ASSESSMENT OF IRRIGATION WATER PRICE FOR RICE AND WHEAT CROPS IN INDIA

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ABSTRACT

In India, gross irrigation potential has increased about five folds since 1951 as a result of phenomenal expansion in irrigation development. But, in terms of direct recovery from these irrigation schemes it has been abysmally low. This staggering difference between expenditure incurred and revenue recovered is largely responsible for dismal performance of the irrigation sector. This can be attributed to defective pricing structure for irrigation water, which is highly subsidized not reflecting true supply cost. Under pricing of water induced unscrupulous use leading to environmental problems like waterlogging in the irrigation commands. Water rates have not been revised in many states. Even now, lower and outdated water rates have been continuing and as a result there has been a drop in the revenue from water charges. Another important issue is less water allocation for agriculture in future due to diversion of water to meet demands of urban areas, growing industries and ever increasing population. So a study was undertaken with an objective to estimate cost of irrigation water to grow per kg of rice and wheat in Paliganj distributary command under Sone canal system in India.

Data/information regarding canal water and tube well water charges were collected from Irrigation/Water Resources Department and data/ information from farmers were collected through developed questionnaire and by applying Residual Value method in which difference of gross returns of each crop and costs of production (excluding water) is divided by the amount of water applied (m^3), price of irrigation water in terms of (kg of cereal per m^3 of irrigation water) was worked out. The studies brought out a better assessment of Irrigation water price and it was observed that present irrigation water charges are much lower than actual irrigation water price. If assessment of irrigation water price is done correctly and it is included in cost of cultivation properly, Govt. may think of revising MSP of agricultural products and thus farmers' benefits may increase. In addition to this when farmers will know the real cost of water, they may start using water more efficiently.

1. INTRODUCTION

Water is one of the most important finite natural resources for survival of life and development. Currently about 70% of world's fresh water abstraction is used in agriculture (FAO-COAG, 2007) and irrigated land is projected to increase by 27% in next 20 years in developing countries (World Bank, 2008). But water is increasingly becoming scarce in India and diversion or allocation of water for agricultural use is reducing due to growing population, industrialization and urbanization. To grow more food to feed ever increasing population with limited or reduced availability of water is a great challenge. This challenge can be met out, if water is utilized efficiently and judiciously in crop production system. For example, in rain deficit regions, food production can be enhanced by providing irrigation at critical crop growth stages. In irrigated areas, water is efficiently utilized if those crops are selected, which consume less water and relatively give better yields. Water productivity, which is the ratio of

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output produced in terms of Kg, ` or $ and water consumed, diverted or depleted in terms of m^3, ha-cm is a very relevant concept, which is being discussed all over the world. Water productivity can be enhanced by either increasing the crop production without increasing water consumption or sustaining crop production and reducing water consumption. According to Cook et al. (2006), estimates of water productivity have two basic uses: firstly as a diagnostic tool to identify the level of water use efficiency of a system under study and secondly to provide insight into the opportunities for better management towards increased water productivity at the scale under consideration. Upadhyaya and Sikka (2016) also discussed the concept of water, land and energy productivity in agriculture and pathways for improvement. Upadhyaya (2018) assessed Rice and Wheat water productivity in India and discussed various influencing factors and their impacts on crop water productivity. Studies on water productivity clearly reflect the role and importance of water in crop production system and suggest the ways and means for utilization of water efficiently and effectively.

Irrigation water pricing is very interesting subject of study. At some places it is decided keeping in view the cost of water resources, Xian et al. (2014), whereas at other places farmers' willingness to pay for water is considered as reference for pricing, Motta and Ortiz (2018). Jiang et al. (1993) proposed that the essence of value of water resources was in capitalization of water resource rent, upon which the differences in price and value of water resources would be clarified. Various water resources value estimation approaches based on equilibrium pricing, value mosaic, energy estimation and fuzzy comprehensive evaluation have been reported in the literature. Rational pricing of agricultural irrigation water has drawn attention of many researchers.

Residual imputation model or residual value method (RVM) is a technique which has been used to value water productivity where water is used as an intermediate input into production. In valuing water, very few studies have employed residual imputation technique. Emad *et al.* (2012) estimated the average economic value of irrigation water for twelve crops in Jordan. Kiprop *et al.* (2015) also determined the economic value of irrigation water in Kerio Valley Basin (Kenya) by Residual Value Method and reported that crop level water values estimated for field crops were generally higher compared to fruit trees. In the present studies, Residual Value Method (RVM) has been considered. Basic assumptions and theoretical aspects of RVM are briefly mentioned below.

2. RESIDUAL VALUE METHOD

According to Euler's theorem if a production function involves constant returns to scale, the sum of the marginal products will actually add to the total product. Considering a production function f $(x_1...x_n)$ is homogeneous of degree 1 (i.e. has constant returns to scale). Euler's theorem shows that if the price (in terms of units ofoutput) of each input i is its "marginal product" $f'_i(x_1...x_n$. then the total cost, namely $\sum_{i=1}^{n} x_i \, f_i^{'}(x_1...x_n)$ is equal to the total output namely $f(x_1...x_n)$. Production function Y is assumed to be influenced by four factors i.e. capital (K), labour (L), natural resources such as land (L) and water (W). It may be expressed as:

$$Y = f\,(K, L, R, W) \tag{1}$$

Assuming production and prices are known and technology is constant. P_y is the price of output; P_x is the price of input under perfect information. Assuming that farmers' objective is to maximize production, the production function may be written as:

$$\pi = \sum_{j=1}^{n} P_y . Y_j - \sum_{i=1}^{n} P_x . X_i - P_w Q_w \tag{2}$$

To find the conditions for optimal profits, the first derivative of π with respect to x was set equal to zero.

$$\frac{d\pi}{dx} = P_y . \frac{df(x)}{dx} - P_x = 0 \tag{3}$$

Therefore P_y (dy/dx) = P_x.

If all the inputs, including water are exchanged in a competitive market and employed in a production process, the value of water will be

$$P_w . Q_w = P_y . Y - \sum_{i=1}^{n} P_x . X_i \tag{4}$$

The residual imputation model determines the incremental contribution of each input in the production process if appropriate prices can be assigned to all inputs except water. The residual obtained by subtracting the non-water input costs equals the gross margin and can be interpreted as the maximum amount the farmer would pay for water and still cover the cost of production. The residual calculation can be expressed as:

$$P_w = \frac{\sum_{j=1}^{m} Y_j . P_j - \sum_{i=1}^{n} X_i . P_i}{\sum Q_w} \tag{5}$$

2.1 STUDY AREA

The study was undertaken in Paliganj distributary which emanates at 75 Km off Patna Main Canal in Right side. It is controlled by Sone Canal Sub Division Bikram. The total length of Paliganj distributary is 27.4 Km and its design discharge is 5.1 cumecs. It has two sub distributaries Chandos and Bharatpura emanating at 10.45 Km and 17.1 Km, respectively from Paliganj distributary with design discharge of 0.85 cumecs each. Paliganj distributary is divided into three reaches. The lengths of I, II ans III Reaches are 10.45 Km, 6.65 Km and 10.3 Km, respectively. The Gross Command Area (GCA) of these reaches are respectively 2767 ha, 2513 ha, 2794 ha and Culturable Command Area (CCA) are 2479 ha, 2102 ha and 2400 ha, respectively. During 2017-18, only 1285 ha in I reach, 1070 ha in II reach and 764 ha area in III reach totalling to 3119 ha could be irrigated with available canal water. Index map of Paliganj Distributary of Sone Canal System in India is shown below in Figure 1.

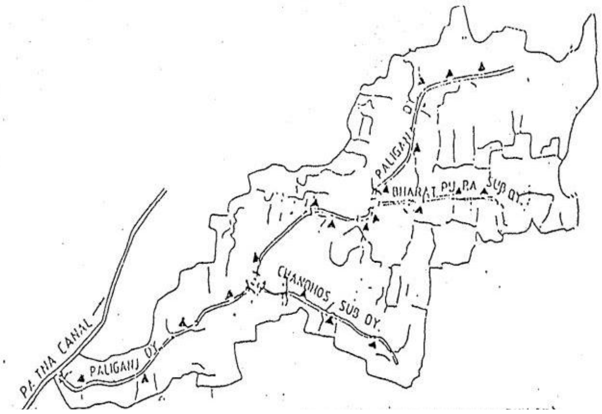

Figure 1: Index map of Paliganj Distributary in Sone Canal System

2.2 Rainfall Characteristics

Rainfall analysis at Paliganj reveals that average annual rainfall is 888.9 mm with maximum of 1342.4 mm in 1997 and minimum of 490.2 mm during 1998.90.3% rainfall occurs during monsoon months (June to September) and 9.7% during non-monsoon months. Among average monthly rainfall at Paliganj, July had the highest of 292.6 mm followed by 214,8 mm in August, 183.7 mm in September and 111.3 mm in June. Average weekly rainfall was maximum of 75.4 mm in 28th week. The rainfall during this week varied in the range of 534.8 to 0.0 mm. Maximum weekly rainfall of 534.8 mm was observed in 28th week of year 1997.

2.3 Rice and Wheat Crops Evapotranspiration

Reference Crop evapotranspiration was estimated from FAO 56 Penman-Monteith method, which uses maximum and minimum temperature, maximum and minimum relative humidity, wind velocity and solar radiation. The values were multiplied by crop coefficient values of rice and wheat crops established for this region and then rice and wheat crops evapotranspiration was determined. Average seasonal rice crop evapotranspiration was estimated as 754.6 mm and average seasonal wheat crop evapotranspiration as 195.6 mm. At 75% probability level of rainfall, rice and wheat crops evapotranspiration was always higher than rainfall and total difference in rice as well as wheat crops evapotranspiration and rainfall during the growing seasons of rice and wheat at this probability level was found as 571.7 mm 168.4 mm, respectively.

2.4 Canal Water Charges

The records of the revenue department show that from Rabi 1983 to Kharif 1995 canal water charges were at the rate of ` 36.20 per acre for paddy, ` 20.70 per acre for wheat, ` 63.80 per acre for sugarcane and other crops. From Rabi 1995 to Kharif 2001 water charges were ` 70/- per acre for paddy, ` 60/- per acre for wheat, ` 120/- per acre for sugarcane and other crops. From Rabi 2001-02 till date water charges are ` 88/- per acre for paddy, ` 75/- per acre for wheat, ` 150/- per acre for sugarcane and other crops. This clearly reveals that canal water charges are very low and need revision. One more important thing to note here is that already registered Water Users Association is here and its' responsibility is to collect revenue from water users, keep 70% of revenue with Water Users Association for operation and maintenance of distributary in participatory mode under technical guidance of water Resources Department, Govt. of Bihar and deposit 30% revenue to Department. Earlier under World Bank Project and through technical support of IWMI, Sri Lanka, WALMI Patna initiated a pilot project and tried to reform the system by training, capacity building, and irrigation management transfer programme. It worked well for quite some time and farmers used to get sufficient water to irrigate their crops but later on gap in supply and demand started increasing due to poor leadership, wide gap in water supply and water use due to no meeting and dialogue between water managers and water users. At present canal water satisfies only I and II reaches and rarely water reaches in III reach. Accordingly farmers in III reach, try to use ground water or any other source of water to provide life saving irrigation to crop.

2.5 Water Delivered from Paliganj Distributary and Days of Operation

Water delivered through Paliganj distributary during June 2017 to March 2018 was computed from the records available with Water Resources Department, Govt. of Bihar and is given below in Table 1.

Table 1. Irrigation water delivered through Paliganj distributary and days of operation

Month	Volume of water (m^3)	Days of operation
June,17	1203384	10
July, 17	6225168	20
August, 17	6244744	17
September, 17	6626476	19
October, 17	6626476	18
November, 17	1585656	5
December, 17	-	-
January,18	601962	8
February, 18	1137855	14
March, 18	922519	15

3. METHODOLOGY

In order to collect required data/ information about agricultural inputs used and their costs, labour cost involved in agricultural operations, value of land, implements, infrastructure, output (main as well as bi-product) produced along with their sell price, a structured questionnaire was developed. Thirty farmers representing I, II and III reach of Paliganj distributary were interviewed and questionnaires were filled up. Irrigation water price was assessed by considering water actually used by crops (i.e. on the basis of crop evapotranspiration) as well as water available from canal and ground water and applied by farmers.

4. RESULTS AND DISCUSSION

Data collected through structured questionnaire for 3 representative farmers having 1 ha or near 1 ha area in I, II and III reach of Paliganj distributary are given below in Table 2.

Table 2. Data of 3 farmers from I, II, and III reach of Paliganj distributary

Sr. No.	Particulars of Inputs/ outputs	Reach I Area 1.13 ha		Reach II Area 1 ha		Reach III	
		Rice	Wheat	Rice	Wheat	Rice	Wheat
1.	Input cost (including seed, organic matter, fertilizer, insecticide, pesticide etc. But excluding water) (`)	11680	16605	9930	14170	10010	15550
2.	Labour cost involved in ploughing/ rotavator/ tilling/ harrowing/ sowing/ dibbling/ planting/transplanting/ weeding/ harvesting/ threshing etc.(`)	27100	23100	22500	19000	22500	19000
3.	Fixed cost including rental value of land, depreciation cost of farm building and implements and interest on fixed cost (`)	48000	23820	44500	25408	43100	20160
4.	Total cost of cultivation (`)	86780 (76796 per ha)	63525 (56217 per ha)	76930	58578	75610	54710
5.	Yield of Main Product (T)	6	3.5	5.5	3.2	5.3	3
6.	Sale Price (`/T)	17500	18400	17500	18400	17500	18400
7.	Yield of Bi-product (T)	3	3	3	2.5	3	2.4
8.	Sale Price (`/T)	5000	5000	5000	5000	5000	5000
5.	Output from Main product and Bi-product (`)	120000 (106195 per ha)	79400 (70265 per ha)	111250	71380	107750	67200
6.	Output – Input (`)	33220 (29398 per ha)	15875 (14048 per ha)	34320	12802	32140	12490

Irrigation water applied by these farmers through canal and tube well was computed and given in Table 3.

Table 3. Irrigation water price (`/m^3) computation based on water applied and irrigation requirement

Source of water	Volume of water applied (m^3)					
	Reach I Area 1.13 ha		Reach II Area 1 ha		Reach III Area 1 ha	
	Rice	**Wheat**	**Rice**	**Wheat**	**Rice**	**Wheat**
Canal	5835	1160	5160	1060	4950	-
Tubewell	1190	1670	1450	1525	1750	2000
Total irrigation applied	7025	2830	6610	2585	6700	2000
Profit (`)	33220	15875	34320	12802	32140	12490
Irrigation water price (`/m^3)	4.73	5.61	5.19	4.95	4.80	6.24
Irrigation requirement (ET-75% dependable rainfall) (m^3)	6460	1902	5717	1684	5717	1684
Irrigation water price based on actual irrigation requirement (`/m^3)	5.14	8.35	6.00	7.60	5.62	7.42

It may be observed from the above Table that Irrigation water price considering irrigation water applied through canal and tube well in Reach I, II and III for rice crop is 4.73, 5.19 and 4.80 `/m$^3$ and for wheat crop is 5.61, 4.95 and 6.24 `/m^3. When Irrigation water price was computed considering actual irrigation requirement (Crop water requirement - effective rainfall), in Reach I, II and III for rice crop is 5.14, 6.00 and 5.62 `/m$^3$ and for wheat crop is 8.35, 7.60 and 7.42 `/m^3. It is also observed that in all the three reaches, irrigation water price for rice and wheat crops computed considering actual irrigation requirement is always more than irrigation water price computed based on total irrigation water applied through canal and tube wells. It may also be observed from the above Table that in Reach III, canal water could not be available to irrigate wheat crop and it was solely irrigated by tube well water. Though profit was not much even than irrigation water price was relatively higher.

5. CONCLUSIONS

Assessment of irrigation water price for rice and wheat crops in Paliganj distributary of Patna Main Canal under Sone Canal System was made employing Residual Value Method. In this method, contribution of each input in the production process with assignment of appropriate prices to all inputs except water was considered. The residual obtained by subtracting the non-water input costs was made equal to the gross margin and was interpreted as the maximum amount the farmer would pay for water after covering the cost of production. The study indicated that irrigation water price for rice and wheat crops in Paliganj distributary varied in the range of 4.73 `/m$^3$ to 6.24 `/m^3, when total water applied was considered and between 5.14 `/m$^3$ and 8.35 `/m^3, when actual irrigation requirement was considered. For wheat crop irrigation water price when irrigated by tube well water alone was higher as compared to irrigated by canal and tube well both. This study may also be helpful in convincing farmers, planners and policy makers to review the canal water charges revised in 2001-02, and fixed as 88, 75 and 150 `/acre for Kharif, Rabi and other annual crops.

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