Economic analysis of ground water exploitation and productivity of water

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ABSTRACT

The total demand for water in India is projected to be 886 billion cubic meter in 2030. The increase in demand will be higher for urban and industrial uses than for agriculture. A portion of the growing demand for water will be met though new investment in irrigation and water supply systems and some potential exists for expansion of non-traditional sources of water supply. However supply expansion will not be sufficient to meet the increasing demands. Battles are very high between different users of a single source of water such as for drinking water, irrigation and industrial use. Therefore the rapidly growing urban and industrial water demands will need to be met increasingly from water transfers out of irrigated agriculture. The effective management of this limited resource requires a nexus approach to governance which integrates the cause and the effect of water on the environment, society and the economy. With constraints to further supply-side augmentation because of over-abstraction and overuse of water in multiple geographies, demand-side management plays a crucial role in closing this gap. It is essential to manage their use efficiently and policymakers, researchers and farmers continually discuss how to formulate policies that will help. Hence it was one of the important objectives in this study. One hundred fifty samples were analyzed and assessed for the groundwater exploitation and agriculture in the lower Bhavani basin.

Keywords: Water market; cost; water; productivity; inter-sectoral transfer; water lifting

INTRODUCTION

The existing rights are such that farmers are not restrictive for their water transfer (Agrawal 2012). Competition for limited water resources increasingly occurs between different stakeholders and at different levels: between farmers within an irrigation system; between irrigation systems in the same river basin; between the agricultural sector and other rural uses such as fisheries or domestic water supply and drinking water and more and more between agricultural and urban and industrial users and uses.

The increase in demand will be higher for urban and industrial uses than for agriculture (Cullet 2012). The increasing demand over supply of water, the worked out supply-demand gap based on the growth rates of irrigated crops is 2.12 Mham (44.72%). The gap is 0.48 Mham (National Commission on Agriculture's estimate) and it is 10.12 per cent (Palanisami 2013). In India, average food grain consumption at present (Anon 2019b) is 550 g per capita per day whereas the corresponding figures for China and USA are 980 and 2,850 g respectively. Present annual requirement on the basis of present consumption level (550 g) for the country is about 200 million tonnes (MT). A moderate rise in consumption level of 750 g per capita per day is considered to be realistic for assessment of future needs. The annual food grain requirement of the country thus works out to be 450 MT by the year 2050 (Pavelic et al 2015).

The real challenge is providing additional irrigation water to increase food production while satisfying the rising demand for water from other competing sectors (Srinivasan and Kulkarni 2014). Since irrigation sector being the largest consumer of water, greater attention in water management is needed in this sector. That is, almost all the utilizable potential will have to be harnessed to meet the demand for agriculture, industry, energy generation and domestic consumption. Even among the user sectors, the consumption of water in India is highly skewed (Thakkar 2018).

A portion of the growing demand for water will be met though new investment in irrigation and water supply systems and some potential exists for expansion of non-traditional sources of water supply (Anon 2019a). However supply expansion will not be sufficient to meet increasing demands. Therefore the rapidly growing urban and industrial water demands will need to be met increasingly from water transfers out of irrigated agriculture (Anon 2018). Hence it was one of the important objectives in this study. Total 150 samples were analyzed and assessed to find out the extent and nature of water transfer in the lower Bhavani basin.

The public works department controlled water allocation up to the distributory level while farmers were responsible for farm level water distribution (Anon 2011, 2012). In the wet season, water was distributed (both old and new Ayacut) via continuous flooding of the fields; in the dry season, farmers rotated their turns (in LBP) during alternate weeks only. This policy indicates how the allocation of water in Tamil Nadu has evolved to become user-based which is a prerequisite for market-based water allocation (Rathore 2011).

In an eight-day period of water supply (in LBP) to a distributory from the canal, water allowance to a farmer is calculated (WA), where water allowance (WA) is the time (minutes or hours) multiplied by the area owned. This determines the total time of water use allowed for each farmer. Farmers who had wells and farmers who were not in need of water exchanged their turns with their neighbours (eg Thindal distributory of the LBP) using the concept of water allowance defined in terms of number of hours per unit area. Currently two major forms of water transfer have been observed in the lower Bhavani basin ie within the basin (agriculture and non-farm sector) and between the basin (agriculture and non-farm sector).

METHODOLOGY

To find out the water market at farm level, random sampling procedure was adopted in the study representing head, middle and tail regions of canal based on the location with respect to the distance from the Bhavanisagar reservoir. From each region, 50 water sellers were selected using random sampling procedure. Thus 150 samples were analyzed and assessed to find out the extent and nature of water transfer in the lower Bhavani basin. A reconnaissance survey for each region (head, middle and tail end) was undertaken with a view to assess the nature and extent of water transfer and productivity of water by such water transfer. To collect the required information an interview schedule was prepared, pre-tested and used. The analyses of data were taken up with the help of different econometric models using the both primary and secondary level data to derive relevant policy options.

RESULTS and DISCUSSION

Water was transferred in all three sectors in different ways in the lower Bhavani basin. Here the ways of water transferred and quantity in these 3 sectors were studied.

Agriculture sector water transfer

Mode of exchange/transfer between farmers

Transfer of water in LBP occurred mostly between farmers of the same sluice and to a limited extent between farmers of different sluices. When farmers were not irrigating their turns (fixed timing), they gave them to relatives or neighbourers who might return the turn the next time (eg Thindal distributory of the LBP). Farmers whose fields were located near canals received seepage water rather than canal water for irrigation. In such cases they gave their canal turns to other farmers and waited to use their turn next time (eg Mogagoundavalasu). In many cases farmers who grew sugarcane instead of rice gave their excess water to neighbourers who grew rice (eg Velliyangiripudur). According to a farmer from Chitode, about 10 per cent of the farmers in their distributaries exchanged water. When the farmers in the tail end had acute water shortage, well owners used their well water and left their canal turns to others in the sluice without expecting compensation. According to a farmer in Allampalayam village (Muthur), canal turns were given to others as electricity was free. If farmers charged for electricity, they would ask the recipients to pay the electricity bill according to the number of hours pumped.

Direct lift irrigation in agricultural sector

Large number of farmers who had their land along with the Bhavani river course were engaged in lifting water from the river. In some cases farmers who had lands far away from the river were also engaged in water lifting. These farmers owning cultivated lands at far off locations from the river course, bought small pieces of land usually around five to ten cents nearby the river in which they dug wells, laid pipelines to their holdings and pumped water. Farmers lifted water either directly from the river or from dug wells established by them in the river side. If lands were located near the river bank, they would set pump sets individually. If lands were located within a reasonable distance, they would jointly engage in lifting water because of high establishment and running costs. This practice was illegal because wells within 200 m of the river were considered to be recharged directly from the river. Thus pumping from these wells diverted water to which the pump owner had no rights. The pucca well constructions were made with reinforced concrete and conduits were laid from them to the interior fields. PVC, GI and HDPE pipes of large dimensions were used. Farmers used both electric motors and diesel engines to lift water. In most cases farmers used diesel pump sets in these types of operations though some used electricity by transferring their existing electric connections to the new wells. This practice further compounded the illegality of river pumping: selling water from pumps that used electrical power was prohibited because electricity was provided free for direct agricultural purposes only. Despite the illegality of the practice, farmers/pumpers often simply paid the necessary penalties and continued the water selling business which generated more than adequate revenues to cover the modest fine.

This lift irrigation existed both in upstream (Mettupalayam Taluk of Coimbatore district) and downstream (Erode district of Bhavanisagar). In the case of electric pump sets, the horse power used to lift water varied from 5 to 15. Most of the farmers used 5 HP electric motors. In the case of diesel engines, it varied from 2.5 to 10 HP. Most farmers used 5 and 10 HP diesel engines.

Water pumping from river was allowed as authorized activity. The authorization was given to Patta landowners. These Patta landowners paid water charges (Rs 150 for wet crop) to revenue department like others and were not needed to pay extra to revenue department for water pumping activity. Due to non-extra payment to authorization pumping, every landowner wanted to take water from river and got authorization. In the upstream of Bhavanisagar, the authorized 845 farmers lifted water with the help of electric motors and diesel engines to irrigate 1,023 ha land. In the downstream of Bhavanisagar, authorized 1,012 farmers in Sathiyamangalam, Gobichettipalayam and Bhavani Taluks set diesel engines and electric motors to lift water. By the water pumping in downstream irrigation they irrigated 2,691 ha land. The total authorized river-pumping irrigation was 3,714 ha and quantity of water pumped was 31.38 MCM.

The authorization of water pumping activity in head and middle regions of river had affected the tail end farmers resulting in government stopping the authorization process. Hence unauthorized river water pumping had arisen. The details of numbers, area under irrigation through authorized and unauthorized driver pumping and quantity of water pumped from river are indicated in Table 1. Total 2,961 lifted water directly from river by authorized or unauthorized and 49.36 MCM of water was lifted. Hence 8,228 ha was irrigated in non-command area in the basin by river water pumping.

Domestic sector water transfer

By farmers/individuals: Inter-sectoral water markets were operating in and around the LBP basin particularly near the tail region of the canal system. Farmers/well owners sold water to tanker operators who transported the water to urban centers and sold it to barrel operators who in turn sold it to households. Tankers supplied water to textile industries, households and other groups in Vellakoil within a radius of 5 to 10 km from the pumping point. They covered a distance of about 25 km but during peak demand might cover up to 40 km. Each tanker had a capacity of 13,500 liters and made six to seven trips per day (up to 22 trips per day during peak demand). Approximately water was being sold from more than 200 wells to non-agricultural purposes and 500 tankers were operating daily in the basin. Hence 47.25 million liters per day (mld) or 17.24 MCM per year water was transferred in lean season and 148.5 mld or 54.18 MCM per year in peak season to drinking purposes from agricultural sector.

Cost and productivity of water in different sectors

Growing urban and industrial water demands would be met increasingly from water transfers out of irrigated agriculture. In this transfer process to analyze and assess the cost and productivity of water in different sectors (agricultural sector, domestic sector and industrial sector) was a key strategy for addressing water scarcity.

Table 1. Number and area under authorized and unauthorized pumping

Nature of water pumping	Number of units	Area covered (ha)	Quantity of water pumped (MCM)
Authorized river and canal pumping	1,857	3,714	31.38
Unauthorized river and canal pumping	1,064	4,514	17.91
Total	2,921	8,228	49.36

Source: PWD survey data, Erode

Table 2. Cost analysis of 1 kl water pumping from 1 km distance from river

Component	Amount/quantity
Well (200 ft) at 70/ft cost (Rs)	14,000
Pipe for 200 ft well (Rs 35/ft)	7,000
Wiring and labour fitting cost	20,000
Pipe for 1 km distance field (Rs 35/ft)	1,22,500
Total cost of well (Rs)	1,63,500
Land value of 5 cent near to river (at Rs 3,000/cent)	15,000
Average life of wells (years)	30
Assumed land duration (years)	100
Average life of electric motors (years)	15
Age of well/electric motor (2003 year of construction)	1
Interest rate (@ 12%)	0.12
Cost of electric motor and accessories (Rs)	24,000
Electric motor and accessories (hp)	5
Compounded cost of well (Rs)	1,83,120
Compounded cost of land (Rs)	16,800
Compounded cost of motor & accessories (Rs/year)	26,880
Annualised cost of well (Rs/year)	22,733.19
Annualised cost of land (Rs/year)	2,016.024
Annualised cost of motors (Rs/year)	3,946.636
Total annualised cost (Rs/year)	28,695.85
Total hours of pumping (h/day for 300 days)	1,200
Energy consumption (kwh)	4,476
Quantity of water pumped (M3)	15,120
Labour cost in rupees/year (@ Rs 70/day)	10,500
Maintenance cost (Rs/year)	480
Electricity cost (Rs 3.1/kwh/year)	13,875.6
Total irrigation cost (Rs 3.1/kwh/year) case	53,551.45
Total cost in field itself case (Rs)	51,535.42
Cost of river pumping scheme (Rs/M3 of water)	3.54

Cost of water in agricultural sector

In agricultural sector, there were cases ie authorized or unauthorized water pumping in field itself or pumping from 1-3 km distance from river. The cost difference between these two cases was in pipe cost (water transfer to long distance) and well cost.

The cost of pumping of one kilo liter of water is given in Tables 2 and 3. In case of water pumping from long distance of river, the cost of pipe for 1 km distance was Rs 1,22,500 at Rs 35 per feet and well cost Rs 41,000 was incurred and these two costs in the case of field itself water pumping, water transfer pipe cost was nil and well cost was Rs 95,500. The average

Table 3. Cost analysis of 1 kl water pumping in farm well

Component	Amount/quantity
Well cost (650 ft) (Rs)	45,500
Pipe (Rs)	30,000
Wiring and labour fitting cost (Rs)	20,000
Total cost of well (Rs)	95,500
Average life of wells (years)	30
Average life of electric motors (years)	15
Age of well/electric motor (2003 year of construction)	1
Interest rate (@ 12%)	0.12
Cost of submerged motor and accessories (Rs)	30,000
Electric motor and accessories (hp)	5
Compounded cost of well (Rs)	1,06,960
Compounded cost of motor & accessories (Rs/year)	33,600
Annualised cost of well (Rs/year)	13,278.41
Annualised cost of motors (Rs/year)	4,933.29
Total annualised cost (Rs/year)	18,211.70
Total hours of pumping (h/day for 360 days)	1,620
Energy consumption (kwh)	60,42.6
Quantity of water pumped (M3)	20,412
Labour cost/per year (@ Rs 70/day)	14,175
Maintenance cost (Rs/year)	500
Electricity cost for commercial purpose (Rs 6 per kwh)	18,732.06
Total cost (Rs/year)	51,618.76
Cost of water pumping (Rs/M3 of water)	2.53

cost of 1 kl of water was Rs 3.54 in pumping scheme from the river and Rs 2.53 in water pumping.

$$\text{Amortized cost of well} = [(\text{Capital cost of well})*(1+i)^{AL}*i] \div [(1+i)^{AL}-1]$$

where AL= Average life of wells constructed during 2012

Cost of water in domestic sectors

Inter-sector water transfer in study area basin occurred in two ways viz one by farmers and another by TWAD Board. Productivity of water in these two cases was worked out separately.

Farmers/individual water supply case

Farmers or individuals transferred water from farm wells or house wells near agricultural fields to domestic sectors. The number of tanker trips on a given day depended upon the price of water as well as demand. Farmers sold water for Rs 15 per 1,000 liters and Rs 200 per tanker (13,500 liters) and tankers sold it for about Rs 60 per 1,000 liters and Rs 800 per load. One kwh power in 5 minutes was needed to fill 1,000 liters. Farmers incurred cost in electricity to pump water for commercial sale 6.50 per kwh per 1,000 liters (Table 4). Depending upon demand, farmers might increase their rates during some seasons to Rs 40 per 1,000 liters and Rs 540 per load. Because farmers owned both the land and the well, they faced no authorized constraint in pumping out well water to sell and the government did not interfere in the process.

In several cases tanker operators delivered water in huge tanks to barrel operators who then sold it in small quantities such as Rs 12 per barrel of 200 liters and Rs 20 per barrel to bullock-cart owners. The bullock cart owners in turn sold the water to households at about Rs 35 per barrel. The cost analysis furnished in Table 4 show cost of 1 kl of water and the profit margins farmers made from selling water from their wells. The cost of 1 kl of water was Rs 6.68 and farmers got Rs 2,310 per day for 21 loads on a normal day. Farmers whose wells were near cities and were serviced by relatively good road facilities had the best market potential to sell water.

As noted above, demand for water varied depending on the season but it also changed according to the level of water in the wells and the pricing

Table 4. Cost and return in non-farm sectoral water transfer

Component	Amount (Rs)
Quantity of water pumped in a day	283.5
Average cost of water to the farmer*/tanker	
Electricity pumping cost	87.75
Labour cost (at Rs 50/day)	2.38
Total cost	90.13
Farmer's selling price	200
Profit to farmer (13,500 liters/tank)	110
Profit to farmer/day (@ 21 loads on normal day)	2,310
Cost of 1 kl of water	
Electricity pumping cost	6.5
Labour cost	0.18
Total cost	6.68

*Well cost not included in the calculation per tanker water filling

mechanisms used. For example in the summer season, each well had sufficient water for only 10 to 15 tankers as canal water was stopped during this time and recharge was comparatively less. In fact these wells were capturing the canal flows indirectly as evidenced from the recharge pattern and the quantity of water sold. However markets handled variability in supply and price very well. During water scarcities, farmers would activate wells located far away. Similarly tanker operators reduced their intake from farmers who had increased their rates. In the rainy season demand was comparatively less.

The details of the profit and cost of tanker operators in the inter-sectoral water transfer are given in Table 5. The tanker operators got profit of Rs 3,770.06 per day in normal period and Rs 13,307.25 per day in demand period.

The details of the profit and cost of barrel operators in the inter-sectoral water transfer are given in Table 6. The barrel operators got profit of Rs 550 per tanker in normal period and it was doubled during peak demand.

The details of the profit and cost of bullock cart operators in the inter-sectoral water transfer are given in Table 7. The bullock cart operators got profit of Rs 1,012.5 per tanker or Rs 15 per barrel or Rs 175 per 1,000 liters in normal period and it was doubled in demand period.

The details of the profit and cost of different types of operators in the inter-sectoral water transfer are given in Table 8. The bullock operators got profit of Rs 75 per kilo liter more than other operators in normal period and it was doubled during peak demand.

According to the farmers, water selling as such was uncommon in agriculture particularly in the head and middle regions of the system because water was sufficient even during scarcity periods. It was difficult to take water to farmers who needed it as their locations were at long distance to transfer the water cost effectively. Conversely in the tail region of the LBP command area, water selling was quite common. Farmers in Chitode, Thindal, Allampalayam, Velliangavalasu, Manthapuram and Muthur were familiar with water selling. There water was being sold from more than 200 wells to non-agricultural purposes.

The farmers indicated that they understood the importance of water rights. The selling of water for non-agricultural purposes was more profitable than using it for agricultural purposes due to labour problems and unfavourable crop prices. In several cases farmers grew coconut and other perennial crops that consumed less water thereby releasing water for sale. Among the farmers who were selling water, about 55 per cent had been growing coconut and other fruit crops mainly to minimize labour and water consumption. Well-off farmers sold water to alleviate labour problems (for example, hiring and keeping farm workers) and the high demand for water in urban markets made the market promising.

Table 5. Cost and profit margin of tanker operators among non-farm sectoral water market sellers

Component	Amount (Rs/tanker)
Normal period	
Tanker operator's purchase price (13,500 l)	200
Tanker operator's purchase price (1,000 l)	15
Tanker operator's selling price	800
Operational cost per load within 5 km	
Driver (Rs 150/day)	21.42
Cleaner (Rs 70/day)	10
Fuel charges and others	30
Total	61.42
Profit	538.58
Profit/day (@ 7 loads)	3,770.06
Demand period	
Farmer's selling price (Rs 40/1,000 l)	540
Tanker operator's selling price	1,500
Operational cost/load within 5 km	
Driver	28.57
Cleaner	14.28
Fuel charges and others	30
Total	72.85
Profit	887.15
Profit/day (@15 loads/day)	13,307.25

Table 6. Cost and profit margins of barrel operators among water market sellers in normal period

Component	Amount (Rs)
Tanker operator's selling price/tanker (13,500 l)	800
Barrel operator's selling price/barrel (200 l)	20
Total income/tanker (67.5 barrels)	1,350
Profit/tanker	550

Table 7. Cost and profit margins of bullock-cart owners among water market sellers in normal period

Component	Per	Amount (Rs)
Barrel operator's selling price	Barrel	20
Bullock-cart operator's selling price to household	Barrel	35
Final price of water to household	Tanker	2,362.5
	1,000 l	175
Profit	Tanker	1,012.5
	Barrel	15
	1,000 l	75

CONCLUSION

Inter-sectoral water markets were operating in and around the LBP basin particularly near the tail region of the canal system. Farmers/well owners sold water to tanker operators who transported water to urban centers and sold it to barrel operators who in turn sold it to households. For water pumping from long distance from river, the cost of pipe for 1 km distance was Rs 1,22,500 at Rs 35 per feet and well

Table 8. Cost and profits of different type of operators in the inter-sectoral water transfer

Operator	Incurred cost (Rs/1,000 l water)	Profit (Rs/1,000 l water)
Farmers	6.68	8.15
Tankers	15	39.85
Barrel	60	40.74
Bullock	100	75.00

cost Rs 41,000 was incurred and farm well cost was Rs 95,500. The average cost of 1 kl of water was Rs 3.54 in river pumping scheme and Rs 2.53 water pumping in farm well. Incurred cost was Rs 6.68, 15, 60,100 for 1,000 liters for farmer, tanker, barrel and bullock operator respectively.

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