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Analyzing the Determinants of Farmer's Choice of Adaptation Strategies to Climate Change

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ABSTRACT

Climate change has created challenges for agriculture sustainability in Pakistan. Today Pakistan ranks 8th worldwide in farm output due to low crop productive ha^{-1}. This study analyzed the constraints influencing farmers' choice of adaptation strategies to climate change using comprehensive data from 120 farmers of Sindh province. Different social and economic factors were studied including age, education level, access to credit, phone facility, farming experience, farm size, income, access on weather information, particularly rainfall forecast. A binary logit regression model used to understand determinants of farmer's choice of adaptation strategies revealed that access to credit and timely weather information were the most dominant factors affecting the farmers' decision on adaptation to climate change. This study concludes that the structure of current agricultural extension service department should be improved, which can effectively work by educating farmers about climate change adaptation strategies, the metrological departments should establish a direct connection with farmers through phone messaging and update them timely, and the government should immediately introduce farmers' friendly loan program.

Key words: Climate change, Adaptation strategies, Binary logit model, Sindh province, Pakistan.

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INTRODUCTION

Global climate change poses an enormous risk to the world life and future development (Gashaw et al.,2014). According to Holden (2016) a remarkable change in earth's climate is observed since the last century with an increase of 0.85°C in the global atmosphere. It is expected that global temperature will more due to the human anthropogenic activities that continue to induce greenhouse gases (Deressa et al., 2008). Developing countries are more vulnerable to climate change, while only share 10% to annual global emissions of carbon dioxide. The countries of South Asia are specifically affected by the large population that still depends on the agricultural sector for their livelihoods (Devkota and Phuyal, 2018). Therefore, it stands as a severe challenge to their social, ecological and economic system and makes them poor. The South Asia climate change strategy of the World Bank reported same concern that poor people are going to suffer the most from the climate change effects due to adverse geography, finite assets and enlarged dependents on climatic sensitive income sources (Ali, 2017). Over recent years, the intensity of weather extremes in the regions (such as flash floods in Pakistan and India) are noted as being directly link to climate change and likely to continue the poor's in a constant trap of poverty (Berhanu and Beyene, 2015;Devkota et al., 2017; Devkota and Phuyal, 2018). Climate change has manifested itself through increasing weather variations, and has generated fluctuations, such as depletion of ozone layers, deposition of acids, loss of biodiversity, deforestation, desertification, degradation of soil resources, destruction of coastal areas, increase in sea level, changes in rainfall series and shifts in climatic region such specific consequences of environmental problems are faced by the modern world, today (Apata et al., 2009).

Agriculture is the backbone of the economy of Pakistan, contributing about a dominant share accounting 20% in total Gross Domestic Product (GDP) and 43% of the workforce employed (Abid et al., 2016). Agriculture is still the main source of livelihoods, where over two-thirds of Pakistan's population lives in rural areas (Abid et al., 2016). Structural improvements in agriculture have been made with the time, but agro-based products still provide motivation for overall economic growth and economic development (Rehman et al., 2015). Wheat, rice, cotton, maize, vegetables, fruits and sugar cane account for over 75% of total value of the crops (Magsi et al., 2012). In this context, the agricultural sector has remarkable importance to ensure food security and to reduce poverty (Ali et al., 2017). Although, the sudden variability in weather and climate have jeopardized the agriculture and have added an alarming challenge for a country (Pakistan) that is still struggling for food security and poverty issues (Janjua et al., 2010). Climate change has brought all sectors of Pakistan in serious endangered such as human health, water resources, agricultural sector, forestry, biodiversity and ecosystem (Iqbal et al., 2016). Consequently, Pakistan is considered one of the ten countries in the world to be seriously threatened by climate change impacts (Javed, 2016). However, the agricultural sector is also influenced by harsh climatic conditions, especially crops, animals, soils and therefore has significant effects on agricultural prices, agricultural production, agricultural trade, agricultural demand, regional comparative advantage, and agricultural consumer and agricultural producer welfare of Pakistan (Mansur et al., 2008). However, such peril challenges are being faced by the whole world to meet food demands of a rising population under the current climatic conditions and circumstances (Bryan et al., 2013). Research conducted by Magsi (2012) examined that an increase in the temperature of 1°C can result in the decline of 149,47 thousand tons in Rice production, 3493,39 thousand tons of Sugar cane production, 378,76 thousand tons of Wheat production, 381,157 thousand tons of Maize production and 55,27 thousand tons of Cotton production, respectively.

World Bank`s South Asia climate change strategy recently ranked Pakistan in top 10th countries, most affected by climate change between 1997 and 2016 (Chandio, 2016). However, inside Pakistan, Sindh province is the worst affected by extreme weather conditions and the biggest manifestation is Moen-Jo-Daro because the ever-highest recorded temperature in Pakistan is 53.5°C in the city of Moen-Jo-Daro, Sindh province (Iqbal et al., 2016). It was considered as the hottest ever measured temperature on the Asia continent and the fourth hottest temperature ever measured on earth (Rasul et al., 2012). Moreover, Sindh is also witnessed of massive floods in 2010 and 2011 due to changes in climatic conditions, these floods were considered as nothing but the worst disasters that had ever seen in the history of Pakistan (Chandio et al., 2016). The flood caused total estimated damage of USD 9.7 billion, however, the heavy loss reduced agricultural production by more than 15% and the loss of livestock was over 10 million (Raza et al., 2015). In addition, the frequency and harshness of drought in Sindh has increased because of a sequence of rising temperature and reduction in precipitation and due to that agricultural production is reduced at a significant level and resultant in increasing poverty and unemployment (Afzaal et al., 2009).

Any challenge's sensitivity depends generally on its identified resolution and adaptive ability in changing the environment (Devkota et al., 2017). Adopting strategies to climate change impact involves taking the right measures at the right time to alleviate the effects of climate change through proactive judgments and decisions (Phuyal et al., 2017). Nguyen (2002) refers to adaptation strategy as a variation in human or natural system due to the reason of actual or expected climatic situations or impact that is constantly in favorable opportunities and also defines as the actions taken by countries, societies and by the people to adapt to climate change that has risen. Adaptation has three major objectives: To reduce the disclosure of risk, to establish the ability to cope with mandatory damages and to take benefits of new technologies (Mabe et al., 2014). Adaptation to climate change for agriculture include: (a) micro-level choices, such as crop varieties and operation timings (Deressa, 2008; Devkota et al., 2018; Leghari et al., 2018). (b) Market responses, such as diversification of revenues and credit strategies (Ahmed, 2017; Devkota et al., 2017). (c) Institutional changes, like improvements in the agricultural market, and government responses towards subsidies/taxes (Mendelsohn et al., 2006). (d) Technological developments, as the evolution and

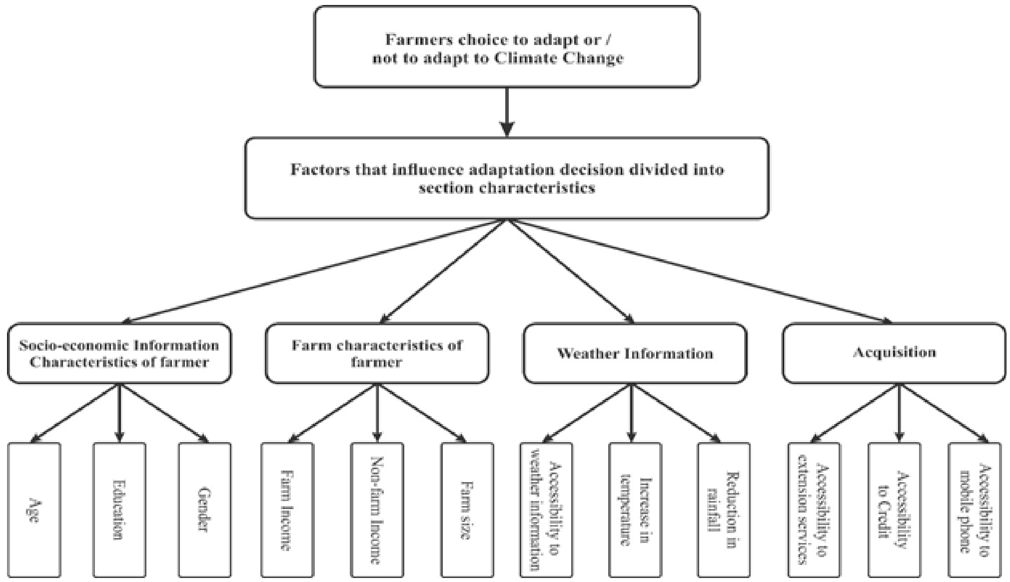

Figure 1. Conceptual framework for farmer's adaptation to climate change: Source (Borges et al., 2015).

improvement of new varieties of crops and progress in water management strategies (Abid et al., 2016; Devkota et al., 2018). Some of the adaptation methods are highly sectarian and could not be adopted and implemented directly in several regions or suitable for agricultural settings (Ali, 2017). Mendelsohn et al. (2006) observed that farming sector is affected by climate change on a considerable level and without adopting some strategies that would make farmers more vulnerable (Devkota et al., 2018).

The choice of growers to select any strategy is based on their expectation of an outcome that may be generated in future (Devkota et al., 2018). This means there are some costs associated with adaptation to climate change (Smit et al., 2002). This cost that one incurs in adapting to climate change is what Maddison (2007) called "traditional adaptation cost". The use of a particular adaptation strategy can be linked to so many factors. What are left unknown are the determinants of the choice of the various adaptation strategies that farmers use in minimizing he effects of climate change on agricultural production (Maddison, 2007). (Di Falco 2014; Devkotaet al., 2017) in his research observed that crop productivity is expected to decrease at lower latitude for even small increase in temperature (1-2°C), hence It has become very essential to determine some strategies to cope with increasing temperature of the world and that how the various components of these determinants influence on farmer's decision to choose any particular strategy that could be pursued to adverse the impact of climate change in the province of Sindh, Pakistan. Consequently, analyzing of these determinants has a very vital role in developing an intervention to measure those key factors that may be perceived by farmers to improve their adaptation capacities. Several studies Trnka et al. (2004), Parry et al. (2004), Nkomo et al. (2005), Stem (2007), Deressa (2008), Apata et al. (2009), Kaminski and Fleischer (2012); Phuyal et al. (2017); Ali, (2017), Kawasaki (2018) and Devkota et al. (2018); showed a great focus on climate change modeling, climate change impacts mitigation and risk assessment has been given with relatively little attention at country level on adaptation strategies for those experiencing climate change. Climate change impact studies (especially rainfall and temperature) and climate-related food safety measures are very limited at the country level. In the study area, studies on the impact of climate change (especially rainfall and temperature) is limited. Therefore, the objective of this study was to investigate the constraints influencing farmers' choice of adaptation strategies to climate change in the Sindh province of Pakistan.

MATERIALS AND METHODS

Conceptual framework of adaptation policies effective outcomes in the agricultural country, where a larger number of populations depends on agricultural related activities (Gao, 2017). Herfzeld et al. (2008) presented the conceptual framework for adaptation. Figure 1 represents the conceptual framework of variables, which are used in the present study. These variables are expected as factors, which influence a farmer's choice to be adopted or not to be adapted to climate change. They are divided into four characteristics including socio-economic characteristics, farm characteristics, weather

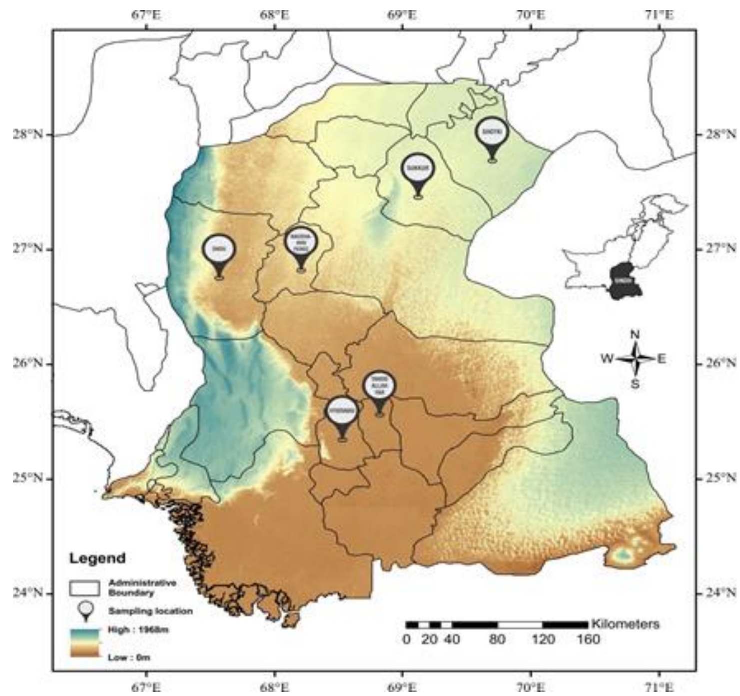

Figure 2. Selected districts in the Sindh province of Pakistan for survey districts selected for study.

information and acquisition information to alleviate the adverse impact of climatic conditions on farm crops (Abid et al., 2016). These factors may be used to make assumptions as for how a farmer chooses to adopt innovation to his farm or not to adopt.

In Pakistan, most of the farmers utilize forefather's traditional methods, land management practices, farmer socio-demographic characteristics, livelihood strategies and farm management practices whilst some farmers are able to adapt better strategies to meet the current requirements of the crops and livestock (Gorst et al., 2018).

Data Collection

The present study uses primary dataset collected in 2018 in Sindh province. Total six districts were purposely selected as a study area because in these districts there were many villages that were largely affected by climate change due to the fact that they form Sindh province with very harsh climatic conditions. Prior to this initiation survey, an informal survey of farmers was conducted to understand the impact of climate change and the choice of adaptation strategies for climate change. A random sampling technique was used to select two union councils (UCs) from each district and from each union council UC two villages were selected similarly, from each village five households were also selected. By this procedure, a total of 120 respondents were selected. The data was analyzed by using e Views. Figure 2 highlighted the selected districts for the current study in the Sindh province of Pakistan.

Theoretical Background

Different choices are associated with different levels of utility (Devkota et al., 2018). Therefore, individual households generally reflect their preferences for different coping strategies based on their understanding (Devkota et al., 2018). However, Deressa (2008) and Gbetibouo (2009) opined that the decision regarding whether or not to adopt any adaptation options is considered to be under the general framework of utility and profit maximization (Phuyal et al., 2017). Furthermore, it is assumed that a rational farmer uses adaptation methods only when the net benefit from using such a method is significantly greater than the cost of not doing so (Khanal et al., 2018). Although the benefit is not directly observed, the action of economic agents is observed through the choices they make (Devkota et al., 2018). By selecting the *jth* adaptation strategy (*Uj*), the linear random utility model to cope with Changes in climate can be expressed as:

$$U_i i = x_i \beta i' + \mu i \quad (1)$$

And, the farmers who do not choose any *jth* but rather *kth* adaptation strategy is presented as:

$$U_i k = x_i \beta k' + \mu k \quad (2)$$

Where x_i is a vector of explanatory variables (socio-economic characteristics, farm characteristics, weather information and acquisition information), $\beta`_j$ and $\beta`_k$ are parameter vectors for the selection of adaptation strategy j^{th} and k^{th}. In addition, μ_j and μ_k are error terms for selecting the adaptation strategy for j^{th} and k^{th}. In the above equations, the error terms are expected to be identically and independently distributed (Gujrati, 2006; Devkota et al., 2018). Deressa (2008), Bryan et al. (2013) Mabe et al. (2014) and Devkota et al. (2018) conducted the researches and identified some adaptation strategies discussed in this study and confirmed through the pretest survey, hence the commonly used adaptation strategies include: changing planting dates, changing cropping varieties, destocking of crops and livestock, diversification in crops, fallowing the land, using fertilization, increasing farm size, mulching and plantation of trees. As a result, when a grower decides to pursue a *jth* adaptation strategy to adversely affect the impact of harsh climate, the expected utility that grower derives from using it, is higher than the expected utility from not to use this strategy (Devkota et al., 2018).

$$E(U_{\text{adopting } j^{th} \text{ strategy}}) > E(U_{\text{adopting } k^{th} \text{ strategy}}) \quad (3)$$

The actual inequality is expressed as:

$$Uj(x_i j \beta' j + \mu j) > Uk(x_i k \beta' k + \mu k) \quad (4)$$

Where *j ≠ k*. The expectation of adjusting any strategy to minimize climate harsh impact by selecting *jth* is given as:

$$P(U = 1|x) = P\{(x_i \beta' j + \mu j) > (x_i \beta' k + \mu k) \quad (5)$$

$$P(U = 1|x) = P\{(x_i \beta' j + \mu j) - (x \beta' k + \mu k) > 0|x\} \quad (6)$$

$$P(U = 1|x) = P\{x_i(\beta' j - \beta' k) + (\mu j - \mu k) > 0|x\} \quad (7)$$

$$P(U = 1|x) \; P(U = 1|x) = P\{(\beta x + \mu) > 0|x \quad (8)$$

$$P(U = 1|x) = F(\beta + \beta X + \cdots + \beta X \quad (9)$$

Empirical Modeling

As discussed above, researchers have generally estimated the general framework of utility and profit maximization when measuring perception and determinants. To measure this estimation, recent studies in South Asia have been conducted Devkota et al. (2018). (Following previous studies, a logit regression model was selected to identify the significant variable that determines whether or not youth rural rice farmers are adopting available adaptation options (Phuyal et al., 2017; Devkota et al., 2018). The current study employs Binary logit regression models to analyze the determinants of choice of the farmer to minimize the impact of climate change thus; there are binary choices for a farmer. The independent variable is a binary decision that is dummied as 1 if the grower selects *jth* strategy of adaptation to cope with the negative effects of climatic conditions and 0 otherwise (Mabe et al., 2014; Devkota et al., 2018). The outstanding benefit of Binary logit regression models is that it analyzes the choice and examines the associated expectations for the selection of a specific adaptation approach (Devkota et al., 2018). Analysis of each adaptation strategy is individually in this research and the application of the multinomial logit model is independently dissimilar, which excludes the impact of one strategy on another (Anley et al., 2007). Fosu-Mensah et al. (2012) revealed the binary logit regression model as:

$$P(YX) = F(Z) = \frac{e^{Z} j}{1 + e^{Z}} = \frac{1}{1 + e^{-Z}} \quad (10)$$

$$P(Y = JX) = F(Z) = \frac{e^{Z}}{1 + e^{Z}} = \frac{1}{1 + e^{-Z}} \quad (11)$$

$$Z_i = \beta_0 + \beta_1 X_{1i} +, \ldots, + \beta_{ni} X_{ni} \mu_i \quad (12)$$

Therefore Herzfeld (2008) expressed the binary logit regression model as:

$$n[\frac{P_j}{1 - P_j}] = \beta_0 + \beta_1 X_{1i} +, \ldots, + \beta_{ni} X_{ni} \mu_i \quad (13)$$

n=1,2,3….

EMPIRICAL FINDINGS AND DISCUSSION

Demographic Characteristics

Table 1. Descriptive statistics of categorical and continuous variables.

Explanatory Variables	Mean	SD	Description	Expected Sign[2]
Age	33.4	10.5	Continues	(±)
Education	5.8	3.7	Dummy takes the value 1 if education is higher than the secondary level and 0 otherwise	(+)
Accessibility on credit	0.7	0.4	Dummy takes the value 1 if the farmer has access to credit and 0 otherwise	(±)
Farming experience	12.2	11.7	Continues	(+)
Farm size (Acres)	11.8	10.4	Continues	(+)
Accessibility on phone	0.6	0.4	Dummy takes the value 1 if the farmer has access on phone and 0 otherwise	(+)
Weather information	0.6	0.4	Dummy takes the value 1 if the farmer has access on weather information and 0 otherwise	(+)
Extension services	0.3	0.4	Dummy takes the value 1 if the farmer has access to extension services and 0 otherwise	(±)
Perception on temperature increment	0.9	0.3	Dummy takes the variable 1 if the farmer is in the favour of increment of temperature and 0 otherwise	(+)
Perception on rainfall reduction	0.8	0.3	Dummy takes the variable 1 if the farmer is in the favour of reduction in rainfall and 0 otherwise	(+)
Farm income	178262.2	200374	Continuous	(+)
Non-farm income	6129.1	8671.5	Continuous	(+)

Table 1 presents the results regarding descriptive statistics of categorical continuous variables of respondents in the study area. The mean age of the farmers is 33 years. On average 45.8% of farmers can no read or write, while as many as 43.3% have completed their primary education and 10.9% have completed their secondary education. The minimum, maximum and average size of farms is 0.5, 39 and 11 acres, respectively. The farmers have a minimum 1-year experience, maximum 44 and on average 11 years of farming experience. The results indicate that the majority 67.5% (81) of growers have credit accessibility from respondents interviewed by 120. 63.4% have access to weather information and only 31% of farmers have access to agricultural extension services while the remaining 69% respondents do not have access to agricultural extension services. Perceptions regarding changing in temperature, a greater % (90.8) of farmers were in the favor of increment whereas others perceived otherwise. When the farmers were asked about their perception of rainfall changes, most of the 84% were in the favor of rainfall reduction. Furthermore, the average farm income is 1, 760, 00 R.s (US$ 1259.33) per annual and the In the Nepalese context Devkota et al. (2017) found the farm income 0.6755% which is less than the farm income of current average Non-farm income is 6129.17 R. s (US$ 43.86), respectively.

Constraints to Adaptation Strategies

Barriers of adaptation can be defined as factors, conditions or obstacles that are believed to reduce the effectiveness of the farmers' adaptation strategies (Devkota et al., 2018). The major farmer adaptation barriers are socio-ecological factors, psychological factors and resource constraints, which arise due to poverty levels, lack of information and communication on adaptive measures, lack of access to credit, and the perception of the importance of climate change and adaptation. Such barriers can be overcome with creative management, changed thinking and concerned effort (Van et al., 2015; Gerenee et al., 2003). Factors such as inadequate capital, poor access to weather forecasts and climate change information, and inadequate awareness programs on climate change from governmental and non-governmental agencies were major barriers for more than 90% of farmers. Similarly, more than 80% of farmers stated that the high cost of improved seeds, fertilizers and irrigation, the inadequate knowledge of coping mechanisms and resiliency and the inadequate access to credit facilities were major among the given hindrances to farmers. Among the barriers, the top five barriers that the farmers in Sindh province cope with in a changing climate can be observed in Figure 3 Farmers argued that insufficient information and inadequate awareness was the first barrier. Mendelsohn et al. (2006) revealed that adaptation of any strategy to climate change is costly and the requirement of intensive labor could share to increase the cost. Therefore, farmers need to have sufficient family labor or financial support otherwise; they cannot adapt the strategy to climate change. Most of the farmers occupy small land plot due to the fact of poverty and high population pressure which emphasis farmers to farm a small plot and unable them to use advanced technologies or adapt strategies to climate change.

In water resources, basin in Sindh province is very rich (Bunning, 2017) despite the fact that

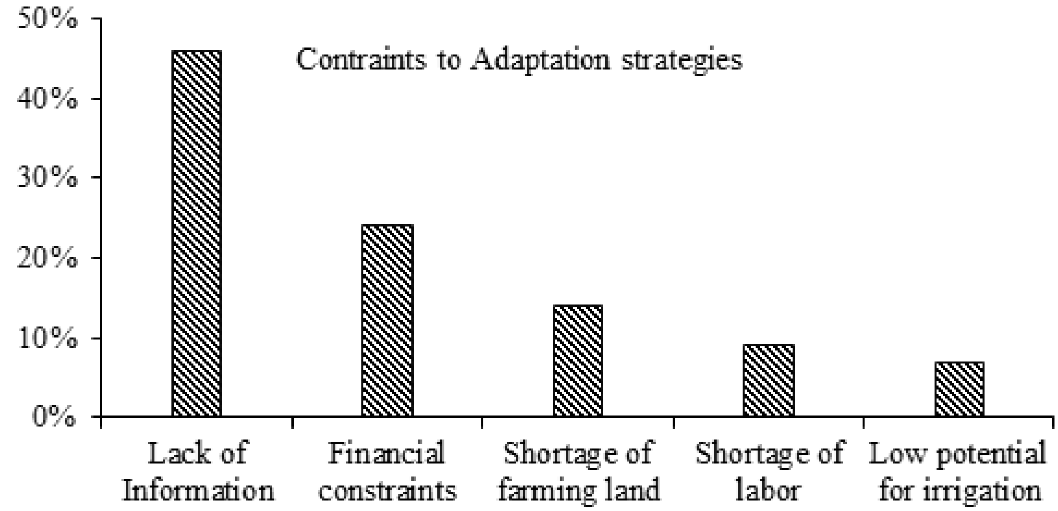

Table 3. Indicates the percentage of each constraint by farmer in adaptation to climate change.

water is already present there, farmers are not fully able to utilize it because of the inadequate facilities and technological in capabilities. Most of the farmers in Sindh province are poor and cannot afford to invest on irrigation this is the reason of poor irrigation potential resultantly, they face harsh climatic extremes such as drought.

Econometric Results: Adaptation Strategy Determinants

The main objective of this research is to estimate the factors affecting farmer's choice in the adaption of different strategies to overcome the impact of harsh weather conditions on agricultural production by using Binary logit regression models, some factors were identified that have a significant impact on each adaptation strategy, nine different BLRMs were used to remove the expectations of the relationship between the adaptation choice of farmers. Table 2 shows the results of the BLRM.

Changing Planting Dates

A literature review of over study Devkota (2018) indicated seven variables, which were found to significantly affect the change in planting date as an adaptation option for rice farmers in Nepal and the current study has found five factors to significantly affect changing planting dates as a climate change adaptation strategy out of the twelve independent variables entered into the model were found. Age at 10% probability level is statistically significant. Whereas the negative sign implies that farmers with young age, works faster than older farmers and complete crop planting within a shorter duration of time in order to prevent late planting, which may be affected by weather changes. This revelation contradicts what Mabe et al. (2014) demonstrated. A negative relationship between age and changing planting date was observed. The study found a positive relationship between education and changing planting dates to prevent harsh climate conditions. The education is significant 5% probability level and the positive sign indicates that educated farmers know the importance of changing planting dates based on changes in climatic conditions, so the probability of changing planting dates in education is higher than those who are not educated.
The result indicates that access to credit significantly affects the changing planting date's adoption decision at 5% probability level. However, the negative sign indicates that growers with no accessibility to credit, may not bear the risk of changing cropping dates, if they won`t succeed, they certainly have to face critical economic losses. Farmers who have an approach to extension services bear to change in planting dates based on changes in current climatic conditions. At the significant 5% probability level and positive sign specify that farmers with extension services may have information regarding the importance of changing planting dates by extension workers, so farmers with extension contacts are attracted to adopt technologies more than farmers without extension contacts. Finally, the expectation of study as an adaptation study is met by a positive relationship between changing planting dates and weather information. Access to weather information by the farmer is significant at 1% and positive sign implies that growers with weather information are more

Table 2. Results of maximum likelihood Binary Logit Model presenting determinants affect the choice of adaptation strategies.

Adaptation Strategies									
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**	**Model 9**
Determinants	**Changing Planting Dates**	**Changing Crop Varieties**	**Destocking**	**Diversification**	**Fallowing**	**Fertilization**	**Increase in Farm Size**	**Planting of Trees**	**Mulching**
Constant	4.665	-7.195	-4.263	1.127	-2.075	2.138	4.467	2.174	-14.12
	-0.167	0.025	0.181	0.034	0.561	0.508	0.155	0.024	0.085
Age	-0.318	0.458	0.243	-0.081	0.216	-0.137	-0.219	-0.124	0.839
	0.082*	0.375	0.153	0.656	0.258	0.435	0.195	0.348	0.064*
Education	1.409	-2.217	-0.415	0.407	-0.104	0.707	0.113	-0.041	2.523
	0.048**	0.096*	0.542	0.553	0.857	0.261	0.016**	0.331	0.019**
Credit access	-3.751	1.634	0.471	-4.056	-0.598	0.168	3.212	1.296	0.961
	0.018**	0.375	0.701	0.007***	0.625	0.901	0.018**	0.374	0.455
Farming experience	0.056	0.127	0.061	0.451	-0.051	-0.405	0.293	-0.978	-0.299
	0.849	0.579	0.049**	0.085*	0.759	0.103	0.202	0.661	0.257
Farm size	-0.241	0.109	0.012	0.448	-0.069	0.412	-0.051	0.134	0.387
	0.448	0.701	0.946	0.137	0.103	0.034**	0.216	0.151	0.143
Phone access	1.263	-0.267	0.772	2.018	-0.179	0.474	-0.804	-0.379	0.489
	0.258	0.84	0.369	0.086*	-0.842	0.794	0.379	0.706	0.602
Weather information	3.48	0.295	1.986	2.245	-0.794	-0.849	1.445	-1.061	1.057
	0.001***	0.705	0.006***	0.001***	0.201	0.258	0.031**	0.169	0.088*
Extension services	1.762	0.113	-0.357	0.938	1.517	0.912	-1.193	2.618	0.455
	0.011**	0.886	0.422	0.142	0.076*	0.114	0.834	0.044**	0.935
Increase in temperature	0.795	-0.319	2.784	2.983	2.318	-1.122	-1.316	2.177	-0.514
	0.541	0.839	0.028**	0.807	0.034**	0.328	0.273	0.037**	0.388
Reduction in rainfall	3.48	3.022	0.25	0.007	-0.265	0.008	0.912	1.461	0.912
	0.399	0.011**	0.176	0.943	0.758	0.992	0.344	0.312	0.114
Farm income	7.02E-07	1.02E-05	9.93E-08	8.88E-07	-1.93E-06	2.07E-06	1.01E-06	1.04E-08	2.08E-06
	0.646	0.052**	0.925	0.581	0.103	0.151	0.062**	0.035**	0.162

Significance levels: * p<0.1; **p<0.05; *** p<0.01

probable to change their planting dates in order to minimize the impact of climate change at some extent.

Changing Crop Varieties

The results in Table 2, model 2 indicates that education, reduction in rainfall amount and farm income is identified as determinants of farmer's choice to change crop varieties. The disclosure contradicts the researcher`s expectation. Since education is significant at 10% but the coefficient is negative, it implies that educated farmers are less likely to change their variety of crops than farmers without education. Assuming that educated farmers have managerial skills to manage, protect and grow the same varieties and have marginal benefits. Meanwhile, uneducated farmers could not have such skills, so they can change their crop varieties. A positive relationship is observed between farm income and changing crop varieties to climate change. Farm income is statically significant at 5% and the positive sign implies that the higher the farm income is, the greater the likelihood becomes, that will boost farmers to change their crop varieties. Furthermore, farmers who observe a reduction in the amount of rainfall, have to use such varieties of particular crops, which requires a minimum amount of water to grow their crops to cope with the harsh climatic conditions, then other farmers.

Destocking

Table 2, model 3, agricultural farming experience, weather information and perception of an increase in temperature are considered to be determinants of the choice of farmers to destock their agricultural production. Farming experience an increase in temperature, both are significant at 5% and the positive indication refers that farmers save their crops and animals by destocking them to prevent the harsh climatic condition's effects on livestock. Finally, this study shows that weather information is significant at 1% and the expectation line is satisfactory. The positive sign of the coefficient indicates that growers having weather information accessibility should replenish their cattle in order to avoid the harsh weather conditions affecting their animals. This revelation contradicts what Bryan et al. (2013) demonstrated. A positive relationship between access to weather information and destocking was observed.

Diversification

Access to credit, agricultural farming experience, access to mobile phones and weather information are found in Table 2, model 4, as determinants of farmer's choice to diversify their crops to overcome the negative effects of climatic conditions. Access to credit, as factors of a diversification strategy, is significant at 1%. The negative sign meanwhile implies that farmers, without access to credit bear to diversify their products as compared to those farmers who have credit accessibility. Furthermore, the results of model 4 show that farming experience has a significant and positive influence on diversification at 1%. The results met the expected outcomes. It is logical that the greater experience farmer has the more tendencies to diversify his agricultural production as to introduce new enterprises or cultivation of new crops or preservation of livestock to limit the adverse effect of climate change. Both farmer`s factors, such as mobile accessibility and weather information, have a positive and significant impact on diversification as an adaptation strategy. This suggests that farmers, who perceived access mobile and access to information on weather, will be greater than the farmer who did not perceive access to mobile phone or weather information. Resultantly, growers with access to the mobile phone can easily obtain weather information by calling people who are living in towns or weather information centers nearby, may provide information about the expected rainfall dates and adjust the cropping dates.

Fallowing

The results in Table 2, model 5 showed that two factors significantly and positively influence the accessibility of temperature and agricultural extension services. Since growers with extension services may be educated about the value of leaving the land for the following purpose other than those growers who are without extension services. Growers who perceived an increment in temperature will also bear a positive chance of allowing their land to barren more than others. This conclusion is derived from a positive sign and a significant 5% level of perception of temperature increase.

Fertilization

The current study found only two factors (farm size and Non-farm income) have a positive and significant impact on the application of fertilization choice of farmers in Table 2, model 6 whereas the study conducted by Devkota (2018) has found six variables which significantly affect the increase in the use of fertilizer as an adaptation option for farmers. Farm size is significant at 5% and positive, respectively. The justification is that farmers with a large number of acres of land can easily apply fertilization as compared to those who occupy a small number of acres of land. Fertilization is very important factor which effects on crop productivity (Leghari et al., 2019). Even though, non-farm income is positive and significant at the 10% probability level. Hence this probability of farmers with non-farm income to apply fertilizer is higher than those who do not apply. The deduction for this result is that farmers with higher non-farm incomes can afford the required amount of fertilization for their crops in order to adverse the effect of climate change on soil fertility of crops and obtain higher yields.

Increase in Farm Size

Education, farm income, credit access, and weather information are considered to be sustainable determinants out of twelve explanatory variables that affect a farmer's choice to increase the size of the farm. These results are derived from the model 7, of (BLRM) and these results suggest that Agricultural farm income fulfil the expected direction. High-earning growers are more likely to raise their size of farms. This makes sense because farmers with large farm incomes may use a part of their income, and may expand their farm sizes. Both, education and access of farmers to credit influence positively the choice of a farmer on increasing in farm size. Education and access to credit are significant at 5% probability level because this is logical that educated farmers know the importance of increasing farm size to get better quantity and quality of production by adopting any climate change strategy Fagariba et al. (2018) has shown in his research that education has a strong positive correlation to climate change adaptation and educated farmers as compared to uneducated ones understand and apply new technologies or skills, required on their farms. Growers with information on weather conditions may be more likely to adopt an increase in farm size approach than those are without weather information.

Planting of Trees

In the case of planting trees, the choice of a farmer to plant trees to cope with harsh climatic conditions, three factors are identified such determinants are, access to agricultural extension services, farm income and perception of temperature increase. Farmers with a long-term rise in temperature are more probable to plant trees. Compared to low farm income, farmers with high farm incomes are more likely to adopt a trees planting strategy. All these observations are in accordance with the hypotheses of the author. Similarly, large farm income's farmers are capable to follow the learning of extension agents of the plantation of trees to overcome the increase in atmospheric temperature.

Mulching

The choice of mulching by the farmer has produced some remarkable results. Table 2, model 8, implies that in terms of age, education, and access to weather information, farmers` choice of mulching is important. Farmer`s age reflects farmers' work experience in fields and mulching is more likely to be adopted as a strategy to climate change adaptation strategy. In addition, the results revealed that educated growers know the mulching value; therefore, they are more likely to adopt mulching than other farmers.

Finally, the results in model 8 demonstrated that weather information accessibility has a significant impact on the mulching adoption decision of the farming community and it is positive and significant at 10% probability level. The positive sign indicates that farmers with weather information accessibility are more probable to adapt mulching strategies to limit the climate change effect on the crops. At the core of the ongoing debate regarding the implementations to climate change, there is a growing issue of food security, therefore, it is essential to adapt mulching strategy to prevent the harsh weather conditions (Di falco et al., 2011).

CONCLUSIONS AND RECOMMENDATIONS

This study described farmers' adaptive practices and determined factors influencing farmers' adaptation to climate change in Sindh province of Pakistan. Therefore, the research investigates the effects of socio-economic characteristics, farm characteristics, weather information and acquisition information on agricultural production to alleviate climate change in study area. The study employed Binary logit regression models to examine the determinants that significantly influence the farmer's decision to adjust a strategy. The adaptation strategies identified during the pre-test survey and confirmed for review of the literature are therefore changing planting dates, changing crop varieties, destocking, diversification, fallowing, fertilization, increase the size of the farm, mulching and planting of trees. The results of Binary logit regression models show that different explanatory variables affect climate change adoption strategies differently. Age of the farmers, years of education, access to credit, farming experience, acres of land (farm size), access on mobile phone, farm income, non-farm income, perception about changes in temperature, perception of changes in rainfall patterns, farm income and non-farm income have positive and significant impacts on the choice of climate change adaptation strategies. Of these factors, access to credit and access to weather information were the most important factors affecting the farmer's decision on adaptation to climate change. Following the results of the study, access of farmers on agricultural extension service should be strengthened by organizing educational programs or farmers field schools (FFS) to educate them about climate adaptation strategies.

The government should instruct investors to establish agro-climate information centers that educate and empower farmers in revising their adaptation choices to cope with the effects of climate change and farming activities. Lastly, farmers are assembling to adapt those strategies to climate change which are the most profitable and reasonable therefore Government should design affordable adaptation technologies to the growers who are poor. Hence future strategy should concentrate on raising awareness of climate change by using various sources such as media, facilitating credit availability, extension services and trainings in particular to adaptation technologies to improve research on the use of new crop varieties that are more suitable to drier surroundings, enhancing earning opportunities for former`s farm and off-farm income, boost their educational status and advance their market accessibility. In addition, promoting informal social networks and environmental information in increasing the agricultural adaptive capacity of smallholder farmers because of the enhanced adaptive capacity and adaptation strategies help to decrease the negative impacts of climate change and contributes in the development of both; agricultural sector and economic development and reduces the poverty at a remarkable level.

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