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Estimation of the Economic Value of Irrigation Water

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ABSTRACT

The main objective of this study was to suggest a methodology to evaluate the economic value of water. The methodology involved the use of agricultural sector models incorporating water as a scarce input. The economic values of water for different crops were estimated from the shadow prices of water and irrigated land constraints. The economic value of irrigation water for wheat, rice, sugarcane and cotton was Rs. 1.13, 0.63, 0.30 and 1.52, respectively. For the minor crops i.e. potato, onion, and sunflower, the economic value of irrigation water was Rs. 6.60, 13.10, and 0.53, respectively. The results were consistent with previous studies.

Key Words: Water; Economic value; Shadow price; Crops

INTRODUCTION

Water is a precious commodity, which needs to be maintained in its natural form. A little rise in glacier melts, from where most of the rivers take their major flows might drown entire habitat of the earth.

Pakistan is basically an agricultural country whose agriculture mostly depends on irrigation. Out of its total area of 79.61 Million hectares (Mha), forests are on 3.44 Mha while irrigated agriculture is spread over 16 Mha. This agricultural land depends on a total of 173 billion cubic meter of water. The present population of Pakistan is 149 millions out of which rural population is 67 percent, which by the year 2010 would rise to 175 millions (Government of Pakistan, 2004). In order to be self reliant in agriculture, the yields are to be increased by 50%, cropping intensity is to be maintained to the level of 150% and additional area of 2 Mha is to be brought under irrigation command (World Bank, 1994).

Inadequate funding for maintenance of irrigation works and emerging shortage of water are prevalent. The water logging and salinity, theft of canal water, over-exploitation of fresh groundwater, low efficiency in delivery and use, inequitable distribution and maintenance and inefficient cost recovery have been recognized as main problems of Pakistan's irrigation system.

Until recently, the water has been plentiful in most countries, and the role of water pricing as a means to ensure efficient allocation and productive use has attracted little attention. Now, water is becoming scarce in many countries. Individuals, agencies and international declarations advise that water should be treated as an "economic good" (ICWE, 1992). In parallel with this development, the maintenance of water-related facilities is often observed to be inadequate. These two issues have provided an impetus for the introduction of various forms of pricing for water and water services. A primary target for these interventions is irrigation in agriculture sector, because it is by far the largest consumer of water, typically 80%, in most countries where shortage is a problem. The main objective of this study was to estimate the marginal value product of irrigation water derived from residual imputation approach from crop budgets and to measure the efficiency of water use on farms.

METHODOLOGY

Estimating financial and economic returns. Farm costs have three components, namely fixed costs, variable costs, and total costs. The fixed cost (FC) portion includes rent of land, and farm machinery etc; variable cost (VC) includes labor, both family and hired, seed, fertilizer, farm yard manure, pesticides, draught power, and irrigation service etc. The FC and VC are added up to arrive at the total cost (TC). All costs are estimated on a per acre basis.

The financial returns (FR) are estimated by taking the average yield from each crop times the farm gate prices (FGP), and adding up the by-product times the prices received by the farmers. The financial net returns are obtained by subtracting the total cost from the gross returns. The financial returns FR are estimated on a per acre basis.

The economic returns (ER) are obtained by valuating the main product of the crop at economic prices (EP). Economic prices are also referred to as social prices or efficiency prices. By-product prices are the same as used for estimating gross returns. The input costs are also estimated at world prices. World prices of inputs and outputs are the cornerstone for estimating the efficiency prices.

The costs of production are separated into tradable and non-tradable components. World prices are the prices for tradable commodities, which can be traded in the world market. To obtain economic prices, the market prices of the tradable inputs and outputs have been adjusted by applying a standard conversion factor (SCF) i.e. 0.85. The SCF has been derived by taking into account, CIF (cost insurance freight) value of imports and FOB (free on board) value of exports, net value of taxes on imports and on exports.

Shadow pricing is used to convert financial prices into economics prices. Shadow pricing aims to ensure that values applied to inputs and outputs reflect their real scarcity in society (i.e. the cost to society of their being used or produced in the specific activities).

Seeds, fertilizers, and materials for plant protection (pesticides, insecticides, sprays, weedicides etc.) can be traded internationally, so prices of these inputs also have been adjusted by applying SCF to arrive at economic prices. For hired labor, actual wage rate is the private price. To estimate the economic price of the hired labor, wage rate is multiplied by SCF.

Residual imputation method. The technique for determining the shadow prices (for un-priced input) is called the "Residual Imputation". The method is simple and, under certain specified conditions, is applicable for estimating the value of resources used in production. If appropriate prices can be assigned to all inputs but one, and certain other assumptions are met, then the residual of the total value of product is imputed to remaining resource (Young, 1979).

Consider the following example where fertilizer, insecticides, pesticides, labor, water, and capital are used in the production of cotton, wheat, sorghum and groundnuts. Our problem is to impute a value to the water resource. By the postulates stated above we may write:

$$TVPQ = MVPL . L + MVPW . W + MVPZ . Z \qquad (i)$$

Where:

TVPQ = total value product of cotton plus total value product of wheat plus total value product of sorghum and groundnuts.

MVPL = marginal value of product of labor.

MVPW = marginal value product of water.

MVPZ= marginal value product of all other inputs employed in the production of the four crops.

If the marginal value products of labor and all other inputs have been separately determined then the marginal value of water (MVPw) may be computed by rewriting the previous equation as follows:

$$TVPQ - MVPL . L - MVPZ . Z = MVPW . W \qquad (ii)$$

Then substituting Pi for MVPi according to the first postulate we have:

$$TVPQ - PL .L - PZ .Z = MVPW.W \qquad (iii)$$

$$TVPQ – PL \ . L – PZ \ . Z = PW \ .W \qquad (iv)$$

and solving for PW:

$$Pw = \frac{TVP_Q - P_L.L - P_Z.Z}{W} \qquad (v)$$

Pw is the shadow price of water or MVP of water or the imputed value of water used in the production of the four crops in the specific season. The question arises whether or not factor payments, made according to marginal productivities, will exhaust total product (Elobeid, 1982).

The answer is provided by application of Euler's Theorem, which when applied to factor utilization and payment, may be stated as: "Under certain conditions resources paid according to marginal productivity will result in complete exhaustion of total product" (Henderson & Quandt, 1980). Young (1979) reported that, while residual imputation appears to be a very simple technique for estimating shadow prices of resource values, it is faced with certain limitations, which should be recognized by the user.
The limitations are:

(i) The problem of exact exhaustion of the total product (Are the conditions for Euler's Theorem satisfied?).

(ii) The question whether prices equal marginal value product except for the one whose value is being estimated (Does the production process exhibit optimal factor input levels?).

(iii) The problem of omitted variables (Are all inputs with positive MVP properly accounted for?).

(iv) Problems of estimation when price supports, subsidies, or other exogenous influences are exerted on production (Do factor and product prices properly reflect scarcity values?).

All of the above shortcomings impose constraints on value estimated by residual imputation.

RESULTS AND DISCUSSION

Estimating the economic and financial returns. Farm budgets of seven crops (i.e. wheat, cotton, sugarcane, rice, potato, onion, and sunflower) were developed. The crop budgets of four major crops i.e. wheat, seed cotton, sugarcane, and rice were taken from Agriculture Price Commission series No. 201, 199, 198, and 200 respectively (Anonymous, 2002). The other minor crop budgets were also collected from the APcom. The data had designed on average basis from whole Punjab Province. These crop budgets possessed cost of irrigation including both type of irrigation (tube well irrigation and canal irrigation). These returns were calculated on per acre basis. These crop budgets were utilized to determine the price of water ($Rs./M^3$) through Residual Imputation Method.

Residual imputation method. The cost of production for a specific crop with out irrigation cost was calculated. This cost of production was deducted from gross returns of that crop. These net returns were further divided by the amount of water applied (M3) to get the price of water. It was the price of water (Rs.) at zero cost of irrigation. The contribution of water in the production of each crop was represented by this value.

Table I. Financial and Economic value of Irrigation Water for Different Crops (Rs./M^3)

Crops	Financial net returns /acre	Economic net returns /acre	Financial returns per M^3/acre	Economic returns per M^3/acre
Wheat	2620.43	1979.74	1.44	1.13
Cotton	4369.58	3130.58	2.12	1.52
Sugarcane	3864.15	1938.21	0.59	0.29
Rice	4560.86	3639.26	0.80	0.63
Potato	52659.71	43441.01	11.64	6.60
Onion	30978.51	25576.41	15.85	13.09
Sunflower	1559.51	1027.68	0.80	0.53

The financial and economic values of water for wheat crop were Rs. 1.44 and 1.13 respectively. The results were consistent with the other studies (Anonymous, 1994; Chaudhry & Young, 1989), who calculated it as Rs. 1.2 and 1.09. Similarly the financial and economic returns of irrigation water for cotton were calculated as Rs. 2.12 and 1.52. The Anonymous (1994) calculated it as Rs. 0.26 and Hussain and Young estimated it as Rs. 0.81. The low values may be due to the reason of low production of cotton crop during those years due to Cotton Leaf Curl Virus (CLCV). For sugarcane crop, the financial and economic values of irrigation water were estimated Rs. 0.59 and Rs. 0.29 respectively. These results were also consistent with Rs. 0.65 (Anonymous, 1994) and Rs. 019 (Chaudhry & Young, 1989). For Basmati rice, the financial and economic returns per M3 of irrigation water were Rs, 0.80 and 0.63 respectively. Mellor (1994) calculated it as Rs. 0.56 and Hussain and Young (1989) calculated it as Rs. 0.20.

Similarly the financial value of irrigation water for minor crops i.e. potato, onion, and sunflower were Rs. 11.63, 15.85 and 0.80 respectively. The economic value of irrigation water for potato, onion and sunflower were Rs. 6.60, 13.1, and 0.53 respectively. The results were consistent but it possessed some assumptions which may lead to over or under estimation. The method is simple and, under certain specified conditions, is applicable for estimating the value of resources used in production.

CONCLUSION

Through Residual Imputation Method, the financial and economic values of irrigation water for seven crops were estimated on per acre per cubic meter basis. The economic value of irrigation water for wheat, rice, sugarcane and cotton was Rs. 1.13, 0.63, 0.30 and 1.52 respectively. Similarly for the minor crops i.e. potato, onion, and sunflower, the economic value of irrigation water was Rs. 6.60, 13.10, and 0.53, respectively. These values of water provided a range for the water pricing according to its contribution in production process. Based on the results, following suggestions are advanced for improving irrigation system effectively

i. Issue clear policy guidelines and draft supporting legislation.

ii. Provide technical assistance to strengthen the role of farmers to operate and maintain the infrastructure, approve water transfers, and enforce water rights.

iii. Implement a pilot program under which tradable water rights would be established.

iv. Introduction of public and private initiative partnership on the pattern of PIDA (provincial irrigation development authority) for management of irrigation system at the secondary and tertiary levels.

v. Distribution of water across inter-canal command area on the basis of economic value of water in order to rational use of scarce water recourses.

vi. The present flat rate policy is neutral; therefore water charges could be levied on the basis of at least some percentage of economic value of water.

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