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Estimation the Economic Value of Irrigation Water for Rice Farms in Iran

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ABSTRACT

In Iran, there is a huge difference between the amount of water supply and demand in all sectors of the economy, especially in agriculture sector as the most consumer sector. Economic valuation is used as a strategy to balance supply and demand. The purpose of this study was to determine the economic value of agricultural water in rice farm of Khuzestan province. The farms were divided into two groups based on homogeneity and using cluster analysis method. Then, using the production function and analysis of five flexible and non-flexible functions, the best function was selected by statistical comparisons and finally the economic value of each group was calculated. Cross-section data obtained from the Iranian Ministry of Agriculture production costing questionnaires during 2015-2016 crop years were used in this study. The economic value of water in the first group with transcendental function was $0.4783\$/m^3$*and in the second group with generalized Leontief function was calculated* $0.5479\ \$/m^3$*. Reforming the current tariff system and reducing the water price gap to reduce losses on rice farms and increase water productivity is an effective measure to increase water productivity. Therefore, the increase in water tariff was considering the economic and social conditions of the area under study. Creating local water markets is effective in changing farmers’ view of water as public entity and understanding its true value.*

INTRODUCTION

In Iran, water has been an obscure free input in recent years. This attitude has kept the real value of water hidden from the viewpoint of consumers, especially farmers. The agricultural sector uses water more than any other economic sector in the country, and they have not paid any price. Currently, water scarcity is one of the most important limiting factors for agriculture.

Currently, water scarcity is one of the most important factors limiting agriculture in Iran. Population growth, changing standards of living, and decreasing atmospheric rainfall are some of the factors causing the imbalance between water supply and demand. Balancing supply and demand requires sound and integrated management. Different methods of water valuation are used in each country. These methods vary according to the status of water resources, the history of water pricing, the extent of irrigation systems, the development of social and legal water institutions, and the contribution of the agricultural sector to water consumption. In many countries, these methods have changed over time. In Iran, water resources management is based on socio-political criteria, which in itself creates a problem of optimal allocation. Pricing system in Iran has some problems such as lack of relation between irrigation water tariff and economic value and cost of water supply, which makes the irrigation water tariff system not successful in achieving better economic efficiency and reducing water losses in water resources management. Recently, high pressure on water resources in Iran has led to more attention to demand-based management in water resource management optimization (Sadati et al., 2010). In Iran, Maroon irrigation network supplies water of about 185 thousand hectares of rice farm in Khuzestan fields. Depending on the type of crop, the type of irrigation system and the size of each farm, the tariff will be payable. Payments to farmers whose farms are covered by irrigation networks account for approximately 1 to 3 percent of their income to provide irrigation water. During the survey, 65% of farmers are not willing to pay more for water tariffs (Tahamipouret al., 2015). Changing water resources management approaches to demand-based management using water economic evaluation is one of the efficient tools in optimizing the allocation of water that plays a decisive role in balancing supply and demand.

In Tanzania used the amount of water consumed and paddy crop for the new formulation and policy making so that a 6% increase in requirement water resulted in a 10% increase in crop yield coefficient. A negative value was calculated for price of water, which means that a one percent increases in water price would reduce the water demand by 0.30 percent. So it can be concluded that pricing based on the economic value of water can be an important factor in reducing water consumption in products whose performance depends on the amount of water consumed. Cheng et al. (2016) showed that the amount of water consumed affects the amount of rice production. According to this used five functions to select the best function in accordance with the performance and growth period of local rice in Jilin Province. Comparison of calculations with reality showed that Johnson function the most appropriate is the production function local rice in the study area. The study was carried out at rice fields in northern Italy at different levels of programmed supply and under different pricing and with increasing cost levels. This program can be used as a useful tool to support future water resources policies to better allocate resources (Sali and Monaco, 2014).The positive mathematical programming is another important method that is widely used to estimate the value of water in agriculture. Among the studies carried out with this method are the studies of modeling (Medellín-Azuara et. al., 2010), (Sabouhi and Tahmipoor, 2014), (Shawerdi and Tahmipoor, 2016), (Varziri et al., 2016).

In the Kenya watershed, the economic value of irrigation water for crop and horticultural was estimated using the residual method. The results showed that there was more potential in crops than fruit trees in the study area. This means that the value of final water production for crops was higher than the value of final water production for fruit trees (Kiprop et al., 2015). As well as Musamba et al. (2011) estimated the net value of irrigation water for rice and non-rice crops using the residual method of 0.32 $ and 0.073 $ per cubic meter, respectively. Al-Karbiyahetal. (2012) used the same method to estimate the economic value of irrigation water in Jordan.

They cited the existence of subsidies for water as a factor in hiding the real value of water fromthe minds of farmers and the potential use of this valuable input. Sadeghi et al. (2012) not only found that paying too low a price for water by farmers was a reason for inefficient allocation, but also showed that it caused farmers to make inappropriate use of this valuable input in producing unnecessary crops the water also gets high.

The residual methods, budgeting and linear planning methods discussed above are some nonparametric methods of determining the economic value of water. Parametric methods are based on the use of econometric models, one of which is the most applicable production function method. The benefits of parametric methods in estimating the economic value of water include the possibility of performing statistical tests for the estimated parameters of econometric models, the need to determine the limitation of inputs and the use of various functions including flexible and inflexible functions (2016).

Due to the advantages of production function method and its suitability for single crop cultivation patterns and its widespread use in agriculture and industry, this study was carried out to calculate the economic value of irrigation water in Khuzestan province, Iran. Estimating the economic value of aquaculture water in terms of real water value and changing the view of water users as a free input to a valuable economic commodity means that a product with a higher final production value is given priority in the allocation if it is in region one. The product is produced, the water is allocated to areas where the product is present the potential is higher than the value of production. Based on the results of this study, the necessary strategies for sustainable management of water resources in the Maroon irrigation and drainage network will be presented through identifying and setting priorities, constraints, problems and challenges of water resources management in this network.

1. MATERIALS AND METHODS

In the present study, the production function method was used to estimate the actual price of water because the data are cross-sectional and no significant changes were observed in input prices as well as in crop prices. The production function method with econometric techniques is a parametric method that analyzes primary or secondary information of irrigation and industrial inputs and outputs with statistical techniques (usually regression). This method is used in the valuation of water at the place of consumption for agricultural or industrial producers.

Khuzestan province is one of the major provinces for agriculture in Iran. Precipitation in the crop season, lack of provision for water storage due to rainfall, decrease in maroon reservoir volume due to sediments, pay more attention to water as a valuable input (KWPA, 2010). Lands covered by Maroon Irrigation and Drainage Network are divided into three irrigation areas including Maroon (Development G units) with 75.8 hectares area, permissive area (Development F units) with 49.7 hectares area and eastern area (Development D units). It is spread over 54,000 hectares (KWPA, 2010). Hybrid cultivation is traditionally irrigated, but productivity in this method is low and water loss is high. Dependence on rice production on water and scarcity of available water resources for sustainable cultivation of this crop requires strong planning and management to make optimal use of limited water resources. In this regard, determining the economic value of water and accepting the real value of water by farmers paves the way for strengthening the economic role of water in sustainable development.

The amount of production of each product depends on the amount of inputs consumed. The production function is a mathematical relationship that determines how the relationship between the yield of a product in a growing season and the amount and type of production factors such as manpower, chemical fertilizers, pesticides, etc. The general form of production function is as follows:

$$y = y\,(x_1, x_2, \dots, x_2 - 1, wat) \tag{1}$$

$$VMP_{wat} = p_y \times MP_{wat} = p_y \times \left({}^{\partial y}/_{\partial wat} \right) \tag{2}$$

In this respect, y and wat are the amount of rice produced and water used,$\mathrm{x_1}$ to $\mathrm{x_{n-1}}$are production inputs other than water also,$\mathrm{P_Y}$ is the price of yield produced, $\mathrm{VMP_{wat}}$ is the economic value of water or the value of marginal product of its, and also$\mathrm{MP_{wat}}$ is the marginal product of water. It is clearly understood from equations (1) and (2) that the calculated $\mathrm{VMP_{wat}}$ is a function of$\mathrm{MP_{wat}}$and this is obtained from they. Therefore, primary production function is effective in determining economic value of water, and any changes in primary production function after the functions estimated in final output and the economic value calculated for input. The purpose of estimating this function is to apply production input coefficients to determine the economic value of water for the above product. Therefore, the more careful the selection of the production function model and the more appropriate one is chosen, the production relationships will be more accurately reflected and the error in expressing the relationship between inputs and outputs will be reduced. In this study, in order to determine the best model for estimating the economic value of irrigation water, the Cobb-Douglas and transcendental flexible functions and the transversal flexible functions, generalized Leontief and generalized quadratic were fitted and compared in Eviews econometric software.

2. INTRODUCING FUNCTIONAL FORMS OF PRODUCTION

2.1 Cobb-Douglas function

This function is one of the most widely used function that expresses the structural relationship between production inputs and the output produced in agricultural and other economic activities. Also, has the specification of uniformity, homogeneity, necessity, non-nullity derivability, concavity, continuity and non-negative. This function could represent only one stage of production at a time. This functional form is written as in Eq. (3):

$$y = \alpha_0 \times W^{\alpha_{wat}} \times L^{\alpha_{lab}} \times M^{\alpha_{mac}} \times F^{\alpha_{fer}} \qquad (3)$$

The marginal product as in Eq. (4) (Debertin, 2002):

$$MP_{wat} = \alpha_{wat} \times \left(\frac{Y}{W}\right) \qquad (4)$$

2.2 Transcendental function

This functional form offers all the features of the neoclassical function. The input striation is not constant, that its value pertains on the amount of input used. Another characteristic of this form is that the elasticity of the scale is not fixed, but depends on the inputs value. This functional form is an improved function of the Cobb-Douglas form, but this function is able to show the final unstable productivity and the negativity of the final production (marginal product) in all three production areas. This functional form is written as in Eq. (5):

$$y = \alpha_0 \times W^{\alpha_{wat}} \times L^{\alpha_{lab}} \times M^{\alpha_{max}} \times F^{\alpha_{fer}} \times P^{\alpha_{pes}} \times S^{\alpha_{sed}} \times \exp((\beta_{wat} \times W) + (\beta_{lab} \times L) + (\beta_{\ mac} \times M) + (\beta_{fer} \times F) + (\beta_{pes} \times P) + (\beta_{sed} \times S) \qquad (5)$$

The marginal product of water input is obtained from Eq. (6) (Halter et al., 1957):

$$MP_{wat} = \left(\frac{\alpha_{wat}}{W} + \beta_{wat}\right) \times Y \qquad (6)$$

2.3 Generalized Quadratic function:

This functional form includes all the features of the neoclassical function, except for the necessity condition. For the sign of the first derivative is no limitation. Another feature of this function is that, if the use rate of one input or use all of inputs would be zero, then the output will not be zero. This functional form written as in Eq. (7) (Green, 1993):

$$\begin{aligned} y = \alpha_0 + \alpha_{wat} + \alpha_{lab} + \alpha_{mac}M + \alpha_{fer}F + \alpha_{pes}P + \alpha_{sed}S + 0.5\beta_{wat}W^2 + 0.5\beta_{lab}L^2 \\ + 0.5\beta_{mac}M^2 + 0.5\beta_{fer}F^2 + 0.5\beta_{pes}P^2 + 0.5\beta_{sed}S^2 + \beta_{watlab}WL \\ + \beta_{watmac}WM + \beta_{watfer}WF + \beta_{watpes}WP + \beta_{watsed}WS + \beta_{labmac}LM \\ + \beta_{labfer}LF + \beta_{labpes}LP + \beta_{labsed}LS + \beta_{macfer}MF + \beta_{macsed}MS \\ + \beta_{ferpes}MS + \beta_{ferpes}FP + \beta_{fersed}FS + \beta_{pessed}PS \end{aligned} \qquad (7)$$

The marginal product of water written as in Eq. (8) (Tahamipour et al., 2015):

$$MP_{wat} = \alpha_{wat} + \beta_{wat}W + \beta_{watlab}L + \beta_{watmac}M + \beta_{watfer}F + \beta_{watpes}P + \beta_{watsed}S \qquad (8)$$

2.4 Translog function

This functional form also includes all the features of the neoclassical function. For the sign of the first derivative is no limitation and shows all three regions of producing. Also, the marginal product can be, decreasing, increasing or negative. In Translog functional form, both the correlations coefficients of the variables and parameters of the main variables can be estimated and evaluated, simultaneously. It functional form written as in Eq. (9)

$$\begin{aligned} ln(y) = \alpha_0 + \alpha_{wat}ln(W) + \alpha_{lab}ln(L) + \alpha_{mac}ln(M) + \alpha_{fer}ln(F) + \alpha_{pes}ln(P) + \alpha_{sed}ln(S) \\ + 0.5\beta_{wat}lnW^2 + 0.5\beta_{lab}lnL^2 + 0.5\beta_{mac}lnM^2 + 0.5\beta_{fer}lnF^2 \\ + 0.5\beta_{pest}lnP^2 + 0.5\beta_{sedt}lnS^2 + \beta_{watlab}\,ln(W)\,ln(L) \\ + \beta_{watmac}\,ln(W)\,ln(M) + \beta_{watfer}\,ln(W)\,ln(F) + \beta_{watpes}\,ln(W)\,ln(P) \\ + \beta_{watsed}\,ln(W)\,ln(S) + \beta_{labmac}\,ln(L)\,ln(M) + \beta_{labfer}\,ln(L)\,ln(F) \\ + \beta_{labpes}\,ln(L)\,ln(P) \\ + \beta_{labsed}\,ln(L)\,ln(S) + \beta_{macfer}\,ln(M)\,ln(F) + \beta_{macpef}\,ln(M)\,ln(P) \\ + \beta_{macsed}\,ln(M)\,ln(S) + \beta_{ferpes}\,ln(F)\,ln(P) \\ + \beta_{fersed}\,ln(F)\,ln(S) + \beta_{pessed}\,ln(P)\,ln(S) \end{aligned} \qquad (9)$$

In this functional form, the marginal product determined as in Eq. (10) (Tahamipour et al., 2015):

$$MP_{wat} = \frac{\partial ln(y)}{\partial ln(w)} \times \frac{y}{w} = \left(\alpha_{wat} + \beta_{wat} + \beta_{watlab}\,ln(L) + \beta_{watmac}\,ln(M) + \beta_{watfer} + \beta_{watpes}\,ln(P) + \beta_{watfer}\,ln(S)\right) \times \left(\frac{y}{w}\right) \qquad (10)$$

2.5 Generalized Leontief function

This functional form includes all the features of the neoclassical function, except for the necessity condition. For the sign of the first derivative is no limitation. If the use all of inputs would be zero, then the output will be zero, but if the value of using one of the inputs is not zero, the output will not be zero. This functional form written as in Eq. (11):

$$\begin{aligned} y = \alpha_0 + \alpha_{wat}W^{0.5} + \alpha_{lab}L^{0.5} + \alpha_{mac}M^{0.5} + \alpha_{fer}F^{0.5} + \alpha_{pes}P^{0.5} + \alpha_{sed}S^{0.5} + 0.5\beta_{wat}W \\ +0.5\beta_{lab}L + 0.5\beta_{mac}M + 0.5\beta_{fer}F + 0.5\beta_{pes}P + 0.5\beta_{sed}S + \beta_{watlab}W^{0.5}L^{0.5} \\ +\beta_{watmac}W^{0.5}M^{0.5} + \beta_{watfer}W^{0.5}F^{0.5} + \beta_{watpes}W^{0.5}P^{0.5} + \beta_{watsed}W^{0.5}S^{0.5} \\ +\beta_{labmac}L^{0.5}M^{0.5} + \beta_{labfer}L^{0.5}F^{0.5} + \beta_{labpes}L^{0.5}P^{0.5} + \beta_{labsed}L^{0.5}S^{0.5} \\ +\beta_{macfer}M^{0.5}F^{0.5} + \beta_{macsed}M^{0.5}S^{0.5} + \beta_{macpes}M^{0.5}P^{0.5} + \beta_{macsed}M^{0.5}S^{0.5} \\ +\beta_{ferpes}F^{0.5}P^{0.5} + \beta_{fersed}F^{0.5}S^{0.5} + \beta_{pessed}P^{0.5}S^{0.5} \end{aligned} \qquad (11)$$

The marginal product of water based on generalized Leontief function written as in Eq. (12) (Debertin, 2002):

$$\begin{aligned} MP_{wat} = 0.5\beta_{wat} + 0.5W^{-0.5}(\alpha_{wat} + \beta_{watlab}L^{0.5} + \beta_{watmac}M^{0.5} + 0.5\beta_{watfer}F^{0.5} \\ +0.5\beta_{watpes}P^{0.5} + 0.5\beta_{watsed}S^{0.5} \end{aligned} \qquad (12)$$

In these functions Y, W, S, M, L, F, P, α and β were respectively rice yield (Y), cubic meter of water consumed (W), seed consumption in kg (S),machinery cost (M), cost of labor in day work (L), fertilizer consumption in kg (F), pesticide consumption in kg (P), and α and β as regression coefficient. These factors are the most important inputs in rice production. In the study of Michael et al. (2014) most of these inputs are considered.

At first the function forms were calculated by the above equations and the best function was determined by economic criteria and tests such as coefficient of determination (R-squared), the adjusted coefficient of determination(Adjusted R-squared), Akaike information coefficient (AIC), Schwarz criterion, and probability coefficients of significant estimated coefficient on form was identified. In addition, the Glejser test, T- test and Jarqe-Bera tests were used to check the variance and the normality of the errors, respectively, and the results are presented in Tables 2 and 5.

In present research, cross-sectional data received by the production cost questionnaires plan forthe years of 2015–2016 were applied, which were presented by the agriculture Ministry. In this research, 457questionnaires were used for rice farms. The amount of consumed water was calculated by the quadratic relationship between rice product and consumed water as in Eq. (13):

$$y = -0.0095w^2 + 14.551w - 1136 \qquad (13)$$

Where y is $\mathrm{kg/ha}$, and w is irrigation water in millimeter and water used in the two groups farms was estimated using the Eq. (14). This equation was obtained by sampling of paddy fields in Iran, which aimed to determine the relationship between water use and rice yield for homogenous farms (Davatgar, 2010).

In the current research was carried out at a large scale and the required data were collected by the Ministry of Agriculture production costing questionnaires. The data were cross-sectional and grouped by cluster analysis using cumulative hierarchical method, so that the yield to water ratio or average production values for all farms were calculated first and then the SPSS software with 2 to 5cluster analysis. Five groups were divided. After examining the number of farms in each group, it was found that comparisons were made between the clustering of two groups of farms and because of the low number of farms in the other clusters, statistical comparisons would be meaningless.

According to this grouping, the first group consisted of 218 farms and the second group consisted of 165 farms. The studied fields were Maroon irrigation and drainage network development units whose geographical location had no effect on grouping. The farms with low level of mechanization irrigation were in the first group and farms with high level of mechanization irrigation were in the second group. The purpose of this clustering was to examine the homogeneity of the data and to determine the differences in the economic value of the farms in the grouping based on differences in average production; because cluster analysis is a method for grouping individuals or subjects, so that individuals within groups are very similar. However, there is a significant difference between groups (Kalantari, 2003). Finally, using the parametric method of production function, the superior production function in each group was identified and selected. With this estimation, the importance of water inputs in rice yield is becoming more apparent, as a factor in encouraging farmers to save or use it efficiently and minimizing water losses. Also, the priorities of allocation and gap between water price paid and the real value of water were identified in this study. By identifying this gap, increasing water prices will be the right policy to take with caution and consideration all social and regional aspects.

3. RESULTS AND DISCUSSION

3.1. First Group farms

The results of the descriptive statistics on the amount of inputs consumed in the first group of 218farms are presented in Table 1. In the first group farms, the poison with the coefficient of variation 0.867 had the highest fluctuations and water consumption with the coefficient of variation 0.056 lowest variations. These numbers show that the farmers in this group were very similar in their water use and their irrigation system was similar. Also, the average yield of rice per hectare in the first group was 3535 kg and water had the least fluctuations. It can be concluded that rice yield is largely dependent on water consumption. On average, 64 people were working day-hectare. The average cost of machinery was 688.25$/ha. Minimum and maximum amount of seed consumed was 45 and 136.4 kg / ha, respectively. Also, the amount of fertilizer in this group was varied between 60 and 455 kg.   In order to achieve the purpose of studying and selecting the best production function to calculate the economic value of irrigation water, five functional forms including Cobb-Douglas, Transcendental, Translog, Generalized quadratic and Generalized Leontief estimated. The results of the evaluation of these functions for First-Group farms are presented in Table 2. Econometric tests and criteria were used to select the best production function. In the first step, the fitted functions were evaluated for the normality of the error distribution by Jarqe-Bera statistics. According to this the generalized Transcendental, Translog, and Leontief forms were excluded. The next criterion in selecting the best production function is the number of significant coefficients.

Table 1. Descriptive statistics of input consumption per hectare in the first group

Input	*Yield (kg)*	*Irrigation water(m^3)*	*Manpower (labor)*	*Machinery (Dollar)*	*Fertilizer (kg)*	*Pesticides (kg)*	*Seed (kg)*
Min	3000	8459	17.8	219.987	60	0	45
MAX	3867	10580	117.5	785.669	455	33.4	136.4
Median	3583	9800	62	6662.48	233	2.5	87.5
Average	3535	9845	63.3	286.6	250	9.6	87.5
STDV.S	222	548	19.5	2.3	80	8.4	22.6
CV	0.063	0.056	0.309	0.249	0.319	0.867	0.258

Table2. Comparison of different fitted functional forms to rice produce in per hectare in the first group

Criteria	*Cobb-Douglas*	*Transcendental*	*Generalized quadratic*	*Translog*	*Generalized Leontief*
R-squared	0.981	0.985	0.986	0.987	0.986
Adjusted R-squared	0.980	0.984	0.984	0.985	0.984
Akaike info criterion (AIC)	9.749	9.689	9.634	-6.739	9.608
Schwarz criterion	9.958	9.894	10.076	-6.297	10.050
Significant proportion of the estimated coefficients	57.14	15.4	14.3	21.43	14.3
Jarqe-Bera(Prob)	2.44 (0.03)	1.37(0.42)	8.55 (0.01)	7.75 (0.02)	8.23 (0.01)
Glejser test (Prob)	2.314 (0.03)	2.156 (0.05)	1.213 (0.3)	1.156(0.33)	1.28 (0.27)

Thus, the Cobb-Douglas function with the significant coefficients of 57.14% was considered as the best production function, but because it is limited in the analysis of the third production area, the transcendental function was selected as the superior function in this group of farms. R-squared coefficient 98.5% and Adjusted R-square98.4% in transcendental function indicate the high ability of this function to justify changes related to the performance dependent variable.

Table 3. Results of fitting the Transcendental form for the first group

No	*Symbol*	*Coefficients*	*Standard Error*	*t-statistic*	*p-value*
1	α_0	-2815.061	21.289	2.992	0.00
2	α_{wat}	3.898	3.745	-3.125	0.00
3	α_{lab}	-0.198	0.877	-0.228	0.821
4	α_{mac}	-1.435	1.303	-1.105	0.272
5	α_{fer}	-0.426	0.453	0.938	0.348
6	α_{pes}	0.038	0.148	0.405	0.688
7	α_{sed}	0.832	0.685	1.214	0.227
8	β_{wat}	1.205	0.362	3.429	0.00
9	β_{lab}	-0.108	0.052	-2.107	0.038
10	β_{mac}	0.018	0.066	0.292	0.772

11	β_{fer}	-0.017	0.011	1.488	0.139
12	β_{pes}	-0.0002	0.0003	-0.692	0.408
13	β_{sed}	-0.104	0.027	-3.939	0.00

The results of the transcendental function fitting for the first group farms are presented in Table 3. The results showed that regression coefficientsα_0, α_{wat} and β_{wat} were significant at 1% probability level $(\mathrm{P} < 0.01)$. Also, the $\beta_{fer}$was significant at the probability level of 5% $(\mathrm{P} < 0.05)$ probability level. As can be seen, water consumption with a coefficient of 3.898 had the most significant effect on rice production. This means that a one percent increase in water consumption increases the yield by 3.898 percent. This result can be applied to all farms in this group. Also, the lowest effect was shown by the consumption poison. Also, labor force, machinery cost and fertilizer coefficients were negative, indicating that the amount of inputs used was higher than the average compared to the optimal sample .Because, in the transcendental function, the coefficients of the variables production elasticity. If the coefficients are negative, it indicates those are in the third region of production and indicates overuse of these inputs. Based on the results for the first group farms, considering the median final production (0.387) of irrigation water in the sample and the economic value of 1.2414$per kg of rice produced in the 2015-16 crop year, the marginal production value (economic value) for per cubic meter of irrigation water was calculated to be 0.4783$ (Table 7). However, farmers in the modern part of the network pay a price of 0.0136$, which is 2.58% of the estimated economic value of irrigation water per cubic meter.

Table 4. Descriptive statistics of inputs consumption for farms per hectare in the second group

Input	*Yield (kg)*	*Irrigation water* (m^3)	*Manpower (labor)*	*Machinery (Dollar)*	*Fertilizer (kg)*	*Pesticides (kg)*	*Seed (kg)*
Min	3600	9800	25.2	204.27	86.7	0	40
MAX	4420	11546.18	117.49	804.53	450	34	140
Median	4050	10797	64	395.98	250	5	80.33
Average	4074	10874.12	66.879	421.12	251	9.664	82.4
STDV.S	199	440	22	4.4	80.3	8.4	22
CV	0.049	0.040	0.328	0.328	0.319	0.882	0.267

Table 5: Comparison of different fitted functional forms for rice production per hectare in the second group

Criteria	*Cobb-Douglas*	*Transcendental*	*Generalized quadratic*	*Translog*	*Generalized Leontief*
R-squared	0.978	0.98	0.983	0.983	0.983
Adjusted R-squared	0.977	0.977	0.979	0.979	0.979
Akaike infocriterion (AIC)	9.65	7.9	686.9	-6.899	232.10
Schwarzcriterion	786.9	950.9	224.10	-6.362	913.9
Significant proportion of the estimated coefficients	57.28	7.7	86.17	28.14	28.14
Jarqe-Bera (Prob)	10.33 (0.006)	10.63 (0.005)	5.94 (0.05)	5.76(0.056)	5.33 (0.07)
Glejser test (Prob)	2.122 (0.054)	2.022 (0.066)	1.39 (0.221)	0.529 (0.786)	1.160 (0.331)

3.2 Second group farms

The results of the descriptive statistics of input consumption for the second group are presented in Table 4. The highest amount of seed consumed in this group was 140 kg / ha. In this group, as in the first group, the highest fluctuations of inputs were observed in the poison consumed with an average of 9.6kg / ha. The maximum cost of the machinery was 804.53$/ha, with an average of 67 people-day / ha. The median fertilizer used was 250 kg/ha. Water use and yield per hectare of the group had the least granges, respectively. The average water consumed in this group was 10874 m^3/ha, which is higher than the first group. The yield of the second group was also higher than that of the first group. So it can be concluded with certainty that rice production depends on the amount of water consumed. These results were in agreement with those of Michael et al. (2014) and Cheng et al. (2016). In order the best model and calculate the economic value of irrigation water for rice crop production in the second group farms, five functions were considered as main options for expressing the relationship between the production factors and the amount of rice production, their results are along with the econometric results are presented in Table 5. The results showed that the generalized Leontief function was the superior functional form in the second group farms. The reason for this choice was the normal distribution of the error obtained by the Jarqe-Berastatistic. Also, this functional form, like the generalized quadratic and Translog forms, shows all three areas of production and has no limited in term of sing. In addition, this function had no heterogeity of variance and R-square and adjusted R-square determinations were 0.983 and 0.979, respectively, indicating that the model variables were able to explain more than 95% of the variation. The estimated results of this function are presented in Table 6.

Also, this table shows, the β_{labpes} coefficient is significant at the 5% probability level $(P < 0.05)$ and theβ_{sed}, α_{mac} and β_{watmac} coefficients are significant at the 10% probability level $(P < 0.1)$. The negative interaction coefficients of the inputs indicate the inverse relation ship between them and the positive interaction coefficients indicate the direction of their changes. For example, the negative coefficient of machinery and seed means that using more machinery will reduce the amount of seed consumed. The positive coefficients of manpower and fertilizer interactions also means that as the number of farm labor force increases, the amount of fertilizer increases and, conversely, if the farm labor force decreases, fertilizer also decreases.

Table 6: Results of fitting the generalized Leontief form for second group

No	*Symbol*	*Coefficients*	*Standard Error*	*t-statistic*	*p-value*
1	$\square_0$	-2665.043	4701.568	-0.567	0.572
2	α_{wat}	8.698	83.55	0.1041	0.917
3	α_{lab}	66.40	113.963	0.583	0.561
4	α_{mac}	1.981	1.111	1.783	0.077
5	α_{fer}	-77.68	55.288	-1.405	0.077
6	α_{pes}	-68.59	121.608	-0.564	0.574
7	α_{sed}	1699.035	134.855	1.253	0.212
8	β_{wat}	1.070	0.777	1.377	0.171
9	β_{lab}	1.236	2.613	0.473	0.637
10	β_{mac}	0.0001	0.0002	0.479	0.632
11	β_{fer}	0.513	0.806	0.636	0.526
12	β_{pes}	5.567	0.806	0.636	0.526
13	β_{sed}	-6.171	3.339	-1.848	0.067
14	β_{watlab}	-0.896	1.006	-0.890	0.375
15	β_{watmac}	-0.02	0.010	-1.953	0.053
16	β_{watfer}	0.604	0.519	1.163	0.247
17	β_{watpes}	0.610	1.066	0.572	0.5681
18	β_{watsed}	-0.992	1.24	-0.8	0.425
19	β_{labmac}	0.006	0.017	0.372	0.711
20	β_{labfer}	0.056	0.962	0.578	0.954
21	β_{labpes}	5.127	2.015	2.545	0.012
22	β_{labsed}	-0.865	1.795	-0.482	0.631
23	β_{macfer}	0.0002	0.0096	0.025	0.980
24	β_{macpes}	-0.012	0.019	-0.63	0.53
25	β_{macsed}	-0.002	0.02	-0.122	0.903
26	β_{ferpes}	-0.332	1.088	-0.306	0.760
27	β_{fersed}	0.792	1.102	0.719	0.473
28	β_{pessed}	-3.842	2.808	-1.368	0.174

Based on the results for the second group farms, considering the production in the 2015-16 crop year, the marginal production median (0.443 kg/m^3) of irrigation water in the economic case studyequals 0.5479$ and the economic value of 1.2413$/kg of rice was calculated (Table 7).The results of Table 7 can be used to optimally allocate and achieve the most economic benefit. According to these results, in case of water resources limitation, allocation priority belongs to the second group farms, because per cubic meter of water is obtained 0.443 kg rice and its economic value of water was $0.0696 more than the first group. Priority may be assigned to irrigation water allocation, resource development, irrigation network renovation, or any changes to improve the network.

Table 7. Comparing the marginal production of irrigation water and value of marginal production in both categories.

Group	Marginal production of irrigation water (Kg)	Value of marginal product of irrigation water (economic value)
First group	0.387	0.4783
Second group	0.443	0.5479

As the results show, the value of irrigation water per cubic meter was calculated to be $0.478 and $0.5479, respectively. However, paddy farmers pay $0.0136 for modern network and 0.0009$\$/m^3$for semi-modern network for irrigation water in Khuzestan province.

According to the results of Table 7we find that can be applied as water resources allocation guide. The priority in water allocation is for farms where crops creating more marginal production value for water input. As according to the results of Tables 7 and 8, Jayzan in the second group has preference for allocation water. According to the results, in the water allocation for the farms, the second group is given priority over the first group; because the marginal production value of water input in the second group, 0.0696$\$/m^3$ is more than the marginal production value in the first group and in the second group produced 0.443 kg of rice crop per cubic meter of irrigation water. The use of independent T-test showed that there was a statistically significant difference in the economic value for both groups. Initially, the homogeneity of variance was evaluated in the groups of farms. Considering F (0.05) and its level (0.85), the null hypothesis of differences between the two groups was accepted. The value of calculated T-statistic, in comparison to the mean of the economic value of water, was estimated to be equal to 15.87; in addition, given the significance level for an alternative hypothesis, the significant difference between the two groups was acceptable for homogeneity and mean is different between the two farm groups. The statistical difference between all farms of these two groups being equal to 0.012$\$/\mathrm{m}^3$. In order to obtain the economic value of water in each place, calculations were conducted for each city, in each group (Table 8).

Priority for resource development and water allocation management strategies can be understood for each of group of farms by considering the differences in economic value of water calculated based on the different cities. Based on the obtained results for the fields with homogeneity in second group, and high level mechanization (based on the ratio of machinery cost to labor cost per hectare), three priorities for allocation water resources are as: Jayzan, Lali, and Meydavood cities. Also, for infrastructure irrigation systems and development of resource are desired for the farms with low-level of mechanization for irrigation, three priorities in first group will be: Jayzan, Lali, and Izeh cities.The mean of economic values fortwo groups of farmsare 0.48 $\$/\mathrm{m}^3$for first group and 0.55 $\$/\mathrm{m}^3$for second group. Variations in the economic value of irrigation water for items of the first group are 5.5%, so that is lower compared to the second group with a coefficient of variation of 7.1%. In the Bagmalek city from the first group, the level of mechanization available is suffices to produce rice. The highest and lowest economic values of water were obtained in the second group with high irrigation mechanization in Jayzan and Gotvand cities, respectively. Due to the proximity of the Jayzanto the Maroon dam, the rate of water loss is very low. Also, the highest economic value of water in the farms for the first group whose level of irrigation mechanization is low belongs to the Jayzan, and Ramhormoz has the lowest economic value of water. Based on the results, the economic values of water in the first and second groups was0.4783 and 0.5479 $\$/m^3$, respectively. The difference of calculated values reflects the impact of technology on the economic value of water, while farmers pay about 0.0136 $\$/\mathrm{m}^3$ for water in the modern networks, 0.0089 $\$/\mathrm{m}^3$in the semi-modern networks, and 0.0047 $\$/\mathrm{m}^3$in the traditional networks.

The economic value of water for rice in the Alborz network was estimated at 0.4730$, with the transcendental function being the superior function of choice (Zolpirani et al., 2015). The results of study made it clear that the price paid by farmers was very different from the real value of water. Also, Khajeh-Roshanaei et al. (2010) calculated the economic value of irrigation water for wheat in the city of Mashhad, which was calculated as 0.059$/$m^3$, which was significantly different from the highest exchange price (0.0122$/$m^3$) for local water. The differences of estimated values in different studies can be explained by different crop types, their characteristics such as water stress tolerance in wheat and rice, crop cultivation methods and the climate of studied area.

The results of other studies confirmed the huge difference between the real value of water and the price paid of water by farmers, e.g., Chowdhury (2005) studied on the Ganges River watershed in Bangladesh using Translog function, and Michael et al. (2014) in Tanzania and Salar Ashayeri et al. (2018) in Iran studied the economic value of water for rice farms.

Table 8. Economic value of irrigation water by city with different groups

City Name	*Value of marginal product of irrigation water (Economic value) (Unit: \$/m^3)*	
	First group	*Second group*
Bagmalek	0.4948	-
Behbahan	0.4442	0.5628
Dezful	0.4976	0.5144
Gotvand	0.4454	0.4917
Hamidieh	0.4920	0.5225
Hoveyaze	0.5124	0.5055
Izeh	0.5202	0.6670
Jayzan	0.4750	0.5369
Lali	0.5199	0.5322
Maltasani	0.5020	0.5954
Meydavood	0.4819	0.5404
Ramhormoz	0.4542	0.5872
Seydon	0.3917	0.5335
Shavar	0.4769	0.5618
Shadegan	0.4762	0.5184
Susa	0.4684	0.5504
Average	0.4783	0.5479
CV	5.5	7.1

OVERALL CONCLUSION

In the present study, the economic value of irrigation water in rice fields was estimated in Khuzestan, Iran. For this purpose, the farms were first grouped by cluster analysis and then the economic value of each group was calculated using superior production function method. The transcendental production function was selected as the superior function in the first group according to econometric tests and criteria and the economic value of irrigation water in this group was calculated 0.4783$/$m^3$.Accordingly, the generalized Leontief function was the superior function of the second group and the economic value of irrigation water was calculated to be 0.5479$/$m^3$. However, farmers in the modern and semi-modern network pay 0.0136$/$m^3$and 0.009$/m^3, respectively. According to the results, allocation to second group farms is a priority because these farms produce 0.055 kg more rice with equal water consumption and for sustainable economic management of water it is necessary to utilize water input in a way that maximizes economic value. Production may be included in the water tariff. Public policies, and in particular non-targeted subsidies, prevent the promotion of factors contributing to increased productivity and economic value of water in agriculture. Therefore, formal water tariffs need to be implemented fairly to enhance the incentive to use water economically and to cover maintenance and operation costs and part of the costs of investing in water projects. In addition, the development of local water markets is another effective strategy for the proper management of water resources and efficient use of water resources in the province. In these markets, farmers play an important role and the real value of water becomes more apparent. Given the shortage of water inputs in the country, increasing the price of irrigation water is reasonable. However, the final cost-based pricing is often too heavy for low-income farmers, so it is advisable to implement policies that coordinate farmers' situation and increase water efficiency. In order to increase the efficiency of water use in agriculture and to make effective use of this scarce input, the long gap between the economic value of irrigation water and the amount paid by farmers should be gradually reduced. Improved water resources management can be achieved through new irrigation methods that reduce water loss or increase water efficiency by reusing drainage water, such as the intermittent irrigation as an alternative to permanent flooding irrigation. Also, change the pattern of crop cultivation from high water consumption to lower water consumption. So that equal benefit of rice can be earned with less irrigation water consumption. In addition, to improve water resources management, increasing the scope of activities of irrigation and drainage networks or establishing other government agencies to manage irrigation system at the second and third channel levels, and to provide control water distribution in farms. Give the shortage of water in Iran, the rise in irrigation water prices makes sense, of course, the prices that reduce the tariff gap and its economic value are very high by marginal costs for low-income farmers. Therefore, it is recommended to adopt new policies that take into account the financial conditions of farmers and at the same time increase water efficiency.

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