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Calculating the economic value of water in paddy farms in the area of Alborz Dam

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ABSTRACT: Water shortage in Iran is one of the limiting factors of sustainable development in the future. The factors influencing the shortage are management, and use of water in various economic sections including the most important part namely agriculture. The most important tool for management and allocation of water resources in agriculture is water pricing which can prevent the vital liquid from the indiscriminate and unlimited use. For this purpose, we use the methods of production function to calculate value of water in the paddy farmlands covered by Alborz Dam in the area of Alborz project. Required data were collected through 387 questionnaires, and field studies in this domain for 2014. According to the results of the transcendental production function, the economic value of water for crops covered by the Alborz Dam was calculated 15210 IRR per cubic meter. Results show a significant difference between the price obtained and Water prices paid by farmers that is 232 IRR in the modern semi network per cubic meter.

***Keywords*:** Economic Value of Water, Production Function method, Sustainable Development, Agricultural sector, Alborz project.

INTRODUCTION

From the past, Iran has always encountered with water shortage and imbalances of the spatial and temporal distribution. Although, more than one percent of world population belongs to Iran, the Iran's share of freshwater resources is less than half a percent (0.37 percent*)* of it (Pajooyan and Hoseini, 2003). Also, due to exposure in the desert belt, the water scarcity is one of the basic problems and it includes the main limiting factors to economic development in future (Mansuori and Qiasi, 2002). Meanwhile, the average rainfall in Iran is equal to 252 mm, and it is equivalent to the amount of 30% of the average rainfall in the world and Asia (Nazemosadat, 2001). Therefore, to produce and to achieve sustainable agriculture depend on the correct and rational use of scarce water resources. Because, more than 90 percentage of extracted water in Iran is used in the agricultural sector which it has low yield and efficiency in comparison to the international average (Falahati ., 2012).

Excessive use of water in the agriculture, the main sector of economic, isn't economical. Also, water is the most important limiting factor for the agriculture development which it has been considered. Hence, to consider the water as an economic input is determinant (Keramatzde, 2010). In recent years due to the problems of using of water resources, the management and the allocation of water resources are imported. The policy makers are concerned about make ways to agriculture water supply and demand management as the major consumer of water (Ehsani and Khaledi, 2003). The main issue of water management in Iran is the establishment of the balance between the supply and the demand of water. For this reason, the value or price of water has determinant role. If the price is set properly, many problems in water resources management can be solved (Gibbons, 1987). So, knowing value of water in the agriculture has important role in the management of water demand (Qaraeli, 2002).

Alborz project is located in area of Babol, Babolsar, Juybar and Ghaemshahr cities in the Mazandaran province, and it has about 52 thousand hectares farmland. Alborz Dam is the primary sources of water supply in the agriculture that has more important in providing and reserving of water for the agriculture (Shahnazari ., 2012). In this area, water is limiting factor for agriculture and other economic activities. Therefore, any attempt to conserve in agriculture water consumption can be valuable and vital. One of the most effective means for achieving this objective is water pricing and water right receiving (Daneshvarkakhki, 2003).

In field of urgency and importance of water conserve in the agricultural sector, various studies have been done on estimating the economic value of water. For example, Ziolkowska (2014) by calculating shadow price of water for four crops such corn, cotton, wheat, soybeans and sorghum in the plains of North Texas, stated that the higher prices for water cause to protect water resources, but the higher prices results the severe economic effects in the farm productivity. Amirnejad ., (2014) determined the economic value of water for rice equivalent 530.39 IRR in Sari. Rezaei (2014) calculated the value of water 1607 IRR for wheat and 1173 IRR for barley by using production function in the farms under the irrigation network of Dorudzan in Fars province. Dehqanpur and Sheikhzeinodin (2012) estimated the value of water 997.7 IRR by using production function in the Ardekan of Yazd plain. Mesa-Jurado ., (2012) resulted that the farmers will to pay 10 to 20 percent more than the present price for guarantee of providing water in annual irrigation.

MATERIALS AND METHODS

In this study, the estimation of the economic value of water in paddy fields in the area of Alborz Dam was done by using calculation of production functions. In this method, a function is estimated that water is used as the independent variable and the value of marginal production of water as its economic value is calculated (Debertin, 1997).

Theoretically, the certain amount of production of crop is function of variety used inputs. If Y represents the amount of production, we have:

$$\mathbf{Y = f\,(x\,,\,z)} \qquad \mathbf{(1)}$$

Where X is the vector of variable inputs and Z is the vector of fixed inputs. If amount of fixed or quasi-fixed input represent with W, the value of marginal production of water equals to the product of the marginal product of water to production price which it is equivalent of the economic value of water. So, it can be formulated as:

$$\mathbf{P_w = \left(\frac{\delta\, Y}{\delta\, w}\right) \times P_y = Mp_w \times p_y = Vmp_w} \qquad \mathbf{(2)}$$

Where in the relation 4, VMP_w is the value of marginal production or of the economic value of water, MP_w is the marginal production of water and P_x is the price of production (Chamberz, 1988).

$$\mathbf{MP_w = E_w \times AP_w = \frac{\delta\, Ln\,(y)}{\delta\, Ln\,(w)} \times AP_w} \qquad \mathbf{(3)}$$

To estimate the value of marginal or economic value of water in agriculture (the rice crop) using the production function, according to the priority of the flexible functions to the non-flexible functions, Cobb-Douglas, Transcendental, Translog, Generalized Quadratic and Generalized Leontief functional forms were used. The various functional forms are compared by F test, adjusted R square, significance of coefficients, stability of model, functional form specification (Ramsey’s RESET test), Wald test, autocorrelation (Durbin- Watson statistic) and heteroscedasticity (White test) (Samdeliri, 2013). The existence of heteroscedasticity in the functions was obviated using White test. By Jarque-Bera statistic the Normality of residuals was investigated, in result the models that haven’t normal distribution were eliminated (Judge ., 1988). Finally, among the favorite production functions, the Transcendental form was selected for calculating the economic value of water.

The used variables in this study are the yield at kilogram (Y), the used water at cubic meter (W), the used chemical fertilizer at kilogram (F), the used chemical pesticide at liter (P), the amount of seed at kilogram (S), the number of labor force at person/day (L) and the used machines at an hour (M). The mathematical relation of the empirical transcendental function and the value of marginal productivity of water or the economic value of water are represented in equation (4):

$$\mathbf{lnY = \alpha_0 + \alpha_1 lnW + \alpha_2 lnF + \alpha_3 lnP + \alpha_4 lnS + \alpha_5 lnL + \alpha_6 lnM + \alpha_7 W + \alpha_8 F + \alpha_9 P + \alpha_{10} S + \alpha_{11} L + \alpha_{12} M} \quad (4)$$

So, the value of marginal product of water by using the functional form in equation (4) can be calculated as follows (Halter ., 1957):

$$\mathbf{VMP_w = P_y . MP_w} \quad (5)$$
$$\mathbf{MP_w = ((\frac{\alpha_1}{w}) + \alpha_7)Y}$$

The target population of this study for determining the economic value of water is the paddy farmers in the area of Alborz Dam that includes Babol, Babolsar, Joybar and Ghaemshahr city. The required sample volume was determined with a pretest and Cochran formula (Cochran, 1997), and then the two-stage cluster sampling method was used.

$$n = \frac{N(t.s)^2}{Nd^2 + (t.s)^2} \quad (6)$$

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RESULTS AND DISCUSSION

To estimation of various production functions for the rice crop in the paddy farmlands in the area of Alborz Dam 387 questionnaire information was used in 2013-2014 year. In continues of function estimation steps will be presented various goodness of fit tests in order to selecting the best model. The table (1) shows the results of the investigating of the existence of collinearity among the variables by Principal Components Analysis method. As it is noted, probing the correlation among the variables shows that multicollinearity doesn't exist.

Table 1. The results of considering colinearity among the variables by principal components analysis in the rice production function

Principal Components Analysis (Ordinary correlations)						
lM	lL	lS	lP	lF	lW	variables
					1	lW
				1	0.0772	lF
			1	0.0333	-0.0244	lP
		1	0.0290	-0.0607	0.0092	lS
	1	0.0099	-0.1131	0.0587	0.0021	lL
1	0.3374	0.1919	0.0056	0.1508	-0.0006	lM

Consequently, the models were estimated using 6 variables. The table 2 represents the results of comparison among the different models for the rice crop in the area of Alborz Dam.

Table 2. The comparison of the estimated production function forms for the rice crop

production function form	Total coefficient	Significant coefficients percent	JB	Significant level
Cobb-Douglas	7	42.85	3.32	0.19
Transcendental	13	92.3	1.13	0.56
Translog	28	39.28	2.93	0.23
Generalized Quadratic	28	42.85	44.55	0.00
Generalized Leontief	28	50	8.79	0.01

According to the Jarque-Bera statistic (JB), the hypothesis of the normal distribution of the residuals was rejected for the generalized quadratic and the generalized Leontief models. Therefore, both of the generalized quadratic and the generalized Leontief models were rejected at this stage. Among other functions, the transcendental function due to the more number of significant coefficients (with the suitable stability and autocorrelation tests) was selected as the best functional form. The table (3) shows the results of the estimation of the Transcendental model for the rice crop in the paddy farmlands.

Table 3. The results of the estimation of the selected production function

Variable	Ab.	coefficients	Standard Deviation	t statistic	Significant level
constant	C	0.7886	0.3860	2.0428	0.0431^{**}
logarithm of Water	lW	1.0241	0.2125	4.8192	0.0000^{***}
logarithm of Fertilizer	lF	0.0229	0.0060	3.7779	0.0002^{***}
logarithm of Pesticide	lP	-0.0955	0.0194	-4.9190	0.0000^{***}
logarithm of Seed	lS	0.5974	0.1460	4.0902	0.0001^{***}
logarithm of Labor	lL	-0.3215	0.0938	-3.4253	0.0007^{***}
logarithm of Machine	lM	-0.0726	0.0377	-1.9249	0.0548^{*}
Water	W	0.0000	0.0000	4.2840	0.0000^{***}
Fertilizer	F	-0.0008	0.0008	-0.9969	0.3193
Pesticide	P	0.0019	0.0007	2.5688	0.0105^{**}
Seed	S	0.0043	0.0014	3.0939	0.0021^{***}
Labor	L	0.0072	0.0021	3.3048	0.0010^{***}
Machine	M	0.0017	0.0008	2.1789	0.0298^{**}
	$R^2 = 0.78$		F = 117.95		
	$R^2 = 0.79$		Prob= 0.000		

Note: ***, ** and * denote significance at 1%, 5% and 10% respectively.
2. Ab denotes abbreviation.

Base on the table (3), the model has the sufficient significant coefficients and the goodness of fit tests is confirmed. The table (4) explains the results of stability of the model (Ramsey's RESET test), residual serial correlation (LM test) and variance heteroscedasticity (White test) for the selected model.

Table 4. The results of the stability, serial correlation and variance heteroscedasticity tests for transcendental function

Type of Test	Ramsey RESET Test	Breusch-Gogferey Serial Correlation LM Test	Heteroskedasticity Test: White
F-Statistic	1.056	1.246	0.791
Prob	0.304	0.129	0.895

With regard of the table (4), the null hypothesis of three tests doesn't reject. Hence, the Transcendental functional form as the best functional forms is selected. After estimation of relation (5), the economic value of water in the paddy farmlands in the area of Albors Dam 15210 IRR per cubic meter was calculated.

Comparing the present results with other studies shows which the achieved economic value of water for the rice crop in the study of Samdeliri (2013) was 3864 IRR, for the wheat crop in the study of Rezaei (2014) 1607 IRR, Dehqanpoor and Sheikhzeinodin (2013) 997.5 IRR, Samdeliri (2013) 5886 IRR, for the barley crop in the study of Rezaei (2014) 1173 IRR, Samdeliri (2013) 2445 IRR, Hayati ., (2009) in North, Razavi and South Khorasan respectively 703.1, 1343.67 and 112.67 IRR and for the corn crop in the study of Ehsani ., (2010) was 847 IRR. The different in the estimated value of water in these studies may be caused to difference in the crop type, location or time of the studies that these could be affected on the economic value of water.

CONCLUSION

To calculate the economic value of water in paddy fields in the area of Alborz Dam the various production functions (Cobb-Douglas, Transcendental, Translog, Generalized Quadratic and Generalized Leontief) were estimated. Then, by using the econometric tests Transcendental form as the best functional form was selected. The result of the estimation of Transcendental production function and comparison of the economic value of water obtained in this study represented the large difference between it and the paid water right by the farmers in Alborz Dam area in 2014 which it was 232 rial/cubic meter. The difference between the calculated value of water and the paid water right by the farmers causes to overuse. Therefore, this price gap should gradually be corrected. The continuation of the present position and the gap between the actual price and the paid price for water lead to overuse and unsuitable farmer productivity and to reduce the farmer stimuli for thrift of water.

Suggestion

1. With regard that one of the most important goals of economic development in the agricultural sector is the optimum use and thrift of water, hence water pricing and receiving water right which is equivalent to the economic value of water are essential.
2. Although the water pricing based on the economic value should be done the benefits of receiving water right from farmers should be expended to improve water resources and better management of water supply scheme to agriculture.

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