EFFECTS OF ECONOMICAL FACTORS ON IRRIGATED WHEAT PROFITABILITY AND WATER PRODUCTIVITY IN LOWER KHARKHEH RIVER BASIN OF IRAN

EFFETS DES FACTEURS ECONOMIQUES SUR LA RENTABILITE DE BLE IRRIGUE ET LA PRODUCTIVITE DE L'EAU DANS LE BASSIN FLUVIAL INFERIEUR DE KHARKHEH EN IRAN

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ABSTRACT

In the management of water demand in the arid and semi-arid regions, measures that ensure water saving and enhancing water productivity (WP) are important. The general objective of this study is to assess the effects of such measures on WP of irrigated wheat under farmers' condition in lower KRB (L-KRB). This includes socio-economic characteristics of sample farmers and target regions, determination of profitability indexes and average WP in irrigated for the sample farmers, estimation of production value of one Rial worth of water use and determination of different factors affecting water use efficiency and inefficiency in the Azadegan (DA) and Sorkheh plains (DS) in the lower KRB. The study was implemented in the DA and DS plains in the L-KRB, during 2006-2007. Relevant data were collected in two steps. In the first step, library studies were conducted to collect basic information from previous research on the subject. In the second step, 166 farmers were selected in the two locations by stratified random sampling method. Average productivity was calculated as total production divided by water use. Profitability indexes (Net income : cost ratio and sale of return) were calculated using Microsoft Excel.

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Socio-economic factors influencing WP were determined using stochastic production and cost frontier function.

According to the results, in DS, average planting area for wheat and maize were, respectively, 19.1 ha and 13.3 ha.. Average water use for wheat was 7323 m^3/ha. In the DA, average planting area was 18.6 ha and the average water use for wheat was 6570 m^3/ha. In the DS and DA, the average net profit from wheat was 4922.6 and 1186.8 000Rials/ha, respectively. Results also showed that, In the DS and DA, 43.5% and 77.3% of the gross income from wheat was spent for fixed and variables costs of production, respectively. Meanwhile, for one Rials of sale, profit gained was 56.5% and 22.7%, respectively. The value of production Wheat for one Rials of water used was 10.7, and 4.1 Rials, respectively. Water cost ratio showed that, out of Gross income of Wheat, about 10% and 24% were consumed for Water costs, respectively.

In the DS and DA, average WP for Wheat was 0.58, and 0.39 kg/m^3, respectively. In target regions, water price, seeding rate, Urea and Phosphate rates had significant effects on WP of wheat. Variables of land tenure, water limitation, soil salinity and soil texture had significant effects on inefficiency. The average technical efficiency of wheat farmers in water use was estimated 88% .

Keywords: *Wheat, Profitability, Water productivity, Khuzestan, Kharkheh River Basin, Iran.*

RESUME

Pour la gestion de demande d'eau dans les régions arides et semi-arides, il est nécessaire à prendre des mesures qui assurent l'économie d'eau et l'amélioration de la productivité de l'eau (WP). Cette étude vise à évaluer les effets de telles mesures sur la productivité de l'eau (WP) de blé irrigué par les fermiers dans le bassin fluvial inférieur de Kharkheh (L-KRB). Cette étude comporte les caractéristiques socio-économiques de certains fermiers et des régions cibles, la détermination de l'index de rentabilité et la moyenne productivité de l'eau (WP), l'évaluation de la valeur de la production et la détermination des différents facteurs qui affectent l'efficience et l'inefficience de l'utilisation d'eau dans les plaines d'Azadegan (DA) et de Sorkheh (DS) du L-KRB. L'étude a été mise en oeuvre en 2006-2007 dans les plaines de DA et de DS du L-KRB. Les données appropriées ont été recueillies dans deux étapes.

Dans la première étape, les études de bibliothèque ont été menées pour recueillir les informations de base de recherche menée dans le passé à ce sujet. Dans la deuxième étape, 166 fermiers ont été choisis dans deux endroits par la méthode d'échantillon randomisée stratifiée. La productivité moyenne fut calculée par rapport à la production totale divisée par l'utilisation de l'eau. Il a été procédé au calcul des indices de rentabilité en utilisant Microsoft Excel. Les facteurs socio-économiques étaient aussi déterminés qui influent sur la productivité de l'eau, en utilisant la production stochastique et le coût de fonctionnement limité.

Selon les résultats, dans la plaine DS, la superficienne moyenne utilisée pour la cultivation du blé et du maïs était respectivement, 19,1 ha et 13,3 ha. L'utilisation de l'eau moyenne pour le blé était 7323 m^3/ha. Dans la plaine DA, la superficienne moyenne était 18.6 ha et l'utilisation de l'eau moyenne pour le blé était 6570 m^3/ha. Dans les plaines DS et DA, le *profit net moyen du blé était 4922,6 et 1186,8 000Rials/ha. respectivement. Les résultats ont également montré que dans les plaines DS et DA, un revenu brut du blé de 43,5 % et 77,3 % était dépensé sur les coûts fixes et variables respectifs de production. Pour un rial utilisé, le profit était de 56,5 % et 22,7 % respectivement. La valeur de production du blé en utilisant l'eau d'un rial était de 10,7 et 4,1 rials respectivement. La proportion de coût d'eau a montré que, sur le revenu brut du blé, environ 10% et 24% du montant respectif at été utilisé pour les coûts d'eau.*

Dans les plaines DS et DA, la productivité de l'eau moyenne pour le blé était de 0,58 et 0,39 kg/m3 respectivement. Dans des régions cibles, le prix d'eau, le prix de graine, etc. portent des effets significatifs sur la productivité de l'eau de blé. Les variables telles que le droit d'exploitation de la terre, la disponibilité limitée de l'eau, la salinité du sol et la texture du sol affectent de manière significative l'inefficience. L'efficience technique moyenne des fermiers de blé dans l'utilisation de l'eau a été évaluée à 88 %.

Mots-clés: *Blé, rentabilité, productivité de l''eau, Khuzestan, bassin fluvial de Kharkheh, Iran.*

1. INTRODUCTION

In Iran, the irrigation water use for agricultural crops is high compared to other countries in the world. The average water use for wheat is between 4500-6500 m^3/ha in world, but in Iran, it is 8000 m^3/ha. About 93% of the renewable water resources of the country is used in agriculture, but, the agricultural production is insufficient (Keshavarz and et al, 2005). The Karkheh River Basin (KRB) is located in the west to south – west of Zagroos ranges in Iran between 56°, 34° - 58°, 30° North Latitude and 46°, 06° - 49°, 10° longitude. The area of the basin (in Iran) is 50764 km2, out of which 27645 km2 are mountains and 23119 Km2 are plains and hills. The mountainous areas are mostly in the eastern and central parts. The Plains, mostly in the Northern and Southern parts, cover almost 45% of the basin area. Water in the KRB is limited and becoming scarcer as population and demand are increasing. The productivity of rain-fed agriculture is low, conventional irrigation management is poor, cropping systems are sub-optimal, and policies and institutions are weak. However, Iran's agricultural strategy identifies water productivity improvement as a top priority. The KRB reflects in many aspects the problems of water management in other basins in the region (Keshavarz and Koroosh ,2005; Ministry of Enery of Iran, 2003). According to a study of on-farm water use efficiency in Syria, a total of 80 farmers were sampled from 24 villages in Aleppo province, northwest Syria. The average amount of water applied to a farm was 19831 m3 and average water application by crop was 4833, 3770 and 15385 m3 for wheat, barley and cotton, respectively. Results showed that the water productivity for wheat, barley and cotton were 0.9 ,0.56 and 0.57 kg/ m3, respectively. The adjusted coefficient of determination (R^2) were 0.65, 0.53 and 0.93 for wheat, barley and cotton, respectively. Output prices appear to be a strong determinant of short-run decisions on water allocation among competing crops. The price variables for wheat, barley and cotton are positive and significant in explaining water use. On-farm water use efficiency (FWUE) in wheat, barley and cotton was 0.61, 0.45 and 0.76, respectively (Shideed and Oweis, 2005). In another study of on-farm water use efficiency in Rabea district in northwest Iraq, 100 farmers were sampled. The average amount of water available to the whole farm for winter cropping was 448006 m^3 and average water application by crop was 5424, 75216 and 40289 m^3 for wheat, potato and sugar beet, respectively.

Water productivity was highest for potato 1.44 kg/m^3. Water productivity for wheat, sugar beet and tomato were estimated as 0.7 ,0.97 and 0.73 kg/m^3, respectively. Results implied that, crop area and price were the most important two variables explaining the farmers water use decision in irrigating potato, sugar beet and tomato. The estimated coefficients of these two variables were positive and highly significant in each water-use equation of the three crops. The water constraint variable was positive in the water-use equations of the four crops, but it was significant in wheat and tomato. Average of On-farm water use efficiency (FWUE) in wheat, potato, sugar beet and tomato was 0.34, 0.45, 0.32 and 0.68 in Fix-allocate input model (Oweis, et al , 1999). In Al Ghor of Jordan, the study of on-farm water use efficiency was done on a sample of 70 farms. Results showed that water productivity under irrigation condition for tomato, potato, wheat and onion were 1.706, 2.854, 0.172 and 0.63 kg/m^3, respectively. The value of water productivity estimated was 16.89 JD/m^3 for tomato,17.84 JD/m^3 for potato and 4.81 JD/m^3 for onion (1 JD = 1.421 USD). Actual water used for tomato, potato, wheat and onion was estimated to be 4038, 2212, 2160 and 2770 m^3, respectively. Required water for tomato, potato, wheat and onion were estimated as 4014, 2222, 1684 and 2809 m^3, respectively (Shideed and Oweis, 2005). The purposes of this study were to: Investigate the Socio-economic characteristics of sample farmers; determine the factors that explain water productivity and the status of on-farm water use efficiency and determine the sources of inefficiency in wheat production in L-KRB of Khouzestan province.

2. MATERIALS AND METHODS

1. Research theory:

There are three common approaches for estimating technical efficiency namely, the non-parametric, the non-stochastic and the linear programming. The second approach uses econometrics to estimate a stochastic frontier function and to estimate the inefficiency component of the error term. The stochastic frontier model assumes an error term with two additive components: an asymmetric component which accounts for pure random factors (vi) and a one-sided component which represents the effects of inefficiency relative to the stochastic frontier (ui). The random factor (v) is independently and identically distributed with N (0,бV2) while the technical inefficiency effect, (u), is often assumed to have a half normal distribution IN (0,бV2). The Battese and Coelli (1995) model specification may be expressed as:

$$Yi = Xi\,\beta + (v^i - ui)^*$$

Where Yi is the logarithm of the production of the ith farm, Xi is a K*1 vector of input quantities of the ith farm, β is a vector of unknown parameters, vi are random variables, assumed to be distributed N (0, бV2), and independent of the ui which are non-negative random variables accounting for technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the N (mi, бu2), distribution where: m i = z i φ (z I is a p*1 vector of variables which may influence the efficiency of a farm and φ is an 1*p vector of parameters to be estimated). Variance parameters expressed as: б2 = бV2 + бu2 and γ = бu2 / (бV2 + бu2).

The parameter γ, varies between 0 and 1 such that 0 is associated with the traditional response function, for which the non-negative random variable, ui, is absent from the model. Thus, this model specification is non-nested and hence ni set of restriction can be defined to permit a test of one specification versus the other. In this specification, the parameters β, б, бu and γ can be estimated by the maximum likelihood method, using the computer program: Frontier Version 4.1. This program also computes estimates of efficiency. The measures of technical efficiency relative to the production frontier and of cost efficiency relative to the cost frontier are defined as:

$$EFFi = E(Yi^* \ Ui, Xi) / E(Yi^* \ Ui,=0, \ Xi)$$

Where Yi* is the production or cost of the ith farm, which will equal Yi when the dependent variable is in original units and will equal exp(Yi) when the dependent variable is in logs. In the case of a production frontier, EFFi will take a value between 0 and 1, while it will take a value between 1 and ∞ in the cost function case.

Average water productivity (WP), profitability, cost ratio and sale of return indexes were determined using, respectively, the following equations:

WP = Total product / water use
Cost ratio = (Total cost / Gross income) * 100
Sale return = (Net profit / Gross income) * 100
Net Profit = (Gross income - Total cost)

2. Research method:

The study was done in the DA and DS plains in the Khuzestan province for wheat, barley and maize during the years 2006-2007. Data were collected from the literature and from a sample of 166 farmers selected by stratified random sampling method.

$$n = \frac{\Sigma (Ni2 \ .Vi / Wi)}{N2 \ \ D + \Sigma (Ni.Vi)} \qquad i= 1 , 2 \qquad Wi = Ni / N \qquad D= B2 /4 \qquad ni = n (Ni/N)$$

i = (1- Azadegan plain , 2- Sorkheh plain), n = Sample size, N = The number of population of farmers in regions (Azadegan and Sorkheh plain), Vi = The variance of area land in stratum I, Ni = The number of farmers in stratum I, Wi = The fraction of observation allocated to stratum i, D = Bound of error and ni = The number of sample size in stratum i.

The required data were collected through questionnaire. Variables including land size (ha), water price (rial/m^3), seed rate (kg/ha), urea rate (kg/ha), phosphate rate (kg/ha), price of crop (rial/kg), technology and cropping area explain water productivity (WP). Dummy variables including land tenure: private (1) and rented (0)), water limitation: yes (1) and no (0), soil salinity: low (1), otherwise (0), soil texture: light (1), otherwise (0), irrigation technology: sprinkler (1), otherwise (0), method of irrigation, method of land preparation and water quality explain inefficiency.

3. RESULTS AND DISCUSSION

Socio-economic characteristics of sample farmers in DA and DS plains

In Sorkheh plain, the average distance between farm and village is 4.1 km, average age of the farmers is 45.1 year, average number of children per person is 5.1. Education level of farmers is between preparatory and secondary. Average experience in agriculture was 25 years. About 7% of farmers participated in extension program. The share of irrigated crops in household income was 96.9%. In Azadegan plain, the average distance between farm and village is 2.6 km, avarage age 44.7 year, average number of children per person is 6.1, average number of children active in farm was one. Average experience in agriculture was 24.3 year. About 52% of farmers participate in extension program. The share of irrigated crops to household income was 78.3%. The contribution of off-farm and on-farm activities to household income was 9.6 and 90.4 percent, respectively.

Table 1. Socio-economic characteristics of sample farmers in DA and DS plains

Characteristics	Means		Max		Min	
	Azadegan plain	Sorkheh plain	Azadegan plain	Sorkheh plain	Azadegan plain	Sorkheh plain
Age (year)	44.7	45.1	75	70	23	32
Number of children	6.1	5.1	18	10	0	1
Number of children active in farm	1	1.9	11	4	0	0
Experience in agriculture (year)	24.3	24.9	60	50	3	10
Land tenure(ha)	20.8	22	100	65	1.5	4
Contribution of irrigated crops to household income (%)	78.3	96.9	100	100	10	60

Source: Research data

In Sorkheh plain, average seeding rate, urea, phosphate and potassium rates for irrigated wheat were 255, 323.3, 158.3 and 81.5 kg/ha. Average water use was 7322.3 m^3/ha. The average net profit of irrigated wheat was 4.9 million rials/ha with a cost ratio and sale return of 43.5% and 56.5%, respectively. The average water productivity (WP) was 0.58. The value of wheat production for one rial water use was 10.74 rials. Water cost ratio was 10%.

In Azadegan plain, average seeding rate, urea and phosphate rate for irrigated wheat were 283.1 ,215.3, and 121.4 kg/ha. Average water use was 6569.5 m^3/ha. The average net profit of irrigated wheat was 1.2 million rials/ha with a cost ratio and sale return of 77.3% and 22.7%, respectively. The average water productivity (WP) was 0.39. The value of wheat production for one rial water use was 4.1 rials. Water cost ratio was 24%.

Table 2 . The mean of input use by sample wheat farmers in total target regions

Explain	Azadegan plain	Sorkheh plain
Seed rate(kg/ha)	283.1	255
Urea rate(kg/ha)	215.3	323.3
Phosphate rate(kg/ha)	121.4	158.3
Potassium rate(kg/ha)	-	81.5
Planting area(ha)	18.6	19.1
Number of plots	2.4	3
Water applied rate(m^3/ha)	6569.5	7322.3

Source: Research data

Table 3 . The mean of profitability indexes of sample wheat farmers in total target regions

Explain	Azadegan plain	Sorkheh plain
Yield(kg/ha)	2575.1	4146.7
Gross income (000 rial/ha)	5237.7	8705.7
Total cost (000 rial/ha)	4051	3783.2
Net profit (000 rial/ha)	1186.8	4922.6
Cost ratio (%)	77.3	43.5
Sale return (%)	22.7	56.5
Average WP	0.39	0.58
Value of production for one rial water use (rial)	4.1	10.74
Water Cost ratio (%)	24	10

Source: Research data

Average water productivity for wheat was 0.58 and 0.39 in Sorkheh and Azadegan plain, respectively. According to the results for wheat in target regions, variables including water price (t-ratio = - 4.7), seed rate (t-ratio= + 2.14), urea rate (t-ratio= + 4.4), phosphate rate (t-ratio = +3.27) had significant effect on water productivity (WP). These variables explain water productivity. Relation of between land size under wheat and water productivity was negative. For wheat in target regions, the different levels of inefficiency can be explained by land tenure (t-ratio= - 3.25), water limitation (t-ratio= + 8.51), soil salinity (t-ratio = - 2.61), soil texture (t-ratio = + 2.53). These variables had significant effect on technical inefficiency. Sigma-squared and gamma estimates were 0.598 and 0.841, respectively. Log likelihood function was -0.129 For wheat. The mean technical efficiency of sample farmers in water use was 0.88.

Table 4. Maximum likelihood estimates of the variables explaining water productivity (WP) for wheat crop

Variable	Name of parameters	Estimated of coefficient	Standard-error	t-ratio
Intercept	B_0	- 4.61	1.83	- 2.52
Land size	B_1	- 0.0139	0.0219	- 0.64
Water price	B_2	- 0.172	0.037	- 4.68
Seed rate	B_3	0.324	0.152	2.14
Urea rate	B_4	0.219	0.0498	4.4
Phosphate rate	B_5	0.161	0.0492	3.27
Wheat price	B_6	0.121	0.143	0.85

Source: research data

Table 5. Maximum likelihood estimates of the variables explaining inefficiency for wheat crop

Variable	Name of parameters	Estimated of coefficient	Standard-error	t-ratio
Intercept	Z_0	0.183	0.0618	2.96
Land tenure(LT)	Z_1	-0.187	0.058	-3.25
Water limitation (WL)	Z_2	0.136	0.016	8.51
Soil salinity(SS)	Z_3	-0.126	0.048	-2.61
Soil texture(ST)	Z_4	0.0836	0.0331	2.53
Sigma-square	$Б_2$	0.0598	0.0062	9.62
Gamma	γ	0.0084	0.0415	0.202
Log of likelihood function	L	-1.29	-	-

Source: research data

Estimated model :

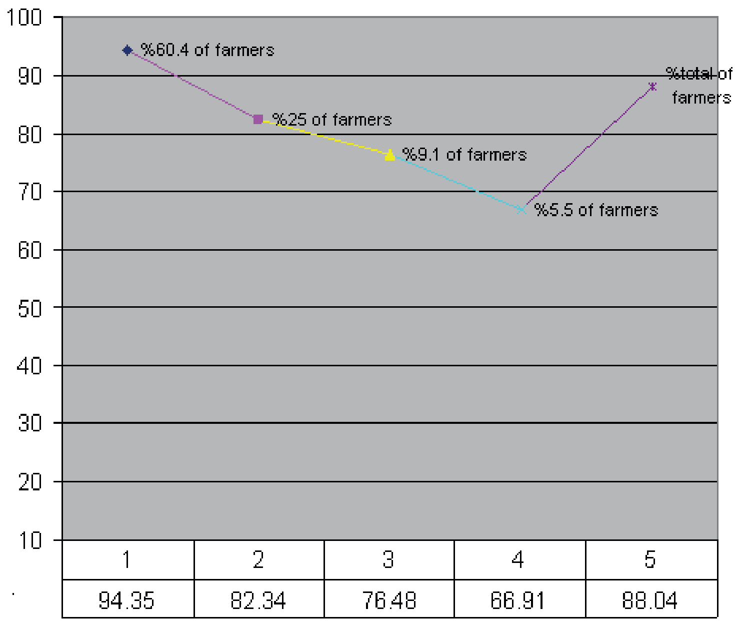
WPw = -4.61WP-0.172 SR 0.324 UR 0.219 PR 0.161
U w = 0.183- 0.187 LT+ 0.136WL - 0.126 SS+0.084 ST
Log Likelihood = - 1.29 б2 = 0.084 γ = 0.0084

Technical efficiency (TE) of wheat farmers in water use varied greatly: For 60.4% of the farmers it was greayer than 90%, for 25% the range was (>=80%<90%), for 9.1% the range was (>=70%<80%) and 5.5% of wheat farmers had a TE in the range of (>=60%<70%). The mean of TE of wheat farmers in water use was 88.04% , with the maximum and minimum values of 99.6% and 66.8%, respectively.

Table 6 . Technical efficiency of sample farmers in water productivity

Efficiency (%)	Wheat farmers	
	Frequency	% of frequency
>= 90	99	60.4
>= 80<90	41	25
>= 70<80	15	9.1
>= 60<70	9	5.5
Mean	88.04%	
Max	99.6%	
Min	66.8%	

Source: Research data



Per cent Farmers

Fig. 1. Average technical efficiency of water use by wheat farmers.

For about 77.1% of farmers in target regions irrigation development resulted in better livelihoods and increase and stability of the production.

Table 7. Describing the effects of irrigation development on household livelihoods

Item	Shorkheh plain			Azadegan plain			Total		
	F	F %	CF %	F	F %	CF %	F	F %	CF %
Income increasing	1	3.3	3.3	23	16.9	16.9	24	14.5	14.5
Income decreasing	2	6.7	10	-	-	16.9	2	1.2	15.7
Do not effect	2	6.7	16.7	-	-	16.9	2	1.2	16.9
Increase and stability of the production	21	70	86.7	107	78.7	95.6	128	77.1	94
Without answer	4	13.3	100	6	4.4	100	10	6	100
Total	30	100	-	136	100	-	166	100	-

Source: Research data. (Legend: F=Frequency; CF=Cumulative Frequency)

4. CONCLUSIONS

According to the results in target total regions, the averages of water use and water charge for wheat were estimated as 6705.5 m^3/ha and 128.9 rial/m^3, respectively. Variables including water price, seed rate, urea rate, phosphate rate had significant effect on water productivity (WP). The mean technical efficiency of sample wheat farmers in water use was estimated as 88% with the maximum and minimum values of 99.6% and 66.8%, respectively. The mean net profit of irrigated wheat in Sorkheh and Azadegan plain were estimated as 4.9 and 1.2 million rials/ha, respectively. The mean of WP for wheat in Sorkheh and Azadegan were 0.58 and 0.39. Water cost ratio and sale return in Sorkheh and Azadegan was 10% and 24%. About 77.1% of the farmers in target regions had benefits of irrigation development in terms of better livelihood and stability of the production.

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