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ORIGINAL PAPER

Flood hazards: household vulnerability and resilience in disaster-prone districts of Khyber Pakhtunkhwa province, Pakistan

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Abstract Pakistan is alarmingly exposed and vulnerable to flood disasters as a result of rapid urbanization that has not taken into account the threats posed by climate change. The devastating impacts of floods and other natural disasters put extra pressure on the country's budget and has driven the country's leadership to adopt a proactive approach instead of traditional, aid-based, approach, one that encourages the inclusion of disaster risk reduction measures within local disaster management policies. This research elaborates household vulnerability and resilience to flood disaster within two districts within Pakistan. It uses a dataset of 600 households collected through face-to-face interviews from two districts within the Khyber Pakhtunkhwa province that were severely affected by the 2010 flood and data from the Directorate of Khyber Pakhtunkhwa Provincial Disaster Management Authority. In a second step, we assigned weights to the selected variables for vulnerability (exposure, susceptibility and adaptive capacity) and resilience (with social, physical, economic, and institutional components) and used a subjective method (based on expert

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judgment) to weight these. The survey findings revealed that both study areas were highly vulnerable and had low resilience to flood disasters. The study findings indicated that community households in the flood-prone areas of Nowshera district were more vulnerable and less resilient than those in Charsadda, with a higher composite vulnerability index scoring and a lower composite resilience index score. This study shows that provincial and local disaster management authorities can play a vital role in reducing vulnerability and that more efforts are required to strengthen social, physical, economic, and institutional resilience through capacity-building training, preparedness, and awareness building about preventing and mitigating flood damage.

Keywords Climate change · Flood disaster · Vulnerability and resilience · Indices · Disaster risk reduction · Khyber Pakhtunkhwa · Pakistan

1 Introduction

The frequency and severity of 'natural' disasters have been increasing tremendously and have caused catastrophic losses, mainly due to high vulnerability and exposure of inhabitants and their properties (Khan 2013). It has been estimated that the numbers of humans exposed to the deadliest natural disasters will be doubled by 2050 (Wilkinson and Brenes 2014). Among the natural disasters to which humans are exposed, floods are the most common, leading source of fatalities, and bring many social and economic risks (Doocy et al. 2013). Estimates show that the frequency and intensity of flooding, especially in South and Southeast Asia, have increased over the past several decades (Krausmann and Mushtaq 2008; Hirabayashi et al. 2013). An emphasis on integrating disaster risk reduction and climate change adaptation within local disaster management policies has been highly recommended in order to reduce vulnerability and enhance resilience to natural disasters. Pakistan, which is the focal point of this study, has been one of the countries most affected by natural disasters over the last two decades, not only including floods, but also earthquakes and droughts (Abbas et al. 2015). People's exposure, and vulnerability to flood disasters, has increased over time, and policy makers need to pay serious attention to building effective mitigation and adaptation plans in order to reduce flood damages (Tariq 2013).

Vulnerability is defined as the potential threat to humans and societies from a catastrophic hazard (Alexander 2000) and depends on individuals' and society's ability to cope with, and adapt to, the negative impacts of the hazard (Maantay and Maroko 2009). The more limited a community's or society's adaptive capacity to hazards, the more vulnerable it will be. The adaptive capacity of Pakistan to natural disasters, including flood hazards, is very limited due to a lack of infrastructure, such as early warning systems, as well as a lack of awareness about advance mitigation options and financial and resource constraints. In an ideal situation, there should be high resilience and low vulnerability, but in the present scenario, Pakistan is highly vulnerable and has low resilience. In order to reduce vulnerability and to develop adaptive policy, information on the current level of vulnerability and adaptive capacities are first required (Shafique and Khan 2015). The main purpose of vulnerability assessments is to identify the vulnerable areas and possible risk reduction measures and to develop appropriate adaptive strategies. Vulnerability assessment mainly focuses on three main indicators, i.e., adaptive capacity, exposure, and sensitivity.

Disaster resilience is a concept that has recently come to the fore and is now widely used globally in disaster discussions. This was evident at the 2005 World conference on disaster reduction where much attention was paid to the growing efforts to address disaster resilience at the global, national, and local levels. The International Strategy for Disaster Reduction describes resilience as the ability and capacity of the community or society to achieve an acceptable level of functioning (ISDR 2004). Pelling (2003) explains resilience as the capacity to cope with and adapt to the stress of catastrophic hazards, while Cimellaro et al. (2010) define resilience as the ability to uphold a certain level of functionality for lifeline networks, buildings, and bridges. In the other various literatures on disaster resilience, the concept is broadly defined in terms of coping capacity (Authority 2011).

Generally, there is an inverse relationship between resilience and vulnerability as the resilience level of a household or community decreases the likely degree of damage from a given hazard intensity hazard (Fuchs and Thaler 2018; Proag 2014; Bahadur et al. 2010). Vulnerable communities have a lower level of resilience to the catastrophic impacts of flood disasters. The measurement of resilience involves taking into account a number of key parameters (Cutter et al. 2008a). One influential study (Joerin et al. 2012) uses six kinds of resilience indicator (social, economic, physical, ecological, institutional capacity, and technical viability). Each of these indicators has various subcomponents. The key indicators of social resilience include demographic characteristics, strong social networks, and knowledge about the specific hazard risk, communication, societal norms, strong values, and faith-based organizations (Joerin et al. 2012). The economic resilience indicators include income level, the value of property and assets, wealth sources, and revenue status (Cutter et al. 2008a). For institutional and organization resilience, Shafique and Khan (2015) report that the community involvement in various hazard reduction initiatives (such as hazard mapping, planning, building codes, communication, emergency services, hazard contingency, and operational plans) plays an important role. In many respects, physical resilience and technical resilience are more or less similar in nature. The key subindicators of physical and technical resilience are communication, means of transportation, irrigation, water storage systems, lifelines, a functioning sewerage system, the quality of the housing stock, and institutional establishment (Joerin et al. 2012).

In Pakistan, most flood research has focused on the economic effects of floods on peoples' livelihoods or agricultural productivity, and little work has been done on flood vulnerability and resilience at the household level. This study is the first of its kind (that we know of) that measures flood vulnerability and resilience at the household level in two flood-prone districts of the KP province of Pakistan. Specifically, the study has three objectives: (1) to assess vulnerability, including exposure, susceptibility, and the adaptive capacity of households; (2) to examine households' resilience to flood hazards; and (3) to compare vulnerability and resilience across the two districts.

2 Materials and methods

2.1 Study area description

The study was conducted in two rural areas of the KP province (Fig. 1; Shah et al. 2017). KP province was chosen as the study area because it is plagued by natural disasters, such as floods from the Indus River, and earthquakes that occur since it lies in the weak tectonic zone.[1] These floods usually happen every other year during the monsoon season and bring catastrophic damage to property and human lives. KP has experienced various devastating

[1] International Disaster Database EM-DAT, Centre for Research on the Epidemiology of Disasters.

floods in the last two decades. There have been 22 recorded serious floods between 1950 and 2014 (Shah et al. 2017; Yaqub et al. 2015), of which the one in 2010 was the most disastrous, affecting millions of households and their livelihoods in the province. Elsewhere in the province's mountainous regions (in the north), flooding occurs due to landslides and torrents and rapid glacial run, glacial lake outburst floods[2] can also (though quite rarely) be another cause of flooding, and avalanches occur frequently during the winter season. In the southern part of the province, drought frequently occurs during the summer. As a large province, KP has a climate that contains extremes and is representative of most of the climate types found in Pakistan. Rainfall in the province also varies enormously: Most of it is usually dry (Shah et al. 2017), although the eastern side of the province is known to be the wettest part of Pakistan especially during the monsoon season, between June and mid-September.

2.2 Sampling strategy and data collection

The primary data collection was done between February and June 2016. About 600 households were interviewed targeting mainly the household head in a field survey. The majority of the household heads we spoke to were male due to the strong cultural values and norms of the Pakhtun tribe, which inhibit females coming to the forefront (Ainuddin and Routray 2012). KP province was selected as the main study area due to its exposure and vulnerability to extreme climatic risks and natural disasters like floods, earthquakes, heavy rains, and cyclones. The province has experienced eight major flood disasters during the last 25 years, of which the 2010 flood was the most disastrous, affecting 24 out of 25 districts in the province (Ullah et al. 2015; Shah et al. 2017). The study adopted a multistage sampling technique to select the study sites and sample households. In the first stage of sampling, we chose two districts out of the 24 districts affected by the 2010 flood, using purposive sampling. In the second stage, three Union Councils (UCs) with a high exposure to flood risks were selected randomly from each district and then two villages were selected randomly from each UC using an assessment report by the Khyber Pakhtunkhwa Provincial Disaster Management Authority (KP-PDMA 2014). In the last and third sampling stage, we selected about 50 households from each village through simple random sampling, using lists of affected households provided by the Nazims (administrative head) of the UC.[3] In addition to the household questionnaire, we designed a separate questionnaire for the director of KP-PDMA to get expert opinions to enable us to assign weights to each variable. A structured pretested questionnaire was used for data collection from selected household heads. Our enumerators were graduate students from local university who were trained well before starting the data collection The household-level data were entered into SPSS version 16 software for analysis, and the household vulnerability and resilience indices were calculated using MS Excel (Table 1).

All the interviews were conducted in the context of shared research principles and research ethics (Bogner et al. 2009). Formal permission was sought before initiating the household interview, explaining the purpose and objectives of the study and usage of data for research purposes. Respondents (mainly female household heads) who refused to participate in the survey at the briefing stage were replaced by other household heads.

[2] Glacial run is a phenomenon involving flash floods that occur when the melting or breaking off of glacial ice releases torrents of water that were previously dammed. These are usually glacial lakes that have been prevented from escaping by a glacier that are suddenly released when the ice becomes thinner.

[3] A union council is an elected local government body headed by a Nazim (equivalent to a mayor).

Fig. 1 Khyber Pakhtunkhwa province, showing the two selected study districts (Shah et al. 2017)

2.3 Choosing components and indicators

2.3.1 Vulnerability

For the current study, we selected three components of vulnerability: exposure, susceptibility, and adaptive capacity (IPCC 2007) to measure flood vulnerability at the household level. Many variables used in the current study cannot be quantified. We have used the index to measure the vulnerability and provide insights into the underlying processes and determinants which could be of help to policy makers and other development practitioners. For the first vulnerability component (exposure), we used two indicators: past flood experience and the number of houses within the flood-prone area. Susceptibility or sensitivity is measured through various indicators, i.e., poor building materials, disabled people (both physical and psychological), dependents (households with members more than 60 years old and/or less than 15), illiteracy, coping mechanisms, multi-unit structures (housing units with three or more units), fatalities (deaths due to flood events), and livestock losses. The last and third vulnerability component, adaptive capacity, is measured through indicators which include access to information (weather information) and credit,

Table 1 Total affected villages, affected households, and selected villages in the study area. *Source:* Communications with the relevant Nazims 2016

District	Union council	Total affected villages	Selected villages	Affected households*
Charsadda	Agra	10	Agra Payan	400
			Geedar Kally	450
	DolatPura	7	Sooker	250
			Naqhi	200
	Do-Sehra	6	Sher Bahadar	400
			Do-Sehra	300
Nowshera	Akbar Pura	8	Banda Malla Khan	350
			Tarkha	300
	PirSabak	6	Pirsabak	470
			Zandy Banda	360
	Mohib Banda	7	Camp Koruna	550
			Banda Shaikh Ismail	500

*50 households were selected randomly from each selected village for the survey

social networks (membership or informal contacts with other members of the community), education (up to 10 years of schooling), working age group (household members between 15 and 60 years), multiple income sources, and employment.

2.3.2 Resilience

We took four components of resilience: social, physical, economic, and institutional (Joerin et al. 2012), to measure the resilience level of the households across the two severely affected districts of KP province. The resilience for each component is measured by using indices, and variables for each component of resilience were selected from the extensive available literature on flood disaster. One of the subcomponents of resilience is social resilience, which refers to the social capacities of households in flood-prone communities to combat flooding risks. The socioeconomic and demographic characteristics comprise a set of variables, i.e., age, education, past flood experience, disability, religious beliefs (that a flood is the result of God's will), health insurance, access to a vehicle, and a social network. The economic resilience component deals with house ownership, employment, female labor, and multiple livelihood sources. The institutional resilience component is concerned with the efforts that have been made by the relevant disaster management departments to ensure better-quality services through the provision of awareness, recovery, and capacity-building training programs. In the institutional resilience component, we have included hazard reduction programs, flood-warning information, hazard mitigation training, zoning and building code training, flood awareness and management, recovery assistance from the government or NGOs, first aid training, livelihood restoration, and water sanitation and hygiene training (PHAST). The last and fourth component of household resilience is physical resilience and includes variables for building materials (whether or not houses are constructed with bricks), the location of the house within 1 km of the source of flood risk, and local infrastructure (i.e., houses near government-built structural measures, e.g., flood protection/retaining walls).

2.4 Calculating the index

A normalization process is needed to be done to get the variable values within a comparable range (Nelson et al. 2010; Gbetibouo and Ringler 2009). We took the percentages of all the chosen variables of household vulnerability and resilience to avoid normalization process. As mentioned before, three household vulnerability components (exposure, sensitivity, and adaptive capacity) and four resilience components (social, physical, economic, and institutional) were used to measure the vulnerability and resilience levels among households in the selected districts. The next step was to assign weights to these variables. For this purpose, we used a subjective method, based on expert judgment (Cutter et al. 2010; Vincent 2007; Adger and Vincent 2005; Vincent 2004; Davidson 2006; Esty et al. 2005). However, the literature provides no clear guidance about the most appropriate method, which appears to vary according to the circumstances. Given the importance of context, we asked the director of the KP-PDMA to call a consultative meeting and invited all the relevant disaster management department heads for their valuable inputs. Prior to the meeting, the participants were briefed about the research and shared relevant literature with them. They were asked to assign weights to each variable in Tables 2 and 3, ranging from 0 (less vulnerability and less resilience) to 1 (high vulnerability and high resilience) to get variable vulnerability index (VVI) and variable resilience index (VRI). For each household vulnerability variables (Table 2), the low values show less vulnerability and high values show high vulnerability. Similarly, the low values against each variable in Table 3 show that the variable is less resilient (value close to 0) and variables with high values are more resilient (value close to 1). However, for those variables whose high values show less resilience, the scale was reversed ranging from 1 (less resilience) to 0 (high resilience) in the questionnaire designed for the director of KP-PDMA. The component vulnerability indices (EVI, SVI, and AVI, representing exposure, sensitivity, and adaptive capacity, respectively) were calculated by taking the averages of their VVIs. The composite vulnerability index (CVI) (Karmaoui et al. 2016) for the two selected study areas was calculated by the formula shown below

$$\text{Flood vulnerability index (FVI)} = \frac{\text{Exposure} * \text{Sensitivity}}{\text{Adaptive capacity}} \tag{1}$$

Similarly, the component resilience indices were made up of a social resilience index (SRI), physical resilience index (PRI), economic resilience index (ERI), and institutional resilience index (IRI). The component resilience index (CRI) was calculated by taking an average of the respective VRIs. For the composite resilience indices (CRI), we added the four-component RIs and divided it by four.

3 Results and discussion

3.1 Descriptive statistics

The descriptive statistics data for household vulnerability to flood disaster revealed that the majority of the households in Nowshera and Charsadda had experienced flooding. Households in Nowshera resided closer to the river source than those in Charsadda district, one of the main reasons why flood damages were more frequent there. About 6% of the households in both districts reported human losses due to past floods and 64% of the

Table 2 Household vulnerability indices for the chosen study areas. *Source:* Derived from field survey 2016

S. no.	Vulnerability indicators	Nowshera		Charsadda	
		% value	VVI	%value	VVI
1	*Exposure*				
	Past flood experience	82	0.83	77	0.78
	Houses constructed near the river	73	0.81	67	0.74
	EVI		0.82		0.76
2	*Sensitivity/susceptibility*				
	Poor building materials	64	0.86	70	0.93
	Disabled people	3	0.04	6	0.08
	Dependents	12	0.65	14	0.96
	Illiteracy	50	0.83	53	0.89
	HH coping mechanism	81	0.90	62	0.69
	HH multi-unit structure	18	0.37	13	0.27
	Human loss	6	0.13	6	0.11
	Animal loss	64	0.67	48	0.50
	SVI		0.56		0.55
3	*Adaptive capacity*				
	Information about extreme weather conditions	37	0.41	30	0.34
	HH access to credit facilities	20	0.27	23	0.31
	Social networks	3	0.22	10	0.67
	Education	50	0.51	47	0.48
	Working age group	63	0.70	61	0.67
	Multiple income sources	30	0.75	36	0.90
	Employment	43	0.51	40	0.47
	AVI		0.48		0.55
	Composite vulnerability index (CVI)		0.95		0.77

households in Nowshera and 48% in Charsadda reported animal losses due to past floods. The majority of the houses in both study districts were made of poor building materials, mainly mud. There were more households with disabled people in Charsadda (6%) than in Nowshera (3%). About half of the households head in both districts were illiterate. We found that flood-coping strategies were more widely adopted in Nowshera (81%) compared with Charsadda (62%). This might be due to a larger number of dwellings in Nowshera being multi-unit houses, a less frequent phenomenon in Charsadda. Households in both districts reported having limited access to information and access to credit compared to other regions in the province. Social networks in both districts were very weak due to the absence of any formal or informal associations. More than 60% of the household members were between 15 and 60 years old and able to work. About one-third of the households in both districts have multiple livelihood sources and 30–36% household heads in Nowshera and Charsadda districts were employed.

Table 3 Household resilience indices. *Source:* Derived from field survey 2016

S. no	Resilience indicator	Type of indicator (%)	Nowshera		Charsadda	
			% value	VRI	% value	VRI
1	Social Resilience	Percent of household head age	16	0.16	28	0.29
		Literacy status of the HH	50	0.51	47	0.48
		Past flood experience	82	0.83	77	0.78
		Physical disability	7	0.13	6	0.10
		Household head who believed flood is the act of God's will	40	0.62	58	0.89
		Health insurance	15	0.33	2	0.05
		Own vehicle	8	0.09	6	0.06
		Social networks	3	0.11	10	0.33
		SRI		0.35		0.37
2	Economic resilience	Homeowners	83	0.85	77	0.78
		Employment	43	0.67	40	0.62
		Household income	4	0.05	3	0.04
		Female labor force participation	11	0.38	14	0.46
		Multiple livelihood sources	30	0.46	36	0.55
		ERI		0.48		0.49
3	Institutional resilience	Participation in hazard reduction programs	7	0.10	6	0.08
		Flood warning	37	0.37	30	0.31
		Access to credit	20	0.25	23	0.29
		Zoning and building codes standards	1	0.01	1	0.01
		Humanitarian assistance from Govt. or NGOs	47	0.59	60	0.75
		First Aid	9	0.10	10	0.11
		Livelihood restoration	10	0.11	9	0.10
		Water sanitation and hygiene (PHAST training)	10	0.14	20	0.29
		IRI		0.21		0.24
4	Physical resilience	Building material	36	0.36	30	0.30
		Location	73	0.73	67	0.67
		Infrastructure	4	0.04	5	0.05
		Housing units with second floor	10	0.19	11	0.21
		Multi-unit structure	18	0.37	13	0.27
		PRI		0.34		0.30
		CRI		0.34		0.35

3.2 Results from the household vulnerability indices

3.2.1 Exposure

Exposure is the extent to which the community is troubled with catastrophic environmental stress (Bosher et al. 2009). In this study, we separated the indicators of exposure into two categories: past flood experience and the location of the housing units built in proximity to the river (Table 2). The results in Table 2 show that the exposure was higher in Nowshera district (0.82) than in Charsadda district (0.76) and are more likely to experience flooding damages. These findings are in line with studies by Qasim et al. (2017) and other studies (Braun and Aßheuer 2011; Bradford et al. 2012; Miceli et al. 2008; Ludy and Kondolf 2012) which show that houses located near to a river are more likely to be affected by flood damage.

3.2.2 *Sensitivity/susceptibility*

Sensitivity or susceptibility is defined as the extent to which a system is affected by various internal or external disturbances or series of disturbances (Gallopín 2003). The susceptibility index values for both districts show a high sensitivity to flood hazards, due to a combination of different factors. Coping mechanisms, household construction materials, and illiteracy are key factors influencing the sensitivity of households to floods. Effective mechanisms (households' preparedness for flood hazards through adopting different mitigation strategies) will reduce sensitivity of households to floods as these households will be able to better cope with a flood and thereby reduce the damage to their assets or livelihoods. The construction material used for building houses was the second most important component of sensitivity/susceptibility in the study areas. Houses built with mud are more likely to be damaged by flood as they are less resilient to flood water and may be easily destroyed, leading to substantial loss to the household through damaged property, food, and in the worst-case scenario loss of livestock or human lives. Literacy is another important component of the household sensitivity to flood hazards: Less-educated households are less likely to adopt advance coping strategies and are more sensitive to floods due to lack of forward-looking behavior. Loss of animals and the proportion of dependents (Balica et al. 2009; Scheuer et al. 2011) are two other important factors affecting the sensitivity of households to flood hazards. In both districts, livestock are an important factor in sustaining household food security, and any loss of livestock may have a severe impact on the daily calorific intake of household members. Similarly, more dependents (children or elderly people) in a household increase its sensitivity to flood hazards. The dependents may require additional care and sometimes special food that may not be possible to arrange during the time of the flood. Construction of multi-story houses is another important factor that contributes toward household sensitivity to flood hazards as multi-story houses decrease the flood sensitivity. These findings are in line with other vulnerability studies (e.g., Piya et al. 2012; Kissi et al. 2015) that indicate the role of education, property damages, and depending on the sensitivity to floods. The overall sensitivity/susceptibility index results of our study are in agreement with the findings of Qasim et al. (2017), who found that both study regions are vulnerable and prone to flood disasters.

3.2.3 *Adaptive capacity*

Adaptive capacity is defined as the ability of an individual, household, or community to devise and execute different adaptation measures adopted at the household level to deal with adverse outcomes as a result of unforeseen climate-induced events such as flood (Adger et al. 2005). The adaptation process entails not only drawing on previous experiences of disasters to deal with the current climate, but also apply previous disaster experience for future climatic risks (IPCC 2007; Klein et al. 2014: Adger et al. 2005; Gallopín 2003). Table 2 shows that the adaptive capacity in Charsadda district (0.55) was higher than in Nowshera (0.48). This implies that households in Charsadda district have more adaptive capacity and, as a result, are less vulnerable to flood disaster. Some factors can be identified as contributing to some households having a higher adaptive capacity, including social networks, education, the proportion of household members of working age, and having multiple income sources. A strong social network will increase the adaptive capacity of households and reduce the adverse impact of catastrophic flooding. When the household head is an active member of a local community-based organization (CBO) and maintains formal or informal contacts with other members of the community, this helps reducing vulnerability to flood disaster. Education was another important factor in the study areas: Illiterate people lack knowledge about potential adaptation measures and remain highly vulnerable to disaster risks, while educated people have more knowledge about preventive measures which makes them more resilient and less vulnerable (Dufty 2008; Gwimbi 2007). Most the households in both study areas had a large number of working age people giving them more financial resources and making it easier to afford, sometimes costly, adaptation measures. Similarly, households with multiple income sources are less vulnerable to flood disaster. This is because people with higher incomes are more likely to live further away from flood-prone areas and/or be more likely to be able to afford sturdy building materials. Thus a higher income increases households' adaptive capacity and reduces their vulnerability. Further, employment is another factor that can influence household vulnerability to disaster risks. The more people employed in the household will have more options to invest in flood adaptation measures. Access to information sources and credit facilities were other important factors in both study areas. Access to credit or loans and good information can provide a safety net against all types of natural shocks, and both factors reduce vulnerability to disaster risks. These findings are supported by other vulnerability studies (e.g., Fuchs and Thaler 2018; Balica et al. 2009; Cutter et al. 2003; Qasim et al. 2015) which report that the social networks, education, working age of the people, multiple income sources, and employment have a significant role in the households' adaptive capacity in dealing with flood disaster.

3.3 Results from resilience

3.3.1 Social resilience

Social resilience is the ability of an individual, or community inhabitants, to deal with risks or disturbances as the outcome of environmental, social, or political change (Adger 2000) while maintaining the sustainability of their livelihoods (Adger et al. 2005). It is clear from this definition that social resilience has social, economic, and spatial dimensions and requires interdisciplinary understanding and analysis. The social resilience results illustrated in Table 3 captures the different social characteristics of the households within the chosen study areas. The social resilience index values show that both study areas have low resilience due to the high number of household heads who believed flood is the act of God's will (Schmuck 2000). This strong religious beliefs lead household heads in both study areas to not take any preventive measures to deal with flood disaster. Other factors that strengthen social resilience are: past flood experience (Cutter et al. 2008a), the literacy status of the household heads (Elena-Ana et al. 2013; Norris et al. 2008; Morrow 2008), disability (either physical or psychological) (Heinz Center 2002; Elena-Ana et al. 2013) and age (Poussin et al. 2014). Household heads with past flood experience have more knowledge about the adaptation measures to adopt. The high percentage of literate household heads with up to 10 years of schooling should also attribute to high resilience in both study areas since education enhances individual resilience and ability to deal with disaster risks (Shah et al. 2017). In addition, a lower percentage of disability (physical or psychological) is another important factor that may enhance social resilience in the sampled areas. Households with health insurance (Heinz Center 2002; Elena-Ana et al. 2013), access to a vehicle (Tierney 2009), and a social network (Bohensky and Leitch 2014) also are likely to exhibit higher social resilience than those lacking these attributes. The social resilience index findings of our study are in line with previous resilience study findings in the same region by Qasim et al. (2015) showing that the both study regions have low social resilience and the inhabitants in these regions are encouraged to adopt preventive measures to enhance their resilience level to deal with flood disaster.

3.3.2 Economic resilience

The second component of resilience resides in the economic activities of households. It is defined as the ability of an individual or system to function normally when shocked. Economic resilience is aligned with the efficient allocation of resources in response to disaster risks (Rose 2004, 2007). The economic resilience values shown in Table 3 illustrate that both study areas had high economic resilience (0.48 and 0.49 for Nowshera and Charsadda, respectively) and the various factors that are responsible for this higher economic resilience. Employment (Tierney et al. 2002; Poussin et al. 2014), home ownership, and multiple livelihood sources (Motsholapheko et al. 2012) of the household heads are the key factors influencing household economic resilience to flood disaster. The households with multiple livelihood sources have more economic stability to deal with flood disaster since they have more (and more diverse) financial resources and adoption options to safeguard their livelihoods from disaster risks. Diversified income sources by the household heads in both study areas leads to quick recovery and rehabilitation from flood disaster. The high level of household heads with employment is another factor responsible for higher resilience in both study areas, for employment reduces poverty and increases the economic capacity of the household to deal with disaster risks. Household heads who are home owners are more likely to consider adopting different preventive measures to safeguard their houses (Norris et al. 2008; Cutter et al. 2008a) as they are more likely to invest in building flood-resilient structures, thereby increasing their resilience. The other economic resilience variables such as female labor force participation (NRC 2006) and the income (Hewitt 2014; Poussin et al. 2014) of the household heads attributed to low economic resilience in both study areas. This is true in the sense that women are culturally restricted to staying within the walls of their compounds obliging the men of the household to amass the financial resources to support the family and recover in the event of a flood disaster. The findings of the economic resilience index are in line with other resilience studies (e.g., Poussin et al. 2014; Motsholapheko et al. 2012) showing that households with employment, house ownership, and multiple livelihood sources are less likely to be affected by, and more resilient to, flood disaster.

3.3.3 Institutional resilience

From the flood disaster perspective, the third component, institutional resilience, refers to the existence of zoning and building code standards (Cutter et al. 2008a, b) and the access that household heads have to hazard reduction programs (Burby et al. 2000; Godschalk 2007), flood warning (Bohensky and Leitch 2014), credit, humanitarian assistance (e.g., non-food relief items, hygiene kits) (Tulane University 2011), first aid training, water, sanitation and hygiene-related capacity-building training (PHAST), and livelihood restoration programs (Table 3). The institutional resilience values show in Table 3 show that both study areas had low institutional resilience (0.21 and 0.24 for Nowshera and Charsadda districts, respectively) due to the low access households reported to these facilities. There were marked differences between the two districts in terms of access to factors that enhance institutional resilience. For example, in Nowshera 20% of households reported having access to credit facilities or humanitarian assistance (compared to 23 and 60%, respectively, in Charsadda district), while in Charsadda district less than 10% of housholds participated in flood hazard reduction programs or having access to advance flood warning (30%) (compared to 7 and 37%, respectively, in Nowshara). However, in both districts, institutional resilience is significantly lower than the other types of resilience, indicating a lack of engagement between the communities and local disaster management institutions that could protect the social system within the community (Norris et al. 2008). Greater levels of participation in hazard reduction programs would enhance the knowledge and skill of households and help them ensure their safety while facing disaster risks. This highlights the need for the relevant local authorities to roll out effectively and accessible training and other programs in order to enhance households' preparedness for flood disaster. It also highlights the need for the availability of early flood-warning systems, the current lack of which is a major cause of low institutional resilience in the study areas. Advance flood warning can help households to adopt a proactive approach and to take preventive measures before a flood disaster or be prepared for evacuation, should that be necessary. Access to credit is another important factor affecting institutional resilience in both study areas. The majority of the household heads did not have access to credit facilities, due to the complicated institutional procedures involved, and these households are likely to be less resilient than those that do have access to credit. Households with more financial resources have more options to settle in areas that are not at high risk of flooding, or if they do, to adopt more effective preventive measures. First aid training is another important factor of institutional resilience, and the low percentage of household heads who have received first aid training contributes to low institutional resilience to flood disaster during the rescue and relief operations in an emergency situation. Again, this highlights the potential role of local government which can contribute to saving human lives during disasters by ensuring that there is a pool of local inhabitants who have been trained in providing first aid. Similarly, the relative absence of zoning, building code standards, and livelihood restoration plans contributes to the low institutional resilience in both study areas. This highlights the need for the relevant disaster management institutions to come together and establish risk reduction measures, planning procedures, and local capacity building that would help mitigate against the worst effects of flooding and help the local population more quickly recover from catastrophic flood impacts. The low institutional resilience index results for the current study are supported by the study findings of Qasim et al. (2016) who show the need for local institutions in these regions to come forward, establish prevention and emergency plans, and encourage the inhabitants of flood-prone areas to adopt proactive measures to lessen the adverse impacts of flood disaster.

3.3.4 Physical resilience

The fourth and last component of household resilience, physical resilience, is mainly an appraisal of households' response and ability to recover from disaster risks (Table 3). It provides an overall picture of households' property that could be vulnerable to sustaining economic losses. The physical resilience value of the Nowshera district (0.34) was found to be slightly higher than in Charsadda district (0.30), but it is still low in both areas, due to a number of factors. For instance, majority of households in both study areas were located within a 1-km radius of the main river source (Bohensky and Leitch 2014) and often experience different types and magnitude of flood disaster. Further, in both areas, only a low percentage of the households (36% in Nowshera and 30% in Charsadda) have houses constructed with sturdy building materials, such as bricks and concrete, and this further diminishes their physical resilience. Most of the respondent's houses are built of mud (Bohensky and Leitch 2014) which is easily destroyed or damaged by a flood. The other important factor in this study is resilient infrastructure (Cutter et al. 2010). For instance, majority of the households in both study areas were living far from the reservoirs, embankments, levees, and flood protection walls constructed by the government and NGOs, which can protect households and their property from the adverse impacts of flood disaster. In addition, the relative low resilience of infrastructure, either housing with a second floor (Papathoma-Koehle et al. 2016) or multi-structure units (Schinke et al. 2016), also contributes to the low physical resilience in both study areas. Another critical aspect of low physical resilience in the study districts is the lack of joint mitigation strategies among the people. Households were mainly found to be investing in individual preventive measures rather than collective ones. The findings of the physical resilience index are in line with other resilience studies (e.g., Cutter et al. 2010; Bohensky and Leitch 2014) showing that inhabitants living in the vicinity of the main river source often experience floods and adverse impacts compared with the household who are away from the river sources.

3.4 Comparative analysis of flood vulnerability and resilience indices across the two chosen study areas

We also compared household vulnerability and resilience to flooding disaster between the two study areas, based on the selected variables for each component (Figs. 2 and 3). For this purpose, we categorized the indices into three subcategories, with 0 considered as low vulnerability and/or low resilience, 0.5 as a medium level, and 1 as high vulnerability and/or high resilience. Figure 2 shows that Nowshera district was comparatively more

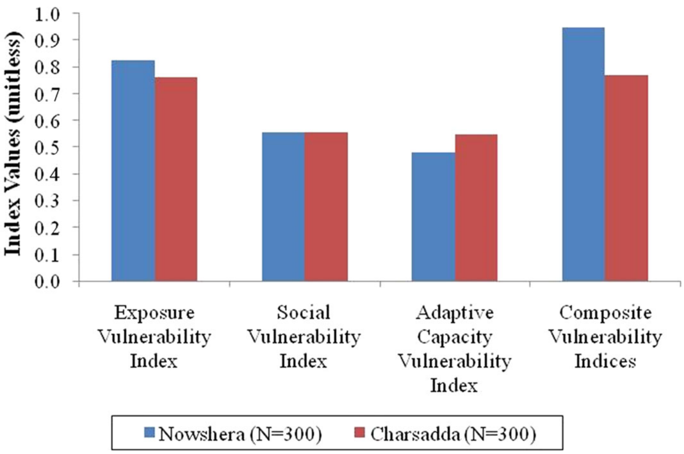

Fig. 2 Household vulnerability indices across chosen study sites

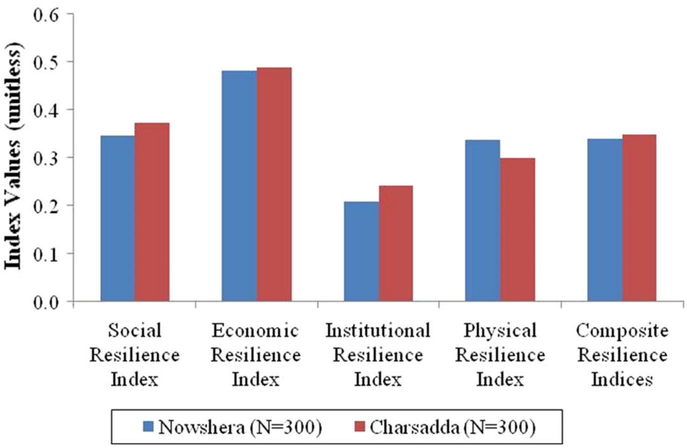

Fig. 3 Household resilience indices across chosen study sites

vulnerable to flood disasters due to high exposure (0.82), susceptibility (0.56), and adaptive capacity (0.48) values (EVI, SVI, and AVI, respectively). This suggests that more efforts are required by the relevant disaster management departments to work closely with the local population and devise low-cost and effective flood prevention and mitigation strategies. Similarly, the composite vulnerability indices (CVI) (0.95 for Nowshera district and 0.79 for Charsadda district (Fig. 2 and Table 2) were still quite high and should provoke the relevant disaster management departments to establish effective policies at the local level to make flood-prone communities less vulnerable and more resilient to flood disaster risks.

Figure 3 shows the resilience indices values across the selected sites at the household level. The survey findings (Fig. 3) revealed that Charsadda district was less vulnerable and more resilient due to higher social, economic, and institutional scores (SRI-0.37, ERI-0.49, and IRI-0.24, respectively, although physical resilience (PRI) was slightly higher in Nowshera district (0.34) than in Charsadda (0.30). The reason behind this is that the majority of houses in Nowshera were built with brick or other reinforced material which are resistant to flood water or contain multiple units. Overall the composite resilience indices values for the two sites were low: 0.34 and 0.35 for Nowshera and Charsadda, respectively (Fig. 3). In both cases, the composite resilience values were pulled down by low institutional resilience.

4 Conclusion and suggestions

This research study allows us to draw two main conclusions, concerning household vulnerability to flooding disaster, and household resilience. Pakistan is blessed with abundant natural resources, but due to lack of expertise, the unsustainable utilization of available natural resources, rapid growth, environmental degradation, inadequate hazard forecasting (especially advance hazard warning systems), awareness, and lack of vulnerability assessments, a large proportion of the country is highly vulnerable to natural disasters, particularly flooding. In an ideal situation, communities would have low vulnerability and high resilience, but in the present scenario, at least in our two case study districts, the opposite holds: high vulnerability coupled with low resilience. Climate change has increased the frequency and severity of floods, and this has prompted the government to take some bold steps and put disaster management policies and planning in place at the local level with the aim of building communities that are resilient against catastrophic extreme weather events. The vulnerability indices (EVI, SVI, AVI) for the two study areas help us to compare how they are faring in terms of exposure, sensitivity, and adaptive capacity. The composite vulnerability indices show that both study areas are prone to flood disasters, although Nowshera district is more vulnerable to flood disasters than Charsadda district. This vulnerability can be reduced by more effective (or more effectively policed) zoning policies to restrict houses being constructed in the flood-prone areas, which necessarily involves identifying and providing infrastructure to alternative sites, further away from flood risk. The sensitivity of households to flood disaster can be overcome by increasing literacy and arranging awareness programs which enable the people to shift from traditional structures (mud) to more flood-resistant ones (concrete or bricks). Similarly, the adaptive capacity of the households in flood-prone communities can be improved through the provision of employment opportunities, multiple livelihood sources to earn sufficient income, and greater efforts by the government and (NGOs) in working closely with affected communities to address their needs. Institutional services, e.g., access to extreme weather information and credit facilities should be locally accessible.

Parallel to this, our resilience indices (Fig. 3) show that the chosen areas have low resilience to flood disasters due to low component indices values (SRI, ERI, IRI, and PRI). The survey results also revealed that the majority of the sampled household heads reported that floods come due to God’s will that cannot be resisted, which leads them to think that it is pointless to take appropriate preventive measures. The government could arrange awareness-raising programs for religious leaders and other influential persons to better educate people in this respect, to bring about a positive change in the attitudes of flood-affected communities and thereby improve social resilience. Establishing strong social networks between communities and government and/or NGOs is also another way to strengthen social resilience which will help build trust, which is an important prerequisite for working together in case of any devastating natural events. Although, in both study areas, the economic resilience component was relatively strong, and it was slightly higher in Charsadda due to the higher ratio of the female labor force engaged in various income generating activities. The government should pay more attention to female labor force participation by providing social attitudes and enable women to make more contribution to household livelihood. Institutional resilience was found to be very low, 0.21 in Nowshera district and 0.24 in Charsadda. This highlights the need for local government and relevant disaster management departments to recognize the importance of different capacity-building activities: training, public participation in hazard reduction programs, zoning, and building codes, first aid, and hygiene-related training, which would make people more resilient to the impacts of catastrophic flooding. Local government should ensure that up-to-date information and credit facilities are available close to people’s doorstep in order to combat flood risks. With regard to physical resilience, there is a clear need for local governments to restrict residential building in the proximity of flood-prone areas and to encourage people to construct their houses with flood-resistant materials (bricks and/or cement). The findings of this study provide some detailed empirical evidence on the state of households’ vulnerability and resilience in the flood-prone communities and could be the basis for further research in the field of flood disasters and for governmental action to reduce affected communities’ vulnerability to flooding and increase their resilience.

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