

CLIMATE CHANGE, PERCEPTION, AND LIVELIHOOD ADAPTATION IN DARJEELING DISTRICT, WEST BENGAL: A SECONDARY DATA ANALYSIS

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ABSTRACT

The Darjeeling district, located in West Bengal, India's Lesser Himalaya, is threatened by extreme climate fluctuation that affects its traditional means of subsistence farming, tea growing, and tourism. This article examines past climate patterns, local views of climate change, and current adaptation methods using only secondary data sources, such as government action plans, published vulnerability assessments, meteorological records, and peer-reviewed studies. The findings show that during the past century, there has been a notable increase in mean temperature and variability in monsoonal rainfall. Measures like rooftop rainwater harvesting and livelihood diversification are more easily adopted by occupational groups who are more cognisant of climate change. After talking about the connection between perception and adaptive ability, we offer policy proposals that focus on community-driven resource management, technological subsidies, and focused awareness campaigns to increase resilience.

Keywords: Climate Trends, Perception Index, Adaptation Strategies, Livelihood Vulnerability Index, Rainwater Harvesting

INTRODUCTION

Over the past century, Darjeeling has had a notable warming trend, according to historical meteorological records from the Indian Meteorological Department (IMD). The most noticeable warming occurred after 1980, with mean minimum temperatures rising by 0.02 °C per decade and mean maximum temperatures rising by about 0.03 °C per decade between 1901 and 2020 (Indian Meteorological Department, 2021). Although there has been a slight increase in monsoonal rainfall of roughly 9 mm every ten years, variability has increased, leading to an increase in the frequency of erosion events, landslides, and flash floods (Indian Meteorological Department, 2021; Mondal et al., 2024).

This article synthesizes secondary data on climatic trends, community perceptions, and adaptation outcomes in Darjeeling district to address three key questions: (1) What changes have we seen in climate factors during the last century? (2) How do perception levels vary between professional groups? (3) In what ways can policy interventions improve the efficacy and inclusivity of documented adaptation strategies? This study offers an evidence-based basis for developing fair, community-driven climate adaptation policies in the Darjeeling Himalaya by solely depending on government reports, peer-reviewed research, and meteorological records

RESEARCH PROBLEM

This research problem aims to explore the disconnect between local perceptions of climate change and the adoption of sustainable livelihood strategies, shedding light on socio-economic and cultural factors that facilitate or hinder resilience in this fragile Himalayan region.

OBJECTIVES

- To synthesize existing secondary datasets on temperature, precipitation, and extreme weather events in Darjeeling District to characterize recent climate change trends that affects the livelihood of the people living in that area.
- To examine the relationship between climate-change perception scores and measured vulnerability levels among tea garden laborers, casual workers, informal sector employees, petty businessmen, formal-sector workers.
- To identify key gaps in household climate awareness where adaptive capacity is weakest and propose targeted, livelihood-specific education and communication strategies.

- To formulate recommendations for integrating local knowledge into formal vulnerability assessments and designing multi-stakeholder adaptation frameworks that initiate resilience in Darjeeling's hill communities.

MATERIAL AND METHODS

This study relies exclusively on secondary data obtained from authoritative government agencies, peer-reviewed literature, and institutional reports on Climate Change, perception and Adaptation of household of Darjeeling District, West Bengal. The study integrates the following secondary data sources:

Climate Data: Annual temperature and rainfall series (1901–2020) from the IMD (2021).

Government Plans: State Action Plan on Climate Change, West Bengal (WB-SAPCC, 2012), and Detailed Project Report for the National Adaptation Fund—Darjeeling (CPGD–West Bengal, 2016).

Published Research: Peer-reviewed studies on perception and vulnerability (Basu, 2020; Kumar & Brewster, 2022; Mondal et al., 2024), and media-reported risks (Pandey, 2024; CSE, 2024).

IPCC Assessments: WGII Sixth Assessment Report on regional impacts and adaptive capacity (IPCC, 2022).

RESULTS

Climate Trends: Analysis of IMD data shows:

Warming Trends

Over 120 years, mean maximum temperatures rose by roughly 0.36 °C, and minima by about 0.24 °C, indicating a consistent hill-station warming pattern. The higher slope and R^2 for T_{max} (0.003 °C/year; $R^2=0.34$) suggest daytime warming is more pronounced than night-time warming (0.002 °C/year; $R^2=0.29$) [IMD, 2021] .

Rainfall Variability

Monsoonal rainfall increased by approximately 108 mm between 1901 and 2020, but the moderate R^2 (0.31) reflects substantial inter-annual fluctuations. A positive slope (0.90 mm/year) coupled with an increasing coefficient of variation—from 14% (1901–1950) to 22% (1971–2020)—highlights more erratic monsoon behavior and a rise in extreme precipitation events (flash floods, landslides) [IMD, 2021] .

These results from the empirical foundation for linking climatic shifts to livelihood vulnerabilities in Darjeeling district.

Indicator Selection and Index Construction

Two composite indices frame the analysis. A perception index in the context of climate change adaptation is a composite metric that quantifies how individuals or communities understand and respond to climate risks. It integrates multiple dimensions—such as awareness of climate change, perceived severity of impacts, and willingness to engage in adaptive actions—into a single standardized score. The Perception Index aggregates six awareness indicators: recognition of changing rainfall patterns, temperature shifts, extreme events, long-term climate trends, institutional support awareness, and personal risk perception. Each indicator was normalized following Kumar and Brewster’s (2022) methodology, with higher values indicating greater awareness.

Second, the Livelihood Vulnerability Index (LVI) adopts the IPCC triad—exposure, sensitivity, and adaptive capacity—as operationalized by Hahn, Riederer, and Foster (2009).. Each subcomponent score was normalized and equally weighted to produce an LVI score between 0 (least vulnerable) and 1 (most vulnerable).

Perception Across Occupational Groups

Basu (2020) reports:

Tea garden laborers exhibit the lowest climate awareness and highest vulnerability, whereas formal-sector employees show the inverse pattern (Basu, 2020).

Perception–Vulnerability Link: A strong negative correlation indicates that occupational groups with higher climate-change awareness consistently exhibit lower vulnerability scores (Basu, 2020).

Perception–Adaptation Link: A moderate positive correlation shows that groups with greater awareness of climate variability are more likely to install rooftop RWH systems (CPGD–West Bengal, 2016). Both correlations are statistically significant, confirming that improved awareness is a critical driver of reduced vulnerability and increased uptake of structural adaptation in Darjeeling district.

Adaptation outcomes—such as rainwater harvesting adoption, livelihood diversification, and community network engagement—were synthesized from CPGD–West Bengal (2016), Kumar and Brewster (2022), and Mondal et al. (2024), triangulating quantitative uptake rates with descriptive project reports. By integrating these methods, the study provides a robust, replicable framework for assessing how secondary data reveal links among climate trends, perception, vulnerability, and adaptation in Darjeeling district.

DISCUSSION

Adaptation Strategies

Rainwater Harvesting

Adoption Rates: 72% of formal-sector households and 65% of petty businessmen installed rooftop RWH units (1,000–5,000 L), compared to 18% among tea garden laborers (CPGD–West Bengal, 2016). Impact: Participating households reported a 40% reduction in water-fetching time and 25% fewer seasonal shortages during the dry season (CPGD–West Bengal, 2016).

Livelihood Diversification: Tourist guides and petty businessmen maintain at least two income streams (handicrafts, farm produce), improving resilience against climate-driven tourism downturns (Kumar & Brewster, 2022).

Community-Based Initiatives: Self-help groups and cooperatives have co-financed soil-conservation terraces and shared water-storage tanks, enhancing social capital and collective resilience (Mondal et al., 2024).

Policy Recommendations

- Establish a network of community-managed micro-weather stations across Darjeeling's elevation gradient, feeding real-time data into a shared dashboard that village councils and cooperatives can use to calibrate planting dates, irrigation needs and landslide warnings.
- Institutionalize annual participatory vulnerability assessments at panchayat level, combining household surveys with focus-group mapping of microclimate hotspots, landslide-prone slopes and wildlife-crop conflict zones—ensuring adaptation plans reflect local knowledge and evolving risks..
- To foster livelihood diversification among Darjeeling's hill communities, the state government should launch a Climate-Resilient Enterprise Fund offering matched grants and low-interest loans for small enterprises that process or add value to locally produced goods—such as freeze-dried high-altitude vegetables, medicinal herb tinctures, and artisanal handicrafts. Technical training centres co-located with panchayat offices will provide business development services, marketing support, and digital literacy workshops, ensuring women's self-help groups, youth collectives, and tea garden workers can develop off-season microenterprises.

CONCLUSION

Both objective exposure to changing climate variables and subjective perception of these changes contribute to the livelihood vulnerability of the Darjeeling district. Analysis of secondary data demonstrates that while high-awareness groups implement more successful adaptation strategies, low-

awareness groups continue to be the most vulnerable. Resilience can be increased by closing the perception gap, for instance, by providing subsidised technology and focused training. The long-term effectiveness of combined structural and non-structural interventions should be assessed in future studies, and community-driven solutions should be improved for scaling up in comparable mountainous environments.

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