INPUT USE EFFICIENCY AND IRRIGATION IN AGRICULTURE: THE CASE OF IRAN

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Abstract: The present paper attempts to study the resource use efficiency over a cross section of sample farms drawn from two development blocks (one from highly irrigated region and other from less irrigated region) in Arak district of Markazi province, Iran; with the purpose to find out whether the increase in irrigation facilities leads to increase the efficiency of other inputs in the crop production, identify the inputs which are not efficiently utilised in the production function and draw policy implications. Using a Cobb-Douglas type of function and computing marginal value productivity of each input, according to the findings of the regression model, irrigation and fertilizers & manure are efficiently used in both the blocks, while labor is efficiently utilized only in highly irrigated area and bullock labor, farm implements & machinery are inefficiently used in both the blocks. Comparative study of wheat and barley crops in both the blocks exhibits that wheat farming is profitable only in highly irrigated block while barley farming is profitable in both the blocks.
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1. Introduction

Like other productive enterprises, resources used in agriculture are also scarce and need to be used and managed in an efficient manner to enhance farm output and income (FAO, 2002; Seckler et al., 2003). Irrigation is one of the crucial inputs for obtaining higher growth in agriculture (Gowing, 2002). It is a deciding factor in augmenting the efficiency of other complementary inputs. This factor along with its complementary inputs increases the productivity of land with the existing inputs and also induces the other inputs for their increased use (IWMI, 2002a, b). Raising thereby, the level of production and employment still further. Various studies have been conducted on different aspects of input use efficiency in agriculture (Howell, 1994; Skewes &Meissner, 1998; Shannon & Raine, 1996; Cai et al., 2001). The studies of Saini (1969), Sharma and Rathi (1985) and Kaushik and Gangwar (1985) show higher input use efficiency in small farms while the findings of Singh (1973) divulge the higher input use efficiency in large farms. The study of Begi (1980) which shows the nexus between irrigation and resource use efficiency indicates higher input use efficiency on irrigated farms in comparison to unirrigated farms (Machibya, 2003; Molden et al., 2003). Dhawan (1983) and Thakur and Kumar (1984) found higher input use efficiency on private tube well irrigated farms as compared to other sources of irrigation (Lankford, 1998). The results of the study conducted by Gajja et al. (1994) indicate that as the land irrigability class and soil degradation level deteriorate, the marginal value productivity and allocative efficiency of all inputs decline. The study of Das (1993) evinces higher resource use efficiency on farms having new dug well with pumpsets. The present paper attempts to study the resource use efficiency over a cross section of sample farms drawn from two development blocks (one from highly irrigated region and other from less irrigated region) in Arak district of Markazi province, Iran; with the purpose to find out whether the increase in irrigation facilities leads to increase the efficiency of other inputs in the crop production, identify the inputs which are not efficiently utilised in the production function and draw policy implications. The study is confined only to two main crops (wheat and barley) of the district.

2. Material and Methods

The present study is based on primary data collected through pre-tested questionnaire schedule for the agriculture year 2009-2010. On the basis of available irrigation facilities, the study area has been divided into two regions, viz. highly irrigated and less irrigated. The highly irrigated region which comprises 9 development blocks covers 81% of net sown area (NSA) of the district. The less irrigated region includes 2 development blocks and covers only 19% of NSA. The net irrigated area in highly irrigated and less irrigated regions was 93.14% and 42.65% respectively. Stratified random sampling technique of survey has been adopted to collect the primary data. At the first stage, Khondab block from highly irrigated region and Farahan block from less irrigated region are selected. In the second stage, five villages from each block are selected and at the third stage 150 operational holdings (75 holdings from each block) are selected. The operational holdings are categorised as small (0-2 ha), medium (2-4 ha) and large (4 ha and above).

3. Results

Wheat and barley crops have been selected for the analysis of resource use efficiency maily because these two crops are the common crops of both the blocks and they occupy a sizable area in the district. In highly irrigated block, i.e. Khondab block, wheat and barley occupy 55% and 23% of cropped area (GCA) respectively. While in less irrigated block, i.e. Farahan block, they cover 20% and 31% of GCA respectively. In highly irrigated block, the major sources of irrigation are canal, diesel operated tube wells (DOTW), electric operated tube wells (EOTW) and conjunctive (canal plus DOTW). The net irrigated area by all sources of irrigation on sample farms was 99.65%. The irrigated area under canal, EOTW, DOTW and conjunctive was found 18.38%, 18.49%, 26.95% and 36.19% respectively. Farahan block has spare irrigation facilities. This block has no canal irrigation. Minor irrigation is the only source of irrigation in the block. The net irrigated area on sample farms was observed only 18% of which DOTW and EOTW constitute 83% and 17% respectively.

The input elasticity's along with their standard errors for wheat and barley, marginal value productivities (MVPs) and geometric mean of gross income and all inputs have been worked out to know the input use efficiency. Cobb-Douglas type of function has been fitted to work out the inputs elasticises with respect to farm income. The choice of the function is based on its theoretical fitness to agriculture.

$$Y = A . X_1^{b1} . X_2^{b2} . X_3^{b3} . X_4^{b4} . X_5^{b5} . X_6^{b6} X_7^{b7} .U$$

By taking logarithms of both sides the above function is linearised as follows:

$$\text{Log } Y = \log A + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + b_7 \log X_7 + \log U$$

Where:

Y = Gross income (GI) per hectare / 1000 Rials

X_1 = Value of seeds per hectare / 1000 Rials

X_2 = Value of fertilizers and manure per hectare / 1000 Rials

X_3 = Standard hours of irrigation per hectare (one standard hour of irrigation = 10000 gallon of water)

X_4 = Labor absorption in man days / hectares

X_5 = Bullock labor days per hectare

X_6 = Per hectare cost of machines in 1000 Rials. It includes charges for owned as well as hired implements and machinery for the purpose of ploughing, threshing, transportation etc.

X_7 = Per hectare cost of rest of inputs in 1000 Rials.

In order to know the input use efficiency, marginal value productivity (MVP) of each input is computed. The ratio of MVP of an input to its cost must be either equal to one or more than one if the resource is to be utilized efficiently. MVP of X_i, the i^{th} input, is worked out by the following equation:

$$MVP (X_i) = b . Y / X_i$$

Where:

b is the elasticity of GI of i^{th} resource

Y is Geometric mean of GI

X_i is Geometric mean of i^{th} resource

1.3. Resource Productivity in Wheat

The value of regression coefficients, their standard errors and R^2 for different categories of farms in both the blocks is given in Table 1. In Khondab block, the values of R^2 reveal that 6% to 28% variations in GI per hectare from wheat are explained by the explanatory variables. The magnitudes of regression coefficients which have positive and significant impact on GI are: 0.207 for fertilizers & manures for small farms, 0.184 for fertilizers & manure and 0.329 for irrigation on medium farms; 0.296 for fertilizers & manures, 0.657 for human labor on large farms and 0.231 for fertilizers & manure, 0.115 for irrigation, 0.413 for human labor on over all categories of farms. The bullock labor on large and over all farms has not been efficiently utilized as its coefficients have significant negative values. The regression coefficients for all other inputs are not found statistically significant.

In Farahan block, 6% to 84% variations in GI are explained by the explanatory variables. The magnitudes of regression coefficients which have significant negative impact on GI are seeds, irrigation, human labor, bullock labor, farm implements & machinery and other cost on small farms. Except irrigation on medium and over all farms, all the inputs have either negative values or insignificant positive values. A close look on the table indicates that wheat is not found a profitable crop in less irrigated block. All the inputs used in wheat production show general inefficiencies. In highly irrigated block, fertilizers & manure, irrigation and human labor are the inputs which are found efficient to raise the GI from wheat while all other inputs are not judiciously applied.

2.3. Marginal Value Productivity in Wheat

The MVPs of the resources and their standard errors for different categories of farms of wheat are presented in Table 2. In Khondab block, the resources whose MVPs are significantly higher than their acquisition cost are: fertilizers & manure on all categories of farms, irrigation on medium and over all categories of farms, human labor on large and over all categories of farms. The MVPs of bullock labor are found negative and significant which exhibit that reduction in the use of bullock labor in wheat would increase GI. The MVPs of all other inputs are not found significantly different from zero. A perusal of the table reveals that except fertilizers & manure, irrigation and human labor in highly irrigated block, rest of the inputs are not efficiently utilized by the farmers in wheat. The bullock labor and farm implements & machinery are excessively used. Therefore, expenditure on these inputs must be curtailed to raise GI from wheat.

Table 1: Results of Regression analysis for Wheat

Size of farms	No. of farms	Value of Intercept	Regression Coefficients							
		Log A	X_1	X_2	X_3	X_4	X_5	X_6	X_7	R^2
Khondab block										
Small	25	3.103* (0.970)	0.057 (0.140)	0.207*** (0.138)	-0.086 (0.242)	0.253 (0.363)	0.094 (0.154)	-0.069 (0.105)	0.60 (0.059)	0.06
Medium	25	2.175* (0.853)	0.051 (0.076)	0.184*** (0.129)	0.329* (0.163)	0.342 (0.286)	-0.026 (0.042)	0.027 (0.029)	0.013 (0.092)	0.21
Large	25	2.619* (0.835)	-0.138 (0.111)	0.296** (0.168)	-0.038 (0.277)	0.657** (0.297)	0.085*** (0.060)	-0.028 (0.057)	0.048 (0.078)	0.28
Overall	75	2.595* (0.415)	-0.004 (0.046	0.231* (0.065)	0.115*** (0.084)	0.413* (0.130)	0.034*** (0.025)	-0.006 (0.018)	0.013 (0.029)	0.25
Farahan block										
Small	11	15.440* (3.132)	-1.097 (0.256)	-0.398 (0.321)	-0.598** (0.183)	1.608*** (0.264)	-1.126** (0.371)	-1.419* (0.361)	-.676** (0.284)	0.84
Medium	10	1.958 (2.850)	0.241 (0.246)	0.103 (0.234)	0.611** (0.207)	-0.519 (0.571)	0.499 (0.462)	-0.240 (0.365)	0.336 (0.240)	0.52
Large	15	5.843* (1.981)	-0.781 (0.823)	0.002 (0.336)	0.146 (0.130)	-0.007 (0.488)	0.454 (0.985)	0.362 (0.424)	-0.496 (0.429)	0.06
Overall	36	4.389 (0.894)	-0.075 (0.130)	0.112 (0.153)	0.184* (0.091)	-0.408 (0.259)	-0.003 (0.208)	-0.086 (0.102)	0.001 (0.134)	0.18

Figures in parentheses are standard errors of regression coefficients.
* Significant at 1 percent level of significance.
** Significant at 5 percent level of significance.
*** Significant at 10 percent level of significance.

In less irrigated block, wheat is not found profitable as MVPs of all inputs except irrigation on medium and overall size of farms are either negative or positive but insignificant. All the resources are severely under used in wheat in this block. The inadequate availability of water in this block might be the main reason of inefficient utilization of scarce resources. A comparative study of these blocks evinces that resources are relatively more efficiently used in wheat in the highly irrigated block.

3.3. Resource Productivity in Barley

In Khondab block, the values of R^2 show that 11% to 70% variations in GI on different categories of barley farms are explained by the combined effect of exogenous variables (Table 3). The magnitudes of regression coefficients which are found to have significant positive influence in explaining variability in GI are: 0.144 for irrigation, 0.366 for human labor, 0.071 for farm implements & machinery and 0.062 for other cost for small farms; 0.165 for irrigation and 0.228 for human labor for medium farms and 0.168 for fertilizers & manure and 0.107 for irrigation for large farms.

For over all categories of farms, the values of regression coefficients which turn out significant are: 0.133 for irrigation, 0.141 for human labor, 0.042 for farms implements & machinery and 0.056 for other cost. It is clear from the table that irrigation, human labor and farm implements & machinery turn out significant in causing variations in the level of GI. The values of regression coefficients which are found insignificant indicate that further increase of these variables would not make any beneficial effect on GI. In Farahan block, the values of R^2 indicate that 48% to 84% variations in the level of GI on different categories of barley farms are explained by the explanatory variables. The values of regression coefficients which are found to have significant positive effect on GI are: 0.456 for fertilizers & manure and 0.244 for irrigation for small farms, 0.415 for irrigation on medium farms and 0.225 for fertilizers & manure; 0.449 for irrigation and 0.145 for bullock labor on large farms; 0.127 for fertilizers & manure, 0.303 for irrigation and 0.122 for other cost on overall size of farms. It is evident from the table that irrigation and other cost in both the blocks, fertilizers & manure in Farahan block, human labor and farms implements & machinery in Khondab block are found the main income generation variables for barley crop. Bullock labor, seeds and fertilizers & manure in Khondab block and seeds, farms implements & machinery in Farahan block are not efficiently used. The reduction in the use of these inputs would not do any harm to GI.

On the basis of the comparative study of wheat and barley, it is concluded that wheat is profitable crop in highly irrigated block while barley is equally profitable in both the blocks. In general, the resources are better utilized in barley crop than wheat crop.

Table 2: Marginal Value Productivities for Wheat

Size of farms	Variables						
	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Khondab block							
Small	1.399 (3.437)	4.245* (2.830)	-16.083 (45.257)	34.060 (48.867)	43.618 (71.458)	-7.393 (11.251)	3.382 (3.325)
Medium	1.331 (1.983)	3.776* (2.647)	68.495** (33.935)	47.039 (39.337)	-13.800 (21.032)	1.795 (1.928)	0.732 (5.184)
Large	-3.897 (3.135)	5.762*** (3.264)	-6.748 (49.192)	104.76*** (47.357)	-97.278*** (68.667)	-0.585 (1.192)	2.549 (4.142)
Overall	-0.105 (1.208)	4.634** (1.304)	21.90* (16.003)	59.250** (18.650)	-21.865* (16.077)	-0.318 (0.954)	0.718 (1.602)
Farahan block							
Small	-12.790** (2.980)	-6.030 (4.870)	-95.360*** (29.180)	-49.500*** (21.490)	-332.300*** (109.490)	-30.390** (7.730)	-12.400*** (5.210)
Medium	3.900 (4.070)	1.380 (3.140)	112.230*** (38.020)	-42.020 (46.230)	164.960 (152.720)	-9.760 (14.840)	8.950 (6.390)
Large	-16.310 (17.190)	0.031 (5.190)	31.510 (28.060)	-0.660 (45.910)	207.730 (450.680)	12.170 (14.250)	-16.280 (14.080)
Overall	-1.220 (2.110)	1.660 (2.260)	34.470** (17.050)	-35.170 (22.330)	1.090 (75.610)	2.650 (3.150)	0.030 (3.440)

Figures in parentheses are standard errors of regression coefficients.
* Significant at 1 percent level of significance.
** Significant at 5 percent level of significance.

Table 3: Results of Regression analysis for Barley

Size of farms	No. of farms	Value of Intercept	Regression Coefficients							
		Log A	X_1	X_2	X_3	X_4	X_5	X_6	X_7	R^2
Khondab block										
Small	25	3.239** (0.653)	-0.127 (0.154)	-0.051 (0.154)	0.144 (0.048)	0.144** (0.054)	0.366* (0.264)	0.027 (0.034)	0.062** (0.023)	0.70
Medium	25	2.932** (0.716)	0.129 (0.224)	-0.015 (0.079)	0.165*** (0.083)	0.228* (0.138)	-0.046 (0.058)	0.017 (0.050)	0.061 (0.059)	0.11
Large	25	3.435** (0.419)	0.080 (0.098)	0.168** (0.063)	0.107* (0.068)	-0.067 (0.212)	-0.047 (0.049)	-0.027 (0.054)	0.019 (0.035)	0.20
Overall	75	3.305** (0.262)	-0.001 (0.068)	0.022 (0.031)	0.133** (0.037)	0.141*** (0.075)	-0.014 (0.022)	0.042*** (0.020)	0.056** (0.018)	0.34
Farahan block										
Small	14	-2.201 (4.330)	0.951 (1.629)	0.456* (0.278)	0.244*** (0.093)	0.536 (0.423)	-0.328 (0.241)	0.411 (0.302)	0.048 (0.140)	0.84

Medium	12	0.881 (9.266)	-0.351 (0.521)	-0.039 (0.225)	0.415*** (0.124)	-1.317 (1.259)	0.088 (0.724)	-0.706 (2.676)	0.064 (0.224)	0.48
Large	15	5.483** (1.214)	-0.003 (0.419)	0.0225* (0.148)	0.449** (0.132)	-0.864* (0.513)	0.145* (0.071)	-0.313 (0.262)	-0.222 (0.221)	0.50
Overall	41	4.241 (0.614)	-.423* (0.231)	0.127*** (0.069)	0.303** (0.051)	-0.233 (0.051)	0.027 (0.046)	0.029 (0.125)	0.122*** (0.067)	0.53

Figures in parentheses are standard errors of regression coefficients.
* Significant at 1 percent level of significance.
** Significant at 5 percent level of significance.
*** Significant at 10 percent level of significance.

Table 4: Marginal Value Productivities for Barley

Size of farms	Variables						
	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Khondab block							
Small	-4.211 (5.107)	-0.618 (0.581)	25.560** (9.584)	51.287 (36.994)	24.021 (30.248)	1.569 (0.707)	1.662** (0.616)
Medium	3.946 (6.852)	-0.171 (0.899)	28.525*** (14.349)	33.231* (20.114)	-43.240 (54.520)	0.277 (0.815)	1.852 (1.792)
Large	2.259 (2.676)	2.085 (0.782)	19.561* (12.431)	-11.640 (36.837)	-71.257 (74.289)	-0.349 (0.698)	0.431 (0.793)
Overall	-0.031 (2.081)	0.263 (0.371)	23.636** (6.575)	21.510*** (11.441)	-14.071 (23.812)	0.701*** (0.334)	1.480** (0.476)
Farahan block							
Small	24.310 (41.640)	5.950* (3.630)	42.400*** (16.160)	79.320 (62.600)	-241.870 (177.710)	5.060 (3.710)	1.000 (2.920)
Medium	-9.080 (13.480)	-0.460 (2.630)	70.240*** (20.990)	-179.220 (171.320)	-54.840 (451.200)	-8.980 (34.030)	1.700 (5.930)
Large	-0.090 (12.120)	2.590* (1.700)	69.570** (19.060)	-138.820* (44.250)	139.020* (44.250)	-8.020 (7.980)	-8.020 (7.980)
Overall	-11.350* (6.200)	1.530*** (0.830)	50.100** (8.430)	-34.670 (32.590)	20.860 (35.540)	0.390 (1.680)	3.340* (1.830)

Figures in parentheses are standard errors of regression coefficients.
* Significant at 1 percent level of significance.
** Significant at 5 percent level of significance.
*** Significant at 10 percent level of significance.

4.3. Marginal value Productivity in Barley

The MVPs of resources and their standard errors for different categories of farms are given in Table 4. In Khondab block, the estimated MVPs of factors of production which are significantly higher than their respective acquisition cost are Rials 25560, 1570 and 1660 for irrigation, farms implements & machinery and other cost respectively on small farms; Rials 28530 and 33230for irrigation and human labor respectively on medium farms; Rials 2090 and 19560 for fertilizers & manure and irrigation respectively on large farms and Rials 23640, 21510 and 1480 for irrigation, human labor and other cost respectively on overall size of farms. The MVPs for seeds and bullock labor for all farms, fertilizers & manure on small, medium and overall size of farms and other cost, farm implements & machinery on medium and large farms are not found higher than their respective acquisition cost. This indicates that further investment on these resources would not contribute to GI. In Farahan block, the MVPs of resources which are found significantly higher than their acquisition cost are: Rials 5950 for fertilizers & manure and Rials 42400 for irrigation on small barley farms; Rials 70240 for irrigation on medium farms; Rials 2590 for fertilizers & manure, Rials 69570 for irrigation, Rials 139020 for bullock labor on large farms and Rials 1530 for fertilizers & manure, Rials 50100 for irrigation and Rials 3340 for other cost on overall size of farms. The resources which have significant negative MVPs are seed on overall size of farms and human labor on large categories of farms. The expenditure on these resources must be reduced to raise the level of GI. The MVPs of all other inputs are not found significantly different from zero. Therefore further increase in investment on these inputs in barley would not enhance GI. The comparative analysis of the MVPs of inputs indicates that MVPs for irrigation and fertilizers & manure are found encouraging in less irrigated block. This reveals that increase in irrigation and fertilizers would contribute a lot to barley growing farmers in less irrigated block. The negative MVPs for human labor in less irrigated block evince that human labor is disguisedly unemployed while the MVPs for human labor in highly irrigated block indicate the absence of unemployment of unskilled labor in the block.

4. Discussions

The study of the resource use efficiency in two blocks brings out the following conclusions:

- High MVPs of labor in highly irrigated area reveal that this factor is efficiently utilized in this block while in less irrigated block, MVPs of labor are either negative or positive but insignificant which reflect the acute problem of disguised unemployment in this block.
- Relatively in both the blocks, it is observed that irrigation and fertilizers & manure are efficiently used. Generally, bullock labor and farms implements & machinery are inefficiently used in highly irrigated block. In less irrigated block, besides, bullock labor, farm implements & machinery and human labor is also used inefficiently. It is suggested that expenditure on these resources may be reduced for their rational use.
- Comparative study of wheat and barley crops in both the blocks exhibits that wheat farming is profitable only in highly irrigated block while barley farming is profitable in both the blocks.

Above empirical evidences suggest certain policy implications. They could cover sum of the main resources used in the production of crops, but primarily attention needs to be given to human labor in less irrigated block as negative MVPs of this factor indicate the presence of under employment and disguised unemployment. To overcome this problem, concerted efforts will have to be made to generate extra employment opportunities in the rural sector itself. For this, crop activities should be integrated to complementary farm activities such as livestock, fishery, and horticulture etc. on the one hand and agro-based rural industries such as fruit, food and vegetable processing small scale industries on the other. Besides, ongoing rural development programs will have to orient towards generating employment opportunities in non-farm sectors. Farm implements & machinery also requires serious attention. This factor is severely underutilized in both the blocks. Therefore, the expenditure on this input may be curtailed to increase farm income. The provision of subsidy on small tractors and power tillers may further aggravate situation. Irrigation and fertilizers have been efficiently utilized in most of the cases in both the blocks. However, to make the better utilization of scarce water resource in less irrigated block, in ongoing water-development program, people's participation should be encouraged.

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