Environmental Science and Pollution Research (2022) 29:53691–53703
https://doi.org/10.1007/s11356-022-19646-5

RESEARCH ARTICLE

Flood risk public perception in flash flood-prone areas of Punjab, Pakistan

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Received: 19 April 2021 / Accepted: 6 March 2022 / Published online: 15 March 2022

Abstract

Floods due to higher severity of destruction are considered the most destructive natural hazards in the world. Initiating the appropriate strategies of disaster risk reduction is necessary to understand risk perception. This study attempted to examine the flood risk public perception in flash flood-prone areas of Punjab, Pakistan. A simple random sampling technique was used for collecting the data of 560 household respondents, and a logistic regression model was employed to make out the factors of flood risk perception. In classification of low and high perceived risk of relevant indicators, flood risk perception index was constructed. Risk perception is significantly influenced by socioeconomic factors which have a direct impact on disaster preparedness and potential adaptive capacities. After that, potential correlation of risk perception with the demographic status of respondents was investigated in this study. Empirical estimates indicated as respondents' schooling, ownership of house, size of household, employment status and past flood experience significantly influence flood risk perception. Risk perception determinants also diverse among both communities portray spatial differences. Inadequate protection measures from public authorities and institutions, limited preparedness regarding actions of private mitigation, reduced intensity of reliance in institutions and authorities are major reasons for high risk and lower mitigation in these flash flood-prone areas. The outcomes of this research can facilitate to understand flood risk perception and its factors for conniving appropriate management plan of flood risk and communication strategies. Furthermore, this research can help consider multidimensional flood risks and its spatial vibrancy from the perspective of social science.

Keywords Flash floods · Flood mitigation · Risk perception · Risk management · Punjab

Introduction

Floods, earthquakes, landslides, cyclones and droughts are some severe natural hazards in global scenario (Eckstein et al., 2018; Verlynde et al., 2019; Ahmad and Afzal, 2020). Floods are considered more destructive and most sequential (UNDP, 2016; Teo et al., 2021) rather than other hazards (Shah et al., 2021). Flood severity is the reason for significant involvement in social risks, economic losses and fatalities to society as frequently exposed via humans (Aldrich and Metaxa, 2018; Ahmad et al., 2019). These hazards have affected more than 96 million populations in 2017, majority as 60% was affected by floods (Emergency Event Database, 2017). Asian countries such as Bangladesh, India, China and Pakistan have been designated as the supermarkets of floods (Diakakis et al., 2018; Ahmad and Afzal, 2021) due to higher recurrence and intensity of floods in the last two decades (Bodoque et al., 2019; Ballesteros-Cánovas et al., 2020). More specifically, the rural population of developing countries is more highly vulnerable to floods due to scare resources and inadequate flood mitigation measures (Abbas et al., 2015; Ahmad et al., 2020). In developing countries, environmental and climate change factors are more severe regarding increasing flood risks (Abid et al., 2016; Khan et al., 2021) rather than anthropogenic factors such as human river encroachment (Gaurav et al., 2011; Birkholz et al., 2014).

Responsible Editor: Philippe Garrigues

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Pakistan is one of the five countries, including India, Bangladesh, China and Vietnam, in which 80% of population is severely exposed to ongoing floods within a decade (World Resources Institute, 2015). In the last two decades, Pakistan is considered in mainly hazard-affected, more particularly the flood hazard-affected, countries of the world owing to being located in a hazard-prone region and facing repeated floods (Abbas et al., 2015; Ahmad and Afzal, 2020). Glacier melting and consecutive cycles of rainfall are major factors associated with flood hazards in connected river flow downstream and upstream in rivers (Ullah et al., 2018; Ahmad et al., 2019). In the scenario of flood hazards, particularly in 2010, Pakistan faced the most horrible flash flooding (National Disaster Management Authority (NDMA), 2011), which caused 10 billion dollar economic loss, devastating the cropped area of 2 million hectares and adversely affecting the twenty four million population of the country (UNDP, 2016; Abid et al., 2016; Pakistan Bureau of Statistics (PBS), 2017).

In Punjab, higher frequency of flood vulnerability has been estimated rather than earthquakes and tornadoes due to consecutive dramatic climatic changes and extreme monsoon seasons (Provincial Disaster Management Authority (PDMA) Punjab 2014). Punjab province is more vulnerable to these three types of flood risks formally known as flash floods, river in floods and urban floods (PDMA, Punjab 2017). In monsoon season, these floods most frequently occur every year, which causes tragic property costs and human lives (Ahmad and Afzal, 2020). Frequent destructive floods were experienced in Punjab from 1950 to 2014, documenting almost twenty-two serious floods (Yaqub et al., 2015; Shah et al., 2017). In Punjab, twelve districts are categorized as higher risk flood-prone districts, among them, three districts as Mianwali, Dera Ghazi Khan and Rajanpur indicated as flash flood districts areas due to neighboring mountainous regions with storms of high force direct rapid flooding frequently passing through narrow watercourses (PDMA, Punjab 2017).

In the current era, flood risk perception is recognized as a central factor in flood risk management (Verlynde et al., 2019; Ahmad et al., 2020) and most significant to ongoing integration of conventional risk assessment method (Ballesteros-Cánovas et al., 2020) and social features (Botzen et al., 2009; Ahmad et al., 2019). A person's belief, actions and behaviors are factors comprising perception regarding source of hazard regarding its harshness of shocks, upcoming flood likelihood and examining dynamic tendency of risk (Becker et al., 2014; Špitalar et al., 2014; Cole et al., 2016). There is a significant association of risk perception and flood risk, further developing the combination of flood risk assessment to risk management through built-in approach (Rowe and Wright, 2001; Baan and Klijn, 2004; Messner and Meyer, 2006). The state of affairs as overestimation about the level of personal preparedness or underestimation regarding risk occurs due to inadequate possible awareness responses in situation of emergency or inadequacy information of public perception (Barberi et al., 2008). Flash floods indicate the scenario of heavy rains on mountainous areas and intense water storms from heights force direct to rapid flooding (Shah et al., 2017) as frequently passing through narrow mountainous watercourses (Ballesteros-Cánovas et al., 2020). Public and local administrative authorities have limited time to prepare for upcoming hazard or vacate hazardous areas affected by flash flooding (Verlynde et al., 2019; Ahmad et al., 2020).

In research paradigm, development of psychometric paradigm based on logical assumption as risk is psychologically determined and inheritably subjective (Slovic, 1992; Fischhoff et al., 2016). The main purpose of psychometric paradigm is to reveal the factor of risk perception (Slovic, 1987). In most risk perception research studies to evaluate the various rating scales for hazards (Fischhoff et al., 1978), psychometric paradigm is utilized in hazards newness (familiar or new), consequences of severity (how consequences will fatal) and risk knowledge (how extent of risk). Risk perception in most research studies analyzed through accounting average method of participants related to their qualitative characteristics as hazards file becomes highly correlated. In majority research studies, two principal components, firstly dread risk and secondly unknown risk, are used to reproduce the rating scales (Slovic, 1987). Psychometric paradigm method has been used in most research studies for measuring risk perception (Brun and Teigen, 1988; Goszczynska et al., 1991; Karpowicz-Lazreg and Mullet, 1993; Savadori et al., 1998; Chuk-ling Lai and Tao, 2003; Siegrist et al., 2005). Psychological risks are major factors to determine flood risk perceptions (Kraus and Slovic, 1988; Lechowska, 2018).

In literature, flood hazards in developed and developing countries specifically focused on the aspects of hazard causes, mitigation measures choices and constraints (Jonkman and Kelman, 2005; Paul and Routray, 2010; Birkholz et al., 2014; Ahmad and Afzal, 2020), flooding risk adaptation (Wisner et al., 2004; Osberghaus, 2015; Ahmad et al., 2020) and local community flood risk management (López-Marrero and Yarnal, 2010; Wilby and Keenan, 2012; Verlynde et al., 2019). Limited empirical studies focused on a person's belief simulate a notable effect on risk perception about flood hazards (Bubeck et al., 2012; Kellens et al., 2013; Diakakis et al., 2018; Lechowska, 2018), whereas some studies indicated human behavior and actions as major factors comprising perception regarding source of hazard, its shocks and their harshness, upcoming flood likelihood and examining dynamic tendency of risk (Kellens et al., 2011; Špitalar et al., 2014; Becker et al., 2014: Cole et al., 2016). The aspect of nonprofessional (laymen) awareness and factors associated to different emotions regarding risk perception and mitigation was also discussed in some studies (Armaş and Avram, 2009; Kellens et al., 2011; Pagneux et al., 2011; Becker et al., 2014). Limited research work highlighted the aspect of actual individual behavior with regard to risk including mitigation actions, insurance adaption and seeking information about flood's major factor regarding flood risk perception (Rowe and Wright, 2001; López-Marrero and Yarnal, 2010; Terpstra and Lindell, 2013; Ryan, 2013; Poussin et al., 2014). Psychometric aspects regarding flood hazards such as demographic factors or experience regarding the previous flood were indicated as predictor of awareness, behavior, future flooding likelihood and perception of risk also discussed in some empirical studies (Fischhoff et al., 1978; Werritty et al., 2007; Terpstra and Gutteling, 2008; Pagneux et al., 2011; Terpstra and Lindell, 2013; Wachinger et al., 2013; Knuth et al., 2014; Birkholz et al., 2014).

In literature, flood hazard scenario is discussed through various aspects such as hazard mitigation, perception, adaptations, management measures, person's belief and psychometric aspects, while the aspect of flood risk perception more specific to flash floods in Pakistan is not yet not investigated according to the best knowledge of the author. An attempt to investigate this significant research gap regarding flood risk perception of flash flood in Pakistan was done in this study. This study aims to (i) investigate risk perception levels in both communities, (ii) find out socioeconomic factors affecting risk perception in the study area, (iii) understand the spatial variability of risk perception in both flood-prone communities in Punjab province of Pakistan and suggest proper policy measures regarding the study area. This study is categorized into four sections. Introduction of the study is elaborated in the first section, while the second section discusses the material and method of the study. Results and discussion are illustrated in section three, while the last section discusses the conclusion and suggestion of the study.

Material and method

Study area

Punjab the province of Pakistan, formally known as the fertile land of five rivers (GOP, 2019), is particularly given focus in this study due to some significant reasons. Firstly, Punjab occupies 26% area of the country and is the most populated province, sharing almost 53% population of the country (PBS, 2017). Secondly, Punjab is mostly affected by floods compared to other hazards, such as earthquake, drought and tornados (PDMA, Punjab 2014; GOP, 2019), and its major population is directly or indirectly more susceptible to flash, urban and riverine flooding (PDMA, Punjab 2017). Thirdly, Punjab consists of mostly plain area, and the country's five major rivers Indus, Chenab, Jehlum, Ravi and Sutlej flow throughout this province, causing higher risks during floods (GOP, 2017). Fourthly, Punjab province faced major losses of properties, lives and infrastructure due to experiencing consecutive five floods from 2010 to 2015 in the current decade (Yaqub et al., 2015; NDMA, 2016; Shah et al., 2017). Lastly, the southern area of Punjab consisting of the neighboring mountainous region that causes flash flooding (NDMA, 2018) is also the major contributor to consecutive flooding and a reason for major losses of lives and properties in the province (PDMA, Punjab 2017) as indicated in Fig. 1.

Geographical features of the study area

In Punjab, the southern Punjab region, due to its neighboring mountainous region and the major Indus river that flows side by side of the region considered a higher flash flood-prone area in the province (NDMA, 2016; GOP, 2020), is particularly chosen for this study. Rajanpur and Dera Ghazi Khan districts of the southern Punjab region located on the riverbank and neighboring mountainous region having a higher risk of flash floods (PDMA, Punjab 2014) were purposively selected. Rajanpur district administratively consists of three tehsils Rojhan, Rajanpur and Jampur covering an area of 12,318 km^2 having a population of 1.99 million (PBS, 2017). District Rajanpur with extreme and long summer indicates hot region and is struck strongly by severe flash flooding due to the western side mountainous region and Indus river on the eastern side as indicated in Fig. 2 (PBS, 2017). Dera Ghazi Khan district administratively consists of four tehsils de-excluded area Dera Ghazi Khan, Dera Ghazi Khan, Kot Chutta and Taunsa with 115 union councils (GOP, 2019), covering an area of 11,294 km^2 with a population of 2.87 million (PBS, 2017). This district faces higher severity of floods due to the western side mountainous region with higher flash floods and Indus river that flows on the eastern side (GOP, 2018). Hot summer and mild winter are some major aspects of this arid climate in this region with an average rainfall of 127 mm and a maximum of 54 °C (129 °F) and a minimum of 1 °C (30 °F) temperature (GOP, 2019).

Sampling procedure and collection of data

In this study, a simple random sampling approach was applied for data collection from flash flood hazard-prone affected rural households. In the scenario of higher severity of flash flooding, the southern Punjab region was specifically selected for the study in the first stage (PDMA Punjab, 2018; NDMA, 2019). In the second stage, from the southern Punjab region, two higher flash flood-prone districts Dera Ghazi Khan and Rajanpur were purposively selected for

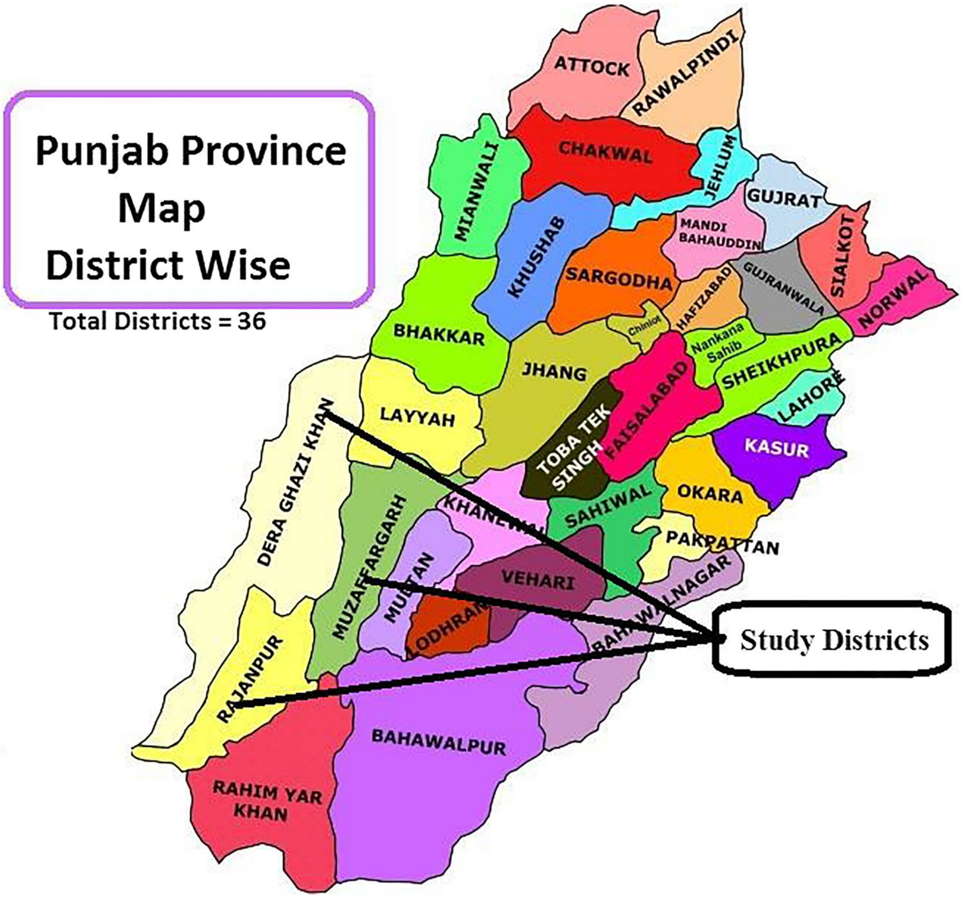

Fig. 1 Map of study districts Dera Ghazi Khan and Rajanpur of Punjab province Pakistan

the study (PDMA Punjab, 2018). Tehsil Dera Ghazi Khan and de-excluded area Dera Ghazi Khan from district Dera Ghazi Khan and tehsil Rajanpur and Rojhan from Rajanpur district were specifically chosen due to the experienced higher severity of flash floods from the mountainous region of the western neighbors in the third stage (PDMA, 2017; NDMA, 2018; GOP, 2019). In the scenario of information about higher severity of flash flood-affected area provided by the local government and official land record holder (patwari) of the area, two union councils from each tehsil were chosen in the fourth stage. In the last stage, two villages from each union council were selected with thirty-five households from each village randomly selected.

In chosen villages and listed flash flood-affected households, information was obtained by the local official land record holder officer and agriculture department for data collection. In the data collection procedure, households were the basic unit, while household head (male/female) was the major respondent of the study. This study used the sampling method of Cochran and William (1977) to determine the minimum sample required for study as indicated in Eq. (1). Household heads from each village were targeted, and data were collected from 560 respondents, while 5% population was considered adequate for cross-sectional data (Kotrlik and Higgins, 2001). In the selection of these households, a random numeral table was created through the computer and was used for the list chosen for these households. Enumerators completed the given respondent numbers from each village, while respondents not willing to participate were replaced by others. Equation (1) indicated sample size as SS. Z is the confidence level as (± 1.96 at 95%), choice of percentage picking was denoted as p, expressed as decimal (0.5 used as sample size required), whereas precision value was denoted as e ($0.07 = \pm 7$).

$$\text{Sample size} = \frac{Z^2(p)(1-p)}{e^2} \tag{1}$$

In the data collection procedure with direct interaction of respondent from December 2018 to May 2019, a well-developed questionnaire was used which integrated the major feature of objectives with related questions about flood risk. In avoiding ambiguity and to find out accuracy and adequacy of information, 20 respondents were pilot tested with questionnaire prior to proper survey in the study area. The author himself and five trained enumerators started the survey, and all relevant issues were

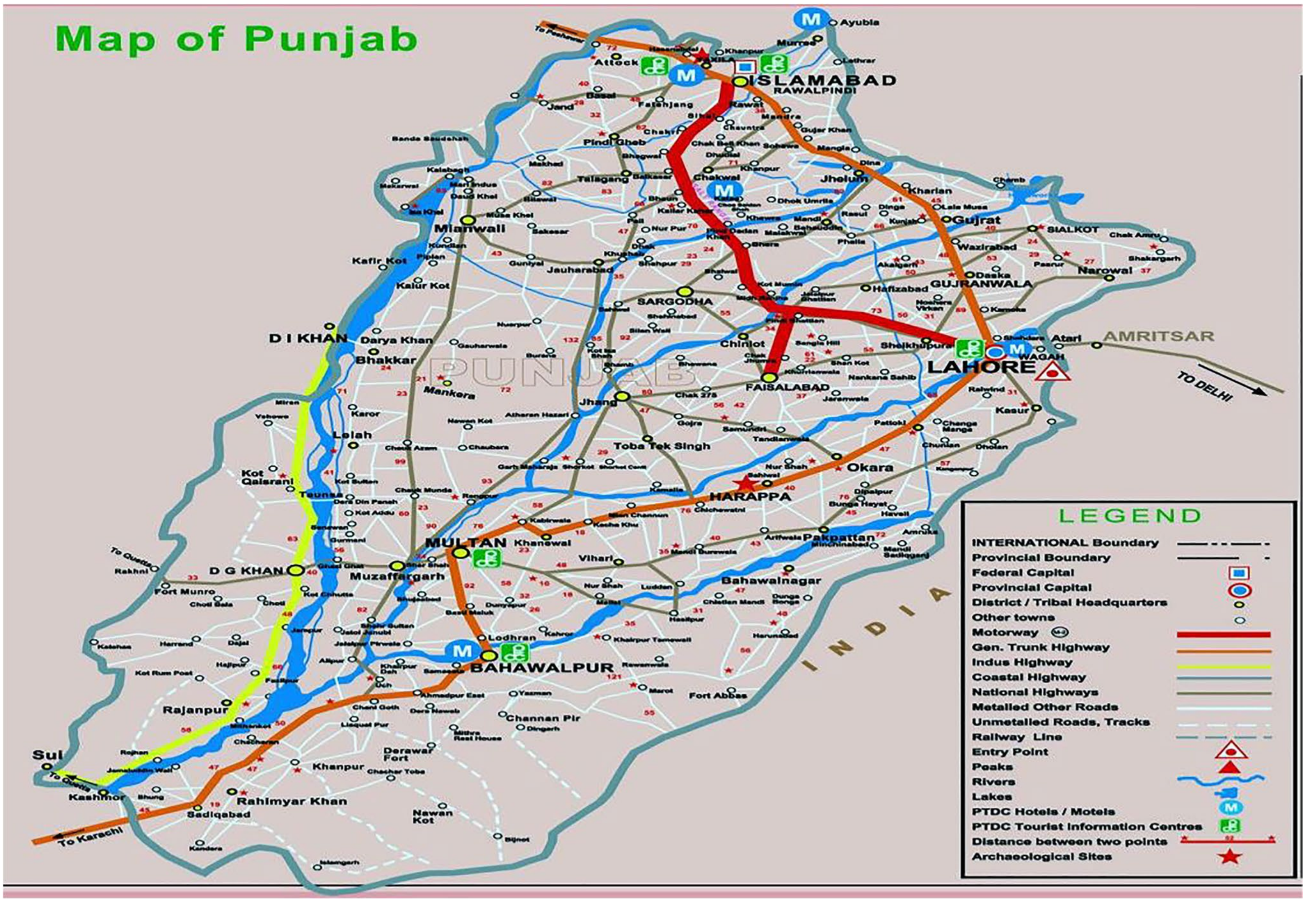

Fig. 2 Study districts Dera Ghazi Khan and Rajanpur with Indus river flows

clarified and corrected. Almost 29 respondents not willing to participate in the data collection procedure were replaced by other households.

Flood risk perception index

The aspect of risk perception was mostly considered qualitative naturally, whereas index application has justified it as suitable measure to quantify it. In quantifying and summarizing complicated data such as vulnerability of climate change and disaster risk in simple appearance, usage of indices is perceived as a vigorous methodology (Birkmann, 2006). In aggregating the data sets, it required standardization of data for index construction, whereas weights are also applied for response standardization to composite index computation (Rana and Moradkhani, 2016). In the scenario of precise literature review, indicators of risk perception were cautiously selected as indicated in Table 1.

Indicators such as government policy trust, emergency protocol knowledge and coping perceived ability have no directly considered impact to risk perception measures whereas are indirectly correlated to general perceived risk. Likert scale 1–5 was applied for mapping each indicator by giving the weighted risk perception increases (Very low = 0.2, Low = 0.4, Moderate = 0.6, High = 0.8, Very high = 1). These scores/weights were added to come up with the value of the composite index (CI) for each household as illustrated in Eq. (2), whereas index of flood risk perception was developed by application of Eq. (3). In measurement aspect, index values below average are considered low risk perception (0), while above average were indicated as high risk perception.

$$\text{Composite index} = \frac{w_1 + w_2 + w_3 + w_4 + \ldots \ldots . w_n}{n} \tag{2}$$

$$\text{Risk perception index} = \sum_{i=1}^{10} Wi/\text{n} \tag{3}$$

Data analysis

Risk perception in this study was calculated as a discrete variable either low risk perceived or high risk perceived such as application of dummy as related to high risk perceived

Table 1 Risk perception perceived assessment selected indicators

Serial no	Indicators of flood risk perception	Indicator range and weights	Sources of indicators
1	Perceived flood likelihood (in upcoming year's flood likelihood assessment)	Very high (1), High (0.8), Moderate (0.6), Low (0.4), Very low (0.2)	Twigg (2003), Ho et al. (2008), Botzen et al. (2009), Kellens et al. (2011), Sullivan-Wiley and Gianotti (2017), Diakakis et al. (2018), Aldrich and Metaxa (2018)
2	Flood perceived fear (fear/afraid from upcoming flood likelihood)	Very high (1), High (0.8), Moderate (0.6), Low (0.4), Very low (0.2)	Twigg (2003), Ho et al. (2008), Aldrich and Metaxa (2018)
3	Perceived life threat (probability of life losses in the floods)	Very high (1), High (0.8), Moderate (0.6), Low (0.4), Very low (0.2)	Ho et al. (2008), Kellens et al. (2011)
4	Perceived flood damages likelihood (future damage likelihood in floods)	Very high (1), High (0.8), Moderate (0.6), Low (0.4), Very low (0.2)	Twigg (2003), Ho et al. (2008), Botzen et al. (2009), Lo (2013), Sullivan-Wiley and Gianotti (2017), Aldrich and Metaxa (2018)
5	Perceived flood coping capability (having capability to cope with floods)	Very high (1), High (0.8), Moderate (0.6), Low (0.4), Very low (0.2)	Ho et al. (2008), Aldrich and Metaxa (2018)
6	Perceived interruption in supply (likelihood supply interruption in flood)	Very high (1), High (0.8), Moderate (0.6), Low (0.4), Very low (0.2)	Twigg (2003), Rana and Routray (2016)
7	Perceived lifestyle adaptation (likelihood of lifestyle change in floods)	Very high (1), High (0.8), Moderate (0.6), Low (0.4), Very low (0.2)	Ho et al. (2008), Aldrich and Metaxa (2018)
8	Perceived relationship variations (chance of neighbor/friends' change in relationship)	Very high (1), High (0.8), Moderate (0.6), Low (0.4), Very low (0.2)	Armaş and Avram (2009), Rana and Routray (2016)
9	Emergency protocol awareness (understanding level of emergency protocol)	Very high (1), High (0.8), Moderate (0.6), Low (0.4), Very low (0.2)	Ho et al. (2008), Diakakis et al. (2018)
10	Government policy trust (trust in climate and disaster government policies)	Very high (1), High (0.8), Moderate (0.6), Low (0.4), Very low (0.2)	Rana and Routray (2016), Diakakis et al. (2018)

as 1 otherwise 0. Adjustment regression logit model was applied having the dependent variable in the form of 0 or 1 (Greene and Pershing, 2007; Webel, 2011). In estimation scenario with a dichotomous dependent variable, alternative or binary rather than continuous estimation standard econometric technique logistic regression is applied. This econometric technique is based on the prophecy of probability of an incident that may not or may occur so risk perception probability can be alike to 0 or 1. These models of logistic regression are additionally distinguished into regression of odd ratios and ordinary least squares. In this study, both methods were applied to confirm the influence of socioeconomic independent variable on flood perceived high risk dependent variable to identify risk perception determinants.

Respondents' age, schooling, household size, employment status household, ownership of house, earning members, income status, income sources and past flood experience were major socioeconomic indicators regressed on flood risk perception as illustrated in Table 2. In the scenario of economic vulnerability, occupation variable was classified such as government employed = 5, commerce and trade related = 4, agriculture-related worker = 3, daily wage earner = 2, unemployed = 1. Furthermore, in hazard proximity of house location, another variable is categorized as related to height and distance (upland = 3, surrounded by floodplain = 2, between riverbank and levees = 1), whereas schooling level was categorized into five classifications (university/college graduate = 5, high school = 4, middle school = 3, primary school = 2, illiterate = 1).

Results and discussion

Selected communities flood hazard exposure and risk perception

In both study areas, selected communities experienced severe flash flooding due to being surrounded by the neighboring mountainous region in the western side and riverine flooding because of consecutive flowing of Indus river on the eastern side. Dera Ghazi Khan and Rajanpur districts have frequently experienced flash and riverine flooding; 2010 flood was considered more destructive because of extreme scenario. More particularly, erratic rains during the monsoon season cause severe flash flooding from the mountainous region experiencing major destruction of crops, infrastructure, homesteads and livestock.

Some significant variations about the indicators of flood risk perception in both study areas were indicated except perceived supply interruption and perceived coping abilities which illustrated the minimum special unpredictability in Table 3. In flooding likelihood aspect, Dera Ghazi Khan district (3.68) has a higher likelihood of future incidence of flash flood rather than Rajanpur (2.97) and illustrates a significant variation ($F = 23.543$ p value 0.000) witnessing the limited flash floods of Rajanpur rather than Dera Ghazi Khan. Furthermore, Rajanpur community has less fear of flood (3.41) and life threat owing to flood (3.29) rather than Dera Ghazi Khan, flood fear (4.79) and life threat (4.98). Both communities have significant variation in perceived life threat ($F = 69.245$, p value 0.000) and perceived fear ($F = 98.431$, p value 0.000) in the study areas. The lower value of Rajanpur district is because of experiencing limited flash floods rather than Dera Ghazi Khan in the past years. There seems no significant variation in both district communities regarding the perception about coping abilities in dealing with floods almost having same mean values as Rajanpur (2.27) and Dera Ghazi Khan (2.39). The aspect of perceived perception to supply interruption due to flood, with Rajanpur and Dera Ghazi Khan having almost same mean values (3.41) and (3.56), illustrates that both study areas have same threat of supply interruption in flooding season as indicated in Table 3.

Higher mean values of Rajanpur (3.54) and Dera Ghazi Khan (3.67) about perceived relationship variations due to flood indicated that friends' and relatives' close connection

Table 2 Study variables applied in the model with mean value and standard error

Study variables	Type of variable	Dera Ghazi Khan	Rajanpur	Cumulative values
Respondents' age	Continuous variable	41.74 (15.61)	39.89 (14,67)	40.815 (15.24)
Respondents' schooling	Continuous variable	6.53 (1.64)	5.78 (1.51)	6.155 (1.675)
Size of household	Continuous variable	7.49 (1.71)	6.98 (1.68)	7.235 (1.895)
Household head employment status	Dummy variable (yes = 1, otherwise = 0)	0.93 (0.301)	0.89 (0.342)	0.91 (0.372)
Ownership of house	Dummy variable (yes = 1, otherwise = 0)	0.87 (0.336)	0.91 (0.301)	0.89 (0.349)
Earning members	Continuous variable	1.73 (1,231)	1.64 (1.187)	1.69 (1.409)
Income per month (PKRs)	Continuous variable	24,876 (17,542)	23,943 (16,572)	24,410 (19,057)
Income sources	Continuous variable	1.57 (0.598)	1.49 (0.521)	1.53 (0.580)
Past flood experience	Dummy variable (yes = 1, otherwise = 0)	0.91 (0.294)	0.88 (0.304)	0.895 (0.301)

Parenthesis illustrated the standard deviation values

Table 3 Study area flood risk perception indicators mean values and standard deviation

Indicators of flood risk perception	Dera Ghazi Khan	Rajanpur	Analysis of variance (F test)	Cumulative values
Perceived flood likelihood	3.68 (1.423)	2.97 (1.157)	23.543***	3.444 (1.538)
Flood perceived fear	4,79 (0.874)	3.41 (0.593)	98.431***	4.46 (1.026)
Perceived life thereat	4.98 (0.687)	3.29 (0.615)	69.245***	4.635 (1.243)
Perceived flood damages likelihood	4.27 (0.921)	3.97 (0.861)	37.421***	4.12 (1.682)
Perceived flood coping capability	2.39 (0.745)	2.27 (0.694)	1.176	2.33 (0.879)
Perceived interruption in supply	3.56 (1.031)	3.41 (0.867)	1.473	3.585 (1.147)
Perceived lifestyle adapting	2.54 (0.786)	2.39 (0.694)	15.791***	2.465 (0.694)
Perceived relationship variations	3.67 (0.869)	3.54 (0.781)	49.253***	3.755 (1.239)
Mitigation emergency awareness	2.18 (1.023)	2.04 (0.871)	5.214***	2.11 (0.713)
Government policies trust to climate and disaster	1.59 (0.791)	1.63 (0.812)	13.689***	1.61 (0.598)
Risk perception dichotomous (low risk = 0, high risk = 1)	0.76 (0.418)	0.73 (0.409)	38.798***	0.745 (0.541)
Index of risk perception (standardized)				
Maximum	0.67	0.63	67.743***	0.67
Minimum	0.28	0.23		0.23
Mean value	0.526	0.497		0.512
Standard deviation	0.084	0.079		0.117

Parenthesis illustrated the standard deviation values

***1% level of significance, **5% level of significance, *10% level of significance

will be affected due to floods. In both study districts, there exist significant variations about changing relationship ($F=49.253$, p value 0.000) and altering lifestyle ($F=15.791$, p value 0.000). There is almost same and low mean value of emergency procedure and mitigation action knowledge in both study districts Rajanpur (2.04) and Dera Ghazi Khan (2.18), indicating that household have limited knowledge of emergency procedure and mitigation in the study areas as indicated in Table 3. In comparing to other indicators, the lowest value of household trust on government authorities related to disaster coping policies indicator illustrates the mistrust of community on government disaster-based measures. Government policies' higher stern mistrust is due to poor performance in flood mitigation measures, relief and rescue as indicated by the study areas in both districts with Dera Ghazi Khan having lower mean values (1.59) followed by the Rajanpur (1.63) as illustrated in Fig. 3.

Flood risk perception in overall aspect indicated the significant variations in both communities ($F=67.743$, p value 0.000). Risk perception was higher in Dera Ghazi Khan rather than in Rajanpur, and this is an alarming aspect with an overall lower value of risk perception in the higher flood affected study areas. Estimates indicated the fear and threat of life were poorly perceived in contrast to other indicators as maybe based on perception of widespread public approach as in upcoming scenario floods would not damage them but others. These results are consistent with the studies as flood-prone communities having perception as in future

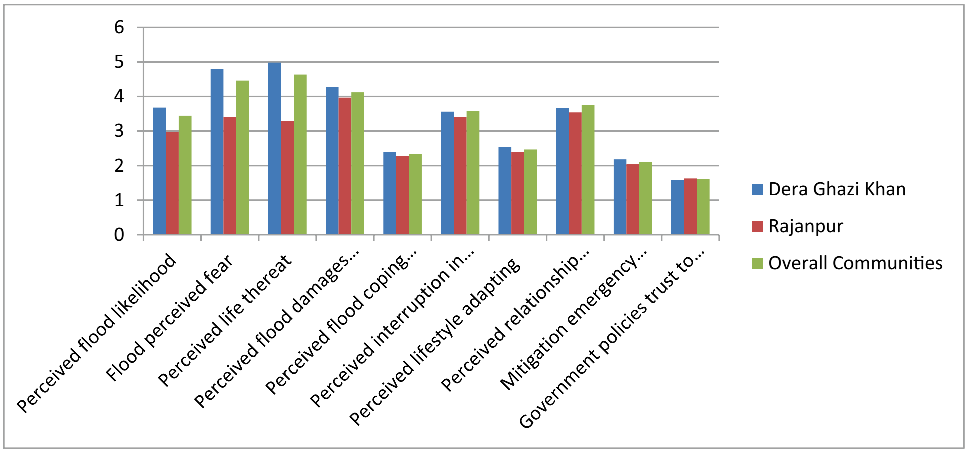

Fig. 3 Flood risk indicators mean values of district level and overall communities

risk will be lower than previous scenario (Botzen et al., 2009; Ahmad and Afzal, 2020), whereas this aspect can be reversed due to low mitigation strategies for future flood severely damage these communities (Lechowska, 2018).

Logistic regression model estimates

In the initial stage to find out robust estimates and logistic model limitations correlation matrix was erected. Matrix estimates illustrated a weak correlation in risk perception of various determinants of variables that confirms the absence of multicollinearity in variables. Hosmer–Lemeshow test was applied for measuring the fitness of logistic model illustrating the higher estimating value as a good fit of model (Greene, 2009; Webel, 2011) as in Table 4. In illustrating the possible influence of socioeconomic factors on flood risk perception, four models were applied in this study as indicated in Table 4. Odd ratio regression and ordinary regression square both were applied for each model counter checking in which model 1 and 2 were applied for estimating Dera Ghazi Khan and Rajanpur whereas model 3 was used for estimation of both communities collectively.

In district Dera Ghazi Khan, positive and significant association was estimated in the size of household and their flood risk perception illustrating that this is because of households' higher flood exposure with past events of floods. District Rajanpur and overall community's aspect estimated positive, while insignificant values indicated that household size has no influence on flood risk perception. Estimates illustrated the positive and significant relationship in schooling status and flood risk perception in both study districts in cumulative model indicating individuals with higher schooling would potentially perceive higher flood risk in these study Bait areas; findings are alike with studies of Qasim et al. (2015), Diakakis et al. (2018), Lechowska (2018), and Verlynde et al. (2019). The reason is that literate farmers have proper understanding of extreme climate change and environmental degradation and are more aware about future issues related to frequent and extreme floods that is why they have higher perception related to future uncertainties; findings are similar with the studies of Gkiouzepas and Botetzagias (2017), Ahmad and Afzal (2020), and Shah et al. (2021). In district Dera Ghazi Khan, household head employment status significantly and positively influences flood risk perception, whereas positive while insignificant status on Rajanpur and cumulative study area estimates. Individual's employment status enhances their communication among community and interaction to awareness variation effects of climate so employed individuals have increasing perception of flood risks rather than others; these findings are in line with the studies of Abbas et al. (2018), Eckstein et al.

Table 4 Study variables regressed to the indicators of risk perception

Study independent variables	Dera Ghazi Khan Model 1		Rajanpur Model 2		Cumulative study areas Model 3	
	OLS estimates	Odds ratio estimates	OLS estimates	Odds ratio estimates	OLS estimates	Odds ratio estimates
Respondents' age	0.037 (0.041)	1.027 (0.053)	0.034 (0.039)	0.937 (0.047)	0.029 (0.017)	0.986 (0.021)
Respondents' schooling	1.154*** (0.743)	2.979*** (1.863)	−0.278*** (0.321)	0.843*** (0.216)	−0.186*** (0.149)	0.891*** (0.124)
Size of household	1.326** (0.598)	0.314** (0.174)	0.913 (0.328)	2.764 (0.811)	0.154 (0.089)	1.243 (0.126)
Household head employment status	8.764* (3.561)	14,569.41* (54,768.2)	−1.583 (1.943)	0.473 (0.716)	0.586 (0.642)	1.497 (0.894)
Ownership of house	2.659** (1.473)	11.352** (12,874)	1.876*** (1.423)	0.167*** (0.279)	0.891** (0.476)	0.734** (0.176)
Earning members	−0.716 (0.804)	0.631 (0.398)	−0.698 (0.711)	0.543 (0.386)	−0.297 (0.349)	0.684 (0.173)
Income per month (PKRs)	−0.000 (0.000)	0.999 (0.000)	−0.000 (0.000)	1.000 (0.000)	0.000 (0.000)	1.000 (0.000)
Income sources	0.497 (0.732)	1.497 (1.023)	−0.897 (0.714)	0.413 (0.267)	0.074 (0.298)	1.056 (0.0387)
Past flood experience	1.243** (0.694)	3.658** (2.156)	0.798* (1.132)	1.576* (0.987)	0.798** (0.387)	1.487** (0.564)
Constants	−8.976** (2.893)	0.000** (0.000)	3.467 (2.513)	38.243 (139.543)	1.354 (2.065)	0.287 (0.341)
Hosmer–Lemeshow test		4.97		5.43		8.97
Pseudo R^2	0.2854	0.1687	0.1437			

Standard error indicated in parenthesis

***1% level of significance, **5% level of significance, *10% level of significance

(2018), Ahmad et al. (2019), Verlynde et al. (2019), and Martins et al. (2019).

In both study areas and cumulative estimated model, the variable of household ownership estimated the positive and significant results indicating that inhabitant household have higher risk perception of floods. Extreme and frequent floods cause extreme destruction to houses, and inhabitants have to bear cost of reconstruction or maintenance of their houses; these finding are in line with the studies of Ashfaq et al. (2008), Qasim et al. (2015), Gotham et al. (2018), Ullah et al. (2018), Scalise et al. (2019), Guardiola-Albert et al. (2020). In combine model 3 and both study districts, past experience variable was found to be positive and significant indicating that individuals have past experience of flood higher risk of flood perception rather than those with no experience of floods. These estimates indicated that individuals' experience of floods is well aware about severe destruction of their crops, livestock homesteads and losing valuable land due to erosion so they have higher perception of flood rather than those with no experience. Inhabitants of the study area have experienced to face consecutive floods in the current decade from 2010 to 2015 which shows their higher perception to flood hazards and destruction. These findings are alike with the studies of White (1942), Burton and Kates (1964), Siegrist and Gutscher (2006), Botzen et al. (2009), Qasim et al. (2015), Mills et al. (2016), Sullivan-Wiley and Gianotti (2017), Gotham et al. (2018).

The study variables such as respondents' age, number of earning members, income and sources of income in all three models have no influence in risk perception. According to estimates respondent's age does not influence the flood risk perception; these findings are alike with the studies of Qasim et al. (2015), Ullah et al. (2015), O'Neill et al. (2016), Gotham et al. (2018). Income variable have no influence on flood risk perception as results are in line with the studies of Ho et al. (2008), Botzen et al. (2009) and Gotham et al. (2018). These estimates illustrated that household member's economic status and respondents' age have no influences on flood risk perception of flood prone area inhabitants. Risk perception considered multifaceted psychological observable fact which can for a while be affected by many uncountable and unquantifiable factors (Lennart, 2000; Wisner et al., 2004; Booth, 2018). Estimates illustrated that factor persuaded risk perception differs spatially in both flood-prone communities which causes to draw conclusion caution. Methodology adopted holds up present literature on psychological features of flood risks particularly geophysical vulnerability, hazards proximately and past experience (Qasim et al., 2015; O'Neill et al., 2016). Findings entail that risk communications approach has to basically be targeted by household who have not formerly experienced floods and who are inhabited close to hazard sources.

Conclusion and suggestions

Flood risk appropriate understanding would persuade community readiness to implement precautionary measures. Hence, it is significant that the public must recognize flood risk to believe and sustain climate change and disaster risk reduction policies. To mitigate flood risk multidimensional impacts, it is necessary to adopt multidisciplinary methodology to combine all mechanisms of vulnerability, risks and behavioral evaluation. The specific objective of this study is to understand psychological features of many-sided flood risks in flash flood-prone area of Punjab Pakistan as this flash flood aspect in Punjab is not particularly given focus in literature. Estimates of the study indicated that socio-economic factors influencing flood risk perception were not similar in both study areas, therefore showing spatial discrepancy. Furthermore, for flood risk perception consideration, the study corroborates significance of respondents' schooling, ownership of house and past flood experiences in affecting perceived risk. Flood planners, disaster managers and policy makers have to embark on the realistic approach in rising under fire risk communications and strategies for flood risk reduction for the purpose that it may twist into practical measures on justification. This study also has some limitations. Firstly, this research aspect is focused on a limited study area due to financial constraints; there is a need to enhance to a wider aspect national level for appropriate understanding of such severe flood risks. Secondly, research is necessary to investigate the influence of socio-cultural norms and local institutions on flood risk perception. Thirdly, it is also supported that gender-based influence on flood risk perception must be give focus in the future. Lastly, the connections and associations in risk communication and risk perception are required to investigate empirically. Understanding and knowing the challenges of the psychological feature of risk perception should be enhanced for better community risk assessment and resilience for both disaster risk science and climate change adaptation.

Author contribution DA, analysis of data, methodology, results and discussion, conclusion and suggestions and manuscript writeup. DA and MA, finalization and proofreading of the manuscript. Both authors, reading and approval of 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

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

Consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare no competing interest.

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