



The economic value of irrigation water in paddy farms categorized according to mechanization levels in Guilan province, Iran



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ABSTRACT

The economic value of irrigation water is not considered as a highly affective criterion in water tariff system in Iran. To this end, proper measures and viable scientific and management solutions are very important for the optimal use of this input. This study aims to determine the economic value of irrigation water used in rice agriculture in Guilan province. For this purpose, production functional forms were utilized. In addition, determining the marginal product and its value led us to achieve economic value of irrigation water for farms with different mechanization levels. It is noted that the cross-section data used in this study were derived from questionnaires in the “production cost plan” of Iranian Ministry of Agriculture during 2013–2014 crop years. Generalized Leontief functional form was selected as the favorable form for the farms with high mechanization level. The economic value of irrigation water considered in these farms is 0.5108 \$/m³. For the farms with low mechanization level, Translog functional form is chosen as the superior form whose final water economic value equals 0.5054 \$/m³. Reviews of the statistical difference between the two groups showed significant differences between the economic values of water. Considering water scarcity in Iran and the existing difference between its tariff system and economic value, it is recommended that the present tariff system be reformed and economic value of irrigation water be considered in the corresponding tariff system.

1. Introduction

In Iran, the Ministry of Energy announces irrigation water tariffs and communicates them to regional water companies. The tariffs in the agricultural sector are determined by a definite and simple method to prioritize the plain, types of irrigation system, performances of agricultural products, and their price. Efficiency of water production in developing countries, such as Iran, is very inefficient compared with other developed countries, and determined tariffs are handled based on financial considerations rather than economic considerations. Furthermore, only minor amount of all financial costs of water supply is considered. Consequently, the determined tariffs for water are too cheap; therefore, the value of water as a scarce source is not completely given priority. Thus, farmers do not find any convincing incentive to economize water use; for this reason, water is considered as a free input among water users. Paying low-irrigation water fee bills by farmers has only led to inefficient water allocations and frequent consumption of this scarce input in producing relatively high-water-requirement crops, which are called non-strategic crops sometimes (Sadeghi et al., 2012).

Now, in Iran, irrigation and drainage network of Sefidroud supplies water requirement of about 180 thousand hectares of paddy fields in Guilan province. Based on the facilities of each unit, payable tariff concerning irrigation water in the territory covered by the network is estimated to be between 1–3 percent of the rice cultivation income in each year. About 65% of farmers are not willing to pay more. There are those who do not even pay their annual water costs. The highest payable cost of water is specified to be less than 5% of the total input costs in a crop season. Therefore, farmers need to become more aware of the actual value of water. Determination of water tariff encourages farmers to save water intelligently, resulting in improving water productivity, mitigating environmental degradation, funding a part of repair and maintenance costs, and finally maintaining the rights of future generations (Tahamipour et al., 2015). In the Asian humid tropics, it is too early to apply water pricing because there is seldom a right concept of water or any practical organization of water management. In this region, it is important to facilitate the establishment of sound management organizations of irrigation water before introducing a strict water pricing mechanism to levy the charge (Fujimoto and Tomsho, 2003).

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There are a number of studies on water economic valuation in agriculture such as those of He et al. (2004), Abernethy (2000), and Tahamipour et al. (2015). Singh (2007) and Al-Karablieh et al. (2012) proposed that the existence of water subsidies is a sure factor in the low level of water productivity and the concealment of water value as a rare input from the eyes of farmers and the possibility of using more than required for this valuable input. Singh (2007) reported that there is a big gap between supply cost as water price and economic value of water. Therefore, in this study, irrigation water pricing is determined by the production function method. Chowdhury (2005), Khajeh Roshanayi et al. (2010), and Sadeghi et al. (2012) measured the economic values of irrigation water in Bangladesh, Iran, and Pakistan, respectively. In this regard, Ehsani et al. (2012), Chowdhury (2005), and Khajeh Roshanayi et al. (2010) used the production function method to determine the economic value of irrigation water. Khajeh Roshanayi et al. (2010) calculated the economic value of water for wheat as 0.5 \$/m³.

Cheng et al. (2016) emphasized that the amount of water affects the rice yield, and they conducted a study in Jilin province, China. They used five common production functions, and the water sensitivity index of each model was calculated based on the evapotranspiration and yield. Comparison of the calculated results with observed data showed that Jensen model is the most suitable production function for this region. Ashfaq et al. (2005), in Pakistan, calculated the economic value of water for different crops. The economic value of irrigation water for rice was 0.01 \$/m³ in India (Ashfaq et al., 2005), 0.002–0.015 \$/m³ in Bangladesh (Chowdhury, 2005), and the average tariff of water was 124 \$ per hectare for a 4-year study in Nigeria (Abernethy, 2000). Michael et al. (2014) used the relationship between the yield of rice and water consumption to reformulate and establish a new policy in water consumption in Tanzania. They found that an increase of 6% in water consumption made an increase of 10% in yield. Furthermore, the coefficient of water price was negative, meaning that an increase of 1% of the water price reduces the water demand by 0.03%. Therefore, we can conclude that pricing is an important factor in reducing water consumption for irrigated crops.

The proposed solution of this study is improving the irrigation efficiency using modern management practices and irrigation methods. Literature reviews show the dependence of agricultural production on irrigation water. Lack of water necessitates the efficient and judicious use of this input. Research into economics and economic valuation of water can provide optimum allocation of water to agricultural production and the factor in preventing water loss. In order to optimize the allocation of irrigation water residual, entropy, production function, and linear optimization methods were used for the valuation of irrigation water. In parametric method, parameters' estimation is based on the assumption of linearity model parameters. As a result, when this assumption is not correct, fitted surface response cannot be a precise function based on input and output variables of the system. In those situations where there is uncertainty over the non-linear model parameters, the non-parametric optimization function is proposed where both the mean and variance are assumed unknown in this method. In the present study, for the first time, the amount of irrigation water per hectare was estimated using the water-yield function derived from Davatgar (2010), and it was considered in the production function. Furthermore, this research was carried out on a large scale, aiming to estimate the economic value of irrigation water in rice production. The best production function was selected using the parametric methods and was compared with other functions to estimate the value of irrigation in the farm with different levels of mechanization.

A grouping of fields has been done to evaluate the impact of production technology on the economic value of water. In this study, the priorities with respect to the allocation of limited water stored in Sefidroud dam have been determined. This has been done to achieve higher productivity per water unit and prevent water loss as a valuable input. The volume of water allocated to Guilan province is declining

constantly due to increasing water demands in the upstream section, and it has been reduced from 4000 to 850 million cubic meters, according to the new policy of the government. Increasing the price of water is a correct policy and an effective step to reduce the gap between the economic value of irrigation water and payable tariff of irrigation, and this effective measure should be taken with caution along with considering other aspects. This research has attempted to clarify the importance of water use in the agricultural section of Guilan province, compared with similar studies done in the rival provinces in the upstream section of Sefidroud River. The results of this study can be helpful for planners and policy makers concerning the appropriate allocation of water resources in the watershed of Sefidroud River.

2. Materials and methods

Estimating the value of water as a production input was done using two methods: parametric and non-parametric methods. The production function method is a parametric method which is commonly used for determining the economic value of irrigation water. Linear programming is one of the most popular non-parametric methods used to determine the economic value of water (Decaluwe et al., 1999). In this study, the production function method is preferred for estimating the economic value of irrigation water, because the used data is cross-sectional, and there were no significant changes in the price of inputs and the product during this study. Production function is a technical relationship between the factors of production and the product value while assuming that other conditions are constant. In this method, the production function in which water is used as independent variables is estimated, and the marginal value of water is determined as its economic value (Debertin, 1997).

$$y = y(x_1, x_2, \dots, x_{n-1}, wat) \quad (1)$$

$$VMP_{wat} = p_y \times MP_{wat} = p_y \times \left(\frac{\partial y}{\partial wat} \right) \quad (2)$$

where y and w at represent the production and water consumption, respectively, X_1 to X_{n-1} are the other production inputs, p_y is the output price, MP_{water} is the marginal product of irrigation water, and VMP_{water} is the value of marginal product of irrigation water or its economic value. Regarding relations (1) and (2), it is clear that the obtained value is a function of the marginal product, and the marginal product is derived from the production function. Thus, the initial production function is effective in determining the economic value, and any change in the initial production function changes the estimated parameters in the final production and the economic value calculated for the input. With this description in mind, accuracy in the process of selecting the correct functional form is an important step to determine the economic values of each input. In this study, flexible and inflexible functional forms are fitted and compared by Eviews econometric software to select the superior one. Through inflexible functions, the Cobb-Douglas and the transcendental functions were fitted; through flexible functions, the generalized quadratic, the Translog, and the generalized Leontief forms were fitted for the determination of irrigation water's economic value.

Variables in the mentioned functional forms include production quantity (Y), consumption of irrigation water in cubic meter (W), labor in a day work (L), cost of machinery (M), pesticides consumption in liter (P) and fertilizers consumption in Kg (F), seed consumption in Kg (S), and α and β as the regression coefficients.

The reason for choosing these inputs is their importance for rice production in the study area, because the most important task in defining an empirical model is determining the factors or inputs that are included as independent variables into the model of production. Consumed water using a quadratic relationship between the yield and irrigation water was calculated as follows:

$$y = -0.0095X^2 + 14.551X - 1136 \quad (3)$$

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