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RESEARCH ARTICLE

Livelihood diversification in managing catastrophic risks: evidence from flood-disaster regions of Khyber Pakhtunkhwa Province of Pakistan

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Abstract

Pakistan's agricultural productivity is considered to be low despite several agriculture promotion policies. Such policies concentrate primarily on on-farm development and overlook rich prospects for off-farm diversification. Livelihood diversification of small-scale farmers plays a major role in reducing hunger and mitigating the adverse impacts of climate change. Therefore, this paper seeks to analyze livelihood diversification in managing catastrophic risks among rural farm households of Khyber Pakhtunkhwa Province of Pakistan. We have interviewed a total of 600 farm households through a standardized questionnaire in two districts (Nowshera and Charsadda) of Khyber Pakhtunkhwa Province of Pakistan that were badly affected by the 2010 flood. For empirical analysis, a logistic regression model was chosen to analyze the important attributes that are correlated to livelihood diversification of the rural households in flood-susceptible areas of Pakistan. The survey findings indicate that 50% of the total sample respondents adopted off-farm livelihood diversification strategies, while 40.5% of farm households adopted on-farm livelihood diversification strategies in managing catastrophic risks. The logistic regression model results show that attributes including socioeconomic and demographic, institutional, and risk perception significantly influenced households' choices of livelihood diversification. Also, the findings indicated a wide range of livelihood diversification constrained including climatic risks and uncertainties (23%), inadequate natural resources (17%), limited level of skills and training (15%), lack of institutional support (12%), lack of credit facilities (11%), poor infrastructure including markets and roads (16%), and lack of labor availability (4%). The study urges the need for robust climate change adaptation policies, in particular, by aiming at training initiatives, improving access to services, and enhancing institutional assistance, and better infrastructure. The livelihood of small-scale farmers could only improve if the Government pays due consideration and adopts the right policy initiatives that promote the diversification of livelihoods as part of the creation of national jobs to save many lives and improve livelihoods.

Keywords Climate change · Agriculture · On-farm/off-farm livelihood diversification · Farm households · Khyber Pakhtunkhwa · Pakistan

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Introduction

The developing countries have been facing significant climate risks in the twenty-first century, which have posed enormous challenges to agricultural development (Barros et al. 2017). Pakistan is known as one of the most vulnerable and affected countries to climate threats due to insufficient adaptive capacity and weak infrastructure (Abid et al. 2016; Shah et al. 2018a). The temperature is expected to increase in Pakistan by 2–3 °C, with major variations in precipitation by 2050 (Abid et al. 2016; Gorst et al. 2018). Pakistan is ranked 5th among the countries most affected by climate change and events in the period 1995–2014 under the Global Climate Risk Index (GCRI) (Eckstein et al. 2019). In the last two decades, rural livelihoods and production for major crops such as wheat, cotton, and rice have been significantly affected because of extreme events and climate variability (Iqbal et al. 2020; Khan et al. 2021). The experience of flooding between 2010 and 2014 and extreme droughts from 1999 to 2003 indicate that the rural households of Pakistan are vulnerable to changing climate (Abid et al. 2015). The resilience of agriculture to climate change is one of the major economic development concerns in Pakistan since over two-thirds of the country's population lives in rural areas and relying upon agriculture for its living and livelihoods (Khan et al. 2019). The national and provincial governments must thus promote preventive actions by the masses to protect their lives and livelihoods from catastrophic risks.

People in rural areas earn their livelihoods using three main strategies: intensification of agriculture, migration, and diversification of their livelihoods (Barrett et al. 2001a). Livelihood diversification corresponds to the main strategy for rural households that take place at various levels to reduce vulnerability and potential adaptation options for detrimental climate change impacts (Kassie et al. 2017). Some studies have described household diversification as income strategies for rural households where their numbers of activities can be increased irrespective of their locations (Alobo Loison 2015). Alternatively, Barrett et al. (2001b) have identified four distinct rural livelihood strategies leading to different returns and distributions. Some rural households depend entirely on their farm income (the approach of "full-time farmers"), while others combine their own agriculture production on-farm with wage labor on others' farms ("farmers and farm worker's strategy"). The third strategy combines agriculture returns with non-farm returns, while the fourth strategy includes all three main components (on-farm, off-farm, and non-farm). In times of high-risk agriculture, small-scale farmers (without having the necessary assets) can be driven towards alternative income while participating in low returns and often risky off-farm activities (Barrett et al. 2001a). Therefore, diversification is linked to both survival and distress under worsening conditions and enhancements of livelihood under unfavorable economic conditions (Niehof 2004).

Livelihood diversification is greatly determined by the heterogeneity of cultural, geographical, and technical knowledge; the existence of catastrophic risks; and seasonality (Ellis 2000). When people expect a threat, they seek an alternative livelihood strategy to mitigate the risk. In Khyber Pakhtunkhwa, for example, households have to turn to alternate means of earnings, because they face multiple catastrophic threats (including events such as floods, drought, and heavy rain). This implies that households are encouraged to diversify their livelihood to survive, and therefore, it is not a desirable course of action but an adaptation mechanism.

The vast literature is available on how different attributes potentially influence livelihood diversification among rural households in disaster-prone areas. Some of them studied on-farm diversification (Bartolini et al. 2014; Finocchio and Esposti 2008; Mesfin et al. 2011; Nienaber and Slavič 2013), whereas others studied off-farm diversification (Babatunde and Qaim 2009; Ullah and Shivakoti 2014) for households relying on farm-based activities. However, only a few studies analyzed factors that could influence livelihood diversification (Ahmed 2012; McNamara and Weiss 2005). Especially in the case of Pakistan, studies on the determinants of livelihood diversification in disaster-prone zones are very rare. Considering the research gap highlighted, the current empirical study explores the determinants that can cause the diversification of the livelihoods of farm households to cope with catastrophic risks in Pakistan. More precisely, to achieve our set study goals, we formulated three research objectives: (i) identification of the types of farm household livelihood strategies adopted, (ii) the main attributes that encourage the diversification of livelihoods among rural households, and (iii) the key constraints that restrict farm households to diversify livelihoods.

The remainder of this paper is structured as follows. The "Catastrophic risk and rural livelihood: literature review and conceptual framework" section discusses the literature review and conceptual framework. A brief description of the data collection and methodology is presented in the "Materials and methods" section. The "Results and discussion" section deals with the empirical findings, and the "Conclusions and policy implications" section addresses policy consequences arising from the study.

Catastrophic risk and rural livelihood: literature review and conceptual framework

Despite rapid urbanization, more than 70% of the world's poor are still living in rural areas. Rural livelihoods are expanding and becoming unsecured, leading to substantial migration and economic diversification (Ellis 2000; Yiridomoh et al. 2020). Rural inhabitants generate income from numerous asset allocations among different income-

generating activities, of which agriculture remained predominant (Yiridomoh et al. 2020). They mostly participate in primary production, and farming is the predominant one. Such activities are dependent on natural resources. The security and durability of livelihoods of rural people rely on the sustainable use of natural resources system that includes soil, vegetation, and climate. Climate instability has led to a decline in the performance of the agricultural sector and has become a well-accepted fact in most parts of the world, particularly in the Global South (Ayers and Huq 2009). Literature shows that smallholder farmers in rural areas are most likely to experience greater consequences of climate change in developing countries (Mertz et al. 2009). They are vulnerable as their socioeconomic, demographic, and policy patterns hinder their ability to respond to external shocks. Rural areas depend heavily on rainfed agriculture that makes food security and rural livelihoods extremely vulnerable to climate change (Lyimo and Kangalawe 2010). Also, unpredictable precipitation and rising seasonality render rural livelihoods vulnerable, as crop production is very sensitive to climate parameters (Khan et al. 2020a).

Agrawal and Perrin (2009) observed that climate variability and its associated threats undermine rural livelihood in two aspects: reduced livelihood options and randomness in livelihood streams. This implies that climate adaptation remained critical for sustainable rural livelihoods. Rural people have to develop strategies that can help to safeguard their living conditions due to changing climatic conditions. In certain situation, rural communities have indigenous techniques which would mitigate the effects of climate change. Generally, measures to overcome the existing climatic conditions are plausible responses under adverse circumstances and are viewed as short-term solutions for livelihood activities (Iqbal et al. 2020). Livelihood diversification is seen as an adaptation and coping mechanism for climate change (Mertz et al. 2009). The literature shows that rural people have adapted increasingly to collective poolings to deal with and respond to climate variability concerning livelihoods (Agrawal and Perrin 2009). Therefore, communities are collecting resources in times of risk that can help poor or vulnerable people receive loans from village savings schemes that have been helping rural communities over many years. This is required to guarantee the overall well-being of all community members (Kangalawe and Lyimo 2013).

Conceptual framework

The livelihood framework outlined in Fig. 1 shows that the combination of livelihood assets with multiple livelihood strategies would result in higher livelihood outcomes when faced with a particular vulnerability (shocks, patterns, and seasonality). The framework of climate-smart livelihoods, using a top-down strategy, begins from disasters or threats caused mainly by climate change. These disasters could be direct climatic threats such as floods; droughts; cyclones; or other social, economic, or biological hazards (pests, insects/diseases) (Khan et al. 2021; Khan et al. 2020c). Farmers who see these threats as detrimental to their livelihoods prefer to take account of multiple income choices. These alternative income strategies could be on-farm (crop-intensification, livestock) and off-farm livelihood strategies, including off-farm labor (Abid et al. 2015).

The inclination of farmers towards the abovementioned strategies is correlated with various rural household attributes, such as their socioeconomic statuses and climate risk beliefs (perception and recognition of livelihood risks). Farmers who are more resourceful, more trained, and more aware of the risk of livelihoods could take a diversification approach (Memon et al. 2020). In addition to the determinants of livelihood diversification, there may also be certain limitations that could limit rural peoples' ability to follow various livelihood options. These limitations include resource constraints, information asymmetries, and financial limitations.

Materials and methods

Study area and sampling strategy

Geographically, Pakistan is located at 23.35–37.50 North and 60.50–77.50 East, which covers a total area of 881,913 km^2 (https://www.worldatlas.com/as/pk/where-is-pakistan.html) in South Asia (Fig. 2), having more than 210 million population (http://www.pbscensus.gov.pk/). Pakistan shares its border with Iran, Afghanistan, China, and India and has an extensive coastal line that provides access to the Arabian Sea. Due to its unique geographical features, Pakistan is divided into three main regions including the Indus River plains (east), followed by the Balochistan Plateau (center), and the Karakoram Mountains from the north side (https://en.wikipedia.org/wiki/Pakistan#cite_note-17). Pakistan is prone to various catastrophes that undermine its socioeconomic development (Abbas et al. 2015). Since its inception in 1947, the country has been affected by twenty-two severe flood events, countless erratic monsoon rainfalls, several extreme drought periods, and increasingly disastrous biological hazards such as the recent outbreak of the locust insect (Khan et al. 2021). Such catastrophes caused an irretrievable loss of hundreds of human lives, millions of livestock, and thousands of hectares of essential food crops. The flood of 2010 alone caused a loss of more than US$10 billion to Pakistan's economy (Shah et al. 2017). Various studies showed that the Khyber Pakhtunkhwa region is highly susceptible to climate change (Saif-Ur-Rehman and Shaukat 2013; Ullah et al. 2015). The Khyber Pakhtunkhwa is the third-largest province among Pakistan's provinces in terms of economy and

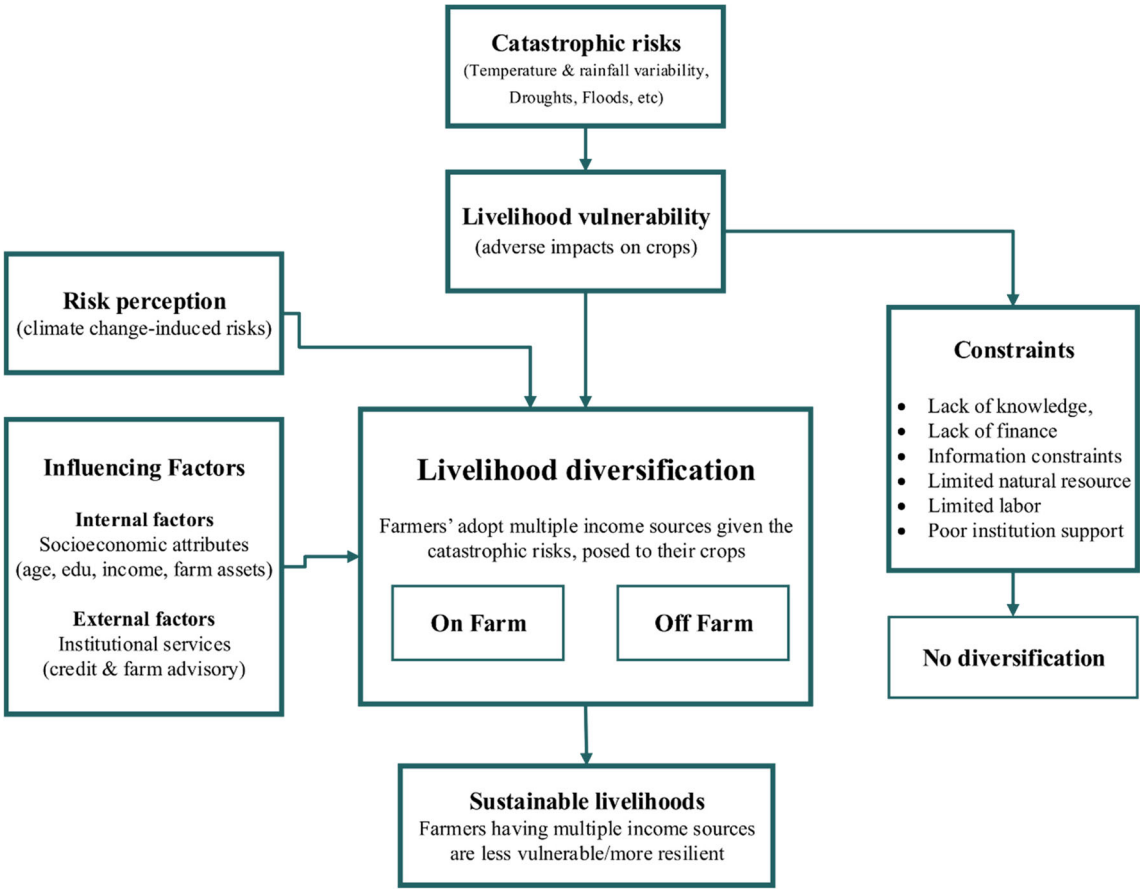

Fig. 1 Conceptual framework of the study (author's own design)

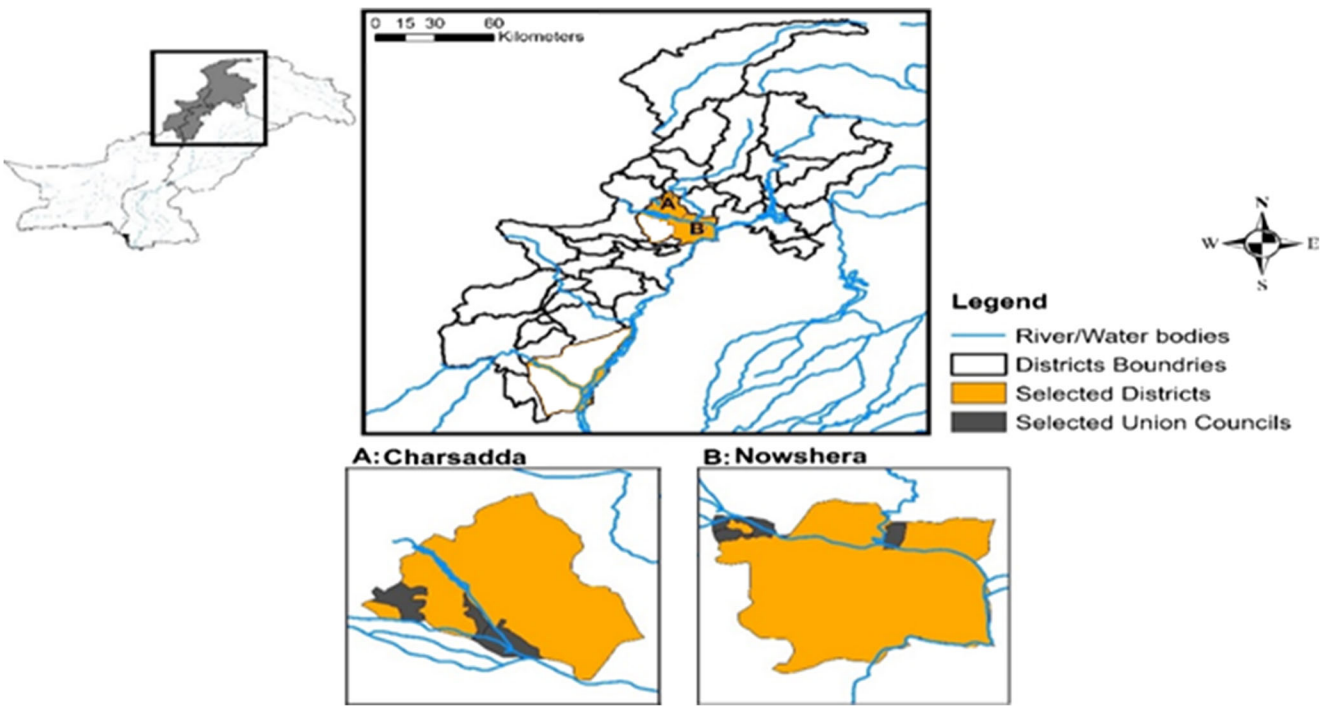

Fig. 2 Study area map

population (Claus et al. 2003). The total share of agriculture in GDP in Khyber Pakhtunkhwa is 22%, whereas agriculture accounts for 44% of the workforce. Most of the people of Khyber Pakhtunkhwa rely on or participate in agriculture, and about 80% of the total population earns a living from agriculture (FAO 2011). The province has experienced significant flooding over the past two decades. The flood in 2010, for example, killed 1985 people, affected millions, and destroyed 17,553 villages spread over 160,000 km^2 (Shah et al. 2017). These alarming stats show that the Khyber Pakhtunkhwa Province needs concrete solutions and policies to reduce the impact of future climate disasters especially on the poor.

Between July and September 2019, the current study investigated how local people respond to catastrophic risks in Khyber Pakhtunkhwa Province. Due to its high vulnerability to catastrophes, Khyber Pakhtunkhwa has been deliberately chosen for the current study (Shah et al. 2020; Shah et al. 2019a; Shah et al. 2019b). The Khyber Pakhtunkhwa Province has approximately 15 million inhabitants with an area of 10.17 million hectares. In the last two decades, eight catastrophic floods have taken place in the province. Flood in 2010 alone affected 24 out of 25 districts (the second highest unit of the local governance system in Pakistan) in the province (Shah et al. 2017; Shah et al. 2018b). After the selection of the Khyber Pakhtunkhwa Province (first stage), we purposively selected two districts: Nowshera and Charsadda (second stage), as they were listed by the Provincial Disaster Management Authority as the most vulnerable districts in the 2010 flood disaster (Saif-Ur-Rehman and Shaukat 2013). The Charsadda region has an area of 996 km^2 with a population of 1.45 million inhabitants which is affected by the floods from the Kabul River regularly. About 71,813 households were severely affected because of unexpected flooding on the Kabul River in 2010. Nowshera District has 1748 km^{2}of surface area, with a population of 1.25 million people, and is also disproportionately vulnerable to the flooding in Kabul River (www.pdma.gov.pk). In the third stage of sampling, three union councils (UCs) were chosen randomly in each district. In the fourth stage of sampling, two villages from each UC were selected randomly by using a list of all affected villages shared by the Khyber Pakhtunkhwa Provincial Disaster Management Authority. In the fifth and last stage of sampling, a total of 50 households were chosen randomly from each sampled village. Overall, 600 household heads were interviewed face-to-face (300 HHs from each district) through a structured questionnaire. Figure 3 shows the sampling stages.

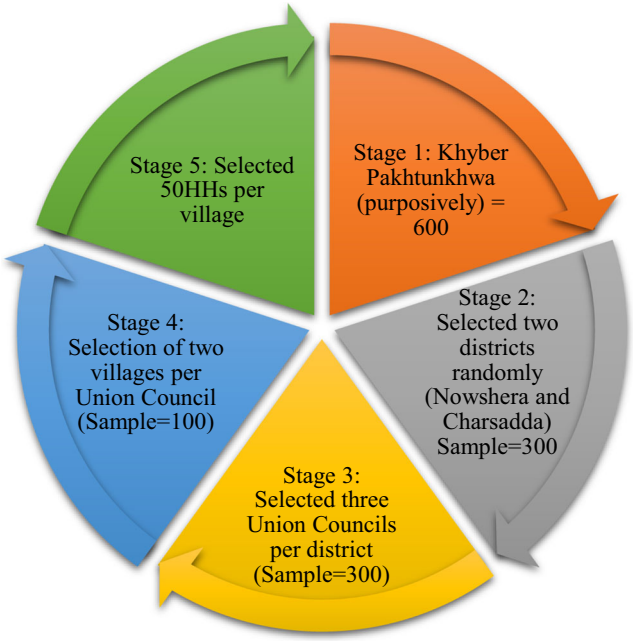

Fig. 3 Sampling framework (authors' construction)

Empirical modeling

In this research, logistic regression was used to explore the elements that affect livelihood diversification in response to various catastrophic risks. Considering the binary nature of the dependent variable, the estimation can be carried out using a linear probability model (LPM) or Logit/Probit model depending on the validity of assumptions. The advantage of LPM is that the interpretation of the estimated coefficients is relatively easier than the Logit or Probit model, while LPM also poses the following disadvantages: (1) expected values can exceed 1 and 0; (2) linear variable marginal impacts can be consistent across all rates; and (3) residual effects can violate homoscedasticity assumptions. The drawbacks of the LPM are dealt with the Probit and Logit models (Khan et al. 2020c). In this case, Logit and Probit models give comparable outcomes, so the logistic regression model was used in the analysis under common practice in the field of disaster management. SPSS program version 19 has been used for statistical analysis. The probability of a disturbance term of zero mean and constant variance is discussed in this model.

$$\mu \in (0, 1) \tag{1}$$

Here, μ is a disturbance term.

If the above assumption of the error term is not met within the logistic regression (LR) model, then the distribution of Bernoulli is based upon the binomial subset with a binomial denominator of 1. In Bernoulli's distribution, the mathematical form of LR can be entered as,

$$f(y_i; \pi_i) = \pi y_{ii}(1-\pi_i)1-y_i \tag{2}$$

where π_i shows the probability of success and y_i is Bernoulli distribution.

The deviance, which can be used as a goodness of fit statistic, is twice the difference between the saturated log-

likelihood and model log-likelihood. For the LR model, the deviance is expressed as,

$$D = 2\sum_{i=1}^{n}\left\{y_i \ln(y_i/u_i) + (1-y_i)\ln((1-y_i)/(1-u_i))\right. \quad (3)$$

where D is the deviance, and u_i is mean,

$$x_i'\beta = \ln(\mu_i/(1-\mu_i)) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n \quad (4)$$

Here, $x_i'\beta$ is linear predictor; $\ln(\mu_i/(1-\mu_i))$ is the link function β_0; β_1, β_2, and β_n are the parameters; and x_1, x_2, and x_n represent the coefficients.

The value of μ_i, for each observation in the logistic model, is calculated as,

$$\mu_i = 1/\left(1+\exp\left(-x_i'\beta\right)\right) = \exp\left(x_i'\beta\right)/\left(1+\exp\left(x_i'\beta\right)\right) \quad (5)$$

Here μ is the probability for the logistic model.

The equation for this model is given as,

$$\text{logit}(Y_i) = \ln\left(\frac{p}{1-p}\right) = \alpha + \beta_1 x_1 + \beta_2 x_2 \quad (6)$$

In this equation, Y_i represents a binary-dependent variable, which symbolizes a household's diversification of livelihoods in response to catastrophic risks, both on-farm and off-farm. X_i is a vector of independent variables (the socioeconomic and demographic characteristics, institutional variables, and the perception of risk). The selected variables with their reference source are given in Table 1, β_i embodies the parameters to be identified, α refers to intercept, and Ln represents odd ratio logs in the equation to calculate a function of probability density.

Table 1 Explanatory variables used in the study

S. no	Variables	Sources
Socioeconomic and demographic attributes		
1	Gender	(Bezabih et al. 2010; Larson et al. 2015)
2	Age	(Ashfaq et al. 2008; Mesfin et al. 2011; Mishra and El-Osta 2002)
3	Off-farm monthly income	(Ullah and Shivakoti 2014)
4	Family size	(Khatun and Roy 2012; Ullah and Shivakoti 2014)
5	Education	(Deressa et al. 2010; Kouamé 2010)
6	Farming experience	(Ullah and Shivakoti 2014)
7	Farm size	(Kassie et al. 2017; Ullah and Shivakoti 2014)
8	Land ownership	(Abid et al. 2015; Ali and Erenstein 2017; Javed et al. 2015)
9	Membership with cooperative	(Ali and Erenstein 2017; Deressa et al. 2010; Gautam and Andersen 2016)
Institutional attributes		
10	Access to credit	(Eneyew and Bekele 2012; Sallawu et al. 2016)
11	Access to extension services	(Barrett et al. 2001a; Khatun and Roy 2012; Lanjouw and Lanjouw 2001; Selvaraju et al. 2006)
Risk perception		
12	Perceived risk of flooding	(Barrett et al. 2001a; Barrett et al. 2001b; Gautam and Andersen 2016; Kaija 2007; Selvaraju et al. 2006; Ullah and Shivakoti 2014)
13	Perceived risk of drought	(Abid et al. 2016; Ali and Erenstein 2017; Deressa et al. 2010; Ullah and Shivakoti 2014)
14	Perceived risk of heavy rains	(Abid et al. 2015; Ullah and Shivakoti 2014)

Source: authors' own elaboration based on literature review

Results and discussion

Descriptive statistics of the respondents

Table 2 displays descriptive statistics of the variables. In this study, 14 independent variables were used and quantified in several categories. The study found that the majority of the sampled respondents were male (comprising 82% of the overall sample size). The average age of the sample household head was 50 years, with an average of 6.5 years of formal education received. The average off-farm income of the household head was 14,992 Rupees per month (~ $94 equivalent), and households consisted of 8 members, on average. In addition, the average household farm size was nearly 3 ha, with 65% of the total sample households owned the land. The average farming experience of the household head was 20 years, and 56% of respondents were cooperative members. Concerning institutional characteristics, 43% of the total sample respondents had access to credit facilities operated by the local government as compared to 65% had access to extension services. Most of those responding to the survey considered the flood risk (73%) followed by the drought (0.07% average) and the danger of heavy rains (20%) as possible threats to their livelihoods. These findings are supported by the survey studies (Khan et al. 2020a; Khan et al. 2020c) conducted in Punjab, a leading agricultural province in the country, reporting similar nature of risk perception at the farm level.

Household livelihood diversification and constraints

In disaster-prone communities, the ability of individuals or households to deal with catastrophic risks depends on

Table 2 Summary of the descriptive statistics

S. no	Variables	Explanation	Mean	SD	Min	Max
Explanatory variables						
Socioeconomic and demographic factors						
1	Gender	1 = male, 0 = female	0.82	0.39		
2	Age	In years	50.21	15.83	21	88
3	Off-farm monthly income	In PKR	14,992	12,357		
4	Family size	Number of individuals in a family	8.01	3.29	2	14
5	Education	In years	6.5	5.80	0	16
6	Farming experience	In years	20.29	10.23	9	44
7	Farm size	In hectare	2.82	2.74		
8	Land ownership	1 = land owned by the HH	0.65	0.48	0	1
9	Membership with cooperative	1 = yes, otherwise = 0	0.56	0.50	0	1
Institutional factors						
10	Access to credit	1 = yes, otherwise = 0	0.43	0.50	0	1
11	Access to extension services	1 = yes, otherwise = 0	0.65	0.48	0	1
Risk perception						
12	Perceived risk of flooding	1 = high, otherwise = 0	0.73	0.48	0	1
13	Perceived risk of drought	1 = high, otherwise = 0	0.07	0.25	0	1
14	Perceived risk of heavy rains	1 = high, otherwise = 0	0.20	0.40	0	1

Source: field survey, July–September 2019

available resources, relevant information, and strong social connections (Daramola et al. 2016; Shah et al. 2017). The study findings reveal that farm households adopted both off-farm and on-farm livelihood strategies to address the disaster risks in the study areas. For instance, 50% of the total sampled households have used off-farm livelihood diversification, whereas 40% have used on-farm livelihood diversification to cope with catastrophic risks in the selected study areas (Fig. 4). More inclination towards the off-farm diversification could be due to many factors, for instance, agriculture and related business are dependent on climatic conditions and induced threats. Therefore, farmers are less likely to be involved in farming-related livelihood options; instead, they choose off-farm income alternatives.

The study findings further highlighted that farmers in the Nowshera District were more reliant (56%) on off-farm livelihood options as compared to those in the Charsadda District (44%), indicating a higher availability of more off-farm employment options among the population of this region. In line with our survey findings, previous studies also found that farm households generally engage themselves in off-farm work to cope with the adverse effects caused by different catastrophic

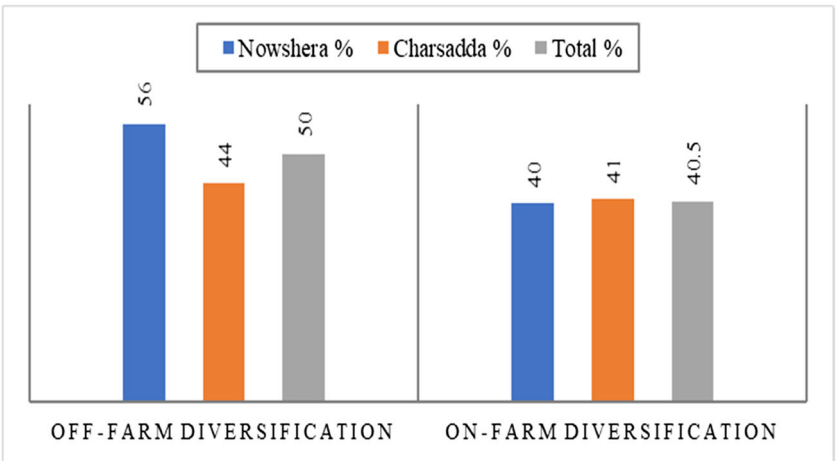

Fig. 4 Livelihood diversification strategies adopted at the household level (source: field survey, July–September 2019

risks including floods, droughts, and heavy rains (Bartolini et al. 2014; Finocchio and Esposti 2008; Mesfin et al. 2011; Nienaber and Slavič 2013; Ullah and Shivakoti 2014).

In the sampled areas, households identified numerous constraints (Fig. 5) to the diversification of livelihoods, including climatic risks and uncertainties (23%), inadequate natural resources (17%), limited level of skills training (15%), lack of institutional support (12%), lack of credit facilities (11%), poor infrastructure including markets and roads (16%), and lack of labor availability (4%). Figure 5 indicates that climate risks and uncertainties are among the major bottlenecks in the diversification of livelihoods as a considerable proportion of the participants did not diversify their main livelihood sources because they were faced with these uncertainties. Thus, the sample households had little scope to diversify their primary sources of livelihood. The inadequate natural resources were further indicated by households as another constraint on livelihood diversification in response to catastrophic risks. The households who have not freely accessed natural resources are the most vulnerable to climatic disasters because of difficulties in obtaining food, collecting other natural resources, and rehabilitation after disasters (Ellis 2000). The majority of households live near the main river and are therefore under great threat of flooding.

Contrary to Pakistan's other regions (Khan et al. 2020b; Khan et al. 2020d), the communication system was weak in the study areas because the sample households were not able to obtain sufficient information about the progress of livelihood activities and skill development programs. That is why most of the sampled respondents were engaged in traditional livelihood activities (e.g., labor work). Literature shows that household heads or members with specialized knowledge have more opportunities to participate in many rural businesses or to be self-employed (Khatun and Roy 2012; Paudel Khatiwada et al. 2017). Moreover, the lack of credit facilities was another significant constraint reported by the sample respondents because most households in the sampled areas had weak financial conditions. As a consequence, their livelihood could not be diversified, as their access to credit was limited. Studies show that household heads with more access to credit tend to diversify their livelihoods or set up a rural business (Brown et al. 2006; Carney 1998; Ellis 2000). Furthermore, a good infrastructure is also an important factor in the development of rural livelihoods (Khatun and Roy 2012). However, unfortunately in our case, the respondents pointed out that poor infrastructure (including markets and roads) was among the key constraint because markets were not functional, and the farm households were forced to go into urban centers to trade goods. Finally, the lack of institutional support was another reported constraint limiting households' ability to livelihood diversification. In response to the catastrophic risks, the respondents pointed out that institutional support was not provided to improve livelihoods and increase resilience.

Empirical model results

Gender of the household head

Gender, in many cultures, defines various social roles in society. These roles relate primarily to power, choice, and control of available resources (Kassie et al. 2017). The coefficient of gender (male = 1) in Table 3 has a positive and significant influence on the adoption of both on-farm (at 10% significance level) and off-farm (at 1% significance level) livelihood strategies, indicating that households headed by the male members have higher odds of adopting on-farm and off-farm livelihood diversification strategies in the study areas. The

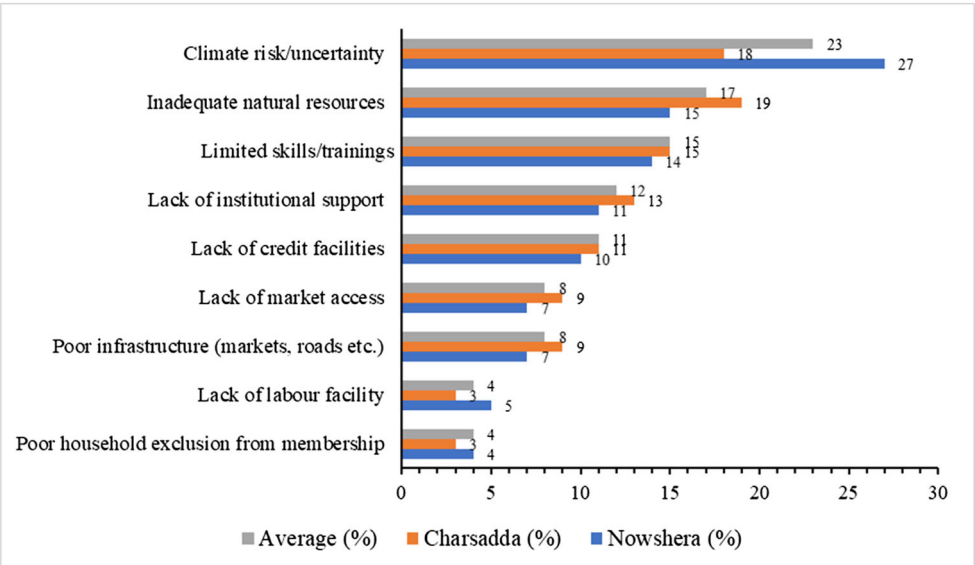

Fig. 5 Livelihood diversification constraints (source: field survey, July–September 2019)

Table 3 Empirical modeling of livelihood diversification

Explanatory variables	Livelihood diversification	
	On-farm diversification	Off-farm diversification
Gender	0.505* (0.284)	0.637** (0.285)
Age	− 0.020^{ns} (0.069)	− 0.012* (0.007)
Off-farm income	− 0.000 (0.000)	0.000** (0.000)
Family size	0.193* (0.103)	0.024^{ns} (0.036)
Education	− 0.027^{ns} (0.119)	0.069*** (0.020)
Farming experience	− 0.011^{ns} (0.011)	0.029** (0.011)
Farm size	0.102^{ns} (0.156)	− 0.099* (0.053)
Land ownership	0.214^{ns} (0.228)	0.203^{ns} (0.229)
Membership with cooperative	0.364^{ns} (0.457)	0.877** (0.327)
Access to credit	0.099^{ns} (0.301)	− 0.585*** (0.102)
Access to extension services	0.519^{ns} (0.731)	− 0.023^{ns} (0.530)
Perceived risk of flooding	− 0.514^{ns} (0.524)	0.686** (0.325)
Perceived risk of drought	− 0.215^{ns} (0.744)	− 0.254^{ns} (0.647)
Perceived risk of heavy rains	0.375^{ns} (0.495)	0.9049* (0.496)
Total observation	600	600
LR_chi^2 (14)	290.57	294.47
Prob > chi^2	0.0000	0.0000
Pseudo R^2	0.3546	0.3996
Log-likelihood	− 264.41763	− 262.17584

ns, insignificant

*10% significance level; **5% significance level; and ***1% significance level

possible reason is that in Khyber Pakhtunkhwa, a patriarchal society, men have strong control over household resources, which is why they have greater freedom to participate in livelihood diversification activities compared to women. Secondly, women household heads in the study areas typically participate in domestic chores, childcare, and home-management practices, which are not financially valued, though these are accredited equally in modern societies. These results are in line with the findings of Larson et al. (2015), Memon et al. (2020), and Bezabih et al. (2010), who concluded that the male household head has a significant effect on livelihood diversification in contrast to the female household head.

Age of household head

The coefficient of household head age indicated an insignificant negative effect on the on-farm livelihood diversification and a significant negative effect on the off-farm livelihood diversification. This implies that an increase in household head age decreases the probability of livelihood diversification by the farm households. Firstly, it could be because old farmers are more likely to concentrate on on-farm practices as they have been doing for generations. Secondly, the rural population has grown rapidly in Pakistan, suggesting that numerous young farmers participate in off-farm agricultural operations. With limited resources, the new young farmers have to work with insufficient resources to diversify (off-farm) livelihoods to earn sufficient income to finance their annual consumption. Our study findings are inconsistent with the findings of other studies (Ashfaq et al. 2008; Mesfin et al. 2011; Mishra and El-Osta 2002) who found that older farm household head tends to adhere to conventional agricultural methods because they have been practicing for decades and cannot properly maintain their fields.

Monthly income of the household head

We further found that the coefficient of farm household head income has a mixed effect. In Table 3, the household head income coefficient indicated a negative effect on the on-farm livelihood diversification, while a clear positive relationship was found to the off-farm livelihood diversification at a 1% significant level. The possible explanation may be that higher income farm household head is more likely to select and diversify their livelihood into high-income off-farm activities. The results of this study support the findings of Ullah and Shivakoti (2014), who found that farmers with higher monthly income have greater chances to invest in the off-farm business because of better off-farm prospects.

Family size of the household head

Family size plays a major role in livelihood diversification as it influences households' ability to provide the farm with labor (Gebru et al. 2018; Khatun and Roy 2012). The coefficient of the family size in Table 3 indicated a positive and significant relationship (at 10% sig. level) with on-farm livelihood diversification while a clear positive but non-significant relationship with the off-farm livelihood diversification. The possible explanation for this may be the fact that households with more family members are better able to find ways to diversify their farm incomes. For example, the larger family size means several hands that encourage the family head to adopt both types of livelihood diversification strategies, since they can stay in traditional agriculture and opt for non-farm activities as well. However, our results differ from Amanor-Boadu (2013), who suggested that the probability of diversification decrease with more than two adults in the household.

Education level of the household head

Education plays an important role in the diversification of household livelihood (Khatun and Roy 2012). The coefficient for education shows a positive relationship with the diversification of off-farm livelihoods, whereas a negative non-significant relationship with the diversification of on-farm livelihoods. This indicates that the education level of the household head determines the decision to adopt both forms of livelihood diversification. For example, the head of households with higher educational standards diversifies their earning options through off-farm (self-employment or paid work, etc.) while the head of households with low educational attainment diversifies through different wage-earning options available in the study areas. The results of the current research work support the findings of Deressa et al. (2010) and Kouamé (2010), who found that investing in higher education could allow households in disaster-prone areas to obtain alternative sources of income and increase the probability of spending more on off-farm activities as a preventive measure to cope with different climatic risks. It is important to recognize that the diversification of farm livelihoods (both on-farm and off-farm) is an important strategy to reduce the chances of a climate-induced catastrophe such as floods and to build up household assets to reduce possible impacts (Herani et al. 2009).

Farming experience of the household head

Farming experience is another critical variable that greatly promotes the decision of the farmer on livelihood diversification to manage risks (Ashfaq et al. 2008). The results of the coefficient of farming experience as shown in Table 3 indicate a significant positive relationship (5% significance level) with the off-farm livelihood diversification and the negative and non-significant relationship with the on-farm livelihood diversification. This indicates that farming experience strongly dissuades the adoption of on-farm livelihood diversification while strongly encouraging farm households to adopt off-farm livelihood diversification to deal with adverse climate conditions. These findings are in line with the results of Ullah and Shivakoti (2014), who concluded that farmers with more farming experience like to diversify their off-farm activities because they have more experience and more skill than farmers with less experience in coping with climate-induced disasters.

Farm size of the household head

The farm size coefficient shown in Table 3 indicates a direct relationship to on-farm diversification, while it has an adverse relationship with off-farm diversification of livelihoods. This implies that the total production of crops increases with increasing cropland sizes at a given level of agriculture technologies. This implies that total agricultural crop production increases at a given level of agricultural technologies as farm sizes (cropland) increase. Moreover, livestock ranchers will raise and grow livestock production and farm incomes as the farm household's land size increases. Farming households would most likely rent additional farmland to other farmers facing agricultural land scarcity, which increases their profits. However, this relationship does not inherently mean that farm productivity increases because rents are usually not tied with the profitability of the crops. Small farmers have often been argued for being more productive than bigger farms. Current survey results are backed by many other studies (Fabusoro et al. 2010; Kassie et al. 2017; Ullah and Shivakoti 2014), which found that when farmers earn enough income to sustain their families from farming activities, they would be less likely to diversify their livelihoods into off-farm.

Land ownership of the household head

Land is the key agricultural asset for productivity. It is widely accepted that farmers with larger properties are usually believed to diversify income from risks linked to climate-driven natural disasters (Abid et al. 2015). There is also a strong association between land ownership and livelihood diversification. The present results in Table 3 show that both types of diversification (on-farm and off-farm) are positively influenced by the land ownership status. However, the relationship is statistically insignificant. Some studies have identified a positive connection between the diversification of livelihoods and land ownership, while others have found a negative relationship (Abid et al. 2015; Javed et al. 2015). Our study results coincide with Ullah and Shivakoti (2014), who found that landowners can decide more quickly than the

tenants (adoption decisions), who are often swayed by landowner's decisions.

Membership with cooperatives of the household head

A structured social organization such as the Self-help Groups (SHG) or cooperatives or village committee constitutes a critical social capital when it comes to assessing the diversification of livelihoods. SHG membership strengthens its social standing and enhances access to the following property services and various government and non-government projects (Khatun and Roy 2012). The coefficient of farm household head membership with the cooperatives leads to an increase in the off-farm livelihood diversification (statistically significant at 5% level). This indicates that sampled households in the developed study region have more diversified livelihoods than those sampled respondents in the backward regions. This is due to the disparity in different attributes (agro-climatic as well as socioeconomic) in location-specific areas. Furthermore, membership in cooperatives would increase the social capital and entrepreneurial skills of farm households to inspire a rise in the rate of participation in livelihood diversification (off-farm). The results of our study coincide with Khatun and Roy (2012) and Gebru et al. (2018), who found that households that are members of cooperatives benefit from income-sharing, credit access, reduction in individual transaction costs, and updated agricultural product market statistics, such as farm equipment and inputs.

Access to the credit of household head

Figure 4 above has listed all the livelihood adoption constraints faced by the farm household heads who participated in this survey. Furthermore, a reasonable number of farm households mentioned that free access to credit facilities is one of the main hindrances faced in adapting to the adverse impacts of climate change. Hence, undoubtedly, access to credit is crucial for poor rural farmers in Pakistan and similar settings because it plays a major role in providing quick access to resources in the time of hardship. The results obtained through regression analysis show that farm household heads' access to credit facilities has an inverse relationship (at a 1% probability level) with off-form livelihood diversification that can provide alternative ways of income generation to farmers of the sampled study areas. Similar to our study, Eneyew and Bekele (2012) had found a significant but negative influence of farm household heads access to available credit facilities to non-farm sectors. Moreover, Sallawu et al. (2016), in a similar study, reported that easy access to credit institutions and their loans are very crucial attributes for farm households' participation in non-farm activities. Our findings suggest that providing better access to credits to marginalized farmers would result in increasing their choices of participating in non-farm income generation activities.

Access to extension services of household head

The literature indicated that extension programs or services are the core element of farmers' institutional support for improving capability and information access (Khan et al. 2021; Khan et al. 2020b). Extension workers or agents in rural areas may play an important role in disseminating information, where extreme weather-related information sources are scarce. Also, an extreme weather information system may assist in the adaptation as well as diversify livelihoods at the farm level. The previous studies conducted by different scholars have found that farmers with more access to the extension services are the ones who consistently diversified their livelihood into non-farm activities (Abid et al. 2015; Adesina et al. 2000; Ali and Erenstein 2017; Nhemachena and Hassan 2007); however, it is not true in our specific case. Farmer's access to extension services was limited and hence could not benefit from their services. The possible explanation could be that extension workers provide farm households only with agricultural extension services, but do not spread weather and climate information to help farmers adapt adequately, help build capacities by improving entrepreneurial skills, and provide knowledge on the starting points to take part in off-farm income, as explained by Kassie et al. (2017) in a study in Ethiopia.

Perceived risk of flooding

Climate uncertainties like floods, drought, and unpredictable heavy rains may lead to crop failure and leave a significant impact on farmer's livelihoods. Such uncertainties discourage the adoption of on-farm diversification and hinder income generated from agricultural activities. Results presented in Table 3 show that the risk of floods for off-farm livelihood diversification is significant at a 5% confidence interval. This implies that farmers who perceive flood risk due to climatic changes are likely to make changes to their livelihood and extend their sources of income to other than agriculture. Other studies (both from Pakistan and other countries) have also shown similar findings where flood significantly affected farmers' livelihood options at the farm level (Barrett et al. 2001a; Gautam and Andersen 2016; Selvaraju et al. 2006; Ullah and Shivakoti 2014). However, off-farm livelihood opportunities available make the copying and/or adaptation task relatively easier for farmers.

Perceived risk of drought

For farmers in Pakistan in general, and specifically in our study area, drought is not a new phenomenon. Farmers can recall several drought periods that occurred in the country and acknowledge that in recent decades, climate has shifted towards lower annual rainfall levels, greater frequency of dry

periods, unpredictable, and shortening of the rainy season (Ullah and Shivakoti 2014; Ullah et al. 2018). Though the risk of the drought was not significant at the three confidence intervals used for analysis in this paper, however, a large volume of literature has proved that drought is still believed to be one of the major threats to overall agricultural productivity, especially in areas with less rainfall (Abid et al. 2016; Ali and Erenstein 2017; Deressa et al. 2010; Senaka 1998; Ullah and Shivakoti 2014; Ullah et al. 2018). Even other studies performed in different parts of Pakistan (Khan et al. 2020a; Khan et al. 2021) have proved that drought is indeed a primary source of concern due to climate change in the dry parts of the country. The insignificant correlation is, in fact, a strange yet important finding of our study, which is suggested to further look into in future research work.

Perceived risk of heavy rains

Unpredictable and heavy rains are a common climate risk for farmers in Pakistan. However, household's low coping capability makes them highly vulnerable to it. The loss of agricultural produce and land due to heavy rainfalls is unbearable for poor rural farmers. Thus, farm households often tend to reduce the impacts of heavy rains by diversifying on and off-farm income sources (Ullah and Shivakoti 2014). Results of the present study (Table 3) depict that the risk of heavy rains has a significant positive relationship with the off-farm livelihood diversification, whereas a non-significant relationship with the on-farm livelihood diversification. Our findings are in line with previous work conducted in Pakistan, reporting that poor rural farmers face severe damages due to heavy rainfalls every year, especially in the monsoon season, i.e., July–September (Abid et al. 2016; Ullah and Shivakoti 2014; Ullah et al. 2018). Due to these rainfalls, standing crops' failure and loss of fertile land and livestock push farmers in Khyber Pakhtunkhwa to seek sources of income other than agriculture. This is probably the reason off-farm income diversification has a 1% chance of happening if there is an increasing risk of heavy rains in the study area.

Conclusions and policy implications

The current research concludes that rural farmers in the Khyber Pakhtunkhwa Province of Pakistan have used various livelihood strategies to respond to climate-induced natural catastrophes. The research findings show that farmers have allocated their labor to off-farm operations to support household food demand by obtaining additional money from other resources in the face of climate shocks such as floods, droughts, inadequate agricultural output, market failures, and price fluctuations. The ability to diversify different income sources is important for the livelihoods of poor rural households because they are more susceptible than urban families to seasonal and risk factors. Farm households must diversify to gain enough to satisfy their food and other subsistence demands. However, growing income sources are not always easy for the rural inhabitants due to labor market constraints; land market conditions; unavailability of natural resources; limited training or skills; lack of institutional support (that could help farm yield improvement and choice of more diversification options for livelihoods); and poor access to credit, extension, and climate risk information. The regression analysis reveals that gender is directly associated with both kinds of livelihood diversification, which means that men are more expanding sources of income than women since women are unable to work in agricultural production due to various cultural and religious barriers.

Further deliberation on cultural challenges is beyond the scope of this study; however, it is an interesting avenue for future research. Similarly, older farmers prefer to concentrate on conventional farming rather than take opportunities to raise their income by participating in other non-farm activities to preserve their livelihood needs. On the other hand, young farmers would more likely to take chances and explore other ways to achieve the annual consumption of their household through the limited resources available to them. The large households would be better suited to expand their income sources, as they would have extra unemployed labor to pursue additional sources of income. Institutional factors such as access to credit, extension personnel, and cooperative membership are considered vital in order to effectively diversify rural livelihoods. The study findings further highlighted that rural farmers are at great risk of flooding and heavy precipitation, as it is destroying standing crops and fertile soil.

The survey concludes that it is important for farm-level diversification strategies to account for the social-demographic and institutional factors that impact rural households' capacity to respond and adapt to climate uncertainties. The study recommends investing in education, especially higher education which would allow rural families to become active in off-farm livelihood diversification. Furthermore, lower interest credit and entrepreneurial skills will need to be addressed through the provision of adequate loans and entrepreneurship training before farmers pursue off-farm activities intending to generate additional income. Finally, there is a need to target uneducated and resource-restricted households through public policy to increase their capacity to engage in livelihood diversification.

Author contribution Ashfaq Ahmad Shah conceived this study, performed data collection and analysis, and wrote the article; Gong Zaiwu supervised the research; Nasir Abbas Khan contributed to the research methodology, and original draft writing; Imran Khan contributed to the literature review; Muhammad Ali contributed to the empirical model; and Syed Asif Ali Naqvi contributed to results and discussion. All authors read and approved the final manuscript.

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

Declarations

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Consent for publication Not applicable

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