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FACTORS INFLUENCING WATER SAVING MEASURES AND WATER-USE EFFICIENCY OF WHEAT GROWERS IN SINDH, PAKISTAN

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ABSTRACT

As the food supplies will have to be increased according to the growing population, water demand will be on the rise in the future. Therefore, improved water consumption patterns must be followed to match future food demands. The paper analyzes the farmer's adoption of improved irrigation technology to avoid excessive irrigation water use in cultivating crops. In addition, this paper also investigated the factors influencing the water-use efficiency of the farmers. A total of 390 farmers who grew wheat crops were selected from the Naushahro Feroz and Benazirabad districts of Sindh, Pakistan. Socio-economic variables and efficiency scores of the respondents were taken as variables, and both binomial logistic and Tobit regression models were applied. Results indicated that household head's experience and formal education have a positive and significant impact on their decision to adopt improved irrigation and their efficiency scores. The elasticities reveal that a 1 % increase in experience of farming possesses the probability of lining the water courses by 23%. Whereas, with the change of 1% in the formal education of respondents, the tendency to laser land leveling changed by 0.1%. In comparison, the distance of the farm from the canal and the area of the farm bears a negative impact on water conserving measures opted by them and their water-use efficiency scores. It was found that proper lining of the water courses, usage of drought tolerant varieties of crops, irrigation technology adoption, and laser land leveling were the measures taken to avoid the excessive use of irrigation water. These measures were found to significantly impact the water-use efficiency scores of sampled farmers. These findings might be helpful for researchers and policymakers to realize such factors influencing the adoption of farmers and their farm efficiency.

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INTRODUCTION

Agriculture's lifeblood, as well as the backbone of the national economy and human progress, is water (Munir et al., 2021). The status of water resources and their usage have become essential reference points for assessing a country's economy's long-term growth in an area (Zhang, 2020). If plants are not adequately hydrated, even the best seeds and fertilization will not reach their full potential (Bareke, 2018). Animal farming relies on adequate water supply as well (Schlink et al., 2010). The allocation of these water resources is similarly unequal over the substantial expanses of the areas (Dhawan, 2017). The increasing pressure on water resources by a population boom (Arnell, 1999), the deterioration of existing water resources due to pollution, and the additional demands of serving spiraling out of control industrial and agricultural expansion have resulted in a situation where water consumption is increasing dramatically while fresh water supply remains relatively constant (Dhawan, 2017). Agricultural ecosystems are the world's largest consumers of hydric resources, accounting for over 80% of total hydric resources, with regional variance owing to economic growth and climatology (Fischer et al., 2005; Wada et al., 2011). Water consumption for irrigation accounts for around 60% of available hydric supplies in advanced economies, while it can approach 90% in underdeveloped ones (Velasco-Muñoz et al., 2018). Irrigated cropland is projected to be 275 million hectares globally, and it is growing at a rate of 1.3 percent per year (Hedley et al., 2014). Although this sort of crop accounts for only 23% of the farmed area, it provides 45 percent of overall food output (David, 2007). By 2050, the global food supply will have to expand by 70% to fulfill demand (Wu and Ma, 2015). This anticipated rise in global food production necessitates the expansion of cultivated land, the intensification of the present cultivated land supply (Tscharntke et al., 2012), or the implementation of an integrated management system (Stoeckl et al., 2015). To meet the objective for food demand by 2050 under low-production scenarios, a 53 percent increase in hydric resource consumption and a 38 percent increase in the worldwide cultivated area would be required (De Fraiture and Wichelns, 2010). Irrigation increases in underdeveloped nations; water consumption to fulfill those food demands is projected to be 50%, whereas, in rich countries, it is predicted to be 16% (Singh, 2010). Increased water usage can lead to biodiversity loss (Pereira et al., 2010). degradation of water sources and ecosystems, soil salinization, soil floods, loss of supplementary services, inequity amongst users, increased susceptibility, and deterioration of water sources and ecosystems (Velasco-Muñoz et al., 2018).

Pakistan is one of the most enigmatic countries when it comes to climate change (Andres et al., 2011). Temperature swings, rainfall variations, and the occurrence of identified hazards are all examples of climatic events (Azeem et al., 2021). Droughts and floods are the leading causes of economic and social concerns for individuals among the various environmental dangers to which individuals are subjected, contributing to an increase in fatalities (Hasnat et al., 2018). Because of their limited adaptive capacity and assets, rural residents in underdeveloped nations are particularly vulnerable to floods (Fahad and Wang, 2020). There is a severe shortage of irrigation water witnessed in Pakistan, and the problem is haunting the agricultural outputs in the coming years (Ebrahim, 2020). Pakistan is now considered as a water-scarce region in the world (Awais et al., 2017; Naseer, 2013). Literature warns that the Indus River is the most rapidly depleting river basin in the world (Laghari et al., 2012). Plenty of reasons can be a causal fact to this depletion, including changes in run-off over a span of time and intensification of water-consuming crops (Sadoff and Muller, 2009). This issue of lacking water to irrigate lands have force the growers to extract groundwater (Qureshi et al., 2010; Scott and Shah, 2004). The fact rapid groundwater extraction has led to a situation of lowering water tables at an alarming rate (Singh, 2002). According to the literature, this depleting groundwater tables in Pakistan will give a boost to increased production costs in the agriculture sector (Imran et al., 2018). Not only the agriculture sector that pays the price of this depletion, but the environmental costs would be another matter of concern (Brown and Halweil, 1998). In pursuit of saving this precious resource, the scenario moves in the reverse direction, as the rate of extraction of groundwater in Pakistan is more rapid in the current decade than in comparison to previous decades (Shah et al., 2003). This situation is a matter of grave concern for the sustainability and agricultural supply of the region (Ashraf et al., 2021).

In order to conserve or save the excessive use of irrigation water, the adoption of improved irrigation methods is a key element proposed, especially in countries where agriculture is the mainstay of national income (Garb and Friedlander, 2014; Qureshi, 2011). Improved irrigation methods are playing an important role in enhancing the efficiency of farmers in growing major crops around the world (Deng et al., 2006; Loveys et al., 2004). However, in countries like Pakistan, this adoption of modern irrigation is yet to take place, with plenty of obstacles (Qureshi, 2011). A number of obstacles mainly include the lack of knowledge about the benefits of improved irrigation methods (Levidow et al., 2014) and the cost of installation as the returns and scale of cultivating a crop is commonly marginal in low-income countries (Shiferaw and Holden, 1999). There are numerous studies presenting various factors influencing the technical efficiency of farmers in growing various crops (Kea et al., 2016; Onumah et al., 2010). However, the work on the factors influencing their adoption of improved irrigation methods and water conservation is yet to conduct in many agricultural regions (Prokopy et al., 2008). There are some notable exceptions, including the works of (Koundouri et al., 2006; Watto et al., 2018), who worked on the adoption of farmers in perceiving improved irrigation methods. The results of empirical studies suggest that farmers are mostly found in risk-averting nature (Levidow et al., 2014; Rouzaneh et al., 2021), whereas the adoption of improved technology reduces the risk significantly (Worku, 2019).

Therefore, accepting this situation of irrigation water saving as a priority, this study aimed to analyze the factors influencing the decision of farmers adopting to conserve or avoid the excessive conjunctive use of irrigation water. The main objectives of the study are to determine the existing efficient water-use strategies prevailing in the study area and to explore factors influencing the water-use strategies of the farmers. This paper also aims to assist policymakers and researchers in developing improved irrigation policies by working on the influencing factors of the adoption of new technologies.

METHODOLOGY

Study Area and Sample

The research was conducted in the Naushahro Feroz and Benazirabad districts of Sindh, Pakistan. Respondents were selected who were growing wheat crops near two minor irrigation canals, namely Chihu and Malwa in Naushahro Feroz and Benazirabad districts, respectively. In this research, a sample of 390 farmers was selected based on the location of their cultivable land near minor canals. The sample was divided into two strata's, with 195 respondents from each district. The aim was to analyze whether farmers are involved in improved irrigation technology adoption or avoiding excessive use of irrigation water. Further, the socio-economic condition of farmers bears any influence on their decision to avoid excessive use of irrigation water and the water-use efficiency scores they are achieving in prevailing practices.

Variables of the Study

In this study, the variables were taken in the context of influencing the technical, allocative, economic, and water-use efficiencies of respondents. Moreover, the same factors affect the measures taken by respondents to avoid the over-use of irrigation water. On the basis of the respondent's survey and in the context of the literature cited (Abid et al., 2016; Iqbal et al., 2015), the selected variables are described Table 1.

Table 1. Variables used and their descriptions.

Variables	Unit	Description
Age	Years	The age of the respondent
Experience	Years	Farming experience of the respondent
Farm area	Acres	Cultivable land owned by the respondent
Education	Years	Number of years of formal education acquired by the respondent
Family size	No.	Number of members in a household
Depth of tube well	Feet	Tube well extraction depth
Tube well nature	Binary (1,0)	0: if the tube well is diesel operated 1: if the tube well is tractor operated
Groundwater perception	Binary (1,0)	1: if the groundwater quality is felt good 0: if the groundwater quality is felt bad
Discharge	Million cubic per acre	The discharge rate of groundwater
Distance	Kilometers	Distance of the farm from distributary canal
Water course lining	Binary (1,0)	1: if the respondent lines the water course 0: if the respondent does not line the water course
Irrigation technology application	Binary (1,0)	1: if the respondent applies irrigation technology 0: if the respondent does not apply irrigation technology
Laser land leveling	Binary (1,0)	1: if the respondent applies laser land levelling 0: if the respondent does not apply laser land levelling
Drought tolerant variety	Binary (1,0)	1: if the respondent applies drought tolerant variety of crop 0: if the respondent does not apply drought tolerant variety of crop

Model Specification

Binary logistic regression

In order to assess the impact of respondent's socio-economic factors on water-saving measures taken, binary responses were gathered in yes or no, referring to measures taken or not. The studies such as Abid et al. (2016); Rizwan et al. (2017a) suggest that for binary responses of dependent variables, dichotomous logistic regression is the best-suited model. Therefore, a model is developed with latent variable (Y_i^*) denoting expected benefits of measures taken to save irrigation water, depending upon X_k;

$$Y_i^* = \alpha + \sum \beta_k X_k + \varepsilon_{Y_i 1*} \qquad (1)$$

Where, $Y_i^*$is representing the dependent variable, which is a binary response. and X_k Represents the independent explanatory variables impacting the respondent's adaptive measures taken to save irrigation water. And $\varepsilon_{Y_i 1*} \cong N(0, \sigma^2)$ is the error term that is normally distributed and homoscedastic (Deressa et al., 2010). The latent observation is not examined directly.

$$Y_i = \begin{cases} 1 & if\ Y_i^* > 0 \\ 0 & if\ Y_i^* \leq 0 \end{cases} \qquad (2)$$

Here, Y_i is an observed variable that identifies that respondent i will select for specific measures of irrigation water saving ($Y_i = 1$) if the respondent anticipated gains are greater than 0 ($Y_i^* > 0$), else if respondent i do not prefer to take a specific measure of water saving if the anticipated gains are ($Y_i^* \leq 0$). Therefore, in terms of binary variables, the equation can be interpreted as;

$$\Pr(Y_i = 1) = Y_i = G\,(X_k \beta_k) \qquad (3)$$

Whereas, G refers to the specific binomial distribution (Fernihough and Alan, 2018).

Hypothesis testing for model significance

A null hypothesis was adopted by (Peng et al., 2002) and developed to check the significance of the model. A null hypothesis was created in this study, supposing all coefficients were equal to zero in the model.

H0: $\beta_i = 0$

H1: at least one $\beta_i \neq 0$

The method is similar to the F test commonly taken in OLS estimation models. The χ^2 values for technical, allocative, economic, and water-use efficiencies are positive. The related p-value for all the estimation models is < 0.001. Therefore, it can be concluded that all the models are significantly fit. Moreover, the pseudo-R^2 values ranged from 0.26 to 0.92, which illustrates that the models are well fit in exploring the measures taken by respondents to save and avoid the over-use of irrigation water.

Influencing Factors and Tobit regression

The multiple linear regression model is adopted from the study of Wang et al. (2018), who worked on the influencing factors of water-use efficiency. A separate model for each technical, allocative, economic, and water-use efficiency was developed. The equation of the model is shown as follows:

$$EF = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \ldots\ldots\ldots + \varepsilon \qquad (4)$$

Where EF expresses the technical, allocative, economic, and water-use efficiencies, and β (β=1, 2, 3,.....10) refers to the coefficients that are undetermined of the factors influencing the efficiencies. The Tobit regression analysis was performed using STATA software.

RESULTS AND DISCUSSION

Descriptive statistics

Table 2 illustrates the descriptive statistics of the variables used in logistic regression and Tobit regression analysis. Both continuous and binary responses were gathered. Results of the analysis illustrate that the mean age of respondents was found to be approximately 43 years, bearing an average educational level of 7.1 years, and an average experience in farming was found to be 21.3 years. The average distance of farms from the distributary was 4.4 kilometers. The family size of respondents comprises approximately nine members on average. The average farm area of respondents was found to be 9.6 acres.The results of dependent variables depict that respondents were more involved in cultivating drought tolerant crops with 45%, than any other measures taken to save irrigation water. Respondents with lining the water courses were found to be 33%. At the same time, fewer respondents were involved in laser land leveling and applying irrigation technology as an adaptive measure with 22% and 17%, respectively.

Table 2. Descriptive statistics of variables.

Variables	Mean	SD	Max	Min
Water course lining	0.33	0.47	1	0
Irrigation technology application	0.17	0.38	1	0
Laser land leveling	0.22	0.42	1	0
Drought tolerant variety	0.45	0.50	1	0
Age	43.35	10.66	75.00	17.00
Experience	21.32	10.99	55.00	2.00
Farm area	9.16	9.76	50.00	1.00
Education	7.10	6.30	27.00	0.00
Family size	9.62	5.76	50.00	2.00
Depth of tube well	90.29	19.47	160.00	40.00
Tube well nature	0.22	0.42	1.00	0.00
Groundwater perception	0.33	0.47	1.00	0.00
Discharge	37017.51	32004.08	41157.21	32137.42
Distance	4.42	2.40	20.00	0.00

Determinants of Water Saving Techniques Applied on Farm

The coefficient of the age of respondents is significant and has a positive sign for both water course lining and drought tolerant variety opted for cultivation. Representing a positive relationship between age and lining of water courses and opting for drought tolerant varieties of crops. The elasticity calculations in Table 5 reveal that 1 % increase in the age of respondents will increase the probability of lining the water courses by 16%. The results of the study are in alliance with Rizwan et al. (2020), who also found a positive and significant and positive relationship of respondents' age and adaptation measures taken by the respondents against natural calamities. It could be concluded from the results that people of greater age tend to save water by adopting positive measures. The positive sign of the coefficient indicates a direct relationship between respondent's experience of farming and lining their water courses and cultivating drought-tolerant varieties of the crop. The estimation results of elasticities from table 5 reveal that 1% increase in experience of farming possesses the probability of lining the water courses by 23%. Similarly, an increase of 1% in farming experience increases the possibility of cultivating drought resistant varieties of crop by 12% respectively. A positive and significant relationship between adaptive measures taken and the experience of farmers was also witnessed by Iqbal et al. (2015) and Rizwan et al. (2017b). In conclusion, it could be that farmers having more farming experience are expected to be more aware of the historic environmental catastrophes and adopt better management practices in their farming with respect to future environmental risks.

Farm area indicates the total cultivable land controlled by the household that utilizes it as a source of income generation. Findings from Table 5 reveal that the farm area bears a negative relationship with all the dependent variables. Consequently, an increase of 1% in the farm's area possesses the possibility of a decrease in adapting improved irrigation technology by 28%. Similarly, a decrease of 27% in the probability of cultivating drought-tolerant varieties of the crop.

The positive sign of the coefficient of the variable indicates that education is playing a significant role in adaptive measures taken towards irrigation water saving. The elasticity estimation results in Table 5 reveal that with the increase of 1% in the formal education of respondents, the tendency to laser land leveling increased by 0.1%. Similarly, with the increase of 1% in education, there is a tendency of an increase of 2% in opting for drought tolerant varieties of the crop. The study results are in line with the findings of Iqbal et al. (2015), who studied and concluded a positive relationship between educated respondents with adaptive measures taken in the field of agriculture. Another study by Abid et al. (2016) also revealed that there is a significant relationship between the education of farmers and measures of adaptation taken by farmers against environmental hazards.

The depth level of the tube well was found to be significant with the drought tolerant varieties cultivated by the respondents. The coefficient sign of the variable indicated a negative relation between drought tolerant variety opted and depth of tube well. The results of the elasticity estimation in table 5 Indicate that with an increase of 1% in the depth of the tube well, the probability of a decrease in cultivating a drought tolerant crop will decline by 2 percent.

It was found that the distance of the farm from the main distributary canal had a highly significant and negative relation with water-saving measures taken by the respondents in their respective fields. This phenomenon was mainly noted because the farthest of the farms were less likely to receive an adequate supply of canal water, thus having lesser attention and motivation towards lining of course. A study by Iqbal et al.

(2015) also witnessed such negative relation between the remoteness of farms from the main city and adaptive measures taken by the respondent to cope with natural calamities related to agriculture. Table 5 indicates that an increase of 1% in the distance of cultivated area from the main distributary canal would decrease the probability of lining the water courses by 0.8%. Likewise, with an increase of 1% in the distance of farms from distributary canals, the probability of a decrease in irrigation technology adoption declined by 36 percent.

Table 3. Binary logistic regression results.

Independent Variables	Water course lining	Irrigation technology application	Laser land levelling	Drought tolerant variety
Age	0.099**	-0.030	-0.0073	0.0157
	(0.008)	(0.007)	(0.0097)	(0.0083)
Experience	0.076*	-0.038	0.0713	0.0631**
	(0.025)	(0.048)	(0.0245)	(0.0488)
Farm area	-0.216	-0.142*	-0.0886	-0.1632*
	(0.064)	(0.073)	(0.0642)	(0.0758)
Education	0.002	-0.003	0.002*	0.0027*
	(0.003)	(0.002)	(0.0027)	(0.0023)
Family size	-0.008	-0.068	-0.0080	-0.0742
	(0.012)	(0.023)	(0.0212)	(0.0132)
Depth of tube well	-0.032	-0.007	-0.0532	-0.0070*
	(0.033)	(0.034)	(0.0347)	(0.0366)
Tube well nature	-0.085	-0.034	-0.0785	-0.0324
	(0.036)	(0.030)	(0.0157)	(0.0202)
Groundwater perception	-1.246	1.547	-1.0833	1.5353
	(0.258)	(0.216)	(0.4572)	(0.2280)
Discharge	-0.646	0.346	-0.7685	0.3679
	(0.364)	(0.268)	(0.2744)	(0.2656)
Distance	-0.055***	-1.413*	0.0281	-1.4348
	(0.271)	(0.374)	(0.2713)	(0.4013)
Log likelihood	-265.74	-232.99	-267.11	-227.00
LR χ^2 (16)	88.82	104.39	76.83	104.73
Pseudo R^2	0.143	0.183	0.126	0.187

Table 4. Marginal effects after binary logistic regression.

Independent Variables	Water course lining	Irrigation technology application	Laser land levelling	Drought tolerant variety
Age	0.0019**	-0.0031	-0.0027	0.0037
	(0.0027)	(0.0023)	(0.0027)	(0.0025)
Experience	0.0171*	-0.0087	0.0161	0.0076**
	(0.0076)	(0.0073)	(0.0076)	(0.0071)
Farm area	-0.0227	-0.0353*	-0.0278	-0.0246*
	(0.0151)	(0.0123)	(0.0132)	(0.0121)
Education	0.0001	-0.0002	0.0001*	0.0002*
	(0.0003)	(0.0002)	(0.0004)	(0.0003)
Family size	0.0018	0.0137	0.0018	0.0142
	(0.0032)	(0.0018)	(0.0032)	(0.0029)
Depth of tube well	-0.0070	-0.0020	-0.0074	-0.0008*
	(0.0036)	(0.0032)	(0.0036)	(0.0030)
Tube well nature	-0.0188	-0.0034	-0.0179	-0.0043
	(0.0047)	(0.0057)	(0.0057)	(0.0037)
Groundwater perception	-0.3262	0.3205	-0.3075	0.2305
	(0.0752)	(0.0535)	(0.0685)	(0.0523)
Discharge	-0.1522	0.0683	-0.1347	0.0673
	(0.0582)	(0.0435)	(0.0574)	(0.0532)
Distance	-0.0076***	-0.2242*	0.0080	-0.2328
	(0.0638)	(0.0680)	(0.0621)	(0.0685)

Table 5. Elasticity estimates of binary logistic regression.

Independent Variables	Water course lining	Irrigation technology application	Laser land levelling	Drought tolerant variety
Age	-0.1621** (0.1442)	-0.2313 (0.1273)	-0.1368 (0.1266)	-0.1892 (0.1231)
Experience	0.2395* (0.0836)	-0.1332 (0.2028)	0.3076 (0.0796)	0.1253** (0.1013)
Farm area	-0.3781 (0.2520)	-0.2877* (0.2287)	-0.4041 (0.2396)	-0.2703* (0.2217)
Education	0.0025 (0.0187)	-0.0277 (0.0244)	0.0017* (0.0181)	0.0205* (0.0354)
Family size	0.0669 (0.0865)	0.39163 (0.0771)	0.0808 (0.0934)	0.5302 (0.0748)
Depth of tube well	0.1773 (0.0821)	-0.0286 (0.0706)	0.1645 (0.0984)	-0.0283* (0.0871)
Tube well nature	-0.3497 (0.0908)	-0.0242 (0.0409)	-0.2402 (0.0865)	-0.0456 (0.0403)
Groundwater perception	-0.3874 (0.1385)	0.2737 (0.0646)	-0.3505 (0.1322)	0.3652 (0.0617)
Discharge	-0.2286 (0.0928)	0.0926 (0.0271)	-0.1907 (0.0766)	0.0794 (0.0578)
Distance	-0.0830*** (0.0844)	-0.3636* (0.1205)	0.0085 (0.0815)	-0.3535 (0.1406)

Note: *, **, *** specify the probability level at 10%, 5% and 1% respectively and figures in parenthesis indicate standard errors.

Table 6. Tobit regression results.

Independent variables	Technical efficiency	Allocative efficiency	Economic efficiency	water use efficiency
Age	-0.0013 (0.0009)	-0.0006 (0.0010)	-0.0008 (0.0011)	-0.0048*** (0.0017)
Education	0.0146*** (0.0022)	0.0059*** (0.0023)	0.0023 (0.0026)	-0.0012 (0.0042)
Experience	0.0024*** (0.0007)	0.0014* (0.0007)	0.0023*** (0.0008)	0.0018 (0.0013)
Farm area	-0.0043*** (0.0007)	-0.0025*** (0.0008)	-0.0025*** (0.0008)	-0.0010 (0.0013)
Family size	-0.0007 (0.0016)	-0.0004 (0.0016)	0.0006 (0.0018)	0.0008 (0.0029)
Depth of tube well	0.0002 (0.0004)	0.0007 (0.0005)	0.0000 (0.0005)	-0.0059*** (0.0007)
TUBE well nature	0.0215 (0.0174)	-0.0065 (0.0175)	0.0203 (0.0195)	-0.0702 (0.0313)
Groundwater perception	0.0268 (0.017)	0.0005 (0.0172)	-0.0062 (0.0190)	0.0085 (0.0305)
Discharge	0.0007 (0.0001)	0.0004 (0.0000)	0.0003 (0.0000)	0.0000 (0.0000)
Distance	-0.0035** (0.0016)	-0.0035** (0.0017)	-0.0045** (0.0019)	-0.0136*** (0.0053)
_cons	0.7490 (0.0860)	0.7703 (0.0853)	0.5072 (0.0950)	1.4740 (0.1455)
Log likelihood	1.8172344	22.6034	66.6199	-128.95734
Pseudo R^2	0.9272	0.3353	0.4182	0.2672

Factors Affecting Efficiency Scores

The average efficiency scores of farms cultivating wheat were taken and regressed using a two-limit Tobit regression model. Table 6 presents the results of the two-limit Tobit regression. Presented below are the discussed results of significant and influencing variables. The coefficient of the age of respondents has a negative sign for all of the efficiency scores. However, the relationship of age with water-use efficiency was found to be significant. It can be concluded that with an increase in respondents' age, the water-use efficiency tends to decrease. However, the study results oppose the results of Wang, (2010), who stated a positive relation between age with efficiency scores of farmers. It was found that level of education has a highly significant and positive relation with technical and allocative efficiency. Indicating that the higher the respondent's formal education level, the higher will be the technical and allocative efficiency score of the respondent. The study results are in line with the results of Alam et al. (2012); Fatima et al. (2020); Ganji et al. (2018); Wang et al. (2018); Wang (2010) also found a positive and significant relationship of education of farmers and the efficiency scores. Similar to formal education, the farming experience of the respondent was found to be highly significant with technical, allocative, and economic efficiency scores. The positive sign of the coefficient (Table 6) indicates that with more experience in farming, technical, allocative, and economic efficiency tends to improve at a significant rate. The study results are satisfied with the result of Asghar et al. (2018), Ganji et al. (2018), Wang et al. (2018) also witnessed a significant and positive relation between respondent's experience of farming with efficiency improvement.

The results of the Tobit regression (Table 6) indicate that there is a negative relationship between respondent's area of cultivation and the efficiency scores. However, the P-value of the coefficient indicates that there is a significant relationship between farm area and all the efficiency scores except water-use efficiency, where the results were found to be insignificant. Implying that the greater the respondent's farm area, the lower the efficiency scores of the farms. The study results are satisfied with the results of Wang (2010). The depth level of the tube well was found to be significant relation to the water-use efficiency scores of the respondents. The coefficient sign of the variable indicated a negative relation between the depth of tube well water-use efficiency. This phenomenon was noted commonly due to the higher cost incurred to uplift the groundwater. It was found that the distance of farm from main distributary canal had a highly significant and negative relationship with all the efficiency scores. Implying that the farther the distance of the farm from the distributary, lower will be the efficiency score. The results of the study are in line with the study conducted by Iqbal et al. (2015) indicated that the distance of the farm from the main resource hub bears a negative impact on farm management practices.

CONCLUSIONS

In order to explore farmer's adoption towards avoiding excessive use of irrigation water and the factors influencing their decision of adoption and water-use efficiency scores, the study concluded with some captivating findings. The current study selected 390 farmers from two districts of Sindh province, Pakistan. The study examined the impact of socio-economic characteristics of farmers in addition to the institutional factors on their adoption of water conservation strategies and water-use efficiency. There were mixed responses from farmers regarding the knowledge and adoption of improved irrigation. However, most of the farmers were aware of the adopted measures to conserve irrigation water but lacked adoption due to socio-economic constraints. The results of the binary logistic regression analysis indicated that farmers' formal education and their experience of farming have a significant and positive impact on their decision to adopt water conservation measures. Whereas the depth level of the tube well, the distance of the farm from the canal, and the size of the farm area have a negative impact on the decision regarding the adoption of the conservation of irrigation water. Similar results were estimated from Tobit regression analysis, where factors influencing the water-use efficiency of farmers were analyzed. It was found that with increasing age, formal education, and experience of the farmer, efficiency scores tend to improve significantly. While with increasing distance of farm from the canal, depth of tube, and farm area, the efficiency scores tend to worse off. Results from both logistic regression and Tobit regression models evaluated similar variables responsible for the adoption of measures and water-use efficiency scores. The overall results of the study might be helpful for researchers and policymakers to realize such socio-economic factors influencing the adoption of farmers and their efficiencies in producing agricultural outputs.

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