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PRICING OF WATER RESOURCES USED IN THE PRODUCTION OF DATES IN SAUDI ARABIA

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ABSTRACT

The aim of this study is to determine the pricing of water resources used in the production of dates, based on the estimated production function and the derivative functions of marginal product and the marginal water resources return. Then calculating the value of marginal water resources return, which are equal to marginal costs (the unit price of resource) at the point of economic efficiency. The most important findings include the following: according to the local market price, the average unit price of water used in the production of dates ranged between the minimum of 0.51 SR / m^3 in the Jawf region up to maximum of 0.75 SR / m 3 in the eastern region, with an average estimated at 0.63 SR / m^3. While at the export price (social price for dates), the unit price of water used in the production of dates ranged between the minimum of 0.30 SR / m 3 in the Jawf region up to maximum of 0.40 SR / m^3 in the eastern region, with an average estimated 0.34 Real / m^3. At increasing the unit price of water used in the production of dates by 50%, it is expected to decrease the amount of water used in the production of dates in Riyadh region from 27.66 thousand m^3 / ha to 12.29 thousand m 3 / ha. In the eastern region is expected to decrease the amount of water used in the production of dates from 29.28 thousand m 3 / ha to 13.42 thousand m^3 / ha. Finally, it is expected to decrease the amount of water used in the production of dates in Jawf region of 32.86 thousand m^3 / ha to 15.72 thousand m^3 / ha. The study recommends the need to include water in the context of economic value in order to rationalize water consumption, preserved water for future generations, and achieving sustainable agricultural development.

Key words: water pricing, revenue and marginal cost of water, dates.

INTRODUCTION

Dates occupies an important economic position in the cropping pattern of Saudi Arabia agriculture, with total area of 155 thousand hectares of dates, representing 19.23% of the crop area of 806 thousand hectares in 2010. The production of dates is concentrated in the Riyadh region, reaching production of 248 thousand tons, a rate of 25 % of the total production of dates which is equal to 991.5 thousand tons in 2010, followed by Qassim region, a rate of 19%, the eastern and Medina regions grew by 15 %, 14% each respectively, and Hail, Makkah, Al-Jouf regions by 11%, 4.5%, 4.7%, respectively. (Ministry of Agriculture, 2010). It is known that water resources are scarce, as a result of the lack of the Kingdom to the rivers and regular heavy rainfall, in addition to the high costs of obtaining water from non-traditional sources (Ghanem and Ruwais, 2004). Despite the suggestion of fixed dates area cultivation of the future strategy for the Saudi Arabia, but the area of dates increased from 139.1 thousand hectares in 2001 to 155 thousand hectares in 2010 (Ministry of Agriculture, 2010). The dates consider one of productive activities with high water requirements, with an average of 27.6 thousand cubic meter / ha, so the expansion in the area of crops with high water requirements, leading to increased consumption of non-renewable groundwater, which represents water reserves strategic in the Kingdom of Saudi Arabia.

There some pervious studies shed light on pricing of water resources used for agricultural purposes. FRCU, (1984) study targeted the pricing of water irrigation in Egypt, it was found that the economic value of water irrigation (priced) were dependent on the cropping pattern, soil type , agronomic practices, fertilization, and all Other factors affecting the agricultural production process. Also it was found that the cost of water irrigation ranged from 4-32 pounds / thousand m^3. AlMallah and Kazzaz (1989) study aimed to introduce water irrigation in the Qassim region in the framework of economic accounting, by calculating the total physical return on alternative uses of water in the production of various crops, thus lead to different alternatives for the use of this resource. This study showed that wheat was the most efficient grain crops in terms of physical return on water use, thus wheat has a priority in the cropping pattern of winter crops.

Shafi and Alsefei (1991) study targeted pricing of water stored in Romanian wells. They estimated the cost of storage per cubic meter of water in order to draw economic policy to guide the use of water, which achieves maximum profitability. The study showed that the price of a cubic meter of water ranged between 0.76 -

4.24 pounds. In a study by Shafi (1991) targeted pricing of spring water in the oasis of Siwa. The study found that the cost per cubic meter ranged between 0.64 - 1.54 pounds. Alkamer and Ghanem (2007) study aimed to identify the economic dimension to the growth of the Egyptian agricultural sector and to estimate the cost of economic resources in agriculture. The unit cost of water used for agricultural purposes was estimated at 0.11 pounds / cubic meter, according to data in 2006. Ruwais (2008) study aimed at estimating the cost or pricing of agricultural economic resources based on elasticities derived from the production function for the agricultural sector over the period 1980-2005. The average annual cost for water used in the agricultural sector was estimated at 0.12 riyals / cubic meter during the period 1980-2005. Finally, Ghanem and Nushwan (2009) estimated the social cost and the revenue for the water use in the production of exported quantities of the most important vegetables and fruit in the Kingdom of Saudi Arabia during the period 2003 - 2007. The study showed that in the context of the water needs of the production unit and the amount of Saudi exports of the most important vegetables and fruits, the total average amount of water used in the production of exported quantities of the eight crops (tomatoes, potatoes, melons, onions, carrots, dates, citrus fruits, grapes) was 249.5 million cubic meter, representing 1.47% of the average amount of water used in crop pattern during the period 2003 - 2007. The ratio of the water value to the economic value of Saudi exports of the most important vegetables and fruits ranged from a minimum of 3.59% for tomatoes up to a maximum of 24.63% for the dates during the study period. The main objective of this study was to determine the pricing of water resources used in the production of dates in Saudi Arabia. The objective can be accomplished through estimating the production function for dates and deriving marginal product and marginal revenue functions of water resources, estimating the value of the marginal revenue of water resources in the domestic market price and export price (social price for dates), and measuring the impact of changes in the prices of water resources on the water quantities used in the production of dates.

METHODOLOGY

The production function of the dates has been used to estimate water resources pricing, the production function could be expressed in the following equation:

$y=a + b_1x_1+b_2x_2+b_3x_3+b_4x_4+b_5x_5 + e_i$

Where: y: the date production in tons.

x_1: the amount of water used in the production of dates in thousand cubic meter

x_2: the amount of permanent and temporary employment in the farm worker / day.

x_3: the amount of chemical fertilizers in tons.

x_4: the amount of organic fertilizers in tons.

x_5: the number of experience years in the production of dates.

$a, b_1, b_2, b_3, b_4, b_5$ are model parameters, e_i represents random error. Production function of the dates was estimated in the double logarithmic form using ordinary least squares (Gujarati, 1995 and William, 2003). The marginal product function has obtained by the first derivative of water resources production function, with knowing the selling price of the dates marginal return function was derived. The value of marginal return of water resources was obtained by compensating the amount of water used in the marginal return functions, which are equal to marginal costs (the unit price from the supplier) at the point of economic efficiency (Metwally, 1993).

Data Resources: This study relied in reaching its goals on secondary data published in the Agricultural Annual Statistical Yearbook issued by the Department of Studies and Statistics and Planning of the Ministry of Agriculture as well as statistics of the Food and Agriculture Organization (FAO), in addition to the primary data that was collected through the preparation of the questionnaire. A total of 196 farms were chosen by simple random sample technique, divided into three regions, namely Riyadh, Al-Jawf, and Eastern, rates equal to 68%, 19.1%, 12.9%, respectively. Questionnaire was compiled through a personal interview to the owners of farms in the Department of Agriculture for each region. The sample size was set at 5% of significance level and 7.0% of permitted error limit under the following law (Hamad and Ismail, 2001):

$$N = \frac{p(1-p)z^2}{d^2} = \frac{(0.25)(1.96)^2}{(0.07)^2} = 196$$

RESULTS AND DISCUSSION

First: estimating the production function of dates in Saudi Arabia:

The total production of a crop of dates (y) can be determined by a set of economic factors including: (1) the amount of water used per thousand cubic meters, (2) the amount of employment of permanent and temporary to perform various operations farm workers / day, (3) the amount of chemical fertilizers used in tons, (4) the amount of organic fertilizers in tons, (5) years of experience in the practice of farming activity. Stepwise multiple regression analysis in the double log form has

been implemented to estimate the dates production function of the sample research in the region of Riyadh, the Eastern, and the Jawf. Table (1) illustrates the estimated model parameters. The economic features of the estimated models show the following:

1 – Change of 10% in the amount of water used (X1) leads to a change in the same direction for the production of dates in Riyadh, Eastern, and Jwaf regions by 5.0%, 4.8%, 4.5%, respectively.

2- Change of 10% in the amount of permanent and temporary employment (X2) leads to a change in the same direction for the production of dates in Riyadh, Eastern, and Jawf regions by 0.4%, 1.2%, 0.9%, respectively.

3- Change of 10% in the amount of chemical fertilizers (X3) leads to a change in the same direction for the production of dates in Riyadh, Eastern, and Jawf regions by 0.2%, 0.7%, 0.4%, respectively.

4- The estimated models show a good efficiency in representing the data used, according to the efficiency measure indicators of the models such as the adjusted coefficient of determination (R^{-2}) , the square root of the average squares random error (RMSE), the absolute average error (MAE), the average percentage of absolute error (MAPE), and approached Theil inequality coefficient ((U-Theil) from zero.

5- HeteroScedasticity problem has been detected through Park and Geliggsr test. Park test has been applied through regressing the residual square (e_i^2) on the independent variables included in the model, while Geliggsr test used the regression of the absolute values of the residual | ei | on the independent variables included in the model. The test results turn out to be not significant for the estimated regression coefficients at the probability level of 5%, thus the estimated model is free of the HeteroScedasticity. White HeteroScedasticity test was also used, the (F) value is statistically not significant at the probability level of 5%, which confirms there is no HeteroScedasticity problem.

Second: Estimating the marginal return of water resources in the Riyadh region:

Given the dates average sale price of 10.27 thousand SR / ton in the domestic market, the marginal return function of water resources could be derived as follows:

$$\frac{dy}{dx1} = 1.32\, x_1^{-0.5} x_2^{0.04} x_3^{0.02}$$

$$\frac{dy}{dx1} \cdot p_y = 1672 0 x_1^{-0.5}$$

$$\frac{dy}{dx1} \cdot p_y = 642\, Riyal/\, 1000M^3$$

At the average amount of water used for the dates production of 676.92 thousand cubic meter / farm, marginal return of water resources estimated by about 642 SR / thousand cubic meter. Therefore the marginal cost or unit price of water resources used in the production of dates was estimated at about 0.64 Riyals / cubic meter. Due to the agricultural policy direction of Saudi Arabia to encourage export dates, so that the cost of water used in the production of dates in Riyadh region was estimated in terms of the average price equal to the export price (The economic value of dates), which is calculated as follows:

Economic value of the commodity export = FOB price converted to local currency value using the equilibrium exchange rate minus the costs of storage, shipping and inland transportation (Althnean and Salem, 1993). Given the average export price of dates of the Kingdom of Saudi Arabia of 1374.63 dollars / ton in 2009 (FAO, 2009) and the equilibrium exchange rate of 3.75 Riyals / dollars, the average export price in local currency is estimated to be about 5154.86 SR / ton. Neglecting the storage costs, shipping, and inland transportation of the dates which is equal to 76 SR / ton, an estimated average equal price to the export is about 5078.86 SR / ton. At the economic average value for the export of dates, it was possible to derive the marginal return function of water resources as follows:

$$\frac{dy}{dx1} = 1.628\, x_1^{-0.5}$$

$$\frac{dy}{dx1} \cdot p_y - 8268.38 x_1^{-0.5}$$

$$\frac{dy}{dx1} \cdot p_y = 317.8\, Riyal/\, 1000M^3$$

In terms of the average amount of water used for the production of dates, marginal return of water resources was estimated by about 317.8 SR / thousand cubic meter, therefore the marginal cost or unit price of water used in the production of dates was estimated at about 0.32 Riyals / cubic meter. Estimating the marginal return of water resources in the Eastern region: In terms of the dates average sale price of 9.45 a thousand SR / ton in the domestic market, the marginal revenue function of water resources could derived as follows:

$$\frac{dy}{dx1} = 1.067\, x_1^{-0.52} x_2^{0.12} x_3^{0.07}$$

$$\frac{dy}{dx1} \cdot p_y = 17274.46 x_1^{-0.52}$$

$$\frac{dy}{dx1} \cdot p_y = 747.43\, Riyal/\, 1000M^3$$

In context of the average amount of water used for the production dates of 419.52 thousand cubic meter / farm, the marginal water resources was estimated by about 747.43 SR / thousand cubic meter, therefore the marginal cost or unit price of water resources used in the production of dates was estimated at about 0.75 Riyals / cubic meter. Given the economic average value of exported dates, it has been possible to derive marginal return function of water resources as following:

$$\frac{dy}{dx1} = 1.828\, x_1^{-0.52}$$

$\frac{dy}{dx1}.p_y = 9284.08x_1^{-0.55}$

$\frac{dy}{dx1}.p_y = 401.71\ Riyal/\ 1000M^3$

At the average amount of water used for the production of dates, marginal return of water resources was estimated by about 401.71 SR / thousand cubic meter, therefore the marginal cost or price unit of water used in the production of dates was estimated at about 0.40 Riyal / cubic meter.

Estimating the marginal return of water resources in Jawf region: Given the dates average sale price of the 8.5 thousand SR / ton in the domestic market, it was possible to derive the marginal return function of water resources as follows: $\frac{dy}{dx1} = 1.027\ x_1^{-0.55}x_2^{0.09}x_3^{0.04}$

$\frac{dy}{dx1}.p_y = 12647.01x_1^{-0.55}$

$\frac{dy}{dx1}.p_y = 508.38\ Riyal/\ 1000M^3$

Given the average amount of water used for the production dates of 345 thousand cubic meter / farm, the marginal water resources was estimated by about 508.38 SR / thousand cubic meter, therefore the marginal cost or price unit of water resources used in the production of dates was estimated at about 0.51 Riyal / cubic meter. At the economic average value for the export of dates, it was possible to derive the marginal revenue function of water resources as follows: $\frac{dy}{dx1} = 1.488\ x_1^{-0.55}$

$\frac{dy}{dx1}.p_y = 7556.75x_1^{-0.55}$

$\frac{dy}{dx1}.p_y = 303.76\ Riyal/\ 1000M^3$

Given the average amount of water used for the production of dates, marginal return of water resources was estimated by about 303.76 SR / thousand cubic meter, therefore the marginal cost or price unit of water used in the production of dates was estimated at about 0.30 Riyal / cubic meter. Consequently , at the average selling price of the dates in the local market, the average unit price of water used in the production of dates ranged between the minimum 0.51 SR / cubic meter in Jawf region and up to a maximum of 0.75 SR / m 3 in Eastern region, with an average estimated at 0.63 riyals / cubic

Table No. 1: Estimated production functions of dates at Riyadh, Eastern, and Jawf regions in 2008

	Model		
	Riyadh	**Estern**	**Jawf**
A	0.967 (2.76)**	** (5.02)	** (3.15)
LnX1	0.50 ** (4.25)	0.48 (2.16)*	0.45 * (2.09)
LnX2	0.04 (2.15)*	0.12 * (2.96)	0.09 ** (4.25)
LnX3	0.02 * (2.09)	0.07 ** (20.31)	0.04 ** (7.05)
R-2	0.74	0.79	0.91
F	122.38	26.33	114.59
R.M.S.E	0.25	0.18	0.14
M.A.E	0.16	0.16	0.12
M.A.P.E	2.23%	2.11%	2.01%
U- Theil	0.12	0.09	0.05
White HeteroScedasticity (F)	1.83	1.56	1.12
X1(1000M3)	676.92	419.52	345.0
X2(Man / day)	60.02	30.50	29.81
X3(Ton)	9.03	6.23	5.12
(1000 Riyal) P_y	10.27	9.45	8.50

GG *Significant at 1% level*. G *Significant at 1% level* %5 .*Source: calculated and gathered from the questionnaire in* 2008

Table No. 2: measure the impact of the change in water prices on quantities used in the production of dates

	Riyadh			Eastern		
	Water price Riyal/ 000 cubic meter	**Quantity used (000 m^3/ha)** G **Farm**		**Water price Riyal/ 000 cubic meter**	**Quantity used (000 m^3/ha)** GG **Farm**	
Basic	**642**	676.92	27.66	747.43	419.52	29.28
%10	706.2	560.55	22.86	822.17	349.27	24.37
%20	770.4	471.02	19.21	896.92	295.45	20.62
%30	834.6	401.34	16.37	971.66	253.30	17.68
%40	898.9	346.06	14.11	1046.40	219.66	15.33
%50	963.0	301.45	12.29	1121.15	192.36	13.42

	Jawf	
	Water price Riyal/ 000 cubic meter	Quantity used (000 m^3/ha)
	Farm***	
Basic	508.38	345.0	32.86
%10	559.22	290.11	27.63
%20	610.06	247.66	23.59
%30	660.89	214.12	20.39
%40	711.73	187.12	17.82
%50	762.57	165.06	15.72

G *Average farm area 24.52 ha***.** GG *Average farm area 14.33 ha* GGG *Average farm area 10.5 ha***.**
Source: calculated from the estimated model.

meter. In terms of equal price for the export of dates, unit price of water used in the production of dates ranged between the minimum of 0.30 SR / cubic meter in Jawf region up to a maximum 0.40 SR / cubic meter in Eastern region, with an average estimated 0.34 Riyal / cubic meter. Third: measure the impact of the change in water prices on the quantities used in the production of dates Table (2) illustrates the impact of the change in unit price of water resources on the quantities used in the production of dates in Riyadh, Eastern, and Jawf regions. In Riyadh region, it is clear from the data at increasing the unit price of water used in the production of dates by 10%, 20%, 30%, 40 %, 50%, is expected to decrease the amount of water used from 27.66 thousand cubic meter / ha to 22.86, 19.21, 16.37, 14.11, 12.29 thousand cubic meter / ha, respectively. In Eastern region, it is clear that at increasing the unit price of water used in the production of dates by 10%, 20%, 30%, 40%, 50%, is expected to decrease the amount of water used from 29.28 thousand cubic meter / ha to 24.37, 20.62 , 17.68, 15.33, 13.42 thousand cubic meter / ha, respectively. Finally, in Jawf region, it is clear that with the increase in unit price of water used in the production of dates by 10%, 20%, 30%, 40%, 50%, is expected to decrease the amount of water used from 32.86 thousand cubic meter / ha to 27.63, 23.59, 20.39, 17.82, 15.72 thousand cubic meter / ha, respectively.

As a matter of fact pricing of water resources used for agricultural purposes leads to the rationalization of consumption and preserved for future generations, therefore this study recommends the need to include water in the context of economic value, which means pricing of water resources used for agricultural purposes according to the amount of water used, as is the case in Spain, Morocco, Tunisia, and Cyprus. The implementation of this policy requires several mechanisms including: (1) determining the amount of water used for each farm separately by requiring all farmers to installed meters to measure the amount of water used during the growing season, (2) the Ministry of Water and Electricity should require pricing of water resources and follow-up collection water value.

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