Synchronized Agricultural Credit and Diversification Adoption to Catastrophic Risk Manage for Wheat Production in Punjab, Pakistan

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Abstract

Catastrophic risks caused severe affects on agricultural production particularly in developing countries due to consecutive occurrence of unfavorable climate events. Farmers adopt risk management strategies to minimize marketing, production and financial risks in agriculture. The purpose of this study is to investigate the potential association and implementing synchronized agricultural credit and diversification adoption to catastrophic risk manage for wheat production in Punjab, Pakistan. This study used stratified random sampling technique for collecting data of 480 wheat farmers' respondents from production based categorized six districts of Punjab Pakistan. Multinomial and bivariate probit regression models were used in the study to examine the effects of farm and social feathers, disastrous risks farmers view and their attitude to sources of risk moreover potential relationship in agricultural credit and diversification as risk management strategy. Estimates of the study indicated the association in risk management strategies adoption while adopting single risk management strategy motivates farmers to adopt another strategy at same time. Furthermore, findings also indicated as farmer schooling, age, family return, ownership of land, farm size and farmer risk oppose character were highlighted the most influenced features for adopting various risk management strategies. Policy makers and state based authorities can be assisted by the accumulated information of multinomial and bivariate probit regression models in evaluating plans of risk management and willingness of farmer in accept government supported risk managing strategies in incidence of traditional practices for managing farmhouse risk.

Keywords; Agricultural credit, Catastrophic risk, Diversification, Probit model, Pakistan

1. Introduction

In global scenario, storms, cyclones, floods and drought are considered some major and frequent natural hazards in the current couple of decades owing to increased incidence of severe climate change (Teo et al., 2018; Carter, 2019; Ahmad and Afzal, 2021). These natural hazards generally influenced by risk exposure, geographical locations and lifestyle choices (Doocy et al., 2013; Kreft et al., 2016; IPCC, 2019; Ahmad et al., 2019) whereas having no economic, social, political, geographical and cultural boundaries of continents, countries and communities (Daniell

et al., 2016; IPCC, 2018; Ahmad et al., 2021). Increasing frequency and severity of these natural hazards caused globally severe economic cost and human losses (Gorst et al., 2015; Abbas et al., 2017; Muricho et al., 2019). In current era, owing to increasing vulnerability of climate change, mounting tendency of sever of natural disasters was estimated with disastrous fatalities (IPCC, 2019; Ahmad and Afzal, 2021) such scenario predicted as natural calamities regarding human fatalities expected to twice till 2050 (Doocy et al., 2013; Wilkinson and Brenes, 2014). Floods among natural hazards are estimated recurrently and foremost reason of dead regarding human and commonly basis social and economic risks (Stocker, 2014; Daniell et al., 2016). In global climate index scenario, Pakistan ranked 5th most climate change affected country of the world and expected to rise in temperature 2 to 3% and variations in rainfall till 2050 (Kreft et al., 2016; Eckstein et al., 2021). In couple of decades, the reason of climatic variations Pakistan frequently faced extreme events of floods which consequently worsen rural living due to reduced significant crops productivity (Abid et al., 2016; Ahmad and Afzal, 2021). Agriculture employs 43.5% labor force of the country where 64% population of country inhabited in rural areas (PBS, 2020) so there is significant role of agriculture in subsistence living of rural population where agricultural resilience from climate vulnerability most important for economic stability of the country.

In Pakistan, cereal crops more specifically the wheat crop severely affected by climate change (Ahmad and Afzal, 2020) which raised the issue of food security for population of the country (GOP, 2020). In cereal crops, wheat is one of the major food crop which is major sources of staple diet for population and Pakistan is 8th major wheat producer of the world (FAO, 2020). In agriculture, wheat crop contributes 9.2% in agricultural value added and share 1.8% in GDP of the country (PBS, 2021). In 2020, Pakistan produced 25.248 million tonnes wheat with estimated yield of 2,867 (Kgs/Hectares) which is relatively lower rather than other countries of the world (PBS, 2021). Punjab province produces major share as 77% of total wheat production of the country (PBS, 2020). In the couple of decades, consecutive occurrence of catastrophic threats such as floods, drought and storms severely affected the major crops more particularly the cereals crops (Kresft et al., 2016; Kukal and Irmak, 2018; Ahmad and Afzal, 2020), the reason of consecutive hail, storms, erratic rains and floods in harvesting season while drought in growing season (Gorst et al., 2015; Ahmad et al., 2019). In this scenario, for minimizing the severe impacts these natural hazards due to climate change there is appropriate need of significant measures for developing risk management policies.

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117 In developing countries, farmers more particularly use two types of risk management strategies
118 as risk managing strategies and risk lessening strategies (Ahmad and Afzal, 2020, Adnan et al.,
119 2021) which further more specifically categorized as informal and formal strategies (Akhtar et
120 al., 2019; Ahmad et al., 2019). Strategy applied at farm level known as informal strategy whereas
121 input subsidization, policies of crop insurance, pricing policy, microcredit and other government
122 and institutional based policies are indicated as formal strategies (Daniell et al., 2016; Muricho et
123 al., 2019). In Pakistan, agricultural credit, off-farm and on-farm diversification more preferred
124 practices as applied by farmers regarding risk management strategies (Ahmad and Afzal, 2021).
125 Redistributive of productive assets of farm estates which mostly consist of resources, other
126 grower shares, equipments and farm land properly known as on-farm diversification (Adnan et
127 al., 2019). Alleviating the risks and differences regarding farmer income using the practices of
128 diversification is more significant aspect as mostly practiced in farming community (Ahmad and
129 Afzal, 2020). Farming risk can more significantly reduced by diversifying agricultural
130 enterprises and productive activities of agriculture (Lu et al., 2017; Arora et al., 2019) such as
131 simultaneously producing various crops and specifying agricultural land for other crops or goods
132 (Akhtar et al., 2019; Adnan et al., 2019). To overcoming other financial risks or other related
133 income variations all such are closely associated with adaptation of off-farm income
134 diversification. Minimizing risks effects and boosting up family income, family members instead
135 of off-farm practices take part in farming activities (Teo et al., 2018; Alam et al., 2020).
136 Agricultural credit particularly used for monetary needs to purchasing agricultural inputs such as
137 machinery, soil cultivation, seeds and fertilizer as well as for using risk management adaptation
138 (Ahmad et al., 2019; Adnan et al., 2020).

139

140 In literature, during the last couple of decades catastrophic risk management issue more
141 specifically discussed where some significant studies addressed significant effect of
142 socioeconomic factor on adoption catastrophic risk management strategies such as schooling
143 level (Grace et al., 2015; Harrison et al., 2017; Ahmad et al., 2019; Adnan et al., 2020),
144 respondent age (Ayal et al., 2018; Rehman et al., 2020; Ahmad and Afzal., 2021), size of family
145 (Opiyo et al., 2015; Wako et al., 2017; Harrison et al., 2017; Akhtar et al., 2019), experience of
146 farming (Kagunyu et al., 2016; Mekuyie et al., 2018; Adnan et al., 2020), size of land
147 (Holdschlag and Ratter, 2016; Akhtar et al., 2019; Ahmad et al., 2021), income (Dong et al.,

2016; Mekuyie et al., 2018; Rizwan et al., 2020; Ahmad and Afzal, 2020), ratio of land ownership (Thornton and Geber, 2010; Zulfiqar et al., 2016; Arjjumend, 2018), risk attitude and risk perception (Hurst et al., 2012; Debela et al., 2015; Ambelu et al., 2017; Fanta et al., 2019; Ahmad et al., 2019; Saqib et al., 2021; Ahmad and Afzal, 2021). Some studies focused the aspect of catastrophic risk assessment (Seo and Mendelsohn, 2008; Schlenker and Lobell, 2010; Dadzie and Acquah, 2012; Ayal et al., 2018; Nori et al., 2019), catastrophic risk mitigation (Bradshaw et al., 2004; Seager et al., 2006; Metz et al., 2007; Saqib et al., 2018; Muricho et al., 2019) and adaptation of catastrophic risk management strategies (Bryan et al., 2009; Alam et al., 2012; Grace et al., 2015; Opiyo et al., 2015; Mugi-Ngenga et al., 2016; Harrison et al., 2018; Kgosikoma et al., 2018; Ahmad and Afzal, 2020)

There is limited research scenario regarding catastrophic risk management strategies in the aspect of farm diversification in which some studies discussed off-farm diversification as risk management tool (McNamara and Weiss, 2005; Thornton et al., 2007; Kabubo-Mariara, 2008; Ahmed, 2012; Ullah and Shivakoti, 2014), some studies focused the off-farm diversification as mitigation tool (Adnan et al., 2019; Ahmad and Afzal, 2020). Limited studies elaborated the aspect of farm credit as catastrophic risk managing tool (Fayaz et al., 2006) and combined diversification and farm credit aspect as catastrophic risk managing strategy (Adnan et al., 2021). Farmer's behavior regarding the frequent adaptation measures with associated agricultural credit and farm diversification is most probably unidentified to boot. More specifically in developing countries particularly in Pakistan such type of research aspect not properly addressed according to best knowledge of authors. In finding out this research gap, objective of this study is to investigate synchronized agricultural credit and diversification adoption to catastrophic risk manage for wheat production in Punjab, Pakistan. This study is classified in to five sections as introduction of the study explained in first section and material and method elaborated in section. Results indicated in third section whereas discussion illustrated in fourth section. Last section of the study highlighted the conclusion and suggestions section of the study.

2. Material and method

2.1. Study area

In four provinces of Pakistan, Punjab sharing almost 26% area and 53% population of the country also represents major fertile lands of the country (PBS, 2020). On the basis of some

considerable reasons Punjab mainly chosen for this study firstly, Punjab contributes major 53% agricultural GDP shares of the country (PBS, 2020), secondly Punjab produces almost 77% total wheat production of the country (PBS, 2019). Thirdly in the couple of decades due to climate change and extreme environmental variations, cereal crops more specifically rice and wheat were severely affected by consecutive occurrence of stormy rains, hail and drought particularly in harvesting and growing season of crops. Lastly, in recent decade this country faced five repeated floods since 2010 to 2015 and as compared to other provinces Punjab was more rigorously affected by these floods with heavy losses of crops, livestock, human lives and destruction of infrastructure (NDMA, 2018; PDMA, 2019).

[Figure 1]

In such state of affairs of above reasonable substantial factors, Punjab province particularly selected for this study and based on wheat production six districts were specifically categorized and purposively preferred (BOS, Punjab, 2018). In the scenario of study area selection, Dera Ghazi Khan and Layyah from low wheat producing districts, Muzaffargarh and Vehari from medium wheat producing districts and Rahim Yar Khan and Bahawalnagar from high wheat production districts were chosen (PBS, 2019) as illustrated in figure 2 as given below. Divergence standing in these six districts was estimated about socioeconomic structure, geographical variation and climate change and risk experience. In the couple of decades, higher environmental variation and unexpected climate change was estimated such as discrete pattern of monsoon rainfall season and dynamics of average temperature which caused frequent and severe natural hazards (Abid et al., 2015; Ahmad and Afzal, 2020). Environmental scenario of province is hot in summer and cold in winter, Abid et al (2015) with disperse pattern as 70% rainfall from June to September (Ahmad and Afzal, 2021).

[Figure 2]

2.2. Sampling framework

In procedure of wheat farmer's data collection and study area selection this study employed the multistage stratified random sampling approach. In the first stage, the reason of significant contribution (77%) in wheat production of country (BOS, 2018), Punjab province was purposively selected, whereas based on categorized low, medium and high wheat production areas in province, six districts were randomly selected in the second stage. In the third stage, applying the stratified random sampling approach union councils from each districts were chosen whereas in fourth stage by using the accurate record of revenue department, villages from each

union council were selected. In the last stage, for interviewing procedure framework eighty wheat farmers from each district were randomly selected and total 480 wheat farmers' data was collected from these six districts as illustrated in the table 1.

[Table 1]

For accessing the appropriate information of wheat farmers related to their farm experience, age, schooling, farm size, family size, income, credit, diversification adoption, farmers risk perception and attitude to wheat crop, hailstorm, heavy wind, drought, diseases and pests, heavy rains and floods, this research work used the well-structural questionnaire. Enumerator the students of COMSATS University Vehari firstly trained for collection of data from the study area and for capturing missing information regarding data collection, questionnaire was pre-tested. In the study area data was collected from July to September in 2019 while former to data collection wheat farmers of the study area were well-informed regarding aim and application of data. Mostly farmers from the study area warmly participated in sharing their information regarding wheat crop whereas 34 farmers refused to participate as they replaced to other farmers as data collection procedure illustrated in figure 3.

[Figure 3]

2.2 Empirical specification

In numerous risk management preferences, agricultural credit and diversifications are some significant preferences particularly used like dependent variable for this study. Farmers have to select strategy base preferences out of four combinations in this multinomial probit model, (i) neither adopting any risk management strategy (neither agricultural credit nor diversification), (ii) adopting only diversification (off-farm or on-farm), (iii) adopting only agricultural credit strategy (iv) adopting both strategies (diversification and agricultural credit). Farmers risk management adopting preferences proportion illustrated in table 2 which highlights as in overall sample farmers of the study area, 18.87% farmers adopted diversification strategy, 23.97% farmers used agricultural credit strategy, 21.63% farmers adopted both risk management strategies whereas 35.53% farmers adopted no risk management strategy.

Description of variables

Dependent variables

Agriculture credit and adoption of diversification considered dependent variables in this research work. Institutions (banks) provide any credit or loan for agriculture purpose particularly

recognized as agricultural credit (Ahmad et al., 2019). Such types of financial credit facilitate farmers' to buy farming inputs for smoothly running the farming operations. Losses and gains in farming practices are materialized by the completion of production and selling process of agricultural outputs. Consequently, for appropriate application of risk strategy in agriculture, credit access play significant role as this agriculture credit access includes as dependent dummy variable as indicating 0 for not using agriculture credit and 1 for highlighting using agricultural credit in farming practices. Diversification is considered as tactics for increasing off-farm and on-farm income sources by farming community from the dawn of agriculture (Rehan et al., 2017). Farming community for mitigating severe financial affects of climate change and enhancing their household income specifically uses diversification whereas inter-cropping and crop diversification are among few types of on-farm diversification (Akhtar et al., 2019; Ahmad and Afzal, 2020). In this research work diversification indicated as dummy variable illustrating 0 as farmer not using diversification whereas 1 for farmers using diversification in their farming practices.

Independent variable

In literature, farmers education, age, family income, farming experience, farm proprietorship and farm area consider significant factors for influencing and assessing farmers risk attitude toward climate change (Akhtar et al., 2019; Adnan et al., 2020; Ahmad and Afzal., 2020).

2.3. Assessing risk perception

Risk perception more properly illustrate by Wang and Roush, (2000), as imminent state of affairs in screening the mode of a bit going away incorrect and its forthcoming cost. Likelihood outcomes and its forthcoming product properly level risk detailed the same as a risk factor (Cooper et al., 2005). Risk of hailstorm, risk of heavy wind, risk of drought, risk of diseases and pests, risk of heavy rains and flood risk were categorized as high-flying risks in this study. In the scenario of farm potential in sequence of measuring incidence and severity regarding risk of farmer this study used Liker Scale which varies from 1 to 10. Several important studies Senkondo, (2000), Fahad et al., (2018), Ogurtsov et al., (2008), Akhtar et al., (2018) and Adnan et al., (2021) used this approach for risk perception in which respondents were reported to risk matrix, these scores were ranged accordingly higher risk severity 6 to 10 and lower risk severity

1 to 5 (Cooper et al., 2021) as indicated in figure 4. In estimation procedure, risk perceptions were used like in view of no risk specified as 0 whereas for high risks pointed out as 1.

[Figure 4]

2.4. Assessing risk attitude

In literature risk attitude measured through various approaches where two most appropriate approaches frequently applied for risk attitude measurement properly renowned as direct and indirect approaches (Dadzie and Acquah, 2012). Direct method generally known as interview process related to favorites of farmer's elicitation more used to name of Neumann and Morgenstern (Anderson et al 1977). Several significant studies in literature Torkamani, (2005), Iqbal et al., (2016), Smidts et al., (1990), Hardaker et al., (2010), Ahmad et al., (2019), Ogurtsov et al., (2008), Ahmad and Afzal (2020), Rizwan et al., (2020), Saqib et al., (2018) and Adnan et al., (2021) applied Equally Likely Certainty Equivalent Method (ELCEM) by diverse methods which is properly identified adapted version of Neumann-Morgenstern (N-M) model. In the proxy of economic scenario Elicit Utility model is frequently used to ELCEM while Certainty Equivalents (CE) is subdivision of sequence the risky outcomes in contrasting values of utility (Binici et al., 2003). In relevant to series work of Binici et al., (2003) utility function employed this research works denoted as wealth symbol as perception income of household. There is close and direct relationship illustrated regarding monetary proportion and risk, higher risk as higher monetary value. In such state of affairs, respondent were provoked to show the value of specific outcome to make possible prepared them indifferent in choose connecting risky outcomes by particular of overall income of household in monetary term changeable as 300000(PKR) to 0 with related possibility of as 0.5 in loss and income scenario. In such scenario, farmers were assured outcome of income 200000 (PKR) it carry on to be indifferent. The outcome chain was particular wedged in 0 to 200000(PKR) as leftover of respondent be indifferent 100000(PKR). In further procedure farmer by wish sequence connecting of 100,000(PKR) states similar assure via 0 and indicate the indifferent with 50000(PKR). In advance procedure sum as 40000(PKR) in indifferent classification of farmer, as such assessment was continual. In higher chain of 200000(PKR) to 300000(PKR), farmers have to make a decision and continue indifferent in 180000(PKR). In more sequence of 180000(PKR) to 300000(PKR), farmers stay indifferent in 220000(PKR). In such situation of reappearance of examination through association of likelihood, some number CE spots were consequential. In such scenario, value of utility used of 50,000(PKR) estimated as

$$U(50,000) = 0.5u(0) + 0.5u(100,000) = 0.5(0) + 0.5(1) = 0.5 \quad (1)$$

In situation for more managing diverse CE, furthermore matching them with utility values, cubic utility function was applied for estimation utility for each entity respondents. Cubic utility function highlighted in given equation 2.

$$U(wealth) = \alpha_1 + \alpha_2 wealth + \alpha_3 wealth^2 + \alpha_4 wealth^3 \quad (2)$$

Risk attitude of farmers based on many factors whereas wealth of farmer illustrated as w even as a detailed parameters as specified in equation 2. Cubic Utility Function has close association by risk indifferent attitude, aversion risk and preferring risk, (Binic et al., 2003).

Utility frequently evaluated by method of ordinary scale whereas form of utility function regarding ordinary scale be capable to transformed risk aversion in level of quantitative nature know as absolute risk aversion (Pratt, 1964; Raskin and Cochran, 1986; Arrow, 2000). Arithmetic appearance of absolute risk aversion can be specified as

$$r_a(Wealth) = - \frac{U'(Wealth)}{U''(Wealth)} \quad (3)$$

Absolute risk aversion illustrated as $r_a(W)$ in equation (3) whereas derivatives of second order and first order of wealth (w) indicated as U' and U'' . In such situation respondent income status reported as their wealth (Olarinde et al., 2007). Coefficient sign illustrated the respondent risk behavior; respondents risk likely behavior indicated as negative sign, respondents indifferent risk behavior shows zero value coefficient whereas coefficient of positive sign highlights the respondents absolute risk aversion. Range of 0 or 1 shows respondents risk attitude whereas no risk aversion attitude of respondent is explained as 0 while risk aversion attitude as 1.

Model specification

In analyzing the farmer's agricultural credit and adaptation decisions on diversification this study used both multinomial and bivariate probit models. Bivariate probit model is employed for likelihood of simultaneous association of different decisions for put in to practice diverse risk management policies (Ullah et al., 2015; Ahmad and Afzal, 2020; Adnan et al., 2021) whereas for contrasting the estimates individual probit model was employed. Bivariate probit model equation as illustrated

$$Y_{ij} = X_{ij} \beta_{ij} + \varepsilon_{ij} \quad (4)$$

In above equation, agricultural credit or diversification as adopted risk management strategies indicated as Y_{ij} with i th respondents ($i=1, 2, 3, \dots$). Observed variables vectors that possess the influences on adoption procedure of risk management strategies indicated as X_{ij} whereas the evaluated vectors of unknown parameters indicated as β_{ij} and error term of unobserved shown as ε_{ij} . In this equation Y_j indicated as binary variable that illustrated the m equation format as indicated in the below equations

$$Y_{11}^* = \alpha_{11} + X\beta_{11} + \varepsilon_{11} \quad (5)$$

$$Y_{21}^* = \alpha_{21} + X\beta_{21} + \varepsilon_{21} \quad (6)$$

In the above equation 5 and 6 latent variables are denoted by the notion of Y_{11}^* and Y_{21}^* which highlighting to emphasizing any decisions regarding risk managing approach. Multinomial probit regression used the set of probable arrangements rather than alternative risky decisions (Adnan et al., 2020). In this research work the two risk management strategies indicated probable combination whereas the multinomial probit regression illustrated as in equation 7.

$$Y_{ij} = X_{ij}\beta + \varepsilon_{ij} \quad (7)$$

In equation 7, Y_i shows the several combination of risk management choices reported as ($Y_i=1, 2, 3, 4, \dots, m$) as i th choices ($ij=1, 2, 3, \dots, n$) from the respondents whereas X_{ij} highlights the vectors ($1 \times k$) that shows the observed variables which impacts on the making choice. In this equation unknown parameters are illustrated by β and unobserved random error denoted as ε_{ij} . In such scenario ε_{ij} highlighted is presumptuous as the multivariate standard with variance covariance and with zero mean.

3. Results

Research work variables descriptive statistics has elaborated in table 2. Respondent farmers illustrated higher perception of floods, heavy rains, pests and diseases major risk factors in the study districts to wheat crop production rather than drought and hail storm. Farmers in the study area adopted some significant adaptation strategies to stooping costs from various environmental risks. In the study area, 47% farmers used off-farm or on-farm diversification adaptation strategy for risk management whereas majority of farmers as 53% used various form of credit to wheat production. Majority of farmer 77% were found to be risk averse in the study area. Agricultural credit usage 27.5% indicated as significant adaptation measure for risk management as compared to diversification 22.7% whereas almost one third 29.59% farmers have adopted no risk management strategy in the study area.

[Table 2]

Bivariate probit and individual probit models estimates are indicated in table 3, which determined the correlation coefficient of agricultural credit and diversification for purpose of risk managing technique by using the probit estimations. In Bivariate probit and individual probit models, positive correlation coefficient regarding both risk control methods as verified the estimated by sustaining null hypothesis indicating as risk management decision error term is correlated. Regarding these estimates instead of using the regression probit of two independent it is more suitable to involve bivariate probit model. Positive correlation coefficient illustrates the indication as selection of one risk management strategy significantly influences the other strategy. Wald χ^2 test (154.98) and test of log likelihood p_{kj} (3.8971) more preferably specifies the bivariate probit regression usage and confirms rejection of hypothesis H_0 with conjoint nullity of p_{kj} .

[Table 3]

In risk management decisions for selecting agricultural credit as risk management tool in wheat farming, socioeconomic factors play significant role. In coming to a decision the adaption of agricultural credit to reducing unfavorable catastrophic risks in wheat production of Pakistan farmers schooling, age, family income, farm practices, farm land ownership status, farm size and farmers risk averse nature are considered as most essential factors as showed in table 3. Farmer schooling and size of farm indicated positive correlation with using agricultural credit as adoption of risk management tool. These estimates illustrated as farmers with higher schooling more preferably to using agricultural credit as risk management tool rather than illiterate farmers whereas large farm size farmers more willing to use agricultural credit as risk management tool rather than small farm size farmers. Negative and significant correlation was estimated regarding farmers age and farmer monthly income with using of agricultural credit as risk management tool. Elderly farmers less willing to using agricultural credit as risk management tool rather than young farmers because young farmer more conscious about farming risks. Farmers having increasing monthly income not willing to taking agricultural credit for using as risk management tool whereas farmer with less monthly income more willing to using agricultural credit for risk managing measure. Estimates of the study indicated the negative correlation of farming experience and farmland ownership with using agricultural credit for risk management tool. Estimates illustrated as experienced farmers less willing to using agricultural credit as risk management tool whereas inexperienced more willing to using it as tool of risk management. In

this study area, tenants farmers have higher probability of taking and using agricultural credit for risk management whereas farmers having their ownership of farmland no motivation to using this management measure.

Farmers perceptions regarding the risks of heavy rain, drought, pest and diseases highlighted the favourable affect regarding the adaption of agricultural credit for minimizing the adverse catastrophic risks on crops whereas negative perception on agricultural credit was estimated regarding risks of flood, hailstorm and heavy wind. Majority of farmers in the study area having risk averse attitude and such nature of farmers significantly influences in agricultural credit adaption. On the other hand risk perception decisions of farmers have slanted nature and possible the effect to further factors in the process of decision making.

In scenario of risk management decisions for choosing diversification in wheat farming, socioeconomic factors such as farmers schooling, age, family income, farm practices, farm land ownership status, farm size and farmers risk averse nature play significant role as illustrated in table 3. Estimates illustrated the positive and significant correlation in respondent's ages and schooling with adaption of diversification strategy. These estimates show as aged farmers rather than young farmers and literate farmers rather than illiterate farmers more willing to adopting diversification as risk management strategy. In such scenario increasing schooling and age raises the probability of more prepared to adopting diversification. Positive and significant coefficient correlation of family monthly income and diversification in estimates elaborated increasing family income raises probability of farmers to adaption diversification. Estimates illustrated the negative relation of farming experience and farmers family size with adoption of diversification strategy. These results indicated when farmers experienced increases and their farm size increases they mostly evade to adoption diversification rather than less experienced farmers and small farm size farmers. Small farm size farmers and less farming experience farmers more likely to adopting diversification. Positive and significant coefficient correlation of ownership farmland with diversification adaption illustrates as compared to tenant farmers land owner more inclined to adoption of diversification so there is favourable effect of farm land ownership on adoption of diversification regarding climate risks.

Heavy rains, floods, drought, hail storm, heavy wind, pest and diseases are six significant independent variables of risk perception. Farmers risk perception regarding heavy rain, drought,

pest and diseases showed the positive correlation. These estimated highlighted as farmers have higher risk perception about heavy rains, drought, pest and diseases and more willing to adopting diversification as risk management tool rather than those farmers who have lower risk perception regarding these risks. Farmers risk perception about flood, hailstorm and heavy wind showed the negative correlation indicating as farmers have lower risk perception regarding these risks so less willing to using diversification as risk management strategy rather than those farmers having higher risk perception regarding these risks. Estimates of risk attitude category showed positive correlation illustrating as majority of farmers in study area have risk averse attitude as seeking more risk and eager to using diversification.

Agricultural credit and diversification are two more significant risk managing strategies measured in this study which includes four various risk management strategies adoption of agricultural strategy, adoption of diversification, both strategies simultaneous adoption and not adopting any risk management strategy. In estimation of multinomial probit various combinations as illustrated in table 3 indicated as dependent variable ($Y_i=1....4$). Estimates of multinomial probit regression model reported in table 4 where in estimation procedure basic choice is taken the combined no adoption of risk management strategy. Diversification adaptation significantly influenced by farmer schooling, age, monthly income, land area, farmland ownership, farm area, risk perception about to drought, heavy rain, diseases and pest and risk aversion farmer nature. Major findings of factors are alike with previous results rather than farm size and year of farming experience, because these factors negative impact on individual and bivariate probit estimation, whereas multinomial probit model was positively impacted.

[Table 4]

Adoption of agricultural credit decisions are significantly influenced factors of farmer's monthly income, farmers schooling, ownership of farmland status risk perception about drought, heavy rains, disease and pests. Farmer's tendency regarding risk averse attitude motivates farmers in adoption of agricultural credit for risk management. Major findings are alike individual and bivariate probit regression estimates except ownership of farmland and size of family. Robustness in estimates has indicated the reason of major significant variables both of diversification and agricultural credit in bivariate model showed similar effects like multinomial. In combination 4, farmers adaptation decisions are significantly influenced by factors of farm area, monthly income of farmer, ownership of land risk perception about heavy

rain, drought and pest and diseases also with risk farmers risk aversion status. In the same way, experience of farming and farmers schooling have positive while insignificant on farmers decisions building procedure about agricultural credit adoption for risk managing. Particularly in this research evaluating identification of casual is difficult. Diversification impact related to level of saving is unsure which might have influence agricultural credit adoption for managing catastrophic risk.

4. Discussion

In socioeconomic factors, positive correlation regarding farmers schooling and adoption of diversification strategy was estimated. According to estimates it is observed as qualified farmers more preferably focus to access advance knowledge regarding on-farm or off-farm or both type of diversification measures for improving stability of farm management and enhancing farming income as these finding are in line with the studies of Iqbal et al., (2016), Ahmad et al., (2019) and Adnan et al., (2020). On the other hand, these findings are in contradiction with the studies of Mesfin et al., (2011), Rehima et al., (2013) and Ullah et al., (2015) illustrated as higher educated farmers less willing to adopting diversification in farm activities. Positive relation in age of farmer and diversification in farm activities indicated in this study illustrating as aged farmers mostly are more experienced and more willing to using farm diversification regarding the severe impacts of catastrophic risks. Some studies Abbas et al., (2017), Ahmad and Afzal, (2020) and Adnan et al., (2021) are in line with these findings as indicating positive relation of age and diversification adaption whereas some studies Ali et al., (2019), Abbas et al., (2015) and Shah et al., (2021) illustrated negative impact of age with diversification adaption so mix scenario related to age and farm diversification estimated in literature. Higher probability of diversification regarding higher income was indicated in this study illustrating as higher income motivates farmers for adopting more diversification to generating more income sources. Some studies Ahmad and Afzal, (2020), Alam et al., (2020) Shah et al., (2021) and Adnan et al., (2021) findings are in line with estimate of this study whereas the study of Ullah and Shivakoti (2015) indicated the reverse causality as negatively related of higher income regarding on-farm diversification and positive effect of higher income to off-farm diversification. Farming background of farmers more properly known experienced farmers harmed the adoption of diversification strategy. Experienced farmers are mostly skilful focus higher priority to traditional measures for overcoming catastrophic risks rather than using advance technical skill

and diversification strategies. These findings are in line with the studies of Abbas et al., (2015) Ali, (2018) and Rahman et al., (2020) indicating as negative correlation of experience of farming and adoption of diversification strategy whereas some studies Ashfaq et al., (2008), Iqbal et al., (2016) and Ahmad et al., (2019) showed positively related of farming experience and diversification adoption. Farm size and adoption of diversification strategy illustrated the negative correlation in the findings of this study indicating as small farm size farmers for overcoming catastrophic risks more prefer to adopt the strategy of diversification whereas large farm size farmers slightly requires to risk management tools due to enlarged capacity of risk bearing. Small farm size farmers the reason of limited resources having minimal capacity of risk bearing causes to focus adopting risk management strategy like diversification rather than large farm size farmers as these findings are in line with the studies of Ahmad and Afzal, (2020), Rizwan et al., (2020) and Adnan et al., (2021). Some studies Kouame, (2010), Saqib et al., (2016) and Ali, (2018) indicated the positive correlation of farm size and diversification, showing as large farm size farmers more need adoption strategies to risk managing measure rather than small farm size farmers. Findings of this research illustrated the positive correlation of farmland ownership with adoption of diversification for overcoming the catastrophic risks management the reason of that owner of farmland as compared to tenants can easily and directly made decisions regarding diversification adaption as risk management decision. These findings are in line with the study of Ashfaq et al., (2008), Iqbal et al., (2016), Ahmad and Afzal, (2020) and Adnan et al., (2021) and in contrast with the study of Velandia et al., (2009) illustrated as farmland owner higher capacity regarding risk management due to access of significant resources rather than tenants so use minimal measures for risk management. In choosing the strategy of diversification adoption, the impact of farmers risk perception about drought, heavy rain, pest and diseases is positive whereas impact of negative risk perception regarding flood, hail storm and heavy wind. Flood risk perception in contrast with studies of Ali et al., (2019), Akhtar et al., (2019) and Ahmad et al., (2020) whereas in consistent with the studies of Ullah et al., (2015) and Adnan et al., (2021). The positive drought perception of farmers regarding to wheat crop indicating as wheat crop in Pakistan is grown in winter season where water availability for wheat crop is low causes more issue of drought while flood scenario is extremely low in winter and more probability of summer season. Diversification strategy is mostly adopted by farmers in avoiding production losses and generating income sources through off-farm activates to minimal the risk losses. Water scarcity and catastrophic risk causes to yield losses of

wheat crop which consequently reduces net returns of wheat cultivation. Hail storm and heavy rain threats deterred farmers for adopting diversification as risk management strategy. In decision making process, risk perception of farmer influence indicated as additional determinant. Risk aversion behavior of farmer affects their decisions of diversification regarding adopting the risk management strategy as study findings indicating as majority of farmers in the study area having risk averse nature. These findings are consistent with the studies of Alam et al., (2019) and Ahmad and Afzal, (2020).

In findings of the study, positive correlation in farmers schooling and credit access as risk management strategy illustrates as literate farmers are more familiar regarding advantages of agricultural credit access rather than illiterate farmers. Higher schooling facilitates farmers in proper understanding regarding credit access terms and conditions and appropriately managing all proper documentations. These findings are in line with the studies of Saqib et al., (2018), Ahmad et al., (2019), Rehman et al., (2020) and Adnan et al., (2021). Regarding the estimates of the study indicated the negative correlation of farmer's age and adoption of agricultural credit access as risk management strategy. Aged farmers as compared to young farmers less motivated to access agricultural credit for risk management strategy due to it complicated procedure and inadequate information regarding its usage mostly in developing countries and more specifically in Pakistan. Elderly farmers have to face a number of issues regarding complicated documentation of agricultural credit which causes to discourage access of credit. These findings are in line with the studies of Zulfiqar et al., (2016), Rizwan et al., (2020) and Ahmad and Afzal, (2020). Findings of the study indicated the negative correlation in farmer's higher income and diversification adoption. Higher income farmers due to their own saving particularly invest to on-farm for risk managing issues rather than access to agricultural credit to increasing their financial burden. Results biasness can be as if indicating reverse causality as large farms needs more capital from disasters recovery. Accordingly, large farm required more resources for risk management in contrast to small farms and agricultural credit can be as significant tool to managing these catastrophic risks. These findings are consistent with the studies of Abid, (2017), Alam et al., (2019) and Ahmad et al., (2020). Farm size and agricultural credit indicated the positive correlation illustrating as large farms as compared to small farms more need to additional capital for managing catastrophic farming risks. These findings are consistent with the studies of Ullah et al., (2016), Alam et al., (2019) and Adnan et al., (2021) while in contrast with

the study of Saqib et al., (2016). Adverse affect of farmland ownership and agricultural credit estimated in the estimates of this study illustrating as lower attention of farmland owner to access of credit is due to having more stability and assets with enhanced capacity of risk management. These findings are in line with the study of Ali, (2018), Ahamd and Afzal, (2020) and Rizwan et al., (2020). Risk perception of farmers regarding to heavy rain, hail storm, drought and heavy wind correlated negatively whereas positive concerning to flood, diseases and as pests affects on agricultural credit acceptance to minimize disadvantageous climatic risk in agriculture. Agriculture credit mostly used by farmers by choice for lowering and mitigating the major losses from ex-post shocks, crop failure and crop cultivation. More specifically in Pakistan, farmer's income is significantly influenced by these catastrophic risks which directly affects clothing and food expenditures. In due course, without financial support it is not easy for farmers to restart cultivation and production for next production season. Farmers are extremely discouraged in adoption of agricultural credit in drought, heavy rain, hailstorm and heavy wind as these findings are in line with the studies of Ullah et al., (2016), Abid, (2017), Ahmad et al., (2020) and Adnan et al., (2021). In drought situation, majority of farmers avoid participating in crop cultivation and production so not prefer to use credit for such production process. Heavy rain, hailstorm and heavy wind also have severe affects on crop cultivation and production causes to less prefer the usage agricultural credit. Risk averse nature of farmers more preferably motivates farmers to usage of agricultural credit for adaptation measures to catastrophic risks and majority of the study area farmer showed the risk averse nature as these findings are in line with the studies Saqib et al., (2016), Abbas et al., (2017) and Ahmad and Afzal., (2020).

5. Conclusion and suggestions

Multiple risk management strategies are mostly adopted by farmers to overcoming the catastrophic risks of agricultural production. This study used the multinomial and bivariate probit regression sought to find out the factors influencing farmer's choices of agricultural credit and diversification strategy for managing risks in Pakistan, moreover the potential relationship in these choices. Results of the study indicated the correlation in farmer's adoption of agricultural credit and diversification strategy to managing risks. Findings of the study concluded as farmers adoption of one risk management strategy motivates them at the same time as to adopting other risk managing strategies. Estimates illustrated the significant relationship in risk tolerance nature and socioeconomic factors of farmers related to their adoption the strategy of risk management.

In this study, six production based categorized wheat growing districts of Punjab Pakistan were preferably focused as these outcomes can be extended to various region of country and particularly the other developing countries regarding to availability of various risk managing strategies. Policy makers and state based authorities can be assisted by the accumulated information of multinomial and bivariate probit regression models in evaluating plans of risk management and willingness of farmer in accept government supported risk managing strategies in incidence of traditional practices for managing farmhouse risk. In the same way this study discussed limited researcher's choices and interviewer's decisions because of study focused only limited area of research such as six districts of Punjab Pakistan. In this research, promising conclusions for selecting the poverty and food safety are further than of this study so future research can find out such significant outcomes.

Declarations

Ethical Approval

Ethical approval taken from the COMSATS University Vehari campus, ethical approval committee

Consent to Participate

Not applicable

Consent to Publish

Not applicable

Authors Contribution

DA analyzed data, methodology, results and discussion, conclusion and suggestions and manuscript write up whereas both DA and MA finalized and proof read the manuscript and both authors read and approved the final manuscript.

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Competing Interests

The authors declare that they have no competing interest.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Table 1 study area sampling framework

Categorized wheat crop production zones	Range of wheat crop production	Sample of wheat crop study districts	Respondents wheat farmers in numbers
Low wheat crop production zone	Wheat production below 600,000 tonnes	Dera Ghazi Khan	80
		Layyah	80
Medium wheat crop production zone	Wheat production in range of 600,000 to 900,000tonnes	Muzaffargarh	80
		Vehari	80
High wheat crop production zone	Wheat production above 900,000 tonnes	Rahim Yar Khan	80
		Bahawalnagar	80
Grand total of respondents			480

Table 2 Study variables descriptive statistics

Study variables	Description of variables	Mean value	Standard deviation
Dependent variables			
Agricultural credit	Agriculture credit access 1 otherwise 0	0.53	0.49
Diversification	Adopted diversification1 otherwise 0	0.47	0.46
Independent variables			
Socioeconomic and farm characteristics			
Schooling status	Respondents schooling in years	3.97	5.76
Respondent age	Respondent age in years	36.83	12.98
Family monthly income	Family total monthly income in PKRs	29,549.879	18,876.265
Experience of farming	Farmer agriculture farming experience in years	17.871	13.546
Size of farm	Farm land total area in (acres)	7.428	2.981
Size of family	Family members in numbers	6.324	2.872
Ownership of farmland	Respondent owner 1 otherwise 0	0.438	0.491
Perception of risk			
Heavy rain	High risk of heavy rain 1 otherwise 0	0.71	0.48
Flood	High risk of flood 1 otherwise 0	0.74	0.42
Drought	High risk of drought 1 otherwise 0	0.43	0.41
Diseases and pests	High risk of pest diseases 1 otherwise 0	0.79	0.46
Hailstorm	High risk of hailstorm 1 otherwise 0	0.39	0.40
Heavy wind	High risk of heavy wind 1 otherwise 0	0.47	0.44
Risk attitude			
Risk aversion	Respondent risk averse nature 1 otherwise 0	0.77	0.45
Number of total observations	480		
Wheat farmers adopted different combinations of risk management strategies			
Strategies of risk management	Respondents numbers	Percentage of respondents	
Agricultural credit usage	132	27.50%	
Diversification usage	109	22.70%	
Usage of agricultural credit and diversification	97	20.21%	
Usage of no risk management strategy	142	29.59%	

Sources; authors own survey collected data 2019,

Table 3 Bivariate and individual probit model estimated parameters

Study independent variables	Individual probit		Bivariate probit	
	Agricultural credit	Diversification	Agricultural credit	Diversification
Socioeconomic and farm characteristics				
Schooling status	0.0491*** (0.0176)	0.0314*** (0.0183)	0.0486*** (0.0168)	0.0311*** (0.0179)
Respondent age	-0.0287** (0.0129)	0.0283** (0.0114)	-0.0279** (0.0126)	0.0281** (0.0112)
Family monthly income	-0.00004*** (0.0000)	0.00005*** (0.0000)	-0.00004*** (0.0000)	0.00005*** (0.0000)
Experience of farming	-0.0786 (0.0691)	-0.1179* (0.0594)	-0.0781 (0.0587)	-0.1293* (0.0598)
Size of farm	0.0579*** (0.0189)	-0.0248* (0.0109)	0.0587*** (0.0174)	-0.0239* (0.0113)
Size of family	-0.0138 (0.0248)	0.0147 (0.0231)	-0.0129 (0.0243)	0.0138 (0.0227)
Ownership of farmland	-0.6891*** (0.1761)	0.7984*** (0.1798)	-0.6799*** (0.1741)	0.7821*** (0.1752)
Perception of risk				
Heavy rain	0.4483 (0.1798)	0.1289 (0.1765)	0.4329 (0.1716)	0.1243 (0.1741)
Flood	-0.6147 (0.1987)	-0.2378 (0.1799)	-0.6098 (0.1924)	-0.2289 (0.1765)
Drought	0.0236 (0.2076)	0.1897 (0.1875)	0.0218 (0.1987)	0.1861 (0.1811)
Diseases and pests	0.5798 (0.1869)	0.1986 (0.1821)	0.5776 (0.1834)	0.1954 (0.1799)
Hailstorm	-0.1797 (0.2281)	-0.0139 (0.2457)	-0.1785 (0.2232)	-0.0134 (0.2434)
Heavy wind	-0.0597 (0.3394)	-0.1187 (0.2921)	-0.0582 (0.3411)	-0.1178 (0.2947)
Risk attitude				
Risk aversion	1.0798 (0.2289)	0.8789 (0.2186)	1.0654 (0.2276)	0.8783 (0.2197)
Value of log likelihood	-189.7865	-181.9132	-378.4317	
Wald χ^2	154.98***			
Ratio of log likelihood test ρ_{kj}	3.8971**			
Ratio of log likelihood test χ^2	78.56***	97.43***		
Pseudo- R^2	0.1867	0.2178		
Coefficient correlation	0.389***			
Total number of observation	480			

***indicate at 1% level of significance, ** at 5% level of significance, *at 10% level of significance
Values in parenthesis reports the standard error

935 Table 4 Estimation of Multinomial probit model

Study independent variables	Agricultural credit	Diversification	Both agricultural credit and diversification
Socioeconomic and farm characteristics			
Schooling status	0.0593**(0.0234)	0.0678**(0.0257)	0.0483(0.0294)
Respondent age	-0.0269(0.0279)	0.0399*** (0.0173)	-0.0047 (0.0198)
Family monthly income	-0.00004*** (0.00000)	0.00003*** (0.0000)	-0.00005*** (0.0000)
Experience of farming	-0.0194(0.0243)	0.0287** (0.0146)	0.0291(0.0189)
Size of farm	0.0149(0.1083)	0.2879*** (0.1179)	0.0298** (0.0157)
Size of family	0.0126(0.0398)	0.0142(0.0357)	-0.0164(0.0398)
Ownership of farmland	0.5987** (0,3427)	0.7894*** (0.2687)	1.4786*** (0.2961)
Perception of risk			
Heavy rain	-1.4698(0.4379)	0.2987(0.2978)	0.1098(0.2976)
Flood	0.6789(3954)	-0.2987(2896)	0.4751(0.3781)
Drought	-0.0796(0.6951)	0.1793(0.4854)	-0.0721(0.4973)
Diseases and pests	0.2981(0.2811)	-0.5879(0.2963)	0.6895(0.3086)
Hailstorm	-0.3476(0.5876)	-0.1794(0.4681)	-0.2847(0.46825)
Heavy wind	-0.6693(0.7683)	-0.3987(0.5389)	-0.1794(0.5431)
Risk attitude			
Risk aversion	0.8976(0.4087)	0.7849(0.3467)	2.5983(0.4637)
Value of log likelihood	-298.8976		
Number of total observations	480		

940 Figure 1Map of Pakistan provinces and Punjab districts

Figure 2 Study districts of Punjab province of Pakistan

Figure 3 Data collection sampling procedure of the study area

953 Figure 4 Risk Matrix

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