# Socio-Economic Determinants of Farmers' Adoption of Rainwater Harvesting Systems in Semi-Arid Regions of Pakistan

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## ABSTRACT

This paper analyzes the socio-economic determinants of Rainwater Harvesting Systems (RWHS) in Pakistan. The study was based on a survey of 200 farming households selected from two villages in Pakistan. A binary logit model was used to identify determinants of RWHS. The study found that the age of respondents, size of non-irrigated land, and household monthly income were statistically significant and positively related to the adoption of RWHS. On the contrary, variables such as occupation as laborer and membership of any Community-Based Organization (CBO), though significant, had an inverse effect on the adoption of RWHS. The overall model was significant as shown by $P< 0.05$ which depicts that the socio-economic characteristics of the population are the main factors contributing to the adoption of RWHS. The study recommends that increased public and private investment and active involvement of Non-Governmental Organizations (NGOs) and voluntary organizations for social mobilization are essential for the promotion of RWHS in Pakistan.

**Keywords:** Agricultural productivity, Monsoon, Non-governmental organizations, Rain-fed agriculture.

## INTRODUCTION

Rain-fed agriculture accounts for about 80% of the world's agricultural lands and contributes to over two-third of the global food production (Oweis and Hachum, 2012). Although rain-fed agriculture, particularly in drought-prone areas, poses considerable risks, it is widely accepted that rain-fed agriculture will continue to play a key role in providing food and livelihoods for the burgeoning population of the world (Oweis and Hachum, 2009; Rockström *et al*., 2010). Nonetheless, many parts of the world, especially Asia and Africa, still exhibit large yield gaps, which are not primarily because of the lack of water, rather; due to improper management of available water (Rockström *et al*., 2010). However, farmers have locally managed and stored water resources using indigenous knowledge and skills since ancient times (Schiettecatte *et al*., 2005). Water harvesting methods formerly developed for subsistence are now receiving attention because of their potential to contribute to increased water supplies for agriculture and domestic purposes (Boers and Ben-Asher, 1982).

Water harvesting encompasses methods to induce, collect, and store runoff from various sources and for various purposes (Boers and Ben-Asher, 1982; Schiettecatte *et al*., 2005; Deng *et al.,* 2006). Such water capturing practices are being used in many parts of the world to meet water scarcity problems (van Wesemael *et al*., 2000; Oweis and Hachum, 2006). Water collecting initiatives are driven by a number of assumptions, such as: (1) There is a huge amount of monsoon flow, which remains un-

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captured and eventually ends up in the natural sinks; (2) Local water needs are so small that exogenous water is not needed; (3) Local water harvesting systems are always small and are therefore cost effective; (4) Since the economic, social, and environmental values of water are very high in the regions hit by water shortage, water harvesting interventions are viable; (5) Being small, with low water storage and diversion capacities, they do not pose negative consequences for downstream users (Kumar *et al*., 2006). Being an ancient and highly practiced technique, water harvesting remains a significant source of water for domestic as well as agricultural purposes (Fleskens *et al*., 2005; Frot *et al*., 2008) in many parts of the world.

Despite tremendous importance of water harvesting in rain-fed agriculture (Baiyegunhi, 2015), yield gaps are large, especially in developing countries. Absence of a clear and sound water policy in rain-fed agriculture is one of the reasons for low yield and water productivity in these areas (Rockström *et al*., 2007). Besides, developing countries are experiencing a rapid surge in population (Wallace, 2000; Pyagay *et al*., 2018), with much of it expected to occur in less-developed countries, where most of the poor live and where rain-fed agriculture forms the dominant basis for livelihood security (Singh *et al*., 2009). It is estimated that an additional 1 billion tons of grain will be needed annually by 2025 to meet the food demands of the increased population. Most of this food increase must be supplied from lands already in production, through yield improvements (Borlaug, 2001). In past, much of the progress in boosting agricultural productivity took place in favorable irrigated areas, but in the last few decades, the emerging evidence indicates that crop productivity growth in irrigated areas has been slowed down due to decline in irrigation expansion. Furthermore, the prospects of further irrigation development are limited. In such circumstances, rain-fed agriculture must be increased to fill the gap.

The semi-arid regions of the world are primarily dependent on rain-fed agriculture, where the agricultural productivity of rain-fed systems is low (Singh *et al*., 2009).

Pakistan is primarily an arid country with 80% falling in the arid and semiarid regions (Shah *et al*., 2011). Today, Pakistan stands among the most arid countries with an annual rainfall below 240 mm (Farooq *et al*., 2007). The rainfall distribution varies widely: 60% of rainfall in Sindh and Punjab Provinces occurs during the monsoon season, i.e., from July to early September. Balochistan and the northern mountains receive maximum rainfall during October to March. Pakistan depends heavily on annual glacier melts and monsoon rains. During monsoon, 70% of precipitation falls in just 90 days, and is mostly lost during runoff (Zokaib, 2000).

Agriculture provides food, feed, and fiber (Jamshidi *et al*., 2018), and thus holds a key position in the economy of developing countries including Pakistan. Mountain agriculture, in particular, is largely rain-fed in Pakistan (Shahid and Hasnain, 2000). Water deficiency is one of the major problems that drastically affect rain-fed agriculture. Implementing irrigation schemes in hilly areas is not economically viable because they are time consuming, laborious, unsafe and expensive (Koech and Langat, 2018). Therefore, rainwater harvesting is the most appropriate and feasible technique for such hilly areas (Ghani *et al*., 2013). A number of relevant techniques such as storage of water during rainy seasons and efficient use of the harvested water can be adopted to promote sustainable agriculture development in the rain-fed conditions (Ujjayant, 1998). RWHS are simple, cheap, and locally adaptable (Reiz *et al*., 1988). The systems have also been shown to improve water use efficiency, reduce soil erosion, and increase agricultural productivity (Li *et al*., 1999; Wang *et al*., 2005). The objective of this study was to analyze the determinants of the adoption of RWHS in Khyber Pakhtunkhwa Province of Pakistan.

## MATERIALS AND METHODS

This study was conducted in district of Mansehra, Khyber Pakhtunkhwa (KP) Province in Pakistan. A double-stage sampling technique was used to collect data. In the first stage, two villages, namely, Ghouter and Reerh (Figure 1) were selected purposively because of the presence of large number of RWHS. It was confirmed from the exploratory study that farmers in these villages had adopted various RWHS such as channels, ponds, tanks, and bunds. There were two categories of farming households in each village - the adopters of RWHS and non-adopters. In the second stage, 50 'adopter' and 50 'non-adopter' farmers were randomly selected from each category in each village. Thus, the total number of farmers interviewed was 200. Due to the nature of the study, interviews were limited to only one male household member who was preferably the household head or other active farmer in the household. The questionnaire was pre-tested and improved before the final survey. SPSS ver. 20 was used to analyze the data.

The results of the surveys provide a snapshot of adoption of RWHS in the research area. Farmers were interviewed to obtain information about their adoption of any local RWHS, socio-economic conditions such as family size, number of working household members, income from all sources including agriculture, land tenure system, crop production per unit area, existence of Community Based Organization (CBO), their membership of a particular CBO, and their willingness to cooperate with any CBO in their area. Participants of the survey represented a wide range of ages, land tenure and farming system, and socio-economic conditions. Farmers were interviewed one-to-one. The interviews were conducted from June to September, 2014.
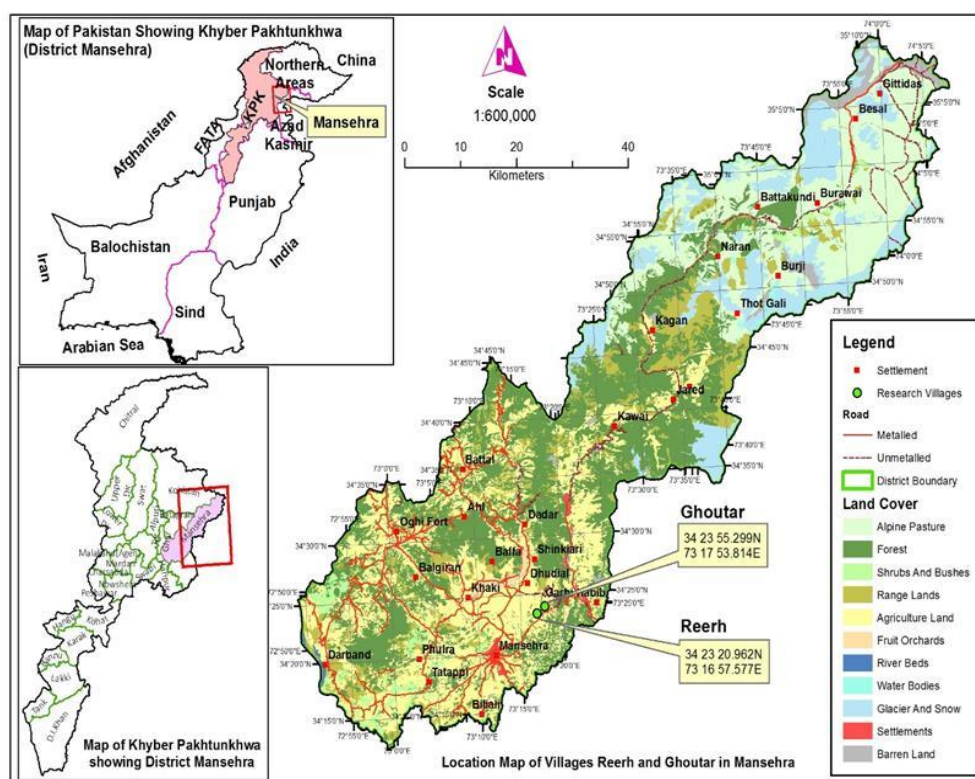


**Figure 1.** Map of Pakistan showing the research villages.

## The Empirical Model

In theory, the adoption of new agricultural technology and active participation in new agricultural interventions depends on a number of factors *viz.*, personal characteristics, socio-economic characteristics, landholding and land tenure system, and farmer's awareness and competence regarding the technology in question (Neupane *et al.*, 2002; Sheikh *et al.*, 2003; Chianu and Tsujii, 2004; Sidibé, 2005; Valizadeh *et al.*, 2018). In this paper, a number of socio-economic factors are hypothesized as the core determinants of the adoption of RWHS. The list of prospective determinants of adoption of RWHS and their descriptive statistics is given in Table 1. The outcome variable is in dummy form and indexes if the farmer has adopted or not adopted the RWHS.

## Model Specification

The outcome variable defined as Y equals to 1 if the household has adopted RWHS, and 0 if otherwise. For binary outcome variables, the most widely used statistical technique is binary regression (Neupane *et al.*, 2002; Baiyegunhi, 2015), the logit

equation form of which is expressed as follow:

$$P = prob(Y=1) = \frac{\exp(x'\beta)}{1+\exp(x'\beta)} \quad (1)$$

$$x'\beta = \beta_0 + \sum_{i=1}^{n} \beta_i X_{ki} \quad (2)$$

Moreover, $\frac{p}{1-p} = \exp(x'\beta)$    (3)

Providing the ultimate form of the Logit model as:

$$\ln \frac{p}{1-p} = x'\beta \quad (4)$$

Where, $\ln \frac{p}{1-p}$ is denoted as Logit (p), i.e.:

$$Logit(p) = x'\beta = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k \quad (5)$$

In this model, each of the β represents log odds ratio. In order to get the results of the model in terms of odds ratios, we take the exponential of the βs, i.e.

Odds ratio= Exp(β)

An odds ratio represents how much likely Y= 1 is, as compared to Y= 0, corresponding to a given explanatory variable X. In other

**Table 1.** Descriptive statistics of the variables used in the logit model.

| Variable | Description | Minimum | Maximum | Mean/ Proportion[a] | Standard deviation |
|---|---|---|---|---|---|
| PARWHS (DV) | Participation in RWHS | | | 50 | |
| AGRESP | Age of respondents | 18 | 85 | 45.25 | 16.21 |
| EDRESP (c) | Education status | | | 76 | |
| OCNONE (c) | Occupation (Jobless) | | | 5 | |
| OCFARM (c) | Occupation (Farming) | | | 61 | |
| OCSERV (c) | Occupation (Services) | | | 12 | |
| OCBUSN (c) | Occupation (Business) | | | 9 | |
| OCLABR (c) | Occupation (Labor) | | | 13 | |
| NOHHWM | Number of working HH members | 1 | 6 | 1.76 | 0.99 |
| NIRIGLD | Non-irrigated Land (Jarebs) | 0 | 26.25 | 4.42 | 4.55 |
| TMINHH | Household monthly income (PKR) | 14167 | 91667 | 32640 | 14743 |
| MEMCBO (c) | Membership of any CBO | | | 23.5 | |
| WANCBO (c) | Want to cooperate with any CBO | | | 59.5 | |

[a] In case of categorical/dummy variable.

words, we can say that the odd ratio determines the likelihood of a household's adoption of RWHS as compared to non-adoption, corresponding to a set of the socio-economic characteristics. The description of the explanatory variables used in the empirical model and their expected signs are given in Table 2.

## RESULTS AND DISCUSSION

### Description of the Explanatory Variables

A vector of potential factors is considered as the core determinants of adoption of RWHS in the research villages. The descriptive statistics of the determinants (explanatory variables) used in the empirical model are provided in Table 1.

AGRESP measures Age of Respondents and is hypothesized to be an important determinant of RWHS in the research area. Evidence shows that age has been an important determinant in adoption studies (He *et al.,* 2007; Baiyegunhi, 2015). In principle, age is considered to have an inverse relationship with adoption of a new technology. The theory of human capital states that the chances of adoption increases with younger age (Sidibé, 2005) and vice versa. The mean age of respondents was recorded as 45.25 years with the standard deviation of 16.21. Based on the mean value of age, which is neither too high nor too low, it was difficult to make a reliable priori

expectation of the net effect of age on adoption of RWHS. Therefore, both positive and negative effects of age on adoption were anticipated in this study.

EDRESP measures Education status of the Respondents. The variable is used in dummy form, which indicates if the farmer is educated or not. The summary statistics revealed that 76% of farmers were educated and the remaining 24% were uneducated. The theoretical framework to include this variable in the model is that the level and quality of human capital affects the choice of new technologies in agriculture (Feder *et al.,* 1985). Education of the respondents has been used as an important and influencing factor in the adoption studies (Adesina and Chianu, 2002; He *et al.,* 2007). Farmers with higher level of education were more likely to adopt agriculture technologies as compared to less educated or uneducated farmers (He *et al.,* 2007). Therefore, in this study the education of farmers is used as an important influencing factor for adoption of RWHS. Based on the higher proportion of educated respondents in the overall sample, the expected sign of the variable in the model was positive.

Occupation of the respondents is another prospective influencing factor determining the adoption behavior of farming households. In the empirical model, occupation of respondents is used as categorical variable. Descriptive statistics revealed that 5% of the sample respondents were jobless (OCNONE), 61% were Farmers (OCFARM), 12% were in Services (OCSERV), 9% were doing Business

**Table 2.** Definition of the explanatory variables used in the probit model.

| Variable | Measurement | Expected sign |
| --- | --- | --- |
| Age of respondents | Continuous (Years) | +/- |
| Education of respondents | Binary (= 1 if educated, 0 otherwise) | + |
| Occupation | Categorical | +/- |
| Number of working household members | Continuous | + |
| Non-irrigated Land | Continuous (Jarebs)[a] | + |
| Household monthly income | Continuous (PKR)[b] | + |
| Membership of any CBO | Binary (= 1 if Yes, 0 otherwise) | + |
| Want to cooperate with any CBO | Binary (= 1 if Yes, 0 otherwise) | + |

[a] 1 Jareb= 0.2 Hectares, [b] Pakistani Rupees (1 USD = 155 PKR or 1 PKR = 273 Iranian Rials as of February 2020 conversion)

(OCBUSN), and 13% were Laborers (OCLABR).

NOHHWM measures the Number of Household Working Members in a household. The variable is used in continuous form with a mean value of 1.76 and a standard deviation of 0.99. The priori expectation was that this variable would positively influence the dependent variable.

NIRIGLD measures the size of the Non-Irrigated Land of the household. Possession of land is an important determinant of the adoption of agriculture related innovations and technology (Sheikh *et al.,* 2003; Senkondo *et al.,* 2004; Sidibé, 2005; Abbasian *et al*., 2017). In this particular model, possession of non-irrigated land is used as an explanatory variable. The theoretical underpinning for using this variable is that the likelihood of a household to adopt RWHS increases with possession of more non-irrigated land and vice versa. The mean size of non-irrigated land was recorded as 4.42 jarebs with a standard deviation of 4.55. It was anticipated that the variable would positively influence a household adoption behavior.

TMINHH measures Total Monthly Income of a Household. Income of a household is another potential factor that may influence a household's adoption behavior (Baiyegunhi, 2015). The choice of a new technology or intervention is strongly influenced by the income level of a household. If the intervention is agriculture related, household income from agriculture is more specifically important in the decision of a household to adopt an intervention. TMINHH is used as a continuous variable in this study with a priori positive expectation. The mean value of the variable is PKR 32,640 with a standard deviation of 14,743.

MEMCBO measures Membership of respondents in any CBO. Participation in various types of social groups is a common element of village life and plays an important role in the spread of knowledge, information, and innovation (Baiyegunhi, 2015). The higher the degree of connectedness between members of a community, the more easily people would be able to share and transfer information about pros and cons of a technology (Baiyegunhi, 2013). Furthermore, members of the CBOs are entitled to provisions such as credit and trainings, which may be used as an incentive to adopt a technology (Sidibé, 2005). Based

**Table 3.** Logit regression estimates of the coefficients associated with variables affecting the adoption of RWHS.

| Variable | Coefficients | Standard error | Significance | Odd ratios |
|---|---|---|---|---|
| AGRESP | 0.040 | 0.021 | 0.058 | 1.040 |
| EDRESP (c) | 0.560 | 0.604 | 0.353 | 1.751 |
| OCFARM (c) | -0.253 | 1.413 | 0.858 | 0.777 |
| OCGOVS (c) | 0.342 | 0.782 | 0.662 | 1.407 |
| OCBUSN (c) | 1.431 | 1.121 | 0.202 | 4.185 |
| OCLABR (c) | -2.154 | 1.249 | 0.085 | 0.116 |
| NOHHWM | 0.359 | 0.330 | 0.278 | 1.432 |
| NIRIGLD | 0.185 | 0.082 | 0.024 | 1.203 |
| TMINHH | 1.367 | 1.814 | 0.043 | 3.818 |
| MEMCBO (c) | -1.545 | 0.896 | 0.085 | 0.213 |
| WANCBO (c) | 0.025 | 0.660 | 0.970 | 1.025 |
| Constant | -1.238 | 1.309 | 0.344 | 0.290 |
| No of observation | 200 | | | |
| -2 Log likelihood | 115.551 | | | |
| Chi-square (11) | 23.78** | | | |

** P< 0.05

on the empirical evidence of membership in any CBO as an important determinant of adoption of agricultural technology, this variable was included in the model as a potential influencing factor in the adoption of RWHS. It was hypothesized that this explanatory variable will positively influence the outcome variable. Descriptive statistics reveal that 23.5% of the respondents confirmed that they were members of CBO in the village.

Despite tremendous importance of participation in social groups in village life, it is not necessary that all members of a community cooperate with the CBO. One of the few important reasons of non-cooperation is passive participation of the community people in the CBO activities. Therefore, the response of the community members who were unaware of the existence of CBO in their village was recorded if they would cooperate with CBO in their village. The variable WANCBO used in the model is in binary form where 59.5% of the respondents noted to cooperate with any CBO in their area. This is an encouraging point for strengthening the social capital of the community, which is important for adoption of RWHS.

## Empirical Results

Logit regression estimates of the coefficients associated with variables affecting the adoption of RWHS in the research villages are presented in Table 3. The table also represents the odd ratio i.e. Exp(B) which determines the effects of explanatory variables on odds of adoption of RWHS. The results further indicate that explanatory variables such as age of the respondents, occupation being a laborer, possession of non-irrigated land, household monthly income, and membership of any CBO had a statistically significant effect on the adoption of RWHS.

The results of the logit model show that AGRESP has a statistically significant and positive relationship with adoption of

RWHS in the research area. This is a positive sign and can be attributed to the fact that older farmers were more experienced, understood the importance of the technology adoption, were more likely to have more money in saving, and were more likely to adopt RWHS. However, the results are in contrast with those of He *et al.* (2007) and Baiyegunhi (2015) who found a negative impact of age on adoption of RWHS in China and South Africa, respectively.

The results of the model also show that Occupation of the respondents as Laborer (OCLABR) was statistically significant but negatively/inversely proportional to adoption of RWHS. It implies that the adoption of RWHS decreases with the occupation of the respondents being labor. This may be attributed to laborers having lesser income and being more likely to have less land. As such, the likelihood of adoption decreases with this profession, which makes theoretical sense.

As hypothesized, NIRIGLD was statistically significant with positive sign. The results of the Exp(B) suggest that for every 1 unit increase in the size of non-irrigated land, we expect a 1.203 times increase in the log-odds of adoption. This implies that the probability of adoption of RWHS increases with increase in the size of non-irrigated land (Sidibé, 2005).

TMINHH has statistically significant and positive effects on adoption of RWHS, i.e. households having higher monthly income are more likely to adopt RWHS. This finding is consistent with our expectation and with literature (Baiyegunhi, 2015). The odds ratio for income is 3.818, which indicates that with an increase of 1 unit in a household's income, the probability of adoption of RWHT increases by 3.818 times.

Membership of a CBO (social capital) plays an important role in a household decision to adopt RWHS. The members of CBO are participating frequently in social activities and are more likely to be aware of the benefits of adopting RWHS. MEMCBO has a statistically significant but negative

relationship with adoption of RWHS. This means that in case of the binary response variable (MEMCBO), the likelihood of adoption of RWHS decreases with the membership of the CBO. These results are opposite to our hypothesis and could mainly be attributed to the fact that only 23.5% of the farmers in the overall sample were CBO members (Table 1). The results are in contrast with those of Birungi and Hassan (2007) and Katungi *et al.* (2007) who found a positive association between connectedness to social groups and early adoption of technologies.

Finally, the results in Table 3 show that the overall model fits well to the data, as shown by the log-Likelihood Ratio (LR) test of -2 log likelihood value of 115.551 with a P-value less than 0.05. This implies existence of a significant relationship between the log of odds, and hence, odds of adoption of RWHS and the explanatory variables included in the model. As such, these variables contribute significantly to the explanation of RWHS adoption behavior of the sample farmers (Neupane *et al.*, 2002).

## CONCLUSIONS

The results of the binary logit model depict that the age of respondents has a significant and positive effect on adoption behavior of the respondents, as elder farmers are more experienced and are more likely to have more savings, which are critical factors for technology adoption. Similarly, variables such as occupation as laborer, size of non-irrigated land, monthly income of the farmers' household, and membership of any CBO (social capital) were also significant in the model. However, negative signs of the coefficients of the two variables, *viz.* occupation as laborer and membership of any CBO reveal that they have inverse relation to adoption of RWHS. Therefore, socio-economic characteristics of farmers contribute significantly to the RWHS adoption behavior of the sample farmers. It is recommended that due to the available

potential for rainwater harvesting in the research area, there is a need for increased public and private investment in promotion of RWHS. Furthermore, efforts should be made to increase connectedness of local people in social networks. For this purpose, the government, NGOs, and other voluntary organizations should play their role to organize local people in different social groups. This will certainly increase the inter-connectedness of people and expose them to more trainings and awareness, and thus, will affect adoption of RWHS in future.

## ACKNOWLEDGEMENTS

## REFERENCES

1. Abbasian, A. R., Chizari, M. and Bijani, M. 2017. Farmers' Views on the Factors Inhibiting the Implementation of Soil Conservation Practices in Koohdasht, Iran. *J. Agr. Sci. Tech.,* **19(4)**: 797-807.
2. Adesina, A. A. and Chianu, J. 2002. Determinants of Farmers' Adoption and Adaptation of Alley Farming Technology in Nigeria. *Agrof. Syst.*, **55(2)**: 99-112.
3. Baiyegunhi, L. J. S. 2013. Rural Households' Social Capital and Welfare: A Case Study of Msinga, KwaZulu-Natal,

South Africa. *J. Agric. Rur. Deve. Trop. Subtro.,* **114(2)**: 123-132.

4. Baiyegunhi, L. J. S. 2015. Determinants of Rainwater Harvesting Technology (RWHT) Adoption for Home Gardening in Msinga, KwaZulu-Natal, South Africa. *Water SA.,* **41(1)**: 33-40.

5. Birungi, P. B. and Hassan, R. M. 2007. Impact of Alternative Land Management Options on Soil Fertility and Erosion in Uganda. *Agrekon.,* **46(3)**: 410-424.

6. Boers, T. M. and Ben-Asher, J. 1982. A Review of Rainwater Harvesting. *Agric. Water Manage.,* **5(2)**: 145-158.

7. Borlaug, N. E. 2001. *Feeding the World in the 21st Century: The Role of Agricultural Science and Technology*. Speech Given at Tuskegge University, April 2001. Online at: http://www.agbioworld.org/biotech-info/topics/borlaug/borlaugspeech.html.

8. Chianu, J. N. and Tsujii, H. 2004. Determinants of Farmers' Decision to Adopt or not Adopt Inorganic Fertilizer in the Savannas of Northern Nigeria. *Nutr. Cycl. Agroecosyst.,* **70(30)**: 293-301.

9. Deng, X. -P., Shan, L., Zhang, H. and Turner, N. C. 2006. Improving Agricultural Water Use Efficiency in Arid and Semiarid Areas of China. *Agric. Water Manage.,* **80(1)**: 23-40.

10. Farooq, U., Ahmad, M. and Jasra, A. W. 2007. Natural Resource Conservation, Poverty Alleviation, and Farmer Partnership. *Pak. Dev. Rev.,* **46(4)**: 1023-1049.

11. Feder, G., Just, R. E. and Zilberman, D. 1985. Adoption of Agricultural Innovations in Developing Countries: A Survey. *Econ. Dev. Cult. Chang.,* **33(2)**: 255-298.

12. Fleskens, L., Stroosnijder, L., Ouessar, M. and De Graaff, J. 2005. Evaluation of the On-Site Impact of Water Harvesting in Southern Tunisia. *J. Arid Environ.,* **62(4)**: 613-630.

13. Frot, E., van Wesemael, B., Benet, A. S. and House, M. A. 2008. Water Harvesting Potential in Function of Hillslope Characteristics: A Case Study from the Sierra de Gador (Almeria Province, South-East Spain). *J. Arid Environ.,* **72(7)**: 1213-1231.

14. Ghani, M. W., Arshad, M., Shabbir, A., Shakoor, A., Mehmood, N. and Ahmad, I. 2013. Investigation of Potential Water Harvesting Sites at Potohar Using Modeling Approach. *Pak. J. Agric. Sci.,* **50(4)**: 723-729.

15. He, X. F., Cao, H., and Li, F. M. 2007. Econometric Analysis of the Determinants of Adoption of Rainwater Harvesting and Supplementary Irrigation Technology (RHSIT) in the Semiarid Loess Plateau of China. *Agric. Water Manage.,* **89(3)**: 243-250.

16. Jamshidi, O., Asadi, A., Kalantari, Kh. and Azadi, H. 2018. Perception, Knowledge, and Behavior towards Climate Change: A Survey among Agricultural Professionals in Hamadan Province, Iran. *J. Agr. Sci. Tech.,* **20**: 1369-1382

17. Katungi, E., Machethe, C. H. A. R. L. E. S. and Smale, M. 2007. Determinants of Social Capital Formation in Rural Uganda: Implications for Group-based Agricultural Extension Approaches. *Afric. J. Agric. Res. Econ.,* **1(2)**: 167-190.

18. Koech, R. and Langat, P. 2018. Improving Irrigation Water Use Efficiency: A Review of Advances, Challenges and Opportunities in the Australian Context. *Water,* **10(12)**: 1771. doi:10.3390/w10121771.

19. Kumar, M. D., Ghosh, S., Patel, A., Singh, O. P. and Ravindranath, R. 2006. Rainwater Harvesting in India: Some Critical Issues for Basin Planning and Research. *Land Use Water Reso. Res.,* **6(1)**: 1-17.

20. Li, F. M., Wang, J. and Zhao, S. L. 1999. The Rainwater Harvesting Technology Approach for Dryland Agriculture in Semi-arid Loess Plateau of China. *Acta. Ecol. Sini.,* **19(2)**: 259-264.

21. Neupane, R. P., Sharma, K. R. and Thapa, G. B. 2002. Adoption of Agroforestry in the Hills of Nepal: A Logistic Regression Analysis. *Agri. Syst.,* **72(3)**: 177-196.

22. Oweis, T. and Hachum, A. 2006. Water Harvesting and Supplemental Irrigation for Improved Water Productivity of Dry Farming Systems in West Asia and North Africa. *Agric. Water Manage.,* **80(1)**: 57-73.

23. Oweis, T. and Hachum, A. 2009. Optimizing Supplemental Irrigation: Tradeoffs between Profitability and Sustainability. *Agri. Water Manage.,* **96(3)**: 511-516.

24. Oweis, T. and Hachum, A. 2012. Supplemental Irrigation, a Highly Efficient Water-Use Practice. ICARDA, Aleppo, Syria.

25. Pyagay, A., Zhekeyeva, K., Aktailakova, G., Iskakova, M. and Tulegenova, Z. 2018.

Ensuring Food Security of Developing Economy: Issues and Perspectives. *J. Agr. Sci. Tech.,* **20**: 1085-1097.

26. Reiz, C., Maulder, P. and Begemann, L. 1988. *Water Harvesting for Plant Production.* The World Bank Technical Paper 91, Washington, DC, USA.

27. Rockström, J., Hatibu, N., Oweis, T. Y., Wani, S., Barron, J., Bruggeman, A., Farahani, J., Karlberg, L. and Qiang, Z. 2007. Managing Water in Rainfed Agriculture. In: *"Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture"*, (Ed.): Molden, D. Earthscan, Colombo, Sri Lanka, IWMI, London, UK.

28. Rockström, J., Karlberg, L., Wani, S. P., Barron, J., Hatibu, N., Oweis, T. Y., Bruggeman, A., Farahani, J. and Qiang, Z. 2010. Managing Water in Rainfed Agriculture: The Need for a Paradigm Shift. *Agri. Water Manage.,* **97(4)**: 543-550.

29. Schiettecatte, W., Ouessar, M., Gabriels, D., Tanghe, S., Heirman, S. and Abdelli, F. 2005. Impact of Water Harvesting Techniques on Soil and Water Conservation: A Case Study on a Micro Catchment in Southeastern Tunisia. *J. Arid Envir.,* **61**: 297-313.

30. Senkondo, E. M. M., Mdoe, N. S. Y., Hatibu, N., Mahoo, H. and Gowing, J. 2004. Factors Affecting the Adoption of Rainwater Harvesting Technologies in Western Pare Lowlands of Tanzania. *Tanza. J. Agric. Sci.,* **1(1)**: 81-89.

31. Shah, A. H., Gill, K. H. and Syed, N. I. 2011. Sustainable Salinity Management for Combating Desertification in Pakistan. *Int. J. Water Reso. Arid Envir.,* **1(5)**: 312-317.

32. Shahid, M. Z. and Hasnain, T. 2000. *Water Harvesting in Mountain Areas of Pakistan: Issues and Options*. Sustainable Development Policy Institute (SDPI), Islamabad, Pakistan.

33. Sheikh, A. D., Rehman, T. and Yates, C. M. 2003. Logit Models for Identifying the Factors that Influence the Uptake of New 'No-Tillage' Technologies by Farmers in the Rice-Wheat and the Cotton-Wheat Farming Systems of Pakistan's Punjab. *Agri. Syst.,* **75(1)**: 79-95.

34. Sidibé, A. 2005. Farm-Level Adoption of Soil and Water Conservation Techniques in Northern Burkina Faso. *Agric. Water Manage.,* **71(3)**: 211-224.

35. Singh, P., Aggarwal, P. K., Bhatia, V. S., Murty, M. V. R., Pala, M., Oweis, T., Benli, B., Rao, K. P. C. and Wani, S. P. 2009. Yield Gap Snalysis: Modelling of Achievable Yields at Farm Level. In: *"Rainfed Agriculture: Unlocking the Potential"*, (Eds.): Wani, S. P., Rockström, J. and Oweis, T. CAB International, 81 PP.

36. Ujjayant, C. 1998. The Economic and Environmental Impacts of Irrigation and Drainage in Developing Countries. In: *"Agriculture and the Environment: Perspectives on Sustainable Rural Development"*, (Ed.): Lutz, E. The World Bank, Washington DC, USA.

37. Valizadeh, N., Bijani, M. and Abbasi, E. 2018. Farmers Active Participation in Water Conservation: Insights from a Survey among Farmers in Southern Regions of West Azerbaijan Province, Iran. *J. Agr. Sci. Tech.,* **20**: 895-910.

38. van Wesemael, B., Mulligan, M. and Poesen, J. 2000. Spatial Patterns of Soil Water Balance on Intensively Cultivated Hillslopes in a Semi-arid Environment: The Impact of Rock Fragments and Soil Thickness. *Hydro. Process.,* **14(10)**: 1811-1828.

39. Wallace, J. S. 2000. Increasing Agricultural Water use Efficiency to meet Future Food Production. *Agri. Ecosys. Environ.,* **82(1)**: 105-119.

40. Wang, X. L., Li, F. M., Jia, Y. and Shi, W. Q. 2005. Increasing Potato Yields with Additional Water and Increased Soil Temperature. *Agric. Water Manage.,* **78(3)**: 181-194.

41. Zokaib, S. 2000. Study of Runoff, Soil Erosion and Local Water Harvesting Practices, at Hillkot Watershed (Mansehra). Unpublished Thesis, Department of Water Management, University of Agriculture Peshawar, Pakistan.

# عوامل اجتماعی-اقتصادی تعیین کننده پذیرش سامانه جمع آوری باران توسط کشاورزان در مناطق نیمه خشک پاکستان

## ا. جان

## چکیده

در این مقاله، عوامل اجتماعی- اقتصادی تعیین کننده سامانه جمع آوری باران (RWHS) در پاکستان تحلیل می شود. پژوهش مربوطه بر مبنای نظر سنجی از ۲۰۰ خانوار کشاورز انتخاب شده در دو روستا در پاکستان انجام شد. به این منظور از یک مدل ورود باینری ( **binary logit model**) برای شناسایی عوامل تعیین کننده سامانه جمع آوری باران استفاده شد. نتایج نشان داد که از نظر آماری، سن پاسخ دهندگان، اندازه زمین آبیاری نشده، و درآمد ماهانه خانوار با پذیرش سامانه جمع آوری باران رابطه معنادار و مثبتی داشتند. بر عکس، متغیر هایی مانند نوع شغل به عنوان کارگر و عضویت در هر نهاد مبتنی بر جامعه(CBO) تاثیر معنادار و معکوسی بر پذیرش سامانه جمع آوری باران داشت. به طور کلی این مدل در سطح p<0.05 معنادار بود و این نشان می دهد که ویژگی های اجتماعی-اقتصادی جامعه عوامل اصلی در پذیرش سامانه جمع آوری باران است. بر پایه توصیه این آزمایش، برای گسترش سامانه جمع آوری باران در پاکستان، ایجاد حرکتی اجتماعی با افزایش سرمایه گذاری عمومی و خصوصی و مداخله فعال سازمان های غیر دولتی (NGO) و سازمان های داوطلب ضروری است.