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Estimating the Cost of Water and the Economic Value of Water in the Farmlands Covered by Man-Made Ponds: A Case Study of the Alborz Project Area in Iran

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Abstract

Water pricing is considered as one of the most important management tools of water resources, which can result in optimized allocation in the agricultural sector. In this regard, this study estimated the cost of water and the value of water in the farmlands covered by the selected manmade ponds (MMPs) within the Alborz project area in Mazandaran Province using the engineering economics methods and production function calculation. The required data were collected via a survey conducted in 2013-2014 growing season. Sample size was estimated to be 198 people. After studying various production functions, transcendental production function was chosen as the best functional form. Next, the economic value of water for rice in the basin covered by the selected MMPs was calculated to be 19,065 IRR per m^3 using an estimation of the production function. In addition, the cost of water per m^3 in the selected MMPs was obtained as to be 868 IRR at the interest rate of 22% and 394 IRR at the interest rate of 12%. Comparing the cost of water with the economic value of water demonstrated that the economic value of water is higher than the cost of water in the selected MMPs, and that both of them had great difference with the price paid by farmers. The implication is that the existing gap between the real price and the price paid by farmers should be filled by the economical pricing of water.

Keywords:
agricultural sector, cost of water, economic value of water, man-made pond, Alborz project

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INTRODUCTION

As one of most precious natural resources, water is indispensable for human beings and economic growth. It is also a matter of cost and value and not just quantity, which cannot be exempt from the principles of economics (Franklin et al., 2005). The crisis of water shortage has aroused extensive attention in the history of humankind, especially in recent decades (Zhao & Chen, 2008). Two-thirds of the world's population will live in water-stressed regions with per capita water of less than 1700 m^3 per year (OECD, 2003). The water supplies are, however, limited, whereas the demand for water is continuously rising. As a result, the competition for water use is rapidly increasing. In Iran, the rapid process of urbanization, economic growth, and increase in population, serious shortage of water resources, the threat of flooding, and aquatic environmental deterioration have become serious concerns. In response to these issues, the government has embarked on a large-scale investment program to increase the capacity of groundwater and surface water sources, for instance the manmade ponds (MMPs) in Mazandaran province (Ehsani & Khaledi, 2003). More efficient allocation of water resources will, hence, become a necessity. It is essential to understand how much water is worth for alternative uses in order to make decisions about improvements in its allocation efficiency. Water price is considered as an instrument for satisfactory allocation of water. It has been proved that improving water price system for promoting water saving is an important approach for maintaining the continuous operation of hydraulic engineering and realizing sustainable development in urban water resources and economy (Rogers et al., 2002).

Water pricing is an effective mechanism to manage water use. Switching to a more appropriate price scheme can adjust inefficient levels of agricultural water use by changing farmers' water demand. Developing countries, which usually suffer from inadequate water supply facilities and lack of comprehensive water pricing systems, are in need for more practical and effective water pricing mechanisms (Pakravan & Mehrabi Bshrabady, 2010). In Iran, the water often used to be provided to farmers almost free of charge as a basic necessity because it was a relatively cheap and abundant resource. Current water pricing is inefficient in most cases in the agriculture sector in Iran (Najafi & Najafi, 2009).

Pricing schemes are evaluated by allocation efficiency, the capacity of the suppliers to capture their costs, and the distributional effects of the policies, in particular, impacts on the poor. One approach has been average cost pricing, which guarantees cost recovery and allows suppliers to provide their product at relatively low rates. However, average cost pricing leads to economically inefficient consumption levels. Therefore, economists have often argued to price resources at their long-run marginal cost (Schoengold & Zilberman, 2014). Accordingly, the current water price system in agriculture must be reformed as it will lead to economic efficiency (Gibbons, 1987). However, the water industry in Iran has an exclusive state; the water pricing system is the main factor in maximizing social welfare and minimizing the loss. Given the fact that farmers follow the maximized profit goal, the logic pricing will make farmers not to consider water as a cheap input and try to curb its consumption (Najafi & Najafi, 2009).

Ponds are frequently human-constructed. An MMP is a body of standing water, either natural or artificial, that is usually smaller than a lake. They may form naturally in floodplains as part of a river system, or they may be somewhat isolated depressions. MMPs generally refer to bodies of water that are built and maintained by humans rather than Mother Nature. Sometime, topology of an area naturally creates it. In Mazandaran, rain falls mostly occur in non-cropping seasons. Therefore, constructing MMPs is one of the ways to control rainfalls and surface waters, and thereby reserve temporary precipitations (Shahnazari et al., 2012).

The economic value of water comes from the diverse uses to which water can be put into satisfying people's needs. Water can have a very high economic value because it is scarce and because it is capable of being applied to many different uses. The economic value of water is defined as the amount that a rational user of a public or privately supplied water resource is willing to pay for it. So, the economic value of an added unit of supply water decreases as greater quantities are offered to water users. For example, people will only use water for irrigating their lawns or for low-value crops if the price of water is suitably cheap. At a high water price, neither of these uses, produces a high enough economic value to make it affordable (Warda & Michelsenb, 2002).

The marginal value of water represents the contribution of an incremental unit of water to whatever public or private objective is under consideration. The marginal value of water provides important information for policy-related analysis of water development or allocation. For the development case, a decision dealing with increased water supply and economic efficiency requires that water development be expanded as long as the marginal value of the added capacity exceeds its marginal cost. That is, if the marginal value of expanding a water system's capacity is greater than its marginal cost, then it is good economics to expand the system. For the allocation decision, economic efficiency in the allocation of scarce water among competing uses can occur only if the marginal value per unit of water is equal for all uses. That is, policies improve economic efficiency when they reallocate water among users if the marginal value gained by the gainer exceeds the marginal value lost by the loser (Warda & Michelsenb, 2002).

In this regard, local water resources can be conserved by pricing per m^3 water. The aim of this study was to use engineering, economics, and estimation of the production function in order to determine and to compare the implemented water price and the economic value of water per m^3 in the farmlands covered by the selected MMPs. A gap is expected to exist between the implemented water price and the economic value of water with the sale price of water. Due to both complexity and importance of water pricing, mechanisms for water pricing have been widely studied. But, the implemented price and value of water have not been subjected to adequate research yet.

Tahamipour et al. (2015) obtained the economic value and price of water in Golestan Province. Results indicated that the weighted average of economic value and supply costs of irrigation water were 1795 and 1399 IRR per m^3, respectively. Hassanpour et al. (2014) calculated the value of water as 336 IRR in the irrigated network of the Khuzestan Province by the production function method, and the implemented water price as 4,398 IRR per m^3. However, the irrigated fee paid by farmers was 68 IRR per m^3. Ziolkowska (2014) calculated the water shadow price for five crops, including corn, cotton, wheat, soybeans and sorghum in the north Texas aquifers as 92.02, 865.99, 170.71, 18.61 and 166.86, in the south Texas aquifers as 5.13, 66.1, 90.73, 685.17 and 84.94, in the Kansas aquifers as 77.64, 56.43, 485.35, 20.74 and 765.1, and in the Nebraska aquifers as 24.94, 9.04, 116.91 and 82.85 dollars per acreage, respectively. Frija and Chebil (2013) investigated the value of water for wheat in Tunisia. They showed 31.7 percent of the farmers used more water than the economic optimum volume of water. It means that the benefit of each additional unit of water is less than the market price of water (0.11 Dinar per m^3). Mashhadizadeh et al. (2014) calculated the value of water as 381.88 IRR per m^3 for the wheat farms in Khuzestan Province by the production function method and estimation of Cobb-Douglass functional. Mesa-Jurado et al. (2012) studied the guaranteed value of water for irrigation in water deficit conditions. The results of their study showed that the farmers were willing to pay 10 to 20 annual percent more than the present prices in exchange for the guaranteed supply of water. Also, they expressed their willingness to decrease irrigation water by, on average, 30 percent.

A review of the literature shows that most studies have focused on water pricing as a mechanism to save water and reduce its wastage. Also, it has a main role in balancing between the supply and the demand of water. This paper aims to study the value of water in the basin covered by MMPs in Alborz project area. The Alborz project is located in Babol, Babolsar, Joibar and Gha'emshahr counties of Mazandaran Province that has economically especial importance with around 62 thousand farmlands (Shahnazari et al., 2012). In this area, water for farming and other activities is restricted. So, every effort for saving water in agriculture is essential. The MMPs of this area plays an important role in providing and conserving water requirement of the farmlands (Daneshvarkakhki, 2003).

MATERIALS AND METHODS

The economic value of water

In order to estimate the economic value of an unpriced input like water, its share in total value added to product should be separated from the share of the other inputs. As water is used for different purposes such as production input and environmental public goods, the methods to determine the economic value of water are divided into two groups: the parametric and nonparametric methods. In the nonparametric methods, the economic value of water is calculated using mathematics and computable models in economic theory. They often include residual method and its extensions, replacement cost method, change in net economic profit, input-output model, and mathematics programming. The parametric methods include analysis based on the production function, extracted demand of observations of water market, and the implicit valuation. Though both methods of mathematical programming and production function are difficult and costly in terms of data collection, they have been used most frequently in studies (Ministry of Energy, 2012). In the present study, the parametric method is preferred to determine the value of water of the crops. The parametric method was selected based on two principals: Firstly, in the parametric method, statistical tests of estimated parameters of econometric models can be made. Accordingly, the obtained value of water can be confidently considered. Secondly, to use parametric methods, we do not need to determine the water restriction bound and provide type. From among the parametric methods, the production function is selected, because it does not use profit and cost functions. Principally, it is possible to use profit and cost function when there are substantial variations in the input and output prices by collecting data (Dashti et al., 2010).

A production function describes the technical relationship that transforms inputs (resources) into outputs (crops). It shows the maximum output, which can be obtained for a given combination of inputs. It expresses the technological relationship between inputs and output of a product. In general, we can represent the production function for a crop as:

$$Y = f(X_1, X_2, \ldots, X_n) \quad (1)$$

where, Y is the maximum quantity of output, $X_1, X_2, \ldots, X_n$ are quantities of various inputs, and f stands for a functional relationship between inputs and output. All values of X greater than or equal to zero constitute the domain of this function. The production function is a technical relationship between production factors and product that expresses maximum product that can be produced, assuming that all other conditions of the inputs are constant.

The marginal physical product (MPP) refers to the change in output associated with an incremental change in the use of an input. In production function with multiple inputs, we can consider that W shows water as one of the inputs in the production function. Therefore, the value of marginal product of water that represents the economic value of water can be formulated as:

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

where, VMP_w is the value of marginal product or the economic value of water, MP_w is the marginal product of water, and P_y is the output price. In this respect, the amount of marginal product can be obtained by Equation 3:

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

The output elasticity is the percentage change in production divided by the percentage change in an input. It is sometimes called partial output elasticity to clarify that it refers to the change in

Table 1
Types of the Functional Forms and Their Marginal Product

Function name	Functional form	Marginal product ($\partial Y/\partial x_i$)
Cobb- Douglas	$Y = \alpha \prod_{i=1}^{n} x_i^{\beta i}$	$\alpha \ \beta_i x_i^{-1} \prod_{i=1}^{n} x_i^{\beta i}$
Transcendental	$Y = \alpha \prod_{i=1}^{n} x_i^{\beta} e^{\gamma_i x_i}$	$((\beta_i / x_i) + \gamma_i) * Y$
Translog	$Ln(Y) = \alpha + \sum_{i=1}^{n} \beta_i Ln(x_i) + 1/2 \sum_{i=1}^{n} Y_{ii} (Lnx_i)^2 + \sum_{i=1}^{n} \sum_{j=2}^{n} Y_{ii} (Lnx_i)(Lnx_j) \quad i \neq j$	$(\beta_i + \gamma_{ii} (\ln x_i) + \sum_{j=2}^{n} \gamma_{ij} (\ln x_j))(x_i / Y)$
Generalized Quadratic	$Y = \alpha + \sum_{i=1}^{n} \beta_i x_i + 1/2 \sum_{i=1}^{n} \gamma_{ii} (x_i)^2 + \sum_{i=1}^{n} \sum_{j=2}^{n} \gamma_{ij} (x_i)(x_j) \quad i \neq j$	$(\beta_i + \gamma_{ij} (x_i) + \sum_{j=2}^{n} \gamma_{ij} (x_j))$
Generalized Leontief	$Y = \alpha + \sum_{i=1}^{n} \beta_i (x_i)^{1/2} + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} (x_i)^{1/2} (x_j)^{1/2}$	$(1/2 \beta_i (x_i)^{-1/2} + 1/2 \sum_{j=1}^{n} \gamma_{ij} (x_i)^{-1/2} (x_j)^{1/2}$

Source: Samdeliri, 2013

only one input. The partial output elasticity to water input is formulated as:

$$E_w = \frac{\delta Y}{\delta w} \times \frac{w}{Y} = \frac{\delta Ln(Y)}{\delta Ln(w)} \quad (4)$$

In general, the functions used in production are divided into two general categories of inflexible functions such as linear function, constant elasticity of substitution function (CES), transcendental, Cobb-Douglas, Leontief and flexible functions such as translog, generalized quadratic and generalized Leontief (Ehsani et al., 2010). Mathematical equations of some of these functions are shown in Table 1 in which. Y is the quantity of output product, Xi is the amount of inputs used in a product, γ, β and α are the parameters of the model and Ln denotes the natural logarithm. To calculate the economic value of water in the agriculture sector using production function, with regard to the sample observations, the forms of Cobb-Douglas, Transcendental, Translog, Generalized Quadratic, and Generalized Leontief were used. The variables used in the functions include the amount of output in kg *(Y)*, the water use in m^3 *(W)*, the fertilizer in kg *(F)*, the pesticide in l *(P)*, the seed in kg *(S)*, the labour force in person-day *(L)*, and the use of machinery in hr *(M)*. After the estimation of these functional forms, the best form is selected according to the econometrics criteria. Finally, the economic value of water can be calculated by the relationships related to the value of marginal product as shown in Table 1.

To choose the preferred form of the production function out of the estimated functions, the econometric tests such as 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) were used.

The cost of water

Because of a great difference between the sale price of water and the cost of water obtained from engineering, economics methods, water use is made with low efficiency. Therefore, the pricing of water is essential as one of the main management tools of water demand (Mansouri & Qiasi, 2002). For a logic pricing, the cost of water and consumer purchasing power should be considered. Calculating the cost of water according to financial costs could be made by Cost Centers (such as reservoir, distribution, filtering, labor, material, utilities, fuel, machinery, and physical assets, depreciation, and maintenance) with their details. The process of calculating the cost of extracting water per m^3 is illustrated by Figure 1.

In this study, to estimate the cost of irrigation water per m^3 using the engineering economics methods, the value of initial and current investments would be first returned to present period with equation 5.

$$C = F_i /(1+ r)^t \quad (5)$$

In equation 5, C is the current value of the investment, F is the future value of the investment in period i, r is interest rate, and t is the periods. Next, the cost of water will be calculated in the selected MMPs with the equations 6 and 7.

$$P_W = \frac{(C_f .A)+C_v}{V} \quad (6)$$

In equation 6, P_w is the cost of water per m3, C_f is the present value of initial investment costs, C_v is the current annual costs (repair and maintenance, working capital, administrative and overhead costs), V is the water volume, and A the rate of return (Daneshvarkakhki, 2003).

The rate of return to discount the annual costs can be calculated by equation 7 in life periods (Oskoonejad, 2002).

$$A = C\left(\frac{r(1+r)^n}{(1+r)^n-1}\right) \quad (7)$$

In equation 7, A is the rate of return, C is the present value of investments, r is the interest rate, and n is the number of periods.

To estimate the economic value of water in the selected MMP_s, the sample size was determined by a pretest and the Cochran formula as shown in equation 8:

$$n = \frac{N(t.s)^2}{Nd^2 + (t.s)^2} \quad (8)$$

where, n is the number of farmers to be sampled, t is the value of the normal deviate corresponding to the desired confidence level, s is the standard deviation of the factor to be tested, d is the level of precision or the margin of error, and N is the population size (Cochran, 1997).

The statistical population of the present study to calculate the value of water included the farmers who grew rice in the area covered by the *MMPs* of *Siah Kola, Kapurchal, Ziarkola 1*, *Kaleh Ben,* and *Kharde Merd* in the Alborz project area in Mazandaran province. Because

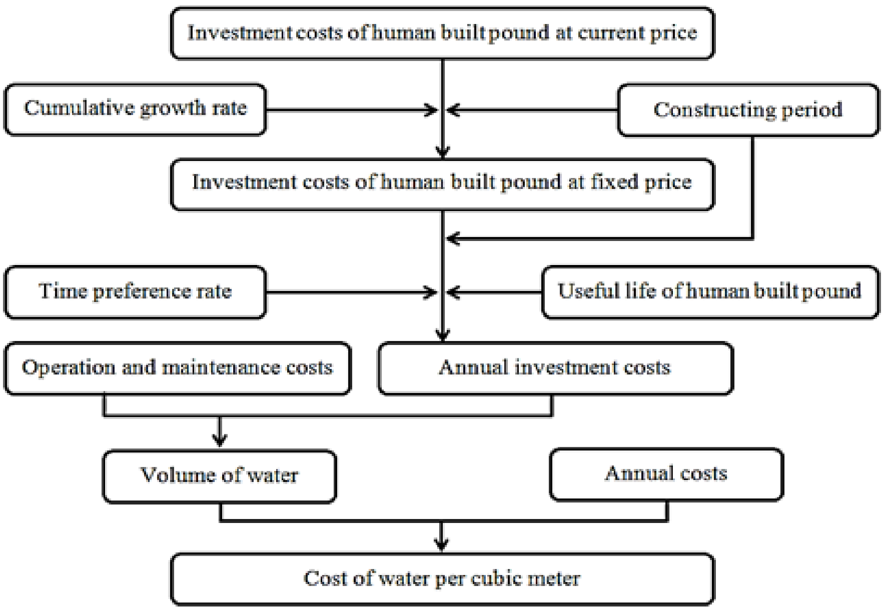

Figure 1. The process of calculating the cost of water per cubic meter
Adapted from (Mansouri & Qiasi, 2002)

rice constitutes about 100 percent of irrigated crops in the area covered by the MMPs, we extend the value of water in rice to total crops in the area.

The Alborz project area is around 62.5 thousand hectares that includes the area within Babol Rood, Talar Rood, and Siah Rood rivers. The agricultural water requirement in this area is supplied from both surface water and groundwater. Mazandaran province has 648 MMPs that cover more than 17 thousand hectares. From among them, 382 MMPs are in the Alborz project area (Yavarpour et al., 2010). Therefore, five MMPs located in the villages Kharde Merd in Babolsar, Siah Kola, Kapurchal in Babol, Kaleh Ben in Juibar, and Ziarkola in Ghaem Shahr for present study were selected. Because there were no MMPs that were recently constructed artificially in the Alborz project area, in this study the number of five MMPs were selected by two criteria: 1. dredged and improved, 2. in different areas of the Alborz project included four cities. Also, these MMPs are homogeneous about scale, high level and other physical details.

The required data of this paper were collected by a survey, interviews, and the databases, and also by consulting statistical centers in 2014. The questionnaires were filled out by farmers taken by simple stochastic sampling in 2013-2014 growing season. All calculations of the study were made in the Microsoft Excel 2010 and Eviews 8.

RESULTS AND DISCUSSION

The economic value of water

In order to choose the best functional form, the classical assumptions were investigated. Table 2 shows the results of investigating the existence of collinearity among the variables by the Principal components analysis. As it is noted, probing the correlation among the variables showed no multicollinearity problem. In this step, the best functional form was investigated. Hence, six production function forms for rice in the studied area were estimated. These are presented in Table 3.

The normality of residuals was investigated by the Jarque-Bera test statistic. In this respect, the normality of residual hypothesis in the Cobb-Douglas form was not accepted. Accordingly, the Cobb-Douglas form was unsuitable. Finally, from among the favorite production functions, the transcendental form was selected for calculating the economic value of water. Among other functions, the transcendental function was selected as the best functional form due to the greater number of significant coefficients (with

Table 2
The Results of Collinearity among the Variables Investigated By Principal Components Analysis

	IM	*IL*	*IS*	*IP*	*IF*	*IW*
IW	1					
IF	0.0127	1				
IP	-0.0585	-0.2462	1			
IS	0.2956	0.3457	-0.266	1		
IL	0.1368	0.3495	-0.0143	0.3395	1	
IM	-0.1736	0.2784	0.1354	0.2045	0.5002	1

Table 3
Comparison of the Estimated Production Function Forms for Rice Crop

Production function form	Total coefficient	Significant coefficients percent	JB	p-value
Cobb-Douglas	7	71.42	5.30	0.07
Transcendental	13	76.92	0.91	0.63
Translog	28	35.71	3.48	0.17
Generalized Quadratic	28	32.14	1.60	0.44
Generalized Leontief	28	46.42	1.03	0.59

Table 4
The Results of the Estimated Transcendental Production Function of Rice in the Selected Mmps

Variable		coefficients	t-statistic	p-value
constant		0.5046 **	2.0687	0.0436
logarithm of Water		1.7918 **	2.2467	0.0271
logarithm of Fertilizer		-0.0497 ***	-3.3445	0.0014
logarithm of Pesticide		-0.0366 **	-2.2576	0.0252
logarithm of Seed		0.1403 ***	2.7746	0.0067
logarithm of Labor		0.6539	0.2205	0.8260
logarithm of Machine		0.0238 *	1.7893	0.0769
Water		0.0000 *	1.9074	0.0527
Fertilizer		0.0007 ***	3.0434	0.0081
Pesticide		0.0045 **	2.1506	0.0368
Seed		0.0058 **	2.4261	0.0173
Labor		0.0142	0.3091	0.7579
Machine		-0.0053	-0.4343	0.6650
	$\bar{R}^2$ =	0.69	F =	37.744
	R2 =	0.71	Prob =	0.000

***p<0.01, **p<0.05 and * p<0. 1. Ab denotes abbreviation.

the suitable stability and autocorrelation tests).

Table 4 shows the results of the estimation of the transcendental model for rice crop in the paddy farmlands. According to Table 4, the model has the sufficient significant coefficients and the goodness of fit test was confirmed. Table 5 summarizes 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. With regard to Table 5, the null hypothesis of three tests was not rejected. Hence, the transcendental functional form was selected as the best functional forms.

It means that based on the goodness of fit tests, the model did not have serial correlation and heteroscedasticity among residuals. After estimation of the suitable production function, the economic value of water using the value of marginal product of water was calculated. Therefore, the economic value of water in the paddy farmlands covered by the selected MMPs was obtained as 19,065 IRR per m3.

$$MP_w=((\frac{\alpha_1}{W})+\alpha_7)Y=((\frac{1.791802}{10692.77})+0.000014)3500=0.6355$$

$$VMP_w=P_y\,.MP_w=30000\times0.507=19065$$

The comparison of the value of water estimated by this research showed that it had a large difference with the paid water fees by the farmers established by the Regional Water Company in the Alborz project area in 2014 which was 348 IRR in modern network and 232 IRR in semi-modern network per m3.

It is consistent with the studies that show the obtained economic value of water is more than the amount of Regional Water Company. For

Table 5
The Results of the Stability, Serial Correlation, and Variance Heteroscedasticity

test / statistic	Ramsey's RESET test	LM test	White test
F-Statistic	0.380	0.979	1.186
Probe	0.539	0.379	0.273

Table 6
The Results of the Updated Costs (IRR) of the Selected Mmps In 2014

MMP name	Investment costs	Maintenance costs	Updated investment costs	
			12% interest rate	22% interest rate
Kharde Merd	347529836.1	200000000	768277747.2	1398012035
Siah Kola	367261866.7	10000000	811898980.4	1477388289
Kapurchal	290974230.6	70000000	643251321.6	1170505189
Kaleh Ben	555765384	30000000	1228620201	2235683429
Ziarkola 1	269773961	50000000	596384279.8	1085222635

Table 7
The Estimated Cost of Water per M3 in the Selected Mmps

MMP	Ziarkola 1		Kaleh Ben		Kapurchal		Siah Kola		Kharde Merd	
	Interest rate									
Parameters	12%	22%	12%	22%	12%	22%	12%	22%	12%	22%
C_F	596	1085	1228	2236	643	1170	812	1477	768	1398
C_V	50	50	30	30	70	70	10	10	200	200
A	0.147	0.232	0.147	0.232	0.147	0.232	0.147	0.232	0.147	0.232
$EUAC$	87	251	180	518	94	271	12	342	113	324
V	225000	225000	720000	720000	280000	280000	625000	625000	1150000	1150000
n	15	15	15	15	15	15	15	15	15	15
P_w	611	1340	292	761	587	1219	207	564	272	456

Note: C_F, C_V, A, $EUAC$, V, n and P_w denote updated investment costs, cost of operation and maintenance, annual uniform cost, volume of dewatering, life of MMP and cost of water per one m^3, respectively.

example, the value of water 3864 IRR in Samdeliri (2013) for rice, 1607 in Rezaei (2014) 997.5 in Dehqanpour and Sheykhzeynodin (2013), 5886 in Samdeliri (2013) and 336 in Hassanpour et al. (2014) for wheat, 1173 in Rezaei (2014), 2445 in Samdeliri (2013) 703.1, 1343.67 and 112.67 IRR in Hayati et al. (2009) in North, Razavi and South Khorasan provinces, respectively, for barley and 847 IRR in Ehsani et al. (2010) for corn.

The difference in the estimated value of water of these studies may be because of the difference in the crop species, location, or studied period.

The cost of water

To determine the cost of water in the selected MMPs, the cost of water in each of the five MMPs was separately calculated at first. Then, the cost of water was estimated as the average of the prices for the whole region at interest rates of 22% (Central Bank of Iran) and 12% (Mazandaran Regional Water Company). The investment cost in these MMPs based on the dredging and improving costs made by Mazandaran Agricultural Jihad in 2007 were considered. At present, there is no MMP that is completely made by the Agricultural Jihad Organization or Regional Water Company in the scope of the Alborz project area. The MMPs in this area were there in the past and there are no cost data for them. Therefore, in the calculation of water cost, the investment costs are considered in terms of the costs of dredging and improvement of basins.

According to data of the costs, the amount of water, the life of the MMPs, rate of return, annual uniform costs and using equation (6), the cost of water per m3 for each of the selected MMPs was estimated in 2014 as summarized in Table 7 in which. CF is updated investment costs (million IRR), CV is cost of operation and maintenance (million IRR), A is rate of return, EUAC is annual uniform cost (million IRR), V is volume dewatering of the MMPs (m^3), n is life, and Pw is the cost of water per one m^3 (IRR).

According to Table 7, the cost per m^3 of water at Kharde Merd, Siah Kola, Kapurchal, Kaleh Ben and Ziarkola MMPs at an interest rate of 22% (Central Bank) were estimated at

Table 8
The Estimated Cost of Water per M in the Selected Mmps in Alborz Project Area

MMP name	County	Cost of water per m³ (IRR)	
		12% interest rate	22% interest rate
Kharde Merd	Babolsar	272	456
Siah Kola	Babol	207	564
Kapurchal	Babol	587	1219
Kaleh Ben	Joibar	292	761
Ziarkola 1	Gha'emshahr	611	1340
Average	selected MMPs	393.8	868

456, 564, 1219 and 741 IRR, respectively, and at an interest rate of 12% (Regional Water Company) at 272, 207, 587, 292 and 611 IRR, respectively, in 2014. To determine the cost of irrigated water per one m^3 for the whole area, the average sum of the cost of water for each MMP was obtained.

As Table 8 shows, the cost of water per m3 at the selected MMPs in the Alborz project area was 868 IRR at an interest rate of 22% (Central Bank) and 394 IRR at an interest rate of 12% (Regional Water Company).

Comparing the cost of water in the MMPs with irrigation fee implemented by the Regional Water Company in the area in 2014 demonstrated that the estimated water price was more than the current price of 348 IRR at modern network and 232 IRR at semi-modern network.

Based on the results, cover percentage of the cost of providing water by irrigation fee paid by farmers in the selected MMPs at the interest rate of 22% was 40.09 percent for modern networks and were 26.73 for semi-modern networks. It was 88.32 and 58.88% for modern and semi-modern networks at an interest rate of 12%, respectively. Therefore, the irrigation fees paid by farmers now compensate only for a fraction of the cost of water supply in the Alborz project area.

This result is in agreement with those of the studies conducted by Hassanpour et al. (2014), Dehqanpour and Sheykhzeynodin (2013), Rahmani and Ansari (2012), Asadi et al. (2013; 2007) and Mansouri and Qiasi (2002). In addition, comparing the cost of water and its economic value in the selected MMPs with irrigating fees paid by farmers reveals that the economic value of water is more than the cost of water and both of them are more than the irrigating fees paid by farmers.

CONCLUSION

Given the crucial role of water in sustainable development, it is inevitable of planning and management of water resources to make balance between water supply and demand. Because of the increasing need for water resources and various uses, water demand management has become more complex. Accordingly, proper water pricing is one of the effective ways to manage water use. Due to the importance of irrigating water in the northern regions of Iran and limitations of this valuable resource, the issue of pricing and determining the irrigation fee in agriculture has a great importance.

This study has made an attempt to determine the cost of water and its economic value in farmlands covered by the selected MMPs in the scope of the Alborz project area. Comparing the cost of water and its economic value in the selected MMPs with irrigating fees paid by farmers showed that the economic value of water was greater than the cost of water and both of them were bigger than the irrigating fees paid by farmers.

Therefore, the current state and the existing gap between the real price and the price paid by farmers results in the lack of saving and low water use efficiency.

In this context, some suggestions are offered for improving the pricing system to achieve water protection:

To achieve the sustainable development in agriculture and reasonable use of water, irrigation fee should be determined in proportion with the economic value of water.

Since the value of marginal product of water is higher than its cost, water use is unreasonable. Therefore, water pricing should be based on the actual price of water. Yet, a sudden increase in the price of water affects the crop production; the implementation of this policy should be long-term and gradual.

Since one of the factors discouraging private sector to invest in the water industry is low water prices, it is recommended to take actions to form water market and realize the value of water as a motive for the private sector.

It does not suffice to price water merely in terms of real price, but rather, the profits gained from farmers through water prices should be invested on the improvement of agricultural water resources and water resources management.

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