Risk Assessment of Flood Prone Urban Areas of Pakistan

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Abstract

Flood disasters and its consequent damages are on the rise globally. Urban areas having underprivileged populations and extensive elements exposed are the most vulnerable. Pakistan has seen an increase in floods severity and damage in the recent decade. Traditional disaster research has been shifted from loss estimation and damage assessment techniques to risk assessment of hazard prone communities. This study measures flood risk at household level of flood prone urban areas of Pakistan. Three communities from different urban centers have been selected based on high flood risk, frequency and population sizes. This survey based study uses 210 questionnaires for analysis. 54 indicators have been used for formulation of risk indices. Classes have been developed and weights have been allocated for every indicator according to their vulnerability. Disaster risk assessment has been done using hazard, exposure, sensitivity and adaptive capacity components. The risk analysis highlights households which are high risk, moderate risk and mild flood risk. Statistical tests confirm that significant difference exists among urban areas. About 7% percent of households are highly vulnerable to flood risk, out of which none of the households belong to Sialkot city. The study recommends appropriate programs and strategies needed for reducing flood risks.

Keywords: Risk Assessment, Flood, Pakistan, Urban, Disaster Risk Reduction

1. Introduction

Throughout the world natural disasters have grown in intensity and frequency (Abramovitz & Starke, 2001; Ahmed, 2013; Khan & Rahman, 2007; Kreimer et al., 2003). In recent decades, a holistic approach for disaster risk management has taken over technically oriented approaches like damage assessment and loss estimation techniques (Strunz et al., 2011). This holistic approach is now focusing on identifying disaster risks of communities. Risk assessment is becoming a matter of concern for disaster risk and sustainability sciences (Zhou et al., 2015). Cities are regarded as engines of economic growth and epitomes of civilization (Pelling, 2012). Urban growth has picked up its pace in already hazard-exposed countries and with it, increasing risks and vulnerabilities.

Asia is considered as “supermarket of disasters” (James, 2008). Forty percent of Asia’s population is residing in urban areas, and by 2025 it will be around fifty percent. Hydro-meteorological events are most common in South and South East Asia as compared to the world (ADPC, 2012). In Pakistan, natural hazard exposure falls under the category of moderate to severe (Bilham et al., 2007; Maqsood & Schwarz, 2010). And floods are the most widely occurring disaster in Pakistan (NDMA, 2012; Tariq & Van de Giesen, 2012). Developing countries like Pakistan are focused more on provision of basic facilities like water, food, education and health. Poverty, rapid urbanization and population growth, political instability, insecurity and terrorism leaves little room for disaster management. Disaster management system of Pakistan still favors top-down approaches (Halvorson & Hamilton, 2007; James, 2008), and disaster response approach (Bilham et al., 2007; Khan, 2007).

Risk can be simply put as the combination of the probability of an event and its negative consequences. It can be defined as the potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period (UNISDR, 2009). Hazard can be defined as a potential threat to humans and their welfare (Smith & Petley, 2008). Once a potential hazard is identified, the risk emerges due to presence of exposed elements. This exposure can be defined as physical features of human society (infrastructure) and economic systems (livelihoods) which can be affected by potential hazard (Birkmann et al., 2013). However, different elements exposed are subject to different degree of vulnerability which can be explained through sensitivity. Sensitivity can be defined as the predisposition of elements at risk to suffer harm (Maiti et al., 2015) or "a tendency/degree of elements at risk" (social and environmental) that can come to any harm as the result of a hazard (Birkmann et al., 2013). The last component of disaster risk is the capacity. It is the "ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters." (UNISDR, 2009).

Diverse definitions, approaches and quantitative methods are existing in disaster risk reduction and climate change adaptation literature due to various disciplinary approaches (Birkmann, 2006). It is generally acknowledged that disaster risk is a function of hazard (H), vulnerability (V) and capacity (C).This study integrates climate change adaptation (CCA) philosophy and disaster risk science. Authors have interpreted the relationship of disaster risk as directly related to hazard and inversely related to capacity. The most commonly used model in disaster risk science is (UNISDR, 2004; Wisner, Blaikie, Cannon, & Davis, 2004):

$$R = H \times V \qquad \text{(Equation 1)}$$

By incorporating CCA approach (also known as IPCC approach), of defining vulnerability as function of exposure, sensitivity and adaptive capacity as (Diouf & Gaye, 2015):

$$V = \frac{E \times S}{C} \qquad \text{(Equation 2)}$$

Integrating the philosophies can results in an equation which represents climate induced disaster risk as:

$$\text{Disaster Risk} = \text{Hazard} \times \frac{(\text{Exposure} \times \text{Sensitivity})}{\text{Coping/Adaptive Capacity}} \qquad \text{(Equation 3)}$$

Coping level can be interpreted when,
R > 1, Households at very high risk and can't cope
R = 1, households can survive and cope
R < 1, households can manage risk

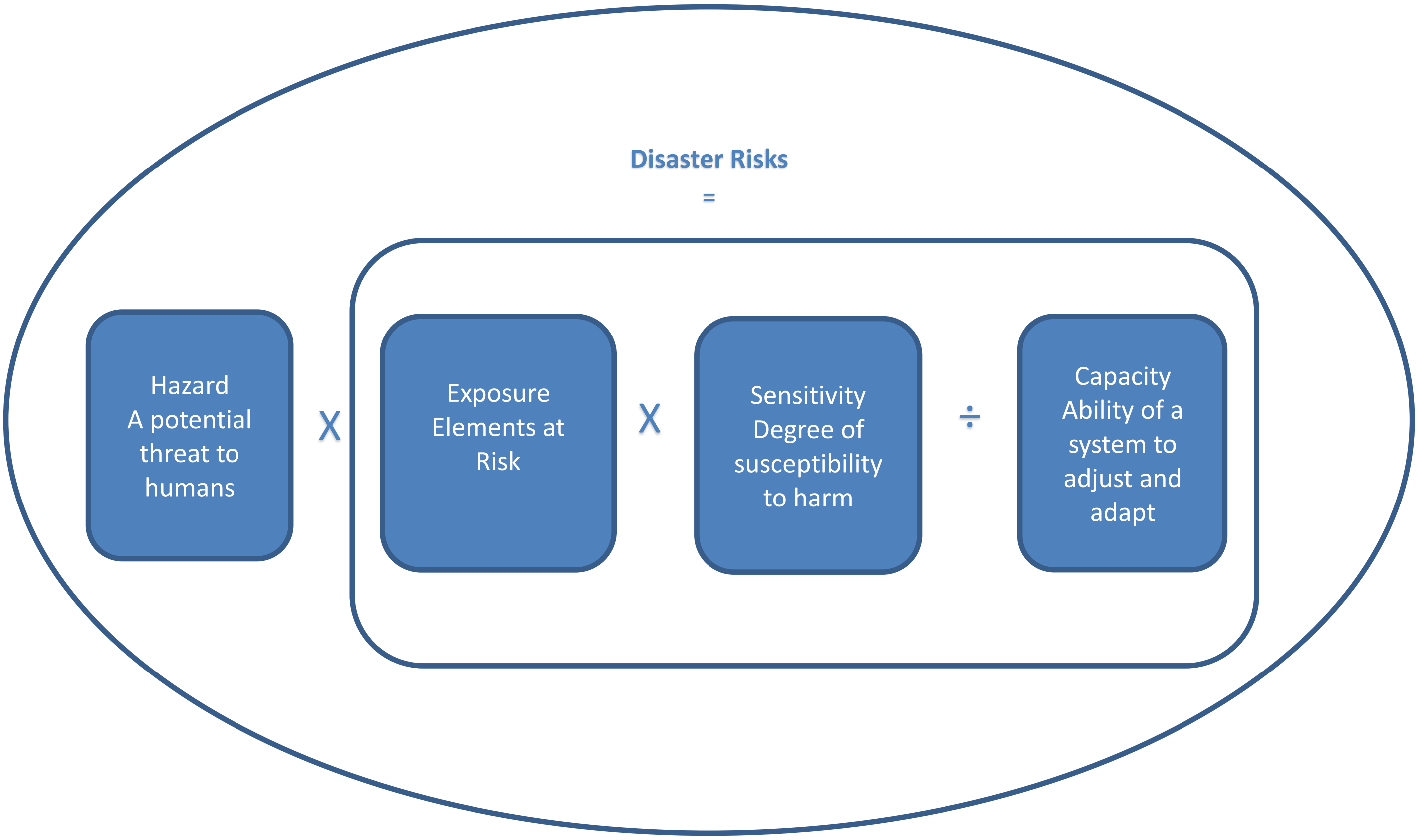

Figure 1: Conceptual Framework for Disaster Risk Assessment

Urban flood risk has been exhaustively discussed in disaster literature. This study attempts to assess risks in three flood prone urban areas of Pakistan. Primary data has been collected through household surveys. Quantitative approach has been used for analyzing components of disaster risk. Various determinants of risks have been identified and discussed. A new quantitative risk assessment model has been proposed and applied for determining flood risk level in communities.

2 Data and Methods

2.1 Study Area Selection

This study uses a comparative approach for risk assessment among three flood prone urban communities. These communities were selected based on urban population at sub-district level (greater than one million, one million half million, less than half million), flood risk level at district level (very high) and flood frequency at district level (recent history, overall history). Maps were prepared and superimposed to select urban sub-district (see Figure 2).

Table 1: Selected Towns and Cities

Urban Centre	District Name	Sub-District Name	Urban Population	Predominant Land use
Metropolitan (Population > 1 Million)	Rawalpindi	Rawal Town	1,166,000	Mixed
City (Population 500,000 to 1 Million)	Sialkot	Sialkot	585,000	Industrial
Medium Town (<500,000)	Muzaffargarh	Muzaffargarh	206,000	Agro-Industrial

Source: Punjab Development Statistics, 2014

2.2 Sampling

Interviews with union council[1] representatives and government officials involved in disaster management of sub-districts helped in selecting three communities based on past damages and proximity to flood hazard. Exact locations of selected urban union councils are pinpointed on map (see Figure 3). Selected communities abutted on rivers and nullahs which cause floods in monsoon season. Cochran's formula was used on number of total households in three communities (Cochran, 1977) Using the formula minimum of 193 samples were needed to be collected from the field (see Equation 4). 210 sample were collected with 70 from each urban community for comparative purposes. Random sampling was done to select households for questionnaire interviews.

$$SS = \frac{Z^2 (p) (1-p)}{e^2} \qquad \text{(Equation 4)}$$

[1] Smallest tier in administrative system of Pakistan according to Pakistan Local Government Ordinance Act 2001

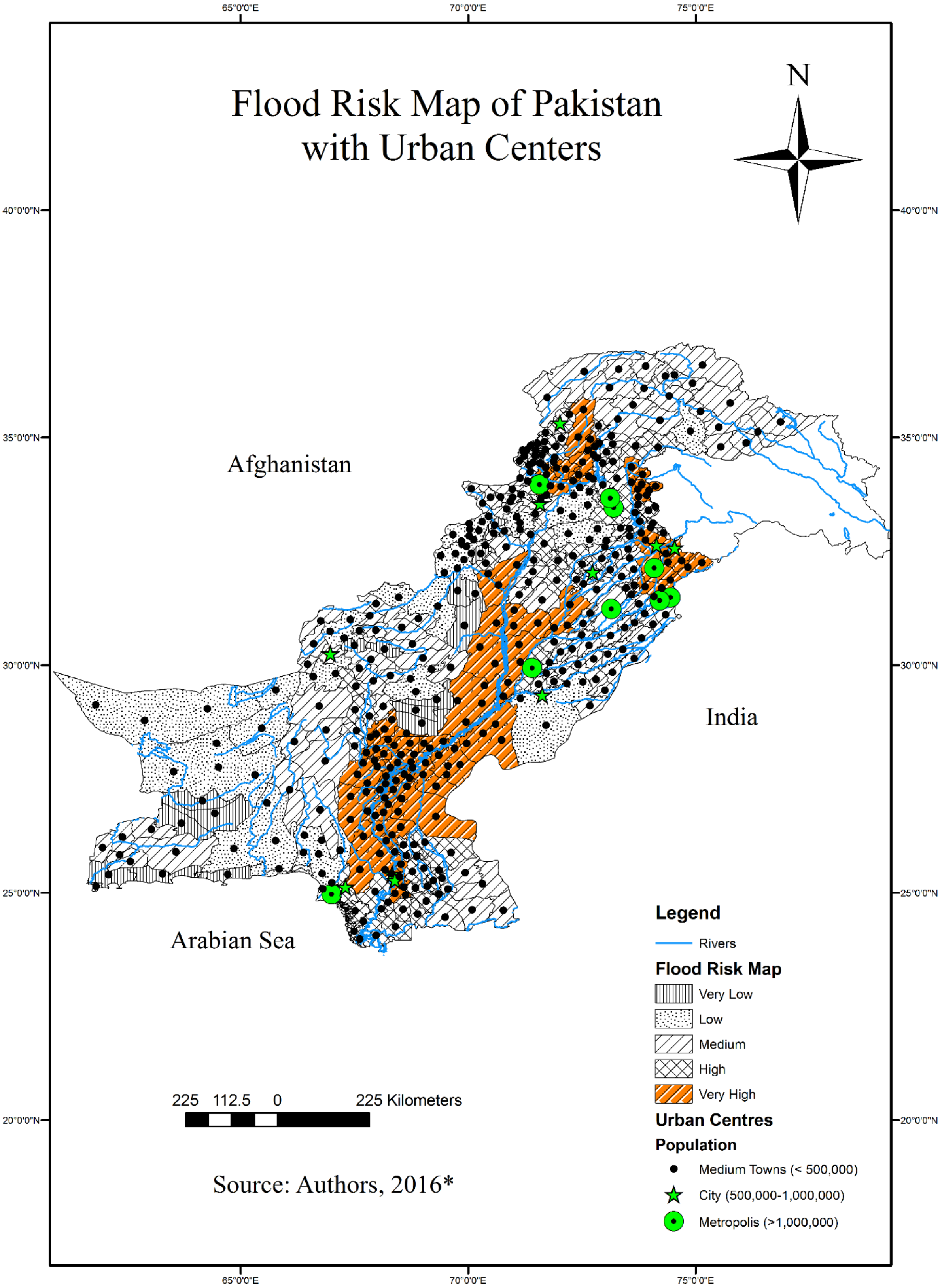

Figure 2: Distribution of Urban Centers and Flood Risk Map

*Note: Flood Risk map is prepared based on the data and information extracted from National Disaster Management Plan, 2012 and urban centers have been superimposed on flood risk zones.

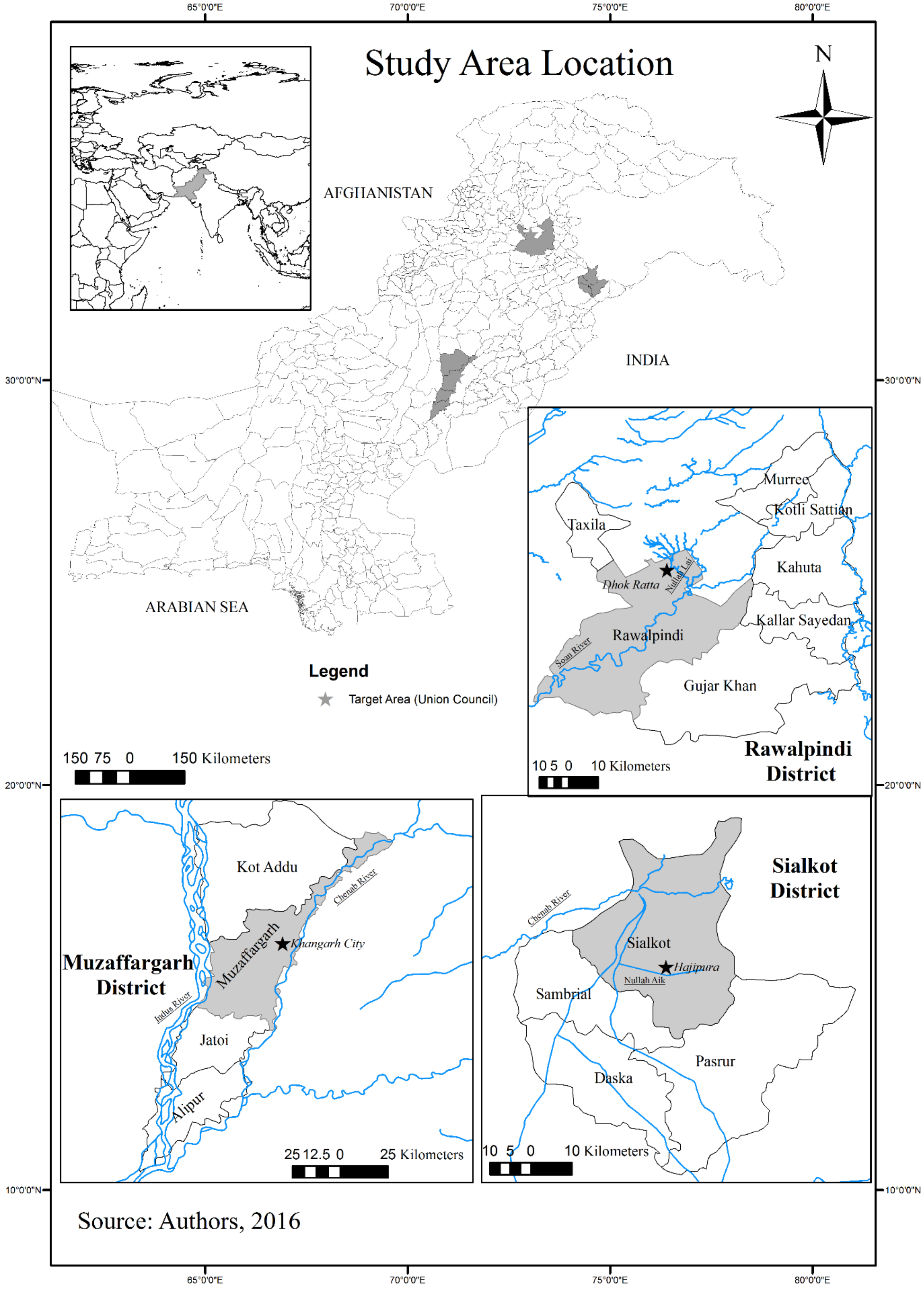

Figure 3: Study Area Location

2.3 Disaster Risk Index

Various methods are used for hazards, vulnerabilities and capacity assessments through which disaster risk can be measured and "reduced". Measuring vulnerability without all or most of these dimensions (social, economic and physical) is likely to be inadequate; thus, this estimate must be some sort of a composite measure or index (Adger et al., 2004). Recently, indices have appeared as a quantitative measures for social dimensions of vulnerability (Tate, 2012). Birkmann (2006) emphasizes that indices can be a powerful tool for analysis because of their "ability to summarize more complicated technical data into a simpler way" that any non-technical person can easily comprehend. Many international organizations (United Nations and its partner organizations; NGOs) often use indicators and composite indices to understand level of vulnerabilities and capacities for formulation of disaster risk reduction strategies. Degree of flood risk and coping has been calculated through development of composite index for each component of disaster risk (see Equation 6). Seven indicators are used for hazard analysis, ten for exposure, seventeen for sensitivity and twenty indictors were used for capacity assessment.

$$CI = (W_1 + W_2 + W_3 \ldots W_n)/n \qquad \text{(Equation 5)}$$

$$\sum_{i=1}^{n} = W_i /n$$

where n is the number of indicators and Wi the weights of indicators.

$$\text{Disaster Risk Index (RI)} = \frac{HI \times (EI \times SI)}{CI} \qquad \text{(Equation 6)}$$

2.4 Weights and Indicators

Numerous risk and vulnerability risk assessment empirical studies were reviewed from climate change adaptation and disaster risk management to construct hazard, exposure, sensitivity and capacity indices. All the indicators of hazard, exposure and sensitivity are kept negative in nature. Whereas, to justify capacity as having an inverse relation to risk, the indicators chosen are positive in nature (see Figure 1). Weights have been allotted for each class on basis of vulnerability (Abbas & Routray, 2014). The weighting scale is devised using five point scale, four point, three point and two point e.g. experience with floods was classified into yes and no, while occupation as government service, trade, agriculture, daily wage earners and unemployed. This can be conceptualized in Table 2 while exact weights used can be seen in Table 3. The highest vulnerable classes are allotted the highest weight i.e. one and least vulnerable as zero hence, standardizing the data. The composite index for each component falls between 0 and 1.

Table 2: General Criteria for Allocation of Weights

Disaster Risk Component	**Levels of Measurement using Corresponding Weights**				
	1	0.8	0.6	0.4	0.2
Hazard	Very High	High	Moderate	Low	Very Low
Exposure	Very High	High	Moderate	Low	Very Low
Sensitivity	Very High	High	Moderate	Low	Very Low
Capacity	Very High	High	Moderate	Low	Very Low

Source: Authors, 2016

Table 3: Disaster Risk Components, Indicators and Weights

Indicators		**Classes**	**Weights**	**Interpretation**
Hazard				
H1	Frequency of flood inside the house (in number)	0 1-2 3-4 5-6 >6	0 0.25 0.5 0.75 1	Past flood events increases the probability that flood will come again
H2	Frequency of Flood in the neighborhood (in number)	0 1-2 3-4 5-6 >6	0 0.25 0.5 0.75 1	
H3	Height of flood measured from residence ground floor (in meters)	0 0 - 0.5 0.5-1.0 1.0-1.5 1.5-2.0 >2.0	0 0.2 0.4 0.6 0.8 1	Higher the flood height means more severity and damages
H4	Height of flood measured from the local roads (in meters)	0 0 - 0.5 0.5-1.0 1.0-1.5 1.5-2.0 >2.0	0 0.2 0.4 0.6 0.8 1	
H5	Duration of flood (in days)	No flood < 1 day 1 day to 1 week 1 week to 2 week 2 week to 1 month > 1 month	0 0.2 0.4 0.6 0.8 1	Longer duration of flood shows the severity of hazard
H6	Probability: Likelihood of Inundation (v. high, high, moderate, low, v. low)	Very Low Low Moderate High Very High	0.2 0.4 0.6 0.8 1	Higher the probability means more chances of hazard occurrence
H7	Severity: Damages of Previous flood (v. high, high, moderate, low, v. low)	Very Low Low Moderate High Very High	0.2 0.4 0.6 0.8 1	Higher the damages of previous flood means hazard potential is severe
Exposure (Vulnerability)				
E1	Household Size (in number)	<5 5-10 >10	0.33 0.67 1	Larger the household size, larger the number of people exposed needed for evacuation.
E2	Family Type	Joint Nucleus Single	0.33 0.67 1	Single family type will be more isolated and have limited access to community resources and support

E3	Households with injury/death in previous floods	No Yes	0 1	Households with injuries and deaths in previous floods means that they are more exposed.
E4	Location of the House	Upland Floodplain Between Levee and Riverbank	0.33 0.67 1	Location of residence (elevation and proximity to rivers) will affect exposure to hazard.
E5	Housing Type	Detached (Bungalow) Semi Detached (Normal) Combined (Row Houses)	0.33 0.67 1	Houses with no alleys or side open spaces will be more at risk
E6	Building Height (Number of stories)	Triple Double Single	0.33 0.67 1	Households living in more than single story building will decrease losses and damages and help in rescue
E7	Building Age	<10 11-20 20-30 >30	0.25 0.50 0.75 1	Older buildings will be more exposed as compared to new structures. New structures will incorporate new stronger construction technologies to resist floods
E8	Building Construction Materials	Pacca (Brick, Cement) Katcha (Adobe, Mud)	0 1	Building construction of building materials will affect exposure
E9	Household's level of understanding National Warning System	Very High High Moderate Low Very Low	0.2 0.4 0.6 0.8 1	Households which understand national warning system will be less exposed as they will know about impending hazard.
E10	Household's did not receive warning about last floods	Yes No	0 1	Households which didn't receive warning last time flood came, means that are so exposed that small chances that they will get warning again.
		Sensitivity (Vulnerability)		
S1	Dependency Ratio (Dependents to Total household size)	< 0.25 0.25 – 0.50 0.50 – 0.75 0.75 – 1 > 1	0.2 0.4 0.6 0.8 1	Infant, children and elderly population will be more at risk than young and adult people because they are less mobile
S2	Female Male Ratio	< 1 1-2 2-3 3-4 >4	0.2 0.4 0.6 0.8 1	Females will be more vulnerable than Males due to limited mobility and physical strength.
S3	Households having family members with chronic illness/pregnancy or disability	0 1 2 >2	0 0.33 0.67 1	Households with special needs will hinder mobility in case of emergency
S4	Household living in community (years)	>40 30-40 20-30 10-20 <10	0.2 0.4 0.6 0.8 1	Households living in hazard prone area for longer time will be aware of evacuation routes and geography of their habitat
S5	Average Monthly Household's Income (in Rs. Amount)	>60,000 40,000-60,000 20,000-39,999 10,000-19,999 <10,000	0.2 0.4 0.6 0.8 1	Lower the income will result in high vulnerability and low recovery rate
S6	Occupation of Household head	Government Service Trade and Commerce Agriculture Daily Wagers Unemployed	0.2 0.4 0.6 0.8 1	Regular and stable source of income through a particular occupation will be less vulnerable

S7	Households who have borrowed for loan anyone in last ten years	No Yes	0 1	Households having taken loan are economically challenged and thus at more risk
S8	Households living in rented houses (Yes, No)	No Yes	0 1	House owners can build and maintain their building whenever they want as compared to renters.
S9	Distance to nearest medical facility (in kilometers)	<1 1-5 5-10 >10	0.25 0.50 0.75 1	The longer the distance of health center from residence, higher will be vulnerability due to time to reach health center.
S10	Households of access to drinking water (%)	Yes No	0 1	Households with no access to certain amenities will be at more risk
S11	Households not having access to improved sanitation	Yes No	0 1	
S12	Households not getting Electricity	Yes No	0 1	
S13	Households having no means of communication (TV)	Yes No	0 1	Households with no access to means of communication will be at more risk
S14	Households having no means of communication (Radio)	Yes No	0 1	
S15	Households having no means of communication (Telephone)	Yes No	0 1	
S16	Households having no means of communication (Mobile)	Yes No	0 1	
S17	Households having no means of Transportation	Yes No	0 1	Households with no access to transportation will be at more risk
Capacity				
C1	Household head's education level	College/University High Middle Primary Not attended	1 0.8 0.6 0.4 0.2	High literacy will increase capacity of households' access to information and communicate better.
C2	Households who have experience with floods	Yes No	1 0	People with past experiences and encounters with floods will be more aware of issues and problems beforehand
C3	Households having family member who can swim	Yes No	1 0	Swimming will increase capacity as it will can help save lives and important household items
C4	Households having family member who has First Aid Knowledge	Yes No	1 0	First aid knowledge will increase capacity by helping households injured due to hazard
C5	Households having multiple sources of livelihood options	>2 2 1 0	1 0.67 0.33 0	Multiple sources of livelihood will increase capacity as even if one source is cut off, households can survive on another
C6	Number of Earning Members in Household	>2 2 1 0	1 0.67 0.33 0	Households with more number of earning members can increase capacity as even if one income is cut off due to flood, households can survive on another
C7	Households having any kind of savings (Bank, Gold, Silver)	Yes No	1 0	Savings will increase capacity as it will help in rainy day
C8	Average Monthly Households Savings (in Rs. Amount)	<10,000 10,000-19,999 20,000-39,999 40,000-50,000 >50,000	0.2 0.4 0.6 0.8 1	
C9	Households having insurance (Life, Health)	Yes No	1 0	Insurance will increase capacity of households if flood happens.

C10	Households having Building insurance	Yes No	1 0	
C11	Households having land/house outside the flood prone community	Yes No	1 0	Households having assets outside the flood prone community can easily settle easily.
C12	Households having relatives outside the city	Yes No	1 0	
C13	Households with family member employed outside flood prone area	Yes No	1 0	Households with a family member employed outside the flood prone area will not be affected
C14	Strength of community cooperation in disaster response	Very poor, Poor, Moderate, Good, Very good	0.2 0.4 0.6 0.8 1	Cooperation strength represents community's help and shared resources to cope with floods
C15	Households aware emergency protocols/shelter	Yes No	1 0	Awareness will prepare households against floods and thus increase capacity.
C16	Households aware of evacuation routes	Yes No	1 0	
C17	Households that have not gone to their local government for assistance in the past 12 months	Yes No	0 1	Households which don't need government assistance means that they can cope with floods by their own
C18	Community having Land use/Zoning laws and HH following them	Yes No	1 0	Households following regulations will avoid hazard prone
C19	Frequency of public awareness programs/ Drills attended by HH member (in number)	2 1 0	1 0.67 0.33	Higher frequency of drill will increase coping capacity against floods
C20	Availability and circulation of emergency plans to households	Yes No	1 0	Availability and circulation of emergency plans among households will increase capacity against floods.

After proper allocation of weights to classes, indices for each component were calculated using Equation 5 and classified in low, moderate and high level categories. Average values of risk, hazard, exposure, sensitivity and capacity were calculated to paint a comparative picture of three urban communities. Risk assessment of each flood prone household was computed using proposed methodology (see Equation 3). It was analyzed in two perspectives i.e. degree of risk and degree of coping level of households. Risk degree of households was calculated by classifying risk values into mild, moderate and severe using equal class interval. Based on the proposed methodology, coping level was classified into households at high risk, manageable risk and 'can cope with risk' were identified. Step by step process of this study can be easily understood through Figure 4.

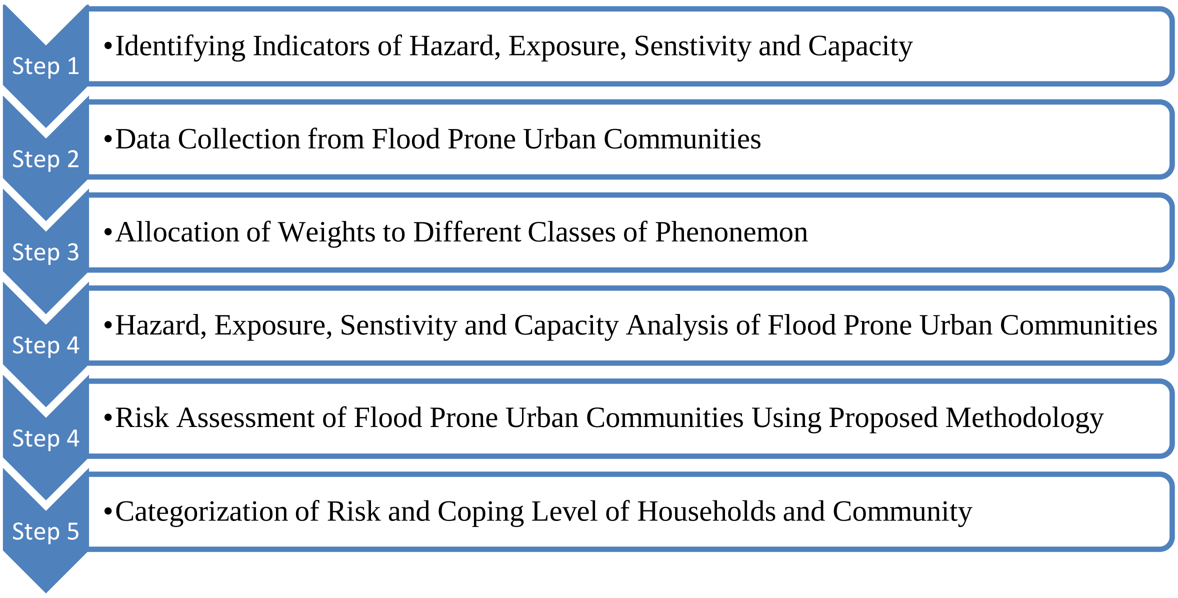

Figure 4: Step Wise Process for Disaster Risk Assessment

3 Results

Urban communities selected were different from each other in some aspects (see Table 4). Average household size was around six in all communities, and generally household head was the sole breadwinner of the family. Education, occupation, livelihood sources and incomes in all three urban centers were different. Households in metropolitan areas are more educated than other communities. Average household income in Sialkot was double than other two cities, mainly because households had private businesses and more secure livelihood sources. In Rawalpindi, households living in vulnerable areas were mostly government employees and daily wage earners. However, in Sialkot and Muzaffargarh households' livelihoods were dependent on agriculture and industry. Generally, household size was small in all urban centers.

Table 4: Socioeconomic Characteristics of Households

Indicator	**Classes**	**Rawalpindi**		**Sialkot**		**Muzaffargarh**	
		Fr	%	Fr	%	Fr	%
Dependency Ratio (Dependents to Total HH size)	< 0.25	9	12.9	22	31.4	30	42.9
	0.25 – 0.50	31	44.3	30	42.9	22	31.4
	0.50 – 0.75	29	41.4	12	17.1	11	15.7
	0.75 – 1	1	1.4	6	8.6	4	5.7
	> 1	0	0	0	0	3	4.3
Education of HH head	College/University	16	22.9	10	14.3	15	21.4
	High	12	17.1	13	18.6	18	25.7
	Middle	14	20.0	8	11.4	5	7.1
	Primary	14	20.0	28	40.0	14	20.0
	Not attended	14	20.0	11	15.7	18	25.7
Household Size (in number)	<5	21	30.0	20	28.6	29	41.4
	5-10	48	68.6	49	70.0	38	28.1
	>10	1	1.4	1	1.4	3	4.3
Occupation of HH head	Government Service	6	8.6	12	17.1	14	20.0
	Trade and Commerce	30	42.9	29	41.4	15	21.4
	Agriculture	0	0.0	3	4.3	7	10.0

	Daily Wagers Unemployed	27 7	38.6 28.0	15 11	21.4 15.7	27 7	38.6 10.0
Average Monthly HH Income (in Rs. Amount)	<10,000 10,000-19,999 20,000-39,999 40,000-50,000 >50,000	1 23 39 7 0	1.4 32.9 55.7 10.0 0.0	1 14 27 17 11	1.4 20.038 .6 24.3 15.7	15 18 28 6 3	21.4 25.7 40.0 8.6 4.3
Earning Members	>2 2 1 0	1 17 52 0	1.4 24.3 74.3 0.0	7 15 47 1	10.0 21.4 67.4 1.4	6 17 47 0	8.6 24.3 67.1 0.0

Source: Field Survey, 2015

The results reveal interesting trends for each component of households (see Table 5). Flood hazard faced by households in Muzaffargarh was more severe as compared to other areas. It was followed by Sialkot and Rawalpindi where hazard level was moderate. Almost 85% households have seen floods entering houses and neighborhoods. Exposure assessment shows that all of the elements at risk had moderate to high level of exposure. Sensitivity analysis shows that Sialkot was less sensitive than other areas. None of the households were in high sensitivity level. About 80% of households living in hazard prone areas had experienced floods. Generally, almost every household had at least one person suffering from chronic illness. In capacity assessment, Sialkot households again had better capacity than others. About 70% of the households were unaware of emergency protocols, nearest emergency shelters and evacuation routes. 95% of the households had never attended a seminar, trainings or drills on flood disaster preparedness and mitigation.

Table 5: Hazard, Exposure, Sensitivity and Capacity Assessment of Flood Prone Households

Level (Max=1)	**Rawalpindi**		**Sialkot**		**Muzaffargarh**	
	Fr	%	Fr	%	Fr	%
Hazard						
Low (<0.33)	28	40	1	1.4	3	4.3
Moderate (0.33 – 0.67)	39	55.7	58	82.9	38	54.3
High (> 0.67)	3	4.3	11	15.7	29	41.4
Total	70	100	70	100	70	100
Exposure						
Low (<0.33)	0	0	0	0	0	0
Moderate (0.33 – 0.67)	57	81.4	62	88.6	54	77.1
High (> 0.67)	13	18.6	8	11.4	16	22.9
Total	70	100	70	100	70	100
Sensitivity						
Low (<0.33)	67	95.7	70	100	62	31.2
Moderate (0.33 – 0.67)	3	0	0	0	8	11.4
High (> 0.67)	0	0	0	0	0	0
Total	70	100	70	100	70	100
Capacity						
Low (<0.33)	55	78.6	25	21.4	41	58.6
Moderate (0.33 – 0.67)	15	21.4	55	78.6	29	41.4
High (> 0.67)	0	0	0	0	0	0
Total	70	100	70	100	70	100

Source: Field Survey, 2015

Degree of risk of households in flood prone urban areas have been identified (see Figure 5). Most households at high risk were in Muzaffargarh. Rawalpindi had only two households at risk while Sialkot had none. This analysis reflect that city of smallest size was more at risk. The second most city at risk was the metropolitan.

Table 6: Risk Degree of Flood Prone Households

Degree of Flood Risk	**Rawalpindi**		**Sialkot**		**Muzaffargarh**		**Total**	
	Fr	%	Fr	%	Fr	%	Fr	%
Low (< 0.21)	42	60	62	88.6	29	41.4	133	63.3
Moderate (0.21 – 0.41)	26	37.1	8	11.4	30	42.9	64	30.5
High (> 0.41)	2	2.9	0	0	11	15.7	13	6.2
Total	70	100	70	100	70	100	210	100

Source: Field Survey, 2015

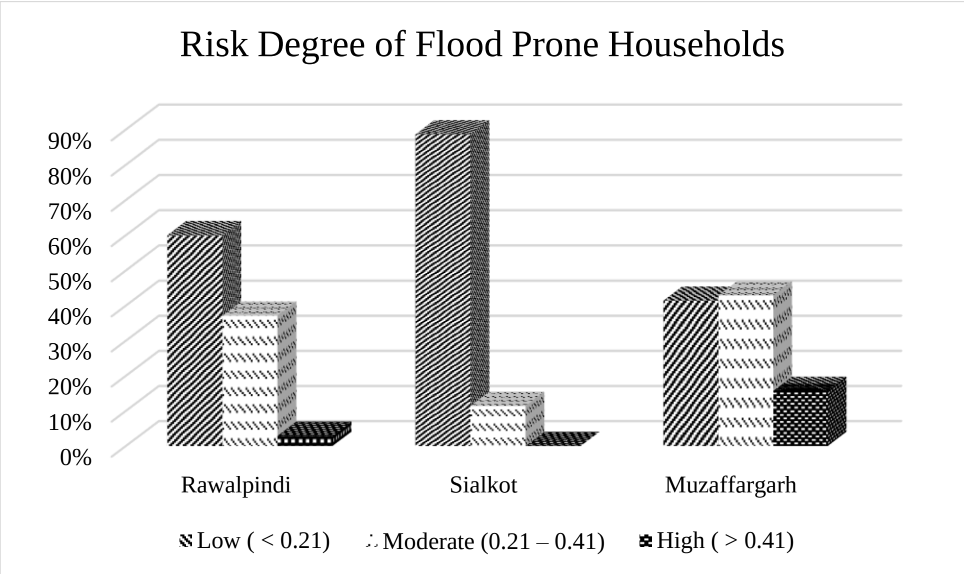

Figure 5: Comparative Degree of Flood Risk

Average values of community show that significant differences exists in hazard and capacity component, which was affecting risks in flood prone urban communities (see Figure 6). Muzaffargarh community was facing severe hazard followed by Sialkot and Rawalpindi. Interestingly enough, elements exposed were almost same in all communities. However, Sialkot city was less sensitive and had more capacity than other two cities.

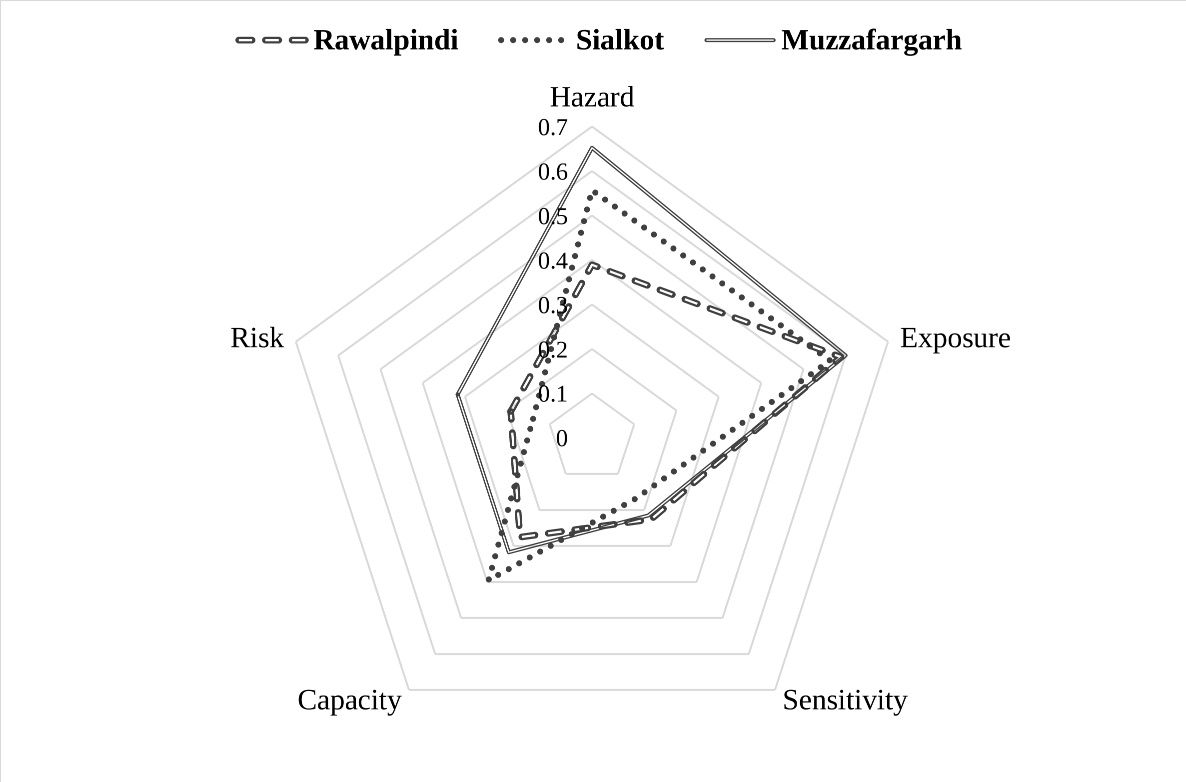

Figure 6: Comparative Analysis of Disaster Components

Coping degree of households was classified into three levels based on proposed methodology (see Table 7). Coping level defines whether households can survive floods or not. Most of the households were managing risk while only 1.4% were at high risk. These three households were from Muzaffargarh community, and unable to cope with future flood and may perish as a result.

Table 7: Coping Degree of Flood Prone Households

Risk Coping	Rawalpindi		Sialkot		Muzaffargarh		Total	
	Fr	%	Fr	%	Fr	%	Fr	%
Can manage risk (<1)	70	100	70	100	67	95.7	207	98.6
Can survive and cope (1)	0	0	0	0	0	0	0	0
At high risk (> 1)	0	0	0	0	3	4.3	3	1.4
Total	70	100	70	100	70	100	210	100

Source: Field Survey, 2015

4 Discussion

4.1 Hazard Analysis

Frequency: Frequency or past events is one of the most important indicator used for hazard assessment. Number of times floods in house and neighborhood shows potential of hazard to penetrate in communities. There was significant difference between number of times floods have come in communities which defines difference in hazard level. Muzaffargarh communities were exposed to severe hazard as two rivers are sandwiching the city. Because of this probability and severity was very high. Indus River is known to be ruthless and its flooding causes severe damage to whole Pakistan. Sialkot and Rawalpindi's hazard were caused by Nullahs passing through city center which can be less disastrous if efficiently tackled. Rawalpindi and Sialkot communities were prone to floods primarily because of seasonal rains and overflowing of Nullahs. Proper maintenance, de-sedimentation and regular cleaning of Nullahs is needed to reduce flood risks. On the other hand, Muzaffargarh is bounded by two rivers on West and East increasing riverine flood hazard in the city. Local people can help in fortifying embankments because of their knowledge about weak points of structures. Hazard can be reduced through strengthening embankments and construction of barrages.

Height and Duration: Height and duration shows the severity of floods. Heights were measured from inside the house from ground level and local roads. Majority of households claimed that water reached around one meter in height both inside the house and on the road. Respondents from Muzaffargarh city asserted that flood water level even crossed two meters in their city. Similarly, duration of flood in communities was around one week in most cases. Muzaffargarh city respondents dealt with floods which remained for more than one month. Due to height and duration indicators hazard level was more than for other two communities.

Likelihood and Damages: Likelihood and damages represent the probability and severity of flood hazard. Majority of the households believed that there was a high chance of flood coming again. However, damages in urban communities varied. Furniture, home appliances and walls were mostly damaged. Households in metropolitan suffered the most damages than other communities because of limited access to warning system, lack of coping mechanism and smaller houses with no open spaces at sides.

4.2 Exposure Analysis

Household Size: Population is one of the most important elements considered for risk assessment. Disaster literature agrees that a large number of people living in the flood prone area makes it difficult in evacuation and hence increasing the risk. Average household size in Punjab province is 6.8 (Punjab Bureau of Statistics, 2014). Most of the households living in flood prone areas were of medium size (5 to 10 members). Family type was another way of judging exposure of households as smaller number are isolated and have limited access to community resources. No significant difference could be detected among metropolitan, city and medium town as similar household structure and lifestyles is prevalent in all of Punjab Province.

Housing: Housing characteristics like locations, structure type, building height and construction materials are known to influence vulnerability of household. Households living in houses in floodplains or even by riverbanks were severely exposed to flood hazard. Building regulations call for leaving wide belts along rivers for protection and allowed no construction in them. People have still constructed houses inside levees and embankments when water receded after last flood. Most of the houses were constructed in the form of row houses having no to little open spaces on any side. This added factor further increased vulnerability. Most of the houses belonged to low to middle income people that live in single story houses built almost 20 years ago which added fuel to fire. However, very few households lived in adobe houses. Special attention must be paid to urban building control department to restrict future urban sprawl in declared flood zones. Hazard resistant methods and technologies must be integrated in building codes and implemented to reduce exposure.

Early Warning System: Most households exposed to floods aren't aware of early warning system in their communities. Some respondents asserted that irrigation department breaks embankments to save critical infrastructure, without informing nearby settlements. Due to non-existent district management authority, no clear responsibility is delegated to warn communities. This means the functionality and presence of early warning system at provincial level becomes meaningless. Early warning system needs to reach local communities through fast and reliable sources.

4.3 Sensitivity Analysis

Household Characteristics: Age and gender are accepted factors which increase the susceptibility of already exposed population. Infants, children, women and elderly people are more vulnerable to hazard than young and adult population due to their little mobility. On the other hand, elders have more knowledge about indigenous coping techniques to tackle floods. Higher dependency and female ratios can influence higher vulnerability in household members in terms of age. Households with more number of sick people or disabled, increases the existing susceptibilities. Households of metropolitan city were more sensitive because residents were relatively new, living in rented houses; apparently unaware of potential risks.
Economic Characteristics: Economic conditions of households make huge implications on vulnerability. Income is one of the main economic factors influencing sensitivity. There was significant difference in average monthly income among the communities. Households living in metropolitan (Rawalpindi) were generally low income, earning daily wages and lived in rented houses. Economically weak class of citizens chose to live there due to unaffordability of planned housing scheme residences. Most households in medium town were middle income people working in agriculture sector. Sialkot, on the other hand, had well-off families with local businesses which were relatively least sensitive. Level of income directly influences vulnerability of individuals, family and community. Income and occupation were the main determinants of household vulnerability among communities. Households must seek multiple sources of income and secure livelihoods to reduce vulnerabilities.
Infrastructure Characteristics: Provision of infrastructural facilities influences the susceptibilities of households. Amenities such as clean drinking water, improved sanitation, communications and adequate transportation directly relates to household’s sensitivity. Almost every household had access to electricity, television, radio and mobile. However, provision of clean drinking water and improved sanitation was very bad. This has led to increased susceptibilities of households in half of the households already exposed to floods. Most roads were not paved in smaller cities which can cause hindrance to evacuation.

4.4 Capacity Analysis

Education: Education is one of the most important factor which defines capacity of households. Highly educated people increase individual and household capacities of communities. They have quick understanding of emergency plans, and can communicate with technical personals involved in disaster management. Education is also known to raise standard of living, income and health. Pakistan adult literacy rate is 54.9% in 2012 (UNICEF, 2012). Significant difference was observed in educational level in three urban communities. Around 20% household heads were illiterate, and 60% household heads were secondary schooled. This adversely affected capacity of households and was instrumental in increasing the overall risk. Literacy rate needs to be raised in flood prone communities so they hone in their capacities through preparedness plans.

Skills and Experiences: Past experiences and skills can help a lot in reducing risks. A member of household trained in first aid knowledge and swimming can help in increasing coping capacity. About 78% households have experienced floods, and would know preventive measure and evacuation protocols. Only about 12% of households had a member who knew swimming, while only 3% households had a member which had first aid training. This type of capacity building measures can be initiated by government.
Assets, Savings and Economic Options: Economic assets and savings help in improving recovery time of households. Households with multiple livelihood options and earning

members increases the capacity. Most of the households had only single earning member and single source of livelihood. Significant difference among occupations was observed among communities. About 12% household heads were unemployed and 33% households were dependent on daily wage earning. Unemployed and daily wage earners like labor, taxi drivers and vendors are at huge risk if flood strikes. Only 3% households had health insurance while none of the households had insured their residences. Insurance is an increasingly used capacity measure being promoted in disaster risk reduction strategies. About 7% and 68% households had an earning members and assets outside the flood prone areas respectively. This could increase coping capacity of households as they can relocate temporarily.
Training, Preparedness and Emergency Planning: Trainings, drills and preparedness activities in flood prone areas greatly increases the community resiliency and capacity. Community awareness is considered determinant of coping capacity. Disaster management institutions are now focusing on increasing preparedness activities to minimize impact of floods. However, 96% of households had never attended any kind of training or seminars. These issues raise serious questions on local institutions efforts for disaster preparedness. Communities blamed government that it has failed to provide flood preparedness and contingency plans. NGOs have mostly focused on rural households which are deemed more vulnerable than their urban counterparts. Almost none of the households felt a need to seek advice or help from local authorities mainly due to distrust. Zoning and land use plans are existing but local administrations have failed to stop urban sprawl in floodplains due to political influences.

4.5 Risk and Coping Assessment

Degree of flood risk was varying among urban centers. Muzaffargarh is prone to riverine floods while Sialkot and Rawalpindi are prone to flash floods making difference in hazard level. Exposed elements in urban communities were almost same which can be linked to similar socioeconomic characteristics, cultural traditions and building construction technologies. Sialkot city had the lowest flood risk than other cities because of strong economic resources and capacities. From coping perspective, people were still living in the flood prone areas having huge exposure and sensitivity. They were not migrating because they have been successful in coping with floods in the past. But, they were still at some degree of risk and were prone to damages. The vulnerabilities and hazard was very high for all cities, but their capacities had countered it; thus decreasing overall risk (see Figure 6). Capacities are huge determinant in deciding the risk level of communities. Slight change in capacity resulted in swift transfer from one risk level to the higher ones.

5 Conclusion

Households in study areas are coping with flood risk and still living there despite huge exposure and sensitivity. Vulnerability is being countered by adaptive capacity in communities. As a result households at high risk are just seven percent. Cross tabulation of indicators shows different levels of vulnerabilities and capacities in metropolitan, city and medium city. Metropolitan was less exposed to floods but communities' vulnerabilities were higher. Smaller cities were more exposed but less vulnerable due to better coping mechanisms and capacity. It can be inferred that households who were more exposed to floods have devised coping and adaptive techniques over time, as compared to less exposed areas where households were unable to do so. This study shows influence of various factors like age, occupation, education and past experiences of urban centers of different population sizes on disaster components. District disaster management authority is non-existent on ground and various local administration are delegated on ad-hoc basis to cope with floods.

The novel and comprehensive method in this paper can be used to assess risk assessment of hazard prone communities. This flexible and easy method can be replicated at rural, regional, national and international scales on any type of climate induced disaster. Governments and international NGOs can adopt this method to identify households at risk. Households who can't cope with floods can be prioritized in granting financial help. Key informants interviews and community focus group discussions can be done further to strengthen, justify or even contradict the achieved results. More statistical tests and correlations can be done to test different hypotheses.

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