Vulnerability to Hazards: A Study in the Darjeeling Kalimpong Hills Region, West Bengal, India

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Abstract

The effectiveness of vulnerability assessment relies on several factors, including the integration of relevant theoretical frameworks and the collection of qualitative and appropriate information. The mountain regions are particularly susceptible to various forms of natural hazards, which can result in substantial devastation, including the loss of human life and valuable resources. The Darjeeling-Kalimpong hills are especially vulnerable to intense precipitation, particularly during the monsoon season as well as landslides, earthquakes and the impact of climate change/variability.

The present study focuses on vulnerability and encompasses a theoretical framework for evaluating risk and a component that incorporates people's perceptions using the Pressure and Release Model. This framework helps to investigate how vulnerability in the Darjeeling–Kalimpong hill region of West Bengal arises from a combination of root causes, dynamic pressure, and unsafe conditions. Moreover, the study emphasises how vulnerable situations can be addressed and reduced in hazard-prone areas. Therefore, the Government should implement policies for monitoring and regulating disaster risk to ensure long-term sustainability in the Darjeeling-Kalimpong hill region.

Keywords: Climate Change, Disaster Risks, Darjeeling, Eastern Himalayas, Pressure and Release (PAR).

Introduction

Many academics in the 1980s thoroughly studied disasters and highlighted their criticism of the hazard-centric paradigm for overlooking social, political and economic factors that increase vulnerability to hazards[5]. An approach centred on hazard fails to consider the influence of social structure and political processes that amplify people's vulnerability to risks[14]. Hoffman[17] asserts that disasters are prolonged social constructs rather than natural occurrences. The vulnerability to hazards is extensively influenced by the socio-political environment. Therefore, academics need to comprehend how social structures determine the risks faced by people of different classes, colours, ethnicities, genders and ages[23].

Mountainous regions are vulnerable to several hazards that impair the physical, ecological and social systems of these areas[16]. Moreover, the elevations in different regions determine the vulnerability of the mountainous landscape[15]. The Himalayan region in India is vulnerable to natural hazards which are further exacerbated by the effects of climate change and variability. Within this region, the Eastern Himalayas are particularly more vulnerable due to numerous factors or occurrence of multiple hazards[33].

The Darjeeling-Kalimpong hills in the Eastern Himalayas are prone to various hazards, including climate variability and change, heavy rainfall, landslides and seismic events[35]. However, there is a lack of studies on risk or difficulties faced by individuals in hazardous situations as a result of many socio-economic and political factors. This study investigates how vulnerability arises from physical, social, economic, and environmental processes in conjunction with hazards generating associated risks that can culminate in disaster. The main objective of this study is to evaluate the relationship between the emergence of vulnerability and the occurrence of various hazards. Furthermore, it seeks to propose solutions for reducing risks through effective management and policy implementation in the Darjeeling-Kalimpong hills.

Study Area

The Darjeeling-Kalimpong hills are located in the northern region of the Indian State of West Bengal. It covers an area of approximately 2320.31 square kilometers. The Darjeeling-Kalimpong hill region extend from 26º45′44″ N to 27º13′51″ N latitude and 87º58′44″ E to 88º53′10″ E longitude (Fig. 1). In the southern part of the region, two major geological structures (Main Boundary Thrust and Main Central Thrust) are present which trigger the phenomenon of mass movement. Moreover, the period from June to September experiences the highest average precipitation over the entire year.

Material and Methods

The study is based on secondary data sources including gridded rainfall data from the Indian Meteorological Department (IMD), landslide and earthquake data from the Geological Survey of India (GSI), District Disaster Management Reports and newspaper articles, along with primary data gathered through semi-structured questionnaires, field visits and observations.

The Pressure and Release (PAR) model is utilised which illustrates the relationship between hazards and vulnerabilities that generate risk and propose the ways for mitigating vulnerabilities to enhance security. Disaster risk is a function of hazard and vulnerability[5].

Risk = Hazard × Vulnerability

Vulnerability encompasses the actions and processes that alter the effects of underlying cause and place them in an unsafe situation. The progression of vulnerability for the study region is categorized into three stages: root causes (poor governance), dynamic pressure (constrained capacity) and unsafe location (risk zone) (Fig. 2). In order to mitigate major repercussions in the hills, it is imperative to adopt proactive measures that directly address the underlying drivers of risk. Furthermore, the progression of release refers to the situation where actions intended to reduce vulnerability are implemented (Fig. 3).

Results and Discussion

Hazards: Darjeeling-Kalimpong hills, characterized by unique natural features, are popularly referred to as the "queens of hills." However, the region is currently grappling with significant challenges caused by calamities, climate unpredictability, intense precipitation events, monsoonal landslides and earthquakes. The Darjeeling-Kalimpong hills are witnessing the nuanced impacts of climatic variability and change (Fig. 4a). The study region receives the highest amount of rainfall during the peak monsoon months; with average annual precipitation ranging between 4000 and 5000mm (Fig. 4b).

A study conducted by Prokop and Walanus[25] revealed that more than 70 percent of precipitation occurred between June and September. A substantial volume of precipitation leads to the descent of wet and loose particles due to the intense downpour[21]. Consequently, landslides are prevalent in the majority of the region (Fig. 4c). In the Darjeeling-Sikkim Himalayas, characterised by high seismic activity (Fig. 4d), a total of eighty earthquakes have been recorded during the past decades[22].

Progression of Vulnerability or Pressure Model - Root Causes

Limited access to resources: The lack of adequate access to resources like safe housing, infrastructure, water, healthcare, transportation, and early warning systems increases the risk from hazards in the Darjeeling-Kalimpong hills. These resource limitations, especially in remote or marginalized populations, reduce their capacity to cope with, prepare or recover from hazards[39]. Therefore, a natural event which could be managed results in disaster due to unequal access to resources and information, and poor service delivery, triggered by social and infrastructural inequality.

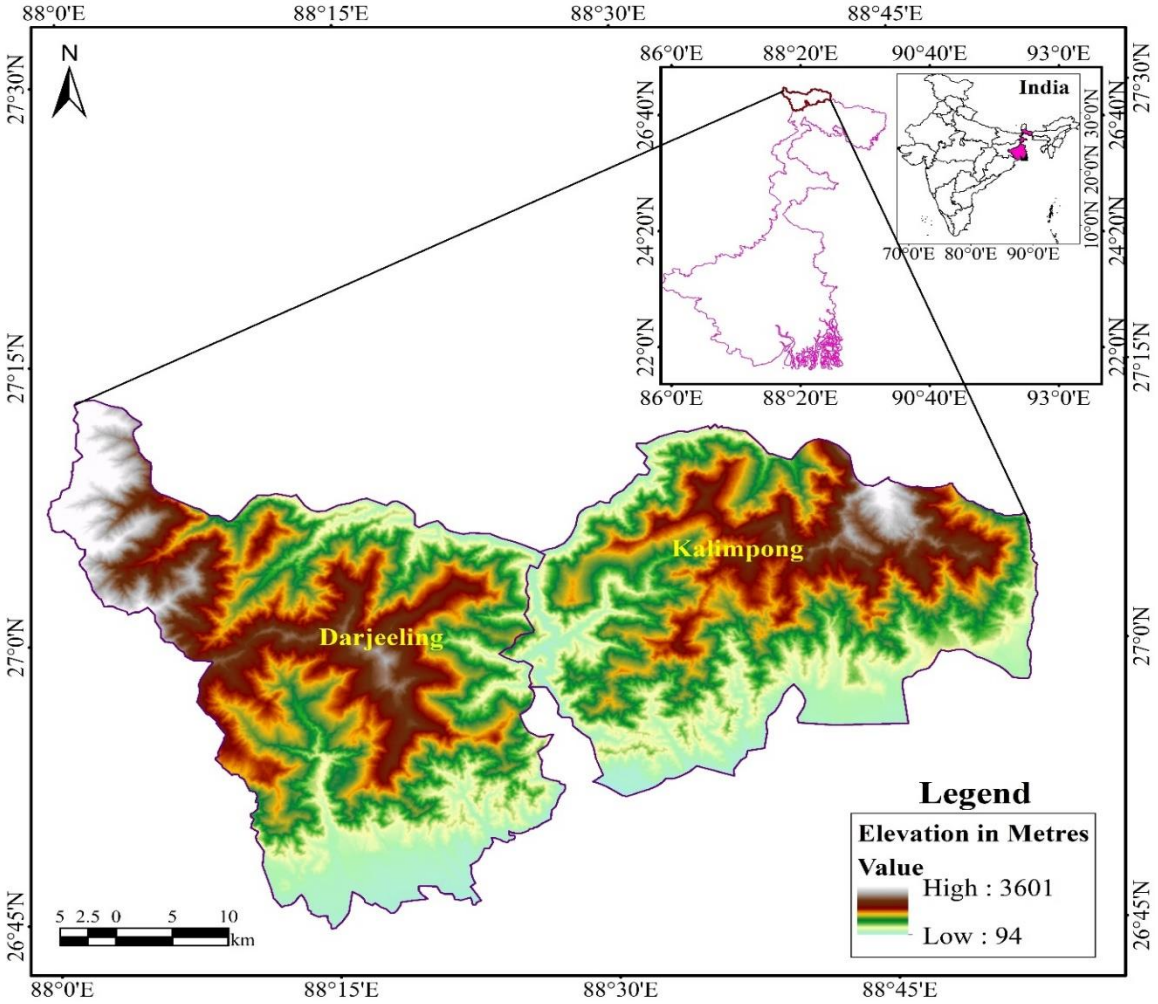

Fig. 1: Location of the Study area

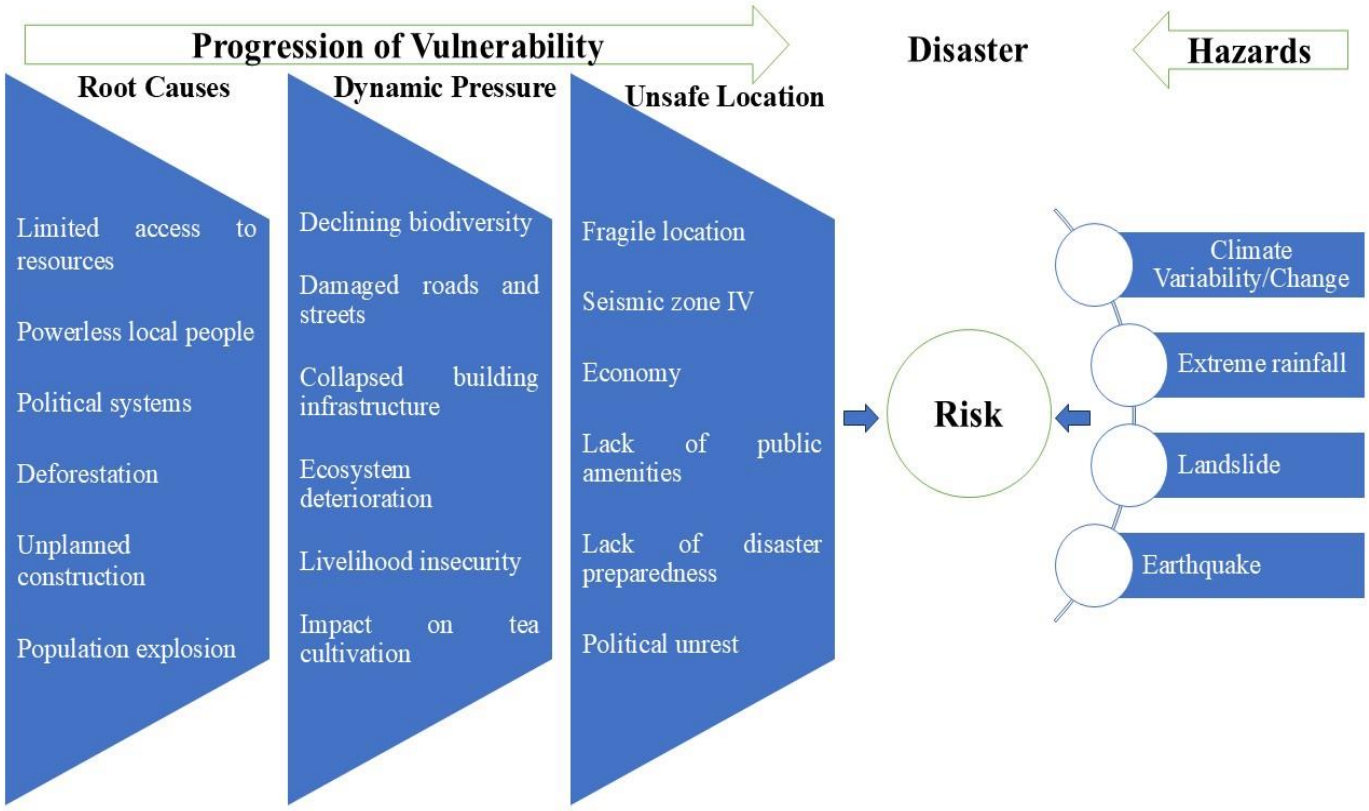

Fig. 2: Progression of vulnerability or pressure model (modified after Blaikie et al[5])

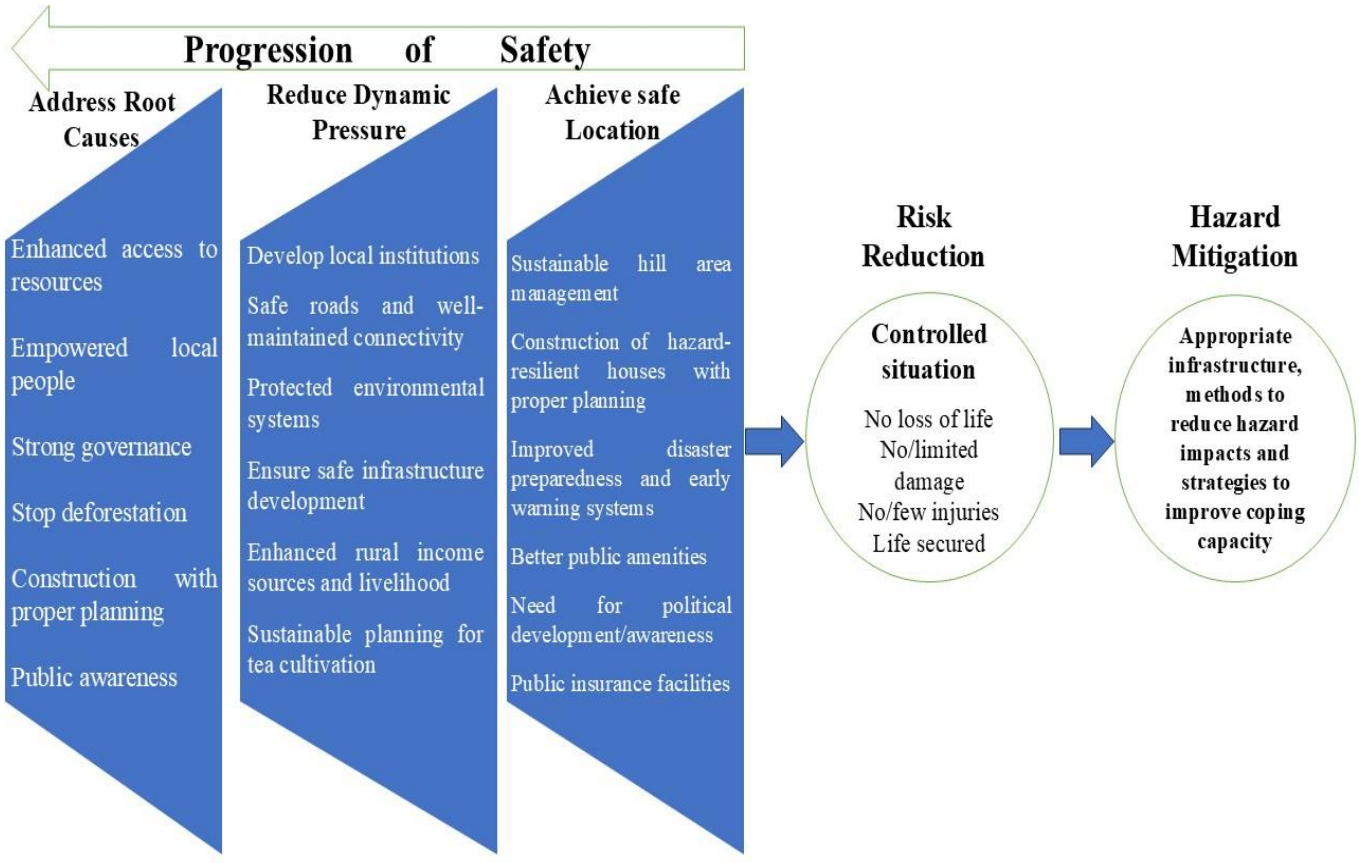

Fig. 3: Progression of safety or release model (modified after Blaikie et al[5])

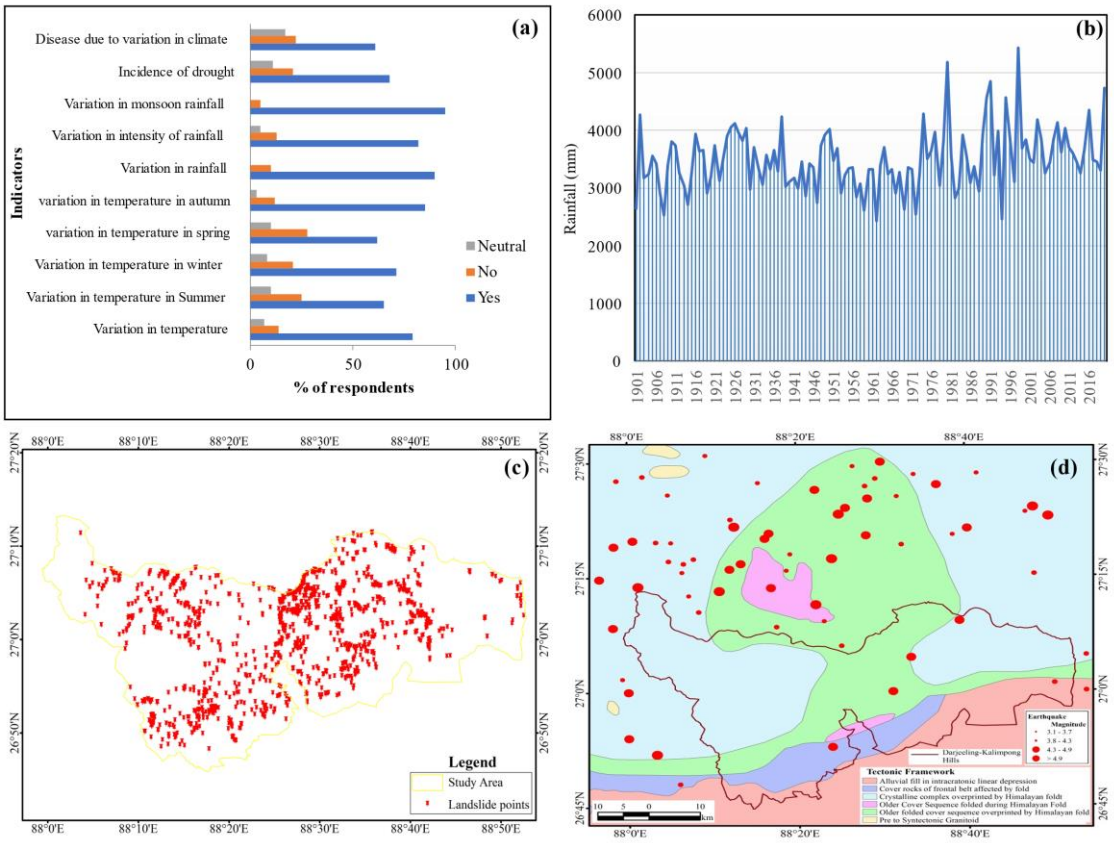

Fig. 4: a) People's perceptions on climate variability/change; b) Rainfall analysis from 1901 to 2020; c) Areas affected by landslides; d) Earthquake magnitudes in and around the study region

Powerless local people: The inhabitants of the hills are predominantly marginalized from participating in decision-making processes, irrespective of whether these decisions yield advantages or disadvantages to them[29]. During a hazard event, people with little knowledge and awareness encounter difficulties in responding and making well informed decisions amidst severe devastation. The administration has neglected to execute actions to address the problems faced by the people in the Darjeeling-Kalimpong Hills[27]. The hill communities are often excluded from decision-making related to development, land use and disaster management. They lack the institutional support and political agency to influence policies that ensure their safety and security in terms of hazard disaster and climate change.

Political systems: The Government has not properly addressed the issues of hazards. The lack of homogeneity is evident due to governmental reluctance[6,30]. The primary factor is the Government's hierarchical approach[37] which overlooks the importance of addressing unpredictable natural hazards[8] through proactive measures aimed at minimising both pre- and post-disaster impacts. "The Government does not provide any compensation for house damage caused by landslides or for injuries during hazardous events. It fails to take the issue of hazards seriously enough to ensure adequate preparedness in advance," stated Luchen Sherpa (name changed), a resident of Rimbick during the field visit in September 2023. The local communities are often excluded or have limited participation in planning and are left vulnerable in disaster risk reduction strategies. Political systems play a crucial role in allocating resources, funds, how land is utilised and governed, and whose voices are to be included in decision-making. In politically corrupt systems, the allocated hazard relief funds can be misused. Weak decentralisation, low political representation makes the community more vulnerable.

Deforestation: Anthropogenic activities such as the continual clearing of vegetation and forests for the construction of high-rise buildings, transportation networks, infrastructure, and tea plantations have contributed to the loss of biodiversity[24]. Illegal logging degrades forest cover over time.

Moreover, the large-scale land alteration has led to the erosion of the uppermost soil layer, leaving the slopes barren and highly vulnerable to further environmental degradation[3]. The absence of trees during heavy rainfall causes flash floods due to increased surface run-off. And landslides are frequent on deforested slopes.

Unplanned construction: Unplanned construction on steep slopes escalates the risk of soil erosion, landslides and building collapse. Constructing buildings, roads on unstable slopes, cutting down trees, and urban expansion without proper planning have made the region more vulnerable[18].

The number of roads is on the rise, along with the construction of multi-story buildings in urban areas. It violates building codes and lacks hazard-resistant design. There is a lack of proper drains in the region. Sometimes due to poor or no drains, the roads get flooded during the rainy season.

Population explosion: The populations of the three hill subdivisions underwent substantial growth from 1901 to 2011. Table 1 shows that the population of the Darjeeling Sadar subdivision has increased by more than threefold. The population growth in Darjeeling-Kalimpong hills can be attributed to multiple factors such as the tea industry, tourism, agriculture, labour migration, hydropower plants, cottage industry, trade and commerce.

Dynamic Pressure

Declining biodiversity: The Darjeeling-Kalimpong hills in the Eastern Himalayas are being impacted by climate change and variability, affecting their ecological diversity. This phenomenon has exposed the potential vulnerabilities of primary habitats, ecological areas, bioclimatic zones, phenology, agrobiodiversity and endemic species[7]. The impact on human activity, environmental stress and ecological disruption, has further intensified the region's overall vulnerability[34].

Table 1
Population growth of three hill sub-divisions

Year	Hill Subdivisions		
	Darjeeling (Sadar)	Kurseong	Kalimpong
1901	91953	45187	41511
1911	102577	41207	49520
1921	106511	40357	60093
1931	119178	51996	68203
1941	147327	59986	79042
1951	169631	65713	93441
1961	203523	80743	120526
1971	245207	100233	134538
1981	281346	111302	158726
1991	347912	146640	190266
2001	388107	177264	225220
2011	310576	140721	202239

Source: Adopted from Das[10]; Darjeeling District Census Handbook, 1951-2011

Fig. 5: Damaged roads due to landslides; a) Sukhia (Source: India.com); b) Kurseong (Source: India.com); c) and d) Gayabari (Source: The Economic Times).

Damaged roads and streets: The Darjeeling district is served by two national (NH 110 and NH 10) only, which connect the hill region to other parts of the country. Every monsoon season, these roadways are blocked and become inoperable due to landslides (Fig. 5), occasionally leading to extended closures. The construction and maintenance of roads in the Darjeeling-Kalimpong hills have posed significant challenges. Often, funds allotted are misused, and the roads are built or repaired with poor material, leading to frequent damage under heavy rainfall. The inadequate road infrastructure hampers the movement of people and essential goods, creating a precarious situation.

Collapsed building infrastructure: Occurrences of building collapses in the Darjeeling-Kalimpong hills have increased during the past three decades[1,2]. Poor quality construction and weak foundations of building infrastructure in high-risk areas are reasons for the sudden failure of the structure. The accelerated construction of multi-story concrete buildings by developers is exerting significant pressure on unstable slopes that are extremely susceptible to hazard[27]. Therefore, there is an urgent need for stricter building codes and regular safety inspections.

Ecosystem deterioration: The potential reasons for ecosystem deterioration include overexploitation of natural resources, improper management, and a reduction in the area's carrying capacity[9].

As a result, these invaluable ecosystems remain under constant jeopardy. Moreover, climate change has a profound impact on hill ecosystems, forcing organisms to adapt to their specific environmental conditions over time. Shrinking species diversity points to ecological stress in the hills.

Livelihood insecurity: In the Himalayan regions, the main livelihood source of the people is based on land and forest[31]. The tea plantations in the hills play a crucial role in the local economy by providing workers with housing, allowances, incentives, medical facilities, and other amenities[28].

At present, it employs over 70,000 workers and earns an annual revenue of 55 million pounds[13]. However, recent garden closures, political instability, and inadequate basic wages have jeopardized the livelihoods of these individuals, increasing their vulnerability.

Impact on tea cultivation: The ongoing variations in temperature and erratic rainfall patterns have had a negative impact on tea cultivation[26]. The tea plantation in the Darjeeling-Kalimpong hills experienced substantial damage due to widespread land use changes and rapid population growth. The primary factors contributing to ecological imbalance include slope and soil erosion, landslides and several other forms of degradation. The aforementioned factors pose significant challenges to the cultivation of tea[38]. Moreover, climate change has impacted the quality and quantity of tea production, along with age-old tea gardens.

Unsafe Location

Fragile location: The Darjeeling-Kalimpong hills have a fragile geological structure. The region experiences a substantial quantity of rainfall; its soil is distinguished by its steep terrain, rich organic material, water retention capacity and substantial volume expansion. The geological structure in the study area is characterized by folding, faulting, thrusting and subsequent dissection by a series of river channels.

Seismic zones IV: The Darjeeling-Kalimpong hills are located in seismic zone IV as per the Bureau of Indian Standards (BIS) (https://pib.gov.in/), which is classified as a zone with a moderate to high risk of damage due to earthquake. The Geological Survey of India (GSI) has ascertained that the entire Darjeeling-Kalimpong Hills region is vulnerable to seismic activity owing to the multitude of seismic sources. It is located in the Lesser and Greater Himalayan regions, with an elevation of 1400 m, with a gradual ascent in altitude from south to north. The region is positioned in the tectonically active fold-thrust belt of the Eastern Himalayas, adjacent to the Darjeeling-Sikkim tract[32].

Economy: The economy of the hills mostly runs on tea production, horticulture, agriculture, tourism and forestry, the tea being a major contributor. Women constitute the predominant workforce in tea plantations, mainly engaged in the task of harvesting tea leaves[12]. However, they are denied minimum wages and there are often clashes between the workers and tea owners/company. The proprietors of Darjeeling tea gardens have redirected their surplus funds towards alternative, more profitable ventures, resulting in a decline in the production of the regional tea sector. In the past few decades, the tea industry has faced competition from tea produced in several States in India[4]. And the political turmoil or volatility in the region often adversely affects the tourism industry by reducing the number of visitors.

Lack of public amenities: The Darjeeling-Kalimpong hills suffer from poor road infrastructure, and mostly rural areas have kuccha streets[19]. The inhabitants of urban areas particularly struggle with the lack of a well-functioning sewerage infrastructure and solid waste management, resulting in an unsanitary condition. And, the town people often lack sufficient access to an adequate public water supply due to poor allocation and management of water resources. The healthcare infrastructure is inadequate in the hills. The hill dwellers are often consulted to go to Siliguri, which has better healthcare if they have any major health issues or emergencies. According to Wangdi Bhutia (name changed), a resident, “The development for the hill people is severely constrained, as it has not reached every corner of the hills in terms of amenities, infrastructure, and opportunities. However, this situation could be improved if the government prioritised hill development” (Field survey, July 2023). There has to be sustainable development in every aspect, starting from the grassroots level of the hills.

Lack of disaster preparedness: According to a resident, "The Darjeeling-Kalimpong hills are a disaster-prone area; yet, the Government shows indifference towards disaster preparedness and management. They show concern only when a disaster occurs and is quickly forgotten until the next one occurs" (Field survey, August 2023). Hence the Government exhibits a lack of prompt response to disasters and neglects to commit resources for enhancing community resilience against such events. Moreover, the governmental organizations tasked with disaster management demonstrate a lack of drive to engage the public in disaster preparedness.

Political unrest: The Darjeeling-Kalimpong hills have a deep-rooted history of protests aimed at creating an autonomous political and administrative system, achieving self-governance[30,36]. Dasgupta[11] observed that the spectrum of various aspirations for self-governance started to solidify as a result of the aggravation of economic challenges in the hill regions. The hills have experienced rather less progress in terms of socio-economic, political, infrastructural development than the plains, belonging to the same district of the State.

Progression of Safety or Release Model

The safety or release model aims to reduce vulnerability by enhancing access to resources and ways for mitigating and regulating hazards. The model also demonstrates methods for improving the capacity of hill communities to competently oversee risks and vulnerability in the Darjeeling-Kalimpong Hills. Transitioning from a risky to a safe situation, alleviating pressure and fostering the development of a resilient society is a challenge. The release model is extremely pertinent for reducing risks and diminishing vulnerability to disasters. This release model can be executed in three stages: addressing root causes, reducing dynamic pressure and attaining a safe location.

The initial stage focuses on addressing essential issues that influence the further development of community assets. It is crucial to enhance the empowerment of the local people residing in hill regions. Furthermore, it is imperative to emphasise the need for the Government to give priority to the welfare of its citizens. Another important guideline is the prohibition of hill excavation and construction without appropriate planning. Moreover, the authorities need to be cognizant of the ongoing population growth, unplanned development, environmental degradation and hazard risks in the Darjeeling-Kalimpong hills.

To reduce pressure, it is vital to establish efficient local institutions, guarantee safe road conditions and execute appropriate environmental measures. Moreover, it is crucial to assist individuals in the hill community by fostering or improving rural livelihoods, implementing policies for rural development and generating employment opportunities. It is vital to redevelop tea gardens and ensure the provision of essential amenities for the people working in tea gardens. Finally, this model suggests that ensuring environmental conservation, proper management of hill areas, construction of well-designed hazard-resistlient residences and the implementation of protective measures can collectively contribute creating safer conditions. Enhancing or reinforcing initiatives aimed at strengthening disaster preparedness and raising awareness is needed. It is vital to note that public amenities should be renovated, which helps in disaster mitigation.

Moreover, it is fundamental to enhance political consciousness and provide financial support during and after the hazard crisis. Improving disaster management, preparedness and early warning systems, along with prompt dissemination of warning information, incentives for volunteers and the implementation of measures in regions exhibiting crisis, can effectively reduce the disaster causing the actual damage.

Conclusion

The study highlighted the role of hazards and vulnerabilities in augmenting risk in the Darjeeling-Kalimpong Hills, as per the pressure and release model. The area is afflicted by some of the dynamic social, political and economic pressures that result in people's vulnerability to risk. A crucial consideration is the probable link between the root cause of the threat and the sociopolitical conditions existing in a particular place. This association can clarify the differences in resource allocation and the varied effects of the hazard on different groups and sectors.

An alternative view of this phenomenon is that disaster and risk emerge when hazards and vulnerabilities converge in the Darjeeling-Kalimpong hills. Unplanned development disrupts the natural landscape and ignores environmental sustainability. This development may turn into a disaster if sustainable measures are neglected. The study also aimed to investigate the social construction of vulnerability in the hills, transcending its physical mechanisms to achieve a comprehensive understanding of its various dimensions. It has the potential to enhance long-term policy solutions to expedite disaster preparedness. The planning and policies should be context-specific, taking into account community needs and hazard risks, and empower hill people to enhance their capacity to be able to cope with risk. Poor governance should be checked as it can lead to unequal resource distribution, and delayed actions on disaster management and preparedness.

Consequently, strategic planning for local and regional development in the Darjeeling-Kalimpong hills must prioritize risk reduction, which can help in preventing disasters of any kind and scale.

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