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Impact Assessment of Institutional Reforms in Irrigation Sector on Rice Productivity: A Case Study of Punjab, Pakistan

Muhammad Arif Raza, Muhammad Ashfaq, Muhammad Iqbal Zafar[1] and Irfan Ahmad Baig
Department of Agri Economics, University of Agriculture, Faisalabad, Pakistan
[1]Department of Rural Sociology, University of Agriculture, Faisalabad, Pakistan

Abstract

Pakistan is an agrarian economy. It has the world's largest contiguous irrigation system which was designed to provide uninterrupted supplies of irrigation water for its agriculture sector. The irrigation network of the Punjab was initially designed for 67 percent cropping intensity. But presently actual irrigation intensity has increased to 122 percent, showing that the system is already overburdened. Irrigation network in Punjab was developed for effective and efficient management of irrigation and drainage infrastructure, equitable distribution of available canal supplies at head, middle and tail end reaches, control of illegal water abstractions and revenue generation through efficient assessment of water fees. But various studies showed that system had lost its efficiency over time. It was found that the irrigation performance needs to be reviewed in the context of system design objectives, operational constraints, institutional systems and the broader socio-economic framework. In this scenario a comprehensive reform program has been introduced in the irrigation sector financed by World Bank and other international financial institutions. Basic aim of the whole reform program is to delegate the system to the ultimate users so that they can efficiently manage the system and increasing the water as well as agricultural productivity. Consequently, management was transferred to the farmers under the PIDA Act, 1997. In the present study, a sample of 360 farmers and 30 farmer Organizations were collected through a multistage sampling technique. Econometric analysis was carried out by applying 'Before and After" technique to assess the impact of the reform process on rice productivity and income in the study area. The results of the study showed that rice productivity and income increased after introduction of irrigation reforms in the study area.

Corresponding author: M. Arif Raza
Department of Agri Economics, University of Agriculture, Faisalabad, Pakistan
E.mail: arifraza166@yahoo.com

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Introduction

Water is precious resource. Only 2.5 percent of the world water is not salty, and of two- third is locked up in the form of ice caps and glaciers. Due to the continuous hydrological cycle, about two-third of remaining water is lost to evaporation while, some 20 percent of the remaining potentially useable water is in areas too remote for human access. After deducting all the quantities of water which can not be utilized by the human beings (for example excess water during the moon soon or the flood water), only 0.08 percent of total water on the planet is actually utilized by the mankind (Lashari *et al.* 2003). Agriculture is the largest consumer of water. Ever increasing population of the earth is putting more pressure on the agriculture sector to meet the demands of the increased population, especially the food requirements. Irrigation water being the single most important input for the agriculture sector is even under more stress as compared to other inputs due to limited supplies. Need for improvement in efficiency and productivity of irrigation water has become one of the key issue for the irrigation as well agriculture sector. It was found that the state owned irrigation systems have not been performing well and were deteriorating day by day, especially in developing countries due to financial, managerial and socio-political factors (Haq 1998). Literature and world experiences on irrigated agriculture have clearly indicated that without integrated approach of water resources that includes irrigation, drainage and environment, the agricultural productivity and sustainability would not be possible in the developing countries. The linkages and coordination among all stakeholders of irrigated agriculture is the most important institutional intervention. The irrigation and drainage sector plays a vital role in the food supply as well as in the economy of Pakistan.

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). It consists of major part of Indus Basin

Irrigation System (PIDA 2005). This system was built up almost a century ago on run off river basis. This system is considered as a life line for sustainable agriculture in Punjab which feeds almost whole the country. It comprised of three major storage reservoirs, namely, Tarbela and Chashma on River Indus, and Mangla on River Jhelum, with a present live-storage of about 15.4 BM^3 (12.5 MAF), 19 barrages; 12 inter-river link canals and 43 independent irrigation canal commands. The total length of main canals alone is 58,500 Km. Water courses comprise another 1,621,000 Kms (Shaikh 2004).

The Indus Basin Irrigation System of Pakistan is now facing multiple problems like deterioration of infrastructure, low irrigation and water use efficiencies, poor *aabiana* collection (water charges), inequitable distribution of irrigating water, inadequate maintenance of the system, poor irrigation infrastructure, illegal diversion from distributaries, inadequate farmer's participation in irrigation management, high conveyance losses and inequitable water distribution both under normal supply and shortage conditions (Haq 1998). 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 These factors led to rapid deterioration of infrastructure, shrinkage of area irrigated, maldistribution and wastage of water (Vermillion and Sagardoy 1999). The deterioration of irrigation system is considered the main cause of stagnant agriculture in Pakistan (Vermillion 1997). At this stage, a number of irrigation specialists articulated the need for all new paradigm for irrigation development as they recognized that sustainable irrigation systems require active participation of the users in order to be properly operated and maintained (Coward and Jr 1987).

The poor functioning of the irrigation system in Pakistan has been a source of concern since the 1960s and since then it has been the subject of considerable external assistance and internal policy reforms (Latif and Pomee 2003). 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 principal objective of reforms in irrigation sector of the Punjab Province is to reverse the deteriorating performance of its irrigation system and the consequent stagnating productivity of irrigated agriculture in the Indus Basin. Under the reform process in Punjab, new institutions have been set up and implemented on pilot testing basis. This process of reforms has been accomplished primarily through three institutional policy initiatives.

- First is the redesigning and decentralization of Punjab irrigation department (PID) into autonomous Punjab Irrigation and Drainage Authorities (PIDA)
- The second is the establishment of Area Water Boards (AWB) at main canal level.
- The third is to engage the farmers in the management process through Farmer Organizations (FO).

In the LCC (East) command area, 85 FOs have been formed and management has been transfer to representatives of the farmers.The present study was aimed to analyze the impact assessment of irrigation management transfer (IMT) on rice productivity in pre and post reform period in the study area.

Objective of the study

The present study was conducted with a specific objective to assess the effectiveness of ongoing irrigation reforms in terms of improving overall management of irrigation system and sugarcane productivity in the study area.

Materials and Methods

Lower Chenab Canal East (LCC East) canal command area was selected for study purpose as it was the only canal command where the reform process was initiated and implemented through PIDA Act 1997. Effectiveness of reform process was estimated through the comparison of established parameters and econometric analysis of the data.

Sampling Technique

A multistage sampling technique was used for collection of data in the field. The study area (LCC East) 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. First level analysis was carried out on the data collected from these distributaries. 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 giving a sum of 60 watercourses. Out of these 60 watercourses, 6 farm household were randomly selected. A sample size of 360 farmers was collected for second level analysis. "Before and After" irrigation management transfer (IMT) situation was compared for analysis purpose.

Data Collection

Data were collected in the study area through comprehensive field survey by using well structured questionnaires.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. year 2003-04 and 2004-05 while for post-reform period it was comprised of two years i.e. year 2005-06 and 2006-07. Primary data was collected for two years i.e. year 2004-05 for pre-reform period and year 2005-06 for post-reform period.

Econometric Analysis of Data

Econometric analysis was carried out by estimating a Single Equation Model to estimate the impact of irrigation reforms on rice productivity. The Cobb-Douglas production function was found to be an adequate representation of the data. The log form of the production function for rice crop was developed to determine the relationship between different endogenous and exogenous variables. Cobb-Douglas production function for rice yield is given as:

$$lnay = \beta_0 + \beta_1 \text{ lnrarea}_{ij} + \beta_2 \text{ lnrscost}_{ij} + \beta_3 \text{ lnrfcost}_{ij} + \beta_4 \text{ lnrsicost}_{ij} + \beta_5 \text{ lnrticost}_{ij} + \beta_6 \text{ lnrmcost}_{ij} + \beta_7 \text{ lnrlcost}_{ij} + \beta_8 \text{ lnedu}_{ij} + \beta_9 D_1 + \beta_{10} D_2 + \beta_{11} D_1 D_2 + \mu_{ij}$$

Where:

β_0	=	Constant
lnay	=	Natural Log of average yield of rice of the i-th farm in the sample area measured in maunds per acre.
Lnragvp	=	Natural Log of average real GVP of rice crop of the i-th farm in the sample area expressed in Rs. per acre calculated (by using GDP deflator for the year 2001-02 as base).
lnrarea_{ij}	=	Natural Log of area under the rice crop in the sample area measured in acres.
lnrscost_{ij}	=	Natural Log of seed cost of the i-th farm for rice crop in the sample area measured in real price (by using GDP deflator for the year 2001-02 as base) and expressed in Rs. per acre.
lnrfcost_{ij}	=	Natural Log of fertilizer cost of the i-th farm for rice crop in the sample area measured in real price (by using GDP deflator for the year 2001-02 as base) and expressed in Rs. per acre.
lnrsicost_{ij}	=	Natural Log of surface irrigation cost of the i-th farm for rice crop in the sample area measured in real price (by using GDP deflator for the year 2001-02 as base) and expressed in Rs. per acre.
lnrticost_{ij}	=	Natural Log of tube-well irrigation cost of the i-th farm for rice crop in the sample area measured in real price (by using GDP deflator for the year 2001-02 as base) and expressed in Rs. per acre.
lnrmcost_{ij}	=	Natural Log of cost of mechanized operations of the i-th farm for rice crop in the sample area measured in real price (by using GDP deflator for the year 2001-02 as base) and expressed in Rs. per acre.
lnrlcost_{ij}	=	Natural Log of cost of labour operations of the i-th farm for rice crop in the sample area measured in real price (by using GDP deflator for the year 2001-02 as base) and expressed in Rs. per acre.
lnedu_{ij}	=	Natural Log of years of schooling of the i-th farm in the sample area.
D_1	=	It is a 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 to capture the effectiveness of reform process the implementation of reform process. If D_2= 1 then it represents post-reform era and if value is 0 then it represents pre-reform era
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 Terms

Results and Discussion

Table 1 shows the important characteristics of the selected variables. The important descriptive statistics of the variables that were included in the analysis along with information regarding the average cost per acre in real terms are also given in Table 1. Apart from above variables, log of farmer's age and education (no of schooling years) were also included in the analysis.

Estimation of Regression Model for Average Yield of Rice

Regression model for average yield of rice was estimated using the average yield (maunds/acre) as explained variable to estimate the effect of the different important cost components and reform process on the farm productivity. Table 2 shows the results of the appropriate model.

Table 1 Descriptive Statistics of Important Variables for Rice Crop

Variables	Mean	Std. Deviation
Real average gross value product (Rs.)	4846.61	4274.15
Cultivated area (acres)	7.10	8.25
seed cost (Rs.)	149.53	62.89
fertilizer cost (Rs.)	1689.55	483.21
surface irrigation cost (Rs.)	64.71	15.95
Tube well irrigation cost (Rs.)	3165.06	1302.47
mechanization cost (Rs.)	1287.63	544.44
labour cost (Rs.)	1032.77	476.30
average cost/acre (Rs.)	7856.96	1628.22
Av. Yield (maunds/acre)	32.99	5.63

Table 2 Estimated Parameter of the Yield Model for Rice Crop

Variable	Parameter	T Value	Significance level
Constant	3.040	7.179	.000*
Ln area	0.008	0.713	0.477
Ln seed cost	-0.021	-0.843	0.400
Ln fertilizer cost	0.089	2.539	0.012*
Ln surface irrigation cost	-0.034	-0.579	0.563
Ln tube well irrigation cost	0.040	-1.883	0.061**
Ln mechanization cost	0.43	1.788	0.075**
Ln labour cost	0011	-2.099	0.037*
Ln education	0.016	1.681	0.094**
D_1	-0.021	-0.523	0.601
D_2	0.056	2.111	0.036*
D_1D_2	0.067	1.699	0.090**
R^2	0.18		
Adjusted R^2	0.14		
F- Value	5.531		0.000

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

It is indicated from the Table 2 that 7 coefficients out of 11 were significant at 10 percent level of significance. Coefficient of fertilizer cost and dummy for reform were significant at less than 5 percent level of significance. While the coefficients of tube well irrigation costs, mechanization cost, dummy for reform and interaction term were significant at less than 10 percent level of significance. The coefficients of seed cost, surface irrigation cost and dummy for location (D_1) were having negative signs which were according to *apriori* expectations.

Coefficient of the dummy for reform (D_2) when explained by using Halvorsen and Palmquist device depicted that the average yield of the farmers have increased by 6 percent in the post reform scenario when compared with base category.

The results of the study showed that on an overall basis, yield of rice crop increased from 31.4 maunds per acre before reforms to 35.5 maunds per acre after reforms, thus showing an increase of 13 percent. This increase in rice yield was attributed to better irrigation management services in addition to other factors like better agronomic factors, soil fertility and timely sowing etc. Table 3 showed that highest increase in yield was found in Burala canal division where yield increased by 22 percent average. Lowest increase in yield was found in Khanki canal division, where average yield of rice increased from 32 maunds per acre to 35 maunds per acre after irrigation management transfer, thus showing an increase of 9 percent. Upper Gogera and Lower Gogera canal divisions showed an increase of 9 percent and 13 percent respectively. The results of the study thus, depicted that the irrigation reforms have the positive impacts on the yield of rice in the study area.

Table 3 Average Yield of Rice Crop across the System (maunds per acre)

Canal Division	Average Yield of Rice		
	Pre reform period	Post reform Period	% change
Khanki	32	35	9
Upper Gogera	31.1	35	13
Lower Gogera	32.1	35.2	10
Burala	30.3	37	22
Overall	31.4	35.5	13

Conclusion

The reform initiatives have enabled the farmers to participate in the irrigation management in a constructive mode. It was concluded that there existed a relationship between the location of farms along the distributary and their respective yield and income. It was found that, on an average the lowest yield was achieved by the farmers at the tail end reaches which was lower than the yields obtained by the farmers at the head and middle reach areas. This low yield at the tail reaches was attributed to low surface water availability. The process of IMT in Punjab is at its early stages. The new system is facing certain administrative problems. These problems can be solved only through strong legal infrastructure and administrative support. However, it is concluded that farmers' participation in irrigation management in Punjab could bring many benefits to the farmers but it would require sufficient time period

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