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Determinants of Adoption of Soil and Water Conservation Practices in Rainfed Agriculture: A Case Study in Pothohar Region, Pakistan

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ABSTRACT

Of the total thirteen rain-fed districts in the Pothohar region, Punjab province of Pakistan, four (Rawalpindi, Jhelum, Chakwal and Attock) are completely rain-fed. Erratic rainfall, moisture, soil degradation, soil erosion and droughts are prominent issues in the Pothohar region, augmenting the dire need for soil and water conservation.; to explore the determinants of the adoption of soil and water conservation practices, this study was conducted in Rawalpindi district because it receives maximum rainfall; which is most of the time lost due to absence of sufficient storage reservoirs exuberating the soil erosion and natural resource degradation. A total of 381 respondents participated in the study respondents were interviewed face-to-face on a structured, validated and reliable questionnaire. The Chi-square test of statistics and a binary logistic model were applied to the collected data using Statistical Package for Social Sciences (SPSS). Results demonstrated a statistically significant ($P<0.05$) association between age, farm size, farming experience, and annual income, with awareness and adoption of soil and water conservation practices. Both awareness and adoption of conservation practices were insignificant ($P>0.05$) with the educational level of respondents. Regression analysis confirmed that awareness and adoption of conservation measures were influenced significantly by the predictors' lack of motivation, reliance on off-farming income sources, and inadequate demonstrations. This study complements the adoption of soil and water conservation technologies in the environment of the Pothohar region. To meet this objective, institutional services need to be mainstreamed. Public sector agricultural extension should emphasize awareness campaigns, advisory services, and training programs for farmers and the establishment of demonstration plots specifying the adoption of soil and water conservation techniques.

INTRODUCTION

Pakistan is characterized by 79.6 million hectares (mha) of land out of which 22 million hectares (mha) are cultivable and about 76% of this area is irrigated while, 25% is rainfed which mainly depends upon rainfall. Unfortunately, rainfed areas confront plenty of problems including moisture stress, soil erosion, poor nutrient use efficiency, weed infestation, nutrient-deficient soils, soil crusting, erratic rainfall and poor crop husbandry practices. Steep slopes turn into eroded ones if proper management practices are not followed. Unsustainable practices are a major barrier towards enhancing the production potential in dryland regions. Anyhow, the potential can be ameliorated by adopting proper rainwater harvesting practices; considering recommended water and soil conservation measures and implementing agricultural practices on a sustainable basis (Baig *et al*., 2013). Rainfed farming in Pakistan

constitutes 10% of total agricultural output and solely relies on rainfall. Water is prominently a restricting factor for agricultural growth in these regions. However, effective management and supervision of water resources can provide an opportunity to increase agricultural output (Siddiqui *et al*., 2011). It was mentioned by Adnan *et al*. (2009) that although, water remains the major limiting factor regarding crop production in rain-fed areas effective management of water through proper implementation of water conservation measures has the potential to dramatically change the scenario. Successful management of reducing the runoff by the adoption of the most appropriate practices minimizes the risk of erosion and improves the moisture reserves in the soil. Proper bunding (putting firm earthen borders), deep ploughing (facilitating the infiltration of water) and levelling (equal moisture distribution over the field) are some of the remedial measures associated with effective soil and water conservation. Each millimetre of the harvested water could effectively be responsible for the increase in the yield of wheat crops by 10 kg in a hectare. An increase of 14% in crop production has been reported, especially in the kharif season, by the adoption of the described conservation measures (Rashid et al., 2004).

Rainwater harvesting can address the issue of water scarcity very effectively. Before we plan to promote the innovative concept of rainwater harvesting it is of primary importance to know the perceptions of local people about this concept. For example, whether they are properly aware of the opportunity of utilizing rainwater and if they are, how they feel about it (Song *et al.,* 2009). It has been established through various research that there exists a very significant relationship between awareness and adoption of technologies and the socio-economic attributes of the farmers. Socio-economic aspects significantly influence the awareness regarding modern technologies and their adoption. The success of an innovation or technology is ultimately measured by the level of adoption of a particular technology and the way it has been diffused among potential users (Reddy & Reddy, 2002).

Literacy level, financial liabilities, tenancy status and farm size were reported among the vital influencing factors responsible for technology adoption (Nzomi, 2007). The information gap and ultimately the adoption gap could effectively be bridged by effective dissemination of the information through the use of ICTs. Before, achieving the target of effective information diffusion through ICTs, there is a dire need to enhance the capacity of farmers by increasing their educational level, and computer literacy and addressing the issue of small landholdings (Saghir, 2009).

It was argued by Rahman (2011) that effective farm management, a better understanding of different farming systems and decision-making regarding the adoption of new farm technology are strongly linked with the age of the farmers. It is considered a very vital demographic attribute which plays a significant role in terms of influencing the attitude of farmers regarding awareness, adoption and acceptance of modern agricultural technologies. Bekele and Drake (2003) described that farmers with old age were wiser and more analytical as they had more experience than young farmers. On the other side, it was also mentioned by them that old farmers were more conscious as compared to those young farmers while taking risks.

Education is another significant element which has a great impact on farmers' awareness, knowledge gain, technology utilization and other aspects related to technology development. Educating illiterate farmers may significantly contribute towards effective technology dissemination and its utilization (Singh and Singh, 2000). Similarly, Ashraf *et al.* (2015) also described that education positively affects the process of technology adoption and associated decision-making. Land holding is another contributing factor which influences the perceptions and involvement of the farming community in different agricultural practices. Larger farm size also provides an opportunity to perform a variety of agricultural practices following different cropping systems which areotherwise impossible with limited farm size. It also influences the knowledge gained about modern farming practices and their proper utilization (Chaudhry, 2006). It has also been observed that farmers having large farm sizes tend to seek more information regarding agricultural technology theto increase their farm productivity. Chandio et al., (2021) studied the relationship between credit availability and farm size on agriculture productivity and concluded that there is a strong linkage between farm size and increased farm productivity.

On the contrary, Gaurav and Mishra (2015) argued that farm size and farm productivity have an inverse relation. They described that small farmers with limited farm size are in a position to apply proper inputs in a limited piece

of land which increases farm productivity. Tenancy status was found to have very strong implications regarding agricultural productivity (Chaudhry, 2006). It has been established that owners can be persuaded comparatively more easily for adopting technology as compared to those tenants and owner-cum-tenants. Moreover, owners are in a position to take the risk while owner-cum-tenants and tenants are found reluctant to take the risk due to plenty of associated factors.

It was reported by Khan and Akram (2012) that farmers with more farming experience had an increased level of income as compared to those with less experience in agriculture farming. Coppard (2001) was of the view that diversification of sources responsible for generating income is very significant for small or poor farmers. Diversification of the source might be very supportive for the poor farming communities to get themselves out of the poverty cycle. Ahmad *et al.* (2003) described that income was found to have a great influence on the adoption of innovative technologies by farmers. Similarly, Khan (2008) described that farmers' income level exhibited a positive association with the use of ICTs for reaching out for agricultural information. Agricultural crop production is directly linked with input supply that is strongly associated with the income of the farmers

Laosutsan *et al.,* (2019) described that among several influencing factors responsible for to increase adoption gap, the income variable is the most prominent factor which influences the process of adoption. The promotion of land, soil and water conservation measures has been a widespread development in a bid to tackle degradation and improve productivity. As a result of the problems arising in agricultural communities, the adoption and diffusion of certain sustainable agricultural practices have become an important issue in the development policy agenda, especially as a way of finding solutions to the problems (Ajayi, 2007).

METHODOLOGY

Punjab, being the most fertile province in terms of agriculture constitutes a major portion of rainfed agriculture. Out of 36 districts in Punjab, almost 13 districts are partially or completely rainfed and known as the Barani Tract of Punjab. The Pothohar region consists of four districts including Rawalpindi, Chakwal, Jhelum and Attock and is considered a completely rainfed region. While Sialkot, Narowal, Gujrat, Khushab, Mianwali, Jhang, Bhakkar, Layyah, D.G. Khan and Rajanpur districts are partially rainfed.

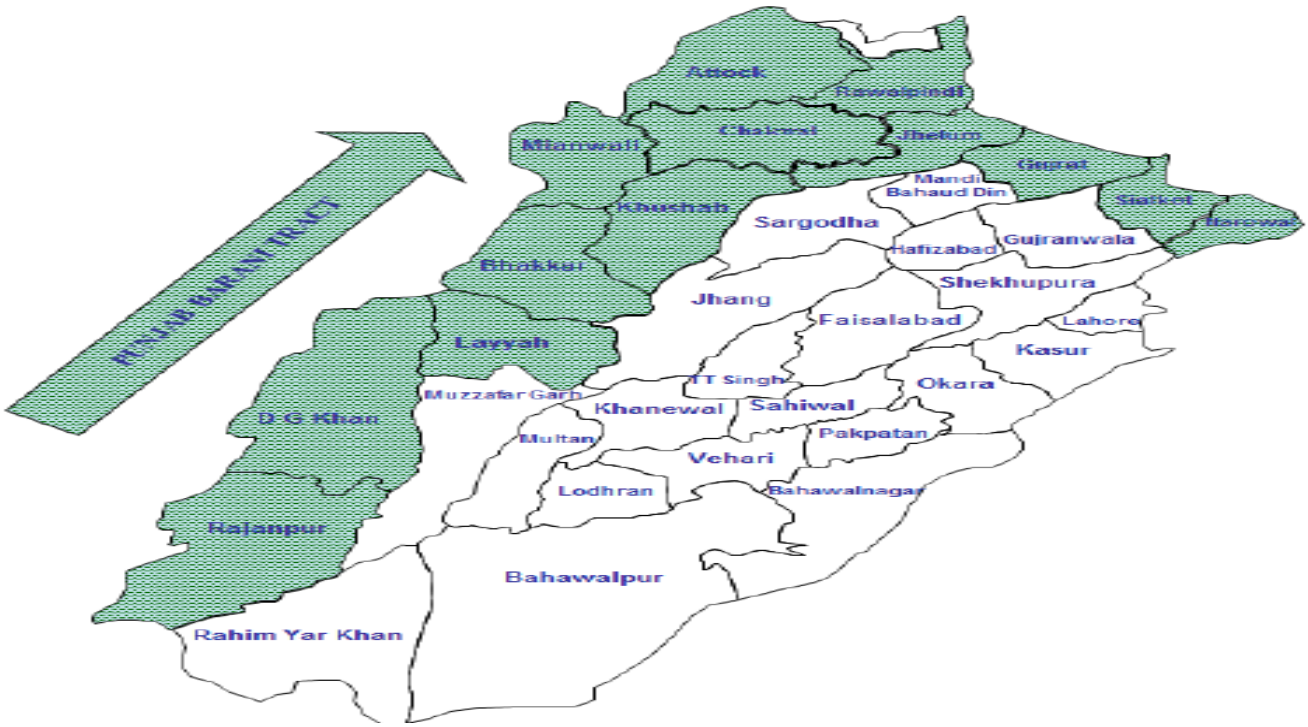

Figure 1. Barani Tract of Punjab.

Of the 5 mha rainfed area 1.8 mha is associated with the Pothohar region of Punjab, Pakistan. The region is characterized by fragmented and small landholdings (Rashid *et al*., 2015). It consists of 4 districts including Attock, Rawalpindi, Chakwal and Jehlum. Being rich in agriculture, its importance is quite obvious. Crop production in the region depends upon rainfall. Erratic rainfall in the region sometimes leads to drought conditions. The region has gone through severe drought conditions in the past (Fatima and Khan, 2018). The region confronts plenty of problems while erratic rainfall, run-off losses, soil degradation and low productivity being the prominent ones (Khan, 2002). Rawalpindi district of the Potohar region was considered purposively for the study as it receives maximum rainfall. There are a total of 7 tehsils in the district and 4 of those were selected purposively based on a maximum number of farmers as per information obtained from the office of the Director, Extension, Rawalpindi Division. Online software, surveysystem.com was used to generate a sample size of 381 farmers. Farmers were interviewed through a well-established, reliable and pre-tested interview schedule. Chi-square test statistics were used to find out the association between different socio-economic attributes and awareness and adoption of various soil and water conservation practices.

RESULTS AND DISCUSSIONS

Socio-economic attributes

Middle-aged (36-50 years) respondents were the maximum in number (34.1%) followed by 33.6% of old age (above 50 years) and 32.3% of young (up to 35 years) respondents. A small number (2.1%) of the respondents were illiterate. A simple majority (50.7%) of the respondents had an education in matriculation. Those who had graduated were 12.1% of the respondents followed by 2.1% having education of master's level or above. Less than half (40.7%) of the respondents had a farm size of 2-5 acres (0.80-0.02 ha) followed by 27.7% having 6-10 acres (2.42-4.04 ha) of land. Only 1.6% of the respondents had a farm size above 25 acres (10.11 ha).

Less than half (44.4%) of the respondents had the farming experience of up to 15 years followed by 36% having an experience farming ranging between 16-30 years. Only 3.6% of the respondents were found to have the farming experience above 50 years. Almost one-third (33.1%) of the respondents declared agriculture farming as the only source of their income. More than one-third (37%) of the respondents reported annual income of 0.21-0.4 million followed by less than one-fourth (23.4%) of the respondents who reported an annual income up to 0.2 million. A great majority (82.2%) of the respondents reported rainfall as the only source of irrigation.

To determine the relationship between the socio-economic characteristics of the respondents and their awareness and adoption regarding different soil and water conservation techniques, the chi-square test was used as a statistical technique for better judgment of different responses. Three categories (low, medium and high) were made for further explanation.

Computation of awareness and adoption levels

First of all, total soil and water conservation techniques were counted so that farmers' awareness and adoption levels regarding different techniques could be ascertained. A score of 1 was given to those aware of the techniques and 2 was given to those unaware of the techniques. The minimum and maximum scores were 18 and 10 for awareness of soil conservation techniques, 36 and 13 for the adoption of soil conservation techniques, 17 and 7 for awareness of water conservation techniques, and 14 and 9 for the adoption of water conservation techniques. Respondents were then divided into three categories i.e low, medium and high based on awareness and adoption scores.

Relationship between Socio-economic attributes, awareness and adoption of respondents regarding soil conservation techniques

Data mentioned in Table 1 indicate a highly significant positive association between the age of the respondents and their awareness regarding different soil conservation techniques**.** While the relationship between age and the adoption of soil conservation techniques was found insignificant which infers that change in age had no effect on decisions regarding the adoption of conservation practices. These results are in accordance with those of Ashraf *et al*. (2015) who reported a significant association between age and awareness of the respondents while an insignificant association between age and adoption.

Data provided in Table 2 reveal that education was found to have an insignificant association with

awareness and adoption of soil conservation techniques. The results infer that the education level of the respondents did not influence their level of awareness and decisions regarding the adoption of conservation techniques. These findings are contradictory with those of (Siddiquie et al., 2006; Salehin et al., 2009) who reported a significant relationship between education, awareness and adoption of the respondents.

Table 1. Relationship between age, awareness and adoption of respondents regarding soil conservation techniques.

Age (in years)	Awareness Percentage			Adoption Percentage		
	Low	Medium	High	Low	Medium	High
Young (up to 35)	7.34	21.25	3.67	32.28	0	0
Middle (36-50)	10.23	23.35	0.52	33.85	0.26	0
Old (above 50)	8.39	24.67	0.52	33.0	0	0.52
X^2 = 18.927**			X^2 = 5.889			

Table 2. Relationship between education, awareness and adoption regarding soil conservation techniques

Education	Awareness Percentage			Adoption Percentage		
	Low	Medium	High	Low	Medium	High
Illiterate	0.26	1.83	0	2.09	0	0
Primary	0.52	2.09	0	2.62	0	0
Middle	6.29	14.17	0.26	20.20	0	0.52
Matriculation	13.38	33.59	3.67	50.39	0.26	0
Intermediate	2.09	7.08	0.52	9.71	0	0
Graduation	2.62	9.18	0.26	12.07	0	0
Masters	0.78	1.31%	0	2.09	0	0
X^2=10.046			X^2= 8.652			

Table 3. Relationship between farm size, awareness and adoption of regarding soil conservation techniques.

Farm size (in acres)	Awareness Percentages			Adoption Percentages		
	Low	Medium	High	Low	Medium	High
Less than 2 acres	3.14	8.13	2.09	13.38	0	0
2-5 acres	9.97	29.39	1.31	40.68	0	0
6-10 acres	7.61	19.16	1.04	27.55	0	0.26
11-15 acres	2.88	5.77	0	8.66	0	0
16-25 acres	2.36	5.24	0.26	7.34	0.26	0.26
Above 25 acres	0	1.57	0	1.57	0	0
X2= 20.243*			X2= 17.967*			

Table 3 indicates that a significant association was observed between farm size and the awareness of farmers regarding soil conservation techniques. Exactly in the same way farm size also showed a significant association with the adoption of soil conservation techniques. It infers that farmers having greater farm size are more interested in agriculture, having more awareness and adaptive attitude towards soil conservation techniques. These findings are following those of Ruzzante *et al. (*2021) who revealed the association between farm size and the adoption of technologies. It was described that farmers with larger farm sizes are better in a position to exploit the resources and make the adoption of innovation more profitable.

Table 4. Relationship between farming experience, awareness and adoption regarding soil conservation techniques.

Farming experience	Awareness			Adoption		
(In years)	Low	Medium	High	Low	Medium	High
Up to 15 years	10.23	30.7	3.41	44.35	0	0
16-30 years	10.23	24.40	1.31	35.43	0.26	0.26
31-50 years	3.41	12.33	0	15.74	0	0
Above 50 years	2.09	1.83	0	3.67	0	0.26
X^2= 14.508*		X^2= 13.944*				

Table 4 reveals that farming experience was found to have a significant association with awareness and adoption of soil conservation techniques. It implies that farmers with more farming experience are well versed with climatic conditions and agriculture farming in their region, therefore, having sufficient awareness and positive attitude towards the adoption of the recommended soil and water conservation techniques.

Table 5. Relationship between annual income, awareness and adoption regarding soil conservation techniques.

Annual income	Awareness			Adoption		
(in Pak Rs.)	Low	Medium	High	Low	Medium	High
Up to 0.2 million	4.46	17.06	1.83	23.35	0	0
0.21-0.4 million	9.97	25.19	1.83	37	0	
0.41-0.6 million	5.77	15.74	0.26	21.52	0.26	0
0.61-0.8 million	2.88	7.87	0.26	10.49	0	0.52
0.81-1 million	1.31	1.83	0.26	3.67	0	0
Above 1 million	1.57	1.57	0	3.14	0	0
X^2= 14.414		X^2= 19.818*				

Table 5 depicts an insignificant association between the annual income and their awareness regarding soil conservation techniques. On the other side, a significant association was recorded between the adoption of SCTs and the annual income of the respondents. It is implicit that farmers having high annual incomes were in a position to adopt SCTs in a better way as compared to those with low annual incomes.

Binary logistic regression

A binary logistic regression model was applied to examine the impact of different socio-economic attributes i.e. age, farm size, farming experience, and annual income on soil and water conservation adoption strategies. Moreover, influencing factors were also analyzed about their influence on farmers' decisions regarding soil and water conservation adoption.

Table 6. Impact of farmers' socio-economic attributes and different influencing factors on their decisions regarding the adoption of soil and water conservation measures.

Variables	Coefficient	Standard Error	Wald	Significance	Odds Ratio
Farm size	.471	.278	2.870	0.090	1.602
Annual income	-.583	.236	6.113	0.013	0.558
Farming experience	-.132	.477	.083	0.773	0.871
Age	.532	.502	1.124	0.289	1.703
Lack of motivation	1.296	.489	7.017	0.008	3.656
Reliance on non-farming income sources	.970	.457	4.499	0.034	2.639
Lack of demonstration facilities	1.228	.469	6.847	0.009	3.415
Constant	-11.107	3.491	10.124	0.001	0.000

R^2: 0.62, Overall percentage: 95.8, Log Likelihood: 101.27, *P<0.05

Estimated logistic regression models showed strong significance at a one percent probability level for statistical parameters that express the model's fit to the study's data set. According to the chi-square (X^2) the model supported and implied that the intercept and explanatory variables were within the model's acceptability range. According to the Cox and Neglekerke estimate, the independent variables contributed 62 percent to the variation in the models. More evidence of the validity and reliability of the model was provided by the 2log-likelihood of 101.27.

As a whole, 9 variables were included in the present model. The dependent variable in the model was farmers' decisions regarding the adoption of soil and water conservation measures. While, independent variables in the model included the farm size of the farmers, farmers' annual income, the farming experience of the farmers, farmers' age, lack of motivation to adopt the conservation strategies, reliance of farmers on non-farming income sources, lack of demonstration facilities by the training advisory service providers. Of the total, 7 testing variables; annual income ($P<0.05$), lack of motivation ($P<0.05$), reliance on non-farming sources of income ($P<0.05$) and lack of demonstration facilities ($P<0.05$) were significantly associated with the adoption of conservation measures. The annual income of the respondents was found significant but negatively associated with the adoption of the conservation measures. Reliance on non-farming sources of income was found to be positively and significantly associated with the adoption of conservation measures therefore, it can be inferred that farmers relying on multiple sources of income other than agriculture were getting more income on annual basis resultantly there focus on the adoption of conservation strategies to accelerate their agricultural production was minimal as they were generating income from non-farming income sources. Although, non-significant, age and farm size were found positively associated with soil and water conservation adoption. An increase in farm size ultimately results in an increase in farm income and increased farm income leads towards better adoption of agricultural technologies like conservation measures (Noack and Larsen, 2019; Bravo et al., 2006).

Moreover, farming experience showed a negative association with the adoption of soil and water conservation adoption. It can be explained that farmers having more farming experience were resultantly the farmers with greater age and stuck with traditional methods of farming who are usually perceived not to adopt modern conservation measures. Therefore, the negative association between farming experience and the adoption of conservation measures indicates that farmers with more farming experience were less interested towards the adoption of modern conservation measures due to following traditional agricultural practices.

CONCLUSIONS AND RECOMMENDATIONS

A highly significant positive association was found between the age of the respondents and their awareness regarding different soil conservation techniques**.** While the relationship between age and adoption of soil conservation techniques was found insignificant which infers that change in age had no effect on decisions regarding the adoption of conservation practices despite influencing their awareness. Education was found to have an insignificant association with awareness and adoption of soil conservation techniques which infers that perhaps the availability of capital and excess to sufficient resources influence the awareness and adoption more than that of education. . It is quite evident from the results of the present study that annual income had a significant association with the adoption of the conservation measures. The Association between farm size and awareness and adoption of conservation strategies was found significant. The farming experience was found to have an insignificant association with awareness and adoption of soil and water conservation measures. Moreover, binary logistic regression model analysis reveals that lack of motivation to the farmers, farmers' reliance on non-farming sources of income and lack of demonstration facilities by the training and advisory staff had a significant association with awareness and adoption of different soil and water conservation measures. Therefore, it is strongly recommended for the stakeholders involved in the process of agricultural development in the Potohar region focus on designing specific farmers' training and advisory programs associated with soil and water conservation measures. Moreover, there is a need to educate and motivate the farming community in the region to realize the scope and potential of agriculture in their region through awareness campaigns. Government authorities need to provide sufficient subsidies and returns over the produced crop so that farmers' income

could be enhanced in an effective manner that would lead towards increased awareness and access to capital for adopting the conservation strategies.

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