0
	Rodawali													0	0
	Satipura													0	0
		19.05	52	45	41				0.0			0.0		470	147
Jaisalmer	Basanpeer												27.00	0	0
	Chandan												117.00	0	0
	Hameera												70.00	0	0
	Sodakor												32.22	0	0
	Thaieyat												81.00	0	0
														0	0
Jhunjhanu	Bakra												111.00	0	0
	Budana												78.00	0	0
	Chudela												57.00	0	0
	Desusar												90.50	0	0
	Rijani												34.00	0	0
														0	0
Jodhpur	Banad												113.00	0	0
	Daizar													0	0
	Dangiyabas													0	0
	Dantiwara	0.10	80	3.43	47.9	11.5	0.5	1.7	586.5	0.1	0.0	1.5	21.00	1,540	4
	Devliya	60.00	600	195.00	88.8	9.0	3.0	2.3	621.0	0.8	0.8	144.0	57.00	4,425	1,026
		30.05	340		68									1,193	206
Najaur	Bhadana												31.00	0	0
	Didiya kala												36.00	0	0
	Junjala												33.00	0	0

	Naradhana												40.00	0	0
	Roll												75.00	0	0
														0	0
Sikar	Badi khuri												129.57	0	0
	Bhadhadar												47.00	0	0
	Bhairupura												77.00	0	0
	Dhassu ka bass												106.30	0	0
	Rashid pura												59.00	0	0
														0	0
Sriganganagar	Ganeshgarh	20.80	115	48.28	33.2	8.5	3.5	0.5	115.5	0.6	0.6	126.0	46.00	664	725
	Mahiyawali	20.80	0	19.93	47.7	11.5	0.5	0.6	189.8	0.2	0.5	10.5	67.00	1,589	88
	Manjhu bass	23.40	133	38.01	48.7	10.4	1.6	0.5	149.1	0.2	0.3	22.8	51.50	960	147
	Ratewala	24.90	35	27.26	40.9	9.2	2.8	1.2	317.4	1.4	1.6	243.6	63.00	2,500	1,918
	Sanwatsar	20.80	15	20.41	47.0	11.2	0.8	0.7	219.7	0.4	0.5	19.2	48.80	1,340	117
		22.14	60	31	44									1,411	599

Groundwater in PV

East Godavari	Amalapuram	7.3	0	7.30	79	11.90	0.00	0.9	2.5	1,210.8			0.0	44.25	6,697	0
	Bikkavolu	6.5	0	6.32	65	11.68	0.33	0.9	1.6	872.6	1.6	1.6	31.3	13.43	1,464	52
	Peddapuram	6.0	0	5.93	70	11.87	0.13	0.9	1.2	750.4	0.9	0.9	7.0	29.33	2,752	26
	Sita Nagaram	6.8	0	6.74	85	11.90	0.10	1.7	1.4	1,111.6	2.0	2.5	13.8	20.77	2,886	36
		7		7	75	12	0	1	2	986	1	2	13	27	3,450	29
Krishna	Nuzividu	1.5	0	1.49	69	12.00	0.00	0.7	1.3	714.6			0.0	17.33	1,548	0
		1	0	1	69	12	0	1	1	715	NA	NA	0	17	1,548	0

Vishakapatnam	Achutapuram	2.5	0	2.44	72	11.70	0.30	1.0	1.1	733.4	2.9	1.3	37.5	24.00	2,200	113
	Anakapalli	1.3	0	1.32	68	11.90	0.10	0.9	1.2	737.2	1.8	2.0	11.5	17.00	1,567	24
	Narsipatnam	3.5	0	3.35	80	11.40	0.50	0.9	1.5	816.5			0.0	20.50	2,092	0
		2		2	74	12	0	1	1	762	2	2	16	21	1,953	46
West Godavari	Pedavegi	12.5	0	12.09	75	11.93	0.40	0.9	1.7	929.1	2.0		24.0	41.00	4,762	123
	Tadepalligudem	18.0	0	18.00	71	12.00	0.00	0.9	1.6	888.0			0.0	17.67	1,961	0
		15	0	15	73	12	0	1	2	909	2	#DIV/0!	12	29	3,361	62

Canal Water in PV

East Godavari	Amalapuram	18.3	0.00	17.34	59	11.40	0.60	0.8	1.3	742.3	1.1	1.9	54.0	44.25	4,106	299
	Bikkavolu													13.43	0	0
	Peddapuram													29.33	0	0
	Sita Nagaram													20.77	0	0
		18.3	0.00	17.34	59	11.40	0.60	0.8	1.3	742.3	1.1	1.9	54.0	24.12	1,026	75
Krishna	Nuzividu													17.33	0	0
														17.33	0	0
Vishakapatnam	Achutapuram													24.00	0	0
	Anakapalli	41.0	0.00	41.00	83	12.00	0.00	0.9	1.0	703.4			0.0	17.00	1,495	0
	Narsipatnam	5.0	0.00	4.92	67	11.80	0.20	0.6	1.0	577.7	1.0	1.0	12.0	20.50	1,480	31
		23.0	0.00	22.81	75	11.90	0.10	0.8	1.0	640.1	1.0	1.0	6.0	20.50	992	10
West Godavari	Pedavegi	0.0	0.00	#DIV/0!						0.0			0.0	41.00	0	0
	Tadepalligudem	28.9	0.02	27.95	69	11.40	0.40	0.8	6.3	2,454.0	23.0	0.0	276.0	17.67	5,419	610
		28.9	0.02	27.95	69	11.40	0.40	0.8	6.3	2,454.0	23.0	0.0	276.0	29.33	2,710	305

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