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RESEARCH PAPER

Economic Management of Water by Using Valuation Policy in Mango Orchards with an Emphasis on Environmental Inputs in Chabahar County

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Abstract
Sustainable management of water resources in order to maintain environmental needs requires an economic approach in the agricultural sector. Given the development and transformation of Iran's national economy, the agricultural sector has emerged as the pivot of economic security and viability. In the economic approach, managing demand requires determining the real price of water. The present study uses the cross-sectional data for the 2018-2019 crop years in order to estimate the price of water for mango and also to estimate its demand with an emphasis on environmental inputs. To this end, the real price of water is determined by the residual method, and the demand function is estimated by the translog cost function and the equations of the contribution of inputs in cost. The results support the good fit of the model used for the cost function of mango in the studied county. The results for the coefficients in Chabahar County indicate that water cost has a positive relationship with the prices of manure, water, seedling, and crop yield and a negative relationship with the prices of pesticides and chemical fertilizers. Based on the results of the water demand function, water is a substitute for manure, chemical fertilizer, and seedling with partial elasticities of >1, revealing the impact of water use management and economic valuation on improving the use of other environmental inputs (pesticides, manure, and chemical fertilizers) and seedling, as well as the water itself, in mango production in this region. It is recommended to adopt policies like optimal pricing of inputs including pesticides, manure, chemical fertilizers, and seedling in order to curb the resulting environmental pollution.
Keywords: Chabahar, Cost Function, Demand Management, Environmental Inputs, Mango, Water Pricing.
JEL Classification: B22, B41, C51.

Introduction

The market of water as a key commodity differs from the market of other public commodities considerably, so its pricing is different too. This being so, water price for industrial uses is higher than that for urban uses, which in turn, is higher than that for the agricultural sector. Water price does not influence the demand for water significantly for two reasons. On the one hand, due to the high costs of agricultural water transfer, local markets are formed in which only a limited number of consumers and suppliers work. On the other hand, due to the shared use of water resources in a certain region, an increase in water use by a group will increase the cost of water extraction by the other groups (Souri and Ebrahimi, 2008). Water demand management and its pricing policymaking are of crucial importance in the agricultural sector, which is the biggest consumer of water.

Mango is considered a horticultural crop in Iran. Agricultural Annals 2016 reported that the infertile and fertile mango cultivation areas were 517 and 973.5 ha, respectively. In terms of yield per ha, Sistan and Baluchestan province has the highest record of 13790.5 kg ha^{-1} among all provinces of Iran. Further, the total horticultural crop in Iran is 16.52 million tons. A total of 13,425 tons of mango is produced in this province, accounting for about 6.2% of the total horticultural production of Iran (Anonymous, 2016). Mango is an important and strategic crop with a key role in the agricultural economy of Sistan and Baluchestan province. The irrigation water for mango orchards in this province is supplied mainly from deep wells and partially from Qanats and semi-deep wells.

To produce their crop or crops, farmers use production inputs, which are mostly interconnected so that these inputs have mutual impacts on one another. The technical relationship among these inputs creates some economic relationships among them. Based on the theories of production, the amount of a crop's production is a function of the amount of different inputs used, which can be expressed with a production function. By estimating this function, the contribution of each individual input to the production can be calculated (Chambers, 1988). In production sectors, e.g. agriculture, water is regarded as a mediating commodity or production input. In this case, since those who demand water is liable for it. Like other production factors, demand for agricultural water emanates from the demand for crops for whose production water is consumed. Accordingly, demand for inputs (fertilizers, pest control tools, agricultural machinery), including water, is called a derivative demand function. The Materials and Method section comprehensively explains the forms of different functions and how they are calculated. It should be noted that the estimation of production function and the extraction of demand function are a parametric approach of econometrics that is used in research on productivity.

Most studies on the productivity of and demand for agricultural water have addressed agricultural water pricing, agricultural water economic value, policymaking, economic views on water management, and optimal allocation of agricultural water. In the broadest sense, water productivity is the net return of each unit of water (Molden et al., 2010). An example of study on the water demand of crops is Sharzeie and Amirtaimoori (2012) who determined the economic value of groundwater in producing pistachio in Ravar County in Kerman province, Iran using the marginal productivity method. They estimated the economic value of water to be, on average, 19,870 IRR by calculating a polynomial production function. Islami et al. (2013) explored the production elasticity and water demand of pomegranate orchards of Charkhab Village in Yazd, Iran. The researchers calculated marginal and mean productivity, as well as production elasticity of the individual production-affecting inputs. The estimation of the pomegranate demand function revealed a negative relationship between the agricultural water price and demand for it. Besides, the results on water demand elasticity indicated that a 1% increase in water price in this desert would reduce water demand by 24.32%.

Varela-Ortega et al. (1998), who studied water policymaking in Spain, stated that pricing as the sole instrument to control agricultural water use does not suffice, so water use is not reduced, especially at low prices. Based on their results, water use is reduced when its price is increased to a level that can affect agricultural revenue and employment negatively. According to Moran and Dann (2008), the good ecological status of the water bodies in Europe and the wise exploitation of water by the European community have made them pursue maximizing the socioeconomic value of water. They concluded that the value of water differed in different regions of the EU. Kavoi et al. (2009) focused on the production structure and demand functions of inputs in dairy farms of Kenya using duality theory. The results showed the lack of economies of scale in the production units. Keskin et al. (2010) estimated the demand function for tomato and cucumber inputs in the Ozondareh region of Turkey using the cost function approach. They found that the own- and cross-price elasticities of inputs were inelastic in cucumber culture and elastic to price variations in tomato cultivation. Han et al. (2011) developed a multi-objective linear programming model with interval parameters. The model was used to allocate water resources with different qualities to urban, agricultural, and industrial consumers in Dalian, China. The model aimed at maximizing socio-economic and environmental benefits. The results revealed that the ratio of water use was increasing, and the ratio of agricultural water use to total water use was decreasing. Omaghomi and Buchberger (2014) estimated the water demands of buildings. The results were presented as a unique curve on a universal perfect designing chart applicable for any number and type. A practical sample shows the application of the new design chart. Mahtsente et al. (2015) estimated the water demand function and valuated it by the SWAT and CropWat models with a monthly validation. They reported that the total water demand in the basin of the Ethiopia river was 0.313 million m^3/month. Tomaszkiewicz et al. (2016) estimated the water demand of the agricultural sector, given climate change parameters. Based on their findings, the parameters of rainfall and soil moisture were most influential in determining the demand function. Shen and Lin (2017) examined shadow price and agricultural water demand in China over 2002-2012 and found that the mean shadow price of the agricultural water was 2.57-3.88 ¥ m^{-3}. The estimated elasticity of the agricultural water was 0.12, and the improvement of the technical productivity of the agricultural sector proved to be very influential on water demand. Sun et al. (2018) evaluated agricultural water demand under different climatic scenarios in China. They found that the irrigation requirement of the main crops under the future climate change scenario would have a decreasing trend. They argued that future research should focus on improving regional climatic deficiency and developing a better understanding of agricultural responses to regional climate change.

Given the review of the literature on the estimation of crop production function and water demand and considering the significance of mango in Chabahar as a strategic crop, the present study aimed to study the water demand function of this crop in this county to examine the policy requirements. The contribution of the study is that it is the first attempt to estimate the translog cost function for mango with an emphasis on environmental inputs by recursive seemingly unrelated regression equations (SURE) in Chabahar County. Also, Allen own and cross partial elasticities and own-price and cross-price elasticities are determined.

Materials and Methods

Water Valuation by Residual Method for Date Palm Orchards

Residual method is a widely used method that employs shadow prices of the production inputs. This is particularly a common practice in pricing agricultural water. In this method, the total value of a crop is distributed among individual inputs used during its production. If appropriate market prices can be determined for all but one of these inputs, the residual of the total value of the crop can be attributed to that specific input (whose price could not be determined in the market). The residual value method can be employed in order to determine the water consumed in the production process. This is a form of budget analysis technique that seeks to find the maximum return of water use by calculating total production return and subtracting the costs of water. The residual value is equal to water return and reflects the maximum production and willingness to pay for water when all costs of inputs are intended to be covered. If only variable costs of inputs are subtracted, the short-term value of water will be derived. And if all costs of the inputs except water (including the natural rate of capital return) are extracted, then the long-term value of water will be obtained. This method seems appropriate only when the claimed input has a considerable contribution to the total value of the crop. This distinction is based on two principles (Young and Gray, 1985).

The first principle holds that the prices of all inputs contributing to production are equal to the value of their marginal product. This is a very good condition for competitive equilibrium and occurs when there is a perfect competitive market for all agricultural inputs. Producers at most utilize the inputs as far as the value of their marginal product is equalized with the cost of the last employed inputs (i.e., the prices of the inputs). When there are other inputs that are not priced by market or they are not employed in a manner whose price is equal to the value of their marginal product, residual imputation method will then provide a good approximation of their values (Saliba and Bush, 1987).

Secondly, the total value of the crop is divided into parts so that each production input is dealt with in terms of its value of marginal product and thereby the total value of the crop is completely distributed among all inputs. This principle is realized when there is a linear homogenous production function. In this respect, Euler's theorem holds that if a production function has a constant return to scale, the sum of input products will be equal to total production (Handerson and Quant, 2005).

The key hypothesis of the residual value method is a part of the neoclassical theory of economics for maximizing the net income and production value, according to which the condition for marginal productivity is defined as below:

$$Y = f\left(X_{La}, X_{SH}, X_H, X_{L1}, X_{L2}, X_W\right) \tag{1}$$

in which crop Y is produced by using several inputs including family and rental labor (L1 and L2, respectively), manure (H), chemical fertilizer (SH), acreage (La), and water (W). The residual intended to be measured is the input water. Input and crop are assumed to be continuously variable, and technology level is assumed to be invariable. According to the first assumption, if all inputs are paid on the basis of their own values of the marginal product, the total production value will be vacated. Then, we will have:

$$Y.P_Y = (VMP_{La})(X_{La}) + VMP_{SH}X_{SH} + VMP_H X_H + VMP_{L1}X_{L1} + VMP_{L2}X_{L2} + VMP_w X_w \tag{2}$$

in which $Y.P_Y$ denotes the total production value, VMP_i represents the value of marginal production for the input i, and X_i expresses the quantity of the i^{th} input. This equation expresses the basis of Wicksteed's theorem: the weighted sum of the amounts of inputs in which the weight of each individual input is the value of its marginal product. The second assumption holds that the producer chooses a level of the input i in that $VMP_i = P_i$. Since the marginal product of each input, and as a result, the value of marginal product is unknown to us, and then according to the second assumption, we replace VMP of each input with its market price. Therefore, Equation (2) is converted to Equation (3).

$$Y.P_y = (P_{La}.X_{La}) + (P_{SH}.X_{SH}) + (P_H.X_H) + (P_{L1}.X_{L1}) + (P_{L2}.X_{L2}) + (P_W.X_W) \tag{3}$$

Now, if we have the values of the prices of the left-hand variables in Equation (3), the right-hand side will show the contribution of water to the total value of crop production. Since it is assumed that we know how much water is used, Equation (3) can be solved to estimate the unit value of water.

$$P_W = \frac{(Y.P_Y) - [(P_{La}.X_{La}) + (P_{SH}.X_{SH}) + (P_H.X_H) + (P_{L1}.X_{L1}) + (P_{L2}.X_{L2}) + (P_W.X_W)]}{X_W} \tag{4}$$

The solution of Equation (4) gives the value of water in the product or its net return. For more general cases in which there are n inputs and m crops, the equation of residual method is as follows:

$$X_n.P_{Xn} = \sum_{j=1}^{m}(Y_j.P_{Y_j}) - \sum_{i=1}^{n-1}(X_i.P_{X_i}) \tag{5}$$

in which X_i shows the quantity of input i, Y_j denotes the quantity of crop j, and P_{X_i} and P_{Y_j} represent the price of water and crops, respectively (Young, 2005).

Translog Production Function and Cost Function

Since the introduction of the logarithmic production function by Christensen, Jorgenson, and Lau in 1971, the cost function method has been widely used to analyze the production structure in different economic sectors. This form of production function is now widely used because it is one of the multiple possible and simple interpretations of Shephard's duality theorem and Translog cost functions.

A reason for the extensive application of this function by contemporary economists is the simplicity of results' interpretation and calculations required to derive the Translog cost function (Johansen, 1972). This function satisfies all characteristics of a neoclassic production function too. Also, the function allows the elasticities of substitution and the production elasticities to vary with the level of input consumptions. Additionally, the first derivative of the function faces no limitation in sign. In other words, the Translog function shows all three production regions, and the marginal product in this function can be ascending, descending and/or negative. In the Translog function, in addition to the parameters of the main variables, the coefficients of the interactions between the variables are estimated too. The requisite is not defined in this function (Christensen et al., 1971). The function has the following general form:

$$Y = a_0 \prod_{i=1}^{n} X_i^{a_i} \; e^{\frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{m} \gamma_{ij} LnX_i LnX_j} \tag{6}$$

in which Y represents the output, a_0 represents the efficiency, X_i and X_j denote the amounts of inputs i and j, respectively, and a_i and Y_{ij} express the unknown parameters. Its logarithmic form is as below:

$$LnY = Lna_0 + \sum_{i=1}^{n} (a_i LnX_i) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{m} (b_{ij} LnX_i LnX_j) \tag{7}$$

There is a cost function for every production function. Thus, the cost form of the Translog function is as below (second-order Taylor's series expansion was used to infer this function):

$$Lnc = Ln\alpha_0 + \Sigma \alpha_i LnP_i + \alpha_Q LnQ + \frac{1}{2}\Sigma\Sigma\gamma_{ij} LnP_i LnP_j + \Sigma\gamma_{iQ} LnQLnP_i + \frac{1}{2}\gamma_Q (LnQ)^2 \tag{8}$$

in which $i, j = 1,\ldots,N$, P_i and P_j denote the price of the inputs, and C denotes total cost. The cost shares equations, which are the equation of conditional demand according to Shephard's theorem, are as below:

$$S_i = \partial Logc \big/ \partial LogP_i = X_i P_i \big/ c = \alpha_i + \sum \gamma_j LnP_i + \gamma_{iQ} LnQ \tag{9}$$

in which $c = \sum X_i P_i$ shows the cost share of input i. Given the features of neoclassic production theory about the summability of cost shares, the following constraints were applied on demand functions containing share equations.

a) Homogeneity assumption:

$\Sigma\gamma_{ij} = \Sigma\gamma_{ji}$ $\Sigma a_i = 1$, $\Sigma\gamma_{iQ} = \Sigma\gamma_{ij} = \Sigma\gamma_{iQ} = 0$

b) Symmetry assumption

$\Sigma\gamma_{ij}=\Sigma\gamma_{ji}$

On the other hand, since the sum of cost shares is equal to the unity ($\sum S_i = 1$), for applying these constraints on the foregoing cost function, we need to write $n-1$ shares and the prices become relative in the main function. To hinder the variance-covariance matrix of error terms from being zero, one of the cost share equations is omitted. In practical works, an equation that has the lowest share in production costs is usually omitted (McGeehan, 1992).

Elasticities of Substitution and Price Elasticities of Demand

Allen-Uzawa own and cross partial elasticities of substitution. These elasticities are used to group each pair of inputs in terms of substitution and complementation. According to Blackorby and Russel (1975), Allen-Uzawa cross elasticity of substitution shows the degree of substitution between two inputs. This elasticity is defined as below:

$$\theta_{ij} = \frac{(\sigma^2 c / \sigma p_j \sigma_{pi}).c}{(\sigma c / \sigma p_i)/(\sigma c / \sigma p_j)} \tag{10}$$

This type of elasticity can be calculated as below for the Translog cost function:

$$\theta_{ij}=\frac{\gamma_{ii}+(s_i-1)}{s_i^2}, \theta_{ij}=\frac{\gamma_{ii}}{s_i^2}+1 \quad ; for \quad i \neq j \tag{11}$$

If the algebraic sum of cross-elasticity of substitution is positive, i.e. $\theta_{ij} \geq 0$, it shows the substitution relation between the inputs and if $0 \geq \theta_{ij}$, it shows the complementary relation. With respect to Allen-Uzawa own elasticity, the sign of this type of elasticity is expected to be negative because the demand for a commodity (except Giffen goods) has a reverse relation with its price.

Own- and cross-price elasticities of demand. The own- and cross-price elasticities of demand for inputs are defined as below:

$$\varepsilon_{ij} = \frac{\partial \ln x_i}{\partial \ln p_j} = \frac{\partial x_i}{\partial p_j} \cdot \frac{p_j}{x_i} \tag{12}$$

In the Translog cost function, these elasticities are calculated as follows:

$$\varepsilon_{ii} = \theta_{ii} s_i, \varepsilon_{ij} = \theta_{ij} s_j \quad ; \quad for \; i \neq j \tag{13}$$

By definition, the demand for the i^{th} input is elastic, lowly-elastic or inelastic if ε_{ij} is greater than, smaller than or equal to 1, respectively. Blackorby and Russel (1975) state that Allen-Uzawa elasticities of substitution provide no information about the curvature of isoquant curve and the relative share in costs, and they cannot be regarded as the marginal rate of substitution. Besides, Allen-Uzawa elasticity of substitution contains low information (Kuroda, 1987).

Data for the research on the variables of acreage, production rate, the amount of inputs used at different phases of planting, cultivating, and harvesting, and the prices and costs of the inputs used were collected from based on Cochran's formula 289 mango orchards in Chabahar County in the 2018-2019 crop year by designing and completing a questionnaire As well as the opinions of Jihad-e-Agriculture experts in the province. The $Eviews_{10}$ software package was used for the calculations, determination of water value, and estimation of the translog cost function.

Heteroskedasticity Test Results

The results of Bruch-Pagan-Godfrey heterogeneity test indicate that the model always has a heterogeneity variance and the computational F statistic is larger than the F table and rejects the null hypothesis of variance homogeneity. To solve the heterogeneity variance problem, due to the fact that the heterogeneity variance is clear in relation to cost, the logarithmic values of the explanatory and dependent variables have been used instead of the simple values of that variable, and the fitted model is given in Table 2.

Table 1. Heteroskedasticity Test Results

	Heterogeneity of variance	**Homogeneity of variance**
Statistics F	7.524	1.435
Prob (F)	(0.00)	021

Source: Research finding.

Results of the Residual Method

Water price (or economic value) is determined for the mango crop by the residual method as below:

$$P_W = \frac{(Y.P_Y) - [(P_B.X_B) + (P_{SH}.X_{SH}) + (P_H.X_H) + (P_L.X_L) + (P_S.X_S) + (P_W.X_W)]}{X_W} \qquad (12)$$

in which P_w is the water price, Y_i is the amount of crop i, P_{Yi} is the price of the crop i, and P_W, P_l, P_h, P_s, P_b, and P_{SH} are the prices of water, labor, manure, pesticide, seedling, and chemical fertilizers, respectively. Also, X_W, X_l, X_h, X_s, X_b, and X_{SH} represent the physical quantities of these inputs.

Table 2 presents the economic value of water per ha and m^3 in terms of the market price for the mango crop in Chabahar County. It can be observed that the mango crop in this region has an economic value of 806.0 IRR m^{-3} in terms of market price. This shows the contribution of water in the production value of mango.

Table 2. The Economic Value (Net Return) of Water in Mango Production in Chabahar (Unit: IRR)

Input	**Cost in market price**
Seedling	81139573.1
pesticide	1103435.7.6
Labor	434107.0.72
Manure	750921508
Chemical fertilizer	58472572.3
Water extraction	9545674.56
Capital profit	179489791
Total cost per ha	1103840250
Management cost (5% of total cost)	55192012.3
Input	**Cost in market price**
Total cost with management cost	1048648230

Total gross value	1055822300
Water economic value per ha	7174065.46
Water economic value per m^3	806.0

Source: Research finding.

Estimation of Water Input Demand Function and Examination of Mango Production Structure

The model developed to derive the mango demand function and identify its production structure, which is composed of a transcendental logarithm total cost function and the equations of the contributions of input costs, is estimated by the iterative seemingly unrelated regression method. Table 3 shows the estimation of the translog total cost equation. It is evident that among 28 estimable coefficients, only 9 coefficients did not differ from zero at a = 0.05 level, so the significance of most coefficients of the equations was supported, which was a very desirable result. Nine insignificant coefficients included the coefficients of water and the coefficients of pesticide × water, pesticides × seedling, pesticide × chemical fertilizer, water × chemical fertilizer, seedling × chemical fertilizers, manure price × production (which is the coefficient of production in the equation of manure cost contribution), water price × production (which is the coefficient of production in the equation of water cost contribution). The equation's R^2 is 0.96, reflecting the good fit of the equation. That is, the independent variables have well accounted for the variations in total cost.

Table 3. Estimation of the Coefficients of The Total Cost Equation of Mango Production in Chabahar County

Parameter	**Coefficeint**	**t-statistic**	**Parameter**	**Coefficeint**	**t-statistic**
C (1)	-2.20217	-0.522427	C (15)	-0.058236	-4.533524
C (2)	0.068608	3.827359	C (16)	0.009572	2.364625
C (3)	0.615878	7.252682	C (17)	0.01322	-4.320011
C (4)	0.064751	1.62821	C (18)	-0.001456	-0.5488
C (5)	0.278318	6.57058	C (19)	0.054672	2.729279
C (6)	0.166393	5.359373	C (20)	-0.007215	-0.841077
C (7)	0.008931	10.23603	C (21)	0.056532	7.379446
C (8)	-0.010988	-2.144622	C (22)	3.470829	3.948892
C (9)	-4.82E-05	-0.033676	C (23)	-0.003765	-2.210822
C (10)	-0.001045	-0.680339	C (24)	-0.003814	-0.486343
C (11)	-0.001678	-1.348718	C (25)	0.002322	-0.58783
C (12)	0.186946	5.674604	C (26)	-0.015509	-3.938799
C (13)	-0.014317	-2.329439	C (27)	-0.006376	-2.229314
C (14)	-0.051358	-3.231414	C (28)	-0.275596	-3.003013
General statistics	$\bar{R}^2$	R^2	General statistics	$\bar{R}^2$	R^2
Contribution of water cost	0.29	0.27	Translog cost function	0.95	0.96
Contribution of seedling cost	0.14	0.15	Contribution of pesticide cost	0.74	0.75
Contribution of chemical fertilizer	0.11	0.13	Contribution of manure cost	0.13	0.14

Source: Research finding.
Note: D.W. = 2.61

The equation of water cost contribution to mango crop, which is very similar to its demand function, is estimated as below:

$$S_W = 0.64 - 4.08\log(\frac{p_S}{p_L}) + 0.014\log(\frac{p_H}{p_L}) + 0.009\log(\frac{p_W}{p_L}) + 0.132\log(\frac{p_B}{p_L}) - 0.0014\log(\frac{p_{SH}}{p_L}) + 0.0023\log Q$$

t = 6.57 , 0.033 , 2.32 , 2.36 , 4.32 , 0.548 , 0.587

It is evident from the t-values that all coefficients of the cost contribution equation are insignificant except for the coefficient of manure. Examination of the above coefficients shows that the equation of water cost share has a positive relationship with the price of animal manure, water and seedlings and a negative relationship with the price of pesticides and chemical fertilizers. In other words, the contribution of water cost to the total cost increases with an increase in the prices of manure, water, and seedling, but its contribution decreases with an increase in the prices of pesticide and chemical fertilizer.

Tables 4 and 5 show substitution elasticities and price elasticities. Since the goal is to calculate the demand for water, the analysis mainly focuses on the elasticity of substitution and price elasticity of this input.

Table 4. Estimation of Elasticities of Substitution for Mango Production Inputs in Chabahar County

	Pesticide	**Manure**	**Water**	**Seedling**	**Chemical fertilizer**
Pesticide	0.75	0.35	0.16	0.14	0.35
Manure		-0.23	1.52	0.97	0.98
Water			-1.78	2.29	1.42
Seedling				-0.67	0.97
Chemical fertilizer					-3.39

Source: Research finding.

The elasticity of substitution for water shows the expected sign, i.e. negative. This means that the demand for water is related to its price inversely. Based on Table 4, the elasticities of substitution of water with other inputs show that water has a substitution relationship with pesticide, manure, seedling, and chemical fertilizer. The partial elasticity of water with other inputs is greater than 1 except for pesticide. This describes a strong substitution relationship between water and the mentioned inputs. Furthermore, the partial elasticity of water with pesticide is smaller than 1, meaning its weak substitution degree. As is evident, the highest degree of substation among the inputs is related to seedling and water (2.29). In other words, an increase in water price increases the use of seedlings and manure. The substitution sensitivity is greater than 1 between water and seedling and between water and manure. This implies that if the water price is increased, seedlings with higher quality and improved seedlings will be used to reduce water use. This result as to manure implies that if water price is increased, more manure will be used in production to reduce water use. The substitution of water with chemical fertilizer (1.42) means that with an increase in water price, more chemical fertilizer will be used to reduce the demand for water. The lowest degree of substitution (0.16) is for water with pesticide in which case the sensitivity or flexibility of the farmers is so low that a change in the price of one of these inputs is expected not to change the use of the other input significantly because both inputs are crucial for mango production.

Table 5. Estimation of Price Elasticities of Demand for Mango Production Inputs in Chabahar County

	Pesticide	**Manure**	**Water**	**Seedling**	**Chemical fertilizer**

Pesticide	-0.42	0.20	0.09	0.08	0.20
Manure		-0.07	0.45	0.28	0.29
Water			-0.64	0.82	0.51
Seedling				-0.36	0.52
Chemical fertilizer					0.42

Source: Research finding.

Data in Table 5 were used to analyze the own-price and cross-price elasticities. The results indicated that the price elasticity of water was expectedly negative, but it was smaller than 1 and the demand was inelastic (-0.64). The inelasticity of water means that its price changes do not influence the demand for it. Partial cross elasticities between water and other inputs show that all inputs are a substitution for water, which is consistent with the results as to the elasticities of substitution. The demand for water is most sensitive to the change in seedling price (0.82) and then to the change in chemical fertilizer price (0.51). Although the changes in seedling use emanating from water changes are small, they are greater than the changes in other inputs. In other words, when water price is increased by one unit, the demand for seedling will be increased only by 0.82 units, showing weak substitution of seedling for water. The partial cross elasticity of water and manure is also trivial (0.13), meaning that the use of more manure will increase the demand for water very slightly. Also, if water price is increased by 1%, the demand for manure will be increased by 0.45%. The cross elasticity of water and labor is almost zero (0.09), showing the insensitivity of the demand for pesticides to water price. According to the elasticities of substitution and prices presented in Tables 4 and 5, it is observed that all inputs have expectedly negative own price elasticity.

Conclusion

Overall, given the estimation of the translog cost and production function with an emphasis on environmental inputs by seemingly unrelated regression equations (SURE), the significance of most coefficients and their high R^2 values mean that the models are well fitted. On the other hand, the own partial elasticities of substitution had the expected sign of negative for the inputs in the studied county. The Allen cross partial elasticities for each pair of the inputs indicates their substitution relationship. Indeed, all inputs have a substitution relationship in Chabahar. The own elasticity of the price has the expected sign too.

The elasticities of substitution of water with other inputs show that water has a substitution relationship with pesticide, manure, seedling, and chemical fertilizer. The partial elasticity of water with other inputs is greater than 1 except for pesticide. This describes a strong substitution relationship between water and the mentioned inputs. Furthermore, the partial elasticity of water with pesticide is smaller than 1, meaning its weak substitution degree; own-price and cross-price elasticities. The results indicated that the price elasticity of water was expectedly negative, but it was smaller than 1 and the demand was inelastic. The inelasticity of water means that its price changes do not influence the demand for it.

1. The results for the Allen partial elasticities of substitution for Chabahar County reveal a supplementary relationship of manure and pesticide with water, so it is recommended to adopt policies like optimal pricing of pesticide and manure to avoid the pollution of the environment, soil, and water.
2. Considering the supplementary relationship between labor and water, policies need to be adopted for water pricing to avoid its wastage and encourage its optimal use. This will also hinder the increasing rate of unemployment in the agricultural sector.

3. The Allen elasticities of substation indicate a supplementary relationship of chemical fertilizer and manure with pesticide and that of water with pesticide, so the government should develop managerial policies for optimal pricing of such inputs as water, chemical fertilizer, manure, and pesticide to avoid excessive use of pesticides, fertilizers, and water for the sake of the environmental conservation. In addition, farmers should aim at the sound management of agricultural input use.
4. To enhance efficiency, it will be instrumental to use extension services to reduce production costs and control the use of inputs to motivate farmers for the optimal consumption of the production factors.

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