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The Role of Water Market in Determining the Economic Value of Agricultural Water (Case study: Qarveh-Dehgolan plain)

Hamed Ghaderzadeh[1], Samira Shayanmehr*[2]

1. Faculty members ofagriculturaleconomics, Department of Agricultural Economics, Kurdistan, University, Kurdistan, Iran.
2. MSc student of agricultural economics, Kurdistan, University, Kurdistan, Iran.

***Samira_shayanmehr@yahoo.com**

Abstract—inthis study, positive mathematical programming method and the maximum entropy are used in order to estimate water demand of Qarveh-Dehgolan plain and the amount of water supply have been calculated with regard to the sum of different sources of water, such as wells, rivers and canals. Therefore from the confluence of the function of water supply and demand, equilibrium price of input water has been estimated. Results demonstrate that there is a negative relation between demand value and water price and tension of water demand is calculated, that is about -0.16. Furthermore, equilibrium price of input water per every cubic meter is 970 rails.

Keywords—Economic value of water, positive mathematical programming, maximum entropy, water market, Qarveh-Dehgolan plain.

I. INTRODUCTION

Water is one of the most valuable natural resources, the common treasure of humanbeings that is a demand of other parts and as one of the most important input of agricultural production has a great position in development of agricultural and economic parts and others. By increasing of the population and on the other hand providing of freshwater resources leads challenge and competition to appear among other parts and regions who consume water. So that some believe that significantly the welfare of the world's population in the near future will depend on sustainable exploitation of groundwater and surface water resources.In the country within the past few years for various reasons, such as indiscriminate and irrational exploitation of available water resources, particularly groundwater,reveal problems such as drought and lack of water resources protection principals, some of the country's water resources are destroyed or are exposed to extinction.

The main issue in the economic management of water resources in each country and region is to establish a balance between water supply and demand. That,the establishment of equilibrium prices and economic value of water as the price of commodities and other factors play a decisive role , if the price is right, it is expected a lot of problems to be resolved in water resources management. In this regard, reform of pricing water system can be one of the most efficient management tools to more optimal allocation between different activities and can help in increasing the productivity of these inputs.

Qarveh-Dehgolan plain is placed in the west of Iran, in dry continental-semiarid zone and the high

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percentage of its water resources needed by plain, supply through ground water resources. In this area, ground water resources had been the most important resource of agricultural water supply, that over 80% of water supply of agriculture is supplied by ground water resources of Qarveh-Dehgolan plain and main aquifer of plain. In recent years, due to the expansion of the cultivation of corps with higher water requirements and immethodical harvesting, water levels in this plain have been reduced intensively, and water ground resources are seriously facing with destruction. In this period, several attempts by the local policy- making have taken place in order to severe discharge of water ground resources but the result was not efficient, and the continuation of immethodical exploitation of water ground resources leads to overly drop of aquifer surface in the last two decades. The main purpose of this paper is determining economic value of irrigation water as an efficient tool in exploitation and protection of ground water of Qarveh-Dehgolan plain usingpositive mathematical programming model.

Ehsani and others (2011), in a study, estimate the economic value of Qazvin watering network. The purpose of this study, is determining the economic value of agricultural water from the viewpoint of applicant using production function approach andmarginal cost function in the lands covered by Qazvin watering network for wheat in cultivation years 1386-87. According to results, economic value of water input production function approach, and cost functions are estimated 586 and 609 rails per each cubic meter, respectively.

Dashti and others(2010) with the purpose of estimating economic value of water in production of wheat crops in the city of Damghan with estimating flexible functions and performing econometric tests in extended extreme quadratic function, as a best selected function, estimated the economic value of water 403/20 rails. According to the results of this paper, the value of the marginal product of water is more than common value.

Ahmadpour and Sabouhi (2009) in a study evaluated the economic water installation of Jam one of the suburbs of Kangan city placed in the south of Boushehr province. Final price for each cubic meter, in flood irrigation and drip irrigation systems are calculated 93.84 and 63.13 rails, respectively, and by using linear programming method accompanied by risk, in calculating shadow price of water, they showed that depending on high or low degree of risk taking, the efficiency of extra water per cubic meter, is in a expanded extent 6.93 to 2010 rials.

Sigraves and Easter(1983) refer to irrigation water pricing in developing countries stated that water regulation in most of these countries depend on the role of water pricing and receive it from beneficiary in order to compensate exploitation costs and protection and probably a part of the capital cost of this project. They showed that farmers pay only 29% of the total water exploitation, and the most important purpose of pricing water system are equalizing water distribution and making competence in irrigation.

McGrigor and others (2000) in an article entitled estimate the economic value of water in Namibia using the analysis method of rest value, estimate the value of the marginal product of agricultural water and described that the economic performance of surveyed farms were poor. Finally estimated the economic value of water for each cubic meter 0.64 dollars.

Medlin Azura and others (2010), by using positive mathematical programming reviewed the effect of spatial aggregation on irrigation water pricing in the north of Mexico four variation scenarios, such as changes in hot and dry weather, changes in prices of agricultural commodities and changes in water and agricultural prices. Results show that the economic value of farm level and concentrated areas are similar.

II. PROCEDURE MATERIALS AND PROCEDURES

Therefore, by using the PMP model with change of water price, rate of demand have been extracted according to the optimal crop pattern and with given rate of water demand and the price of water input, water input demand functions are estimated according to different forms of function, such as linear, logarithmic, linear-logarithmic and logarithmic-linear that are shown in table 1.

ISSN (Online): 2305-0225
Issue 11(3), April 2014, pp. 296-302

Table 1- functional form of demand and the calculating method of the price elasticity of demand

Function	Functional form	Calculating method of the price elasticity of demand
Linear	Qw=a.Pw+b	e= a(Pw/Qw)
Logarithmic	Ln(Qw)=a.Ln(Pw)+b	e=a
Linear-semi logarithmic	Qw=a.Ln(Pw)+b	e=a(1/Qw)
Logarithmic-linear	Ln(Qw)=a.Pw+b	e= a.Pw

Equilibrium price of water inputin the marketpricesetata levelthatthe total demand forwateris equal tobalance of existing water. So, with theequalityof supply and demand, equilibrium price is obtained, and then is focused on evaluation of the impact of equilibrium price on labor force demand, rate of fertilizer consumption, chemical pesticides, water and machinery.

Positive mathematical programming (PMP):

Since one of the policy maker and planner aims in agriculture is awareness of different policy implementation consequences and farmer responses therefore they are looking for modules which can ensure to make this goal achievable. Conventional methods for simulating producers decision is to create a module which reflects current situation constraints, opportunities and objectives and then be solved with the assumptions result of policy implementation. This method as most commonapplicable method for calibrating a mathematical programming modelis applied for a three-step program planning:

At the first stage, calibration limits will be added to set oflinear programming model resource limits. These limitations will bind activity levels to foundation period in observed levels. At this stage, dual values related to mention limitations that represent shadow price of products sub cultivate level will be calculated. Assuming maximizing programming return, basic model will be stated as follows:

$$\begin{aligned} &Max \quad Z = p'x - c'x \\ &s.t: Ax \le b \qquad [\lambda] \qquad (1) \\ &x \le x_0 + \varepsilon \qquad [\rho] \\ &x \ge 0 \end{aligned}$$

Where Z objective function value, P product price matrix $(n \times l)$, X activity productions matrix $(n \times l)$ levels, C cost matrix $(n \times l)$ of per unit activity, A Technical coefficients matrix $(m \times n)$ in resource limitations, b available resource values matrix $(m \times l)$, ‘ x_0 matrix $(n \times l)$ of production activities of observed levels,‘ ε Includes small positive numbers to avoid linear dependence between structural limitations and calibration limitations, ‘ λ matrix $(m \times l)$ of dual variations related to resource limitations, ‘ ρ matrix $(n \times l)$ of dual variations related to calibration limitations.

In the second stage, dual values obtained from the first stage for estimating parameters of a nonlinear objective function will be used. Nonlinear objective function in the second stage by putting a nonlinear production function or anonlinear cost function in the first stage objective function will be obtained. In this study, the maximum entropy method is used to specify the production function.Assume that the quadratic production functionused for each product is based on equation (2).

$$y_j = \sum_{i=1}^{n} a_{ij} x_{ij} - \frac{1}{2}\sum_{i=1}^{n}\sum_{k=1}^{n} q_{ijk} x_{ij} x_{kj} \qquad (2)$$

Where y_j indicates product performance of j. optimal pattern which use production functions based on equation (2) for product j with i inputs can be defined as follows:

$$\begin{aligned} &\pi = \sum_{j=1}^{m} \left(p_j \left[\sum_{j=1}^{n} a_{ij} x_{ij} - \frac{1}{2}\sum_{i=1}^{n}\sum_{k=1}^{n} q_{ijk} x_{ij} x_{kj} \right] - \sum_{i=1}^{n} w_i x_{ij} \right) \\ &s.t: \sum_{j=1}^{m} x_{ij} \le b_i \qquad (3) \\ &x_{ij} \ge 0 \end{aligned}$$

ISSN (Online): 2305-0225
Issue 11(3), April 2014, pp. 296-302

Where π programming return, p_j product price of j, w_i per unit price of production inputs and b_i available resource value.

Also a, q are constant componentand quadratic coefficients of production function respectively. In order to determine mentioned parameters back up pointsfirst order conditions can be used.The first order conditions for this model are:

$$\frac{\partial \pi}{\partial x_{ij}} = p_j \left[a_{ij} - \sum_{k=1}^{n} q_{ijk} x_{kj} \right] - w_i - \lambda_i = 0 \quad (4)$$

Total production constraint in equation (5) along the first-order constraints will be considered in parameters estimations.

$$y_i \times x_{j,land} = \sum_{i=1}^{n} a_{ij} x_{ij} - \frac{1}{2} \sum_{i=1}^{n} \sum_{k=1}^{n} q_{ijk} x_{ij} x_{kj} \quad (5)$$

So if we consider t as backup point and show possibility of backup points za_i and backup points zl_{ij} with pl_{ij}, in this case the elements of vector a and matrix b is obtained by using equations (6) and (7).

$$a_{ij} = \sum_{p=1}^{t} za_{pij} pa_{pij} \quad (6)$$

$$q_{ikj} = (\sum_{p=1}^{t} zl_{pikj} pl_{pikj}) \times (\sum_{p=1}^{t} zl_{pkij} pl_{pkij}) \quad (7)$$

In the third stage vector and matrix in nonlinear production function is replaced and gives mentioned functions along resource limitations of nonlinear programming pattern which is as follows:

$$\max \sum_{j=1}^{m} \left[p_j (\sum_{i=1}^{n} \left[a_{ij} - 0.5 \sum_{k=1}^{n} q_{ijk} x_{ij} x_{kj} \right] x_{ij}) - \sum_{i=1}^{n} w_i x_{ij} \right] \quad (8)$$

$$s.t: \sum_{j=1}^{m} x_{ij} \leq b_i$$

$$x_{ij} \geq 0$$

III. DISCUSSION AND RESULTS

By using collected data from region, programming model components were formed, including technical coefficients, objective function variables and constraints (market constraints, level under cultivation, alternation of cultivation, water, fertilizer, chemical pesticides, capital and machinery). After the calculation of these parameters, as it is previously explained, the formation steps of the PMP model are done. It should be noted that the GAMS software is used to build the studied model.
The area under study contains 3150 wells, with an annual discharge 280/793 million cubic meters, 996 spring with an annual discharge 40/440 million cubic meters and 60 aqueduct with an annual discharge 1/985 million cubic meters. Total water extraction from these sources amounted to 003/302 million cubic meters, of which 032/285 million cubic meters is used for agricultural purposes.

The change in price , the demand pattern of cultivation are worked out.Then , with the water demand and the price of water input , water input demand function according to various functional form , such as linear, logarithmic , linear - logarithmic and logarithmic - linear is estimated using the software package Eviews 7 . After estimating the different function using statistical comparison R2 among various functional forms that they have similar related variables ,the same as the functional linear shape with functional linear - logarithmic form and logarithmic functional form with a logarithmic function - a linear respectively functional linear - logarithmic and logarithmic - linear were selected as the best functionalforms, and then for comparing functional linear - logarithmic and logarithmic – linear, Jark-Bra examination were used, that the result is presented in table 2. As can be seen in this table, according to the lack of significant new estimator factor, in order to accept the null hypothesis, functional linear – logarithmic form is considered as the proper functional form of input water.

Table 2- result of comparing functional demand forms using J examination

Null hypothesis	Alternative hypothesis	Level of the significant new estimator factor	Examination result

ISSN (Online): 2305-0225
Issue 11(3), April 2014, pp. 296-302

Acceptance of functional logarithmic- linear form	Acceptance of functional linear-logarithmic	0	Refusal of null hypothesis
Acceptance of functional linear-logarithmic	Acceptance of functional logarithmic- linear form	0.34	Acceptance of null hypothesis

After selecting functional linear-logarithmic form, as an appropriate formof demand, results ofestimating theinputparametersof the input waterdemand function are presented based on functional linear-logarithmic form.

QW=-46731/47log+(PW)517272/5

As can be seen, input water price has a negative and significant effect on the amount of water demand in the region. So that the factor has been significant in probability level 94% and has reasonable R^2. Figure 1 shows demand curve of input water from PMP model in the region. It is observed that by increasing price of water(PW), the quantity of water consumption(QW) decreases. Theprice elasticityofdemand for waterdue tolowwaterpricesin the study areaisless than one(16/0-), in other words, farmers applying forincreasing theprice of waterwill havelittle reaction.

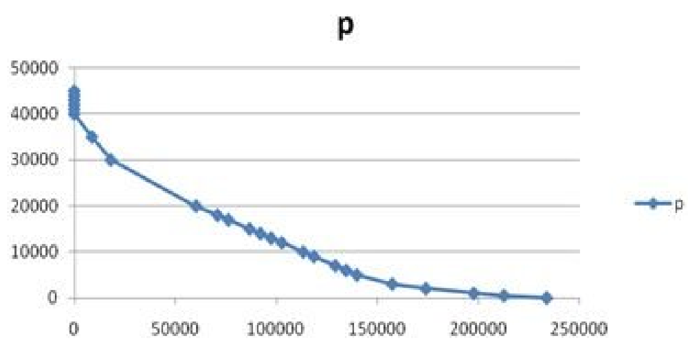

Fig- water demand curve in the region

Waterbalancein the marketpricesetata levelthatis equal tothe total demand forwaterby the amount ofavailable water. Based on thePMP model,market equilibriumprice ofwaterpercubic meteris estimated970rials. This study also examines the impact of equilibrium market water price on labor demand, consumption quantity of fertilizer and pesticides, water consumption and machinery that is presented in table 5.

Table 5- changes in the labor force, machinery, fertilizer, water, pesticides on the market equilibrium price

Product	Labor force	Machinery	Phosphate	Nitrogen (azote)	Pesticides	Water
Barely	-68.75	50.79	-13.13	-13.78	-8.94	282.14
Cucumber	9053.22	6213.37	49.96	-67.75	87.62	390.01
Garlic	3664.27	595.92	-89.89	-76.08	-13.97	-427.56
Potato	5657.1	19400.75	333/11	319/04	328.83	926.96
Canola	184.29	4076.24	-7.4	-5.28	17.44	-321.79
Wheat	-4985.1	-127753	-1402	-1522	-2299	-5955.1
Tomato	876.17	747.64	30.95	13.6	98.96	-45.52
Bean	5005.37	4098.42	130.27	107.48	35.03	144.61

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Issue 11(3), April 2014, pp. 296-302

Onion	1004.24	2450.61	-12.3	-12.31	-2.14	-151.61
Watermelon	1001.89	1609.71	-5.14	5.8	49.57	30.76
Total	21392.65	-88509.55	-985.63	-1251.31	-1706.72	-5127.16

According to thePMPmodelintotalemployment will increasefromcultivation pattern as a result of water market. While theuse ofmachinery and theuseofwaterwill decrease as a result of water market. Also by changing cultivation pattern as a result of water market, the consumption of fertilizers and pesticidesare decreased in total. So thatit can be concludedthat thewatermarket will change cultivation pattern in a way that it will decrease consumption of chemical inputs.

IV. CONCLUSION AND SUGGESTIONS

Based on balancing water demand and its supply, equilibrium price of water input in water market simulation is estimated 970 rails per cubic meter. The price elasticity of demand for water due to low water prices in the study area is less than one (-0.16) , farmers applying for increasing theprice of waterwill havelittle reaction. Also by changing cultivation pattern as a result of water market, the consumption of fertilizers and pesticidesare decreased in total. So thatit can be concludedthat thewatermarket will change cultivation pattern in a way that it will decrease consumption of chemical inputs and reduceenvironmental impactresulting fromthe use ofchemical fertilizers and pesticides.

According to the results of the study, in order to reduce environmental impact, it is suggested that due to the consumption of chemical fertilizers, gradually pricing water resources are increased to the level of economic value in order to provide the condition for using market mechanism.

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