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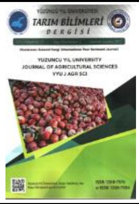

Research Article (Araştırma Makalesi)

An Assessment of Willingness for Adoption of Climate-Smart Agriculture (CSA) Practices through the Farmers' Adaptive Capacity Determinants

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Abstract: Climate-change-related impacts on the agriculture sector have been intensifying in the Asian region particularly for developing countries. In order to encourage innovative adaptation practices, it is critical to understand the farmers' perspectives on the possibility of adopting climate-smart agriculture (CSA) measures and the obstacles they face. However, limited studies have considered how farmers respond to climate change impacts, and concerning to this, the opportunities in the relevance of resilience via adaptive capacity (AC) were addressed. This study investigates the adoption of climate-smart agriculture in Punjab, Pakistan by using a survey of 420 farmers, with a view to understanding the farmers' practices, adaptive capacity to respond, and willingness for the adoption of climate-smart agriculture measures to mitigate the climate change impact. Driving factors of the farm households' intended to the adoption of climate-smart agriculture were examined using a logistic model. The results of the study showed that the drivers of adaptive capacity such as the human, physical, natural, financial and social capacity of the farm households were significantly determinant to the possibility of adopting climate-smart agriculture measures. Further, we also identified lack of institutional support and a lack of information were the major obstacles for adopting these innovative measures. This study suggested that climate-policy should be designed in a regional context specifically focusing on the institutional services and access to the resources. It is the best way to increase the acceptance for the adoption of these innovative measures by increasing the farmers' adaptive capacity endowment.

İklim Açısından Akıllı Tarımın (CSA) Benimsenmesi Konusundaki İstekliliğin Çiftçilerin Uyum Kapasitesi Belirleyicileri Aracılığıyla Değerlendirilmesi

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Anahtar kelimeler
Adaptasyon,
Uyum kapasitesi,
Mal varlığı,

Öz: İklim değişikliğinin tarım sektörü üzerindeki etkilerine yönelik çalışmalar, özellikle gelişmekte olan ülkeler için Asya bölgesinde yoğunlaşmaktadır. Yenilikçi adaptasyon uygulamalarını teşvik etmek için, çiftçilerin iklim açısından akıllı tarım (CSA) önlemlerini benimseme olasılığı ve karşılaştıkları engeller konusundaki bakış açılarını anlamak çok önemlidir. Bununla birlikte, sınırlı sayıda araştırma, çiftçilerin iklim değişikliği etkilerine nasıl cevap verdiğini değerlendirmiş ve buna bağlı olarak, uyum kapasitesi (AC) ile esneklik arasındaki ilgi düzeyi ve fırsatları konu edinmiştir. Bu çalışmada, Pakistan'ın Pencap kentinde iklim-akıllı tarımın benimsenmesi, 420 çiftçi anketi kullanarak, iklim değişikliğinin etkisi araştırılmıştır. Bu konuda çiftçilerin uygulamalarını anlamak, iklim değişikliğini

İklim-akıllı tarım, Çiftçiler.

karşılama durumu ve uyum kapasitesi ile etkilerini hafifletmek için akıllı-iklim tarım önlemlerinin benimsenmesine duyduğu istek irdelenmiştir. İklim-akıllı tarımın benimsenmesine yönelik çiftlik hane halkının lokomotif faktörleri ekonometrik bir model olan "lojistik model" kullanılarak incelenmiştir. Çalışmanın sonuçları, tarım işletmelerinin insan gücü, fiziksel, doğal, finansal ve sosyal kapasiteleri gibi uyum kapasitelerini etkileyen faktörlerin, iklim-akıllı tarım önlemlerini benimseme ihtimalini önemli ölçüde belirlediğini göstermektedir. Ayrıca, kurumsal destek ve bilgi eksikliğinin de bu yenilikçi önlemleri almanın önündeki en büyük engel olduğu belirlenmiştir. Bu çalışma, iklim politikasının özellikle kurumsal hizmetlere ve kaynaklara erişime odaklanan bölgesel bir bağlamda tasarlanması gerektiğini ortaya çıkarmıştır. Çiftçilerin uyum kapasitesi donanımını artırarak bu yenilikçi önlemleri kabul etmesini sağlamak en iyi yoldur.

1. Introduction

Climate change is a global phenomenon, and it has varying impacts on the natural and human systems, which need the mobilization of all the available resources to cope, anticipate, resist and recover from the climatic variability. These climate changes include more frequent and extreme uneven precipitation events, a rise in average temperature, and changes in cropping seasons. The impact of these climate changes has serious effects particularly, on the agriculture sector by the decrease in crop productivity, invasions of pathogens and pests, shifts in crop planting dates and reduced to the resilience of agro-ecosystems. These impacts are more common in developing countries than in developed countries.

Pakistan is ranked the 8th among the most vulnerable countries in the world to the adverse effects of climate change (Sardar et al., 2016). Pakistan's economy is built predominantly on the agriculture sector which is highly sensitive to weather variability and as a result, farmers affect more from these climate changes related to stressors. Traditional farmers' practices result in low crop productivity because these practices are not effective in stabilizing the agricultural production to cope with the impact of climate change. Therefore, the adoption of climate-smart agriculture (CSA) practices is the only possible way of overcoming the adverse effects of climate change. For instance, Food Agriculture Organization (FAO) has introduced the concept of Climate-Smart Agriculture (CSA) under which innovative and sustainable agricultural practices are proposed to adopt at the farm level. Adaptation to climate variability involves adjustments in natural or human systems which reduces the negative impact of climate change and exploits positive opportunities. It also refers to changing farming practices as an important means to cope with climate variability. Examples include CSA practices such as adopting improved water management, nutrient management, zero or minimum tillage, improved crop varieties and modifying planting dates. These selected CSA practices are considered as effective in terms of reducing vulnerability to climate shocks and by increasing the resilience of agricultural systems (Pachauri et al., 2007). The primary purpose of adopting these CSA measures is to improve the average yields and uncertain benefits to the farmers by reducing the risk to the current or expected climate variability stresses. These CSA measures actually contribute to the adaptation of climate variability, which depends on the adaptive capacity of the farmers to undertake the adjustments in farming practices. While, adaptive capacity determinants include weather variability and socioeconomic factors, such as individuals' characteristics, institutional role, and market development, as well as agro-ecological conditions of the region.

Existing literature in Pakistan focuses on the economic and bio-physical relationship among the agriculture sector and climate vulnerability. But actual field-based studies to examine the farm level adaptive capacity and adoption of CSA measures to mitigate the climate change impacts are rare. Therefore, there is the need for a field-based study to truly understand the farmers' adaptive capacity to respond and willingness for the adoption (WTA) of CSA measures responses to climate change at the farm level in Punjab.

This study investigates whether the farmers are willing to adopt CSA practices as adaptation strategies to cope with climate variability in the context of climate change. And, how farmers' adaptive capacity, or lack thereof, affects the possibility of adopting CSA measures at farm level in Punjab. In this study, we seek answers to these questions in the context of the local farmers through the conditioning factors that accelerate or hinder the use of these selected CSA measures.

2. Material and Methods

Literature that examines the farmers' willingness to adopt (WTA) for agriculture adaptation practices is based on the models of human behaviour that is adopted from neo-classical economics theories e.g. Theory of Reasoned Action, The diffusion of innovation theory, and Theory of technology adoption (Sheppard et al., 1994). These economic theories are based on the alternative behaviour models that predict human behaviour for adaptation of new innovative practices. The adaptation of these practices depends on the multiple factors and drivers of adaptive capacity such as individual and social characteristics, their perceived usefulness, compatibility, its relative advantage, and the farmers' acceptance for technology adoption.

Using the theory of technology adoption as a base, we modelled our study in which a rational farm household who faces a problem of choice and chooses adoption of CSA practices option as the outcome to maximize his utility subject to the constraints (Aubert et al., 2012). Farm household experiences the common constraints regarding their adaptive capacity of adopting CSA practices e.g. financial condition, institutional support, assets endowments, social and individual characteristics, availability of the technology and other inputs resources for adopting CSA practices. Following (Aubert et al., 2012; Magruder, 2018; Kumar et al., 2018; Zongo et al., 2015), we demonstrated a utility function (U_{ij}) for a farm household *'i'* who chooses *j* alternatives for willingness to adopt or reject CSA practices to maximize his utility, that can be expressed as:

$$U_{ij} = \alpha_j Z_i + \varepsilon_{ij} \tag{1}$$

where, j=1 if the farmer intended to adopt CSA practices otherwise, j=0 if the farmer is not willing to adopt.

Farmers' decisions for adopting CSA practices are assumed to provide the utility (U_{i1}) for adopters and (U_{i0}) for non-adopted farmers respectively. A farmer, who adopts CSA practices, has a greater value of the utility (U_{i1}) than the alternative (U_{i0}), which can be expressed as follows

$$U_{i1} = \alpha_1 Z_i + \varepsilon_{i1} > U_{i0} = \alpha_0 Z_i + \varepsilon_{i0} \tag{2}$$

In this equation, Z_i is a vector of adaptive capacity that consists of individuals, socio-economic characteristics and institutional support to the farmers. α_1 and α_0 are the vectors of the parameters to be estimated. ε_{i1} and ε_{i0} are the error terms. The probability of a farm household who intended to adopt CSA practices j=1 to the alternative j=0 is given as:

$$W_a = Pr\,(j = 1) = Pr\,(U_{i1} > U_{i0}) = Pr(\alpha_1 Z_i + \varepsilon_{i1} > \alpha_0 Z_i + \varepsilon_{i0}) \tag{3}$$

$$W_a = Pr\,(\varepsilon_{i1} - \varepsilon_{i0} > \alpha_0 Z_i - \alpha_1 Z_i) = Pr\,(\varepsilon_{i1} - \varepsilon_{i0} > (\alpha_0 - \alpha_1) Z_i) \tag{4}$$

$$W_a = Pr\,(\omega_i > \beta Z_i) = \varphi(\beta Z_i) \tag{5}$$

Equation (5) shows that the probability of a farm household who will adopt CSA practices. This is the probability that a farm household achieved from the higher utility after adopting CSA practices than the utility derived by the farmers who are not willing to adopt.

Methods to analyse the farmers' decisions to adopt CSA practices such as logit models, tobit models, and probit models are extensively used in the literature. In this study, farmers' decision for adopting CSA practices depend on the distribution function ($\varphi(\beta Z_i)$) associated with (ω_i). Therefore, the following equation shows the farmers' decision intended to adopt or reject the CSA practices that can be expressed as:

$$W_a = \varphi(\beta Z_i) = Exp\,\left(\frac{Exp(\beta Z_i)}{1 + Exp(\beta Z_i)}\right) \tag{6}$$

In equation (6), W_a represents the dependent variable with a binary outcome (willingness to adopt), and $\varphi(\beta Z_i)$ is the probability that farm households will adopt CSA practices to cope with the impact of climate change.

The more specifically binary outcome variable of willingness to adopt (W_a), representing the choice of adopting CSA practices in terms of its determinants, can be expressed as:

$$\Pr\,(W_{a_{ij}}) = \alpha_j\, Z_i + \beta_j Y_i + \varepsilon_{ij} \quad (7)$$

Where,
Z_i is the vector of adaptive capacity
Y_i is the climate shocks index

This study employs the theory of technology adoption through which an economic agent who intended to adopt CSA practices to mitigate the impact of climate change. The dependent variable (W_a) defines farmers' willingness to adopt CSA practices that refer to a binary outcome variable. It takes 1 if a farmer is willing to adopt CSA practices and 0 otherwise. Explanatory variable (Z_i) is the vector of adaptive capacity that is related to the individual, socio-economic characteristics of the farmers and institutional support provide to the farm household for adopting CSA, while (Y_i) is the climate variable depicting the climate shocks experienced by the farm household. Based on the data behaviour and for unbiased findings, we estimated equation (7) using the logistic regression model to fulfil the objectives of the study. We examined the drivers of adaptive capacity and their willingness to adopt for selected CSA measures by using the primary data sets. We collected survey data from 420 farmers in August 2018 to September 2018 in three study districts such as Jhang, Sialkot and Rhim Yar Khan located in different agro-ecological zones (AEZs). All three selected AEZs have different attributes of environment, geography, and socio-economic conditions. The richness and the relevance of this dataset allowed us to investigate the drivers of farmers' adaptive capacity and their WTA for CSA practices at the farm level in Punjab province. Details of the variables used in the assessment of adaptive capacity and willingness to adopt for CSA practices are given in Table 1.

Table. 1. Variables description of the sampled data used in the study.

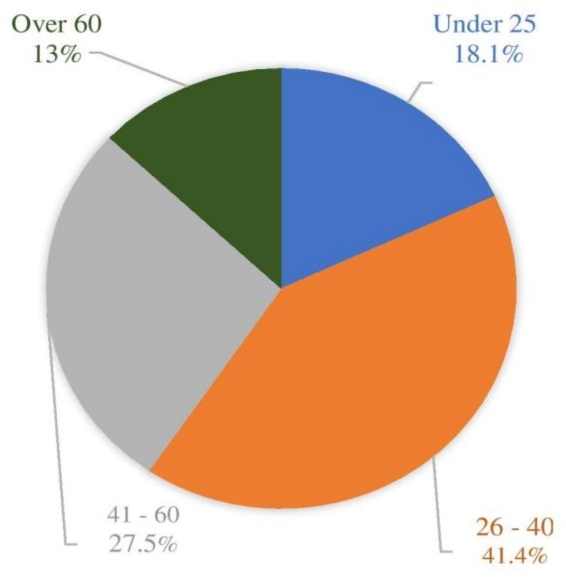
Factor/sub-factor (variables)	Definition
Actual adaptation (AA)	The farmer who adopted full package of CSA practices (1=yes, 0=no)
Willingness to adopt (WTA)	The farmer who could not adopt the full package of CSA practices, but he is willing to adopt (1=yes, 0=no)
Human capacity	
Working family members (Working_memb)	Working family members in a household (in numbers)
Education (Edu)	Education attainment (in years)
Experience (Exp)	Farming experience (years)
Social capacity	
Access to information (Acc_info)	Access to information related to crop and livestock production; and weather forecasting information (1 if a farmer had access, 0 otherwise)
Social network and strength of collective action	
(a) Social dependency (Social_dep)	Dependence on the family system (*i.e.* to the head of the family) or to the head of the village for making a decision related to agricultural production (1=yes, 0=no)
(b) Relative assistance (Relat_assis)	Availability of relatives and friends for assistance such as seeking money or equipment sharing (1=yes, 0=no)
Natural capacity	
Irrigation resources (Irri_resour)	Irrigation resources comprising of surface water resources (such as river and canal water) and ground-water resources
Farm size (Farm_size)	Size of farmland owned or rented for cultivation (in hectares)
Physical capacity	
Distance to extension centre (Dist_ext)	Distance from farmland to the nearest the extension centre (kilometres)
Agriculture technology assets (Agri_tech_assets)	Availability of agricultural technology assets such as tractors and machinery (in numbers)
Livestock owned (Livestock_own)	Total livestock owned (in numbers)
Financial capacity (farm solvency)	
Credit access (Credit_acc)	Availability of credit access (1 = yes; 0 = no)
Financial resources (Financial_res)	Total net income earned from the agricultural production (in rupees per year)
Climate Shocks (Climatic_shocks)	Plot-disturbance-index

Note: Proxy indicators used for assessing the agricultural adaptive capacity based on the observed adaptation strategies /actions are derived from the survey and documented in the literature review.

3. Results

3.1. Farm-level characteristics of sample data

Descriptive statistics of responding farmers with respect to age group and education attainment are shown in figure 1 and figure 2 respectively.



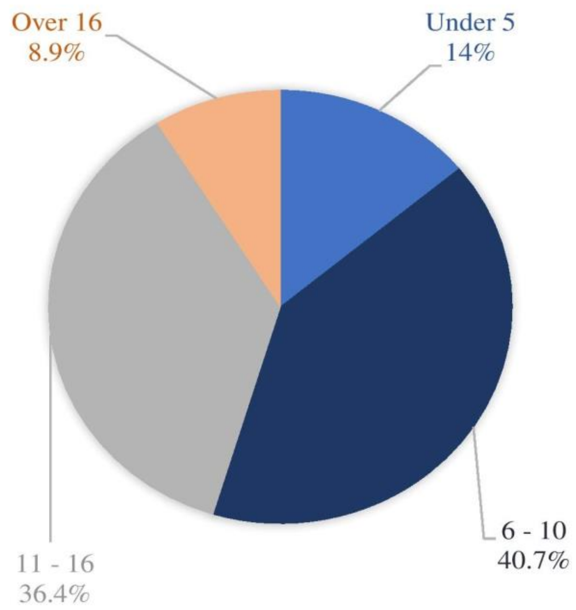


Figure 1. Respondent (%) with age group

Figure 2. Respondent (%) with education attainment.

Fig. 1 shows that around 70% of the farmers who were willing to adopt CSA practices lie in the age of 26 to 60 years while the remaining 30% belong to the rest of the age. This may be pointed out that those farm households who were young and had greater farming experience were likely to have more awareness of climate variability and more intended to adopt innovative CSA practices to cope with climate change impact than the other farmers. The study showed that education attainment is an important factor for taking the decision regarding the adoption of CSA measures. Fig. 2 showed that more than 75% of respondent farmers who were ready to adopt CSA measures were qualified from primary to the graduate level of education. It indicates that education raises more awareness for accessing the information and for the application of the improved agricultural technologies at the farm level to cope with climate change impact. Therefore, the farm households who have higher education and belong to the younger age will likely more to adapt the climate changes as compared with the little education.

We also comparatively examined sample statistics of the farmers' adaptive capacity. To account for this, we disaggregated farmers' socio-economic characteristics based on the averages in three categories. First, the farmer who adopted a full set of CSA measures (named as 'actual adaptation'). Second, the farmer who could not adopt the full set of CSA measures, but he was willing to adopt (referred to as 'willingness to adopt'), and third the farmer who was not willing to adopt CSA practices (named as 'not intended to adopt'). The average characteristics of the farmers in all three categories are shown as follows in fig. 3 (a) and fig. 3 (b).

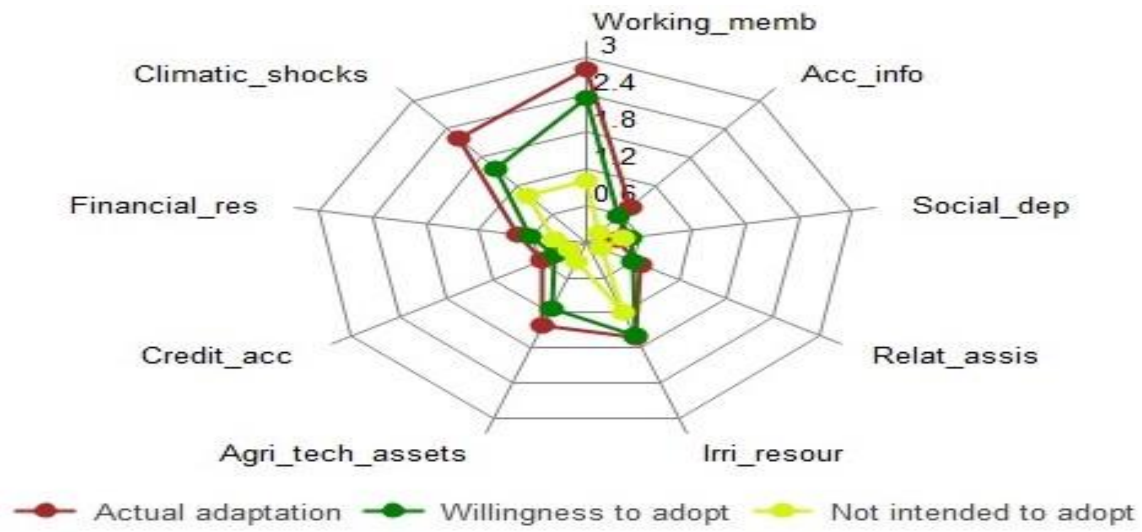


Figure 3 (a): Average characteristics of the sample farmers.

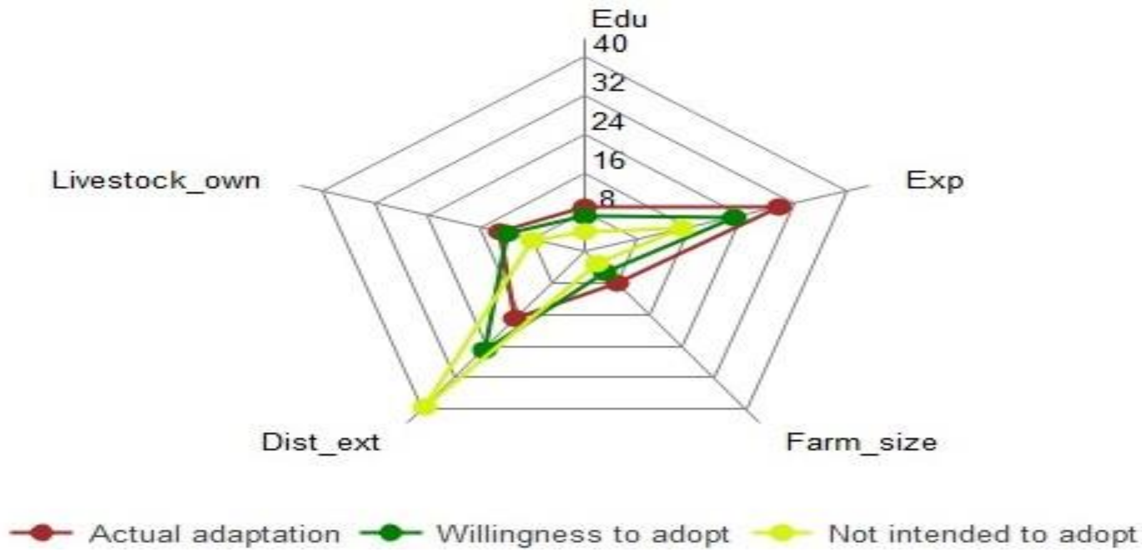


Figure 3 (b): Average characteristics of the sample farmers

Fig. 3(a) and 3(b) showed that the farmers who adopted a full set of CSA measures (Actual adaptation) had a higher adaptive capacity than the farmers who could not adopt but they were willing to adopt (Willingness to adopt). The farmers who had the least adaptive capacity. They were not interested in adopting CSA measures. This may be pointed out that a rise in the adaptive capacity of the farmers stimulated more to the farmers for adopting CSA measures because higher adaptive capacity represents more institutional access, better financial resources, and higher asset endowments that farm households' hold. Therefore, it enables the farmers more to adopt CSA practices to mitigate the climate change impact.

3.2. Factors affecting the adoption of CSA measures

To quantify the impact of farmers' adaptive capacity for the choice of adoption of CSA measures, we employed a logistic regression model. The coefficients of logistic regression estimates are presented in Table 2 of column (1) and the marginal effects are given in table 2 of column (2).

Table 2. Logistic regression results of WTA model and their marginal probability effects

Regressor	Regression estimate	Marginal effect
Human capacity		
Working_memb	0.335*	0.017*
	(0.172)	(0.009)
Edu	0.418**	0.031**
	(0.198)	(0.015)
Exp	0.311*	0.002**
	(0.162)	(0.001)
Social capacity		
Acc_info	0.433**	0.025*
	(0.214)	(0.014)
Social_dep	0.608	0.024
	(0.571)	(0.029)
Relat_assis	1.044***	0.042***
	(0.338)	(0.012)
Natural capacity		
Irri_resour	0.155*	0.003
	(0.078)	(0.002)
Farm_size	0.052*	0.039*
	(0.029)	(0.021)
Physical capacity		
Dist_ext	0.813***	0.011***
	(0.301)	(0.004)
Agri_tech_assets	0.202*	0.061*
	(0.113)	(0.034)
Livestock_own	0.089	0.007
	(0.911)	(0.006)
Financial capacity (farm solvency)		
Credit_acc	0.667***	0.017**
	(0.291)	(0.007)
Financial_res	0.377***	0.055***
	(0.121)	(0.017)
Climatic_shocks	1.268***	0.018***
	(0.424)	(0.006)
Loglikelihood	-361.471	
LR chi-squared	150.385***	
Pseudo R^2	0.328	
Total observation	405	

Note: ***, ** and * indicates the significance of probability levels at 1%, 5% and 10%, respectively. Standard errors in parenthesis.

In this study, we assessed human capacity by using the proxy of working family members, education attainment and farming experience of the farm households. The positive coefficient of working family members, education attainment and farming experience showed a positive association with the probability of willingness to adopt for CSA measures in response to climate change (Table 2). The human capacity indicators with a positive and significant impact confirmed that the farmers who had more education, related knowledge, and skills of agricultural production and to cope with climate variability were enabled more to adopt. The positive association of experience showed that farmers tried their best to adapt and to cope with climate change within the known boundaries of knowledge and experience. Similarly, some NGOs and the government agencies in Pakistan provide the training courses and the awareness about climate variability to raise the knowledge and skills of the farmers. We can conclude that the farm household who had higher education and greater farming experience were likely to have more awareness about climate variability and more intended to adopt. The study suggested that targeted training should be provided across a range of topics to improve their education and knowledge for increasing the ability to manage the increased climate variability. And, the training should be integrated with the active participation of the farmers' leaders, village leaders with NGOs and government authorities.

We estimated social capacity by using the indicators of access to information and social networking of the farmers. Where the farm households' social networks and institutional access were linked with local authorities and to the market development. The results indicated that a positive and significant relationship was found between access to information and social networking for willingness to adopting CSA measures to mitigate climate change impact (Table 2). Positive association of social capacity indicators showed that timely institutional support provided by the extension department and the other related institutions on agricultural production, techniques and for the use of technology to the farmers dealing with climate variability encourage the farmers more to adopt. It showed the importance of the farmer's social networks with relative assistance that how it helps to facilitate the needy farm household who requires money when he is sick or needs to buy any agricultural production-related materials. It is also indicated the significance of the farmer's community interaction with local authorities and the government because farmers require help and support on the adoption of CSA measures such as they need help from the agriculture extension department, development or seeking information regarding applications of adaptation or mitigation measures. It helps the farm household to use that knowledge in their production for adopting CSA measures. It may be pointed out that farmers are living in different agro-ecological zones that vary according to the locally prevailed culture. It also showed that relative assistance was very important when a farmer needed financial and moral support for choosing innovative CSA measures to cope with weather variability. Our results support the study findings (Brown et al., 2018).

Natural capacity, we assessed through irrigation resources and farm size holding by the farmers. Most of the studies had already used these indicators for measuring the natural capacity of the farmers. Estimation showed that farm size (land area cultivated by the farm household) had a positive and significant impact on the probability of willingness to adopt CSA practices (Table 2) but irrigation resources showed an insignificant impact (Table 2). Positive and significant association of farm size confirmed that farm-size was the main factor in the development of the typologies because large landholder framers had more production due to better access to the availability of the resources. It is also indicated that large landholders were better endowed with natural resources than the other farmers. Better endowment enabled the large landholders more to adopt. The insignificant coefficient sign of irrigation resources showed that there is a need for the improvement of the irrigation infrastructure to deliver the irrigation water for growing crops in time. The study suggested that actions should be taken to the improvement of water resources and to improve the appropriate irrigation infrastructure. Focused should be given to the institutional arrangements such as the construction and maintenance of canals, flood bunds, and specifically, to establish the tubewells at the farm levels.

Studies such as (Brown et al., 2018) described that physical capacity was measured by using the proxy indicators of agricultural equipment, and distance of the institutional infrastructure from the farmland. Therefore, we assessed physical capacity by using the proxy indicators of distance to extension centre, agriculture technology assets, and livestock owned by the farmers. The coefficient of distance to the extension centre showed a negative and significant association with the probability of willingness to adopt CSA practices. While the coefficient of agricultural technology assets remained positive and significant with the probability of willingness to adopt. The negative and significant impact of distance to extension centre showed that this distance is very important because less distance will allow the farm household to move easily and quickly from farmland to extension centre whenever he required such as consultation, for getting information and institutional help regarding the application of CSA measures. While agricultural technology assets had a positive impact on the adoption of CSA measures. It can be concluded that the farm household who had better agricultural technology were more likely to adopt to make any adjustment at the farm level to cope with climate variability. It is indicated that agricultural technology helps farmers more to adopt CSA measures to mitigate the impact of climate change. The study suggested that subsidies should be given to the agricultural technologies that are used for agricultural production. And, extension centres should be constructed in each area considering the heterogeneity of agroecological zones and the environmental variability in the region.

The common indicators such as access to credit, cash, and income from other sources were used in the literature for measuring the financial capacity of the farm households. Therefore, we examined financial capacity by using farm solvency indicators such as credit access to the farmers and financial resources through the proxy of total agricultural income earned from agricultural production. Credit access to the farmers and financial condition both had a significant and positive effect on the probability of willingness to adopt CSA measures. The positive and significant impact of access to credit showed that lower interest rate encourages the farmers to save more money and invest more for adopting CSA technologies. Many farmers took loans to mitigate the impact of extreme weather events in Pakistan. They used this money to recover agricultural losses and for adopting CSA measures. Financial resources contributed as positively determinant because a farm household who had a better financial condition due to good income, he will be able to spend more money on the adoption of CSA measures. Even, he can repay the loans easily than those farmers who repaid the debt after the harvest. Thus, a framer with a better financial condition was likely to adopt more.

The climate shocks index was calculated by using a simple count of weather shocks experienced by the farmers in the study area. The coefficient of climatic shocks was found a significant and positive impact on the probability of intended to adopt CSA measures. This positive association may be due to the improvement in adaptation measures that were adopted by the farmers in the context of disaster risk reduction strategies. It also showed that the farmers have learned from the past climatic events. This ongoing exposure has developed their confidence to adopt to mitigate a wide range of climate change-related hazards. We can conclude that the farmers who impacted more climatic shocks were more intended to adopt sustainable agriculture as compared to the other farmers (Alemu and Mengistu 2019).

In this study, we also identified a number of constraints that farm households faced for the adoption of CSA practices in the study area. The farmers who perceived long-term weather changes and intended to adopt CSA practices, but could not adapt due to constraints. Fig. 4 shows the average of the major constraint faced by the respondent farmers in all study districts. The main constraints were the lack of institutional support (54%), lack of information (49%), resource constraint (43%) and followed by the financial constraint (26%), and other constraints (4%).

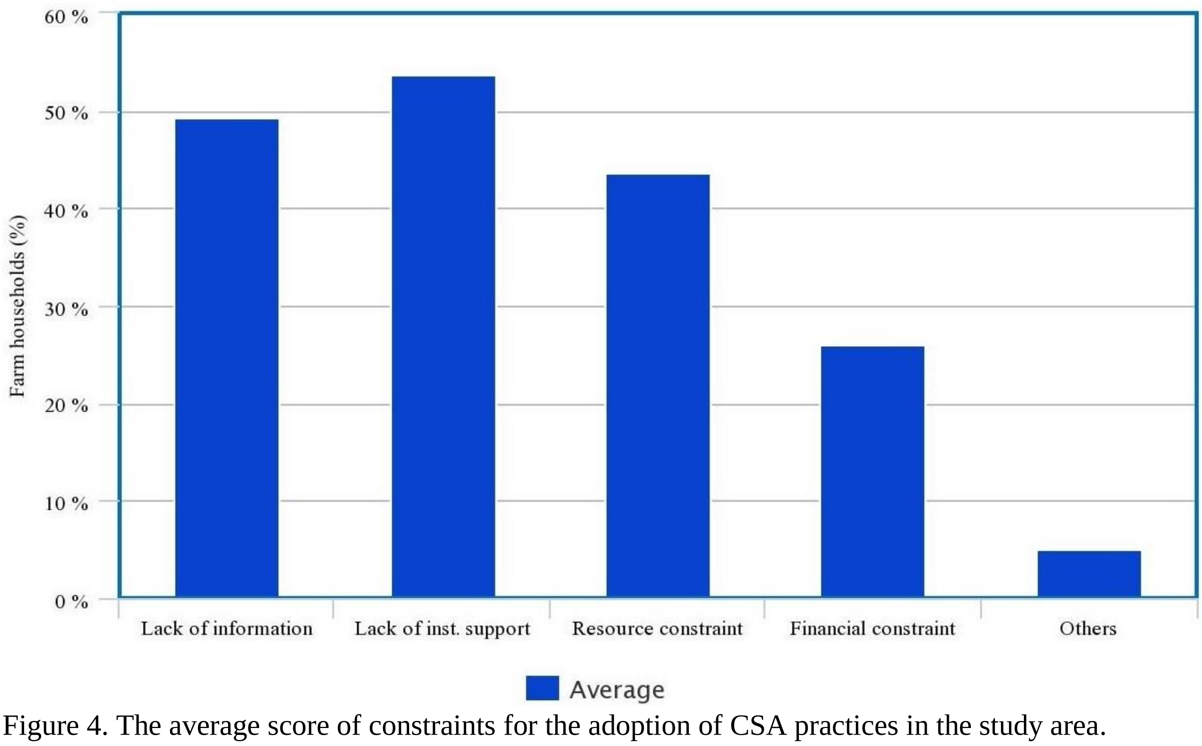


Figure 4. The average score of constraints for the adoption of CSA practices in the study area.

Lack of institutional support was identified as the key constraint for willingness to the adoption of CSA measures to cope with weather variability. Institutional support was measured through the farmers' access to the institutional services provided by private or public institutions. This constraint can be covered by providing timely information related to the weather and climate shocks, information regarding the application of adaptation measures, and by giving subsidies on CSA related equipment to the farmers. Lack of information was another key constraint that deals with weather information and market development information related to agricultural production. This may be pointed out that farmers should provide knowledge of agricultural production and should educate how to deal with uneven patterns of rainfall, extremely high or low temperatures, water stress at the sowing stage, and weather shocks.

Resource constraint was the third major constraint identified by the responding farmers. It can be due to less access to or availability to the adoption of CSA technologies at the farm-level which limits the farmers' capability for adapting to cope with the changes in the climate. Financial constraint was comprised of farm-level credit access and financial capability for the adoption of CSA measures. Lack of credit access may be due to a high-interest rate for poor households and the lack of access to microcredit institutions at the farm level. It may be one of the key reasons for the minimal use of farm credit in the study sites.

4. Discussion and Conclusion

Climate change is a reality that poses significant impacts on Pakistan's economy. Pakistan's economy is based on the agricultural sector, and the sector is severely dependent on natural resources. Consequently, it is more vulnerable to climate change impact. Most of the previous work for measuring the farmers' adaptive capacity was shown without socio-economic considerations. But this study has focused on the concept of adaptive capacity through assessing its drivers that determine the possibility of adopting CSA measures to cope with climate variability. We employed novel farm-level data sets from 420 farm households to examine the farmers' adaptive capacity to response and their willingness for the adoption of CSA measures to cope with climate variability. Also, we identified the constraints that farm households faced for adopting CSA measures. We presented that farm households had different socio-economic features of adaptive capacity and heterogeneous rates of willingness for the adoption of CSA measures to cope with climate change impact. We found that assets pentagon (such as human, physical, social, natural and physical capacity) that farm households hold were the significant drivers of the adaptive capacity. Most of the farmers were willing to adopt CSA practices to mitigate weather variability for sustainable agriculture. We also showed that the farmers, who were well-endowed of assets endowment and had better socio-economic characteristics, were enabled more likely to adopt CSA practices than the other farmers. This study suggested that CSA adaptation measures-oriented training and awareness workshops and programs should be started and should be provided at the household level to facilitate the adoption of CSA practices, but the diversity of the agro-ecological zones should also be taken into the account.

Further, we also identified the major constraints faced by the respondent farmers in the study districts. These constraints can be covered with improving the institutional services by providing better access to the credit services and subsidies to the CSA technologies, information for the use of adaptation measures, by providing access to the availability of CSA technologies for increasing the viability against climate change. Hence, the institutional policy should be designed in the local context to expand the farmers' adaptive capacity for improving the frequency of the adaptation of CSA measures.

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