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VALUATION OF GROUNDWATER EXPLOITATION OF AGRICULTURAL CASE STUDY OF WHEAT FARMERS IN KHATAM CITY

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Abstract:

Country with an annual average rainfall of 250 mm is faced with the problem of dehydration and non-uniform distribution of water resources. Scarcity of water on the one hand, and the enormous costs on the other hand, is considered productivity and economic value of water as one of the most important national goal. Consumption of Water in agricultural sector includes about 90 percent of the country´s water consumption, so the economic value of water in agriculture is one of the most important priorities in water resources management.

In this study the economic value of water by considering methods of calculate, methods based on basic function of social welfare witch economic value of water for production of Wheat in Yazd (Heart - khatam) was analyzed required data and information is collected from 100 questionnaires using two-stage cluster sampling in 1387. For estimation of functions is used from Eviews5 software.

The results show decreasing scale in the region. Also marginal production of factors so that water, labor and pesticides evaluated respectively 1.4, 65 and 1113 kg per unit. Producers are willing to sacrifice to 0.228 unit of labor (or sacrifice to 0.0067 unit of pesticides). Marginal production-factor price ration for water, labor and pesticides are 0.0049, 0.0005 and 0.0159 respectively.

Actual results (economic) value of water is 12,593 Rials witch difference significantly with current value (277.4 Rials) in region that leading to excessive withdrawal of groundwater water in region. The shadow price of labor and pesticides are 604,500 and 10,350,900 Rials respectively. Price and income elasticity of water derived demand are 15.33 and 45.329 respectively.

JEL Classifications : C13, C20, D21, Q11, Q25, Q34.

Key words: *Cobb Douglas production function, economic value, efficiency to scale, demand elasticity, Yazd province, Khatam-Heart.*

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INTRODUCTION:

Given that the farmers have common groundwater resources, the goal of each farmer is to achieve maximum profits. Therefore, each person uses the input of water to a degree where the value of the final production of each unit of water in its activity is equal to the final cost of each unit. It does not consider its excessive use of groundwater resources. Therefore, the low cost of using each water unit and ignoring the negative effect of excessive withdrawal has caused a dramatic decrease in groundwater levels in the studied area and significantly reduced social welfare.Chucktorunio Amesta (2003) used a spatial model and a dynamic planning approach to assess water resource management practices. In this model, the present value of the resulting benefits of agriculture is minus the cost of its was maximized that at the end of the separation of farmers into two groups and moving towards the applied technology for use of water , a better management was applied too. Chandrou and Christo (2006), using the Dynamic Planning Model, for the scarcity of groundwater resources in the Kyoto Region of Cyprus, investigated the results. The results showed that if an explicit margin for extraction is considered, the importance of using the optimal control management method decreases Esteban and Albiak (2011) investigated the relationship between groundwater abstraction and ecosystem damage. In this research, a dynamic programming model was used. The results showed that if not taking into account the effects of extraction and environmental impacts, the Gieser-Sanchez effect is verified but taking into account the external effects of these two, the different results is obtained. Therefore, it is suggested that the method of intervention in the water market must be used. Faifer Woolin (2012) explores the external effects of extraction on agriculture in a Chinese region. In this study, farmers' behavior in exploitation of the aquifer was investigated. In this case, the extraction of a farmer's water from underground water could have effects on his closest neighbors; these external influences will lead to welfare losses. The results showed that 2.5% of the extraction was from the western Kansas aquifer per year due to the neutralization of exterior extractive impacts imposed on the farmer by exploitation. According to the previous internal and external studies for groundwater management analysis, this study calculated the actual value of each unit (cubic meter) of water consumed in the agricultural sector and calculating the total negative effect of excess water extraction from the groundwater resources of the study area in the context of appropriate harvesting policies and conservation of groundwater resources is necessary.

MATERIALS AND METHODS:

Empirical pattern

A method based on social welfare function

In this method, the effect of groundwater consumption of farmers is measured on social welfare.

If i (i = 1,2, .., n) of the product is produced using groundwater, then for the production of Y_i ,the product *i*th will need a certain amount of water (W_i) and other inputs

($X_{ij}; j = 1,2,...,m$).

In order to link farmers' net income and groundwater level, we assume that the water available to farmers depends on groundwater level (R) .

If we show the production function as follows:

$$Y_i = Y_i\lfloor X_{i1}, X_{i2},..., X_{ij}, W_i(R)\rfloor \quad (1)$$

And the cost function for the above function is considered as follows:

$$C_i = C_x.X_{ij} + C_w(R).W_i \quad (2)$$

In the above function, C_i shows the minimum cost that will be generated for producing a certain amount of product using production inputs.

C_w is a function of increasing growth relative to the groundwater level (R) that is, if we derive from the function relative to R $C'_w \succ 0, C''_w \succ 0$:

If for product I , the inverse function of the request is considered as below:

$$P_i = P_i(Y_i) \quad (3)$$

Which in the above function P_i represents the market price of the product, in addition , the price of inputs consumed during the period of production of the product is considered constant.

If S_i shows the social welfare, that is created from a certain amount of production, then it is possible to use the space below the demand curve from which input costs are deducted, the social welfare to be calculated, whose function is shown below:

(4)

$$S_i = S_i\left[X_{i1}, X_{i2}, ..., X_{ij}, W_i(R); C_w(R)\right] = \int P_i(u)du - C_x X_j - C_w(R)W_i$$

By maximizing the above function, we can obtain the optimal value of generated inputs using :the following functions

(5)

$$\frac{\delta S_i}{\delta X_{ij}} = P_i(Y_i)\frac{\delta Y_i}{\delta X_{ij}} - C_{xj} = 0$$

(6)

$$\frac{\delta S_i}{\delta W_i} = P_i(Y_i)\frac{\delta Y_i}{\delta W_i} - C_w(R) = 0$$

Functions (5) and (6) show that when social efficiency occurs that the final output value of each input is equal to the regarded input price but when the above equations are true. Each farmer is the price receiver and is not involved in determining the price of the market, which is considered as a hypothesis in this study.With the assumption that the input and product prices remain unchanged during the study period, the decline in groundwater level has a negative effect on the welfare of the community. According to the function number (4) and using the theory of the coverage of the effect of groundwater drainage on the community **welfare** is shown in the following function:

(7)

$$\frac{\delta S_i}{\delta R} = \left(P_i(Y_i)\frac{\delta Y_i}{\delta w_i} - C_w\right)\left(\frac{\delta W_i}{\delta C_w}\frac{\delta C_w}{\delta R} + \frac{\delta W_i}{\delta R}\right) - W_i^*\left(\frac{\delta C_w}{\delta R}\right)$$

The changes in groundwater levels in different ways affect the welfare of the community which include:

A. The change in the final cost of water extraction changes the total cost of water extraction $\left(W_i^*\left(\delta C_w/\delta R\right)\right)$.

B: the changes in groundwater level affect the final cost of extraction and indirectly affect the extraction of water $\left(\left(\delta W_i/\ \delta C_w\right)\left(\delta C_w/\ \delta R\right)\right)$.

C- Groundwater level directly affects the amount of water extraction.

D: the changes in groundwater level affect the final production value of water inputs in the crop production.

Taking into account these two assumptions that firstly the production of all farmers is on the same production function and secondly all farmers are the price receivers, If K of farmer produces a quantity of product I using a water input W_{ik} then if the groundwater level is reduced from R_0 (the initial level of water) to R_1 (the secondary level of water), the change in social welfare is calculated using the formula given below :

(8)

$$\Delta S_i = \sum_{k=1}^{k}\frac{\Delta S_{ik}}{dR} = \sum_{k=1}^{k}\int_{R_0}^{R_1}\left[\left(P_i(Y_i)\frac{\delta Y_{ik}}{\delta W_k} - Cw_k\right)\times\left(\frac{\delta W_{ik}}{\delta Cw_k}\frac{\delta Cw_k}{\delta R} + \frac{\delta W_{ik}}{\delta R}\right) - W_{ik}^*\left(\frac{\delta Cw_k}{\delta R}\right)\right]dR$$

To use the function (8), we must calculate the production function and the cost function of extracting water from underground resources.

Model Estimation

In the *Cobb–Douglas* function, if you can have different inputs such as L, P, W then the independent and dependent variables of the model are:

Q: the yield of wheat (tons per hectare)

W: the water consumption per hectare (One thousand m3 per hectare)

P: the pesticides used by farmers in the production of wheat (kg) and

L: The amount of labor employed per hectare (person per day).

Using the data collected in the study area, the wheat production function was estimated with the assumption that the farmer always works logically, the results of which are shown in Table (1).

Table 1: The Estimated Coefficients of Wheat Production Function in Khatam city of Yazd

variables	Production function coefficients	Standard error
C	-1.875	0.685*
Log(W)	0.338	0.088*
Log(P)	0.384	0.161**
Log(L)	0.232	0.075*
AR(1)	0.363	0.122*
$D.W = 1.905$	$\overline{R}^2 = 0.8196$	$R^2 = 0.829$
	$\Pr ob(F\_statistic) = 0.000$	$F\_statistic = 83.9198$

. Reference: Findings of the research
. Significance at 1% level : *
. Significance at 5% level : * *

The estimated results show that the explanatory variables W and P can explain 82% of the variations of dependent variable Q. According to the F test, the estimate is significant and acceptable.

Examining the OLS assumptions:
We consider the homogeneity hypothesis of a class of a *Cobb-Douglas* production function and also the zero-assumption of all coefficients using the parent test. The test outputs indicate that the limits imposed are not correct.

Normal test
This test shows the histogram of waste sentences along with descriptive statistics of waste sentences in a box.

The Jargu-Bera statistic is used to test the normality of waste sentences. Since the histogram of the estimated equation is bell-shaped and the Jargu-Bera statistics are not significant, it can be concluded that its waste sentences are normally distributed.

Another classic assumption of linear regression is that there is no linear relationship between the explanatory variables in the model. Studies have shown that the coherence is not severe between the independent variables

- Auto-correlation
Whenever there is a possibility of self-correlation in waste sentences then the use of the LM test is preferable to the Durbin–*Watson* statistic.

According to F statistics and the significance level of the test, one can conclude that the zero hypothesis (the lack of serial correlation to the interruption 2) is accepted, therefore there is no auto-correlation between the equations' residue sentences.

- Inequality of variance
Another classic assumption of linear regression model is that the variance of waste sentences is the same.

To determine the existence or non-existence of heterogeneity of variance the anchor test of the ARCH-LM test is used.

The final significance level of the F test indicates that the hypothesis is zero (the absence of a variance inequality of the conditional self .explanatory type)

Therefore, there is no conditional explanation between waste sentences in the form of heterogeneous variance.

RESULTS AND DISCUSSION

Using the results of Table (1) and also the features of the Cobb-Douglas function, the following results are obtained:

- The final production of inputs is always positive, and as a result, only the second production region exists.

- Inputs are technical complementary to each other.
- The substitutional extension of the inputs of the function estimated is equal to one.
- The aggregate extension of the operating factors is smaller than one, and as a result there is a maximum profit point.

- No maximum production point.
- The law of declining final yield is always there.
- The yield on its scale is constant to 0.9533, which means that with n equalizing the productive inputs of the produced product is less than n.
- The final production of inputs used by farmers in the region to produce wheat averagely is 1.4 and 65 and 1113 respectively for water inputs (cubic meter) labor (person per working days) and pesticide consumption (kilograms) respectively.

The final rate of technical substitution of other inputs instead of water or $MRTS_{k,w}$ that k representing other inputs and is the rate at which the producer or farmer is willing to lose a certain amount of water to obtain a unit higher than the other inputs to maintain a constant level of production levels.

Table 2 shows the values of this rate

Table 2: The final rate of technical substitution of other inputs instead of water in the estimated production function of the region.

Production factor	pesticides	water	labor
Production of the last unit spent on production factors	0.0159	0.0049	0.0005
Reference : results of research			

Using the estimated production function and the inputs price, we can calculate the production of the last unit spent on the cultivating factors , chemical fertilizers, seeds water and labor. To obtain these results we use the following equation:

$$\beta = \frac{MpK}{r_k} = \frac{\alpha_i.Q}{r_k.K} \qquad (9)$$

In which:

β: the production of the last unit spent on production factors

MpK : the final production of inputs

α_i: the input coefficient in the estimated production function

K: Types of inputs and

r_k : The market price of inputs.

Table 3: the production of the last unit spent on the production factors

Alternative input	labor	pesticides
Final rate of technical substitution of other inputs instead of water	0.228	0.0067
Reference : results of research		

The following results were obtained by comparing the production of the last monetary unit spent on water with the production of the last monetary unit spent on non-water production factors.

- Region producers in order to increase the .production should use less labor and more water

Because $\frac{MpW}{r_w} = 0.0049 \succ \frac{MpL}{r_{**}} = 0.0005$ and the producer must use the input of the workforce which results in two equal relationships in order to maximize the use of inputs and maximize its profit.

- Producers in the area need to use less water .and pesticides to grow their production

Because $\frac{MpW}{r_w} = 0.0049 \prec \frac{MpP}{r_{**}} = 0.0159$ and the producer should use some of the plant pesticide inputs which results of in two equations to be equal to maximize the use of inputs and maximize their profits.

In Khatam city, the farmers buy water at a certain amount each year which is determined by members of the board of directors and the water used by farmers is like other inputs which adds to this water cost every year.

All farmers who own and who don’t own , use the natural water of wells and pay for the water.

At the end of the year, the costs of repairs, maintenance, electricity, irrigation and other costs related to well water will be compensated. The surplus of wells income will be paid in profit and in proportion to the ownership of the Therefore, in this city, direct payment .stockholders of water is not paid by the farmer, and it is not necessarily the owners of water wells who are not the farmers and consumers of water. Therefore, in this city, the cost of extraction of water, which is a function of the depth of the well, is directly involved with the farmers and wheat producers of this city. The main objectives of this research are to calculate the economic value of each water unit To this end if the economic .in wheat cultivation value of water is equal to its final production value based on the significant variables in the production

$$S_i = S_i\left[X_{i1}, X_{i2}, \ldots, X_{ij}, W_i, (R), C_w(R)\right] = \int P_i(u)\,du - C_j X_{ij} - C_w(R) W_i$$

function (Table 1), the final production value for each farmer is obtained from the following function:

$$VMP = P_y\left(\frac{\delta\left(AW^{0.338}P^{0.232}L^{0.384}\right)}{\delta W}\right) = P_y \times 0.338 \times \frac{Y}{W}$$

(10)

Equation (4-6) is the final result of performing mathematical operations on the social welfare function.(11)

(11)

By deriving a partial derivative of equation (6-6) to W_i, the we obtain the equation (12)

(12)

$$\frac{\delta S_i}{\delta W_i} = P_i(Y_i)\frac{\delta Y_i}{\delta W_i} - C_w(R) = 0$$

Due to the type of ownership and operation of the wells in the study area, the value of the $C_w(R)$ parameter in the equation (12) is zero. As a result , the finalized model is the simplified .(10) model

In the equation (10):

VMP: The value of the final production

P_y: the prices of wheat producers (Rials per ton)

W: The amount of water consumed per hectare (one thousand m3).

(13)

By placing the results of Table (6-1) in (6-4) we have:

(13)

Considering the fact that wheat farmers in the region in addition to the income from the sale of wheat also earn money from the sale of wheat straw and considering that one of the ineligible items of wheat production is also a straw product, in this research P_y is calculated from the following index and has been replaced:

(14)

$$P_y = \sum_{i=1}^{79} P_{yi} \quad , \quad P_{yi} = \frac{\left(\left(Y_i \times P_1\right) + \left(Y_i^{\,0} \times P_2\right)\right)}{Y_i}$$

in this equation : $VMP = P_y.\left(\frac{\delta Y}{\delta W}\right)$

P_{yi}: The price of one ton of the *i*th farmer's product

Y_i :Production rate per ton of *i*th farmer's wheat

P_1 :The price per ton of wheat produced in 2009 equal to 4200000 Rials

Y_i^{0} : The amount of wheat straw of the *i*th farmer per ton

P_2 :The average price per ton of wheat straw has been equal to 850000 Rials for 2008.

Using statistics collected through questionnaires and by placing them in the equations (13) and (14), the final production value of each farmer and the price of the product of each farmer and the farmers' community were calculated. Table (3): Price information for sampled farmers' products (Rials)

Average price of farmers products P_y	Maximum price of product ($Max(P_{yi})$)	Minimum price of ($Min(P_{yi})$)product	Product Price Variance $Var(P_{yi})$
9300	9300	9300	0
Reference : results of research			

Table (4): Information on the final production value of sample farmers

Average value of final water production (m3 / Rls)	Maximum value of final water production (m3 / Rls)	Minimum final value of water production (m3 / Rls)
12593	43658	0.4082
Reference : results of research		

According to the data of Tables (3) and (4) , it can be concluded that the average value of each cubic meter of water for wheat growers in Khatam city was 12593 Rials .Also, by comparing the value of the final production value of water with the price of water purchased by the farmer in the region, which is equal to 277.8 Rials per cubic meter of water, It is clear that more water is used by farmers in the area considered as an efficient state and farmers should consume more water to comply with the profit maximization law. On the other hand, the authorities should close the price of each cubic meter of water to the real value of water or its economic value in order to maintain groundwater resources. Using the collected data, the value of water used by farmers in the area was calculated per cubic meter.

According to these results, the selling price per cubic meter of water in Khatam city of Yazd is on average 277.4 Rials.

Calculation of the shadow price of other inputs used in the area:

Using the estimated production function of Table (1) and the results of Table (3), we can obtain the shadow price of other inputs. Table 5 shows these results.

Table (5): Information on the value of the final production of other inputs from sample farmers

Production factor	labor	pesticides
The average value of the final production of the production factor or the shadow price of the production factor (Rials)	604500	10350900
Reference : results of research		

The results of the table indicate that the daily labor force employed by a farmer to produce wheat in the studied area has a value of over 600000 rials and the price of one kilogram of plant pesticide is 10 million rials.Consequently, the market prices of the inputs are much lower and include subsidies, without any consideration for their production opportunity costs provided to manufacturers, which requires adjustments to be made.

- By comparing the average values of the final production value of the agricultural labor force (604500 Rials) with its market price (130000 Rials), it is clear that more efficient workforces are profitable for farmers in the area.

- By comparing the average value of the final production value of the pesticides (10350900 Rials) with its market price (70000 Rials), it is found that more pesticides are beneficial for farmers in the area.

Another purpose of this study is to calculate the demand for water supply, which can be calculated based on the following equation:

(15)

$$\varepsilon_D = \frac{\partial W}{\partial r_w} \cdot \frac{r_w}{W}$$

But, before calculating the tensile values for each farmer, we first need to extract the water demand equation of farmers in the area. Therefore, using equation (9) and equating this equation with r_w and following the equation (13):

(16)

$$VMP = P_y\left(\frac{\delta\left(AW^{0.338}P^{0.232}L^{0.384}\right)}{\delta W}\right) = P_y \times 0.338 \times \frac{Y}{W} = r_k$$

By sorting the left side of the equation based on W (the water demand function of the farmers in the region) is extracted.

(17)

$$W_i = 0.338.P_{yi}.Y_i.r_{wi}^{-1}$$

The index i in the equation (17), represents the farmers of the region.

It is obtained from equation (17) that the demand has an inverse effect with water price (r_w)and non-conforming effect with the income of each farmer (the product of the multiplication is equal to the farmer's income from the acquisition) which the equation 17 can be written as below (multiplying of $P_{yi}.Y_i$ is equal to the Farmers' Acquired income from wheat farming) :

(18)

$$W_i = 0.338.I_i.r_{wi}^{-1}$$

In this regard, I_i is as the income earned by each farmer by the result of wheat production. Now, using the extracted demand function and using the equation (15), the price and income elasticity of the input of water were calculated.

Table (6): Earnings and price elasticity of sample farmers

Type of demand elasticity	Maximum values	Minimum quantities	Average amounts	Variance of values
Demand price elasticity	159.415	0.0005	15.33	33.12
Demand income elasticity	471.47	0.00147	45.329	112.2
Reference : results of research				

The results show that in the study area, the input of water is tensile and is considered as a luxury goods also for each percentage point increase in water prices and farmers' income , the demand for water decreases and increases by 15.33% and 45.33% respectively.

Suggestions

1. It is necessary for the farmers of the region to use new production techniques to solve the problem of declining returns to the scale of the region.

2-Since the final production of plant and animal pesticides is very high, farmers need to increase the use of this input to the extent that the environment is less damaged and the losses caused by the pests damages and insects is minimized.

3- Among the two inputs of labor and pesticides, it is better to replace the pesticides by the farmers but since the final rate of technical replacement of both inputs instead of water is less than one unit then replacing them with water will be easier and more convenient.

4- It is necessary to promote the principles of economic production and new production techniques by agricultural promoters in the region and to educate and invest in promoting it.

5 . It is suggested that because the water resources are not available for the generation alone, then the government will take appropriate measures to maintain the resources of the wells in order to maintain both the resources and the minimum level of previous production.

6- According to the results of the production of the last unit spent on the production factors of the region , it is necessary that the farmers of the region have less labor and more pesticides than the plant pests.

6. It is necessary to bring the delivery price per cubic meter of water to the value of 12593 Rials per cubic meter and on the other hand, new irrigation methods will be used in the area.

7- It is suggested that the cost of pesticide inputs and free labor will be closer to the cost of the economy.

8-the increased water prices have an important role in reducing its consumption but it is also necessary to control farmers' incomes and to implement non-price policies such as incentive policies to use new methods of irrigation.

9- Disadvantages of over-harvesting of groundwater resources for regional farmers to be informed from technical perspectives and sustainable development.

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