J. Agr. Sci. Tech. (2022) Vol. 24(3): 493-504

Cost Structure, Economies of Scale, and Sustainable Use of Irrigation Water: A Study of Kurdistan Province Farms, Iran

M. Haji-Rahimi[1*], A. Soltani-Zoghi[2], and E. Sayyad Chamani[3]

ABSTRACT

Agriculture is one of the responsible sectors for adequate food production and contribution to food security. However, due to the rapid population growth and increasing demand for food, this responsibility is becoming more and more challenging. The consequence of this challenge is the excessive exploitation of natural resources and destruction of the environment. This study aimed to investigate the cost structure, economies of scale, and inputs elasticities for the major farm crops of the Qorveh-Dehgolan Plain, in Kurdistan Province, through a translog cost function. The needed data were collected through a multi-stage cluster sampling survey in the 2017-2018 cropping year. The results showed that the average share of water input in the total production cost of the studied products was 12%. Results also showed that all ordinary own-price elasticities of demand for inputs were negative and smaller than one. However, the results of Allen-Uzawa's own price elasticities showed that demands for inputs could be elastic. Ordinary and Allen-Uzawa own price elasticity of water input were -0.76 and -6.7, respectively. The results also showed that wheat, tomato, barley, and alfalfa farms in the area under study were facing economies of scale, on average, while potato, cucumbers, and sugar-beet farms were facing diseconomies of scale.

Keywords: Allen-Uzawa own price elasticity, Cost function, Cost elasticity, Environmental sustainability, Seemingly unrelated regression.

INTRODUCTION

Agriculture is the most essential supplier of human food needs. Due to the rapid growth of the population over the past two centuries, this need has led to the intensification and mechanization of agriculture as a natural response to increasing food demand (Emami *et al*., 2018). Agriculture, as the responsible sector for meeting this basic need, has always faced challenges about how to manage farms, how to use natural resources, and how to justify the economic activities and timing of agricultural production.

Iran uses about 90% of its fresh water resources for agriculture, 60% of which comes from groundwater aquifers. Extraction of these groundwater resources in Iran is 3 times faster than the recovery rate of these resources. The impact of depletion in Iran's groundwater reserves is already manifested by extreme overdrafts in around 77% of Iran's land area, growing soil salinity, and increasing frequency and extent of land subsidence in Iran's plains (Ashraf *et al*., 2021).

The question that always arises is whether agricultural production is based on the economic logic of cost minimizing and choosing optimal combinations of inputs, while considering resource sustainability

[1] Department of Agricultural Economics, University of Kurdistan, Islamic Republic of Iran.
[*] Corresponding author; e-mail: mhajirahimi@uok.ac.ir
[2] Department of Agricultural Economics, Shiraz University, Islamic Republic of Iran.
[3] Department of Agricultural Economic, Extension and Education, Faculty of Agricultural Sciences and Food Industries, Science and Research Branch of the Islamic Azad University, Tehran, Islamic Republic of Iran.

conditions, particularly irrigation water resources, or, it is just based on the living and subsistence needs of the society or farmers and their families. The other important question is whether water price policy could be effective in reducing demand for water and contributing to resource and environmental sustainability.

The answers to the above questions are really needed for Iranian agriculture to enhance inputs efficiency and utilization of farms' economies of scale, particularly in line with water resource conservation and environmental sustainability in different areas and plains with water crisis problems. In fact, sustainability of water resources could have an essential role in identifying the position and the level of development of the agricultural sector in each country or province.

Due to the growing need to pay attention to sustainable water resources management, and in line with the basic research question posed above, the present study aimed to investigate cost structure, economies of scale, and inputs elasticities for the major farm crops in Kurdistan Province, with emphasis on water resource conservation and environmental sustainability, in the framework of cost function analysis.

Kurdistan Province has an area of 28,235 km^2 (1.7% of Iran's area) is located in northwestern Iran. The province has 10 counties, 29 towns, 31 districts, 86 rural districts and 1,697 villages. According to the latest census of Iran (Iran Statistics Center, 2017), in 2016, the Kurdistan Province had a population of 1,603,011 (2% of Iran's Population). The share of rural and urban population in Kurdistan Province were 29.24 and 70.76%; while the same shares for the whole country were 26 and 74%, respectively (Iran Statistics Center, 2017). Expressly, compared to the national average, Kurdistan Province is relatively more dependent on the rural and agricultural sectors. The area of agricultural cultivable lands in this province is about 1.1 Mha, of which 0.7 Mha are allocated annually for production of various irrigated and rainfed crops while only 15% of the total cultivated lands are irrigated. There are 12 fertile plains in this province with an area of approximately 0.22 Mha, in which Qorve-Dehgolan Plain, with 0.07 Mha is the most important area of irrigated agriculture in the province. The Qorveh-Dehgolan Plain cultivated area is mostly under wheat, barley, potatoes, cucumber, and sugar beet (Agricultural Organization of Kurdistan Province, 2019). Agriculture in the Qorveh-Dehgolan Plain is almost entirely dependent on the extraction of irrigation water from the groundwater. The overdraft of groundwater in the study area, like most other parts of Iran, has led to a crisis of water and environmental instability (Abbasi *et al.*, 2016).

This study aimed to investigate the cost structure, economies of scale, and inputs elasticities for the major farm crops of the Qorveh-Dehgolan Plain, in Kurdistan Province. The analysis of production cost structure, farms' economies of scale, and inputs' demand elasticities, in line with sustainable use of groundwater in the study area, can help to better understand of farm management and show ways to improve productivity and environmental protection.

MATERIALS AND METHODS

Cost Structure

Cost function is a well-known and powerful tool for estimation of inputs demand function and has been applied for this purpose widely (Avazdahandeh *et al*., 2020; Ali-Ahmadi *et al*., 2018; Sun, *et al*., 2018; Nauges and Van den Berg, 2010; Liang and Coble, 2009). However, the power of this methodology in resource sustainability analysis has been underestimated in previous studies. Cost function approach can be applied for studying the sustainable use of natural resources, alongside with mathematical programming models (Qorbanian *et al*., 2013; Barikani *et al*., 2011) and econometric approaches (Expósito *et al*., 2020; Ashraf *et al*., 2021). In the present study, this aspect of the cost function approach was emphasized.

There are advantages in using a cost function instead of a production function to estimate production parameters. In general, cost functions have more flexible functional forms (Diewert and Wales, 1989). Therefore, they can be specified without imposing restrictions on technological parameters (Ray, 1982). It is also easier to estimate the parameters using the cost function method because cost is a function of the price of inputs of production, not input quantities. Furthermore, the probability of a collinearity problem between the prices of inputs is less than the probability of collinearity between input quantities (Lu *et al*., 2018). To sum up, it seems that the use of cost function is more appropriate for the analysis of production parameter characteristics and input substitution elasticities (Stier, 1985).

To build the cost function, several econometric models can be used. As Green (1993) points out, lack of sufficient accuracy in the proper definition of functional forms leads to the choice of a type of function that does not show the real relationship between the variables and the estimated parameters of these wrong functional forms do not have the required validity. There is always a risk that such errors will occur because economic theories do not provide the necessary guidance for selecting the best forms. Rather, they select functional forms only by stating the necessary conditions (Chambers, 1988). Cost function approach helps to express the relationship between the dependent variable and the independent variables in a better way, particularly for analyzing the effects of different policies. (Soltani-Zoghi and Haji-Rahimi, 2018; Avazdahandeh *et al*., 2020).

To estimate the cost function, the transcendental logarithmic (translog) functional form was selected based on its flexibility and accuracy for meeting our problem. The translog is a flexible generalization of the Cobb-Douglas production function. This increased flexibility allows it to more accurately represent empirical production functions (Coelli *et al*., 2005). The widespread use of translog functional form in agricultural economic studies has some reasons: flexibility, interrelationship analysis among inputs, and simplicity of extraction demand function for inputs (Christensen *et al*., 1973; Burgess, 1974; Moss *et al*., 2003; Ejimakor *et al*., 2017; Alizadeh *et al*., 2019): The translog multiple cost function can be shown as below:

$$\ln C = \alpha_0 + \sum_{i=1}^{m} \alpha_i \ln y_i + \sum_{i=1}^{n} \beta_i \ln P_i + \frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{m} \delta_{ij} \ln y_i \ln y_j + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} \ln P_i \ln P_j + \sum_{i=1}^{m}\sum_{j=1}^{m} \rho_{ij} \ln y_i \ln P_j \quad (1)$$

Where, C is the Cost of production, y is the amount of production, P is the Price of the production factors, m number of products, n represents number of inputs, ln is the symbol of the natural logarithm; α_0, αi, α_{ij}, β_i, δ_{ij}, γ_{ij}, and ρ_{ij} are the estimated coefficients.

In this study, seven products of the region (wheat, barley, alfalfa, potatoes, cucumbers, tomatoes, and sugar beets) and seven inputs (water, land, labor, machinery, fertilizers, pesticides, and seeds) were entered into the final cost function. For the purpose of homogeneity in the price of the inputs, it is necessary to apply the following constraints (Garcia and Randall, 1994):

$$\sum_{i=1}^{n} \beta_i = 1, \sum_{i=1}^{n} \gamma_{ij} = 0 \ (j = 1, \dots, m), \sum_{i=1}^{n} \rho_{ij} = 0 \ (j = 1..m) \quad (2)$$

Also, to equalize the function across derivatives, the following equation must be hold (Garcia and Randall, 1994):

$$\delta_{ij} = \delta_{ji} \qquad \gamma_{ij} = \gamma_{ji} \quad (3)$$

After estimating the cost function, by seemingly unrelated regression approach, it is necessary to control the conditions of the monotonic cost function for each observation. The monotonicity of the cost function requires that the estimated relative share equations of inputs be positive for each sample. If Si shows the share of the i input, then:

$$S_i = \frac{P_i X_i}{C} \quad (4)$$

Where, p_i and x_i represent the price and value of the input i in the product j, and C represents the total cost of the product. According to Shepard's Lemma, the derived demand function of inputs can be shown as below (Garcia and Randall, 1994):

$$x_i = \frac{\partial C}{\partial p_i} \quad (5)$$

$$\frac{\partial \ln c}{\partial \ln P_i} = \frac{\frac{\partial c}{c}}{\frac{\partial p_i}{p_i}} = \frac{\partial c}{\partial p_i} * \frac{p_i}{c} = x_i * \frac{p_i}{c} = \frac{x_i p_i}{\sum x_i p_i} = S_i \quad (6)$$

$$S_i = \frac{\partial \ln c}{\partial \ln P_i} = \beta_i + \sum_{i=1}^{n} \gamma_{ij} \ln P_j + \sum_{i=1}^{m} \rho_{ij} \ln Y_i \quad (j = 1, ... \quad (7)$$

Since, based on the homogeneity limit, the cost function is linearly homogeneous in the input price, the sum of the proportions of the share of costs must be equal to 1:

$$\sum_{i=1}^{n} S_i = 1 \quad (8)$$

Where, in equations 5 to 8, Si is the cost share of factor i, Pi is the price of inputs, Yi is the amount of output, and βi and ρij are coefficients.

Input Elasticities

After estimating the cost function, own and cross elasticity for inputs, including ordinary, Allen-Uzawa and Morishima measures of elasticity were estimated for each pair of inputs, based on the following equations (Blackorby and Russell, 1989 and 2007; Avazdahandeh *et al.*, 2020).

Ordinary elasticity:

$$e_{ii} = \frac{\partial ln x_i}{\partial ln p_i} = \frac{\partial x_i}{\partial P_j} * \frac{P_j}{x_i} \quad (9)$$

$$\hat{e}_{ii} = \hat{S}_{ii} . \hat{S}_i \quad (10)$$

$$\hat{e}_{ij} = \hat{S}_{ij} . \hat{S}_i \quad \text{for} \quad i \neq j \quad (11)$$

$$\hat{e}_{ij} = \left(\gamma_{ii} / \hat{S}_i \right) + \hat{S}_i - 1 \quad (12)$$

Allen-UOzawa elasticity:

$$S_{ij} = \frac{(\partial^2 c / \partial p_j . \partial p_i) . c}{(\partial c / \partial p_i)(\partial c / \partial p_j)} \quad (13)$$

$$S_{ii} = \frac{\gamma_{ij} + \hat{s}_i(\hat{s}_i - 1)}{(\hat{s}_i)^2} \quad (14)$$

$$\hat{S}_{ii} = \frac{\gamma_{ij}}{\hat{s}_i \hat{s}_j} + 1 \quad \text{for} \quad i \neq j \quad (15)$$

Morishima elasticity:

$$\varpi_{ii} = \frac{\partial ln(x_i^*/x_j^*)}{\partial ln(p_j^*/P_i^*)} \quad (16)$$

$$\omega_{ij} = \frac{\gamma_{ii} + s_i s_j}{s_i} - \frac{\gamma_{ii} - s_j^2 - s_j}{s_j} \quad (17)$$

Economies of Scale

The economies of scale can be calculated by Scale Elasticity (SE), or cost elasticity of production, which is the proportional increase in total costs resulting from a proportional increase in the output, holding all input prices and other explanatory variables fixed. Economies of scale will increase when SE< 1, or if the amount of production increases by 1%, the average cost increases by less than 1%. The criteria for measuring economies of scale for multi-product model are calculated as below (Glass and McKillap, 1989; De Roest *et al.*, 2018)**:**

$$SE = (\sum \frac{\partial lnC}{\partial lny_i})^{-1} = [\sum_{i=1}^{m} R_i]^{-1} \quad (18)$$

Area of Study

In order to have uniformity of climatic conditions and homogeneity of soil and water quality, the study area in Kurdistan Province was limited to villages located in Qorveh-Dehgolan Plain. The study area included 6 rural districts and 120 villages. The geographical location of the study area is shown in Figure 1.

Data and Sampling

The data were collected through a multi-stage cluster sampling survey in the 2017-2018 cropping year. Multi-stage sampling

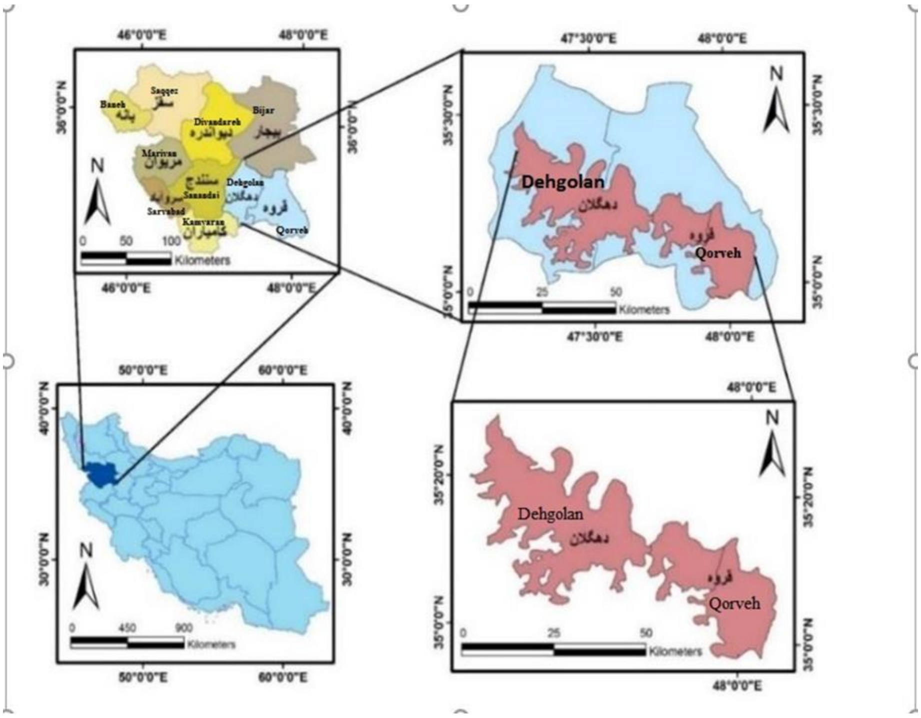

Figure 1. Geographical location of the study area.

method can provide a proper and balanced distribution of samples in the area under study. Villages were considered as sampling clusters. The number of sample clusters in each cluster was obtained based on Cochran formula:

$$n = \frac{Z^2 V^2}{E^2} \quad (19)$$

Where, n is the number of selected samples, Z is confident coefficient at 95%, V is the relative variance of wheat yield per hectare as the main crop in the study area, E is the acceptable error which is considered equal to 10%. According to Equation (19), 16 villages were selected as samples and 10 farmers were interviewed randomly in each village. Therefore, the final sample size was 160 farmers, from whom the needed data of crops and inputs were obtained.

RESULTS AND DISCUSSION

Cost Structure

The result of the estimated translog cost function that simulates the cost structure of farms is presented in Table 1. The calculated determination coefficient, R^2, for cost is 0.87. That is to say, 87% of cost changes are described by the variables of cost fiction. The Durbin Watson (DW) statistic that tests for autocorrelation in the residuals was equal to 1.92 that means no autocorrelation was detected in the study sample. Furthermore, the maximum likelihood ratio test showed that the cost function was non-homothetic and non- homogeneous. In a multiple-output non- homogeneous cost function, the optimal production is affected by the scale of the activity. The results show that a large percentage of the model variables were significant at different confidence levels. The significant coefficients reported in Table 1 cannot be interpreted on their own values; they were used to estimate elasticities.

After estimating the cost function along with the cost share equations by ISUR approach, the conditions of the monotonic cost function for each observation were controlled.

Table 1. The estimated the cost function of the products of the study area.

Parameter	Coefficient	T statistic	Parameter	Coefficient	T statistic	Parameter	Coefficient	T statistic
α_0	-1.642*	-1.49	α_{wh}	0.342***	2.782	β_F	-0.291***	-4.427
α_{Po}	0.783*	1.309	α_{Su}	0.265*	1.472	β_L	0.387**	1.930
α_{alf}	034**	1.696	β_M	-0. 851***	-3.244	β_S	0.719*	1.433
γ_{MM}	0.030*	-1.644	δ_{LH}	-0.079*	-1.292	ρ_{FL}	0.047***	2.150
γ_{MF}	0.039*	1.315	δ_{PH}	0.095**	1.801	ρ_{FS}	-0.050***	-2.117
γ_{ML}	0.071*	-1.456	δ_{FF}	-0.045**	-1.787	ρ_{WM}	0.034***	1.979
γ_{PP}	0.067***	-2.198	δ_{FW}	0.071*	1.294	ρ_{WP}	0.079**	1.713
γ_{PW}	0.036**	1.930	δ_{FH}	-0.052**	-1.366	ρ_{WW}	-0.037***	-3.337
γ_{FF}	0.076**	-1.739	δ_{WW}	0.053**	1.836	ρ_{WL}	-0.045***	-2.715
γ_{FL}	0. 088*	1.370	δ_{WH}	0.072**	1.753	ρ_{WS}	0.080***	1.911
γ_{WW}	0.055**	1.843	δ_{HH}	0.057**	1.999	ρ_{LM}	-0.044*	-1.578
γ_{WL}	0.070**	1.953	δ_{HS}	0.084***	1.979	ρ_{LF}	0.065**	1.701
γ_{LL}	0.044*	1.410	δ_{SS}	-0.039**	-1.713	ρ_{LL}	0.049***	1.903
γ_{HH}	0.060***	2.009	ρ_{MM}	0.035**	1.729	ρ_{LS}	-0.078*	-1.406
γ_{HS}	0.030**	1.654	ρ_{ML}	0.053***	1.983	ρ_{HM}	0.060*	1.421
γ_{SS}	-0.042*	-1.523	ρ_{MH}	-0.072*	-1.592	ρ_{HF}	-0.072***	-2.034
δ_{MW}	0.060*	1.371	ρ_{PW}	0.061**	1.774	ρ_{HL}	0.044*	1.435
δ_{MH}	0.034**	1.696	ρ_{PL}	-0.046***	-1.984	ρ_{SM}	0.056***	2.018
δ_{PW}	-0.030*	-1.644	ρ_{FM}	0.077***	2.047	ρ_{SP}	0.059***	2.277
δ_{LL}	0.039*	1.315	ρ_{FF}	0.053**	1.766	ρ_{SL}	-0.075***	-2.102
		$R^2 = 0.87$					DW = 1.92	

[a] Source: Research findings. *Significance at * 10%, ** 5%, and *** 1% levels.

The monotonicity of the cost function requires that the estimated relative share equations of inputs be positive for each sample. Since based on the homogeneity limit the cost function is linearly homogeneous in the input price, the sum of the proportions of the average share of input costs in production of the model products (wheat, barley, alfalfa, potatoes, cucumbers, tomatoes and sugar beets) must be equal to 1. The cost share coefficients of pesticide input, which had been eliminated from the model, were calculated according to the parameter of other inputs. The cost share of inputs is shown in Table 2. The cost of land with a share of 27% was the highest; the cost share of machinery, labor, water, fertilizer, seed and pesticide were 23, 18, 12, 9, 7, and 4%, respectively. As can be seen, the share of water costs after land, machinery, and labor is in the fourth place; whereas the irrigation water in all the studied farms in Qorveh-Dehgolan Plain was supplied from deep and semi-deep wells using pumps and irrigation equipment. This low cost-share of water has been only possible through direct and indirect subsidies to energy and irrigation equipment that has reduced the price of irrigation water; otherwise, irrigation water was expected to have the highest cost share after land. These results are consistent with Kalae (2015).

Input Elasticities

Own and cross price elasticity of demand and Allen-Uzawa substitution elasticity of inputs are reported in Tables 3 and 4, respectively. According to Table 3, all of the

Tables 2. Average Cost share of inputs.

Inputs	Land	Machin	Labor	Water	Fertilizer	Seed	Pesticide
Cost Share (%)	27	23	18	12	9	7	4

[a] Source: Research findings.

Tables 3. Own and cross price elasticity of input demands. [a]

	Water (W)	Land (L)	Labor (H)	Machin (M)	Fertilizer (F)	Pesticide (P)	Seed (S)
Water (W)	-0.760	0.357	0.207	0.287	-0.663	-0.441	-0.308
Land (L)	0.153	-0.342	0.670	0.634	0.233	0.178	-0.817
Labor (H)	0.550	0.215	-0.199	-0.440	0.201	-0.387	-0.640
Machin (M)	0.110	0.635	-0.303	-0.133	-0.242	0.505	-0.179
Fertilizer (F)	-0.540	-0.116	0.230	-0.155	-0.331	0.248	-0.089
Pesticide (P)	-0.290	0.890	-0.331	0.948	0.449	-0.785	-0.56
Seed (S)	-0.212	-0.490	-0.238	-0.310	-0.099	-0.222	-0.524

[a] Source: Research findings.

Table 4. Allen-Uzawa substitution elasticity of inputs. [a]

	Water (W)	Land (L)	Labor (H)	Machin (M)	Fertilizer (F)	Pesticide (P)	Seed (S)
Water (W)	-6.708	-	-	-	-	-	-
Land (L)	0.578	-3.362	-	-	-	-	-
Labor (H)	0.477	0.913	-3.510	-	-	-	-
Machin (M)	0.523	0.833	-0.573	-3.118	-	-	-
Fertilizer (F)	-0.327	0.674	0.303	-0.124	-2.533	-	-
Pesticide (P)	-0.205	0.245	0.637	0.344	0.349	-4.212	-
Seed (S)	-0.665	-0.287	-0.461	-0.650	-0.051	-0.818	-1.904

[a] Source: Research findings.

own price elasticities of demand for inputs had negative signs, as expected by the theory. These coefficients indicate an inverse relationship between the price and the quantity of demand for inputs. The absolute value of all ordinary own price elasticity coefficients is smaller than one, which indicates that demand for inputs, based on this kind of elasticity is inelastic. In other words, 1% increase in input price leads to <1% decrease in demand for that input. Pesticide and irrigation water demand with -0.785 and -0.760 own price elasticity had the most reverse response to price, while labor and machinery inputs had lowest own price elasticity. In cross elasticity coefficients, the positive values indicate substitution relationship between the inputs and the negative values indicate complementary relationship between the inputs (Liang and Coble, 2009). The results of own price elasticity are similar with Avazdahandeh *et al*. (2020) and Ali-Ahmadi *et al*. (2018).

According to Table 3, irrigation water had a substitution relationship with land, labor, and machinery inputs, while it had a complementary relationship with fertilizer, pesticide, and seed inputs. Therefore, an increase in irrigation water price would results in an increase in demand for land, labor and machinery inputs; while decreasing demand for chemical fertilizer, pesticide, and seed inputs, in the studied farms. The above results are similar with Avazdahandeh *et al*. (2020) in sign for land, labor, machinery, and pesticide.

Allen-Uzawa substitution elasticity of inputs is shown in Table 4. This type of elasticity is symmetrical and, therefore, half of the table is enough to describe the relationship between the inputs. In terms of signs, own and cross elasticity in ordinary and Allen-Uzawa types are identical, but with respect to considering cost shares in Allen-Uzawa measure of elasticity, the amount of elasticity is different in terms of values. That is, Allen-Uzawa elasticity is a sounder measure of how demand reacts to price change. The Allen-Uzawa elasticity showed that own- price elasticity of inputs is far greater than what is estimated by ordinary elasticity and, in fact, demand for inputs is elastic, on the basis of this kind of elasticity.

The Allen-Uzawa own price elasticity of irrigation water was -6.708, which shows water price policy can be effective in reducing water consumption in agriculture. This result is in line with Zhu *et al*. (2018) in China.

The results of Morishima Elasticities of Substitution (MES) and the effects of the input price change on the share of input costs are in Table 5. The Morishima substitution elasticities are non-symmetrical and estimable only for cross demands of inputs. They show that, if the relative price of two inputs is changed, what will be the change of their shares in total cost. The results showed that irrigation water is a Morishima substitute for land, labor, machinery, and seed; but a Morishima complement for fertilizer and pesticide inputs. These results are in accordance with ordinary and Allen-Uzawa elasticities, except in the case of seed inputs.

Land is a Morishima substitute for labor, machinery, seed, fertilizer, and pesticide; But it is a Morishima complement for irrigation water. Labor, pesticide and seed inputs are Morishima substitutes for all other inputs. Machinery is the Morishima substitute for all inputs, except labor. Fertilizer is the Morishima substitute for all inputs, except pesticides. The results of Morishima elasticity are somewhat different from Avazdahandeh *et al*. (2020) for Qazvin Plain in Iran. It should be noted that in addition to the differences in the study area, the data set used in the present study was cross-sectional type obtained by a direct questionnaire from farms, while the data set used in the above study had been panel data type from indirect sources.

Economies of Scale

Considering that the optimal size of the farm is related to that level of the crop at which each unit of the crop is produced at the lowest cost, knowledge of the type of return to scale on farms is essential. The results of the Scale Elasticity (SE) are

Tables 5. Estimation of the Morishima price elasticity. [a]

	Water (W)	Land (L)	Labor (H)	Machin (M)	Fertilizer (F)	Pesticide (P)	Seed (S)
Water (W)	-	0.9882	0.7926	0.0297	-1.8927	-0.4187	0.8089
Land (L)	-2.9563	-	0.046	0.1602	-0.7963	0.6227	0.891
Labor (H)	0.1954	0.41	-	1.0313	0.5412	0.4822	0.2896
Machin (M)	0.0534	0.8663	-0.8213	-	0.7581	0.0185	0.0754
Fertilizer (F)	0.4	0.4481	0.8746	0.342	-	-0.5168	1.4839
Pesticide (P)	0.0861	0.3413	0.2105	0.643	0.6796	-	0.0534
Seed(S)	0.9405	0.3917	0.2348	0.7896	0.4142	0.3623	-

[a] Source: Research findings.

Table 6. The measure of economies of scale for products. [a]

Economies of scale	Average	Standard error	Max	Min
SE_{Wheat}	0.788	0.052	1.418	0.611
SE_{Barley}	0.436	0.085	1.600	0.606
$SE_{\text{Alfa-alfa}}$	0.436	0.085	2.409	0.566
SE_{Potato}	1.727	0.064	3.521	0.800
SE_{Cucumber}	1.388	0.035	2.360	0.831
SE_{Tomato}	0.719	0.033	2.144	0.931
$SE_{\text{Sugerbeet}}$	1.072	0.052	1.816	0.728

[a] Source: Research findings.

presented in Table 6.

According to these results, wheat, tomatoes, barley, and alfalfa farms in the area under study are facing economies of scale, on average, wile, potatoes, cucumbers and sugar-beet farms are facing diseconomies of scale.

CONCLUSIONS

The results showed that average irrigation water cost-share for crops of the study area was 12%. This share is in the fourth place, after land, machinery, and labor. This low cost-share of water has been only possible through direct and indirect subsidies to energy and irrigation equipment that has reduced the price of irrigation water; otherwise, regarding its scarcity, irrigation water was expected to have the highest cost share after land.

The results of ordinary own-price elasticity showed that all elasticities of demand for inputs were negative, having an absolute value smaller than 1, which indicates that demand for inputs is inelastic, in terms of ordinary own-price elasticity. However, the Allen-Uzawa elasticities showed that the own-price elasticity of inputs could be far greater than what was estimated by ordinary elasticity; or, in fact, demand for inputs could be elastic. The implication of these results is that if the government applies real price policy through eliminating subsidies, particularly for irrigation water, the results can be effective and contribute to water resource sustainability in the Qorveh-Dehgolan Plain.

In terms of cross-elasticity coefficients, irrigation water had a substitution relationship with land, labor, and machinery inputs, while it had a complementary relationship with fertilizer, pesticide, and seed inputs. Therefore, an increase in irrigation water price would result in an increase in demand for land, labor, and machinery inputs potentially; while decreasing chemical fertilizer, pesticide, and seed input demands. Furthermore, the results of Morishima substitution elasticities showed that irrigation water was a Morishima substitute for land, labor, machinery, and seed; but a Morishima complement for fertilizer and pesticide inputs. According to these results, the real price policy for water in the study area i.e. elimination of subsidies for water pumping and irrigation equipment, not only can help to reduce the excessive use of water, but also reduces the use of pesticides and fertilizers. That is, the policy of real price for irrigation water in the area of study, in addition to helping water resource sustainability, can contribute to environmental sustainability by reducing pesticides and fertilizers use. It should be noted that these positive effects of real price for water will not be without cost and will naturally be accompanied by some reduction in production.

The results of economies of scale showed that wheat, tomatoes, barley, and alfalfa farms in the study area are facing economies of scale, on average, while potatoes, cucumbers, and sugar-beet farms are facing diseconomies of scale. According to these results, the increase in the area under cultivation of wheat, tomatoes, barley, and alfalfa in Qorveh-Dehgolan Plain potentially can contribute to make more use of the economies of scale and reduce the average cost of these products in the long-run. Nevertheless, it is obvious that farmers cannot immediately adjust the arable land and change farm size, but the knowledge of economies of scale can help them to make better decisions in crop mix, and develop proper strategies for optimal farm size in future.

REFERENCES

1. Abbasi, F., Azarakhshi, M., Chapi, K. and Bashiri, M. 2016. Spatial and Temporal Variations of Groundwater Level in Qorveh-Dehgolan Plain and its Relationship with Drought. *Water Soil Sci.,* **26(3-2):** 143-155.

2. Agricultural Organization of Kurdistan Province. 2019. Statistical Yearbook (2019). (http://kurdistan.agri-jahad.ir)
3. Ali-Ahmadi, N., and Moradi, A. and Hosseini, S. 2018. Application of Translog Cost Function in Estimating Water Demand of Wheat Crop in Sistan Region. *Water and Soil Conservation Research (Agricultural Sciences and Natural Resources)*, **25(4):** 331-338.
4. Alizadeh, P., Mohammadi, H., Shahnoushi, N., Saghaian, S. and Pooya, A. 2019. Evaluating Cost Structure and Economies of Scale of Beef Cattle Fattening Farms in Mashhad City. *J. Agr. Sci. Tech*. **21(Suppl.)**: 1753-1766.
5. Ashraf, S., Nazemi, A. and Agha Kouchak, A. 2021. Anthropogenic Drought Dominates Groundwater Depletion in Iran. *Nature Sci. Rep.*, **11:** 9135.
6. Avazdahandeh, S., Khalilian, S., Vakilpour, M. H. and Najafi Alamdarlo, H. 2020. Estimation of Irrigation Water Demand Function, Analyzing Its Cross and Symmetrical Relations with Other Inputs (Qazvin Plain). *J. Agr. Sci. Tech.*, **22(1):** 1-12.
7. Barikani, E., Ahmadian, M. and Khalilian, S. 2011.Optimal Sustainable Use of Groundwater in Agricultural Sector: Case Study Subsector in Qazvin Basin. *J. Agric. Econ. Dev.*, **25(2):** 253-262.
8. Baltagi, B. H. 2008. *Econometric Analysis of Panel Data*. John Wiley & Sons Ltd., Chichester.
9. Blackorby, C. and Russell, R. R. 2007. The Morishima Elasticity of Substitution. *J. Product. Anal.*, **28(3):** 203-208.
10. Blackorby, C. and Russell, R. R. 1989. Will the Real Elasticity of Substitution Please Stand Up? (A Comparison of the Allen/Uzawa and Morishima Elasticities). *Am. Econ. Rev.*, **79(4):** 882–888.
11. Burgess. D. F. 1974. A Cost Minimization Approach to Import Demand Equations. *Rev. Econ. Stat.*, **55:** 225-234.
12. Chambers, R. G. 1988. *Applied Production Analysis: A Dual Approach*. Cambridge University Press, New York.
13. Christensen, L. R., Jorgenson, D. W. and Lau, L. J. 1973. Transcendental Logarithmic Production Frontiers. *Rev. Econ. Stat.*, **55:** 28-45.
14. Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., and Battese, G. E. 2005. *An Introduction to Efficiency and Productivity Analysis*. 2nd ed. New York, NY, United States: Springer.
15. De Roest, K., Ferrari, P. and Knickel, K. 2018. Specialization and Economies of Scale or Diversification and Economies of Scope? Assessing Different Agricultural Development Pathways. *J. Rur. Stud.*, **59:** 222-231.
16. Diewert, W. E. and Wales, T. J. 1989. *Flexible Functional Forms and Global Curvature Condition*. NBER Technical Working Papers 0040, National Bureau of Economic Research, Inc.
17. Ejimakor, G., Quaicoe, O. and Asiseh, F. 2017. Agricultural Factor Use and Substitution in the South-Eastern United States. *Studies Agric. Econ.*. **119(3)**: 156-159.
18. Emami, M., Almassi, M., Bakhoda, H. and Kalantari, I. 2018. Agricultural Mechanization, a Key to Food Security in Developing Countries: Strategy Formulating for Iran. *Agric. Food Secur.*, **7(24):** 1-12.
19. Expósito, A., Beier, F. and Berbel, J. 2020. Hydro-Economic Modelling for Water-Policy Assessment under Climate Change at a River basin Scale: A Review. *Water*, **12(6):** 1559.
20. Fallahi, A., Khalilian, S. and Ahmadian, M. 2018. Determining the Economic Optimal Use of Water and Environment-Polluting Inputs for Irrigated Wheat Production (Case Study: Seidan-Farough Plain, Marvdasht Township). *Agric. Econ. Dev.*, **22(87):** 139-162.
21. Garcia, R. and Randall, A. 1994. A Cost Function Analysis to Estimate Effect of Fertilizer Policy on the Supply of Wheat and Corn. *Rev. Agric. Econ.*, **16:** 215-230.
22. Glass, J. C. and McKillop, D. G. 1989. A Multi-Product Multi-Input Cost Function Analysis of Northern Ireland Agriculture, 1955-85. *J. Agric. Econ.*, **40(1):** 57-70
23. Greene, W. 1993. *Econometric Analysis*. MacMillan, New York.
24. Gujarati, D. 1995. *Basic Econometrics.* 3rd Edition, McGraw-Hill.
25. Huang, K. S. 1991. Factor Demands in the U.S. Food-Manufacturing Industry. *Am. J. Agric. Econ.*, **73:** 615-20.
26. Iran Statistics Center. 2017. [https://www.amar.org.ir/english/Iran-Statistical-Yearbook/Statistical -Yearbook-2016-2017](https://www.amar.org.ir/english/Iran-Statistical-Yearbook/Statistical-Yearbook-2016-2017).

27. Kalaei, A. 2015. *An Analysis of the Cost Share of Water in the Prices of Agricultural and Horticultural Products.* Agricultural Planning, Economic and Rural Development Research Institute (APERDRI), Tehran.
28. Liang, Y. and Coble, K. H. 2009. A Cost Function Analysis of Crop Insurance Moral Hazard and Agricultural Chemical Use. *Proceeding of Agricultural & Applied Economics Association Annual Meeting*, July 26-28, 2009, Milwaukee, Wisconsin. (https://ageconsearch.umn.edu/record/49485).
29. Lu, H., Xie, H., He, Y., Wu, Z. and Zhang, X. 2018. Assessing the Impacts of Land Fragmentation and Plot Size on Yields and Costs: A Translog Production Model and Cost Function Approach. *Agric. Syst.*, **161:** 81-88.
30. Morishima, M. 1967. A Few Suggestions on the Theory of Elasticity. *Keizai Hyoron* (*Econ. Rev.)* **16:** 144-150. (in Japanese)
31. Moss, C. B., Erickson, K. W., Ball, V. E. and Mishra, A. K. 2003. A Translog Cost Function Analysis of U. S. Agriculture: A Dynamic Specification. Proceedings of Annual Meeting, American Agricultural Economics Association, July 27-30, Montreal, Canada.
32. Nauges, C. and Van den Berg, C. 2010. Heterogeneity in the Cost Structure of Water and Sanitation Services: A Cross-Country Comparison of Conditions for Scale Economies. *Oxford Dev. Stud.*, **38(2):** 199–217.
33. Qorbanian, A., and Zibaei, M., Qorbani, M., and Kohansal, M. 2013. Determining the Optimal Cultivation Pattern Due to Limited Groundwater Resources in Kavar Plain. *Agric. Econ. Dev.*, **27(1):** 1-7.
34. Ray, S. C. 1982. A Translog Cost Function Analysis of US Agriculture, 1939-1977. *Am. J. Agric. Econ.*, **64:** 49-98.
35. Soltani-zoghi, A. 2015. Determination of Pattern of Sustainable Use of Groundwater Resources the Case Study: Bahar-Ghorveh Plain. MSc Thesis, University of Kurdistan, Kurdistan, Iran.
36. Soltani-Zoghi, A. and Haji-Rahimi, M. 2018. Estimation and Comparison the Exploitation amount from Ground-Water Resources under Alternative Exploitation Models and Its Effect on Sustainability: The Study of Bahar-Hamedan Plain. *Agric. Econ. Res.*, **10(40):** 173-194.
37. Stier, J. C. 1985. Implication of Factor Substitution, Economies of Scale and Technological Change in United States Pulps and Paper Industry. *For. Sci.*, **31(4):** 803-812.
38. Sun, T., Huang, Q. and Wang, J. 2018. Estimation of Irrigation Water Demand and Economic Returns of Water in Zhangye Basin. *Water*, **10(1):** 19-40.
39. Surjit S. Sidhu. 1974. Economics of Technical Change in Wheat Production in the Indian Punjab. *Am. J. Agric. Econ.*, **56(2):** 217–226.
40. Zhu, X., Zhang, G., Yuan, K., Ling, H. and Xu, H. 2018. Evaluation of Agricultural Water Pricing in an Irrigation District Based on a Bayesian Network. *Water*, **10(6):** 768.

ساختار هزینه، صرفه های حاصل از مقیاس و استفاده پایدار از آب کشاورزی: مطالعه مزارع استان کردستان، ایران

م. حاجی رحیمی ، ا. سلطانی ذوقی، و ا. سید چمانی

چکیده

کشاورزی یکی از بخش‌های مسئول برای تامین مواد غذایی کافی و کمک به امنیت غذایی کشورها است. با این وجود، این مسئولیت به دلیل رشد سریع جمعیت و افزایش تقاضا برای غذا، روز به روز

سخت تر و چالش برانگیزتر می شود. پیامد این چالش، بهره برداری بی رویه از منابع طبیعی و تخریب محیط زیست است. مطالعه حاضر با هدف بررسی ساختار هزینه، صرفه‌جویی حاصل از مقیاس و کشش های قیمتی و جانشینی نهاده ها برای محصولات عمده کشاورزی در مزارع دشت قروه- دهگلان در استان کردستان با استفاده از الگوی تابع هزینه ترانسلوگ باشد. داده های مورد نیاز از طریق پرسشنانه و با روش نمونه گیری خوشه ای چند مرحله ای در سال زراعی ۹۷-۱۳۹۶ به دست آمد. نتایج نشان داد که سهم نهاده آب به طور متوسط در هزینه تولید محصولات مورد بررسی ۱۲ درصد است. همچنین نتایج نشان داد کشش‌های خود قیمتی معمولی تقاضا برای نهاده‌های تولید منفی و کوچکتر از یک هستند. باوجو این، نتایج کشش‌های خود قیمتی آلن- اوزاوا نشان داد که تقاضا برای نهاده‌ها و بخصوص آب کشاورزی می‌تواند کشش پذیر باشد. کشش خود قیمتی معمولی و آلن-اوزاوا برای نهاده آب به ترتیب ۰/۷۶- و ۶/۷- به دست آمد. همچنین نتایج نشان داد که مزارع گندم، گوجه‌فرنگی، جو و یونجه در منطقه مورد مطالعه از صرفه حاصل از مقیاس برخوردار هستند، در حالی که مزارع سیب‌زمینی، خیار و چغندرقند با عدم صرفه حاصل از مقیاس مواجه هستند.