

SOCIAL VULNERABILITY INDEX: CASE OF PAKISTAN IN THE AFTERMATH OF THE 2022 FLOODS

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Abstract

Despite Pakistan's minimum contribution to global carbon emissions, the country has experienced significant changes in its climatic dynamics in recent years. These transformations have led to pressing challenges, which adversely impact the residents of Pakistan. To map the most socially vulnerable regions of Pakistan, this study has constructed a Social Vulnerability Index (SVI), which includes many socioeconomic factors as the leading indicators along with multiple subcategories. Furthermore, the paper investigates the government's policies and initiatives towards climate change and risk resilience. The study offers policymakers insights for adjusting policies and developing preventive and curative measures to enhance the resilience of the country.

JEL Classification: Q54, I30, R11

Keywords: Climate Change; Floods; Pakistan; Risk Resilience; Social Vulnerability

1. INTRODUCTION

The global landscape is witnessing a rise in the frequency of nature-related disasters. This increase is being attributed to climate change by nations worldwide. Climate change is acknowledged as one of the emergent problems of the 21st century that requires immediate action. Countries in the Global South are being adversely impacted. This has prompted organisations like the World Bank and the UN to take a nuanced approach to understanding the issues generated by climate change. They have been actively working on devising policies to minimise global emissions, which are essential to climate change.

In 2019, a disparity in global carbon dioxide emissions was observed: 10% of the emitters were responsible for 48% of CO₂ emissions, while the bottom 50% accounted for only 12% of CO₂. The first echelon consists of households from the Global North, and the latter comprises those from the Global South (Generation Climate Europe, 2022). These statistics show that the Global South does bear the adverse impacts of climate change. However, frequent floods, droughts, and famine are common to both the Global South and the Global North. The

most vulnerable countries to climate change in the Global South include Chad, Somalia, India, Bangladesh, Pakistan, etc. This paper focusses on Pakistan and its vulnerability to climate change. The global climate risk index ranks Pakistan eighth in its vulnerability to climate change. This makes Pakistan one of the most severely impacted nations by climate change, even though it is contributing only 0.88% to global emissions (Arif, 2022).

The dynamics of Pakistan's climate have been fluctuating in recent years. This fluctuation is noticed through changes in precipitation, plummeting temperatures, glacier melting, loss of biodiversity, and many other factors. This transformation in the atmospheric dynamics has profound consequences for the country, its ecosystem, and the livelihood of its people. A disparity of climate change is evident in Pakistan's monsoon season, where residents have witnessed it getting worse every coming year. Regions traditionally unaffected by monsoons, such as Chitral and Swat, are now grappling with the unexpected challenges of this climatic phenomenon.

In 2022, Pakistan experienced devastating floods that worsened the precarious climate situation. These floods resulting from intense and prolonged

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monsoon rains add to the complexity of the country's climate challenges. Pakistan's rural population became more vulnerable, suffering significant losses in livelihoods, families, homes and livelihoods, among other things. More broadly, communities were displaced and infrastructure destroyed, dealing a significant blow to the economy. These dire ramifications of the 2022 floods place a considerable burden on the long-term resilience of the country, which is studied by this paper. The idea is not novel, but with increased destruction of natural disasters, an extension of the previous work was required. People who were previously living in their own houses are now displaced, emphasising that if similar floods occur in the future, the devastation may be more significant as the weather is predicted to worsen, making these impacts more intense. This paper primarily works on constructing a social vulnerability index using data from the year 2020. The purpose is to assess the pre-existing vulnerability of individuals before the 2022 floods, scrutinise the ensuing impacts, and analyse the efficacy of the current preventive and curative policies implemented by the government. This analysis seeks to gauge the adequacy of these policies in sustaining the livelihoods of affected populations and enhancing resilience to potential similar occurrences in the future.

1.1. Research Questions

1. How was the susceptibility of the population that led to the 2022 flood damage?
2. How do current government policies contribute to developing a resilient nation capable of effectively responding to future disasters?

2. LITERATURE REVIEW

Global climate issues call for a thorough examination of the connections between environmental crises and social vulnerability to see the magnitude of the dire challenge climate change has posed. The acceleration in climate change and the heightened frequency and severity of extreme weather events, particularly floods, magnify the negative impact on susceptible regions. Climate change is affecting almost all countries across the globe. Although the magnitude of the effect is contestable, it is discerned more in developing than developed countries (Generation Climate Europe, 2022). The most precarious impacts

of climate change are devastating floods, droughts, famines, etc. Since most of these disasters hit developing or underdeveloped countries, many researchers have studied the impact and vulnerabilities of different communities to different disasters. This literature review aims to elucidate the global context of climate challenges and delve into the dynamics of social vulnerability, narrowing its focus to the case of Pakistan, with a specific emphasis on the unprecedented floods of 2022.

2.1. Social Vulnerability in Pakistan: Lessons from South Asian Neighbours

The experiences of India, Bangladesh, and Sri Lanka offer valuable insights into social vulnerability, which is highly relevant for Pakistan. Their challenges highlight the multifaceted nature of vulnerability and the necessity of robust adaptation strategies.

2.1.1. India

India's high population density, significant variability in rainfall, and elevated poverty rates make it particularly susceptible to climate change. The country faces frequent episodes of extreme weather, impacting agriculture and public health unpredictably. Similar to Pakistan, India has experienced increases in national mean surface air temperature and significant variations in rainfall patterns. The glaciers on Himalaya are melting, which is adding to the rising sea levels that now pose transboundary risks to Pakistan's river systems and coastal areas. Additionally, high levels of air pollution in India could further alter rainfall patterns, a concern also relevant for Pakistan (Srinivasan, 2019). This has led the population to be highly vulnerable; due to houses not being strong enough, people get displaced and lose their jobs (Hari et al., 2020). Therefore, robust climate models and informed adaptation policies are essential.

2.1.2. Bangladesh

Bangladesh is at high risk from natural disasters due to climate change, particularly those living on riverine islands (chars). A study conducted in Gaibandha, Bangladesh, examined social vulnerability, impacts, and adaptation strategies using data from 180 households. The results show that vulnerability and adaptation abilities vary based on

proximity to the mainland. Contributing factors include geographical location, inadequate housing, illiteracy, displacement, climate-sensitive occupations, and low income levels (Rabby, Hossain, & Hasan, 2019). These factors increase vulnerability. Climate change and its related hazards have severe effects on these communities' lives and livelihoods. While riverine residents adopt various adaptation strategies, challenges such as limited educational facilities, insufficient climate change information, poor infrastructure, and financial constraints impede sustainable adaptation (Hossain, Shi, Ajiang, Sohel, & Yijun, 2023).

2.1.3. Sri Lanka

Research indicates that Sri Lanka's climate has already undergone significant changes. From 1961 to 1990, the average air temperature rose by 0.016°C annually, while mean yearly precipitation dropped by 144 mm (7%) compared to the period between 1931 and 1960. Projections show that by 2100, the country's average temperature could rise by approximately $0.9\text{--}4^{\circ}\text{C}$, with variations in rainfall amount and distribution. These changes might result in a 13–23% increase in the irrigation water required for paddy during the Maha (wet) season by 2050, compared to 1961–1990 (UNDP, 2023). Projections also suggest that coconut yields might not meet local consumption needs after 2040, and a 100mm monthly reduction in rainfall could decrease tea productivity by 30–80 kg per hectare. Regions like Nuwara Eliya, Badulla, Monaragala, Ratnapura, and Anuradhapura are particularly vulnerable due to their dependence on primary agriculture, poor infrastructure, and socioeconomic challenges, combined with high exposure to past hazards. There is a need for a thorough assessment of water resources and agricultural vulnerability, the creation of reliable future climate scenarios, and a national audit of water resources (Eriyagama, Chandrapala, Lalith, & Fernando, 2010).

2.1.4. Relevance to Pakistan

The climate challenges and responses in India, Bangladesh, and Sri Lanka offer valuable lessons for Pakistan. Understanding these dynamics is crucial for crafting effective adaptation strategies to address the multifaceted nature of social vulnerability in Pakistan. Robust climate models, detailed vulnerability

assessments, and targeted adaptation policies are essential to mitigate the adverse impacts of climate change on Pakistan's social and economic fabric. This study serves as a starting point for more investigation on region-specific vulnerabilities and adaptive capacities, aiming to enhance resilience and ensure sustainable development across diverse districts in Pakistan.

3. GLOBAL CLIMATE ISSUES AND SOCIAL VULNERABILITY

The global landscape is increasingly shaped by climate change. Therefore, researchers have conducted many studies to construct SVI for different countries post- and pre-disasters. The pioneering work that initiated the development of the social vulnerability index was done in the US in 2003. It uses 200 variables to quantify the social vulnerability of the residents of the United States. The paper used concepts presented in Table A1 in the appendix to come up with a representative SVI.

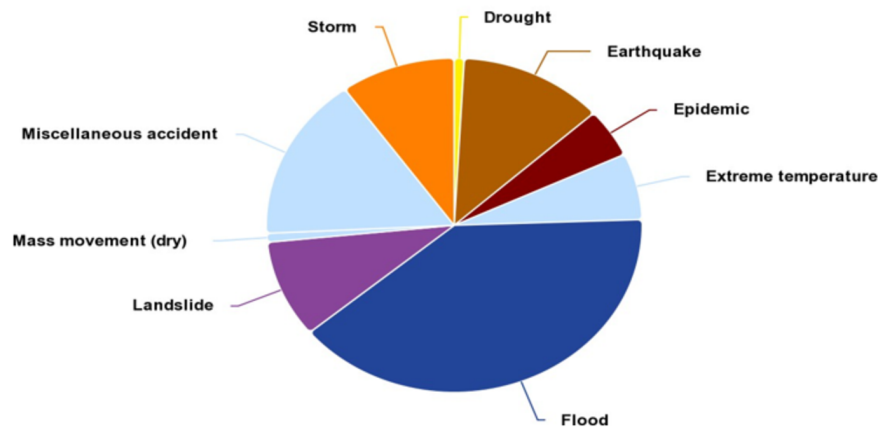
The Social Vulnerability Index (SVI) has undergone multiple modifications to account for distinct categories of hazards and varied geographic settings. Personalised versions for local governments, state-level mitigation planning, metropolitan comparisons (Burton, Kates, & White, 1993), and global applications (Holand & Lujala, 2010) are a few examples of these modifications. Furthermore, the SVI has demonstrated its adaptability in evaluating hazard readiness and analysing post-disaster recovery initiatives (Mendes, 2009).

Notably, the adaptability of SOVI was enhanced by creating a version specifically designed for Nepal and evaluating how susceptible its people were to natural disasters. This study uses a modified approach, with 39 variables used in place of the conventional 200, which are then streamlined through principal component analysis (Aksha, Juran, & Resler, 2017).

4. A CASE STUDY OF PAKISTAN

4.1. 2022 Floods and Devastation

In recent years, Pakistan has been among the top 10 countries most significantly affected by climate change (WIT to Carry Out Climate Technology Market Assessment in Pakistan for GRASP, 2021).

Figure 4.1.1: *Average annual natural hazard occurrence 1980–2020*

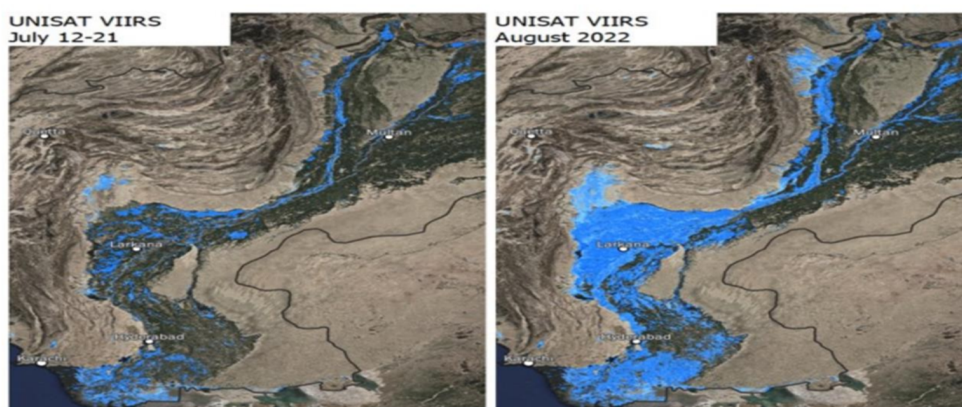
Source: World Bank

From this figure above, we can infer that Pakistan has experienced multiple disasters as a highly vulnerable country to climate change. According to the World Bank, between 1980 and 2020, floods have occurred frequently, leading to the displacement of large chunks of residents of Pakistan (Otto, 2023).

A report by Relief Web states that the most recent floods of 2022 did not occur in a vacuum. Instead, they were the effect of human-caused climate change (Revised Pakistan 2022 Floods Response Plan Final, 2023). Centre for Disaster Philanthropy calculations show that approximately 33 million people were affected by 2022 floods, making 2022 floods the heaviest in the history of Pakistan (One Year After the Pakistan Floods, 2023). A report by UNICEF showed that floods in between June 14 and October 20, 2022, Pakistan experienced devastating floods that claimed approximately 1,740 lives, injured around 13,000 people, caused \$14.9 billion in property damage, and resulted in \$15.2 billion in lost economic output (UNDRR & ADPC, 2019). Otto

(2023) provides an in-depth analysis of these unprecedented floods, highlighting multiday extreme precipitation as a key climatic driver. The probabilistic event attribution methodology used by Otto (2023) links this intense rainfall to human-induced climate change. The Provincial Disaster Management Authority (PDMA) Sindh reported 405 deaths, 1,074 severe injuries, and extensive damage to infrastructure, including 896,084 houses, 2,328 kilometres of road, 60 bridges, and the loss of 15,435 livestock in Sindh alone.

In response to the 2022 floods, the International Rescue Committee (IRC), in collaboration with the Sukaar Foundation and Research and Development Foundation (RDF), initiated the Early Needs Identification (ENI) exercise in four districts of Sindh: Khairpur, Sanghar, Mirpur Khas, and Dadu. This exercise aimed to lay the groundwork for developing a response plan tailored to the needs identified in these areas (Pakistan, 2023).

Figure 4.1.2: *Sindh before and after 2022 floods*

Source: Relief web

4.2. Climate Change Policies and Risk Resilience

Ahmad & Afzal (2019) emphasise the need for localised strategies to enhance resilience, providing a context-specific understanding of the socioeconomic dynamics that influence vulnerability in Naait, Punjab, Pakistan. It serves as a foundational piece connecting global climate issues to the specific vulnerabilities faced by communities in the region. Ploberger and Filho emphasise the integration of climate change-related risks into a broader framework, advocating for recognising climate change as a distinct risk category (Ploberger & Filho, 2016). Adger scrutiny of climate change response strategies underscores the need for policies that strengthen adaptive capacities and promote learning and innovation (Topkins & Adger, 2005). As a nation highly susceptible to natural atrocities, the existing risk management strategies are abysmal. UNDP and the government of Pakistan collaborate to formulate robust disaster risk management policies. These are meticulously designed following a thorough examination of the most vulnerable groups residing in Pakistan, including but not limited to women and ethnic minorities. UNDP proposes a pivotal shift in the dynamics of financial institutions so that it enables financial access to vulnerable groups. This strategy would foster productive capacity, leading to sustainable livelihoods (Pakistan Country Commercial Guide, n.d.).

In parallel, the State Bank of Pakistan has also launched a Financial Inclusion and Infrastructure Project through which it supports small businesses to obtain microfinance, thereby imposing constraints on vulnerable groups of borrowers' exposure to financial risks. The underlying rationale behind the provision of these loans is to engage small businesses to incorporate environment-friendly practices. Concurrent with financial accessibility, the GOP has been devising policies for environmental protection. The National Clean Air Policy (NCAP) is one such recent example. NCAP focusses on reducing emissions from major sources (Change, 2023). There are other policies like the Natural Hazardous Waste Management Policy 2022, which talks about the establishment of an effective regulatory framework for hazardous waste management that involves the development of by-laws, regulations, and rules in consultation with stakeholders, addressing key

aspects such as social vulnerability, transboundary movement, waste hierarchy control, technical requirements, occupational health and safety, environmental liability, and various other provisions. Currently, several policies are in development or underway across various sectors in Pakistan, like the National Electric Vehicle Policy, the National Sanitation Policy, the final Updated National Climate Change Policy, and others that are working towards reducing social vulnerability amongst the people of Pakistan (Pakistan, 2023). According to a report by UNDRR & ADPC, 2019, the government of Pakistan has implemented a comprehensive set of legislative measures and policies to address the multifaceted challenges posed by disasters. The lead agency in disaster response is the National Disaster Response Authority (NDMA). Traditional national emergency services like the Police, Emergency Response Cell (ERC), Crisis Management Cell (CMC), Fire Services, Civil Defence Agency, Federal Flood Commission, and Meteorological Department have actively responded to disasters. In cases of larger emergencies, the armed forces are also tasked with disaster management roles. (IRSHAD, ALI, & IQBAL, 2015). Other measures the government took included the National Disaster Management Plan (2012–2022) (NDMA, 2022), which guides and mainstreams institutional and technical priorities for disaster risk management. The roadmap of the plan (2016–2030) emphasises multi-hazard risk assessments, capacity building, community resilience, and awareness.

Additionally, the National Disaster Response Plan (2019) provides a framework for disaster response, detailing the roles and responsibilities of different stakeholders at the national, provincial, and district levels. (UNDRR & ADPC, 2019). The World Bank has also actively been participating in helping Pakistan with disaster risk management. In 2016, they formed an environment and social framework that advocated a green, resilient Pakistan by strengthening people. Some institutions, like SCARED (Space Application Centre for Response in Emergency and Disaster), are operating under the Pakistan Space and Upper Atmosphere Research Commission (SUPARCO) with technical support from other countries. It monitors, forecasts, and maps various hazards and does damage assessment in affected areas through the Integrated Flood Analysis System. SUPARCO also establishes a disaster

vulnerability assessment for earthquakes, landslides, floods, cyclones, tsunamis, droughts, and heat (Bank, 2023).

5. METHODOLOGY

This paper utilises the methodology developed by Cutter et al. (2003) to create a Social Vulnerability Index (SVI), originally designed to measure social vulnerability in the United States using over 200 variables. Over the years, the conceptualisation of social vulnerability and the SVI methodology have been adapted for various contexts (Hummell, Cutter, & Emrich, 2016). Recognising the need for contextual adjustments, this study refines the variables for Pakistan, incorporating factors such as education, employment, ethnicity, health, and community characteristics to construct a modified SVI suitable for Pakistan's unique socio-physical landscape. Given that the original SVI was intended for the U.S., significant modifications were necessary to align the model with Pakistan's specific demographic and social conditions. Using data from the most recent Pakistan Standard of Living Measurement Survey (PSLM) 2019-20, provided by the Pakistan Bureau of Statistics (PBS), Table A-2 in the appendix details the concepts and variables used to develop the adapted SVI.

To address fundamental demographic disparities between Pakistan and the United States, specific adjustments were made, particularly in capturing the diversity of provincial ethnicities under the umbrella of 'Ethnicity' in the Pakistani context. Sariki's and Muhajirs are not included because, firstly, this paper considers only provincial ethnicities and, secondly, due to limited data being available on these ethnicities. Per capita income is not considered in constructing SVI as there exists high economic inequality in Pakistan, and GDP per capita gives an average measure that significantly masks the existent inequalities. A high GDP per capita doesn't necessarily mean that the entire population is less vulnerable, so to have an accurate estimate of the vulnerability, the GDP per capita was left out.

The study incorporates 39 variables from the PSLM 2019-20, all of which undergo normalisation using percentage, density, or per capita functions before statistical analysis. Principal Component Analysis (PCA) is then employed as a factor reduction

methodology, identifying a condensed set of independent factors. PCA serves the purpose of distilling a comprehensive explanation of the data by grouping similar variables into components that effectively account for covariation among the broader array of analysis variables (Abdi & Williams, 2010).

The SVI scores were then using QGIS to visualise the most and least vulnerable districts in Pakistan. The mapping was based on the standard deviation from the mean, of the components identified by PCA that had the most variance explained.

6. RESULTS

The principal component analysis uncovered 4 components that had eigenvalues greater than one. Based on loaded variables and their cardinality, these four components were named Province and House Material, Read and Write, Language, and Gender. In total, the principal component analysis explains almost 73% of the variance in the data. The description of the four component signs denotes their effect on social vulnerability. The loadings can be seen in the figure 6.1 presented below.

The four main components were added together based on their weights to get the SVI scores.

$$\begin{aligned}
 PC1 &= 0.19371479 \\
 PC2 &= 0.18124598 \\
 PC3 &= 0.15962505 \\
 PC4 &= 0.19397972 \\
 SOVI &= PC1 + PC2 + PC3 + PC4 \quad (1) \\
 &= 0.729 \\
 &= 72.9\%
 \end{aligned}$$

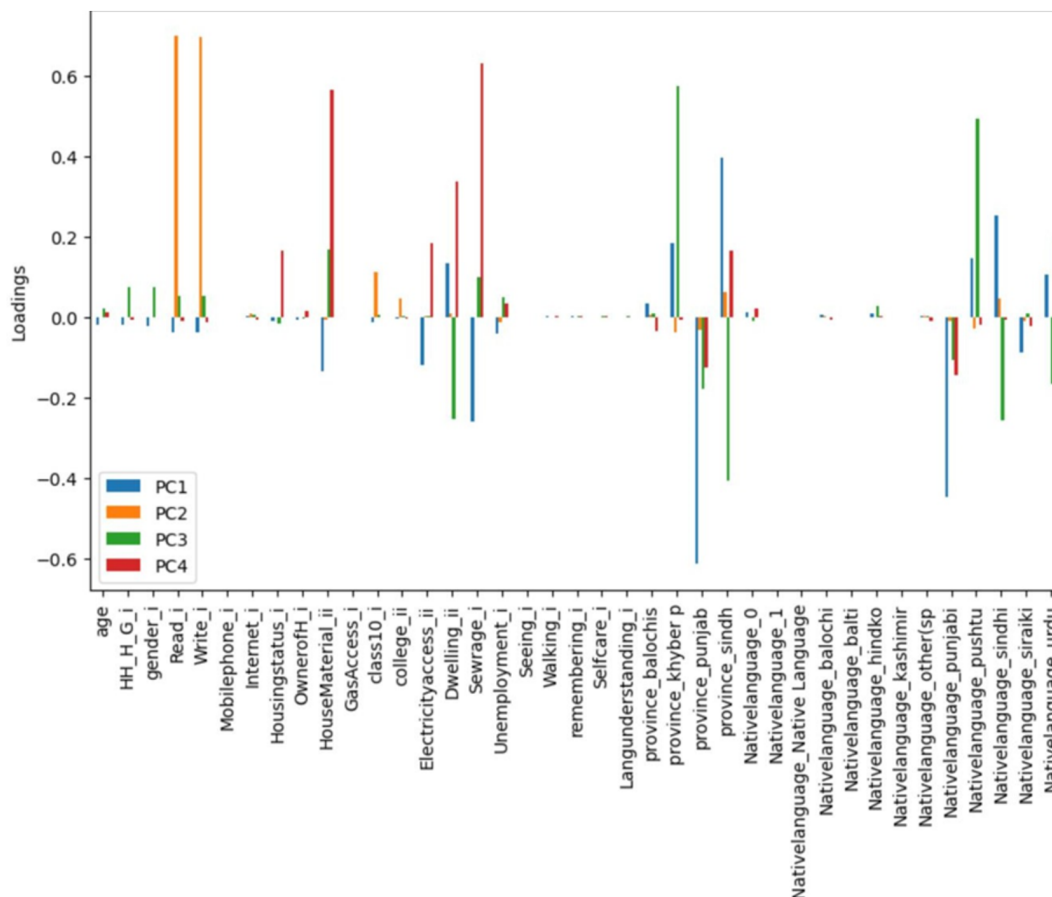
For these scores, mean values and standard deviations were also calculated. Vulnerability scores were divided into five quantiles, or a range from most to least vulnerable, using these standard deviations. The mapped SVI scores are shown in figure 6.2 below, which uses QGIS to show how social vulnerability is distributed throughout Pakistani districts.

The districts in Pakistan with the highest social vulnerability are mostly found in Khyber Pakhtunkhwa, although certain areas in Punjab and Sindh also exhibit increased vulnerability, according to an analysis of Social Vulnerability Index scores. On

the other hand, the least vulnerable area is a single district that is located in Punjab's northern region and serves as the capital territory, Islamabad. On the

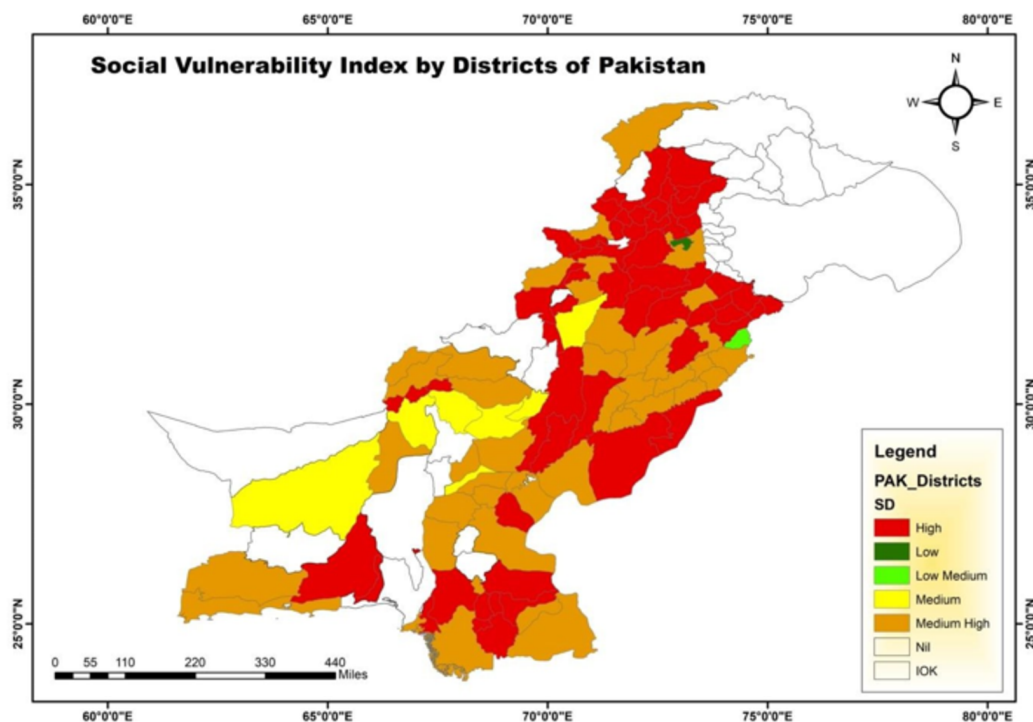
social vulnerability spectrum, most of Pakistan's districts are categorised as medium to high vulnerability.

Figure 6.1: Feature Loadings for Principal Component Analysis.



Source: Author's calculations.

Figure 6.2: Social vulnerability Index by Districts of Pakistan



Source: Author's visualisation.

7. DISCUSSION

The aim of this paper was to quantify social vulnerability using indicators that were relevant to Pakistan's distinct social and physical landscapes. This paper has derived 4 components that contribute the most to social vulnerability in Pakistan. The total SVI scores are not evenly distributed among the districts in Pakistan, and we can see that there is clustering, which means that highly vulnerable districts are often found next to each other.

A major finding of this research emphasises that social vulnerability can occasionally vary among locations with similar hydrometeorological and geographical characteristics. However, there is discernible clustering, suggesting that topographically similar regions frequently display comparable levels of social vulnerability. One striking finding contradicts preconceived notions among locals and existing literature: most districts in Balochistan do not demonstrate high vulnerability. Balochistan's strong sense of community bonding could be the reason for the lower levels of social vulnerability seen there.

The social vulnerability map is not a static image but a dynamic landscape. Each district presents a unique story demanding context-specific interventions. A blanket approach risks exacerbating existing inequalities and further marginalising vulnerable communities. The path to resilience lies in multiple dynamic strategies being implemented through collaboration. Policymakers must move beyond their unilateral lens and work hand-in-hand with researchers, local communities, and civil society organisations. This collaborative spirit would be ideal to advance Pakistan into a resilient nation. PCA helped to identify key areas that impact social vulnerability the most. Each of them is explained as follows.

7.1. Gender

This study shows that households led by women have particular difficulties when it comes to environmental dangers. Their susceptibility may be increased by societal injustices and cultural norms restricting their access to resources, knowledge, and decision-making authority. Imagine a single mother battling societal barriers and restricted access to support networks to

provide her family with safe housing, food, and medical attention following a flood. Targeted interventions that empower women and increase their capacity to deal with and adapt to climate change are necessary to address these gender-based vulnerabilities.

7.2. Disparities in Housing Material

A huge divide appears between the robust structures in certain areas and the flimsy makeshift shelters in others, underscoring the unequal allocation of resources and infrastructure. Sindh and Khyber Pakhtunkhwa are two prominent instances; because of insufficient housing, the communities in these states are disproportionately impacted by environmental shocks. This inequality has real-world repercussions, forcing families into temporary shelters and quickly wiping out their means of subsistence.

7.3. Education (read and write)

A Foundation for Empowerment: Education stands out as an important element, showing the way to independence and flexibility. Lower literacy districts have difficulty getting access to resources and important knowledge on climate change mitigation techniques, especially in Balochistan and Sindh. Their susceptibility is increased by their lack of expertise in navigating the intricacies of a changing environment. Imagine farmers struggling with unpredictable weather patterns and without access to crucial information regarding crop resilience and early warning systems. Education becomes a vital instrument for enabling communities to adapt and develop long-term resilience, not just a statistic.

7.4. Cultural Diversity and Intertwined Vulnerabilities (Provinces)

Distinct issues arise in districts where the majority language spoken is a minority and where access to basic amenities such as clean water and sanitation is restricted. Their voices, frequently ignored in policymaking circles, fight to obtain the funding and assistance required to resist environmental shocks. It takes more than just building infrastructure to address these risks; inclusion and cultural sensitivity are also essential. Specific interventions that recognise and capitalise on each group's distinct needs and strengths

are needed to guarantee that no community is left behind in the face of climate change.

7.5. Social Capital (Language)

Strong social cohesiveness is exhibited by groups such as those in northern Punjab, who act as a cohesive unit and a powerful deterrent to vulnerability. Communities are held together by this social capital, which helps them weather hardships and come out stronger. To create long-term resilience and provide communities with the power to engage in their development and adaptation actively, it is imperative to recognise and nurture social capital.

8. POLICY RECOMMENDATIONS

Targeted policies to reduce social vulnerability in Pakistan must consider the unique social and physical landscapes of its districts. The Social Vulnerability Index (SVI) reveals significant disparities, with vulnerable districts often clustering together. Policies should focus on gender empowerment, as women-led households face greater difficulties due to societal and cultural norms limiting their access to resources and decision-making. Improving housing materials in vulnerable regions like Sindh and Khyber Pakhtunkhwa can mitigate the impact of environmental shocks. This includes the development of mobile movable homes, such as caravans, allowing residents to relocate to safer areas during floods, and constructing stronger shelters that can withstand natural disasters. Incorporating innovative designs, such as elevated platforms and flood-resistant materials, can further enhance the safety of these structures. Enhancing education is crucial, especially in lower literacy districts like Balochistan and Sindh, to provide essential knowledge for climate change adaptation. This involves not only building more schools but also integrating climate change and disaster preparedness into the curriculum. Addressing the intertwined vulnerabilities in culturally diverse areas requires inclusive and culturally sensitive interventions, such as community engagement programs that respect local traditions while promoting resilience.

Additionally, fostering social capital, as seen in northern Punjab, can strengthen community resilience. This can be achieved through the

establishment of local cooperatives and support networks that encourage collective action and resource sharing. Furthermore, improving access to healthcare and social services in remote and underserved areas can reduce vulnerability. Collaborative efforts involving policymakers, researchers, local communities, and civil society organisations are essential to implement these strategies effectively. Partnerships with international organisations and leveraging technology for early warning systems can also enhance preparedness and response capabilities, creating a resilient Pakistan.

9. CONCLUSION

Pakistan, a country with many different civilisations, is at a dangerous crossroads. In addition to being a terrible natural disaster, the disastrous floods of 2022 served as a stark reminder of the systemic socioeconomic injustices that intensify the effects of climate change, leaving people to deal with a reality that is considerably more complicated than rising sea levels. A customised Social Vulnerability Index (SVI), which is suited to Pakistan's particular socio-physical context, is utilised as a dynamic instrument to explore the core of the country's social vulnerability. With the exception of a few Balochistani districts, the results are generally consistent with the larger body of research on socioeconomic vulnerability and climate change. The focus on hydrometeorological elements is in line with worries that vulnerable communities are disproportionately affected by climate-related disasters. Furthermore, as part of the study's investigation into community resilience, it is recommended that local governance and social capital be strengthened as essential elements of climate adaptation plans. Although quantitative analysis offers insightful information, the study recognises the limitations of the data and promotes more research.

Balochistan's lower-than-expected vulnerability underscores the necessity for qualitative study to comprehend the complexities of vulnerable communities' resilience mechanisms and their lived experiences. By bridging the gap between data and reality, this kind of research might inform more potent policy actions. This study serves as a starting point for more investigation and action rather than its conclusion.

The spatial distribution and dynamics of social vulnerability revealed in this study necessitate context-specific policy interventions. A "one-size-fits-all" approach will fall short; instead, policies must address the unique vulnerabilities of each region and community. This calls for collaboration between policymakers, researchers, and other associated local communities to develop together various targeted interventions that build long-term

social resilience.

We can comprehensively understand Pakistan's risk landscape by delving deeper into the social dimensions of vulnerability. This knowledge will empower policymakers, communities, and researchers to collaborate in building a more resilient Pakistan that can withstand social vulnerability and climate change challenges.

APPENDIX

Table A1: *SVI Metrics*

<i>Concept</i>	<i>Definition</i>	<i>Social vulnerability (+/-):</i>
<i>Socioeconomic status</i>	The ability to resist catastrophes and being rich helps in fighting hazards (Cutter, Mitchell, & Scott, 2000).	High income (+/-); Low income (+)
<i>Gender</i>	Women may experience a hard time overcoming the hazards as compared to men. Due to family care responsibilities, sector-specific employment, and lower wages (Cutter, Boruff, & Shirley, 2003).	Women (+); Men (+/-).
<i>Race and Ethnicity</i>	Specific language and cultural barriers hinder the post-disaster aid to certain parts of the country.	
<i>Age</i>	The population that is either elderly or children suffers the most from hazards; older people have mobility constraints, which reduces their resilience to fight these disasters, and for children, parents have a tough time managing given that childcare facilities are affected.	Elderly (+); Children (+).
<i>Commercial and industrial development</i>	Communities around any commercial and industrial zone would help identify the area's economic health.	High Density (+); Low Density (-).
<i>Employment Loss</i>	The potential loss of employment exacerbates the number of unemployed workers in the community, which makes the community less resilient to any disaster.	Employment loss (+).

<i>Rural/Urban</i>	People living in rural regions are less resilient to catastrophes due to lower incomes, subsistence farming, etc., compared to urban area residents.	Rural (+); Urban (-)
<i>Residential Property</i>	The quality and resilience of the residential unit affect the potential losses and recovery.	Mobile home (+).
<i>Infrastructure</i>	The loss of infrastructure puts a significant burden on small communities.	Renter (+).
<i>Occupation</i>	People involved in work in the primary sector or work that requires extraction, labourers, etc., are more likely to be affected by natural hazards.	Professional (-); labourer (+); Service sector (+).
<i>Family Structure</i>	Families with one parent and many dependent people are significantly affected compared to those who have fewer dependents and both parents.	High birth rates (+); Large families (+); Single-parent households (+).
<i>Education</i>	One of the determinants of socioeconomic status is education; when education is high, that translates into better lifetime earnings.	Low education (+); Highly educated (-).
<i>Population growth</i>	Countries with higher rates of population growth tend to have lower living standards; if the change is higher due to high migration, there is a high possibility of a language barrier. All of these contribute to high vulnerability to natural disasters.	Rapid growth (+).
<i>Medical Services</i>	The proximate health care services, like hospitals, nursing homes, etc., increase the availability of post-disaster health care relief.	Higher density of medical (-).
<i>Social Dependence</i>	People who highly depend on social services for survival are more likely to absorb more relief post-disaster.	High dependence (+); Low dependence (-).
<i>Special needs population</i>	Special needs populations, be it homeless, infirm, etc., are disproportionally affected during any disaster (Cutter, Boruff, & Shirley, 2003).	Large special needs population (+).

Source: Author's elaboration

Table A2: *Concepts and variables used to construct SVI for Pakistan*

Concept	No.	Description
Age	1	percentage of elderly population
	2	percentage of children under 5 years
Education	3	percentage of people who cannot write
	4	percentage of people who cannot read
	5	percentage of people who have passed metric (10 th Grade)
	6	percentage of people left passed college
Family Structure	7	Percentage of female headed household
	8	average number of persons in household
Gender	9	percentage of females
	10	percentage of female owned houses
Employment	11	percentage of people unemployed
Health	12	percentage of people employed in healthcare and services
	13	accessibility to public health institutions
Occupation	14	percentage employment in agriculture
	15	percentage of employment in manufacturing
	16	percentage employment in transportation, communication
	17	Percentage employment in accommodation and food services
	18	percentage employment in public administration defence and social services
	19	percentage employment in trade and commerce
Foreign in flow	20	remittances received from Pakistani nationals in foreign countries.
Built environment	21	percentage of houses not having ICC material foundation
	22	percentage of houses with no inside dwellings
	23	percentage of houses with no electricity connection
	24	percentage of houses with no sewerage infrastructure
	25	percentage of houses with no gas connection
Renters	26	percentage of people living in rented houses
Ethnicity	27	percentage of Sindhi population
	28	percentage of Punjabi population
	29	percentage of Pashtoon population
	30	percentage of Baluchi population
Special needs population	31	percentage of people who cannot see
Assets	32	percentage of people who cannot hear
	33	percentage of people who cannot walk
	34	percentage of people who cannot do self-care
	35	percentage of people who cannot understand language
	36	percentage of people who own a TV
	37	percentage of people who on a car
	38	percentage of people who have Internet connection at home
	39	percentage of people who own a mobile phone

Source: Author's elaboration

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