Vulnerability of urban poor communities to climate change impacts – A case study of Pune, India.

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1.Introduction

The United Nations define climate change as natural process wherein wind, rainfall, temperature and other elements differ and form pattern over decades or more (United Nation, Climate action, 2023). The increase in global temperatures gives rise to extreme weather events like heatwaves, floods and cyclones (Thomas V, and López R, 2015). These natural processes impact the human societies adversely affecting their health, safety, infrastructure and other basic needs for survival. The impacts on climate change on urban areas are complex. The concentration of population in urban areas increases the complexity of response to such extreme weather events due to various reasons like lack of resources, capacities, and expertise. Urban areas thus are under the threat of climate change induced disasters (Ebi KL, et.al, 2021). The complex urban systems are under acute pressure to perform in all the scenarios. The day to day scenarios can absorb the stress, but it fails and buckles under the impacts of natural hazards. Natural hazards are stimulated by the urban systems inducing the changes in climate pattern (Berlemann,M, Steinhardt, 2017). Climate change stimulates heavy precipitation, exposing the populations to the risk of urban flooding. The threat to urban poor is more as their exposure and vulnerability is huge (Baker L, 2013). Very few efforts are made in the developmental systems to reduce the vulnerability of urban poor, in the policies, programs, infrastructure planning and development of the city.

Vulnerability in a climate change perspective is defined as the degree of, adverse effects of climate change, a system is able to cope up with or susceptible to, not excluding climate extremes and variability according to IPCC (Schneider, S.H et al, 2007). The important part of this definition is the ‘system’. The entire urban mechanism is a system with all its infrastructural facilities and amenities which is susceptible to climate change impacts. Human systems are primary components to be affected in this system. However, all the social groups in the human system do not have the same impact. Some groups are deprived of resources, cultural identity and livelihoods, experience loss greater than other groups. Hence vulnerability is a multidimensional process interacting at different scales due to various forces like social, economic, environmental and political (Thomas K, et.al, 2019). The climate change impacts apply to the human systems and the interdependent ecosystems, increasing or decreasing their vulnerability, depending on the coping and adapting capacity (IPCC 2022).

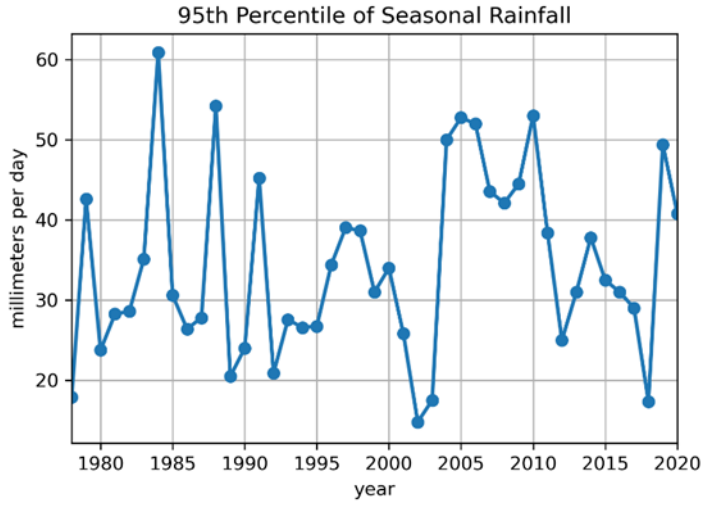
Urban areas are concentrated with resources and opportunities, attracting populations like magnets (van Doorn L, Arnold A & Rapoport E, 2019). The rise in the rate of migration towards cities proves, cities offer the resources and facilities populations aspire (Roy A, Saha M, 2023). However, cities have their carrying capacities, which gets stressed providing for the influx of populations (Li Bingqian, et.al, 2022). The limited resources and livelihood opportunities creates the workforce for servile jobs with minimal wages resulting in poor living conditions (Burgard SA,

Lin KY, 2013). Such populations are forced to reside in informal settlements 'Slums' on hazardous lands, riverbanks, hill slopes, on public or private lands vulnerable to natural hazards. Government provides facilities like water, drainage, electricity, and roads, but the poor living conditions exposes them to various hazards. The impacts of climate change add to the social and economic disparity of the urban populations (Paavola, J, 2017). Conscious interventions and support can dilute the adverse impact and help in reducing the mortality and damage to assets (Kruk ME, et.al, 2018). However, it is necessary to understand the linkages and take informed decisions. Climate change is a reality, governments and administrative bodies fail to acknowledge, in its full form. The cost of climate induced disasters are high and can wipe out the developmental efforts taken up by the administrative bodies. The urban development pattern further increases the risk of flooding attributing to concentration of population and dense built footprint (Sun X, et.al,2021). The built infrastructure in urban areas is not equipped to absorb urban flooding adding to the vulnerability of populations. This paper attempts to study the different vulnerabilities of urban poor communities to urban flooding as impact of climate change, in Pune city of Maharashtra, India.

2.0 Methods

2.1Study Area

Pune, the eight largest city of India, located in the state of Maharashtra, is selected as a case. Pune city is one of the fastest growing city famous for its IT hub, education and livable city rank in India with a geographical area of 331.26 sq km and population of 3.99 million. The city was famous for its green cover and has a tree cover of 46 lakhs trees (ESR 2021-2022). Pune city lies on the confluence of two rivers Mula and Mutha, with 5 upstream dams releasing water in the rivers. The rivers and natural drains called 'Nallas' in the city makes it vulnerable flooding. Pune has tropical climate, with monsoon rains in the months from June to October and rest dry season.



The average annual rainfall 741 mm (29.2 in) or 61.8 mm (2.4 in) per month. The average annual rainfall for the city is stable for the last 4 decades without much variation. However, daily extreme rainfall during the monsoons months from 2000 to 2020 has shown a rise of 40mm as observed in last 4 decades as seen in Fig 1 (Singh A, et al, 2021). The change in rainfall pattern observed reveal there is no increase in trend of rainfall, but there is remarkable increase in years with heavy rainfall days. The heavy rainfall day causes urban flooding in the city.

Figure 1 b. There have been nine years between 2000 and 2020 which have a 95th percentile of daily rainfall greater than 40 millimeters *(Source: https://india.mongabay.com)*

Pune city has 15 administrative wards out of which 2 wards namely Kasbapeth-Vishrambaug wada ward and Dhankawadi-Sahakarnagar ward are high risk wards with high population density (Pune Disaster Management Plan 2016). These two wards are selected as study area. Kasbapeth- Vishrambaug wada ward is the center and the oldest part of the city, with commercial and residential mix use area, while Dhankawadi was peri urban village added to the municipal

limits in 2000 and further merged with Sahakarnagar Ward. These wards differ in its urbanization pattern, topography and culture while both are equally vulnerable to flooding. Kasbapeth Vishrambaug wada ward is prone to riverine flooding from river Mula mostly in its low lying areas, while Dhankawadi-Sahakarnagar ward is prone to urban flooding and flooding of nallas namely Ambil Odha' which is tributary of river Mula.

The built footprint, infrastructure development and inadequate surface drainage system, in past decade has made the city vulnerable to urban flooding. The two past events of flooding severely disrupted the normal functioning of the city. The cloudburst event on 25 September 2019 caused huge losses to assets and 21 casualties while heavy precipitation in 2021caused severe urban floods. The city has witnessed enormous transformation in its built form over last three decades, with increase in built up area by 16% from 1990 to 2019. This built form is not planned and organized with spatial planning approach, but evolved in the peri-urban suburbs which later merged into the municipal limits. Thus lacking in basic services and critical facilities like storm water drainage system the most critical, increasing the flash flood points in the city. The unplanned development of the city is creating stress on the infrastructural services and amenities leading to risk of hazards.

2.2 Selection of Indicators

The study aims to understand the vulnerability of urban poor communities for the impacts of climate change. In this study we focus on wet spells which causes flooding in the urban areas. Indicators assessing the risk in spatial scenario were selected under different types of vulnerabilities. Table 1 shows the list of indicators and its descriptions. Vulnerability is assessed through physical, social, economic and environmental factors which are susceptible to the impacts of hazards, affecting communities, systems and assets (UNDRR, 2023). The physical vulnerability comprised of indicators, location, building design, construction material and technology and critical services. These indicators are significant in understanding the risk to built environment of the communities and their exposure to urban flooding (Chan SW,et.al,2022). The social vulnerability comprised of indicators, population density, accessibility to critical facilities and requirements of persons with special needs (González T, et.al 2020). The economic vulnerability included two indicators employment status and monthly income of the urban poor communities (Gasper R, et.al, 2011). The environmental indicators include pollution levels of air and water to understand their living conditions, exposure to health hazards, vegetative cover and exposure to different type of hazards, which is one of the important indicator increasing the vulnerability of poor populations (Gran Castro, J. A., & Ramos De Robles, S. L. (2019).

Table 1: List of Indicators and Description

DIMENSIONS OF VULNERABILITY	**INDICATORS**	**DESCRIPTION**
Physical Vulnerability	Location Building design Construction material Critical services	River floodplain, nalla flood plain, low lying area, dense built areas Layout, natural light and ventilation, safe evacuation Building construction material and technology Water, drainage, solid waste, electrical, firefighting, security
Social Vulnerability	Population density	Density, composition, migrants,

	Accessibility to critical facilities Special needs	Hospitals, police station, fire stations Number of people, infrastructure facilities like ramps, toilets
Economic Vulnerability	Employment Monthly income	Permanent employment, daily wages, Family income 15000 - 35000rs per month
Environmental Vulnerability	Pollution Exposure to health hazards Natural vegetation Hazard exposure	Air, water Infections, flu, epidemics Amount of vegetative cover in locality, surface drainage Earthquakes, floods, fire, epidemics

2.3 Participatory Approach

The most appropriate method for understanding the vulnerability of the urban poor community of the city was to interact with them hence participatory approach of focus group discussion was adopted (Hildebrandt E, 1999). The findings from the focus group discussions were validated with a field visit in the localities and interviews with key stakeholders of the communities. Table 2 shows the selection of key stakeholders. Urban poor in this study are comprised of low income groups (family income upto Rs35000 ($425) per month) and very low income groups (family income upto Rs15000 ($183) per month). Table 3 shows the groups in the two wards. Four group discussions were conducted, 2 in each ward, each one with group of 25-30 people participating. The participants were adults both men and women in age group of 24-65. The discussion was conducted for 2 hours with an articulated questionnaire and moderated by volunteers of NGO's working in the communities. Each type of vulnerability was discussed with simple questions in local language. The participants were quiet expressive in putting forth their opinions. At the end of discussion on each indicator, the participants were asked to rate their vulnerability on Likert scale as Low, Medium, High and Very High.

Table 2: List of Stakeholders

Stakeholders	No. of Participants	Designation and Description
Urban Planner Architects	2	Practicing in the city for past 3 decades
Structural engineer	1	Practicing in the city for past 3 decades
Disaster Management	1	Disaster Management officer of Pune Municipal Corporation
Civil Society Organizations	4	Working in disaster management of the city in all phases of disasters
Health Care System	2	Doctor with Municipal healthcare system one from each ward
Community Workers	4	One each from community
Community Residents	8	Senior and prominent residents 2 from each group

Table 3: Focus group discussions

Wards	Low Income Group	Very Low Income Group
Vishrambaug wada Ward	Group A	Group B
Dhankawadi-Sahakarnagar Ward	Group C	Group D

3.0 Results

The group discussions were helpful to get the insights from the participants. The opinions were outright and clear. Table 4 shows the responses of the participants. The aggregation of vulnerability for each indicator is marked considering the field visits and opinions of key stakeholders. Figures 2-6 shows the images of the city during heavy precipitation.

Table 4: shows the responses of Participants

DIMENSIONS OF VULNERABILITY	INDICATORS	FOCUS GROUPS				AGGREGATION OF VULNERABILITY
		A	B	C	D	
Physical Vulnerability	Location	H	VH	H	H	HIGH
	Building Design	M	H	H	VH	HIGH
	Construction Material	M	VH	H	VH	VERY HIGH
	Critical Services	M	H	M	H	HIGH
Social Vulnerability	Population Density	M	M	M	M	MEDIUM
	Accessibility to Critical Infrastructure	M	M	M	H	MEDIUM
	Persons with Special Needs	M	VH	M	VH	HIGH
Economic Vulnerability	Employment Status	M	M	M	H	MEDIUM
	Monthly Income	M	M	M	H	HIGH
Environmental Vulnerability	Pollution	M	M	M	M	MEDIUM
	Exposure to Health Hazards	M	H	M	H	MEDIUM
	Natural Vegetation	H	H	H	H	MEDIUM
	Hazard Threat	M	H	H	VH	HIGH

3.1 Physical Vulnerability

All the groups expressed fears for their location. Most of the participants reside in one of the hazardous areas. Group A and B most participants are located in river flood plains and low lying areas, while group C and D are located in flood plains of nallas and on hill slopes. All the participants expressed the threat of hazards and their past experiences of hazards, mostly flooding. Group A and C reside mostly in formal buildings designed by architects and engineers or local contractors, while groups B and D reside in formal or informal slum settlements organically evolved. The building designs occupied by all the groups does not necessarily reciprocate to the hazards which they are exposed to. According to the participants of group A and C the layouts of the houses are satisfactory although it faces issues with natural light and ventilation, as buildings are very close to each other. There was lack of awareness on building design in B and D groups. Though all the participants shared problems they face with their premises.

Groups A and C have their buildings in reinforced cement concrete and brick masonry envelope while groups B and D have a mix of construction material from brick masonry envelope and tin sheets for roofing to complete structure in tin sheets. Groups A and C have multistory buildings constructed by builders and individual houses constructed by local contractors mostly in absence of architects and engineers, as expressed by a participant. Group B and D the construction is done by local artisans. Groups A and C have formal buildings hence they have a formal structure for all the services, which they agree are quantitatively and qualitatively poor. Fire-fighting and security systems are missing for all the groups. Most of the houses for groups B and D do not have formal services. Many have to access water from common tap stands, while use community toilets provided by municipality in most of the localities. Electricity is supplied to most homes, while firefighting and security systems are completely absent formally and informally as expressed by participants.

3.2 Social Vulnerability

All the groups agree on high density of population in their locality. Many household of group B and D houses 6 persons per family, including children, adults and senior citizens. The population in the community is composed of few number of locals and majorly migrants, especially for groups B and D. As expressed by participants, the living conditions are harmonious and in emergency scenarios, people volunteer for help and resources. All the groups agreed to the availability of the critical infrastructure facilities. Hospitals and police stations are within easy reach as expressed by participants. However, the health care services provided by hospitals are not easily affordable as agreed by all the groups. The availability of fire stations is good, the issue of accessibility of fire engines arises during emergency scenarios. The dense built structures and haphazard layouts with width of roads lesser than 3.0 meters make the accessibility of fire engines unfeasible, as evident from past fire events. The number of people with special needs is not significant as per the discussion, however even the smaller number of persons with special needs require the infrastructure facilities like ramps, wheelchair friendly pathways and toilets for their convenience. There is complete lack of such facilities in localities of all the groups. As a participant expressed ‘there are no much facilities for normal people, facilities for people with special needs is unthinkable’.

3.3 Economic Vulnerability

The participants of groups A and C have at least one member of the family with stable employment mostly in private sector while in groups B and D are engaged in mediocre jobs like maids, drivers, labors, street vendors etc. All the groups agree about the uncertainty of the stable income which

increases their vulnerability. The monthly income of all groups ranges from 5000Rs to 25000RS for family which makes living conditions difficult. The overall employment status of the urban poor is not very promising however assurance of employment persists.

3.4 Environmental Vulnerability

The environmental conditions as explained by the participants are not very encouraging. The level of air pollution due to the vehicles plying on the narrow road adjoining the communities is high. The water bodies/ nallas in the proximity are polluted due to the inappropriate drainage system and the disposal of sewage directly into the nallas especially for the groups B and D. Groups A and C have better living conditions compared to other groups with better services and sanitary systems. The dense built footprint, lack of open spaces for fresh air and inappropriate sanitary system makes all the groups vulnerable to health hazards. There is high percentage of health hazards ranging from cough, fever to flu and epidemics as expressed by all the groups. The field visits and interviews with community workers prompts the health care situation in the locality. Children are more vulnerable to these health hazards. The city is famous for its green cover and old deciduous trees, however the need for housing and aligned infrastructure has scourged the vegetative cover in the localities as expressed in every discussion. Concrete roads and paver blocks on concrete base has added to the hardscape completely negating the vegetative cover. The lack of open spaces, gardens, and playgrounds in the locality compromises on the resources required during disaster events. These resources are available as private properties not accessible to general public. All the groups agreed on the probability of hazards from their past experiences. The cloudburst event in 2019, wherein in 21 people lost lives and severe damage to assets was fresh memory for participants in discussion. Groups A and C discussed the inconveniences caused by flooding in their locality while groups B and D are affected to a greater extent by the urban flooding as their houses get drowned, damaging assets. In group B and D, the communities are evacuated and temporarily rehabilitated in public buildings in vicinity. The other hazards participants mentioned is fire in slum settlements from their past experiences. Most participants were unaware about the risks of earthquakes as there is no history.

Fig 2 Flooding of Mula River

Fig 3 Flood waters in Slum settlements (Group B)

Fig 6 Unmaintained buildings (Group C)

Fig 4 Community Toilet in flood waters

Fig 5 Slum Settlements on banks of Nalla (Group D)

4.0 Discussion

4.1 Physical Vulnerability

The land cost in Pune city are high, stressing the real estate market. There are very less affordable social housing projects and other social housing instruments for the urban poor. Hence the urban poor communities occupy the high risk locations in the low lying areas of the city or the banks of Mula river, flood plains of the nallas and the hill slopes as evident in Dhankawadi and Katraj area. These locations have high exposure to riverine flooding, urban flooding and landslides. Every monsoon the group B communities have to be evacuated to safeguard them from riverine flooding. While all the other groups experience inconvenience and damage to assets in every monsoon. Location is singularly important factor increasing the physical vulnerability of the urban poor (Hardoy J and Pandiella,G.2009). The site visits reveal the building occupied by groups A and C do not necessarily follow the building regulations, especially for side margins, layouts and services. The evacuation passageways are cluttered with furniture items and planters. There are no safe open spaces around the buildings for assembly in disaster scenarios. Groups B and D are slum squatters not conforming to any design. These structures are densely built, poor in construction quality, may not stand the impacts of natural hazards. As expressed by a community member, lack of natural light and ventilation has increased the health hazards in children. The overall building design adds to vulnerability of the residents to disaster risks (Kwag S, et.al, 2021).

Reinforced cement concrete (RCC) framed structure and brick masonry is conventional building technology, which is appropriate for earthquake resistance. The apartment building for groups A and C built by local contractors adopts RCC frame structure, however its structural design for earthquake resistance is not guaranteed as expressed by structural engineer in an interview. Maintenance is an important aspect for safety and satisfactory performance of buildings. Maintenance of buildings often is costly affair and hence neglected by the occupants as disclosed by a participant. The buildings hence are not maintained in good condition with the presence cracks and leakages. The combined effect of these factors make these formal residential buildings vulnerable to the impacts of natural hazards increasing the risk to occupants. The houses in slums for group B and D are densely constructed with construction material which is easily available to the occupants, mostly brick masonry and tin sheets for roofing. The slum houses use ply, plastic sheets, tin sheets and other fragile covering materials increasing the risk of fire, and collapse during heavy precipitation. The building material and construction practices has potential to make the occupants highly vulnerable to the impacts of natural hazards (Bosher L, et.al, 2016).

Critical services like water, drainage and solid waste, storm water drainage are important for the day to day functioning of the occupants and buildings. The building occupied by groups A and C have good water supply and drainage facilities, while the city administration takes care of collection of solid waste on daily basis. The buildings lack firefighting systems. There are no appropriate storm water drainage systems for buildings to carry the runoff from adjoining roads. The dense built cover and lack of storm water drains floods the localities during heavy precipitation. The urban flooding situation is more critical in slums, wherein the populations needs to be evacuated in monsoon months. The slums areas of group B and D lack basic services making the living conditions unsanitary and poor. The combined effect of dense built cover and lack of basic services makes the populations vulnerable to impacts of urban flooding increasing their risk to life and assets (Rahman M, et.al, 2021). The aggregation of all the indicators reveals physical vulnerability is high.

4.2 Social Vulnerability

Pune city is preferred choice for migrants in search of livelihoods. The city attracts population from all over the state and country, especially in the building industry and industrial sector as

labors. As there are very few choices of social housing instruments, poor migrants settle down in slums. The population density is 2398.5 persons per hectare with 28% of population living in Pune slums as per the Environmental Status Report of Pune Municipal Corporation (ESR, 2016-17). The population density increases the exposure to natural hazards merely due to concentration of population. Though the living conditions are harmonious, the migrant population lacks belongingness to the city and experience helplessness in emergency scenarios as expressed by few participants. Both these factors add to vulnerability marking it medium on the scale. The availability and accessibility to critical infrastructure facilities can significantly reduce loss of life in disaster scenarios (Mukherjee M, et.al. 2023). These critical facilities are available and needs upgradation further to respond in disaster scenarios. However, in normal conditions the accessibility to these critical facilities is arduous. There is dire need to upgrade the facilities with resources and organize the accessibility of these critical facilities for urban poor to prevent a hazard from turning into a disaster. The vulnerability scale for this indicator is medium. Persons with special needs are more vulnerable in disaster scenarios and easy victims as evident during covid-19 (Winarno E, Rusmiyati C and Probosiwi R, 2021). The complete absence of sensitivity and awareness for requirements of such persons with the society as whole including administration, results in more dependency. The family structure and community support system is evident in supporting the persons with special needs. However, the vulnerability to persons with special needs in disaster scenarios is high. The aggregation of all the indicators suggests the social vulnerability is medium.

4.3 Economic Vulnerability

The city offers opportunities of livelihoods; however, the living costs are high. As expressed by a community worker, though there is uncertainty of permanent jobs, mediocre jobs are always available. The amenities like good health care and education becomes unaffordable to urban poor. Though the administration is trying hard to accommodate the urban poor in the government aided healthcare and education system, it is qualitatively and quantitatively not significant. Further any disaster event puts them in jeopardy, which was evident in covid-19, adding to their economic vulnerability. The economic vulnerability is medium.

4.4 Environmental Vulnerability

The air quality of the city as per the IITM and IQAir report is poor and has the potential to create health hazards (IQAir Safar). The city administration ensures the quality of drinking water with appropriate treatment mechanisms. The surface water bodies, river and nallas in the localities are polluted adding to the health hazards of the communities in proximity. The poor and unhygienic living conditions, inaccessibility to health care systems and lack of awareness on health and hygiene are some prominent reasons for the increased health hazards in the communities as stated by the doctors in the neighborhood and community workers. The pollution levels expose the poor communities to health hazards. The vulnerability to this indicator is medium.

The importance of open spaces and vegetative cover is significant in flood scenarios to retain and absorb surface water. Due to the concretization of roads, other hard paved surfaces and lack of surface drainage system, the localities get flooded during heavy precipitation in monsoon months. The field visits and the study of storm water drainage plans of municipality reveals there is no strategic approach for flood management which acknowledges the importance of vegetative cover and wetlands. The lack of natural vegetative cover makes poor population vulnerable to threats of disasters (Lallemant D, et.al.2021). The field visits and interviews with community workers reveal the exposure to hazards is high due to the haphazard layouts, limiting the accessibility of critical services like ambulances and fire engines, overall poor living conditions and increased frequency of heavy precipitation. These factors add to the vulnerability of the community

increasing their risks to natural hazards. The exposure to different hazards is high in urban poor communities (Zerbo A, Delgado R.C, González P.A, 2020).

Pune city is not a planned city but organically evolved over years from a small village Punawadi to Pune, a metropolitan city. The infrastructure development decisions are 'need' based rather than proactively planned decisions (Kodag S, et. al, 2022). Accommodating influx of migrant population stresses the infrastructure of the city. The growing risks of natural hazards as impact of climate change is further stressing the existing critical infrastructure. Interviews with government officials, Urban planner architects and volunteers of organization working in disaster risk reduction reveal, managing disasters is a reactive process, wherein larger efforts and investments are made in response and recovery in post disaster phase. The administrative mechanisms work effectively in safeguarding people's life, but the damage to their assets make poor communities economically weak further (Hallegatte S, 2020). The awareness on safety mechanisms and preparedness is low in the pre-disaster phase, with the communities and equally with the administrative bodies. Spatial planning hence should adopt the prevention and mitigation measures for disaster risk reduction of urban poor communities. The vulnerability caused due to physical conditions plays a greater role in increasing the risk.

5.0 Conclusion

Heavy precipitation days have become frequent causing urban flooding, affecting mostly the urban poor populations. The cities are not designed to accommodate the urban poor in its developmental process. Poor populations hence have to make their own choice of living conditions as per their affordability, forcing them to settle down on hazardous lands and locations exposed to hazards. The study reveals, risk is enhanced by the physical conditions more than social or economic vulnerability. Urban flooding is causing enormous damages affecting the poor populations located in hazardous areas. The study further reveals the physical vulnerability is an attribute of spatial planning, which needs to be acknowledged along with the environmental vulnerability. The impact of climate change is secondary, while inappropriate development pattern of the urban areas and not acknowledging the needs of urban poor is the primary cause of vulnerability.

The informed decision system for making developmental decisions for the city can go a long way in preventing the damages. The prevention, preparedness and mitigation measures taken in pre-disaster phase can help in reducing the disaster risks. The spatial planning and infrastructural facilities of the city must acknowledge the risks from climate change and must upgrade routinely for absorbing its impacts, making the systems more robust and resilient. The reactive responses to disaster risks fail to strengthen proactive and informed decision making system of the city administration. The vulnerability of the urban poor could be reduced by building the capacities of the urban poor and equally of the administrative bodies to respond to the impacts of climate change. The choices and decisions made for development of urban areas needs to be reconsidered for the impacts of climate change.

6.0 Limitations of the study

This study limits only to few dimensions of vulnerability of urban poor communities, mostly from the spatial perspective. Vulnerability is larger concept in the context of urban communities and climate change. There are various dimensions to study vulnerability with different approaches (Lankao P and Hua Qin, 2011), and this study could be expanded further for different perspectives of vulnerability.

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