

Review Article

Climate Change Vulnerability of Pakistan Towards Natural Disasters: A Review

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Abstract: The paper in hand is a review of scientific findings focusing on vulnerability of Pakistan in the context of climate change (CC). Since last decade, head to head episodes of natural disasters especially floods, leave the country's people highly vulnerable to the negative impacts of climate change due to its geographical location and socioeconomic conditions making it susceptible to natural disasters. In this paper we conclude the state of the art research by discussing and clarifying different conceptual definitions of vulnerability and its association with CC. Further the paper highlights vulnerability and exposure of Pakistan towards natural hazards such as floods, droughts and cyclones stating that the country is vulnerable to numerous hazards, both natural and human induced due to a direct consequence of the country's high variability and regional contrast in terms of geology, topography and meteorology. Next, the paper outlines exposure and vulnerability among the poorest by summarizing that in most cases poorest of the poor communities are hard hit by climate change due to their high exposure and low adaptive capacity and the final part of the paper concludes discussion that for Pakistan, as a hazard-prone country, it is the need of time to actively address natural hazards at all scales by engaging local communities and organizations to better withstand natural disasters.

Keywords: Climate Change, Natural Disaster, Flood, Vulnerability, Pakistan

1. Introduction

The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has provided strong evidence that climate change is affecting most of the countries in the world [1]. The impact in terms of losses from such changes in climate are experienced differently across the world [2]. Developing countries are notably vulnerable (Houghton *et al.*, 2001) because of their rapid population growth, unsustainable resource use, infrastructure constraints, relatively high exposure and low adaptive capacity for example, about 95% of all disaster related deaths occur in developing countries and other losses due to natural disasters are twenty times greater in the developing world than compared to developed countries [2, 4, 5].

The rural, rugged and diverse geographical location as well as unmanaged settlement, increased population, low literacy

rate and lack of awareness in the country are the major contributing factors to the vulnerability of society to natural disasters which primarily hard hit the poorest of the poor communities [6]. Observations shows that different parts of Pakistan are under different climate stress such as northern areas mostly face snowstorms, landslides and avalanches and floods. Coastal areas face the flood and cyclones risk. Central parts and mid-river basins primarily face flooding risks, while southern Punjab, Sindh and Baluchistan are vulnerable to drought [2]. According to the statistics of global vulnerability index, Pakistan is among the top 10 countries hard hit by climate change where large segments of its population are extremely poor and are highly vulnerable to the negative impacts of climate change. Natural disasters are frequently happening in Pakistan every year mainly caused by weather

phenomena [7]. Recently, these disasters are happening more frequent and intensely, resulting in making society more vulnerable to disasters such as floods caused by Monsoon (notably in 2010, called 'the Pakistan flood') [7], droughts [8, 9], storms, cyclones, landslides [10] and heat strokes in Karachi are some of the prominent and recent examples of such incidents.

Damages associated to natural disasters are responsible for the deaths of 6037 people in the period from 1993 to 2002, with a further 8.9 million people also affected [11]. The Pakistan flood in 2010 was the biggest disaster of the century for the country and had effected almost 20 million people with other economic losses of [12]. According to the survey conducted by Asian Development Bank (ADB), the estimated costs of flood damages to irrigation, drainage, infrastructure is Rs 23 billion and its rehabilitation and reconstruction will further cost 83 billion. A study conducted by Khan and Salman [13], showed that flood in 2010 great effect on the society of Pakistani ranging from livelihoods of rural people to food security in urban areas, transport, communication, energy, health, water control, and institutional setup failed during the floods. Another survey conducted by the Asian Development Bank and the World Bank for the Government of Pakistan reported huge recovery losses i.e. USD 8.74 to 10.85 billion [14]. Hence, flood in 2010 disproportionately affected Pakistan especially poorest regions for example, rural Sindh and southern Punjab. Standing crops in these regions were destroyed, thus pushing them into poverty [6]. Another consistent problem for Pakistan's authorities is that natural disasters occur more or less regularly at all scales. Disaster management in Pakistan, particularly with regard to natural hazards, focuses mainly on relief and rescue processes with a lack of information and little understanding of the processes involved in hazard identification, risk assessment and management, and the relationship between people's livelihoods and disaster preparedness [15], which increases chances of vulnerability of the society especially the poor. Notable risk factors that increase vulnerability and contribute to the severity of disasters in Pakistan includes; lack of early or at least timely warning systems; limited awareness and education; lack of skilled manpower and more importantly lack of coordination among various government organizations puts large number of communities susceptible to both natural and human induced disasters [2, 8, 12].

In this context, this paper reviews relevant literature with the objective of documenting different conceptual definitions of vulnerability and its association with climate change. In the next section, the paper highlights vulnerability and physical exposure of Pakistan towards natural hazards such as floods, droughts, cyclones. In addition, the importance of vulnerability mapping is discussed to identify areas critically vulnerable due to the negative impacts of climate change. The following section reviews hazards impacts and trends in Pakistan for the last 3 decades following by exposure and vulnerability among the poorest and the final part of the paper provides a conclusion of the study.

2. Conceptualizing Climate Change Vulnerability

Scientific community have attempted to define vulnerability in many different ways and all those definitions varies so widely that it needs further specification [16] but a consensus can be found that exposure, sensitivity and adaptive capacity are the key elements of vulnerability. Kaspersen et al., [17] has reviewed climate change vulnerability definitions in detail while Adger [18] has endorsed the basic concept of vulnerability mentioning that it has different meanings for different people around the world. For instance, physical exposure to extreme events and its outcome is the core interest of physical scientists and engineers while social researchers have emphasized on socio-political factors in community due to uneven access to resources which makes them vulnerable to natural and human induced disasters. On the other hand, some scholars have also tried to integrate both concepts of physical and social scientists to create a comprehensive understanding of the "vulnerability of place" [19]. In this regards, it is important to highlight the all aspects of vulnerability and cannot be left isolated because it is highly contextualized in social and political spaces [20].

A large number of literature has been published to highlight climate change vulnerability and its associated impacts on communities at different levels and sectors such as [18, 21-31]. Intergovernmental Panel on Climate Change (IPCC), in its Second Assessment Report, defines vulnerability as "the extent to which climate change may damage or harm a system." It adds that vulnerability "depends not only on a system's sensitivity, but also on its ability to adapt to new climatic conditions" [3]. The central idea of the most recent report of the IPCC provides a useful typology suggesting that vulnerability may be characterized as a function of exposure (change in climate and what is effected), sensitivity (direct effect of climate change of system) and adaptive capacity (ability of a system to adapt to climate change, reduce adverse effects or take advantage of beneficial effects) [5]. According to Adger and Kelly [32], vulnerability is the exposure of individual's stress as a result of the impact of extreme climate events. Adger (2006) [18] explained vulnerability as a function of character, magnitude and rate of climate change. He further mentioned that a system must have the potential to adjust itself to the changes that a climate change may bring.

Adger et al., (2005) and Mendelsohn et al., (2006) [33-34] quoted that exposure and vulnerability vary across temporal and spatial scales, and depend on economic, social, geographic, demographic, cultural, institutional, governance and environmental factors. Murray and Ebi [35], focused on the uneven distribution of wealth, inequality in access to education, disability and health status, as well as gender, age, class and other social and cultural characteristics." as the major causes of vulnerability. Some vulnerability studies focus on systems, places and activities [19, 36] while others examine individuals, livelihoods, landscape and ecosystems such as [37]. Loss of resilience creates vulnerability [38], but

there is no standard definition of vulnerability which is generally described as the capacity of a person, group or natural and human system to anticipate, adapt, resist and/or recover from the impact of natural hazards rather it involves a combination of factors that determine the degree to which an individual's life and livelihood is put at risk by a discrete or identifiable event in nature or society [37]. A wide range of literature shows different frameworks for assessing vulnerability of natural systems to climate change [21, 26, 31, 37, 39]. Those studies recognize that vulnerability analysis needs contextualized and that both climatic and non-climatic drivers, including political, institutional and socio-economic are taken into account while others have suggested tools for assessing social, biophysical and economic vulnerability [40]. Thus the concept of vulnerability is central to understanding how ecosystems, communities, institutions and social relationships such as gender are affected by climate change [41]. Scientists may not agree on a single definition but they have showed agreement on the three components of vulnerability i.e. exposure, sensitivity and adaptive capacity.

3. Vulnerability and Physical Exposure of Pakistan towards Natural Hazards

Pakistan lies in a dry region where it receives less than 250 mm of rain every year. There is prominent difference in the climate of Pakistan between northern and southern areas. Most of the annual rainfall (about 59%) is due to monsoon rains. Temperature variation ranges from 30°C to 10°C during the coldest months. Summers are immensely hot in most of the country with cold and dry weather in winter and coastal areas in the south has a moderate climate. Northern areas of Pakistan receives more rainfall in Monsoon season and are moderate in summer while colder in winter. The diversity and regional contrast in terms of geology, topography and meteorology puts Pakistan vulnerable and prone to numerous hazards, both natural and human induced [11, 42].

Pakistan can be classified as one of the most arid countries of the world. Akhter [43] reported that, around 80% of the land is arid or semi-arid and vulnerable to desertification, about 12% is dry sub-humid and the rest 8% as humid. Its population and economy heavily depends on the annual influx into the Indus System which covers about 60% of the country and other rivers, mainly derived from snow melting in the Himalayas [44]. Despite the influence of the summer monsoons, the country is arid and vegetation and crops depend on rainfall intensity and irrigation. Only 20 million ha of the 79.6 million hectares (ha) land is suitable for agricultural production (16 million ha for irrigated farming and 4 million for rain-fed, or barani, agriculture). Forested land is about 4.2 million ha, while a sizeable chunk (28 million ha) are rangelands. About 77% of Pakistan's population is located in the Indus basin, and 40 million people depend on irrigation water for their domestic use, especially in areas where groundwater is brackish [43].

3.1. Exposure and Vulnerabilities of the Poorest

It is commonly understood that the poor are likely to be hit hardest by climate change, and that capacity to respond to climate change is lowest among the poorest residing in developing countries. Adger [18] suggests that, to understand vulnerabilities of poorest to different hazards, it is must to first identify who is poor. Many studies have attempted to identify, rank and map poverty at different levels using different classification techniques and socio-economic indices. For Example, Arif and Farooq [6] and Cheema & Sial [45] previously reviewed the extensive literature on vulnerability of the poor and some other studies have focused on agricultural and agro-climatic zone classifications. Malik [46] and Irfan [47] derived poverty incidence on the basis of 2004–05 Household Income and Expenditures Survey (HIES), agro-climatic zones and differentiated between urban and rural zones at the provincial level. Irfan [47] suggested that differences in land distribution and ownership structures at provinces and districts level were also significant factors in poverty incidence.

People that are most exposed and have least potential to recover and adapt to climate change are considered as most vulnerable [39]. Furthermore, a considerable body of literature exists in Pakistan that has identified the poorest segment of the population based on both quantitative and qualitative research. This literature has identified the following rural groups as the poorest: landless households, sharecroppers and small landowners, agricultural workers, construction workers, female-headed households, large households and zakat recipients [6].

Mustafa [20] noted that in Panjab province of Pakistan, lack of structures such as schools, hospital and irrigation systems primarily contributes to vulnerability at the all levels. However, the effect of exposure and vulnerabilities were found unequal within a community and were considered as causes of powerlessness and poverty. The poorest and landless people tend to have homes in the low-lying areas of the main village while on the other hand, large holders and affluent individuals are usually situated on higher ground beyond the main inundation zones [20]. In Pakistan, rural people make houses with low cost and easily available material called pacca (made of stone, brick and cement or katcha (timber frame). Maheri et al., [48] have reported the vulnerability of such structures to meteorological and geological hazards in Pakistan. Sources of income also play important role in identifying who are most and/or least vulnerable to the negative impacts of climate change such as agriculture sector is among the highly effected livelihood [31, 49]. Large landowners and small farmers report a significantly larger percentage of loss of income (67% and 77%, respectively) during flooding than the landless (41%). Small farmers and landless households have a proportionately higher number of people with non-farming sources of income where livelihood sources other than agriculture are seen as insurance against a total loss of income in disasters [20].

3.2. Flood

In Pakistan, flooding is the most devastating and damaging natural disaster and subsequently causes tremendous loss of human lives, infrastructure and natural resources [50]. Floods normally occur in Pakistan due to tropical monsoon depression systems that originate from the Bay of Bengal during the months from July to September. Districts along the Indus plain are particularly affected by riverine floods, while hill torrents tend to affect the hilly districts located in the northern and western parts of Pakistan [7]. For example, the 2010 flood event named Pakistan Flood 2010, was massive, affecting 160,000 km² (1/5 of Pakistan's total land area). It caused an estimated US\$ 9.7 billion in damage.

Agriculture and livestock were particularly hard hit, while the flooding also destroyed a large number of houses and damaged roads and irrigation facilities. According to the NDMA, the flood caused 1,825 deaths, 157 missing, 20 million individuals were displaced and around 3,000 injured; over 1.9 million houses were damaged and over 6.3 million acres (2.57 million ha) of cropped areas were destroyed as of October 4, 2010. A total of around 78 districts were inundated by the Pakistan Flood 2010, in which 28 districts were severely affected: 1 district in Azad Jammu & Kashmir, 10 districts in Khyber Pakhtunkhwa, 7 districts in Punjab, 2 districts in Baluchistan, and 8 districts in Sindh. The number of individuals affected by the flooding exceeded the combined total of individuals affected by the 2004 Indian Ocean tsunami, the 2005 Kashmir earthquake and the 2010 Haiti earthquake. The 2011 flood affected another 8.9 million people and destroyed 1.5 million homes in 37,000 villages in the Sindh province alone. According to the estimates reported in NDMA report published in 2012, five major flood incidents in 1950, 1973, 1976, 1992 and 2010, are among the top events resulted in many deaths and huge losses to the national economy. Total damage to property by the destructive major floods in Pakistan has reached over Rs. 400 billion since 1950.

3.3. Drought

Droughts are environmental disasters and generally categorized into Meteorological, Hydrological, Agricultural and Socio-economic droughts [51]. Droughts, with different characteristics, can occur in all climatic zones for short and long time depending on the situation of that region. In Pakistan, droughts occur frequently in Sindh and Baluchistan region due to low rainfall in the region and other socioeconomic situations [52]. Drought is complex phenomenon because of its closer links to socio-economic conditions and is usually also closely related to poverty and non-adaptive land, water and agricultural practices leading to the overexploitation of groundwater, deforestation and the depletion of grazing land [9].

Larsen et al., [53] mentioned in his report by quoting (Global Facility for Disaster Risk Reduction) that droughts of 2000 and 2002 in Pakistan were so severe, destroying livelihoods of people. More than 3 million people were severely affected in the Baluchistan and Sindh provinces,

many were forced to migrate. In addition, millions of livestock were killed costing more than US\$ 2.5 billion. The 2001 drought reduced economic growth from an average of 6% to only 2.6%. Another example is of Tharparker in 2001, where hundreds of children died due to malnutrition since the beginning of 2014 due to severe very less rainfall reported from March 2013 to February 2014, i.e. 30 % below normal [9, 53]. Some observers suggested that those deaths were not only because of droughts but extreme endemic poverty and an outbreak of disease were also among the causes [54].

3.4. Landslide

Larsen et al., [53] have mentioned in his report that most of areas in Pakistan are exposed and vulnerable to climate induced landslides especially Kashmir, Northern Areas and parts of the Khyber Pakhtunkhwa province. A fragile soil type of mountain ranges, high deforestation rate, cultivation and unplanned construction are also major causes of increased incidences of landslides. Small scale isolated landslide hazards happen frequently in the above mentioned regions. A total of 13 landslide events have been recorded since 1926 causing the death of 413 people [55].

3.5. Cyclones

Another important natural hazard (though occur less frequently) is cyclone causing numerous large scale damages to the coastal communities in Pakistan. The history of past damages shows coastal areas such as Gwadar, Ketch, Lasbella and Awaran district in Baluchistan and Badin, Karachi, Hyderabad and Thatta in Sindh province are highly vulnerable to cyclones [12]. Recently, changes in climate exacerbate the frequency, intensity and changes in tracks of cyclones in Sindh province. Considerable damages to lives, property and infrastructure have been reported due to tropical cyclones, adversely impacting the socioeconomic situation of the area. The NDMA (2012) [12] report stated that 14 cyclones were recorded during 1971 and 2001. In 2007, Yemyin cyclone hit coastal communities in Pakistan and killed over 213 people in Karachi mainly from rains and strong winds. The number of deaths reached at least 380 in Baluchistan, 250 in Sindh and 100 in Khyber Pakhtunkhwa (KP). At least 10 districts were affected in Baluchistan and 4 districts in Sindh, affecting the lives of at least 1.5 million people. The report further mentioned that around 2 million people were indirectly affected by the cyclone from power outages and shortage of water. In addition, above 2 million livestock were killed by the cyclone. The estimated property losses from the storm were around Rs 24 billion.

Besides those major natural hazards, Pakistan is also seasonally facing Avalanches in Kashmir and Gilgit Baltistan region and northern parts of KP. Forest fires also includes the list. Over the past 10 years, 2040.25 acres of forest area in Margalla Hills National Park rest area has been burnt in 309 fire incidents. Massive deforestation also happens in the northern areas of KP resulting in soil erosion, loss to bio diversity, more frequent landslides and floods.

4. Hazard Impacts and Trends

National Disaster Management Authority [12] described in its report that natural hazards in Pakistan originate mostly from meteorological phenomena such as floods, storms, cyclones, landslides and extreme weather. Climate change and variability are major dynamic pressures that increase the vulnerabilities of Pakistani society to disasters. These disasters accounted for more than 75% all natural disasters between 1980 and 2013. Out of those 75%, floods (riverine flooding and flash floods) accounting for 46% of all hazards [7, 53]. More importantly, all these hazards except droughts are expected to hit very year. Since last three decades, in terms of impact, 85% of the population are affected by flood hazards with 74% corresponding to riverine floods concentrated along the Indus River floodplain, of which more than 35 % can be attributed to a 2010 flood event and droughts affected 3% of the total population during the same period [53]. In terms of overall economic damages, floods have contributed the most. More specifically, in the past few years, riverine floods have predominantly affected majority of the population, livestock and other infrastructures [2, 44]. Riverine flood events accounted for nearly 100% of the total damages in this duration (43-44). This analyses shows that, floods are the major prevalent hazards in Pakistan followed by droughts and storms. In addition, due to the complex nature of droughts, the collection of objective field information on drought events (e.g., geographical extent and timing) and its direct or indirect impact is a real challenge [56, 57].

Table 1. Profile of Natural Disasters in Pakistan.

Type	Deaths/Year	Affected/Event	Losses* /Event
Droughts	143	2,200,000	247,000
Epidemics	27	339,198	274,553
Extreme Temperature	101	48	
Floods	136	565,236	33,908
Storms	85	128,641	95,937

* US\$ 1,000, Source: EM-DAT, 1980-2008

In conclusion, past hazards events show that disasters in the country are seasonal and it is impacting different regions of Pakistan differently due to its diversity in terms of climate and topography. Every province and region faces a diverse range of hazard threats. For instance, the coastal areas of Pakistan are prone to cyclones and tsunamis. Southern Punjab is mostly affected by the threat of droughts and flooding, while Baluchistan is at risk for droughts, earthquakes and flash floods. Furthermore, the Sindh province faces the possibility of droughts and flooding, while Khyber Pakhtunkhwa is affected by earthquakes, landslides, avalanches and flooding. In future, disasters are expected to hit Pakistan more frequent and intensely.

5. Conclusion and Recommendations

This paper provides a detailed review of climate change vulnerability of Pakistan. Climate change is recognized as a major threat in 21st century having different regional impacts

depending on the situation i.e. geography, socioeconomic condition etc. The prediction that the frequency and intensity of natural disasters such as floods, droughts, extreme weather events, unpredicted and unseasonal heavy rainfalls will increase has proven to be true due to the head to head occurrence of natural disasters around the globe every year. Pakistan is in a hazard prone country and is hard hit by the negative impacts of climate change partly because it doesn't have enough resources to cope with and recover from numerous large-scale disasters and partly because dealing with disasters itself is quite complex and resource demanding. Among those disasters, floods are more frequently occurring in the country leaving a huge number of population vulnerable. Every year, monsoon rainfalls destroys agricultural land, kills livestock, and destroys infrastructures which ultimately effects economy of Pakistan. The situation becomes worsen by droughts in Singh and Baluchistan, heatwaves in Karachi and climate induced landslides in the northern areas and Kashmir region, resulting in human and economic loss. For Pakistan, as a hazard-prone country, it is increasingly important to pro-actively address natural hazards and the cumulative risks that they pose. Key gaps in current hazard mitigation plans needs to be recognized primarily considering threats posed by CC vulnerability, socioeconomic risk and other resiliency factors such as demographics, poverty and livelihood alternatives. Creating awareness among vulnerable communities will surely reduce the number of deaths and injuries because risk awareness has been proved an effective measure in reducing negative impacts of disasters. To foster social ecological resilience research and planning at the community level, support should be given to local initiatives and organizations already working to enhance local resilience.

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