



Determining Economic Losses and Factors Influencing Flood, Drought and Earthquake Risk Perception in Disasters-Prone Areas of Punjab, Pakistan

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ARTICLE INFO

Article History:

Received: August 08, 2022

Revised: September 26, 2022

Accepted: September 28, 2022

Available Online: September 30, 2022

Keywords:

Drought

Flood

Disasters

Risk perception

Punjab

Pakistan

JEL Classification Codes:

D81, I24, O13

Funding:

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

Climate-based natural disaster intensity and destruction severity have risen multifold particularly in developing countries owing to an inadequate understanding of disaster risk perception. In using the household data of 398 respondents and the ordered probit model this study focused to investigate the factors influencing flood, drought, and earthquake risk perception in Punjab, Pakistan. In selected study areas, the majority of respondent's likelihood perceived of happening disasters which caused financial losses and severely influenced their livelihood. Disasters-prone-area inhabitants' inadequate understanding of mitigation measures has increased their vulnerability as they have become ineffective to overcome such natural disasters' severe impacts. Empirical estimates of the study indicated as sources of income generating, education level, gender, status, and age of household significantly affect the respondent's risk perception about flood, drought, and earthquake. Females in contrast to male respondents have a limited understanding of mitigation measures and are not as much of capable of controlling disasters as they have become more vulnerable related to disaster effects. In developing the disaster-prone communities' socioeconomic status urgent-based measures are required such as the understanding of the disaster gender-based gap needs to be reduced through better household appreciative vigilance and alleviation of floods, drought, and earthquake disasters.

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1. Introduction

Rising environmental degradation and dynamics in the current era has increased the incidence and sternness of natural adversity namely earthquake, cyclones, landslide, floods, storms and drought (Barrett, Zepeda, Pollack, Munson, & Sih, 2019; Kimaro, Mor, & Toribio, 2018; Lecina-Diaz et al., 2021). These natural hazards are persistently influenced by lifestyle choices, risk exposure and geographical locations (Abbas et al., 2018; Ambelu et al., 2017; Daniell, Lin, Yu, & Chang, 2016; Muricho, Otieno, Oluoch-Kosura, & Jirstrom, 2019) exclusive of the confines of social, political, geographical and cultural margins of countries, communities and continents (Fenta, Hailu, & Hadush, 2019; Kreft, Huber, Wuepper, & Finger, 2021). Recurrent Floods occurrence is a mainly significant cause of human fatalities and usually of social and economic risks (Ambelu et al., 2017; Doocy, Daniels, Murray, & Kirsch, 2013; Mekuyie, Jordaan, & Melka, 2018). In the global aspect and more particularly in the region of South Asia, Pakistan is measured most climate change susceptible country in the region for the reason of dangerous geographical locations and underprivileged natural resources

management (Khan et al., 2020; Kret, Czap, & Pietrucin, 2017; Muricho et al., 2019). In the aspect of regional dynamics of climate change susceptibility and vulnerability severity, Pakistan among most climate change countries as ranked 29th in 2009 while 16th in 2011 and 5th world most vulnerable country in the current era (Eckstein, Künzel, Schäfer, & Winges, 2019; Schilling, Hertig, Trambly, & Scheffran, 2020; Teo, Goonetilleke, Ahankoo, Deilami, & Lawie, 2018).

Pakistan is consistently and incidentally confronted with severe drought and floods each year whereas earthquakes are not the most commonly happening incident in the region (Khan et al., 2020; Mamun et al., 2021). These disasters cause severe losses of millions of human lives, crops, livestock, psychological issues, crisis, migration, seasonal-based food security, destruction of infrastructure and environmental degradation (Ahmad, Afzal, & Rauf, 2021; A. Alam et al., 2018; Haque, Chiang, & Santos, 2019; Sattar & Cheung, 2019). Past backdrop from 1950 to the current era, flood hazards have long-standing major and minor disaster scenarios in Pakistan (Abbas et al., 2018). Intense and repeated flood disasters confronted by the country from 2010 to 2014 the 2010 flood considered mainly overwhelming caused the displacement of 20 million population, damaged houses 1.5 million, fatalities of 1985 people and wipe out 160,000km² residential and cropped areas (Ahmad, Kanwal, & Afzal, 2022; Pakistan, 2018; Rasul, Neupane, Hussain, & Pasakhala, 2021).

Disasters caused fiber, food and animals production reduction (Adu, Kuwornu, Anim-Somuah, & Sasaki, 2018) moved up farming community livelihood vulnerability and insecurity of food for those who depend on agriculture for their continued existence (Paudel et al., 2021; Week & Wizar, 2020; Zhang et al., 2019). Drought considered among the complicated natural hazards emerges with a deficit of rainfall and consequently causes regional losses of agricultural production, water resource loss and energy crisis (Khan et al., 2020; Xu, Yu, Yang, Ji, & Zhang, 2018). From a global perspective and particularly in agro-based developing economies during a couple of decades, several drastic droughts caused a significant decline in agricultural production, deceased livestock and increased the issue of food security (S. Ahmed, 2018; Hoerling et al., 2015; Khan et al., 2020). In Pakistan, over the past decades, several droughts occurred whereas from 1998 to 2002 severe drought was experienced which severely reduced water resources and subsequently influenced the food supply and increased food security issues (N. Ahmed, Thompson, & Glaser, 2019; Khan et al., 2020).

Earthquakes partly occur in Pakistan having a strength of 7.0 which reasons to damage within a radius of 100 km whereas with the aspect of a country size such hazards do not happen frequently (Data, 2021; Pakistan Bureau of Statistics, 2021). In Pakistan, since 1950 earthquakes caused major losses of 83100 human fatalities and the destruction of infrastructure whereas two earthquakes subsequent causes tsunamis which raised resource destruction and human fatalities (Data, 2021). In 2013, one of the strongest earthquakes happened in Kech and Awaran region with a Richter scale of 7.7 with 37-kilometer depth tectonic plates which caused 825 human fatalities (Information, 2021).

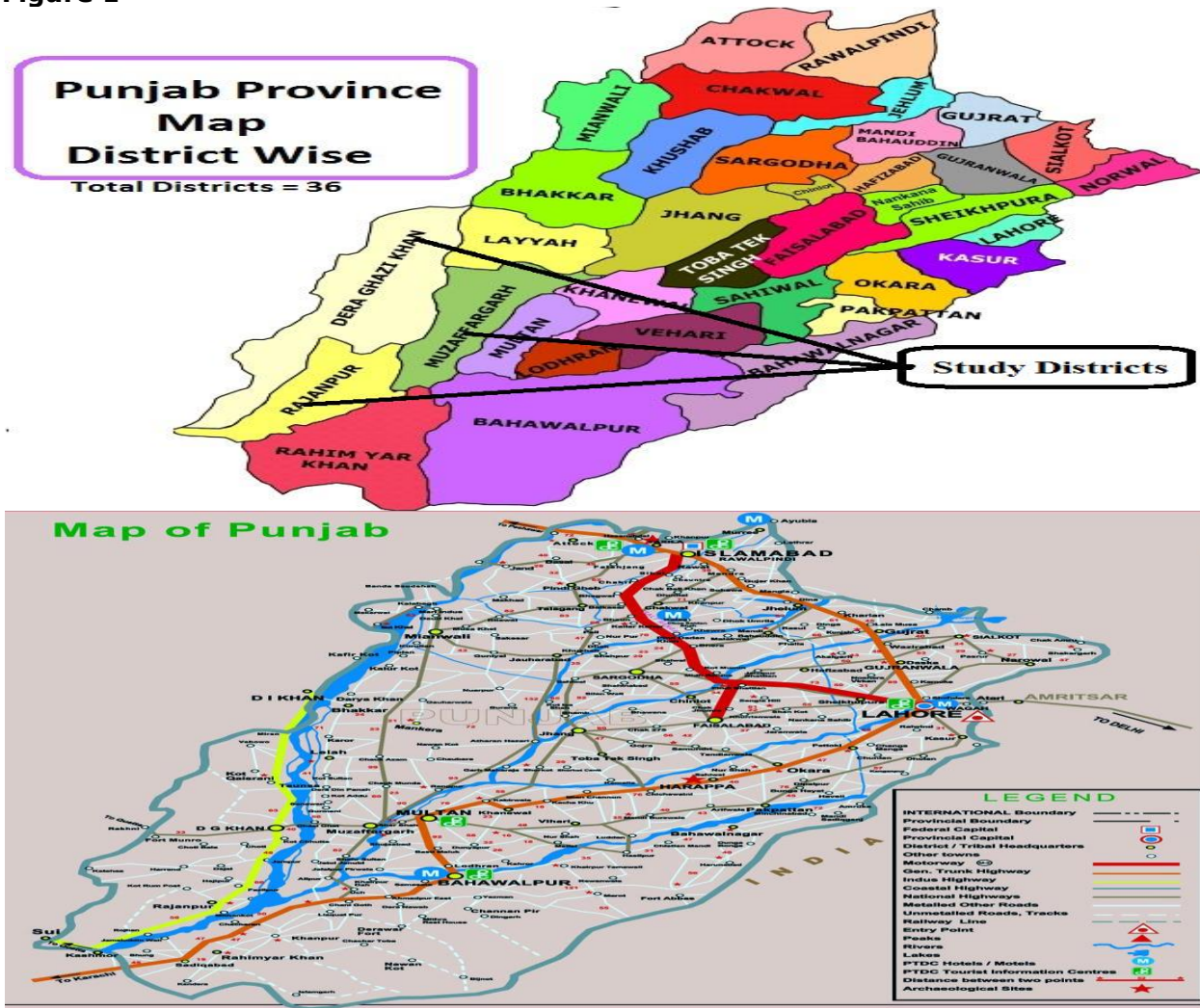
From the literature perspective, local-based and household-level integrated research aspects of risk perception of floods, drought and earthquakes are not properly addressed in Pakistan and particularly in the Punjab region according to the best knowledge of the author. In addressing this research gap this study tried to investigate the household-level risk perception and factors affecting their synchronized risk perception of flood, earthquake and drought in Punjab, Pakistan. In this scenario, the current applied risk management measures were applied on various administrative scales while having no household-level risk perception insight causing the issue of locally based feasible application. To enhance motivation levels among local households regarding the application of disaster risk management measures it is obligatory to identify the factors which motivate them to apply the reproofing measures. In filling up this research gap this study focused on these specific objectives, firstly to recognize the local level of risk perception of floods, earthquakes and drought in the household level of study areas in Punjab, secondly to become aware of the pragmatic and socioeconomic factors influencing the risk perception of households.

2. Data and Methodology

Sindh, Khyber Pakhtunkhwa, Balochistan and Punjab are Pakistan provinces but Punjab is mainly favored for this study for some relevant reasons. First of all, the province of Punjab

reported the country's ¼ area, contributes 53% agricultural GDP and constitutes 52% population (PBS¹, 2021). Secondly, in the context of frequent floods, erratic rains, drought and earthquakes, Punjab province is adversely affected due to massive climatic change (Pakistan, 2020; Punjab, 2019). Thirdly, the region of southern Punjab in the province is particularly favored owing to constantly confronted higher floods, drought and partly earthquake risks and riverbank erosion as situated adjacent to major rivers of the country (Punjab, 2019). Fourthly, this region's farming community higher vulnerable due to being inhabited adjacent to the bank of a major river directly targeted of floods, drought and earthquakes (B. o. Statistics, 2019). Lastly, among severe natural disasters vulnerable districts Rajanpur, Muzaffargarh and Rahim Yar Khan districts according to the higher severity of the issue more preferably selected as indicated in figure 1 (Punjab, 2019; Punjab Board of Statistics, 2020).

Figure 1



Regarding the data collection procedure, the random sampling method was used for this study as firstly, related to the raised vulnerability of floods two tehsils within each district were selected although two union councils were chosen from each tehsil, depending on the hazard severity information given by land record local officer (patwari), agricultural officer and DDMA². Last of all, related to flood hazards vulnerability and destruction from each one union council two villages were selected while interviewed almost sixteen to seventeen respondents from each village. Individuals have an equal chance of selection in random sampling which reduces biases in survey selection. In literature, various sampling approaches are applied while in this research work of Yamane (1967) sampling approach was used as illustrated in equation (1).

¹Pakistan Bureau of Statistics

²District Disaster Management Authority

$$SS = \frac{N}{1 + N(e)^2} \tag{1}$$

In equation 1, SS indicated the sample size, N as the size of the population whereas, e as the precision level. A precision level of 10% and confidence level of 95% as a sample size of 398 respondents was collected by application of random sampling from the research area. In literature, particularly in estimating the hazards disasters risk perception aspect various econometric models such as ordered probit model, multinomial logit model, binary logit model and probit models have been employed in literature (Fadina & Barjolle, 2018; Fernandez, Tun, Okazaki, Zaw, & Kyaw, 2018) whereas the few studies applied the ordered probit model owing to reliable outcomes, calculation of simple statistics and robustness (Gbetibouo, 2009; Ullah, Akhtar, & Zaefarian, 2018). A Likert scale ordered format has benefitted from the ordered probit model as such this model is considered best fitted in ordered data to steer clear of any assumption about the interval data. In the estimation procedure for ordered form data more feasible method is the ordered probit model. Based on such aspects, this research work applied the ordered probit model to investigate the factors influencing the flood, drought and earthquake perception of households as the study model is illustrated in equation 2.

$$Y^* = \beta'x + e \tag{2}$$

In the above equation dependent variable is denoted by Y^* illustrating controllability (CR), mitigation action knowledge (MAK), life equality effects (LEA), financial losses anticipation (FLA), life threat (LT), dread fear (DF) and likelihood perceived (LP). In this equation β showing estimated vector parameters, x as explanatory variable vectors such as disaster experience, type of house, sources of income generating, size of family, income per month, respondents schooling, gender status and age while model error term denoted as e. In this model, the study focused to investigate the factors influencing flood, drought and earthquake risk perception. In this research work ordered probit model was applied which is mostly used in some significant studies.

3. Empirical results of the study

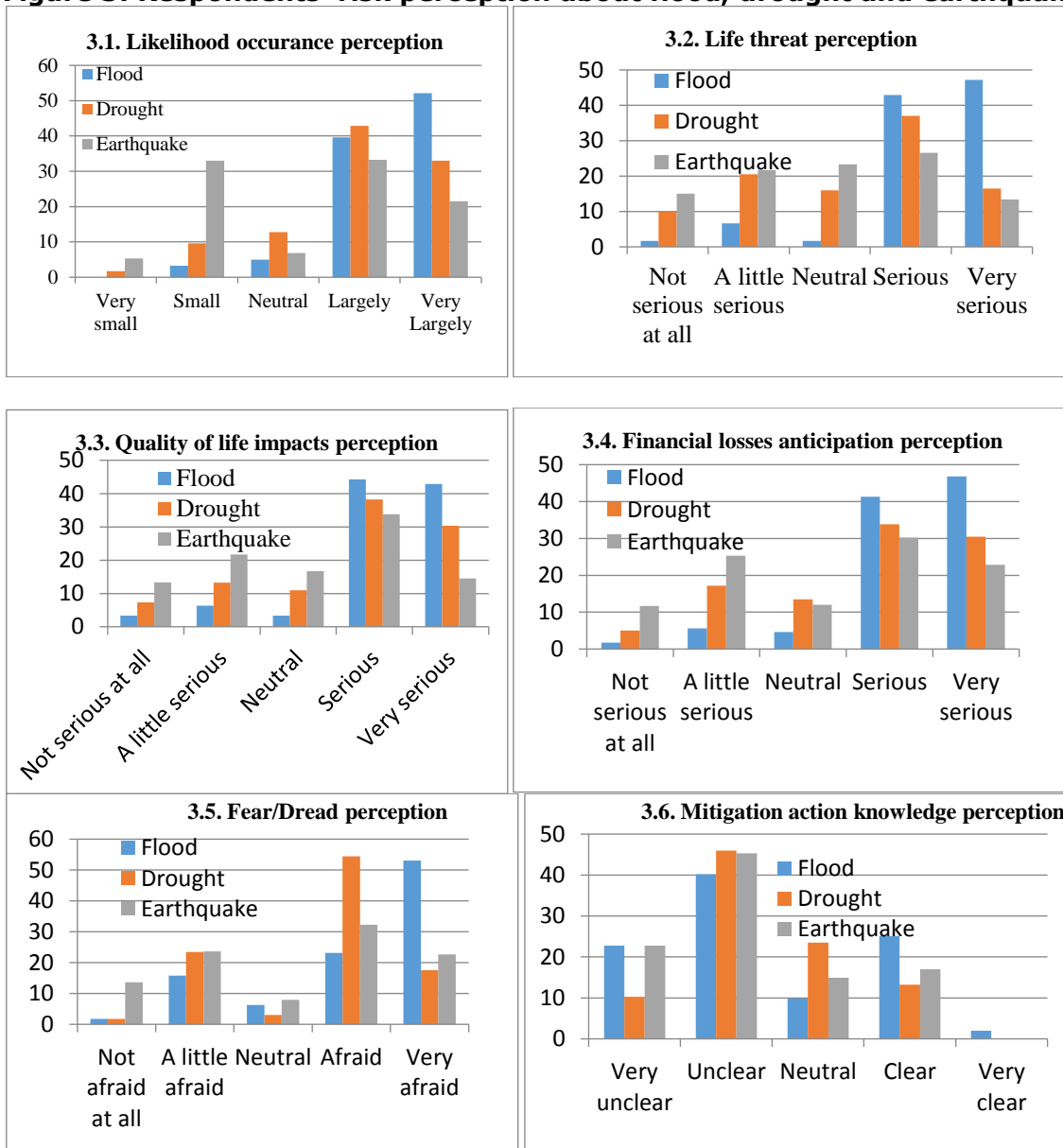
Descriptive statistics, standard deviation and mean of explanatory and explained variables are illustrated in Table 1.

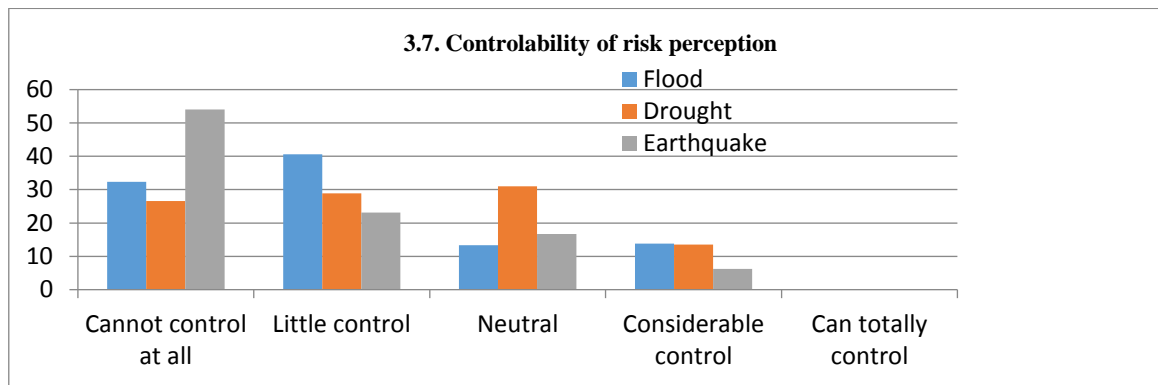
Table 1: Explained and explanatory variables description statistics

Explained variables	Flood	Earthquake	Drought	Description of variables
Likelihood perceived	4.76(0.91)	2.47(1.12)	3.96(2.37)	The categorical variable rang 1-5 (5 very high, 1 very small)
Life threat	4.18(0.98)	3.21(1.34)	3.71(1.02)	The categorical variable rang 1-5 (5 very high, 1 very small)
Quality of life threat	4.86(0.87)	2.98(1.76)	4.21(1.16)	The categorical variable rang 1-5 (5 very high, 1 very small)
Financial loss anticipation	4.43(1.02)	3.11(2.11)	3.99(1.28)	The categorical variable rang 1-5 (5 very high, 1 very small)
Fear/ Dread	3.89(1.29)	3.44(2.36)	4.08(1.36)	The categorical variable rang 1-5 (5 very high, 1 very small)
Mitigation action knowledge	4.73(0.86)	2.19(1.87)	3.77(2.51)	The categorical variable rang 1-5 (5 very high, 1 very small)
Controllability	4.84(0.93)	2.89(1.92)	4.11(1.31)	The categorical variable rang 1-5 (5 very high, 1 very small)
Explanatory variables description with a mean and standard deviation				
Explanatory variables	Mean and standard deviation		Description of explanatory variables	
Respondents age	41.87(13.74)		Continuous variable (age in years)	
Size of family	6.29(2.41)		Continuous variable (family member in number)	
Gender status	1.56(1.28)		Dummy variable (male=1, female=2)	
Educational level	4.28(1.71)		Dummy variable (14 year or above schooling =1, 12 to 14 years schooling=2, 10-to-12-year schooling=3, 5 to 10 year schooling=4, up to 5 year schooling =5)	
Household monthly income	15,798(8254.31)		Continuous variable (family income in PKRs)	

Sources of income generating Type of housing	3.24(2.98)	Dummy variable (agriculture=1, business=2, Government Job=3 private job=4, labour=5, business and agriculture=6, labour and agriculture=7)
Flood disaster experience	3.58(0.94)	Dummy variable (bamboo made=1, katcha=2, semi pacca=3, pacca=4,
Earthquake disaster experience	1.06(0.39)	Dummy variable (yes=1, no=2)
Drought disaster experience	1.34(0.27)	Dummy variable (yes=1, no=2)
Drought disaster experience	1.08(0.34)	Dummy variable (yes=1, no=2)

Figure 3: Respondents' risk perception about flood, drought and earthquake





3.1 Factors affecting flood risk perception of respondents:

Empirical estimates coefficient values of flood-related ordered probit model indicated in Table 2 are as follows.

Table 2: Factors affecting flood risk perception of the respondent

Explanatory variables	Likelihood perceived	Life threat	Quality of life threat	Financial loss anticipation	Fear/Dread	Mitigation action knowledge	Controllability
Respondents age	-0.037*** (0.008)	-0.024** (0.009)	-0.008*** (0.007)	-0.046** (0.008)	0.026*** (0.003)	-0.016 (0.002)	-0.018 (0.001)
Size of family	-0.041 (0.037)	-0.058 (0.34)	-0.178*** (0.043)	0.006 (0.031)	0.074*** (0.37)	0.004 (0.033)	0.058** (0.037)
Gender status	3.147** (0.198)	2.421** (0.289)	1.974*** (0.249)	2.879** (0.234)	1.265*** (0.241)	-1.894*** (0.154)	-1.751** (0.146)
Educational level	0.834** (0.143)	0.617** (0.077)	0.711*** (0.081)	0.294** (0.078)	0.216*** (0.067)	-0.537*** (0.071)	-0.498** (0.091)
Household monthly income	-0.034** (0.051)	-0.043 (0.069)	0.128*** (0.047)	0.084 (0.049)	0.027 (0.051)	0.316*** (0.041)	0.257** (0.053)
Sources of income generating	0.139** (0.054)	0.171** (0.036)	0.158*** (0.039)	0.321** (0.057)	0.056 (0.029)	-0.084*** (0.047)	-0.038 (0.049)
Type of housing	0.26 (0.089)	-0.058 (0.098)	-0.0211** (0.089)	-0.294*** (0.087)	0.92 (0.079)	-0.147*** (0.077)	0.268** (0.074)
Flood disaster experience	-0.319 (0.279)	-0.287 (0.259)	-0.144 (0.248)	-0.034 (0.198)	-0.268 (0.219)	0.039 (0.311)	0.149 (0.278)
Sample size	398	398	398	398	398	398	398

3.2 Factors affecting drought risk perception of the respondent

In Table 3, drought hazards estimated coefficient values ordered probit models are illustrated where expected signs about all explanatory variables indicated the model goodness of fit.

Table 3: Factors affecting drought risk perception of the respondent

Explanatory variables	Likelihood perceived	Life threat	Quality of life threat	Financial loss anticipation	Fear/Dread	Mitigation action knowledge	Controllability
Respondents age	0.018** (0.011)	0.013 (0.010)	0.006 (0.008)	0.029** (0.011)	0.027*** (0.009)	0.021*** (0.005)	0.014** (0.005)
Size of family	-0.034 (0.047)	-0.055 (0.43)	-0.186*** (0.049)	0.008 (0.037)	0.089*** (0.56)	0.002 (0.031)	0.071** (0.046)
Gender status	2.798** (0.239)	1.954** (0.267)	2.321*** (0.198)	2.971** (0.269)	1.764*** (0.231)	-2.453*** (0.188)	-1.376** (0.201)
Educational level	0.684** (0.127)	0.499** (0.081)	0.586*** (0.079)	0.233** (0.091)	0.187*** (0.074)	-0.397*** (0.086)	-0.581** (0.077)
Household	-0.041	-0.029	0.134***	0.068	0.019	-0.298***	-0.273**

monthly income	(0.063)	(0.047)	(0.058)	(0.041)	(0.037)	(0.049)	(0.058)
Sources of income generating	0.151** (0.067)	0.143** (0.051)	0.159*** (0.047)	0.319** (0.054)	0.061 (0.034)	-0.078*** (0.049)	-0.034 (0.043)
Type of housing	-0.396** (0.124)	-0.217*** (0.084)	-0.523** (0.099)	-0.387*** (0.079)	0.135** (0.096)	-0.341*** (0.083)	0.179** (0.091)
Flood disaster experience	-0.248 (0.297)	-0.276 (0.243)	-0.197 (0.263)	-0.039 (0.281)	-0.311 (0.264)	0.047 (0.278)	0.168 (0.296)
Sample size	398	398	398	398	398	398	398

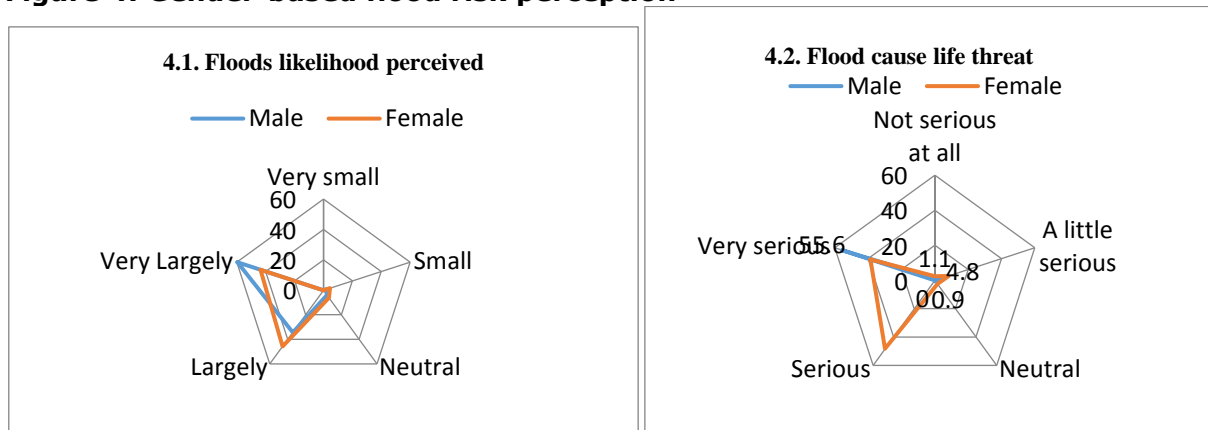
3.3 Factors affecting earthquake risk perception of the respondent

Ordered probit model empirical estimates about earthquake hazard determinants indicated in table 4, portraying as respondents perceived risk was significantly influenced by all explanatory variables except earthquake experience and education.

Table 4: Factors affecting earthquake risk perception of the respondent

Explanatory variables	Likelihood perceived	Life threat	Quality of life threat	Financial loss anticipation	Fear/Dread	Mitigation action knowledge	Controllability
Respondent's age	-0.024** (0.009)	-0.018* (0.010)	-0.007 (0.009)	0.016** (0.012)	0.013 (0.011)	0.009 (0.011)	0.028** (0.009)
Size of family	-0.087** (0.041)	-0.009 (0.048)	-0.031 (0.037)	-0.026 (0.039)	-0.011 (0.043)	0.057 (0.038)	0.041 (0.039)
Gender status	0.941*** (0.216)	0.578** (0.171)	0.874*** (0.147)	0.723 (0.189)	0.799** * (0.213)	-0.857*** (0.193)	-0.598** (0.234)
Educational level	0.234 (0.089)	0.076 (0.089)	0.068 (0.081)	0.059 (0.083)	0.199** * (0.078)	-0.037 (0.093)	0.278** (0.081)
Household monthly income	-0.017 (0.057)	-0.034 (0.041)	-0.011 (0.048)	-0.008 (0.036)	0.014 (0.039)	-0.181*** (0.054)	-0.009 (0.047)
Sources of income generating	0.123** (0.046)	0.027 (0.043)	0.016 (0.049)	0.081** (0.041)	0.136** * (0.038)	-0.043 (0.051)	0.049 (0.038)
Type of housing	-0.298** (0.102)	0.187*** (0.098)	-0.013 (0.087)	-0.071 (0.088)	0.094 (0.117)	-0.297*** (0.097)	-0.009 (0.078)
Flood disaster experience	-0.213 (0.184)	0.097 (0.194)	-0.063 (0.187)	-0.211 (0.171)	-0.158 (0.179)	-0.084 (0.176)	0.079 (0.163)
Sample size	398	398	398	398	398	398	398

Figure 4: Gender-based flood risk perception



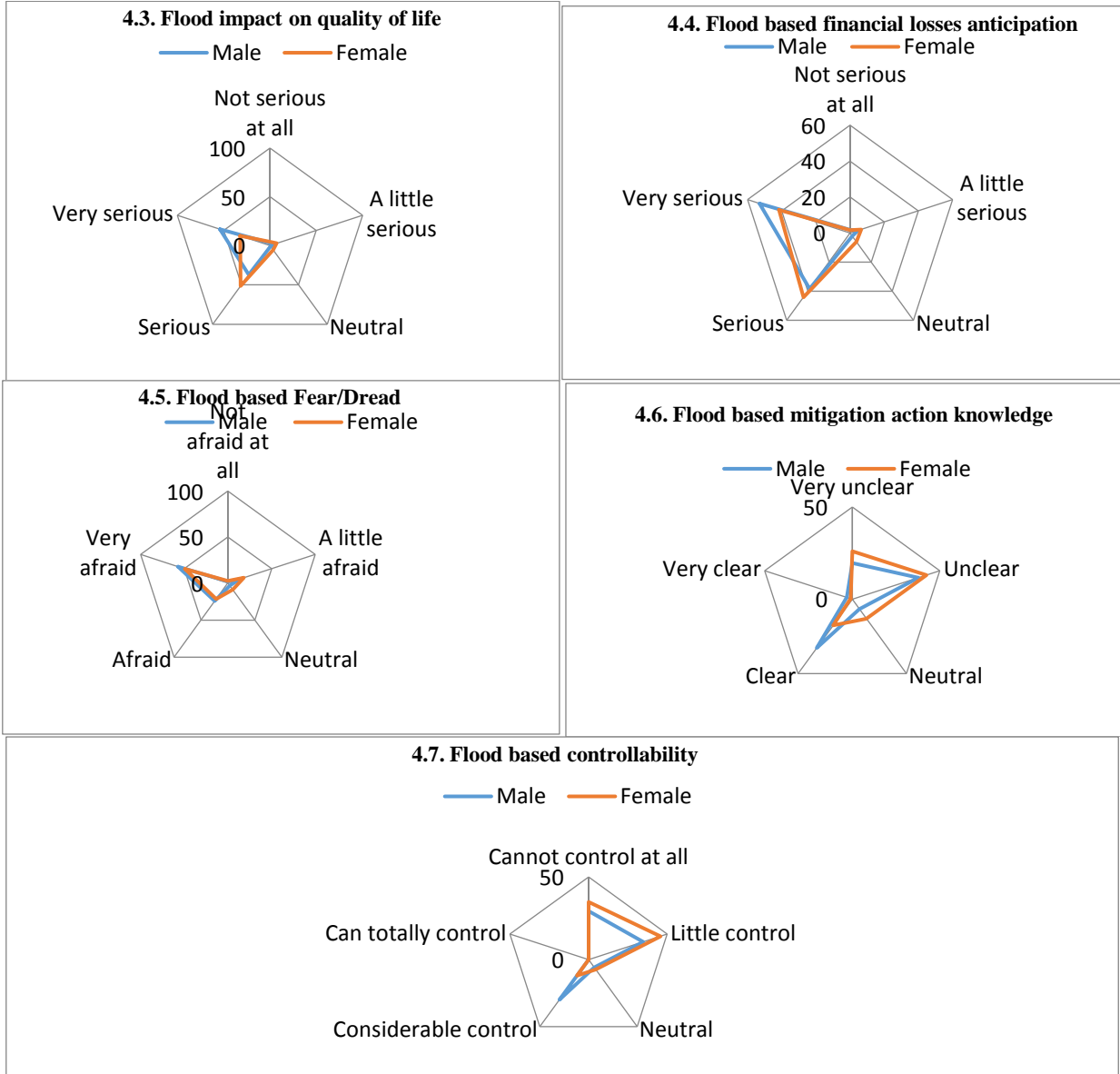
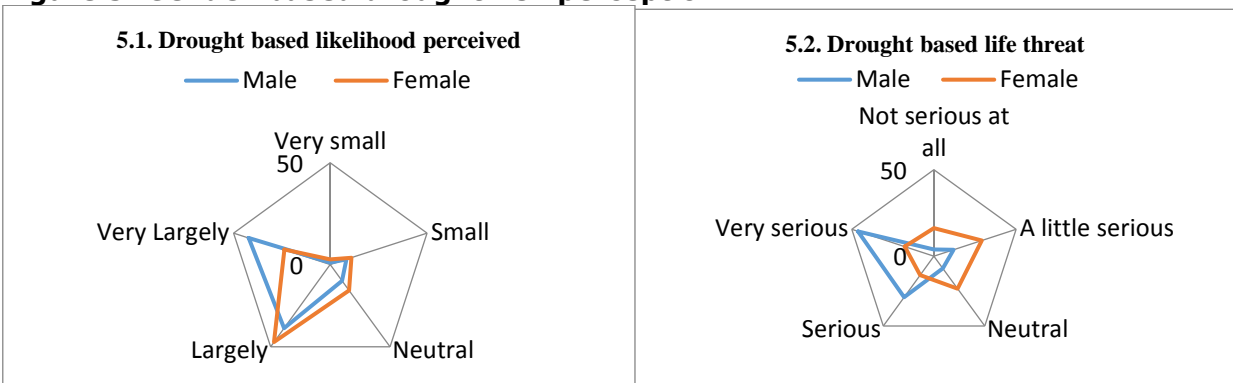
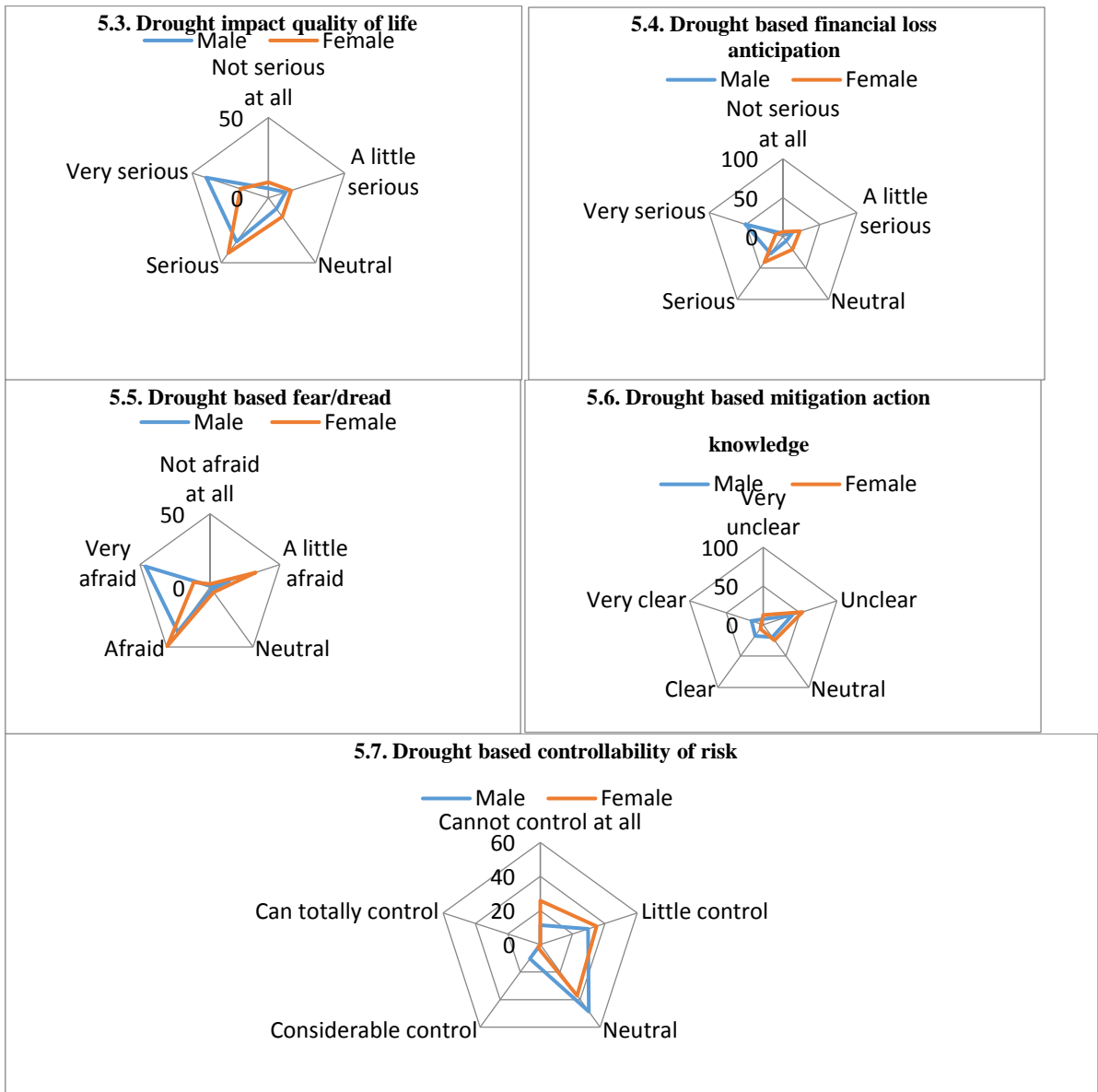


Figure 5: Gender-based drought risk perception



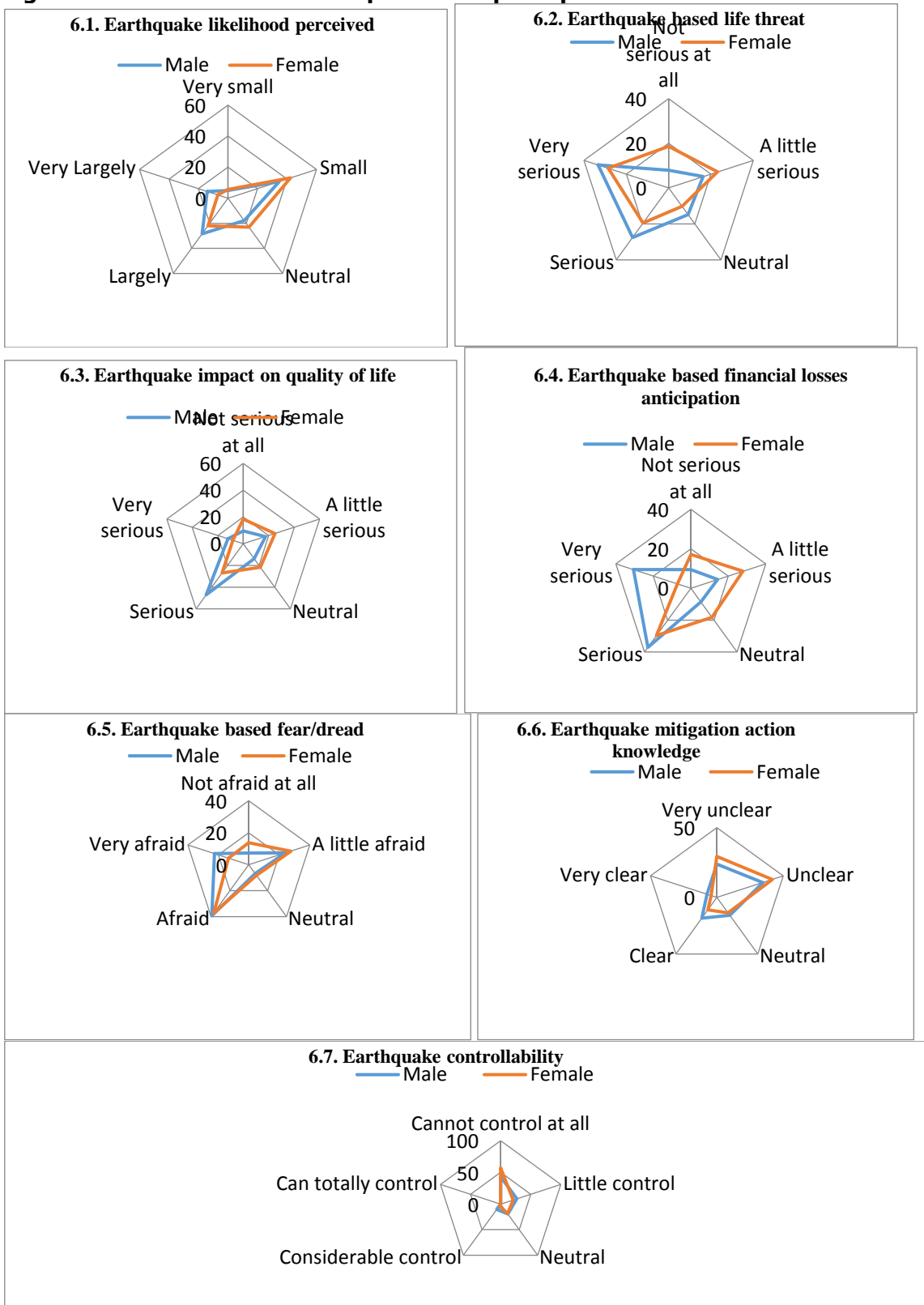


3.4 Gender-based flood, drought and earthquake respondents' risk perception

The significant variation aspect regarding risk perception was estimated from gender to gender, person to person and region to region as such scenarios were particularly discussed in this research work. In the aspect of various factors gender-based flood risk perception is indicated in figure 4(4.1 to 4.7), drought risk perception in figure 5(5.1 to 5.7) and earthquake risk perception in figure 6 (6.1 to 6.7).

On an average basis, females have a higher perception regarding impact and fear related to drought and earthquakes while a higher perception of threat regarding flood and drought disasters. In comparing both genders, female respondents rather than males are having significant lacking of mitigation understanding and measures due to cultural and traditional constraints with a confined role in decision-making empowerment.

Figure 6: Gender-based earthquake risk perception



In the context of controllability regarding disasters both genders have the same understanding of floods and earthquakes except drought whereas the majority of females have serious perceptions and are depressed as they will not be capable to control disasters. In the conclusion, it is indicated as a female in contrast to males will be incapable to overcome upcoming disasters, have insufficient awareness about mitigation measures and have higher risk perception.

4. Discussion

In the research area, most respondents have likely perceived the consecutive and intense happening of upcoming disasters in the future whereas more than 70% of respondents have perceived earthquakes, drought and flood disasters as causing financial losses, negatively influencing the quality of life and causing a severe threat to life status. In normal routine, disaster areas inhabited by population livelihoods have become more vulnerable due to being frequently confronted with the destruction of these disasters. Hazards-prone areas communities have to consecutively remain in fear due to the anticipated incidence of any unfavourable circumstances mostly during devastating or dangerous events where limited people have the mitigation measures understanding to manage such type of dangerous and devastating circumstances. Accurate mitigation understanding about extreme adverse effects is mandatory for minimizing the severe effects of such hazards otherwise the losses will increase on multiple bases. The study findings showing the higher likelihood perceived of flood, drought and earthquake disasters which are consistent with the literature illustrated the higher perception frequently and incidentally happening of storms, earthquakes, flood and drought disasters in future so findings consistent with studies of (E. Alam, 2019; Plapp & Werner, 2006; Udmale, Ichikawa, Manandhar, Ishidaira, & Kiem, 2014).

5. Conclusion and Suggestions

This research work investigated the factors influencing households' risk perception of flood, drought and earthquake in disaster-prone areas of Punjab, Pakistan. The study used the sample data of 398 respondents and applied an ordered probit model for empirical estimation. The majority of respondents in the study area have a higher perception of upcoming disasters of floods; drought and earthquakes which subsequently cause to humiliate their quality of life, life threat, resource depletion and economic losses. Disasters' consecutive and destructive experience makes them serious about the adoption of mitigation measures to the increased level of disaster perception. Recurrent distasteful disaster events make disaster-prone populations more feared and vulnerable. In the aspect of mitigation understanding and managing practices about unpleasant disaster events, only a minor proportion of the population has such capabilities to manage the adverse situation. Households' sources of income generating, education level, gender status and respondent's age significantly affect the risk perception of flood, drought and earthquake disasters. Literate communities, sources of permanent income and both gender should have an appropriate understanding of suitable decisions at the correct moment to minimize the effects of disasters. Fewer risks were perceived by male respondents according to the findings of the study while having an appropriate understanding of certain risks will be more competent in controlling future disasters. In the aspect of financial constraints study remained limited to selected study areas while in the future it is more appropriate to investigate the study to select disaster to such disaster areas to have a comprehensive idea concerning respondents of the area to be resilient with such disasters. The estimates of this study will facilitate the planners and policymakers to take appropriate strategies to stimulate people to adopt proper mitigation measures, formulate secure livelihood preferences and move up consciousness for minimizing the effects of disasters to make certain sustainable disaster resilience communities.

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