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Impact of Farm Sector Electricity Subsidy on Water Use Efficiency and Water Productivity in India

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ABSTRACT

Irrigation plays an important role in the growth of India agriculture and it helped the farmers to grow multiple crops during the year. The share of groundwater in total net irrigated area (20.85 million hectares) increased by 28.67 per cent to 61.40 per cent during 1950-51 to 2010-11. Out of the total net irrigated area in the country, the share of groundwater irrigated area was 28.67 per cent and 61.40 per cent in 1950-51 and 2010-11 respectively. The growth in net area irrigated by groundwater is growing at a compound growth rate of 3.54 per cent per annum during 1950-51 to 2010-11. The total electric operated pump for pumping groundwater in the country increased from 10.27 million to 11.05 million during 2001 to 2006 whereas, the diesel operated pumps declined from 6.55 million to 6.30 million during 2001 to 2006. The electric subsidy to farm sector has increased from Rs 7334.9 crore to Rs 45561.0 crore during 1992-93 to 2011-12 registering a compound growth rate of 8.65 per cent per annum. The present study has tried to assess the impact of electricity on groundwater use and water use efficiency. The study was confined to three Indian states viz., Uttar Pradesh, Bihar and Punjab. In case of Uttar Pradesh and Bihar, diesel pump owners were using less irrigation water for all the crops as compared to electric pump owners. The diesel pump owners were getting the highest physical and economic water productivity for all the crops except paddy as compared to electric pump owners. In case of Punjab, farmers were using less groundwater for all the crops as compared to canal water. The physical water productivity was higher for all the crops grown under groundwater irrigation except bajra and barseem. The net economic value of water productivity was found higher for groundwater irrigated field in maize, bajra and wheat. The study suggests that the introduction of pro-rata pricing of electricity supply to farm sector could be the best option for better management of groundwater. This would help in equitable, efficient and sustainable use of groundwater and reduce the burden of gigantic electricity subsidy to farm sector. Pre-paid metering to farm sector may also increase water use efficiency.

Keywords: Electricity subsidy, Pro-rata pricing, Efficiency of water use.

JEL: Q11, Q15, Q16

I

INTRODUCTION

Irrigation is one of the important inputs for crop production. The major source of irrigated crop production in the country is groundwater. The net area irrigated in the country was 60.86 million hectares and the share of groundwater and surface water irrigated area was 59.01 and 40.99 per cent respectively during 2010-11. For the groundwater development in the country, Government has launched millions well scheme, free boring scheme, etc. in different regions of the country. The groundwater development in the country was also triggered by the subsidised electricity supply to

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the farm sector. There are 19.76 million tubewells in the country out of which, electric and diesel operated tubewells are 11.05 and 6.30 million respectively (Government of India, 2005; 2008). Electric pumps are mainly used by the farmers in those areas where the availability of groundwater is in deeper aquifer and relatively electric supply to the farm sector is sufficient. On the other hand, farmers are using diesel pump in those regions where groundwater availability is in shallow aquifers with poor electrification in farm sector.

The electricity subsidy provided by the government to the farm sector increased from Rs. 7334 crore to the tune of Rs 45561 crore during 1992-93 to 2011-12 (Government of India, 2011). The uncontrolled withdrawal of groundwater for crop production which is supported by subsidised electricity in the farm sector leads to rapid decline in the water level in different parts of the country (Kumar, 2007). The growing dependency on groundwater threatened land productivity, water resource sustainability and power sector viability. Agricultural power – supplied flat-rate or free and viewed as an entitlement – must increasingly be managed as a scarce input (World Bank, 2001). Raising power tariffs in the farm sector to achieve efficiency and sustainability of groundwater use is the need of the hour from social, economical and environmental point of view.

As irrigation is the main source of groundwater in the country, raising water productivity in groundwater-irrigated areas to reduce total water use is essential for arresting groundwater depletion (Amarasinghe *et al*., 2004; Kumar, 2005, 2007). Many Indian states are considering re-introduction of electricity metering in the farm sector to manage groundwater demand. The basic logic behind this is that at higher power tariff, with induced marginal cost of electricity and water, farmers will improve water use efficiency (Kumar *et al*., 2011) and enhanced water productivity.

II

OBJECTIVE

The overall objective of the present study was to find out the impact of electricity subsidy on groundwater use and water productivity for crop production.

III

ANALYTICAL PROCEDURE

3.1 *Data and Its Source*

The present study is based on the primary and secondary data. Primary data were collected on three different states, viz., Uttar Pradesh, Bihar and Punjab. The states of Uttar Pradesh and Bihar have high density of diesel pump sets and Punjab being the highly electrified and canal irrigated state were selected purposively. In Uttar Pradesh two districts, viz., Varanasi from eastern Uttar Pradesh and Mirzapur from Vindhyan

region were selected randomly. In Uttar Pradesh, 30 well owners and 30 diesel pump owners were selected randomly from each district. In case of Bihar state, two villages, i.e., one village dominated by electric pump and another diesel pump dominated village from Patna district were selected purposively. From each village 60 farmers were selected randomly for primary data collection. In case of Punjab, the farmers were using groundwater and canal water for irrigated crop production. Two villages, i.e., one village dominated by groundwater irrigation and another village dominated by canal irrigation were selected purposively from Hoshiarpur district. From each village 60 farmers were selected. Thus, a total of 360 sample farmers, comprising 120 farmers from each state were selected for the study. The data related to inputs use, irrigation water use and output and market price of each crop were collected using pre-tested schedule to fulfill the objectives of the present study.

3.2 *Analytical Tools*

In the study area, on the basis of water utilisation pattern in the farm sector , the farmers were classified into three groups (a) electric pump owner, (b) diesel pump owner and (c) canal irrigators. Due to lack of any incentive and zero marginal cost , electric pump owners do not use pump rationally, while diesel pump owners using their pump rationally keeping in view the marginal cost of extra water use. There are very few Indian states where farmers pay electricity on the basis of actual power consumption. In Gujarat state, new electric connections are providing to the farm sector and Gujarat electricity board charging on actual electricity basis, i.e., meter.

3.2.1 *Estimation of Irrigation Water Use*

For the estimation of total volume of irrigation water (θ) used for a particular crop during the entire crop period, the following equation was used (Singh, 2004; Singh *et al*. 2010):

$$\theta_{crop} = Irri_n * H_{PI} * PD$$

where: θ_{crop} is total irrigation water used for crop production (m^3); $Irri_n$ is the total number of irrigations given to particular crop during the crop period; H_{PI} is the hours of irrigation water used per irrigation; *PD* is the pump discharge rate (m^3/hour).

3.2.2 *Estimation of Physical Water Productivity*

The physical water productivity for a given crop (kg/m^3) was estimated using the data on crop yield and the estimated volume of water applied for all sample farmers growing that crop. The physical productivity ($kg./m^3$) of water for different crops was estimated as:

$$WP_{Crop} = \frac{Q_{crop(main)}}{\theta_{crop}}$$

where: WP_{crop} is the physical crop water productivity (kg./m^3); $Q_{crop(main)}$ is the average yield (main product) of the crops measured in kilogram; θ_{crop} is the total irrigation water used for crop production (m^3).

3.2.3 *Estimation of Net Income*

The net income from the crop was estimated by using data on crop production multiplied by the farmers' sale price of the crop minus cost of cultivation of a particular crop.

$$NI_{crop} = \left(Q_{crop} * P_{FSP}\right) - IC$$

where: NI_{crop} is the net income from crop production (Rs./ha); Q_{crop} is the quantity of crop production (kg/ha); P_{FSP} is the farmers' sale price (Rs./kg) and *IC* is the total input cost used for the crop production.

3.2.4 *Estimation of Net Economic Water Productivity*

The net economic water productivity (Rs./m^3) was estimated using data on net return from crop production and estimated volume of water (θ_{crop}) used for crop production. The net economic productivity of water (Rs./m^3) for different crops was estimated as:

$$NEWP = \frac{NI_{crop}}{\theta_{crop}}$$

where: *NEWP* is the net economic water productivity (Rs./m^3); NI_{crop} is the net income received by the farmers (Rs./ha) and θ_{crop} is the volume of water used for crop production.

IV

RESULTS AND DISCUSSION

4.1 *Growth in Irrigated Area by Source*

The growth in source-wise net irrigated area in India is given in Figure 1. During 1950-51 to 2010-11, net irrigated area in the country was 20.85 million hectares. The source-wise highest net irrigated area was from surface water with 57.10 per cent.

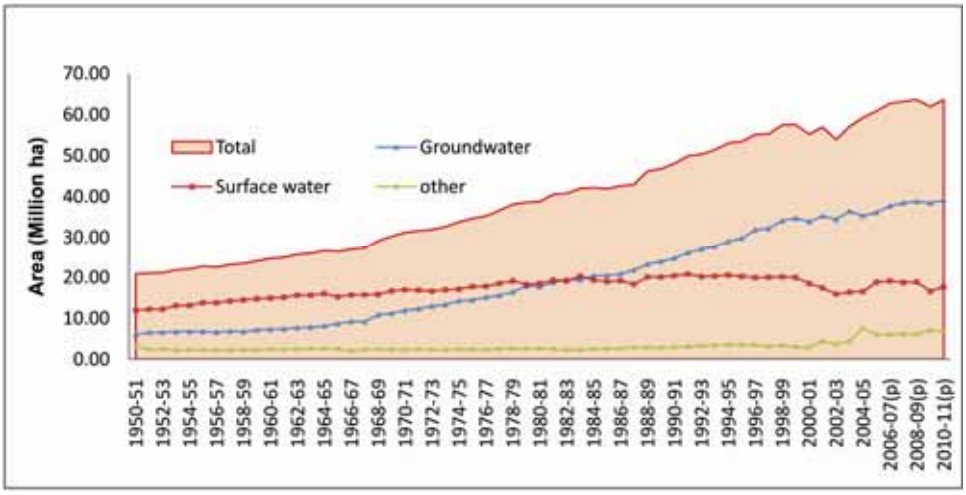

Figure 1. Source-Wise Net Irrigated Area, India.

The share of groundwater and others sources was 28.67 and 14.23 per cent respectively during the same period of time. By the year 2010-11, the total net area irrigated in the country was 63.60 million hectares. The share of surface water, groundwater and other sources was 61.41, 27.78 and 10.80 per cent respectively during the same period of time.

The net irrigated area by groundwater has registered a compound growth rate of 3.54 per cent per annum during 1950-51 to 2010-11, whereas net irrigated area by surface irrigation registered a compound growth rate of 0.63 per cent per annum during the same period of time. In case of net area irrigated by other sources are growing with a compound growth rate of 1.50 per cent per annum during 1950-51 to 2010-11.

The increase in groundwater irrigated area in the country was due to public and private investment in tubewell technology along with different government initiated programmes like millions well scheme, free boring etc. triggered with subsidised power supply to the farm sector. Use of groundwater helped the farmers to take up cultivation of multiple crops which resulted in high cropping intensity.

4.2 *Growth in Electric and Diesel Pump*

As per minor irrigation census 2000-01, total electric operated pump for pumping groundwater in the country was 10.27 million and 0.78 million pumps were added during the five year period and it had increased to the level of 11.05 million by the year 2005-06 (Government of India, 2005; 2008). In case of diesel operated pumps for groundwater extraction in the country it was 6.55 million during 2000-01 which declined to the level of 6.30 million by the year 2005-06 showing a decline of 0.25

million pumps. On an average the annual decline in diesel pumps in the country was 0.05 million. The decline in the diesel pumps in the country was due to reduction in groundwater availability in shallow aquifer and farmers were shifted from diesel pump to electric pump for extracting water from the deep aquifer.

4.3 *Growth in Electricity Subsidy to Farm Sector*

Growth in electricity subsidy to the farm sector is presented in Figure 2. The electric subsidy to the farm sector was Rs. 7334.9 crore in 1992-93 which increased to Rs 45561.0 crore by the year 2011-12 (Government of India, 2001; 2002 and 2011). The growth trend analysis of electricity subsidy reveals that it is growing with a compound growth rate of 8.65 per cent per annum.

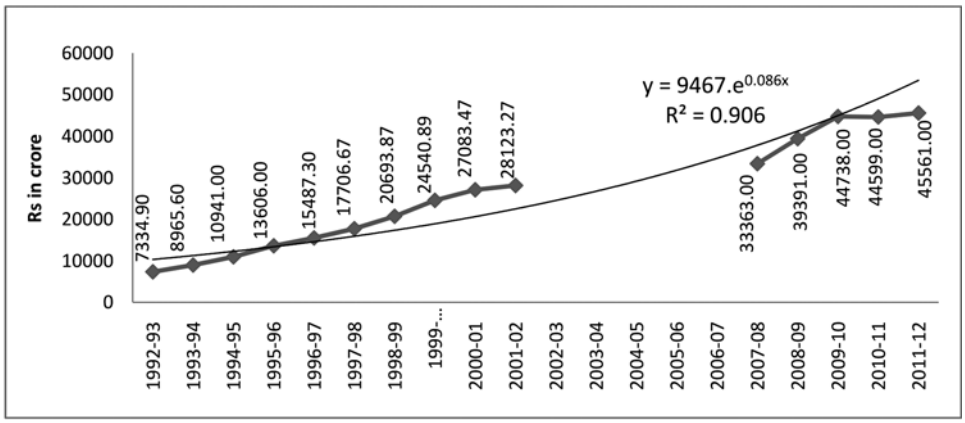

Figure 2. Growth in Electricity Subsidy to Farm Sector, India.

4.4 *Impact on Water Use and Water Productivity*

4.4.1 *Uttar Pradesh*

The volume of groundwater used for crop production under electric and diesel pump irrigation, physical water productivity (kg/m^3) and net economic water productivity (Rs./m^3) is presented in Table 1. Those farmers who are using diesel pumps for irrigation purpose were applying less water for all the crops as compared to electric pump owners. The electric pump owners are using 4.86 and 16.53 per cent higher irrigation water for irrigating paddy and maize respectively as compared to diesel pump owners. In case of wheat, tomato, potato, chilli, okra and mustard, electric pump owners are using 10.19, 136.84, 12.67, 23.53, 13.70 and 32.57 per cent more water as compared to diesel pump owners respectively. The physical water productivity (kg/m^3) and net economic water productivity (Rs./m^3) was higher for all

the crops on the farms of diesel pump owners except in case of paddy. In case of paddy, electric pump owners are getting higher physical and net economic water productivity as compared to diesel pump owners.

TABLE 1. IRRIGATION WATER USE AND WATER PRODUCTIVITY UNDER DIFFERENT MODE OF ENERGY USE IN UTTAR PRADESH

Name of the crop (1)	Irrigation water use (m^3/ha) (2)	Crop yield (kg./ha) (3)	Net income (Rs./ha) (4)	Physical water productivity (kg./m^3) (5)	Net economic water productivity (Rs./m^3) (6)
			Electric Pump Owner		
1. Paddy (*kharif*)	2904.70	4444.19	10079.31	1.53	3.47
2. Maize (*kharif*)	685.80	2955.47	15749.69	4.31	21.51
3. Wheat (*rabi*)	2047.31	3221.25	14828.38	1.57	7.24
4. Tomato (*rabi*)	2430.00	15500.00	76828.13	6.38	31.62
5. Potato (*rabi*)	3199.90	18047.44	101180.84	5.64	8.71
6. Chilli (*rabi*)	3708.30	14536.54	71978.10	3.92	19.41
7. Okra (*rabi*)	3389.90	7796.77	36068.54	2.30	10.64
8. Mustard (*rabi*)	920.70	1233.74	10855.05	1.34	11.79
			Diesel Pump Owner		
1. Paddy (*kharif*)	2770.20	4127.60	7064.01	1.49	2.55
2. Maize (*kharif*)	588.51	2938.95	14584.38	4.99	24.78
3. Wheat (*rabi*)	2255.92	4046.25	25294.38	1.79	11.21
4. Tomato (*rabi*)	1026.00	15437.50	67288.17	15.04	65.58
5. Potato (*rabi*)	2840.10	18261.84	44617.97	6.43	15.71
6. Chilli (*rabi*)	3001.90	12397.85	64330.72	4.13	21.43
7. Okra (*rabi*)	2981.50	7751.90	40071.36	2.60	13.44
8. Mustard (*rabi*)	694.50	1514.01	10945.32	2.18	15.76

The paddy crop is generally grown under the standing water and farmers are maintaining it in the paddy field during the crop period. In case of diesel pump owners they are unable to maintain the required standing water in the paddy field due to marginal cost of pumping groundwater being higher, resulting in lower physical and net economic water productivity. The highest net economic water productivity was observed in case of tomato for diesel pump owners followed by mustard and maize as compared to electric pump owner.

4.4.2 *Bihar*

The irrigation water use and physical and net economic water productivity for electric and diesel pump owners for Bihar is presented in Table 2. It is evident from the Table 2 that electric pump owners are applying more irrigation water as compared to diesel pump owners for all the crops grown by the sample farmers in the study area. The diesel pump owners applied 8.36, 22.98, 14.09, 13.71 and 9.84 per cent less irrigation water for paddy, wheat, potato, mustard and onion crops respectively. The diesel pump owners were getting higher physical and net economic water productivity as compared to electric pump owners except in case of paddy. In case of

paddy, physical and net economic water productivity was higher for electric pump owners as compared to diesel pump owner.

TABLE 2. IRRIGATION WATER USE AND WATER PRODUCTIVITY UNDER DIFFERENT MODE OF ENERGY USE IN BIHAR

Name of the crop (1)	Irrigation water use (m^3/ha) (2)	Crop yield (kg./ha) (3)	Net income (Rs./ha) (4)	Physical water productivity (kg./m^3) (5)	Net economic water productivity (Rs./m^3) (6)
			Electric Pump Owner		
1. Paddy (*kharif*)	2474.40	3191.98	12495.72	1.29	5.05
2. Wheat (*rabi*)	2265.10	3012.58	12299.49	1.33	5.43
3. Potato (*rabi*)	2355.30	26803.31	97038.36	11.38	41.20
4. Mustard (*rabi*)	1320.30	1848.42	18801.07	1.40	14.24
5. Onion (summer)	7061.90			4.18	18.09
			Diesel Pump Owner		
1. Paddy (*kharif*)	2283.50	2785.87	9978.90	1.22	4.37
2. Wheat (*rabi*)	1841.80	2983.72	10958.71	1.62	5.95
3. Potato (*rabi*)	2064.50	25393.35	88050.93	12.30	42.65
4. Mustard (*rabi*)	1161.10	1811.32	21155.24	1.56	18.22
5. Onion (summer)	6429.40	32018.41	133731.52	4.98	20.80

The diesel pump owners were unable to maintain the required standing water in the paddy field due to higher per unit cost of pumping groundwater resulting in lower paddy yield, whereas, electric pump owners are pumping more and more groundwater to maintain the required depth of water in paddy field because the marginal cost of pumping grounder water using electricity is zero.

4.4.3 *Punjab*

The major crops grown in the study area are paddy, maize, bajra, wheat and barseem (fodder crop) using groundwater and canal irrigation. The total irrigation water use, crop yield, net income, physical and net economic water productivity of different crops under groundwater and canal irrigation is presented in Table 3. The net economic productivity for all the crops was estimated to be higher for groundwater irrigation as compared to canal irrigation except for paddy and barseem crop. In case of paddy and barseem, the net economic productivity was higher under canal irrigation. Both crops, viz., paddy and barseem are water loving crops and groundwater irrigators, unable to maintain standing water in the paddy field because marginal cost of pumping groundwater is much higher than the canal irrigation.

Table 3 clearly shows that: [a] the irrigation dosages were much higher for canal irrigated field for all crops; [b] the physical water productivity of water is higher under groundwater irrigation for paddy, maize and wheat crops; and [c] the net economic value of water productivity was higher for groundwater irrigated field for maize, bajra and wheat.

TABLE 3. IRRIGATION WATER USE AND WATER PRODUCTIVITY UNDER GROUNDWATER AND CANAL WATER IRRIGATION IN PUNJAB

Name of the crop (1)	Irrigation water use (m^3/acre) (2)	Crop yield (kg./acre) (3)	Net income (Rs./acre) (4)	Physical water productivity (kg./m^3) (5)	Net economic water productivity (Rs./m^3) (6)
			Groundwater irrigation		
1. Paddy	3318.50	1169.50	548.80	0.57	0.32
2. Maize	598.70	941.70	1629.30	1.53	6.44
3. Bajra	1497.90	6025.00	3425.50	7.82	0.43
4. Wheat	915.40	1003.60	754.10	1.97	4.45
5. Barseem (FC)	1184.50	4864.60	9474.00	1.72	12.99
			Canal irrigation		
1. Paddy	5849.80	1661.20	6183.80	0.41	1.50
2. Maize	2600.00	880.00	4336.20	0.53	2.00
3. Bajra	1935.80	8122.20	7358.20	10.41	0.09
4. Wheat	1109.00	1100.60	2465.40	1.57	3.46
5. Barseem (FC)	2488.50	7216.70	16454.00	3.60	24.01

Source: Trivedi and Singh (2008). FC: Fodder crop.

IV

CONCLUSION AND POLICY IMPLICATIONS

The share of groundwater in total net irrigated area (20.85 million hectares) increased from 28.67 per cent to 61.40 per cent during 1950-51 to 2010-11. Out of the total net irrigated area in country, the share of groundwater irrigated area was 28.67 and 61.40 per cent in 1950-51 and 2010-11 respectively. The growth in net area irrigated by groundwater is growing with a compound growth rate of 3.54 per cent per annum during 1950-51 to 2010-11. Total electric operated pump for pumping groundwater in the country increased from 10.27 million to 11.05 million during 2001 to 2006 whereas, the diesel operated pumps declined from 6.55 million to 6.30 million during 2001 to 2006. The electric subsidy to farm sector has increased from Rs 7334.9 crore to Rs 45561.0 crore during 1992-93 to 2011-12 showing a compound growth rate of 8.65 per cent per annum..

In Uttar Pradesh, diesel pump owners were applying less water for all the crops as compared to electric pump owners. The physical water productivity (kg/m^3) and net economic water productivity (Rs./m^3) was higher for all the crops under diesel pump irrigation except in the case of paddy. In case of Bihar, electric pump owners are applying more irrigation water as compared to diesel pump owners for all the crops grown by the sample farmers in the study area. The diesel pump owners were getting higher physical and net economic water productivity as compared to electric pump owners except in case of paddy. In case of Punjab, the irrigation dosages were much higher for canal irrigated field for all crops. The physical water productivity of water is higher under groundwater irrigation for paddy, maize and wheat crops; and the net economic value of water productivity was higher for groundwater irrigated field for maize, bajra and wheat. The study suggests that the introduction of pro-rata pricing of

electricity supply to the farm sector may be the best option for better management of groundwater. This would help in equitable, efficient and sustainable use of groundwater and reduce the burden of gigantic electricity subsidy to farm sector. Pre-paid metering to farm sector may also increase water use efficiency.

REFERENCES

Amarasinghe, U., Bharat R. Sharma, Noel Aloysius, Christopher Scott, Vladimir Smakhtin, Charlotte de Fraiture, A.K. Sinha and A.K. Shukla (2004), *Spatial Variation in Water Supply and Demand Across River Basins of India*, IWMI Research Report 83, International Water Management Institute, Colombo, Sri Lanka.

Government of India (2001), *Annual Report on the Working of State Electricity Board and Electricity Department*, Power and Energy Division, Planning Commission, New Delhi.

Government of India (2002), *Annual Report (2001-02) on the Working of State Electricity Board and Electricity Department*, Power and Energy Division, Planning Commission, New Delhi.

Government of India (2005), *Minor Irrigation Census – 2000-01*, Ministry of Water Resources, Government of India, New Delhi.

Government of India (2008), *Minor Irrigation Census – 2005-06*, Ministry of Water Resources, Government of India, New Delhi.

Government of India (2011), *Annual Report (2011-12) on the Working of State Electricity Board and Electricity Department*, Power and Energy Division, Planning Commission, New Delhi.

Government of India (2011), *Annual Report (2011-12) on the Working of State Power Utilities and Electric Departments*, Power and Energy Division, Planning Commission, http://planningcommission.nic.in

Kumar, M. Dinesh (2005), "Impact of Electricity Prices and Volumetric Water Allocation on Groundwater Demand Management: Analysis from Western India", *Energy Policy*, Vol.33, No.1, pp.39–51.

Kumar, M. Dinesh (2007), *Groundwater Management in India: Physical, Institutional and Policy Alternatives*, Sage Publications India Pvt. Ltd., New Delhi.

Kumar, M. Dinesh; Christopher A. Scott and O.P. Singh (2011), "Inducing the Shift from Flat-Rate or Free Agricultural Power to Metered Supply: Implications for Groundwater Depletion and Power Sector Viability in India", *Journal of Hydrology*, Vol.409, Nos.1&2, pp.382-394.

Singh, O.P. (2004), *Water Productivity of Milk Production in North Gujarat, Western India*, Proceedings of the 2nd Asia Pacific Association of Hydrology and Water Resources (APHW) Conference, Vol. 1, pp.442-449.

Singh, O.P.; H.P. Singh, P.S. Badal, Rakesh Singh and Usha Tripathi (2010), "Improving Blue Water Productivity in Paddy-Wheat Cropping System in Indo-Gangetic Basin of India", *Journal of Agricultural Development and Policy*, Vol.20, No.2, pp.17-26.

Trivedi, Kairav and O.P. Singh (2008), "Impact of Quality and Reliability of Irrigation on Field Level Water Productivity of Crops", Published in Proceedings of the 7th Annual Partners' Meet on "Managing Water in the Face of Growing Scarcity, Inequity and Declining Returns: Exploring Fresh Approach, Volume I, pp.141-155.

World Bank (2001), *India: Power Supply to Agriculture. South Asia Region*, The World Bank, Washington, D.C., U.S.A.