Flood Hazards and Farm Based Agricultural Production Risks Management Practices in Flood Prone Areas in Punjab, Pakistan

Dilshad Ahmad (dilshad@ciitvehari.edu.pk)
COMSATS University Islamabad, Vehari Campus Pakistan https://orcid.org/0000-0002-3991-805X
Muhammad Afzal
Preston University Islamabad, Pakistan

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Dilshad Ahmad
Department of Management Sciences
COMSATS University Islamabad, Vehari Campus Pakistan
Corresponding author: dilshad@ciitvehari.edu.pk
https://orcid.org/0000-0002-3991-805X

Muhammad Afzal
Department of Economics
Preston University Islamabad, Pakistan
profafzal@gmail.com

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Abstract

Climate induced disasters more specifically the floods have caused severe damages to agriculture sector in Pakistan. These climatic risks have constrained farming community to adopt numerous risk management strategies to overcoming such risks. This research work attempted to examine the association of risk management tools with farmer's perception of risk, risk averse attitude and various socioeconomic factors. The study employed the sample data of 398 farmers from flood prone two districts of Punjab, Pakistan. To investigate the association of dependent and independent variables this study used the multivariate probit model. Results of the study illustrated as heavy rains and floods consider not significant source of risk for large farmers in the study area while for small farmer these indicated as high risks as most of small farmers were more risk averse. Estimates of multivariate probit model interpreted as age of farmer, heavy rains risk perception and landholding size were positively relationship with risk management tool of depletion of assets. Farmers education, off-farm income, age and risk averse attitude of farmer were positive whereas experience of farming were negatively linked with reduction of consumption. Furthermore, experience of farming, risk averse attitude, heavy rains and floods risk perception were positively association with diversification adoption. Flood prone farming community of the study area is more vulnerable to these climatic risks and also relying traditional strategies for risk management. There is need of some specific agriculture base measure such as crop insurance, extending formal credit and flood base measure as pre-flood warning system, flood rescue management and post flood rehabilitation to overcome these climatic risks.

Keywords: Heavy rains, Floods, Risk management, Punjab, Pakistan

1. Introduction

Floods, landslides, earthquakes, droughts and cyclones are a few major and severe natural hazards the reason of higher occurrence of extreme climate change (Toe *et al.*, 2018; Eckstein *et al.*, 2019; Ahmad *et al.*, 2019). In present worldwide circumstances, floods are measured the mainly repeated and more destructive somewhat than other hazards (Field *et al.*, 2012; World

Bank, 2013; Doocy *et al.*, 2013 Toe *et al.*, 2018) due to substantial association to social risk, economic losses and human fatalities as mainly bared by human (Mirza, 2003; Rafique and Blaschke, 2012; Ahmad and Afzal, 2021). In 2017, such type of natural disasters affected more than 96 million peoples all over the world in which floods hazards affected more than 60% population (World Bank, 2013; Emergency Event Database (EEDAT), 2017). In the current couple of decades, increasing repetition and harshness of floods was estimated more particularly in South Asian and South East Asian countries (Hirabayashi *et al.*, 2013; Krausmann and Mushtaq, 2008; Leichenko and Wescoat, 1993) where a few Asian countries India, Bangladesh, China and Pakistan are highlighted as supermarkets of flood disasters (James, 2008; Ahmad *et al.*, 2019). Inadequate infrastructure, scare resources and limited flood adaptive mitigation measures are significant factors of increasing flood vulnerability (Daniell *et al.*, 2016;Abbas *et al.*, 2017) mostly for flood-prone rural community in developing countries (Zhang *et al.*, 2011; Abid *et al.*, 2016). More particularly in developing countries, anthropogenic factors such as human encroachment in rivers coupled with environmental and climatic change have played major role to increasing flood hazards (Gaurav *et al.*, 2011; Toe *et al.*, 2018).

In worldwide aspect, Pakistan showed as world 5th most natural hazards affected country (Eckstein et al., 2019) owing to particularly situated in hazards prone region and facing recurrent floods (Abbas et al., 2017; Ahmad and Afzal, 2021). Erratic rains, glacier melting and increasing cycle of monsoon rainfalls are foremost factors related to repeated floods in interlined rivers concerning upstream or downstream rivers (Teo et al., 2018; Ahmad et al., 2020). In state of natural hazards as more specifically the flood hazards, Pakistan faced three worst flood disasters in rapid succession in 2010, 2011 and 2014 which caused major losses of livestock, crops, forestry, fishery and destructed of primary agriculture infrastructure. Flood disaster of 2010, caused cumulative economic cost of 10 billion US dollars, destroy cropped area of two million hectares and twenty-four million peoples were adversely affected (Rafique and Blaschke, 2012; United Nations, 2011; Khan, 2011; Abid et al., 2016). Balochistan and Sindh provinces were massively struck by flood hazard of 2011, which caused major destruction of crops, livestock, fishery and forestry in these provinces as estimated economic loss was 3.7 billion US$ whereas the estimated cost of reconstruction and recovery as 2.7 billion US$ (Government of Pakistan (GOP), 2011; National Disaster Management Authority (NDMA), 2011). In 2014, flood caused the major losses of 367 human fatalities; damaged 1 million acre of cultivated area, for recovery from flood estimated cost was 439.7 million US$ and for resilience buildings 56.2 million US$ (NDMA, 2014).

In Pakistan, agriculture is consider one of the major sector of economy due to significant contribution as employing 45% labor force of country and sharing 26% GDP of economy (Pakistan Bureau of Statistics (PBS), 2020) yet agriculture is dealing with some erratic and uncertain climatic circumstances such as heavy rainfall and increasing temperature (Azam-Ali, 2007; Ahmad and Afzal, 2020). Agriculture in Pakistan is prominently induced by climate based natural hazards drought, heavy rains, floods and other natural disasters (Khan et al., 2020; Ahmad et al., 2019). In agricultural production, climate variation played severe role through extreme weather scenario in Pakistan such as hailstorms, droughts, cyclones, heavy rains and floods which negatively affected farm production of the country (Saqib et al., 2016; Arora, 2019).

In numerous studies, to undertake these climatic risks in agriculture farmers needs to use these two informal and formal approaches these are more categorized in ex-post and ex-ante (World Bank, 2013; Grubb et al., 2002). Farm level risk management ex-ante informal strategies are intercropping, crop diversification, accumulated assets liquidation, income diversification, adoption advance and new cropping techniques, crop sharing and informally risk pooling. Farm level risk management ex-post informal strategies are assets selling, labor reallocation, mutual aid and reduction of consumption. Market based formal ex-ante risk management approach involves the future market contracts and insurance acquisition whereas at farm level risk management market formal ex-post strategies involves with to manage risk in access of capital (Ullah and Shivakoti, 2014). In these both substitute strategies risk reducing ex-ante publically present extension services, infrastructure establishment (irrigation, roads, dams) and agriculture system of pest management whereas public related risk management formal ex-post strategies include capital transfer, formal credit access and social assistance (Saqib et al., 2016).

In literature, climate change and agriculture aspect significantly paying attention for the duration of the couple of decades specifying the studies of climate risk assessment impacts (Schlenker and

Lobell, 2010; Seo and Mendelsohn, 2008; Ali and Abdulai, 2010), studies of climate risk mitigation (McCarl and Schneider, 2001; Metz et al., 2007; Bradshaw et al., 2004) and climate risk adaptation studies (Abid et al., 2016; Deressa et al., 2011; Alam et al., 2019; Kato et al., 2011; Mugi-Ngenga et al., 2016; Bryan et al., 2013). Some studies focused the perception of farmers risk and risk attitude according to various food and cash crops (Binici et al., 2003; Dadzie and Acquah, 2012; Ullah et al., 2015; Sarwar and Saeed, 2013; Ali et al., 2017; Ahmad and Afzal, 2020; Ahmad et al., 2019; Ahmad et al., 2020). In global scenario a number of studies focused the flood hazards aspect in the scenario of farm based agricultural production risks management practices in flood prone areas while this aspect more specifically in flood prone areas of Punjab province of Pakistan not properly addresses according to best knowledge of author. This study tried to focus this research gap more specifically in scenario of flood prone areas of Punjab province Pakistan. In attendance are some considerable basis for focusing Punjab province flood prone areas for this study firstly in comparing with other provinces Punjab is more vulnerable of climatic risks, stress of extreme climate, floods, rising severe diseases and water shortage (PDMA Punjab, 2018; PBS, 2019). Secondly, five rivers of country flow throughout the fertile lands of Punjab causes major destruction of flood-prone areas agriculture due to frequent erratic rains and floods (PDMA, Punjab 2018). Lastly, among all provinces Punjab is major contributor agriculture production while due to these climatic risks more specifically the consecutive floods from 2010 to 2014, caused significant decline in agricultural production of province (BOS Punjab, 2019; PDMA Punjab, 2014). The aim of this study is to examine the risk management measures association with risk perception of farmers, their attitude of risk averse and various socioeconomic factors in flood prone areas of Punjab province of Pakistan. This research work is classified in to four segments as introduction of the study discussed in section first whereas second section illustrated the material and methods. Third section of study elaborated results and discussion whereas conclusion and suggestions are indicated in last section of the study.

2. Material and methods

2.1 Study area

Balochistan, Sindh, Khyber Pakhtunkhwa and Punjab are four provinces of Pakistan while Punjab province was preferred for this study on the basis of few significant reasons. Firstly, this province represents 26% area of the country and the most populated as indicating 53% population of the country (PBS, 2017). Secondly, this province is higher vulnerable of natural hazards more particularly the floods hazards and erratic rains the reason of consecutive flowing of five rivers throughout the fertile land of province (PDMA, Punjab 2017). Thirdly, southern Punjab region in Punjab mainly selected for this study owing to located both sides of Pakistan's largest river Indus and repeatedly facing the flood hazards (BOS, 2017; NDMA, 2018). Fourthly, in the region of southern Punjab flood prone areas farming community of Indus River, more vulnerable of flood hazards rather than other farming communities so purposely focused for this study. Lastly, out of twelve higher floods risk districts of Punjab province, two higher flood disasters vulnerable district Muzaffargarh and Rahim Yar Khan were (PDMA, Punjab 2014) more preferably selected for the study as indicated in figure 1.

[Figure 1]

Muzaffargarh district consists four tehsils (sub-district in district area) Jatoi, Kot addu, Muzaffargarh and Alipur, 93 union councils (Pakistan fifth administrative unit and local government second tire) (GOP, 2020) with area of 8249 km^2 and population of 4.32 million (PBS, 2017). Muzaffargarh district consider higher vulnerable to consecutive flood disaster owing to located in critical geographical scenario surrounded side by side two major rivers as Indus flows western side even as Chenab flows eastern side of district (Bureau of Statistics (BOS) Punjab, 2019). Hot summer and mild winter, average rainfall of 127mm with lowest 1°C (30°F) and highest 54°C (129°F) temperature are some significant feathers of this area (Pakistan Metrological Department (PMD), 2019). In the couple of decades, this district faced erratic rainfall and frequent floods that caused foremost losses of infrastructure, crops, livestock and human fatalities (PDMA Punjab, 2014) and due to lowest social progress index and cultural, social and economic dimensions indicated as lower socioeconomic status district as indicated in figure 2 (BOS Punjab, 2019).

[Figure 2]

Administratively Rahim Yar Khan district is divided in to four tehsils (sub-district in district area) Khanpur, Liaqatpur, Sadiqabad and Rahim Yar Khan (GOP, 2020) by area of 11,880 km^2 and population of 4.81million (PBS, 2017), higher vulnerable due to extreme flood disasters as located on eastern bank of river Indus (PDMA Punjab, 2014). In scenario of long and extreme summer Rahim Yar Khan regarded as hot region with average temperature 26.2°C in this area

(PMD, 2019). Majority population (65%) of district affiliated with agriculture (BOS Punjab, 2019) whereas during the current couple of decades because of climate change having sever issues of excessive flood hazards and confronted with losses of infrastructure, livestock, crops and human fatalities as indicated in figure 2 (PDMA, 2014).

2.2 Sampling technique and data collection

In this study multistage sampling technique was used for data collection as firstly Punjab from four provinces chosen for the study area because of higher vulnerability of floods destruction (PDMA, 2014). Secondly, the reason of higher flood hazards vulnerability and consecutive flooding, southern Punjab region (BOS Punjab, 2019) from province specifically focused for this study. Thirdly, out of twelve high risks flood hazards vulnerable two districts Rahim Yar Khan and Muzaffargarh (PDMA Punjab, 2017; National Disaster Management Authority (NDMA), 2018) were particularly selected for the study. Fourthly, in every district two tehsils and two union councils from each tehsil were purposively chosen on the basis of flood vulnerability according to list provided from District Disaster Management Authority (DDMA), local land record officer (patwari) and agriculture officer. Lastly, from every union council two villages were selected based on higher flood destruction and vulnerability and farmer's respondents from each village were randomly selected and were interviewed.

In procedure of data collection, households indicated the basic unit whereas the head of household (female/male) consider the major respondents of this study area. In acquiring sample size minimum level, this study employed the Yamane (1967) sampling method as elaborated in equation 1. For this study, household heads were specifically targeted for data collection of 398 respondents, the population of 7% indicated sufficient in many studies (Ullah et al., 2016; Saqib et al., 2016). Sample was equally distributed in both study areas in Muzaffargarh and Rahim Yar Khan. Sample size in the equation (1) indicated as n, total number of household in study area as N whereas precision value denoted as e set as e 7% (0.07).

$$Sample\ Size\ (n) = \frac{N}{(1 + Ne^2)} \tag{1}$$

In the scenario of data collection, direct respondent's interaction a well developed questionnaire was used and data collected from February to May 2019. In finding the adequacy and accuracy of information and avoiding ambiguity, questionnaire was used for pilot study and pre-tested through 20 respondents prior to proper survey in these study areas. Five trained enumerators and author himself corrected and clarified all relevant issues regarding questionnaire prior starting the survey in the study area. In data collection, all respondents were clearly informed about the purpose and use of data and those respondents hesitated to sharing their information was replaced to others. In analyzing the collected data study households STATA and SPSS packages were used. There were two sections in data analysis firstly frequency distribution and percentages in descriptive statistics whereas second section illustrated the independent and dependent variables association.

2.3 Study model and variables

2.3.1 Dependent variable

Informal management strategies such as consumption reduction, diversification and depilation of assets are dependent variables of this study. Household productive assets selling such as car, motorcycle, cycle and various home appliances for managing their farming risks after floods formally known as management strategy as depilation of assets as explained in equation (6) denoting 1 for selling assets otherwise 0. In managing farming risks after floods households need money for maintaining farming activities so they search off-farm sources of income such as sending their family member abroad for remittances or working daily labor in neighboring locality. In management strategy these above mentioned measures known as diversification as indicated in equation (7) if adopted diversification illustrated 1 otherwise 0. If farming households reduces their non-food and food expenditures for managing farming risks known in scenario of management strategy as reducing consumption if adopted indicated as 1 otherwise 0 as illustrated in equation (8).

2.3.2 Independent variable

2.3.2.1 Risk perception

Risk perception as analyzing risks assessments (Wang and Roush, 2000), questions were asked from the respondents for indicating the severity and incidence from risk sources and mentioning the proper probability or subjective weights of Likert scale 5 points. For appropriate use of respondent’s response their risks were converted in low or high (Lansdowne, 1999; Cooper et al.,

2005) by using risk matrix approach by giving high categorization 6 to 10 whereas low level 2 to 5. Low risk perception indicated in unshaded area while high risk with shaded area as illustrated in figure 3. In measuring the risk perception matrix approach considered more appropriate due to addressing both sources of risks as severity and incidence (Ullah et al., 2015; Ahmad and Afzal, 2020).

[Figure 3]

2.3.2.2 Risk attitude

In literature various approaches are used for estimating the farmers risk attitude whereas direct and indirect two approaches are more frequently in numerous research works (Dadzie and Acquah, 2012). Von Neumann and Morgenstern suggested the direct approach more properly discusses the results of various levels of intolerance and tolerance for betting and so as to probability concept by no mean intuitively understandable as indicated the more time consuming and complicated technique (Moscardi and de Janvry, 1977).

In literature frequent studies (Saqib et al., 2016; Smidts, 1990; Iqbal et al., 2016; Torkamani, 2005; Hardaker et al., 2004; Ahmad et al., 2019; Ogurtsov et al., 2008; Ahmad and Afzal., 2020) used the modified version of Equally Likely Certainty Equivalent Method (ELCEM) Neumann-Morgenstern (N-M) model. ELCEM is recurrently applied model proxy of Elicit Utility while Certainty Equivalents (CE) be stem in favor of risky outcomes chain and contest them by utility values (Binici 2003). Income of household has used as utility function toward represent wealth utilized in the study followed via Binici (2003). The chronological and directly share of monetary and risk as measured the more monetary value and higher risk. In this scenario the retorts (farmer) were inquired to indicate the value of monetary a exact outcome that causes him neutral in these two risky outcomes in monetary term the PKR 280,000 like annual income sample farmers as 0.5 allied probability. In the scenario of loss as 0 level of income have the identical 0.5 probability farmers income is prefer in such range. In the situation of the certain outcome of PKR160, 000, farmer stays indifferent. The series of outcome was indicating among PKR 0 to 160,000 as farmer residue to be indifferent PKR 80,000. In more procedure farmer through selecting range in PKR 80,000 say as the equal promises with the PKR 0 and illustrated unconcerned in PKR 40,000. In the other amount of PKR 30,000 with the unresponsive standing of farmer, experimentation was repeated. In higher series of PKR 160,000 to 280,000, farmers involve has come to a decision and keep on indifferent in PKR 180,000. In a more sequence of PKR 180,000 to 280,000, farmers stay neutral in PKR 210,000. The recurrence of experimentation linked of probabilities numerous CE points be resultant.

In favor of instance, the value of utility for example PKR 40,000 measured as

$$U(40,000) = 0.5u(0) + 0.5u(80,000) = 0.5(0) + 0.5(1) = 0.5 \qquad (2)$$

Consequently to find different CE and identical them with values of utility, function of cubic utility was applied for measuring utility of each individual respondent. The given equation illustrated the cubic utility function

$$U(w) = \alpha_1 + \alpha_2 w + \alpha_3 w^2 + \alpha_4 w^3 \qquad (3)$$

Risk indifferent, risk preferring and risk aversion attitude all of such are consistent with cubic utility function (Binic *et al.*, 2003). In general utility procedure accessed through ordinary scale, utility function form on an ordinary scale be able to distorted in risk aversion quantitative degree know as absolute risk aversion (Arrow, 1964; Raskin, 1986; Pratt, 1964). Absolute risk aversion in arithmetically form can be written such as

$$r_\alpha(W) = -\frac{U'(W)}{U''(W)} \qquad (4)$$

Absolute risk aversion coefficients are indicated in above equation such as ra(W) while the wealth (W) second order and first order derivatives indicated as U’’ and U’. Olarinde, (2007) indicated as for wealth the income is supernumerary. Respondents risk behavior justify through coefficients value sign, respondent is risk-averse if absolute risk aversion coefficient values as positive sign, respondents as risk taker illustrated through coefficient absolute risk aversion negative sign while zero coefficient sign as unresponsive to risk. This empirical analysis includes risk attitude of respondent as risk aversion behavior if yes as 1 otherwise 0.

Risk aversion $= r_a(w) < 0$

Risk neutral $= r_a(w) = 0$

Risk preference $= r_a(w) > 0$

2.3.3 Socioeconomic characteristics of farm households

Risk management decision of farmers are significantly influenced by farmers characteristics of socioeconomics such as farmers off-farm income, education and age (Sherrick et al., 2004). Owned land share in cultivation, off-farm monthly income, size of farm, farmer's education, farming experience and farmers age were some significant demographic and socioeconomic factors used in this study. Measurement units of these factors were as monetary unit as PKR for annual off-farm income, schooling years for education, cultivated land in acres for farm size, experience and age in years.

2.4 Empirical model

In estimating the influence of simultaneous independent variables over strategies of risk management this study applied the multivariate probit model as indicated in equation (5). Multivariate probit model be connected the form of model of binary regression which simultaneously estimates the impact of explanatory variables on more than one dependent variable. In this model it is allowed the error term is freely linked. In this research work for managing farming risks, farmers have employed informal three tools of risk management as study focused to adoption these tools simultaneously. In simultaneously adoption decision of farmer's tools of risk management, multivariate model is more feasible and adopted for empirical estimation in this study as indicated below in equation (5)

$$Y_{ij} = X_{ij}\,\beta_i + \varepsilon_{ij} \qquad (5)$$

Dependent variable denoted as Yij, alternative utilized risk management as j=1..3whereas ith farmers indicated as i=1…..n, Independent variables vectors Xij which causes to affect adoption decision risk management, estimated parameters coefficient illustrated as βi, the error term unobserved that distributed normally with constant variance and zero mean explained as εi. In such scenario each binary variable Yij such above equation indicated as system of equations as used for empirical estimation.

$$Y_1 = \alpha_1 + X_i\,\beta_i + \varepsilon_i \qquad (6)$$

$$Y_2 = \alpha_2 + X_i\,\beta_i + \varepsilon_i \qquad (7)$$

$$Y_3 = \alpha_3 + X_i\,\beta_i + \varepsilon_i \qquad (8)$$

In the above mentioned various three equations each equation has different dependent variable Y1, Y2 and Y3 indicating the different risk management strategy as illustrating 1 in Yj and otherwise 0.

3. Results and discussion

In the scenario of landholding size, study area farmers were categorized in to three groups according to land holding size as above five hectares denoted large farmers, holding land above two to five hectares illustrated medium farmers and up to two hectares highlighted small farmers (Saqib et al., 2016; Ullah et al., 2015). The different variables of categorized farmers groups and number of farmers in various groups as large farmers (64), medium farmers (108) and small farmers (226) as indicated in table 1. In the education status, majority of 64.57% farmers groups is literate whereas the higher literacy rate indicated in large farmers rather than medium and small farmers. Majority of farmers 54.77% are young owing to age group up to 40 years as compared to other age groups in all categorized farmers as highlighted in table 1. In farming experience, majority of farmers 46.98% in all categorized farmer groups having the experience up to 20 years whereas limited farmers 20.85% have farming experience above 30 years. In off-farm income scenario majority of farmers have off-farm income up to PKR200, 000 while limited farmer 28.39% have off-farm income more than PKR 400,000.

[Table 1]

3.1 Farmer's perception of risk

3.1.1 Heavy rains and floods risk perception

Farmer's heavy rains risk perceptions have illustrated in two scenarios low risk perception of heavy rains and high risk perceptions of heavy rains. In total sample size majority of farmers 81.12% have heavy rains high risk perception whereas the limited number of farmers 18.88% has low heavy rains risks in the study area. In categorized groups of farmers, small and medium farmers group were more vulnerable to heavy rains so majority small 82.74% and medium 80.56% farmers indicated the higher risk perception of heavy rains rather than large farmers group. Such scenario was empirically proved as heavy rains caused destruction of their crops and other resources in 2010 and onward. In large farmers group almost 23.44% farmers consider heavy rains as low risk for their crops and other resources. The value of Chi-square 1percent confidence level highlights heavy rain risk perception of various farmers not alike.

[Table 2]

Farmers agricultural risk management decisions are significantly influenced by farmers risk perception of climate hazards. Large, medium and small are three groups in which farmers to be categorized. In the scenario of farmers total sample size majority of farmer 74.37% have high risk perception of flood disasters whereas almost ¼ of farmers 25.63% do not consider the flood as major risk to their crops and fields (Khan et al., 2020). Majority in all categorized farmers groups small (73.89%), medium (76.85%) and large farmer (71.87%) have higher risk perception of flood whereas the limited small (26.11%) medium (23.15%) and large (28.13%) group farmer have lower risk perception of flood hazards in this study area. These results are alike by way of the studies of Rana and Routray (2016) and Rizwan et al., (2020) as indicated due poor infrastructure, limited resources and inadequate adaption measures flood prone areas of Punjab province are higher vulnerable to flood disasters. The value of Chi-square less than1percent confidence level highlights differences in risk perception of farmers of flood as an exogenous factor. Majority of farmers perceived higher perception risk about flood whereas somewhat dissimilar.

Floods are considered most destructive natural hazards in the scenario of economic losses and human fatalities (Ali, 2007) rather than other natural hazards that is why farmers highlighted perception of high risk about heavy rains and floods (Qasim et al., 2015; Khan et al., 2010; Deen, 2015). Massive destruction and heavy losses of agriculture more specifically in flood prone areas in floods of 2010, 2011 and 2014 generated higher perception of heavy rains and flood risks (Ahmad et al., 2019; Saqib et al., 2016).

3.2 Risk attitude

In obtaining the first and second derivative the value of coefficient aversion was calculated. Farmer in the study area were categorized in three groups large, medium and small according to their land holding size and their risk attitude are compared in categorized groups as indicated in table 3. In large farmers group almost 2/3 farmers 67.19% are risk averse whereas 1/3 farmers 32.81% are risk lover. Limited numbers 14.8% of farmers in medium farmers group are risk lover while majority 85.2% is risk averse. In small farmers group majority farmers 71.68% are risk averse and small numbers 28.32% are risk lover. In overall scenario majority of farmers in all groups are risk averse 74.62% as compared to risk lovers 25.38% whereas medium farmers group among all groups higher risk averse relatively to small and large farmers. Farmer’s group differences were at 1 percent level of significance. These findings of risk attitude regarding risk averse are consistent to research work of Ullah et al., (2015), Kitonyoh, (2015), Ahmad et al., (2019) and Iqbal et al., (2016).

[Table 3]

3.3 Tools of risk management

Diversification, reduction of consumption and depletion of assets are some management decisions and three commonly and significantly tools used for risk management strategies also employed in this study. In district scenario, 65% farmers in Rahim Yar Khan and 53% in Muzaffargarh district are using the practices of diversification as indicated in figure 4. In Muzaffargarh 74% and 69% in Rahim Yar Khan farmers are engaged with practices about reduction of consumption strategies. Regarding the depletion of assets 68% farmers in Muzaffargarh and 61% in Rahim Yar Khan are using this practice for risk management. In overall scenario regarding risk management tools adoption decisions in both districts, reduction of consumption 71.5% indicated the more practised tool in districts rather than diversification 59% and depletion of assets 64.5% as indicated in figure 4.

[Figure 4]

Risk management strategies adopted among categorized large, medium and small farming groups illustrated in figure 5. Majority of small farmers more preferably engaged with practices the reduction of consumption 54.29% and depletion of assets 47.56% rather than large (21.85%, 23.86%) and medium farmers (20.46%, 31.98%). Large farmers group more preferably engaged with diversification tools (43.76%) rather than medium (29.49%) and small (26.75) farmers. All categorized farmers groups are more or less engaged in all risk management practices as illustrated in figure 5.

[Figure 5]

3.3.1 Risk management decision correlation

Farmers risk management tools application decisions correlation illustrated in the table 4. In multivariate models equations coefficient correlation is pair wise correlation in error terms. This coefficient correlation is at 99 percent level of significance. These estimates illustrated as correlation in equations and fitness of simultaneous adoption models. This study employed the multivariate probit model and estimated positive sign of model highlights as on the similar instance farmers go away for further management practices.

[Table 4]

3.4 Empirical estimates of multivariate probit model

Multivariate models are used for estimating the adoption and management tools are significantly correlated with each others as illustrated in correlation table 4. Multivariate probit model parameters outcomes indicated the decisions of concurrent adoption risk management as highlighted in table 5.

3.4.1 Factors determine depletion of assets

Farmers in the study area indicated the depletion of assets as one of the significant tool of standard risk management. Estimates of the model indicated as age positively (0.036) and significantly ($p<0.02$) associated with depletion of assets as aged farmers highly deplete their assets rather than young farmers as indicated in table 5. The reason is that young farmers manage their farming risks through working as labor in markets whereas aged farmers cannot participate in such working practices so deplete their assets for managing farming activates. These conclusions are alike the research works of Baas et al., (2008), Yassin, (2011) and Saqib et al., (2021). Results illustrated the negative association in farming experience and depletion of assets showing as experienced farmers rather than depleting assets more prefer to adopt other strategies for managing farming activities as compared to inexperience farmers. These results are alike with the studies of Saqib et al., (2016) and Ullah and Shivakoti, (2014). Estimates of study illustrated the negative link in off-farm income and depletion of assets as highlighting that those farmers having adequate off-farm income do not deplete their assets and manage farming activates through off-farm income. Farmers having limited of no off-farm income deplete their assets for managing farming risks and activities. These results are alike with the study of Dixon et al., (2001) and Saqib et al., (2021). The estimates of model showed positive relationship in depletion of assets and size of landholding as indicating as land size increasing farmers more willing to deplete assets for managing farming activities. The reason is that farmers with increasing land size have to purchase machinery and other inputs to managing additional land farming activates or floods so sell their more liquid assets as home appliances whereas the farmers with small farm size relatively less need of resource so randomly need for resources depletion as compared to large farm size farmers. These finding are contradictory with the studies of Kahan, (2008) and Saqib et al., (2021). In estimates of the study, heavy rains risk perception positive related with depletion of assets indicating as heavy rains causes major losses of crops and structure of farm so for managing these farming activities farmers deplete their assets. These conclusions are alike by the studies of Ullah and Shivakoti, (2014) and Saqib et al., (2021).

[Table 5]

3.4.2 Factors determine reduction of consumption

Reduction of consumption is another risk management strategy as majorly experienced in small farmers also closely linked with farmer's socioeconomic factors as indicated in table 5. Estimates of the model illustrated as positive association in education of farmer and reduction of consumption indicating as increase in farmers education increases reduction in farmer's consumption as due to higher schooling farmers more focus to allocate more resources to risk adaptation measures of farming through reducing the consumption. These conclusions are consistent with the study of Saqib et al., (2021). Results of the study illustrated the positive relationship in off-farm income and reduction in consumption as highlighting the off-farm income increases farmer reduction in consumption increases. The reason is that as farmers off-farm income increase it reduces its consumption and allocates more resources off-farm and in farm practices. These results are alike with the studies of Ullah, (2014) and Saqib et al., (2021) while in dissimilar with the study of Velandia et al., (2009). Results of the study indicated the negative relationship in experience of farming and reduction of consumption for risk management practice, illustrating as experienced farmers more prefer to manage farming risk and activates through adopting other risk management sources rather than reduction in consumption. In other scenario, inexperienced farmers prefer to reduction in consumption for managing farming activates and risks. These conclusions are alike with the research of Adnan et al., (2020) and Saqib et al., (2021). Estimates indicated the positive relationship in farmers risk attitude and reduction in consumption highlighting as farmers becomes more risk averse they prefer to sure more risk management practices for managing farming activites and risk through adopting reduction in consumption. Farmer having risk lover attitude do not prefer to reduction of consumption. These results are similar with research of Saqib et al., (2016) and Ullah et al., (2015).

3.4.3 Factors determining the strategy of diversification

In all categorized farmers group's uncertainty and risk prevails as showed in the empirical estimates significant finding of the study. Estimates of diversification illustrated as farmer's education, age, off-farm income, risk attitude of farmers, heavy rains and flood perception were significantly relationship with diversification as indicated in table 5. Results indicated as negative link of farmer's age and diversification indicating as age increase farmers become less prefer to adoption of diversification. These estimates indicated as aged farmers less prefer to adoption of risks management farming rather than young farmers as such conclusions are alike with the research of Deressa et al., (2010), Ashfaq et al., (2008), Dadzie and Acquah et al., (2012), Mesfin et al., (2011), Rehima et al., (2013), Jensen and Pope, (2014) and Mashi et al., (2020). Estimates indicated as among categorized farmers groups large farmer are higher adopting the diversifications because they are higher risk averse rather than small and medium farmers as finding consistent with the study of Saqib et al., (2021). Results indicated as positive and significant relationship in diversification and heavy rains risk perception and floods. Majority of farmers have more heavy rains risk perception and flood highlighting farmers more adopting diversification more risk averse and more prefer risk management measures. These findings are alike with the studies of Van Winsen, (2014), Zulfiqar et al., (2016) and Mashi et al., (2020).

4. Conclusion and suggestions

Farmers risk perception play significant role in farming decisions in application of risk management strategies. In categorized farmers groups, majority of small farmers believe heavy rains and floods foremost risk to their farming. Risk attitude of farmer estimated in the study illustrated as majority of farmers are risk averse in all categorized groups. Large farmers mostly engaged in adopting diversification tool for risk management whereas small farmer mostly focused to adopting reduction of consumption and depleting assets for risk management. Findings of the study indicated the close relationship in socioeconomic factors and risk management tools depleting assets, reduction of consumption and diversification. All categorized groups of farmers were more exposed to heavy rains and floods while small group farmers were highly exposed due to limited land holding size and more risk averse about these risks. Mainstream study area farmers are higher vulnerable due to heavy rains and floods because of practicing the traditional tools for adaptation to climatic disasters. Flood prone farmers more specifically need to provide crop insurance and low interest formal loans as they can use advance tools to manage these climatic risks. In disaster scenario disaster management authorities need to help these flood prone farmers through early warning information, escape from disaster and rehabilitation after disaster.

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 Contributions

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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Figures

Figure 1

Study districts of Punjab province of Pakistan Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

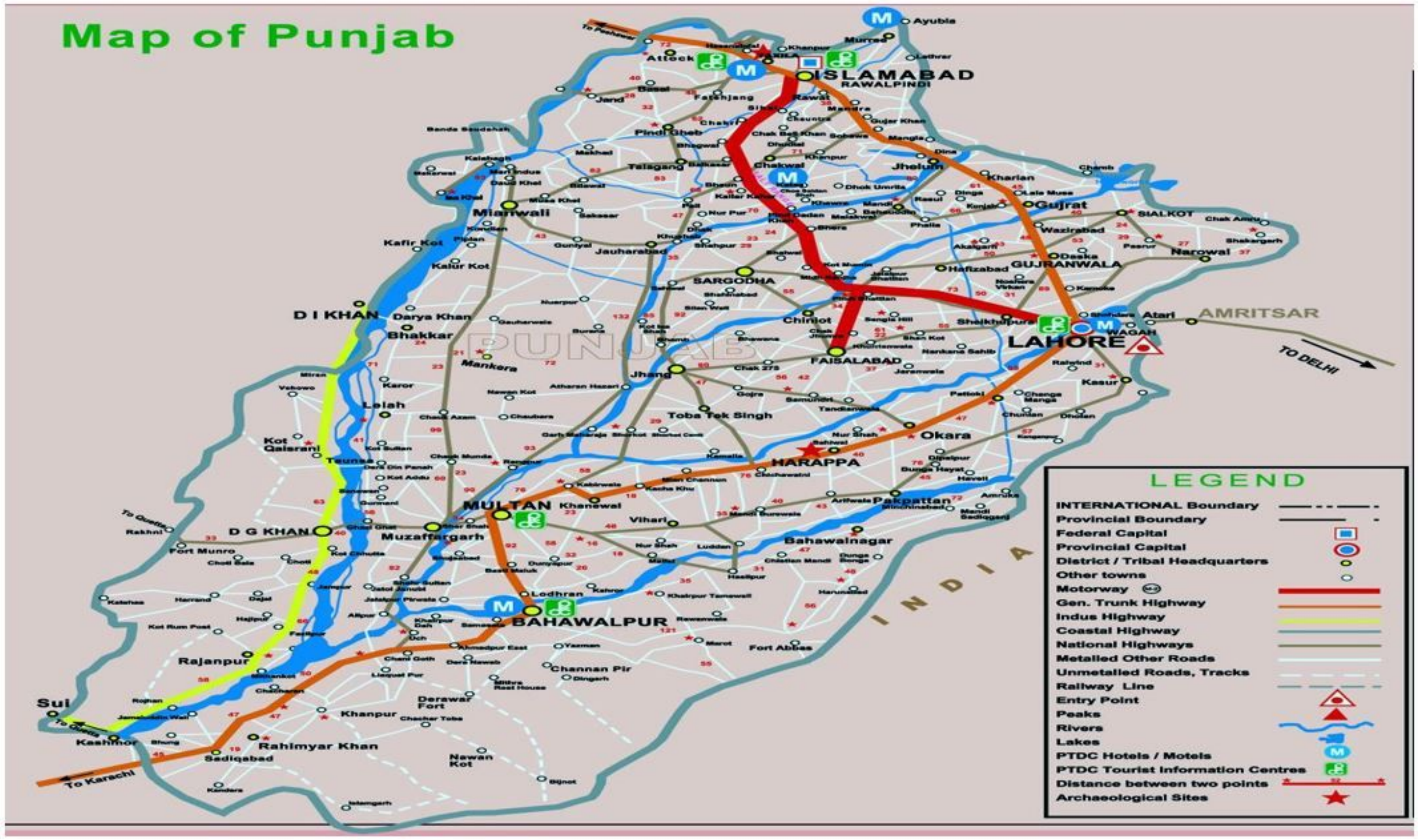

Figure 2

Punjab province and study districts Muzaffargarh and Rahim Yar Khan rivers flows Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

5	6	7	8	9	10
4	5	6	7	High 8	9
Frequency 3	4	5	6	7	8
2	3	4 Low	5	6	7
1	2	3	4	5	6
	1	2	3	4	5
			Severity		

Figure 3

Farmers risk matrix

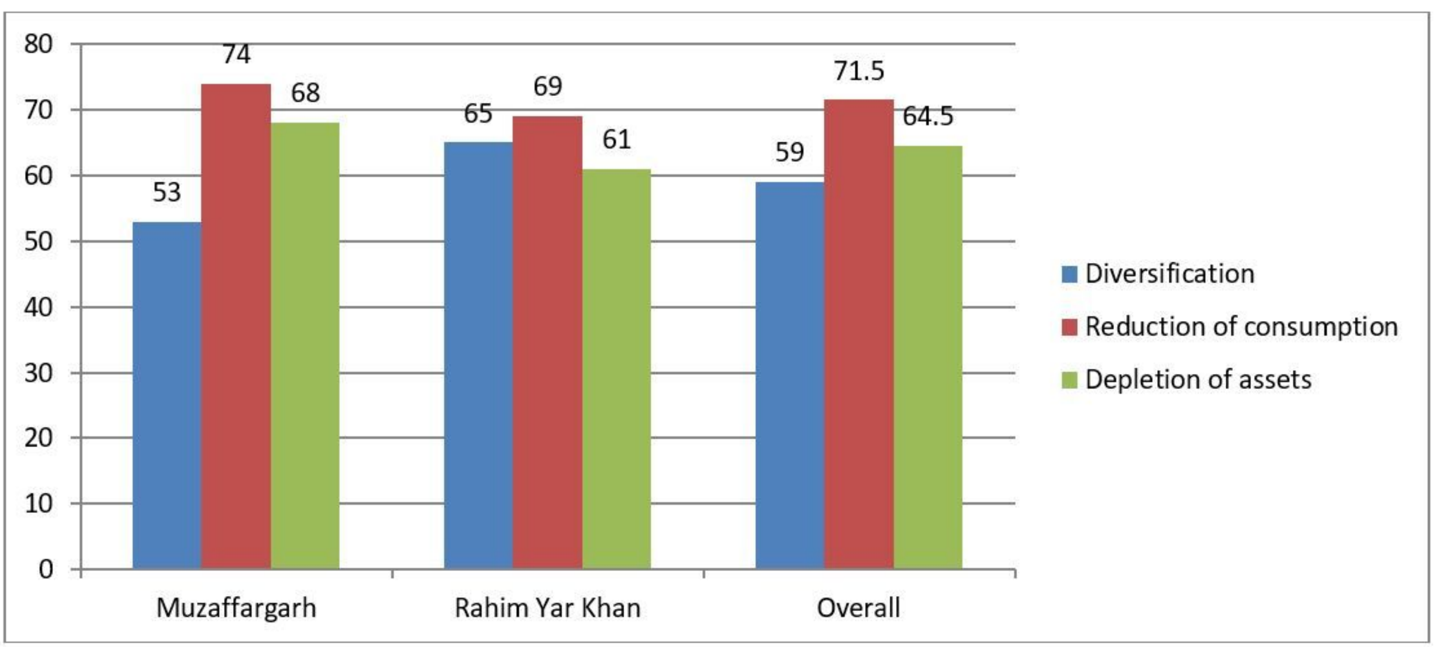

Figure 4

Strategies adopted in both districts Muzaffargarh, Rahim Yar Khan and over all scenario

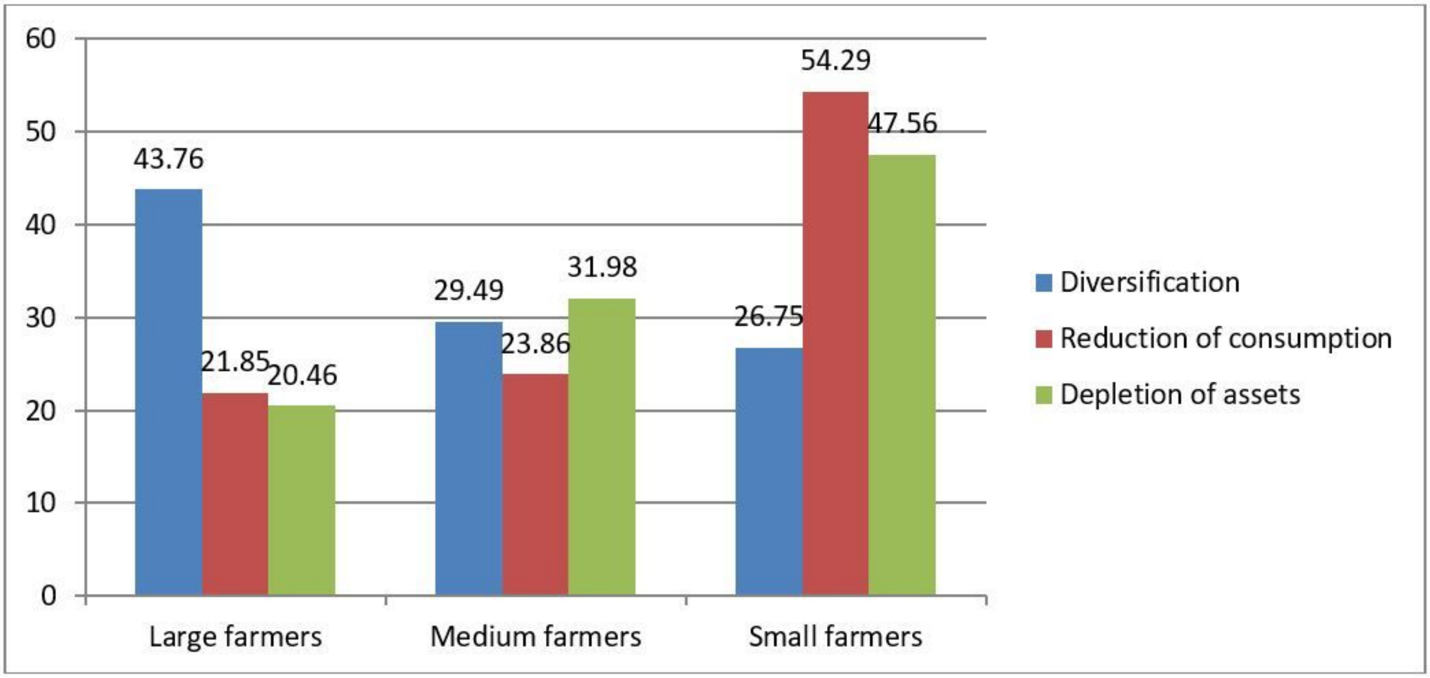

Figure 5

Strategies adopted by categorized farmers groups