Catastrophic Risks Management via Livelihood Diversification From Flood-prone Areas of Punjab, Pakistan

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Abstract

Agricultural lower productivity regardless of significant agricultural policy measures is considered major issue in mostly developing countries like Pakistan. These policies first and foremost focused on-farm development whereas the rich aspect of off-farm diversification is mostly overlooked. In mitigating climate change unpleasant impacts and dipping hunger, small farmers' livelihood diversification performs considerable role. This study aimed to investigate the diversification of livelihood to managing catastrophic risks in rural farmers of Punjab, Pakistan. This research work used the data of 398 flood prone households from two higher risk flood prone districts of Punjab and employed logistic regression model for empirical estimation of the study. In managing catastrophic risks, majority of respondents almost 57% put into practice off-farm diversification of livelihood strategies whereas 44.5% adopted on-farm livelihood diversification strategies. Empirical estimates of logistic model illustrated as demographic, socioeconomic, risk perception and institutional characteristics considerably affect the farmers' preference of diversification of livelihood. Results also highlighted the accessibility of inadequate labour force, poor roads and market infrastructure, be short of credit access, inadequate institutional support, restricted training and skills, limited natural resources and climate uncertainties and risks are some significant constraints in adopting the livelihood diversification in the study area. This research work advocated the necessitate for forcefully adoption the policies of climate change such as getting better services access, focus training initiatives, improved infrastructure and increasing institutional assistance. State based adoption of accurate policy measures and suitable deliberation so as to promote livelihood diversification as a part of enhancing national jobs to get better numerous livelihoods and save lives, as small farmers' livelihood possibly will improve.

Keywords: Agriculture, Farm household, Climate change, Livelihood diversification, Pakistan

1. Introduction

In global scenario, catastrophic risks more specifically the floods, cyclones and droughts are a few significant and consecutive disasters (Ahmad and Afzal, 2020; Ali and Rahut, 2020) during

the current two decades owing to rising incidence of tremendous climatic events (Field et al., 2012; Alam et al., 2019). Risk exposure, geographical locations and lifestyle choices mostly influences natural disasters (Ahmad et al., 2019) and have no limits of geographical, economic, political, cultural and social (Daniell et al., 2016) boundaries of regions, continents and country (Khan et al., 2013; Teo et al., 2018). Generally in the world and more specifically in developing countries higher incidence and rigorousness of these disasters caused severe economic cost and human fatalities (Ahmad and Afzal, 2021; Doocy et al., 2013). In the imminent era of 2050, human fatalities are likely to double owing to these severe disasters (Khan et al., 2013; Wilkinson and Brenes, 2014). Flood disasters commonly are foremost basis of human losses and mostly the causes of social and economic risks (Ahmad et al., 2021). In the upcoming era, flood-prone households are likely to face higher tendency of rising sea level, intense storms, increasing temperature, water logging, prolong drought and severe and repeated flooding (Shukla et al., 2019; Ahmad and Afzal, 2020). Climate change has considerably affected all aspects of human living particularly crop cultivation, managing physical infrastructure and stumble upon environmental diseases (Ahmad and Afzal, 2020) from severe weather of cold or heat and repeated disasters of drought and floods (IPCC[1], 2017).

The 21st century is anticipated the successive rise in climatic changes and foremost risk particularly the developing countries agricultural growth (IPCC, 2014; Abid et al., 2016). Developing countries particularly like Pakistan known as most climate risk affected and vulnerable owing to weak structure and inadequate adaptive capacity (Shah et al., 2018; Barros et al., 2017; Ahmad et al., 2019). According to disaster based events and climate change affected countries from era of 1995 to 2014, Pakistan in world scenario is categorized 5th mostly disaster affected country under to Global Climate Risk Index (Ahmad and Afzal, 2020; Eckstein et al., 2019; Abid et al., 2015) and substantial distinction of rainfall owing to the 2-3◦ anticipated raise of temperature in 2050 (Kreft et al., 2016; Gorst et al., 2018). In the current couple of decades, climate variability and extreme events severely affected rural livelihood and major crops production such as rice, cotton and wheat (Iqbal et al., 2020; Ahmad and Afzal, 2021; Khan et al., 2021). In Pakistan mostly rural population livelihood and living relying on agriculture and

[1] Intergovernmental Panel on Climate Change

more than 60% population lives in rural areas (PBS, 2019) so pliability of agriculture to climate change is the foremost economic growth apprehension (Khan et al., 2020; Iqbal et al., 2020). Provincial and national governments have to endorse anticipatory measures by masses to save from harm their livelihood and lives from these catastrophic risks (Khan et al., 2021).

In spite of urbanization almost 70% global poor's lives in rural areas (Yiridomoh et al., 2020) where their livelihood mounting and becoming unsecure which direct to economic diversification and substantial migration (Ellis, 2000). Generally in global scenario and particularly in developing countries agricultural performance has declined due to climate volatility (Yiridomoh et al., 2020). Rural population earn their income from various sources whereas agriculture stay their leading earning activity and their livelihood durability and sustainability correlated with substantial use of vegetation, climate and soil (Ayers and Huq, 2009; Abid et al., 2015). Livelihood diversification, migration and agriculture intensification are some significant livelihood strategies mostly adopted by rural community (Barrett et al., 2001; Khan et al., 2019). For unfavourable climate change shocks rural household more preferably favour the livelihood diversification at different levels as option of potential adaptation and vulnerability reduction (Kassie et al., 2017). Household diversification illustrated as rural community income strategies by increasing number of activities irrespective of their locations as prominently categorized these livelihood strategies in four types leading to various distribution and returns (Barrett et al., 2001; Alobo Loison, 2015). Firstly, (full time farmers approach) farmers entirely depends on farm income, secondly (strategy of farm worker and farmer) those as wage worker on other farms and work on their own farm, thirdly (farm and non-farm returns) farmers those combine non-farm and farm income lastly (strategy of non-farm, on-farm, off-farm) farmers participate and earn income from adopting all three strategies. In the situation of higher risk agriculture, small categorized farmers comprise no essential assets directly focus toward alternative income sources whereas their participation is normally in high risk activates and low returns (Niehof, 2004; Ahmad et al., 2019). Livelihood diversification closely associated with both distress and survival under worsening conditions and livelihood enhancement under unfavourable economic conditions (Barrett et al., 2001; Kassie et al., 2017).

In the scenario of seasonality and catastrophic risks, livelihood diversification is significantly firmed by technical knowledge, cultural and geographical heterogeneity (Ellis, 2000; Eckstein et

al., 2019). Farming community when anticipating risk initiate to measures for substitute livelihood strategies to mitigating these threats. Flood-prone rural households in Pakistan and more specifically in Punjab when repeatedly facing the catastrophic risks such as floods, heavy rains and drought have to turn to alternate earning means.

In literature, numerous studies illustrated in what respect various aspects possibly affects livelihood diversification along with rural farming community in disaster-prone areas. Some studies focused the diversification participation as source of income activities (Barrett et al., 2001; Niehof, 2004; Alobo Loison, 2015; Kassie et al., 2017), a number of studies discussed diversification association as climate change coping mechanism (Agrawal and Perrin, 2009; Mertz et al., 2009; Iqbal et al., 2020; Kangalwe and Lyimo, 2013). In livelihood diversification scenario some significant studies focused the aspect of participation of sources of off-farm income as livelihood diversification (Ullah and Shivakoti, 2014; Babatunde and Qaim, 2009), whereas a number of studies discussed diversification as aspect of on-farm scenario (Finocchio and Esposti, 2008; Ahmad and Afzal, 2020; Nienaber and Slavic, 2013; Mesfin et al., 2011; Bartolini et al., 2014). In global scenario there is limited literature about analyzing the factors that could affect livelihood diversification in flood-prone areas (McNamara and Weiss, 2005; Ahmed, 2012) whereas this aspect in Pakistan while more specifically in flood-prone areas of Punjab which are higher vulnerable to these catastrophic risks like floods not properly addressed according best knowledge of author. In disclosing this research gap this study attempted to address the aspect of catastrophic risks management via livelihood diversification from flood-prone areas of Punjab, Pakistan. Attempting to attain precise aim of this study three research objectives were formulated firstly, recognition the various types of livelihood strategies adopted by farm households secondly, significant feathers give confidence livelihood diversification to rural households lastly, major limitations that confine farming households to adopting livelihood diversification. This study is classified in to five sections as introduction illustrated in section first, conceptual framework indicated in second section while third section detailed the material and methods of the study. Empirical results and discussion are highlighted in section four while conclusion and suggestion are explained in last section of the study.

2. Conceptual framework

The framework of livelihood illustrated in figure 1 which comprises the assets of livelihood and multiple based strategies of livelihood causes to end in higher outcomes of livelihood in scenario of facing specific vulnerability (seasonality, patterns, shocks). Top-down approach employed in this study by climate smart livelihood framework which starts from threats or disasters based mostly from climatic variation. Disasters indirectly or directly more significantly based on climatic threats such as cyclones, drought, floods and other biological (insects, pests, diseases) economic and social hazards (Ahmad and Afzal, 2020; Khan et al., 2021). Manifold income choices are more preferred by the farmers when there observe these threats as harmful to their livelihood. Livelihood strategies as off-farm income (off-farm labour) and on-farm income (livestock, intensification of crop) are some substitute income strategies more preferred by farmers (Ahmad et al., 2020). Farmer's preference in the direction of above stated strategies is linked by different rural households' characteristics like their climatic risk belief (reorganization and perception of livelihood risk) and socioeconomic characteristics. Diversification approach most probably adopted by the farmers those are more conscious of livelihood risk, more trained and more resourceful (Memon et al., 2020; Ahmad and Afzal, 2021). Despite the factors of livelihood diversification there might be definite financial margins, asymmetries of information and constraints of resources that possibly limit rural population capability to pursue different livelihood preferences. Inadequate finance, inadequate information, scarce natural resources, inadequate labour force and limited institutional support are some significant constraints frequently faced by flood-prone households of the study area.

[Figure 1]

3. Material and methods

3.1 Rationalization of study area and geographical feathers

Sindh, Balochistan, Punjab and Khyber Pakhtunkhwa are four provinces of Pakistan whereas Punjab province was chosen for this study owing to some considerable basis. Firstly, Punjab most populated province sharing 53% population and represents 26% area of the country (PBS, 2017). Secondly, Punjab rather than other provinces more vulnerable of catastrophic risks such as some severe drought periods, extreme events of floods, numerous unpredictable monsoon

seasons, disastrous increasing biological risks such as current occurrence of locust insects (PDMA, Punjab 2017; Khan et al., 2021). Thirdly, in Punjab due to consecutive flowing of five rivers throughout the fertile land of province, higher vulnerable for flood hazards (PDMA, Punjab 2017). Fourthly, 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 and farming community of flood-prone area of Indus River, more vulnerable of flood hazards (BOS, 2017; NDMA, 2018). 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 2.

[Figure 2]

In administrative scenario Rahim Yar Khan district is divided in to four tehsils (sub-district in district area) Sadiqabad, Khanpur, Rahim Yar Khan and Liaqatpur (GOP, 2020) with population of 4.81million and area of 11,880 km^2 (PBS, 2017), more vulnerable owing to extreme flood disasters as located on eastern bank of river Indus (PDMA Punjab, 2014). In scenario of extreme and long summer Rahim Yar Khan observed as hot region with average temperature 26.2°C in this area (Pakistan Metrological Department (PMD), 2019). Major proportion of district population (65%) affiliated with agriculture (BOS Punjab, 2019) but for the duration of the recent couple of decades, climate change caused severe issues of excessive flood hazards and farming community confronted with losses of infrastructure, livestock, crops and human fatalities as indicated in figure 3 (PDMA, 2014).

[Figure 3]

Kot addu, Muzaffargarh, Alipur and Jatoi are four tehsils (sub-district in district area) of district Muzaffargarh also including 93 union councils (Pakistan fifth administrative unit and local government second tire) (GOP, 2020) with 4.32 million population and 8249 km^2 area (PBS, 2017). District Muzaffargarh is regarded as higher vulnerable to repeated flood disaster owing to located in critical geographical scenario surrounded side by side two major rivers as Indus flow western side even as Chenab flow eastern side of district (Bureau of Statistics (BOS) Punjab, 2019). Mild winter and hot summer, average rainfall of 127mm with lowest 1°C (30°F) and highest 54°C (129°F) temperature are some significant climatic significances of this area (PMD,

2019). During the recent couple of decades, this district faced recurrent floods and erratic rainfall with the intention of caused leading losses of human fatalities, infrastructure, crops and livestock (PDMA Punjab, 2014) and owing to lowest social progress index and cultural, social and economic dimensions illustrated as lower socioeconomic status district as indicated in figure 3 (BOS Punjab, 2019).

3.2 Sampling technique and data collection

This research work applied the multistage sampling method for data collection as firstly because of higher vulnerability of floods destruction, Punjab among four provinces preferred for the study area (PDMA, 2014). Secondly, southern Punjab region from province specifically focused for this study the reason of higher flood hazards vulnerability and consecutive flooding (BOS Punjab, 2019). Thirdly, out of seven flood affected districts from southern Punjab two severe flood affected and high risk flood hazards vulnerable Rahim Yar Khan and Muzaffargarh districts were selected (PDMA Punjab, 2017; National Disaster Management Authority (NDMA), 2018). Fourthly, two tehsils from each district 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, two villages from each union council were selected based on higher flood destruction and vulnerability according to information provided from local union Nazim (local government head) and sectary as sixteen farmer's respondents from each village were randomly selected and were interviewed as sampling procedure illustrated in figure 4.

[Figure 4]

In data collection procedure, households specify the basic unit while head of household (female/male) consider the major respondents of this study area. In attaining minimum level of sample size, this study used Cochran (1977) sampling technique as illustrated in equation 1. For this study household heads were particularly focused for collection of cross sectional data of 398 respondents, the population of 5% illustrated sufficient (Kotrlik and Higgins, 2001). Sample size in the equation (1) indicated as SS, confidence level elaborated as Z *(± 1.96 at 95%)* for picking points percentage choices as *p*, as decimal explained (0.5 employed required sample size) and value of precision was indicated as e(0.07 = ± 7).

$$Sample\ Size = \frac{Z^2(p)(1-p)}{e^2} \quad (1)$$

In data collection, direct respondents were contacted and well developed questionnaire applied as data collected from February to May 2019. For sufficiency and accurateness of information and steer clear of doubt, questionnaire was applied for pilot study and pre-tested by 20 respondents, former to appropriate survey in these two study areas. Five trained enumerators and author himself corrected and make clear all related matters about questionnaire prior starting the survey in the study area. In data collection, all respondents were obviously well-versed regarding the purpose and use of data and those respondents hesitated to sharing their information was replaced to others.

3.3 Modelling analysis

This study employed the logistic regression model to investigate the factors that affects the livelihood diversification due to different catastrophic risks. In view of the binary dependent variable nature, empirical estimation is able to concede out employing probit/logit model or Linear Probability Model (LPM) based on strengthens of assumptions. Easier interpretation of estimated coefficients of LPM is the significant advantage rather than Probit/Logit models whereas some notable disadvantages of LPM are firstly, homoscedasticity assumption can violated by residual effects, secondly marginal impacts of linear variables be able to dependable transversely all rates, lastly likely values be able to go above 1 or 0. LPM weaknesses are tackling with logit and probit models (Ahmad et al., 2020; Khan et al., 2020; Ahmad and Afzal, 2021). In this scenario probit and logit models provides corresponding results, hence model of logistic regression more preferably used for the empirical analysis of this study due to its significance of application in disaster management fields. In this study intended for statistical analysis, version 19 of Statistical Package for Social Sciences (SPSS) programme applied. This model also discussed the disturbance term probability of constant variance and zero mean.

$$\mu \in (0,1) \quad (2)$$

In equation 2 disturbance term is denoted as μ as within the logistic regression model if error term assumption not fulfilled that indicate as Bernoulli distribution is based upon subset of

binomial with denominator binomial as 1. In distribution of Bernoulli logistic regression model mathematical form entered as in below equation 3

$$f(y_i\,;\,\pi_i\,) = \pi y_{ii}\left(1-\pi_{i,}\right)1-y_{i,} \qquad (3)$$

In the above equation the success of probability illustrated as π_i and distribution of Bernoulli indicated as y_i.

$$D = 2\sum_{i=1}^{n} \quad \{y_i \ln(\frac{y_i}{u_i} + \frac{(1-y_i)\ln(1-y_i)}{1-u_i} \qquad (4)$$

For statistics goodness of fit the deviance is used illustrated the difference of twice among the saturated model log-likelihood and log-likelihood. Logistic regression model deviance is illustrated in above equation 4 where deviance is denoted as D and mean is indicated as u_i.

$$\dot{x}_i\,\beta = \ln\left(\frac{ln\mu_i}{1-\mu_i}\right) = \beta_0 \; + \beta_1\,x_1 + \beta_2\,x_2 + \beta_3\,x_3 \ldots\ldots \beta_n\,x_n \qquad (5)$$

In equation 5, linear predicator is indicated as $\dot{x}\beta$, function link as $\ln\left(\frac{ln\mu_i}{1-\mu_i}\right)$ parameters are illustrated as $\beta_0,\beta_1,\beta_2,\beta_3,\beta_n$ whereas coefficients are reported as x_1,x_2,x_3,x_n.

$$\mu_i \; = 1/(1+\exp(-\dot{x}_i\,\beta) = \exp(\dot{x}_i\,\beta)\,/\,(1+\exp(\dot{x}_i\,\beta) \qquad (6)$$

Logistic model each observation μ_i value is calculated in equation 6 where logistic model probability is indicated as μ and this model equation is explained in equation 7 given below.

$$logit(y_i\,) = \ln\left(\frac{p}{1-p}\right) = \alpha + \beta_1\,x_1 + \beta_2\,x_2 \qquad (7)$$

Binary dependent variable represented as y_i in the equation 7 which symbolize livelihoods diversification of households regarding catastrophic risks response both off-farm and on-farm, independent variables (demographic and socioeconomic feathers, risk perception, institutional variables) vector denoted as x_i. References sources of selected variables precisely illustrated in table 1. Identified parameters indicated as β_i, intercept reported as α, in equation logs odd ratio represented as Ln for probability density function calculation.

4. Empirical results and discussion

4.1 Respondent's descriptive statistics

Institutional feathers, perception of risk, demographic and socioeconomic feathers of various study variables and their applied sources are briefly explained in table 1. A number of studies used these variables in their research work with their proper significance regarding the research as illustrated in the table 1 below.

[Table 1]

Descriptive statistics of study variables are briefly explained in table 2, which illustrated 14 independent variables that were quantified and applied in various categories. In socioeconomic feathers, the study statistics explained as in overall sample majority of respondents indicated as male (79%) with sample household's average age of 49.68 years. Households of study area average number of family size consists 7.87 members, having the average schooling of 4.97 years and earning on average PKR 13, 998 per month. In the study area, almost 63% farmers holding their own land with average farm land area of 2.98 hectares, having farming experience of 19.74 years and almost 49% household farmers having membership of cooperate organization. In institutional feathers, 63% households of the study area have extension services access and 41% having credit access for farming practices. Concerning the perception of risk, majority (78%) of farming households in the study area consider floods higher risk to their livelihood rather than heavy rain (34%) and drought (8%) as these results are alike with the studies of Khan et al., (2020) focused the research in Punjab province regarding farm level perception of risk.

[Table 2]

4.2 Household based diversification of livelihood and constraints

Household level or individual based disaster-prone population compact by catastrophic risks depends on well-built social associations, significant information and accessible resources (Shah et al., 2017). Estimates illustrates as household farmers of study area applied both on-farm and off-farm strategies of livelihood to deal with study areas disaster risks. In overall total sample scenario almost 44.50% sample farmers used on-farm whereas 57% applied off-farm diversification livelihood strategies to deal by catastrophic risks in the chosen study areas as

illustrated in figure 5. Agriculture and its connected activates mostly depend climate variation and it's persuade threats which significantly more likely leads to off-farm diversification and not as much of prone to concerned on-farm livelihood choices. Findings of the study further illustrated as farmers of Muzaffargarh more dependent (61%) to off farm livelihood choice rather than Rahim Yar Khan (54%) highlighting the more accessibility to off-farm employment opportunities in population of the study areas. Similar with finding of this survey, in literature some research studies also highlighted farmers employ themselves in off-farm practices to overcome the unfavourable affects reasoned by various catastrophic threats such as heavy rains, drought and floods (Mesfin et al., 2011; Finocchio and Esposti, 2008;Ahmad et al., 2019; Ullah and Shivakoti, 2014; Nienaber and Slavic, 2013; Bartolini et al., 2014).

[Figure 5]

In adoption of livelihood diversification, households of the study area illustrated a number of constraints in overall scenario such as climate uncertainty/risk (27%), limited natural resources (19%), inadequate training/skills (17%), limited institutional support (16%), inadequate credit access (12%), insufficient market access (9%), poor infrastructure (11%), inadequate labor force facility (7%) and limited membership partnership (6%) as highlighted in figure 6. Climate uncertainties and risks are with foremost blocks in livelihood diversification while a substantial fraction of contestants do not diversify their most important basis of livelihood for the reason to they were confronted by these uncertainties. Therefore in diversifying the livelihood of primary sources sample household have inadequate capacity. In comeback to catastrophic risk, households showed the insufficient natural resources a further major constraint in diversification of livelihood. Those households having natural resource inadequacy are mainly vulnerable to climate hazards for the reason that of complexity in take shelters, food and post disaster rehabilitation. Households' majority in the study area is inhabited in neighboring of rivers having severe threats of floods and directly hilted by these frequent floods.

[Figure 6]

Households of study area were access of feeble communication structure rather than other region of country for the reason that these sampled size households were not capable to attain adequate information regarding the development schemes of skill development and activities of livelihood

(Khan et al., 2020; Ahmad et al., 2021). That is the reason that majority of sample households affianced in traditional activities of livelihood (labor work). Such research literature indicated as individuals or heads of households with particular information have additional chances to involve themselves in numerous self employed or rural businesses (Paudel Khatiwada et al., 2017; Ahmad and Afzal, 2020). In the study area, access of credit inadequacy consider another major constrain for sample households of study areas the reason of majority of households have feeble financial status. Consequently, the reason of limited credit access households' livelihood cannot diversify. Some significant research studies illustrated as households more set up new business or more livelihood diversified those having adequate access of credit (Ellis, 2000; Carney, 1998; Brown et al., 2006). Well developed infrastructure play significant role in rural livelihood development (Khatun and Roy, 2012) whereas households reported poor infrastructure another major constraint in the study area, the reason of non-functional markets as farmers were forced to move urban areas for trade their farming goods. Lastly, in limited diversification status of households of study area, inadequate institutional role is another major constraint. In the scenario of catastrophic risk, households of the study areas have indicated as they were not given any institutional support for rising resilience and improving livelihood.

4.3 Estimates of empirical model

4.3.1 Household head gender status

Control, choices and power to usage of available resources are some primary social roles of genders in society regarding various cultures (Khan et al., 2020). The significant and positive coefficient of respondent's gender status on adaption of both on-farm and off-farm strategies of livelihood illustrating that heads of households as male members in this study area have more likelihood of application off-farm and on-farm diversification of livelihood strategies as indicated in table 3. The more significant causes of that social status in Punjab is as firstly a patriarchal society where as compared to women; men have higher freedom to actively participation in all activities of livelihood diversification. Secondly, in these traditional societies women are ignored more specific in financial decisions and just allowed to perform limited participation in society like home management, childcare and domestic chores and not treated uniformly like modern societies. This scenario illustrated the significant role of men as compared

371 to women in diversification of livelihood as these results alike to the studies of Larson et al.,
372 (2015), Mintewab et al., (2010) and Memon et al., (2020).

373 [Table 3]

374 4.3.2 Household head age

375 Estimates illustrated the negative and significant off-farm and negative and insignificant on-farm
376 livelihood diversification coefficient of age of household head that indicated household farm
377 probability of decreasing scenario of household diversification with increasing household age as
378 indicated in table 3. Firstly, the reason could be that aged farmers highly give attention to on-
379 farm practice because they could be liability for generations. Secondly, in Pakistan rural areas
380 population has increased speedy suggestive of majority young farmers take part in agricultural
381 off-farm practices. Through access of some degree of resources, young farmers more encouraged
382 to work by way of inadequate resources to off-farm livelihood diversification for earn adequate
383 income for financing annual expenditures of family as these estimates are in line with the studies
384 of Mishra and El-Osta, (2002), Mesfin et al., (2011) and Ashfaq et al., (2008).

385 4.3.3 Household head monthly income

386 Mixed affect regarding the coefficient income of household head was estimated in the empirical
387 results of the study. Coefficient of income of household indicated the positive and significant
388 associated affect with off-farm whereas negative and insignificant associated affect with on-farm
389 diversification of livelihood as indicated in table 3. Estimates more likely illustrated as
390 households with higher farm income more probable to choose and adopt livelihood
391 diversification in high income off-farm activities as these results are similar with the studies of
392 Ullah and Shivakoti (2014) and Shah et al., (2021).

393 4.3.4 Household head family size

394 In diversification of livelihood, family size plays significant role in ability of household through
395 provision of farm labor (Gebru et al., 2018; Ahmad and Afzal, 2020; Khatun and Roy, 2012).
396 Family size coefficient illustrated the positive and insignificant association with off farm
397 diversification of livelihood while positive and significant association with on farm
398 diversification of livelihood as indicated in table 3. These estimates indicated as more family

members' households are more capable to discover way to diversify their income of farms as these several hands encourage heads of family to adopt both off farm and on farm livelihood diversification. These finding are similar with the study of Shah et al., (2021) and in contrast with the study of Amanor-Boadi, (2013).

4.3.5 Household head and level of education

In livelihood diversification of household there is significant role of education. Education coefficient illustrated insignificant and negative association with on farm livelihood diversification whereas positive and significant association with off farm livelihood diversification as indicated in table 3. These estimates highlighted as higher schooling encourage both form of diversification as higher literate household heads more earning choices of high paid employment and self employed where lower literate or illiterate household heads limited and lower earning option (labor worker) in the study area. These findings are alike with the studies of Kouame, (2010), Deressa et al., (2010) and Shah et al., (2021).

4.3.6 Household head experience of farming

In managing risk through livelihood diversification farmer experience of farming play critical role. Estimates of farming experience illustrated the negative and insignificant association with on-farm whereas positive and significant association with off-farm livelihood diversification as indicated in table 3. These findings indicated as farming experience strongly encourage in adopting the off farm livelihood diversification whereas the limited priority in on-farm diversification of livelihood in dealing with poor climate scenario as these results are similar with the studies of Ullah and Shivakoti (2014) and Ahmad and Afzal, (2020).

4.3.7 Household head and farm size

Farm size has significant role in farmers' adoption of livelihood diversification whereas the farm size estimates of the study indicated positive while insignificant association with on-farm whereas negative and significant association with off-farm livelihood diversification as indicated in table 3. These results highlights as crop production increases with available mechanization and rising the farm size in the same scenario the reason of increase farm size more options of livestock rearing which directly causes to increase the farmers income. Farmers with more land

427 can also rent it and increase income sources as these results are alike with the studies of
428 Fabusoro et al., (2010), Ullah and Shivakoti (2014) and Kassie et al., (2017).

429 4.3.8 Household head status of ownership of land

430 In agricultural productivity scenario, land indicated significant agricultural assets as farmers with
431 holding with larger own lands more confident in using income diversification as of risk
432 associated to climate related natural hazards. In the current scenario, close relationship is linked
433 in livelihood diversification and ownership of land. The coefficient of both off-farm and on-farm
434 is positive while insignificantly related to livelihood diversification and ownership of land. These
435 conclusions are in line with the studies of Ullah and Shivakoti (2014) and Shah et al., (2021) and
436 in contrast with the studies of Javed et al., (2015) and Abid et al., (2015).

437 4.3.9 Household head in access of cooperative membership

438 Village committee, cooperative and group of self-help are some social organization structure
439 which are critical social capital in assessment of livelihood diversification. Membership of these
440 organizations makes stronger their social status and develops access to attaining non-
441 government, government projects and property services (Gebru et al., 2018). Coefficient
442 membership of household head is positive and significantly associated with off-farm
443 diversification whereas positive and insignificant with on farm diversification indicating as
444 membership of household increases it rises the off farm diversification. Entrepreneurial skills
445 and social capital also increases with increasing the membership scenario in farming community
446 as these conclusions are alike with the studies of Gebru et al., (2018), Khatun and Roy, (2012)
447 and Shah et al., (2021).

448 4.3.10 Household head credit access

449 Constraints in adopting livelihood diversification of farmers of the study area are illustrated in
450 the figure 6. Majority of household farmers indicated the access of free credit one of the major
451 constraint in the study area in adopting the preventive measures regarding the climate change
452 natural hazards. In hardship time for attaining rapid contact of resources, credit certainly play
453 significant role whereas in developing country like Pakistan credit access for poor farming
454 community is not so easy. In estimates of the study, the coefficient of credit indicated the

negative and significant association with off-farm where as positive while insignificant with on-farm association with livelihood diversification. These results illustrated as adequate access of credit increases the options of contribute in non-farm income generation practices. These results are similar with the studies of Eneyew and Bekele, (2012) and Sallawu et al., (2016).

4.3.11 Household head extension service access

In developing capability and access of information of farmers in rural areas, extension agents, workers, institutional extension services and programme play significant role in circulating information somewhere severe climate information sources are limited (Khan et al., 2020; Ahmad and Afzal, 2020). In assisting farm level livelihood diversification and adaptation such extreme level climate information play considerable role. Estimates of the study with positive while insignificant with on-farm diversification whereas negative and insignificant with off-farm diversification. These results indicating as limited extension services access of farmers in rural areas just related to agriculture aspect while no adequate information related to climate and weather are shared with farmers for building their capacity and skills to overcome these climate hazards through adopting off-farm livelihood diversification. These conclusions are in line with the studies of Kassie et al., (2017) and Ahmad et al., (2020).

4.3.12 Perceived flooding risk

Livelihoods of farmers are significantly influenced by failure of crops due to erratic heavy rains, drought, floods and uncertainties of climate which frequently reduces agricultural income and discourage in diversification based to on-farm adoption. Estimates of the study in table 3 indicated positive and insignificant coefficient of on-farm diversification whereas positive and significant coefficient of off-farm diversification. These results illustrated as farmers those consider flood risk the reason of climate variation more encouraged to change their livelihood and extend their income sources apart from agriculture. These results are in line with the studies of Barrett et al., (2001), Selvaraju et al., (2006), Gautam and Anderson, (2016) and Ullah and Shivakoti (2014).

4.3.13 Perceived drought risk

The phenomenon of drought for the farmers of the study area and in the scenario of Pakistan is so familiar climate hazard during the current decade and past scenario causing lower level of yearly rainfall and shortening rainy season (Ullah et al., 2018). Estimates of the study area indicated the negative and insignificant coefficient in both off-farm and on-farm diversification illustrating the no significant affect of drought in the study area. These conclusions are in contrast with the studies of Senaka, (1998), Deressa et al., (2010), Ullah and Shivakoti (2014), Abid et al., (2016), Ali and Erenstein, (2017) and Ullah et al., (2018) and similar with the study of Shah et al., (2021).

4.3.14 Perceived heavy rains risk

In Pakistan and more specific to study area, the reason of climate changes farmers frequently confronted with unpredictable heavy rains and higher vulnerable to these risks because of inadequate coping capacity. Rural poor farmers have to face the unbearable loss of losing agricultural land and production due to heavy rains which encourage the farmers to generate income via adopting the off-farm diversification (Ullah et al., 2018; Ahmad and Afzal, 2020; Ali and Erenstein, 2017). Estimates in table 3 illustrated the positive and in signification coefficient of on-farm livelihood diversification whereas positive and significant coefficient via off-farm diversification to livelihood in the study area. These results indicated as heavy rains reduces the farmers income sources and increases losses through losing fertile land, losses of crops and livestock mostly every years specifically in monsoon season and motivate farmers to off-farm diversification. These conclusions are alike with the studies of Ullah and Shivakoti (2014), Abid et al., (2016) and Ullah et al., (2018).

5. Conclusion and suggestions

This research work summarized as farmers in Punjab province have adopted many livelihood strategies to overcoming climate based natural hazards. Results of this study illustrated as farmers in the study area have diverted their labor force to off-farm operations to facilitate households for adequate nutritional needs through increasing earning sources while confronting the issues of crops production shocks, market failure and climatic risk such as drought, floods and heavy rains. Capability in diversification of various sources of income is significant in favor of livelihood of rural poor households for subsistence demand as rural community in contrast to

urban more vulnerable to climate risks. In the scenario of multiple constraints such as inadequate institutional support, restricted skills and trainings, lack of natural resources, conditions of land markets and constraints of labor markets so enhancing off farm sources not a easy task for rural community. Estimates of regression analysis indicated gender status directly related to on-farm and off-farm livelihood diversification highlighting men rather than women more increasing their income sources because women owing to religious and cultural constraints have limited role in agricultural production. In age status, aged farmer in contrast to young ones prefer conventional on-farm earning means whereas young farmers more prefer to generate off-farm income sources to meet adequate household needs. In family size status, large families in contrast to small families have additional labor force more unemployed as more suitable to expand their off-farm income. In efficient diversifying livelihood in rural areas institutional factors as cooperative membership, extension services and credit access play significant role. Farming community in flood prone areas have higher perception and flooding risk as it destroys fertile lands and standing crops.

The study area finding have summarized as diversification strategies at farm level are more prerequisite for institutional, demographic and social factors which significantly influences capacity of rural households in adapting and responding the climate reservations. Some specific recommendations of the study are firstly, in rural areas entrepreneurial skills need to develop through entrepreneurial trainings and providing of low interest sufficient loans earlier than farmers pay particular attention to off-farm activates be going to generate further income. Secondly, more investment in education as more specifically in higher level education that will permit rural families, to turn in to the active in off-farm diversification of livelihood. Lastly, resource restricted and illiterate households need to target by public based policy measures for enhancing their capability to take on in diversification of livelihood.

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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Figures

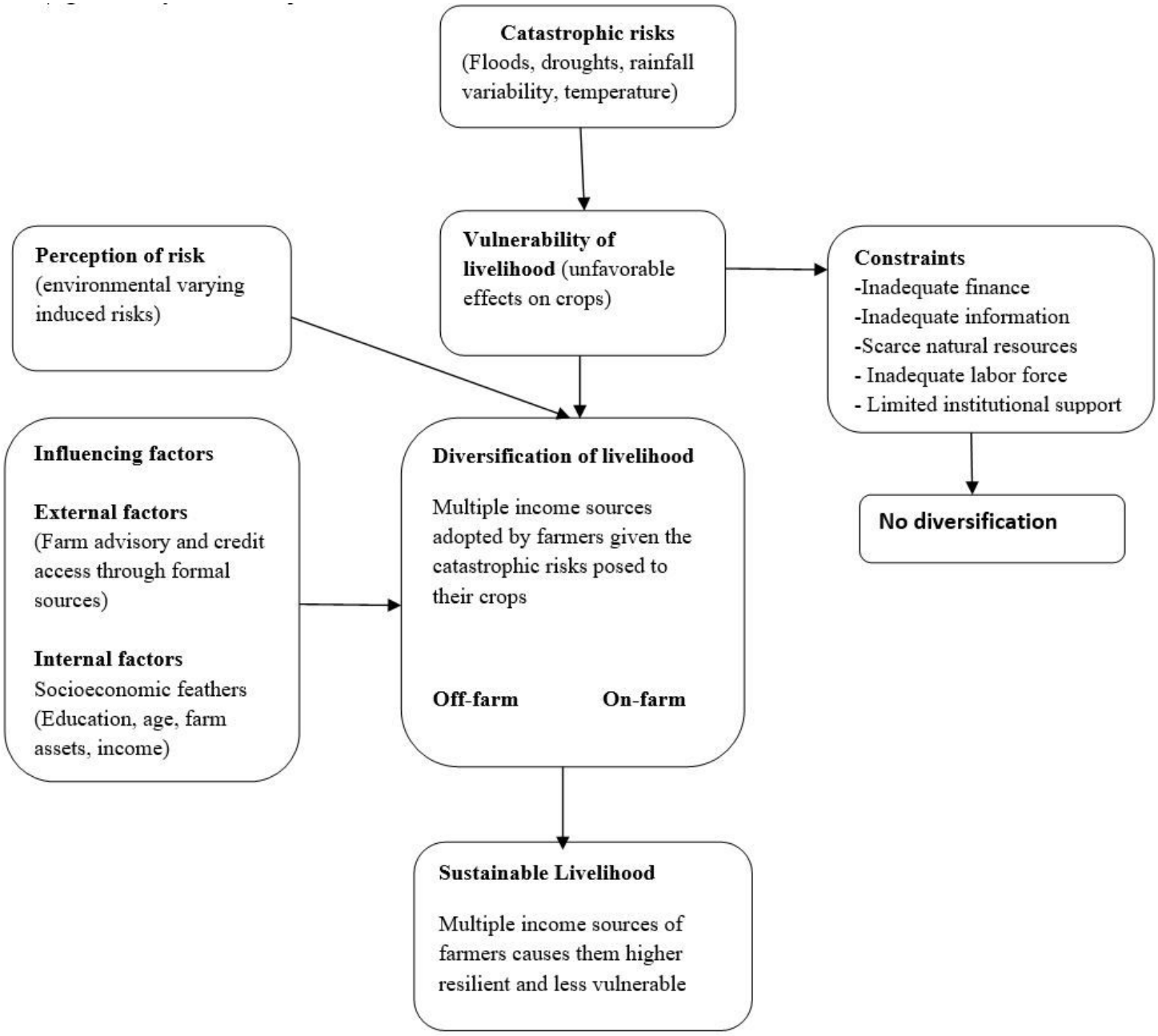

Figure 1

Study based conceptual framework

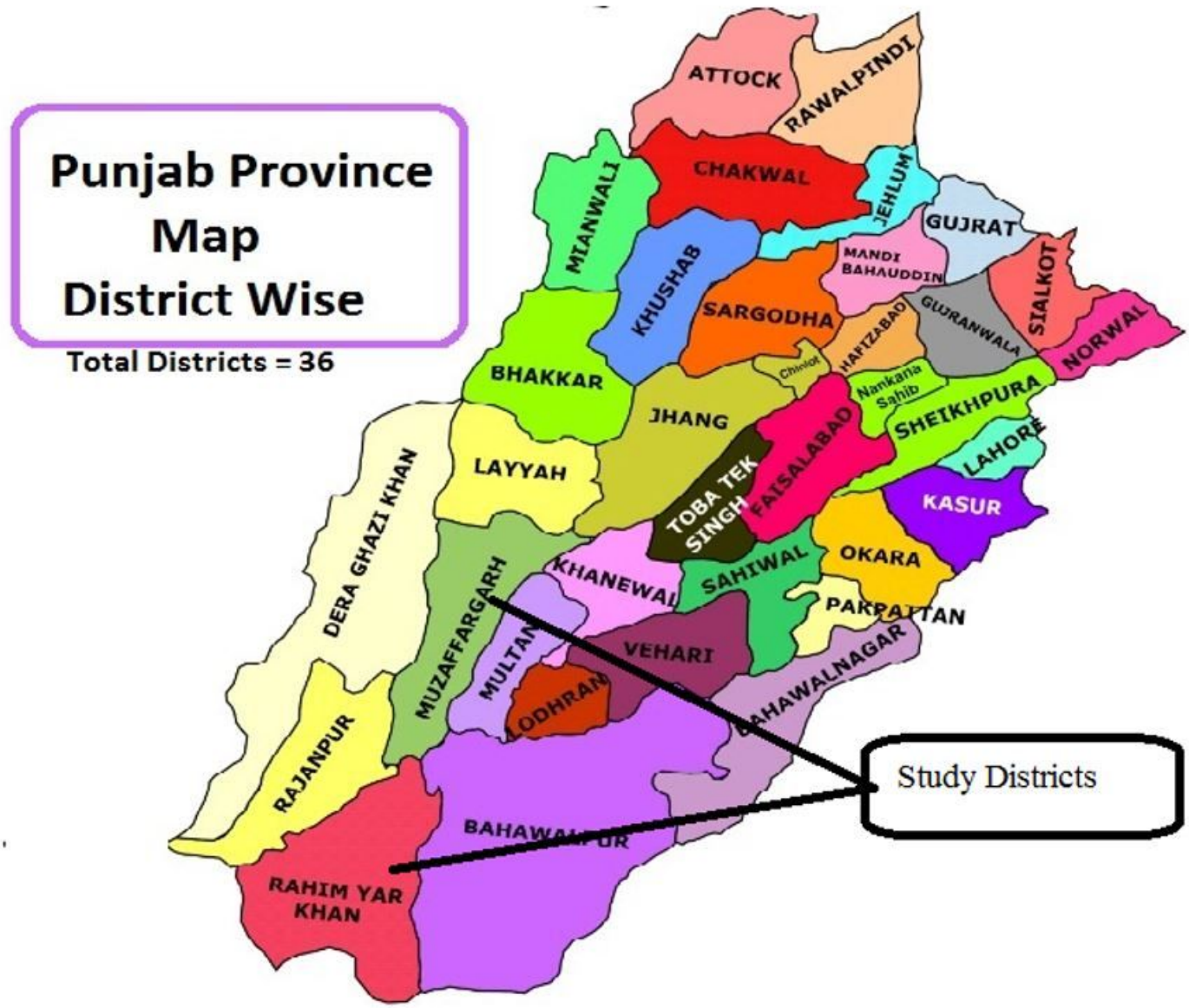

Figure 2

Study area districts of Punjab province Pakistan

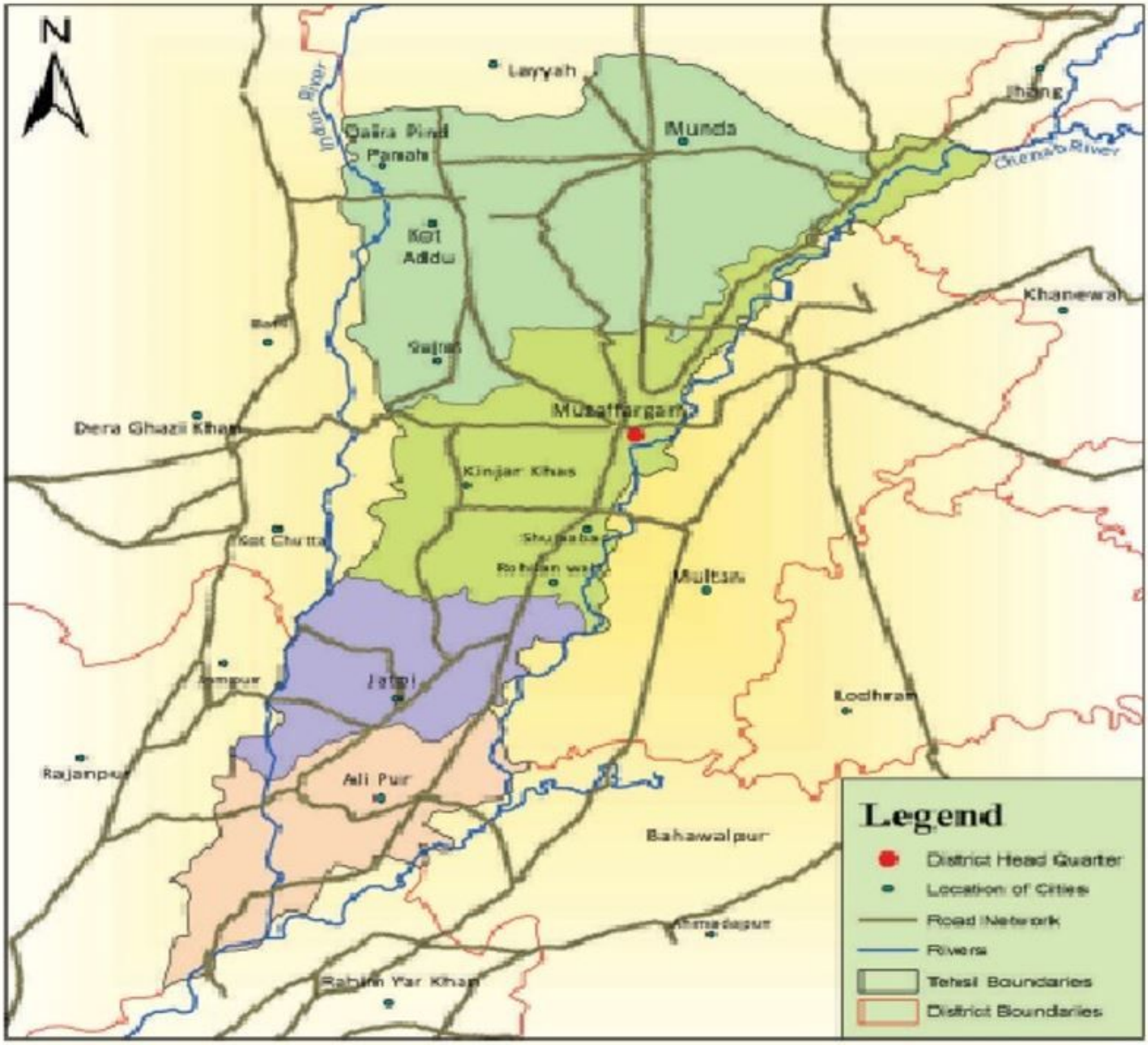

Figure 3

Flowing Rivers from study districts Muzaffargarh and Rahim Yar Khan

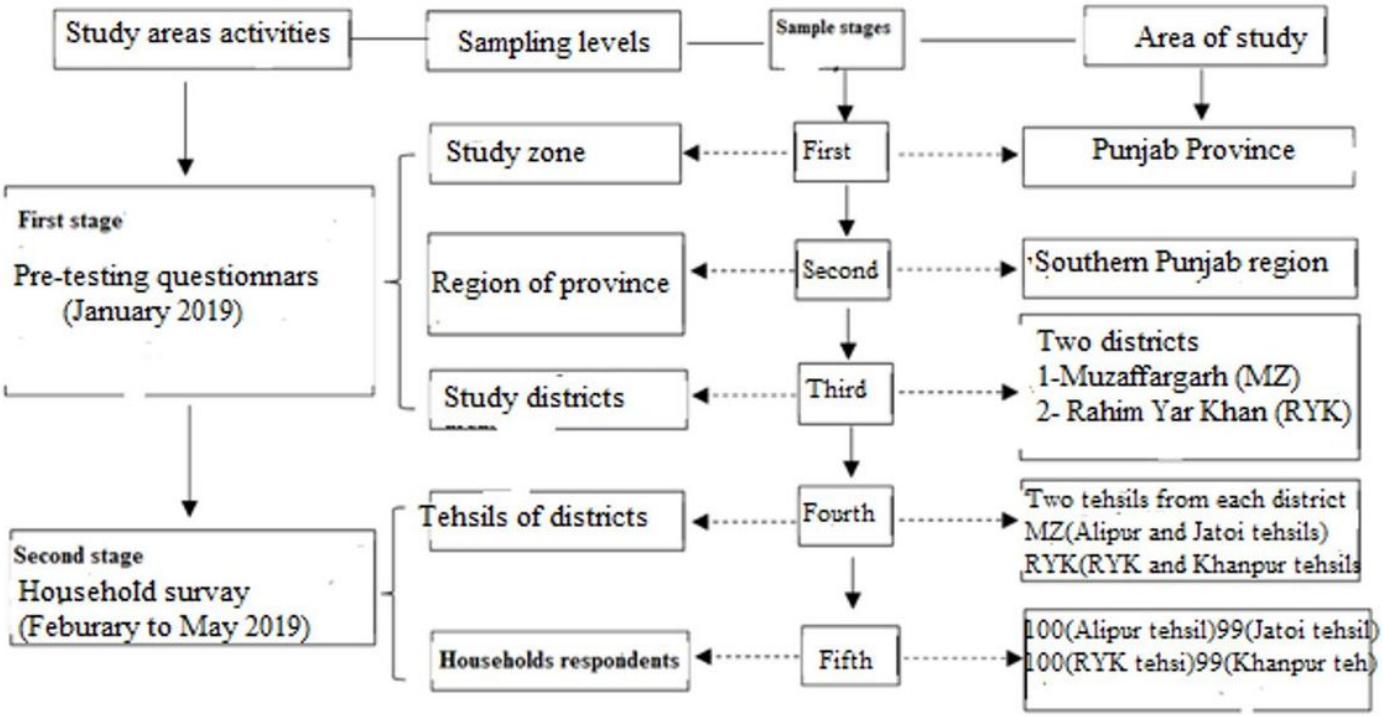

Figure 4

Study area sampling framework

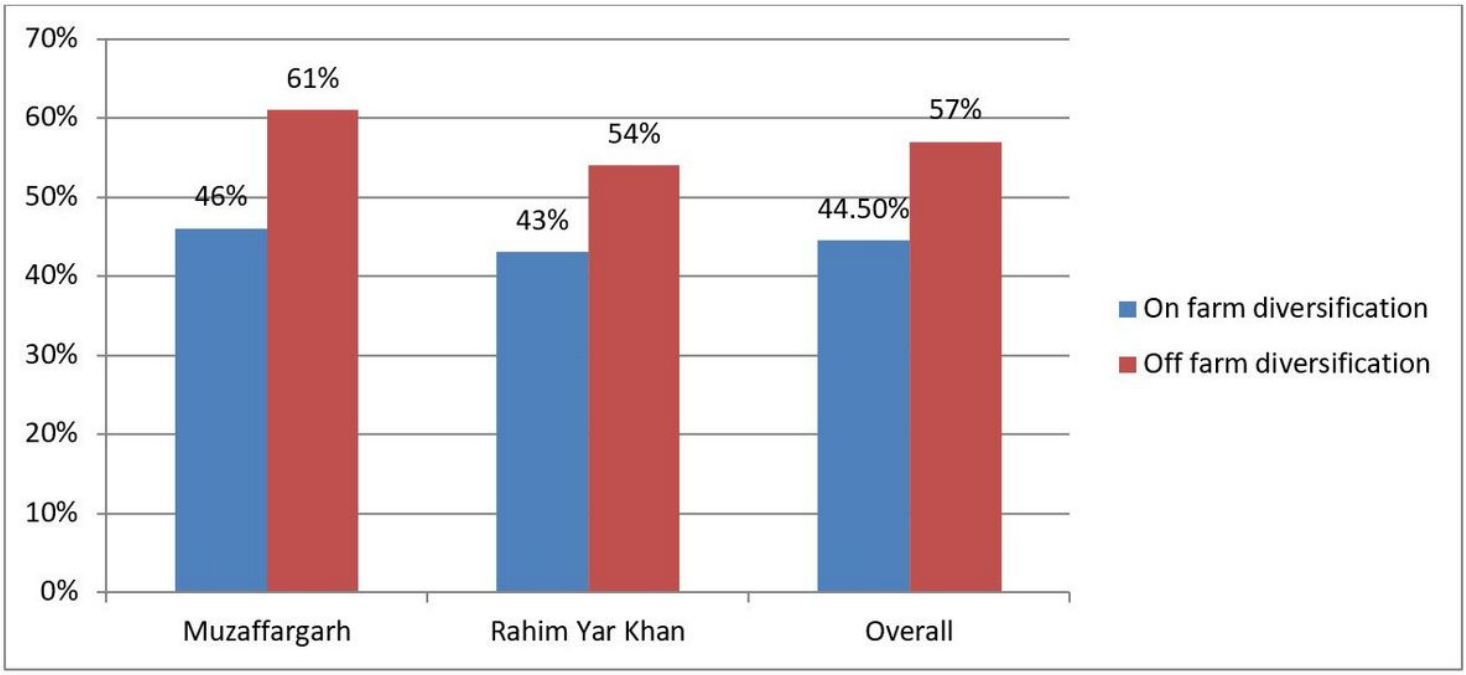

Figure 5

Household level adopted strategies of livelihood diversification

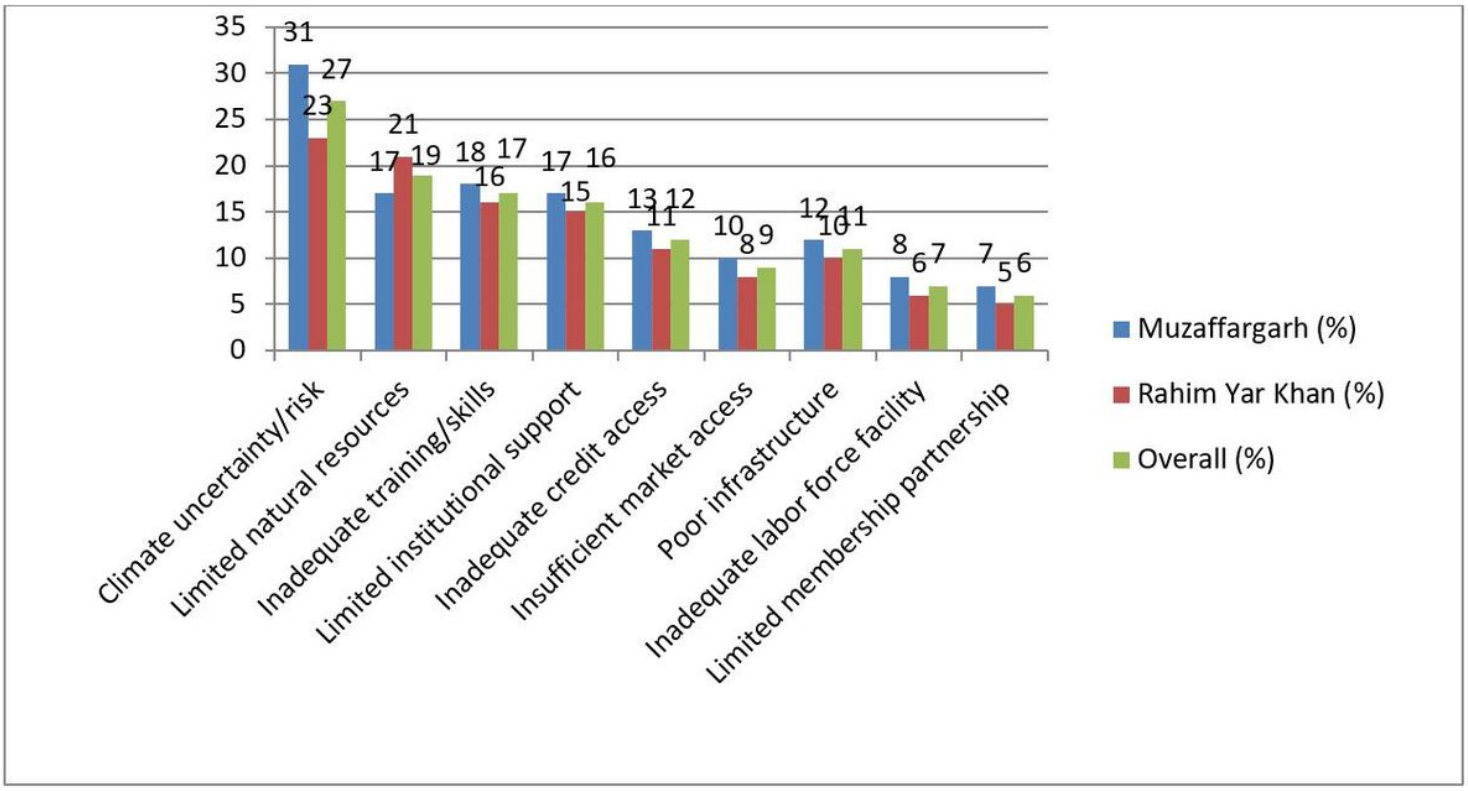

Figure 6

Constraints of livelihood diversification