IMPLICATION OF IRRIGATION REFORMS ON WHEAT PRODUCTIVITY: A CASE STUDY OF PUNJAB, PAKISTAN

Muhammad Arif Raza[1], Muhammad Ashfaq[1], Sarfraz Hassan[2] and Intizar Hussain[3]
[1]Department of Agri. Economics, University of Agriculture, Faisalabad
[2]Department of Environmental & Resource Economics, University of Agriculture, Faisalabad
[3]International Network on Participatory Irrigation Management, Islamabad

Agriculture is crucial for Pakistan's economy and irrigation is the lifeblood of agriculture sector. The irrigation system of Pakistan is the largest integrated network in the world. The state managed surface irrigation in Punjab province had not been performing well and was deteriorating day by day due to financial, managerial and socio-political factors. Keeping in view the above mentioned problems, the government of Pakistan agreed upon institutional reforms in water sector of the Punjab. Consequently, in 1997, Pakistan's provincial assemblies passed bills to implement institutional reforms in the country's irrigation sector. In the province of Punjab, institutional reforms have been introduced in the Lower Chenab Canal (LCC) East irrigation system as a pilot project through PIDA Act of 1997. The objective of the study was to assess the impact of reforms in irrigation sector on wheat productivity in the province of Punjab. A comprehensive survey of the study area was carried out and data from 360 farmers and 30 farmer organizations (FOs) were collected through a well structured questionnaire. The results of the study showed that on an overall basis, wheat yield increased by 10 percent from 32.4 maunds in pre-reform period to 35.5 maunds in post- reform period.
Keywords: Institutional reforms, irrigation management transfer, impact assessment, wheat productivity

INTRODUCTION

Agriculture is the backbone of Pakistan's economy and is the main stay of the populace, directly or indirectly, for seeking food, clothing, employment and perhaps everything, and is also viewed as a dominant way of life. The importance of water for Pakistan can not be under-estimated, particularly for irrigated agriculture in the country The Indus Basin Irrigation system of Pakistan is the largest contiguous irrigation system in the world, serving in excess of 14 million hectares (Johnson III *et al.,* 2004). The system is fed by the waters of the Indus River and its tributaries. The Indus Basin Irrigation System of Pakistan is now facing multiple problems like deterioration of infrastructure, high conveyance losses and inequitable water distribution both under normal supply and shortage conditions. There has been chronic inequity with the upstream water users receiving more water than their due share, while those in the tail reaches of the canal command receiving less. The system is steadily deteriorating and performing far below user's expectations; and there is a great mistrust between the irrigation department and the users. The agriculture in Pakistan is dependent on irrigation due to low rainfall. The system is performing poorly (World Bank, 1994). Some of the causes of ever declining system performance are inequity in water distribution, poor operation and maintenance (O&M) of the system, poor water charges recovery (*Aabiana*), political interference and weak capacities of government institutions. These factors led to shrinkage of area irrigated, maldistribution and wastage of water (Vermillion and Sagardoy, 1999). The deterioration of irrigation system is considered as the main cause of stagnant agriculture in Pakistan (Vermillion, 1997).

Keeping in view the above mentioned problems, the government of Pakistan agreed to introduce institutional reforms in water sector of the Punjab. Consequently, in 1997, Pakistan's provincial Assemblies passed bills to implement institutional reforms in the country's irrigation sector (Nakashima, 1998). In the province of Punjab, the institutional reforms were introduced through the PIDA Act of 1997. The Punjab Irrigation and Drainage Authority (PIDA) has been set up at provincial level with the representation of the farmers and the government representatives, Area Water Board (AWB) at canal command level and Farmers Organizations (FOs) at distributary level. The management of distributaries has been transferred to the representatives of the farmers. The specific objective of the paper was to analyze the early effects/impacts of irrigation management transfer (IMT) on wheat productivity in pre and post reform period.

MATERIALS AND METHODS

In order to meet the objective of the study, the LCC (East) was selected as a case study on account of the reason that first phase of reform process was initiated and completed in this irrigation system which is comprised of the following canal divisions.

i. Khanki Division
ii. Upper Gogera Division
iii. Lower Gogera Division, and
iv. Burala Division

Sampling framework and data collection

A multistage sampling technique was used for the selection of respondents. The study area was initially selected purposively on the ground that irrigation management was transferred to the stakeholders in the area of LCC (East). By using Simple Random technique, 30 distributaries were selected for analysis purposes. The sampled distributaries represented head, middle and tail of the command area. Out of these 30 distributaries, 10 distributaries were selected by using Purposive Random technique on the basis of homogeneous characteristics and their location in the LCC (East) irrigation system. Out of 10 selected distributaries, 6 watercourses per distributary (2 each from Head, Middle and Tail) were selected through Stratified Random Sampling technique, giving a sum of 60 watercourses. From these 60 watercourses, 6 farm household per watercourse were randomly selected. A sample size of 360 farmers was collected for analysis. "Before and After" irrigation management transfer (IMT) situation was compared for analysis purpose. The data was collected for two periods i.e. Pre-reform period and Post-reform period. Secondary data for the pre-reform period was taken for two years i.e. years 2003-04 and 2004-05 while for post-reform period it was comprised of for the years 2005-06 and 2006-07. While primary data was collected for two years i.e. crop year 2004-05 for pre-reform period and crop year 2005-06 for post-reform period.

Econometric analysis of data

Econometric analysis was conducted by estimating a Single Equation Model to capture the impact of irrigation reforms on wheat productivity and income. Single equation model for estimation of wheat yield (maunds per acre) on per acre basis in pre and post reform period was used. The Cobb-Douglas production function was used and found to be an adequate representation of the data. Number of studies (e.g. Hoper, 1965, Welsch 1965, Ahmed *et al.,* 1999 and Hassan, 2004) has used such kind of production function in these types of studies. The logic behind using Cobb Douglas production function was that it is easy to estimate and coefficients are comparatively easier to understandable and interpret as compared to translog production function. The log form of the production function for wheat crop was developed to determine the relationship between different endogenous (dependent variable i.e. wheat yield) and exogenous variables (independent variables i.e. area under wheat, seed cost, fertilizer cost, surface irrigation cost, tube well irrigation cost, mechanization cost, education, dummy for farm location, reform period and interaction term). Cobb-Douglas production function for wheat yield is given as:

$$Lnay = \beta_0 + \beta_1 \, lnwarea_{ij} + \beta_2 \, lnwscost_{ij} + \beta_3 \, lnwfcost_{ij} + \beta_4 \, lnwsicost_{ij} + \beta_5 \, lnwticost_{ij} + \beta_6 \, lnwmcost_{ij} + \beta_7 \, lnwlcost_{ij} + \beta_8 \, lnedu_{ij} + \beta_9 D_1 + \beta_{10} D_2 + \beta_{11} D_1 D_2 + \mu_{ij}$$

Where:

β_0 = Constant

lnay = Natural Log of average yield per acre of wheat crop for i-th farm.

$lnwarea_{ij}$ = Natural Log of area under wheat crop in the sample area measured in acres.

$lnwscost_{ij}$ = Natural Log of seed cost of the i-th farm for wheat crop in the sample area measured in real price (by using GDP deflator for the year 2001-02 as base) and expressed in rupees per acre.

$lnwfcost_{ij}$ = Natural Log of fertilizer cost of the i-th farm for wheat crop in the sample area measured in real price (by using GDP deflator for the year 2001-02 as base) and expressed in rupees per acre.

$lnwsicost_{ij}$ = Natural Log of surface irrigation cost of the i-th farm for wheat crop in the sample area measured in real price (by using GDP deflator for the year 2001-02 as base) and expressed in rupees per acre.

$lnwticost_{ij}$ = Natural Log of tube-well irrigation cost of the i-th farm for wheat crop in the sample area measured in real price (by using GDP deflator for the year 2001-02 as base) and expressed in rupees per acre.

$lnwmcost_{ij}$ = Natural Log of cost of mechanized operations of the i-th farm for wheat crop in the sample area measured in real price (by using GDP deflator for the year 2001-02 as base) and expressed in rupees per acre.

$lnwlcost_{ij}$ = Natural Log of cost of labour operations of the i-th farm for wheat crop in the sample area measured in real price (by using GDP deflator for the year 2001-02 as base) and expressed in rupees per acre.

$lnedu_{ij}$ = Natural Log of years of schooling of the i-th farm for wheat crop in the sample area.

D_1 = Dummy variable for location of outlet of specific farm. If $D_1 = 1$ then it represents location at tail of the distributary otherwise head or middle of the distributary.

D_2 = It is a dummy variable taking into account the implementation of reform process. If $D_2 = 1$ it represents post-reform era else zero.

D_1D_2 = Interaction variable of two dummies i.e. D_1D_2 was used to capture the impact of reform process on the farms located at the tail of the distributary.

μ_{ij} = Error Term

RESULTS AND DISCUSSIONS

Different variables, their Identities, Mean and Standard Deviation along with their expected signs are given in Table 1.

Table 2 shows the average yield of wheat crop across the LCC (East) system in pre and post reform period. The results of the study showed a wide variation in yield across the different canal divisions. It is evident from the Table 2 that the irrigation reforms have positive impact on wheat yields across the study area. In Khanki canal division, average per acre yield in pre and post reform period was 31.1 and 35 maunds, respectively. In Upper Gogera canal division, there was 12 percent increase in wheat yield after the introduction of irrigation reforms. In Lower Gogera and Burala canal divisions, it was found that after reforms in irrigation sector in Punjab, wheat yield increased by 8 and 6 percent, respectively. However, on an overall basis, 10 percent increase was observed in the LCC (East) irrigation system. The substantial increase in wheat yield in Khanki division was attributed to suitable soil conditions and fertility of the soil. Agronomic factors like land preparation, sowing time, variety and quality of seed, timing of application of inputs and quality of land and adequacy of surface irrigation of water contributed significantly in increased production of wheat in Khanki canal division. It was also observed that farmers found sufficient time for sowing of wheat after harvesting of rice due to which wheat yield was comparatively higher (Early sowing of wheat produced high yield).

Data of 360 farmers were obtained in the study area for the two years i.e. 2003-04 and 2005-2006. Collected data was then cleaned and actual analysis was carried out for 320 farmers. The remaining farmers were dropped out due to the reason that they have not sown wheat in any of these two years. Rigorous analysis of data was carried out to capture the effect of irrigation reforms on wheat productivity. Table 3 shows the results of the yield/ productivity impact model. Out of total 11 variables, 5 variables were statistically significant. The results of the study showed that fertilizer cost was significant at about 5 percent significant level indicating that one percent increase in fertilizer cost would increase the yield of wheat by 0.07 percent. Likewise, increasing labour cost by one percent, wheat yield would increase by 0.01 percent. The dummy variable for reform process (D_2) showed that average yield of the farmers was higher after the reform as compared to before reform situation and it was statistically significant at 5 percent significant level. It is also interesting to note that D_1 is significant but have a negative sign, showing that the position of the farm is negatively but significantly affecting the wheat yield i.e. the farmers at the tail have less yield as compared to farmers at the head and middle of the distributary. The value of R^2 was 0.22, showing that 22 percent change in the wheat yield was being explained by the explanatory variables. These values of R^2 and adjusted R^2 were in line with many previous studies like Abedullah and Pandey (2004) and Abedullah and Ali (2006) in agriculture sector.

The model revealed that introduction of the reform has positive impact on the yield of wheat crop of the selected farmers in the study area and there was significant scope for irrigation services to improve further to have their significant and positive impact on productivity.

CONCLUSIONS

The process of institutional reforms in irrigation sector of the Punjab was implemented through PID Act 1997. The reform process showed positive impact on the yield of wheat crop of the selected farmers in the study area. It was also observed that the new system has the potential to address the problems of the farmers regarding bridging head-tail equity in water distribution and hence improving the productivity and income of the farmers. The present study was first empirical study of its kind on the issue of impact assessment of irrigation reforms in Pakistan. It is suggested that further empirical research should be conducted taking into account “With and Without” approach also. There is also need to create a political consensus regarding the introduction of new system. Farmer’s participation can provide useful guidelines and feed back in evolving effective policy frame work, which in turn can be helpful in improving irrigation efficiencies.

Table 1. Descriptive statistics of important variables for wheat crop

Variable	Identities	Expected Signs	Mean	Std Deviation
Real average gross value product of (Rs./acre)	lnay	-	12091	1727
Wheat Area (acres)	$lnwarea_{ij}$	Negative	6.97	10.7
Real seed cost (Rs. /acre)	$lnwscost_{ij}$	Positive	397	44.6
Real fertilizer cost (Rs./acre)	$lnwfcost_{ij}$	Not a priori expectations	1493	377
Real Surface Irrigation cost (Rs./ acre)	$lnwsicost_{ij}$	Negative	37	10.1
Real Tube well Irrigation cost (Rs./acre)	$lnwticost_{ij}$	Positive	862	434.6
Real mechanization cost (Rs./acre)	$lnwmcost_{ij}$	Positive	1254	348.2
Real labour cost (Rs./acre)	$lnwlcost_{ij}$	Positive	1142	430.9
Real average cost/acre (Rs./acre)	-	-	5442	1014.1
Average Yield (maunds /acre)	-	-	33	4.9

Table 2. Average yield of wheat crop across the system (Maunds per acre)

Canal Division	Wheat Yield		
	Pre reform Period (2004)	Post reform period (2006)	% change
Khanki	31.1	35	13
Upper Gogera	30.4	34.1	12
Lower Gogera	33.6	36.4	8
Burala	34.8	36.7	6
Overall	32.4	35.5	10

Table 3. Estimated parameter of the yield model for wheat crop

Variable	Parameter	T Value	Significance level
Constant	2.42	5.53	.000*
$lnwarea_{ij}$	-0.002	-0.195	0.84
$lnwscost_{ij}$	0.07	1.20	0.22
$lnwfcost_{ij}$	0.073	2.52	0.01*
$lnwsicost_{ij}$	-0.018	-0.40	0.68
$lnwticost_{ij}$	0.006	1.06	0.28
$lnwmcost_{ij}$	0.017	0.68	0.49
$lnwlcost_{ij}$	0.011	4.25	0.00*
$lnedu_{ij}$	0.006	2.06	0.03*
D_1	-0.053	-1.76	0.08**
D_2	0.084	3.036	0.00*
D_1D_2	0.026	1.01	0.31
R^2	0.22		
Adjusted R^2	0.19		
F- Value	7.08		.000*

* Significant at less than 5 percent significance level. ** Significant at less than 10 percent significance level.

REFERENCES

Abedullah and S. Pandey. 2004. “Risk and fertilizer use in the rainfed rice ecosystem of Tarlac, Philippines. *Journal of Agricultural and Applied Economics*, 36 (1): 241-250.

Abedullah and M. Ali. 2006. Quantifying the extent and nature of risk in alternative cropping patterns in Claveria, Philippines. *The Pakistan Development Review*, 45(2): 261-280.

Ahmad, M., M. Rafiq and A. Ali. 1999. An analysis of technical efficiency of rice farmers in Pakistani Punjab. *The Bangladesh Journal of Agricultural Economics*, 22: 79-86.

Hassan, S. 2004. An analysis of technical efficiency of wheat farmers in the mixed farming system of the Punjab, Pakistan. A Ph.D. Dissertation, Department of Farm Management, University of Agriculture, Faisalabad, Pakistan.

Hussain, I., W.A. Jehangir, M. Ashfaq and M. Mudasser. 2003. Pro-poor intervention strategies in irrigated agriculture, Punjab, Pakistan. International Water Management Institute, Lahore, Pakistan.

Hopper, W.D. 1965. Allocative efficiency in a traditional Indian agriculture. *Journal of Farm Economics*, 47: 611-624.

Johnson, I.S.H., M. Sevendsen and F. Gonzalez. 2004. Institutional reforms, options in the irrigation sector. Agriculture and Rural Development discussion paper No. 5. World Bank, Washington, D.C. USA.

Nakashima, M. 1998. Water Users organization for institutional reform in Pakistan’s irrigation sector. A report published by Faculty of International Studies, Hiroshima City University, Hiroshima, Japan.

Vermillion, D.L. 1997. Impact of Irrigation management transfer: A review of the Evidence. Research Report No 11. International Irrigation Management Institute, Colombo, Sri Lanka.

Vermillion, D.L. and J.A. Sagardoy. 1999. Transfer of irrigation management services guidelines. Irrigation and Drainage Paper 58. Food and Agriculture Organization, Rome, Italy.

Welsch, D.E. 1965. Response of economic incentive by Abakaliki rice farmers in Eastern Nigeria. *Journal of Farm Economics*, 47: 900-914.

World Bank. 1994. Pakistan Irrigation and Drainage: Issues and Options. Agriculture Operations Division. Afghanistan, Maldives, Pakistan and Sri Lanka Department, South Asia Region. Report No. 11884.