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# Village-Level Assessment of Climate Vulnerability in Darlawn Block, Mizoram, India: Biophysical and Socio-Economic Sectors

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**Abstract** Mizoram has been identified as one of India's most climate-vulnerable states, with its mountainous terrain and shifting weather patterns intensifying environmental hazards. This study evaluates climate vulnerability at the village level in Darlawn Block, Aizawl District, Mizoram, using a structured methodology based on the Intergovernmental Panel on Climate Change (IPCC) risk assessment framework. The Composite Vulnerability Index (CVI) was formulated by integrating biophysical and socio-economic indicators, which were normalized and analysed to rank the vulnerability of 29 villages. The findings indicate that Thingsat village exhibits the highest vulnerability, while Darlawn Vengpui is the least vulnerable. The study also identifies key drivers of vulnerability, including a low percentage of irrigated agricultural land and a lack of diversified income sources. The results emphasize the importance of localized climate adaptation strategies tailored to the specific needs of different villages. By pinpointing the factors contributing to climate vulnerability, this research supports informed policy-making, resource allocation, and adaptation planning to promote sustainable development in rural communities.

***Keywords:*** *Climate change, Vulnerability Assessment, Sensitivity, Adaptive capacity*

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## 1. Introduction

Climate change is widely recognized as a major issue impacting human society, bringing far-reaching effects for the world, its inhabitants, ecological systems, and economies. Scientific evidence from organizations such as the Intergovernmental Panel on Climate Change (IPCC) and NASA has demonstrated that anthropogenic activities—primarily the burning of fossil fuels, deforestation, and industrial emissions—are accelerating global warming, leading to significant disruptions in natural and human systems [1].

India's rural population, which accounts for over two-thirds of the country's total populations, remains heavily dependent on climate-sensitive sectors such as agriculture, forestry, fisheries, and other allied activities. These sectors form the backbone of rural livelihoods, yet they are particularly vulnerable to climatic fluctuation and change. Even modest shifts in temperature, rainfall patterns, and extreme weather events- such as droughts, floods, and cyclones- can have severe consequences on food production, water availability, income stability, and overall economic security [2]. Climate change poses a severe threat to rural communities, particularly the impoverished and marginalized segments of the population. Due to a complex interplay of socioeconomic and structural challenges, these groups face disproportionate risks from climate-related disruptions. Their vulnerability is driven by economic instability, inadequate infrastructure, dependence on climate-sensitive sectors, and limited adaptive capacity, all of which hinder their ability to cope with and recover from environmental shocks [3,4]. Therefore, the rural poor segment of the communities are the most vulnerable due to extensive reliance on climate-sensitive sectors, unstable markets, low socio-economic level, and poor biophysical status [5].

According to a comprehensive vulnerability assessment analysis, Mizoram has been identified as one of the most climate-vulnerable states in India, ranking as the second most vulnerable among the states located within the Indian Himalayan Region. This ranking emphasizes the state's high vulnerability to the adverse impacts of climate change, which stem from a combination of geographical, environmental, and socio-economic factors [6]. The hilly terrain and rugged landscape of Mizoram make it particularly prone to landslides, soil erosion, and deforestation, all of which are exacerbated by changing weather patterns and increasing rainfall variability. The state also experiences shifting monsoon patterns, rising temperatures, and extreme weather events such as cyclones and heavy storms, which pose serious risks to agriculture, infrastructure, and human settlements [7].

Highland communities face significant vulnerability to climate change due to the distinctive characteristics of mountainous regions, which include marginality, ecological fragility, geographical isolation, and an extensive reliance on natural resources and agro-based ecosystems. Moreover, the remoteness of highland settlements frequently restricts access to the essential facilities, healthcare, education, and economic opportunities, further constraining their ability to adapt to environmental changes [8,9,10].

Climate vulnerability refers to the degree to which a system is exposed and susceptible to the adverse effects of climate change, including climate variability and extreme weather events. It is a multidimensional concept that encompasses both biophysical and socioeconomic factors, influencing how communities, ecosystems, and economies respond to climate change. In contrast, climate risk is determined by the interplay of exposure, vulnerability, and adaptive capacity. Over the past decade, climate vulnerability has become a key focus of academic research, with its meaning varying based on different contexts and circumstances [11].

Vulnerability to climate change is analysed through two primary perspectives in climate change research. The first approach focuses exclusively on weather-related factors and their variations over time, including shifts in temperature, precipitation patterns, extreme weather events, and long-term climatic trends. This perspective primarily examines the physical and meteorological aspects of climate change and how these factors evolve due to global warming [12,13]. The second approach takes a broader view, emphasizing the exposure and vulnerability of societies, geographic regions, and economic systems to climate change. This perspective also considers socioeconomic, political, and infrastructural factors that influence a system's ability to cope with and adapt to climate-related disruptions. It highlights the unequal distribution of climate impacts, recognizing that marginalized communities, developing economies, and resource-dependent regions often face greater challenges in managing and mitigating the consequences of climate change [14,15]. Integrating these perspectives enables researchers and policymakers to develop comprehensive climate adaptation and resilience measures that address both the physical drivers of climate change and the social, economic, and institutional variables that shape vulnerability [16].

Index-based vulnerability analysis facilitates a clear and structured assessment of vulnerability by incorporating multiple indicators that represent diverse vulnerability scenarios. Researchers have extensively utilized these indices as valuable tools for informing policy decisions [17]. The recurrent occurrence of climate change-induced disasters has significantly impacted local communities, often exacerbating their vulnerabilities. Therefore, conducting a socio-economic vulnerability assessment is crucial for understanding the extent of these disasters and developing effective management strategies. However, scientific research on this issue remains limited [18,19].

## 2. Study Area

Darlawn Block is an administrative region located in the Aizawl District of Mizoram, India, with Darlawn town serving as its administrative headquarters. The block comprises 29 villages, and Mizo is the predominant local language. Covering a geographical area of approximately 1,184.41 square kilometers, the region sits at an elevation of 48 meters above sea level.

The region features rugged terrains, rolling hills, and dense forests which are characteristic of the broader Aizawl District. Agriculture is the primary economic activity, with locals engaging in the cultivation of rice, maize, vegetables, and fruits. Horticulture also plays a vital role in the region’s economy. However, the region faces numerous socio-economic and biophysical challenges, including inadequate infrastructure, heavy reliance on agriculture, limited access to essential services, deforestation, land degradation, climate change impacts, and various environmental concerns.

## 3. Materials and Methods

This study adopts a structured approach to assessing village-level climate vulnerability in Darlawn Block, drawing from established frameworks in climate risk management and assessment. Specifically, it follows the conceptualizations of climate change-related risk as outlined in the risk management and assessment framework published by the Intergovernmental Panel on Climate Change (IPCC) in 2014. Additionally, the step-by-step methods and guidelines for vulnerability assessment developed by Sharma et al. [20], based on the IPCC’s Fourth Assessment Report [21] risk assessment framework, were incorporated to ensure a comprehensive and systematic evaluation of climate vulnerability. The assessment methodology integrates both biophysical and socio-economic perspectives to provide a holistic understanding of climate risks at the village level in Darlawn Block. By combining these dimensions, the study aims to present a detailed and nuanced picture of climate vulnerability in the region, identifying the most at-risk communities and informing the development of targeted adaptation strategies to enhance resilience and sustainable development in the region.

The methodology used in this study has strong potential applicability to other regions, particularly those with similar socio-economic and environmental conditions. However, successful adaptation of this framework to different contexts requires consideration of region-specific factors that influence climate risk and vulnerability. Below are key aspects of its applicability to other regions:

**i). Structured and Standardized Framework**: Since the study is based on the IPCC’s 2014 risk assessment framework and Sharma et al.'s [20] guidelines, it provides a globally recognized structure that can be applied in different geographic contexts.

**ii). Holistic Approach**: By integrating both biophysical and socio-economic dimensions, the methodology ensures a comprehensive evaluation of climate vulnerability, which is relevant across diverse ecological and social settings.

iii). **Community-Level Focus**: The village-level assessment allows for localized insights, making it suitable for rural and semi-urban areas where climate vulnerability varies significantly from one community to another.

iv). **Informed Adaptation Strategies**: The methodology's emphasis on identifying at-risk communities and designing tailored adaptation strategies ensures that findings are actionable and useful for policymakers.

The methodology employed to assess village-level climate vulnerability in Darlawn Block, Mizoram, India, is detailed below, with a specific focus on utilizing biophysical and socio-economic metrics:

**1. Scoping of Vulnerability Assessment:**

The first step involved identifying and ranking vulnerable villages within Darlawn Block while determining key drivers contributing to their vulnerability.

**2. Selection of type of Vulnerability Assessment:**

The study focused on assessing inherent vulnerability to climate change by incorporating both biophysical and socio-economic indicators.

**3. Selection of Tier Method:**

A Tier-2 (bottoms-up) approach was employed, utilizing primary ground-level data to conduct the vulnerability assessment.

**4. Determining Spatial Scale and Timeframe:**

The unit of measurement for this assessment was at the village level, with data for selected indicators collected across different years.

**5. Identification, Definition, and Selection of Indicators:**

Probable indicators were identified through expert consultations, literature reviews, and data availability at the village level. Indicators were selected based on the following criteria:

i). **Relevance to Climate Vulnerability**: The indicator should directly or indirectly contribute to understanding the climate vulnerability of villages. This includes exposure to climatic hazards, sensitivity of the community, and adaptive capacity.

ii). **Data Availability**: Reliable data for the indicator should be accessible at the village level from government reports, research publications, or primary surveys.

iii). **Measurability and Quantifiability**: The indicator should be measurable using numerical or categorical data, enabling its normalization and comparison across villages.

iv). **Non-Redundancy**: Indicators that were highly correlated with one another were filtered out to avoid duplication and bias in the analysis.

v). **Policy Relevance**: Indicators should provide actionable insights for policymakers to develop effective adaptation and mitigation strategies.

Certain indicators were excluded based on the following considerations:

i). **Data Unavailability or Inconsistency**: If an indicator lacked reliable data or had inconsistent reporting across villages, it was excluded.

ii). **High Correlation with Other Indicators**: If two or more indicators showed a strong correlation, one of them was removed to prevent redundancy. The decision on which to retain was based on expert judgment regarding relevance and policy implications.

iii). **Lack of Sensitivity to Climate Change**: Indicators that did not show significant variation with climate-related risks were deemed less useful and omitted.

After filtering out indicators, a final set of 17 indicators was selected for assessment. Details regarding these indicators, the rationale for their selection, their functional relationship with vulnerability, and their data sources are presented in **Table 1.**

**6.Quantification and Measurement of Indicators:**

A combination of primary data collection and geospatial analysis was utilized to quantify and measure the selected indicators.

**7. Normalization of Indicators:**

Since the indicators were measured in different units, normalization was performed by assigning scores ranging from 0 to 1, ensuring comparability and enabling mathematical calculations. The following formulas were applied according to the functional relationship of each indicator with vulnerability, as outlined by Sharma et al. [20].

Case I: If the indicator has positive relationship with vulnerability

$$Normalized\ value = \frac{(Actual\ IV - Minimum\ IV)}{(Maximum\ IV - Minimum\ IV)} \quad (1)$$

Case II: If the indicator has negative relationship with vulnerability

$$Normalized\ value = \frac{(Maximum\ IV - Actual\ IV)}{(Maximum\ IV - Minimum\ IV)} \quad (2)$$

Where, IV= Indicator value

During the normalization process, each indicator was scaled such that the village with the poorest value received a score of 1, while the village with the best value wasassigned a score of 0. The remaining villages were assigned scores ranging between 0 and 1. This procedure was consistently applied across all indicators **(Table-2).**

**8. Assigning Weights to Indicators:**

The process of assigning weights to a total of 17 indicators was complex. To simplify the procedure and minimize potential bias, no weights were assigned to any of the indicators. Instead, an equal weighting approach was adopted, assuming that all indicators contribute equally to vulnerability.

Implications of not assigning weights:

i). **Reduced Subjectivity and Bias**: By not assigning weights, the study avoids potential biases that could arise from expert judgment or arbitrary weight allocation.

ii). **Equal Representation of Indicators**: Each indicator is given the same importance, ensuring that no single factor disproportionately influences the final vulnerability scores.

iii). **Potential Oversimplification**: Certain indicators may have a stronger influence on vulnerability than others, and treating them equally might not fully capture the true risk dynamics.

**9. Aggregation of Indicators and Development of the Vulnerability Index:**

The normalized values of each village across all indicators were aggregated to calculate the vulnerability index for that village. This process was repeated for all villages, resulting in the determination of Composite Vulnerability Index (CVI) values for each village.

**10. Representation of Vulnerability through Spatial Maps, Charts, and Tables:** Villages were ranked based on their corresponding CVI values, which were presented in tabular form. The village with the highest CVI value was ranked first, followed by others in descending order. Villages were further classified into three vulnerability categories - High, Medium, and Low - using the percentile method Figure 1**.**

**11. Identification of Vulnerability Drivers for Adaptation Planning:**

To identify the primary contributors to vulnerability, the normalized values of each indicator across all villages were averaged. The percentage contribution of each indicator was then calculated by comparing its averaged normalized value to the total of all averaged values. A higher percentage score indicated a greater contribution of that indicator to overall vulnerability, thus highlighting the key drivers of vulnerability.

## 4. Results and Discussion

*Vulnerability profile and ranking of villages*

Based on the collected data, the Composite Vulnerability Index (CVI) was calculated by aggregating the respective scores of each village across various indicators. The results are illustrated in Figure 1. The vulnerability ranking of all 29 villages in Darlawn block was determined using their respective CVI values.

Thingsat village emerged as the most vulnerable in the study area, registering the highest Composite Vulnerability Index (CVI) value of 0.115. This indicates that, in comparison to other villages, Thingsat village exhibits the greatest susceptibility to climate-related risks and has the lowest adaptive capacity concerning both biophysical and socio-economic factors. Similarly, Ratu village ranked second with a vulnerability index value of 0.107, followed by Damdiai village in third place with a score of 0.103.

In contrast, Darlawn Vengpui recorded the lowest vulnerability index value of 0.058, making it the least vulnerable to current climate change and variability when compared to other villages within the study area. It is important to recognize that the classification of vulnerability categories serves as a relative division rather than an absolute classification. However, this does not imply the absence of challenges, as the village faces its own distinct issues and degree of vulnerability. It is also essential to acknowledge that the comparative analysis is based on a specific set of indicators selected to determine the vulnerability index values across villages [22,23,24].

*Classification of Village Vulnerability:*

According to the three-tier vulnerability classification outlined in the methodology, Thingsat, Ratu, Damdiai, Sunhluchhip, and Zokhawthiang villages were identified as highly vulnerable. A total of 21 villages fell into the medium vulnerability category, while N. Serzawl, Pehlawn, and Darlawn Vengpui were classified as having low vulnerability.

Based on these findings, targeted policy interventions are necessary to address the varying levels of vulnerability across villages in the study area. Since Thingsat, Ratu, and Damdiai villages exhibit the highest vulnerability, immediate and substantial interventions are required to enhance their adaptive capacity. These villages should be prioritized for infrastructural improvements, particularly in climate-resilient housing, access to reliable water sources, and enhanced agricultural support. Establishing community-based adaptation programs focusing on sustainable farming techniques, soil conservation, and diversified income-generating activities can mitigate the adverse impacts of climate variability.

For villages classified under medium vulnerability, targeted interventions should focus on enhancing adaptive capacity while addressing key sensitivity factors. These villages require investment in expanding irrigation infrastructure to mitigate the impact of erratic rainfall and drought conditions. Increasing access to credit and financial services for small-scale farmers and entrepreneurs can facilitate livelihood diversification, reducing their dependence on climate-sensitive sectors. Awareness programs on climate change, disaster preparedness, and health interventions should be implemented to enhance community resilience. Strengthening local governance structures by integrating climate adaptation strategies into existing development plans will also be essential in addressing medium-level vulnerabilities. Regarding the villages that have been categorized as having low vulnerability, such as N. Serzawl, Pehlawn, and Darlawn Vengpui, they should not be overlooked in policy interventions. Instead, proactive measures should be taken to sustain their relatively strong adaptive capacity while addressing emerging risks.

This classification was determined using mathematical class intervals based on the calculated vulnerability index values. However, it is important to note that these categories are relative and do not represent absolute measures of vulnerability. Instead, they serve as a comparative framework to highlight areas that may require more immediate adaptation and mitigation efforts to address climate risks effectively.

*Analysing Drivers of Vulnerability:*The key drivers of vulnerability for Darlawn block of Mizoram and their respective percentage contributions to overall vulnerability are given in Figure 2. It is important to highlight that these drivers are derived from indicators representing either sensitivity or adaptive capacity. In other words, the indicators have been adjusted to accurately reflect their role as drivers of vulnerability.

The calculation of these drivers follows a systematic process wherein the normalized values of all villages for a specific indicator (e.g., the percentage of individuals within the vulnerable age group) are averaged. This process is repeated for all selected indicators, resulting in an averaged value for each indicator across all villages. The percentage contribution of each indicator to the sum of all averaged indicator values determines its relative weight in the overall vulnerability assessment. Similarly, the percentage of irrigated area relative to the total cultivated area emerges as the highest contributing driver of vulnerability, with a magnitude of 10.25%, followed closely by the percentage of households with at least three diversified income sources at 10.10%. These two factors are identified as the most significant drivers of vulnerability in the study area.

As previously explained, the normalized values for each village under a specific indicator, ranging between 0 and 1, are averaged to determine the magnitude of that indicator. However, this range does not imply a normal distribution of values across all indicators.

## 5. Conclusion

Vulnerability assessments can be highly subjective if they do not accurately reflect real-world conditions, particularly when assigning weights to indicators. The weighting process significantly influences results, making it essential to carefully evaluate and select the most appropriate indicators for a given study area. It is important to recognize that a variety of inherent factors could serve as indicators for measuring vulnerability, beyond those currently in use. Therefore, before conducting an assessment, a thorough review of indicator selection and weighting - if applied - should be undertaken, ideally through expert evaluation and stakeholder consultations.

Vulnerability assessments play a crucial role in guiding policy formulation aimed at safeguarding environmental resources and ensuring long-term sustainability for both human communities and ecosystems. The categorization and ranking of climate vulnerability provide a framework for prioritizing climate adaptation efforts, ensuring that the most vulnerable villages or regions receive targeted investments and interventions. The identification and quantification of "Drivers of Vulnerability" aids in determining the key contributors to climate risk, influencing the creation of adaptive strategies. Additionally, this process helps in identifying potential maladaptation practices, particularly by analysing indicators related to adaptive capacity. Findings from this study indicate that the primary drivers of overall vulnerability may vary when examined at the individual village level. This suggests that different villages face distinct challenges and require context-specific interventions rather than a one-size-fits-all approach. Policymakers and planners should, therefore, allocate resources strategically, prioritizing factors that are most relevant to the unique vulnerabilities of each area.

Several studies on climate vulnerability have been conducted worldwide to support policy development aimed at mitigating environmental degradation. The ranking and classification of climate vulnerability serve as key tools for directing adaptation investments toward the most at-risk regions. Moreover, assessing the “Drivers of Vulnerability” enables a deeper understanding of the root causes of exposure and sensitivity, helping to design effective adaptation measures. Additionally, examining adaptive capacity indicators can reveal gaps or weaknesses in existing climate resilience strategies, highlighting areas where intervention is needed.

Given the complexity and subjectivity involved in vulnerability assessments, careful consideration must be given to indicator selection. Without a rigorous approach, results may misrepresent actual conditions, leading to ineffective policy responses. The present study underscores the importance of recognizing that top drivers of overall vulnerability at the regional level may not always be the most significant drivers when assessed at the village level. This highlights the necessity for localized assessments that address the specific challenges unique to each community.

To maximize the impact of adaptation strategies, decision-makers should prioritize interventions based on the factors that are most relevant to their respective areas of interest. Ultimately, a well-informed and carefully structured vulnerability assessment can significantly enhance climate resilience by ensuring that resources are allocated effectively and adaptation measures are tailored to the specific needs of different communities.

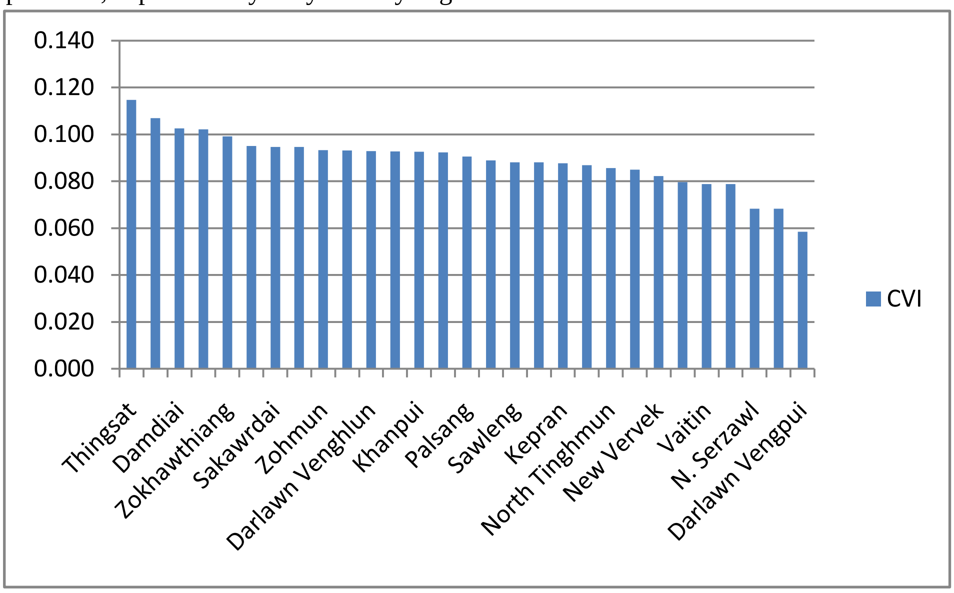


**Figure. 1.** Composite Vulnerability Index (CVI) values and corresponding ranks of villages within study area

**Table 1.** List of indicators, rationale for selection, functional relationship with vulnerability and sources of data

| Indicators | Rationale for Selection | Adaptive Capacity or Sensitivity | Functional relationship with Vulnerability | Source of Data |
|---|---|---|---|---|
| % of individuals within vulnerable age group | Age is a critical factor influencing climate vulnerability, as individuals within certain age groups—such as children, the elderly, and in some cases, adolescents—tend to be more susceptible to climate-related risks. | Sensitivity | Positive | Primary |
| % of persons with disabilities | Persons with disabilities are included as a key indicator due to their heightened susceptibility to climate-related risks and their often-limited adaptive capacity. | Sensitivity | Positive | Primary |
| %HH employed only in agriculture | More than 70% of Mizoram's population is engaged either fully or partially in agricultural activities. Since the majority of the agricultural system in the state relies on rainfed farming, areas with a higher proportion of people solely dependent on agriculture tend to be more sensitive to climate change. | Sensitivity | Positive | Primary |
| % family living in rented house | Families living in rented houses are more vulnerable as they may have limited financial stability, reduced access to essential resources, and lower adaptive capacity to climate-related risks. | Sensitivity | Positive | Primary |
| % HH run by widow | Households run by widows are vulnerable to potential economic hardships, limited access to resources, and reduced social support. The absence of a primary earning member may increase financial instability, making it more challenging for the household to adapt. | Sensitivity | Positive | Primary |
| % BPL family | Poverty increases vulnerability to any changes within a system, particularly when climate change disrupts livelihoods, making adaptation and recovery more challenging. | Sensitivity | Positive | Primary |
| % marginal land holder | Small and marginal land holdings often reflect limited economic and physical resources, making them more susceptible to climate change impacts relative to their size. This, in turn, leads to higher overall sensitivity. | Sensitivity | Positive | Primary |
| % HH with salaried/stable income | Households with a salaried or stable income are less vulnerable as they have a consistent financial resource to meet essential needs, invest in adaptive measures, and recover from adverse events. | Adaptive Capacity | Negative | Primary |
| %HH diversified income sources (at least 3) | Households with at least three diversified income sources are more resilient to economic shocks and climate-related disruptions. A diversified income portfolio reduces dependency on a single source, thereby enhancing financial stability and adaptive capacity. | Adaptive Capacity | Negative | Primary |
| %HH with better housing quality | Well-constructed houses provide improved protection against extreme weather events such as heavy rainfall, storms, and temperature fluctuations. | Adaptive Capacity | Negative | Primary |
| %HH with women workforce | Women are more vulnerable than men because they usually have less access than men to resources that would enhance their capacity to adapt to climate change | Adaptive Capacity | Negative | Primary |
| % reserve forest wrt TGA | Reserved forests are designated protected areas that restrict human activities such as agriculture, settlement, and resource extraction. In relation to the Total Geographical Area (TGA), a higher proportion of reserved forests may indicate limited land availability for livelihood activities, potentially increasing dependence on remaining land resources and influencing overall vulnerability. | Adaptive Capacity | Negative | Primary |
| % irrigated area wrt total cultivate area | The proportion of irrigated area to the total cultivated area is a crucial indicator of agricultural resilience. A higher percentage of irrigated land suggests reduced dependence on erratic rainfall, thereby enhancing food security and economic stability. Conversely, a lower proportion indicates greater vulnerability to climate variability, as rainfed agriculture is more susceptible to droughts and unpredictable weather patterns. | Adaptive Capacity | Negative | Primary |
| Diversification of educational infrastructure | Diversification of educational infrastructure is essential for enhancing community resilience and adaptive capacity. A well-distributed and varied educational system reduces socio-economic vulnerability by empowering individuals with knowledge and alternative livelihood options, making communities less dependent on climate-sensitive sectors. | Adaptive Capacity | Negative | Primary |
| No of Medical professional per 1000 population | It is a critical indicator of health care accessibility and the community's capacity to respond to health-related challenges, including climate-induced diseases and disasters. A higher ratio signifies better healthcare infrastructure, faster medical response, and improved overall resilience. | Adaptive Capacity | Negative | Primary |
| %HH with piped water connection | Piped water connection to household indicate availability of infrastructure to withstand water stress such as erratic rainfall, surface water limitations, etc. | Adaptive Capacity | Negative | Primary |
| Water Reservoir share by population in litres | The water reservoir share per population in liters is a crucial indicator of water availability and security in a region. It reflects the capacity of existing water resources to meet the needs of the population, especially during periods of drought, climate variability, or increased demand. | Adaptive Capacity | Negative | Primary |

**Table 2. Indicator normalised values for all villages used for measurement**

| Sl. No. | Khawhming | % of individuals within vulnerable age group | % of persons with disabilities | %HH employed only in agriculture | % family living in rented house | % HH run by widow | % BPL family | %marginal land holder | % HH with salaried/stable income | %HH diversified income sources (at least 3) | %HH with better housing quality | %HH with women work force | % reserve forest wrt TGA | % irrigated area wrt total cultivate area | Diversification of educational infrastructure | No of Medical professional per 1000 population | %HH with piped water connection | Water Reservoir share by population in litres |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Thingsat | 0.356 | 1.000 | 0.893 | 0.000 | 0.030 | 0.904 | 0.096 | 1.000 | 1.000 | 0.881 | 0.299 | 0.990 | 1.000 | 0.483 | 0.688 | 1.000 | 0.847 |
| 2 | Ratu | 0.480 | 0.139 | 0.432 | 1.000 | 0.016 | 0.668 | 0.425 | 0.776 | 0.779 | 0.709 | 0.310 | 0.978 | 1.000 | 0.725 | 0.826 | 0.474 | 0.963 |
| 3 | Damdiai | 0.118 | 0.840 | 0.857 | 0.000 | 0.009 | 0.446 | 0.219 | 0.889 | 0.947 | 0.857 | 1.000 | 0.956 | 1.000 | 0.311 | 1.000 | 0.000 | 0.804 |
| 4 | Sunhluchhip | 0.408 | 0.313 | 0.494 | 0.145 | 1.000 | 0.787 | 0.000 | 0.830 | 0.969 | 0.990 | 0.000 | 0.966 | 1.000 | 0.288 | 0.843 | 0.344 | 0.847 |
| 5 | Zokhawthiang | 1.000 | 0.273 | 1.000 | 0.068 | 0.065 | 0.709 | 0.129 | 0.932 | 0.979 | 0.942 | 0.053 | 0.941 | 1.000 | 0.656 | 1.000 | 0.175 | 0.000 |
| 6 | Lungsum | 0.651 | 0.000 | 0.000 | 0.000 | 0.124 | 0.735 | 0.254 | 0.500 | 1.000 | 0.887 | 0.847 | 1.000 | 1.000 | 0.311 | 0.853 | 0.345 | 0.995 |
| 7 | Sakawrdai | 0.558 | 0.137 | 0.756 | 0.511 | 0.036 | 0.939 | 0.256 | 0.458 | 1.000 | 0.254 | 0.137 | 0.894 | 1.000 | 0.670 | 0.657 | 0.206 | 1.000 |
| 8 | Khawpuar | 0.340 | 0.545 | 0.451 | 0.107 | 0.079 | 0.574 | 0.128 | 1.000 | 0.830 | 0.514 | 0.639 | 0.999 | 1.000 | 0.288 | 1.000 | 0.000 | 0.975 |
| 9 | Zohmun | 0.432 | 0.150 | 0.171 | 0.220 | 0.043 | 0.374 | 0.045 | 0.860 | 0.985 | 0.850 | 0.066 | 0.996 | 1.000 | 0.264 | 0.875 | 1.000 | 1.000 |
| 10 | Mauchar | 0.545 | 0.063 | 0.950 | 0.019 | 0.014 | 0.623 | 0.342 | 0.844 | 1.000 | 0.975 | 0.166 | 0.535 | 1.000 | 0.296 | 0.921 | 0.025 | 1.000 |
| 11 | Darlawn Venghlun | 0.226 | 0.167 | 0.123 | 0.654 | 0.137 | 0.355 | 0.190 | 0.471 | 0.838 | 0.450 | 0.500 | 1.000 | 1.000 | 0.733 | 1.000 | 0.449 | 0.989 |
| 12 | Chhanchhuahna Khawpui | 0.982 | 0.000 | 0.920 | 0.154 | 0.035 | 0.083 | 1.000 | 1.000 | 0.804 | 1.000 | 0.215 | 0.980 | 1.000 | 0.656 | 0.000 | 0.000 | 0.446 |
| 13 | Khanpui | 0.483 | 0.163 | 0.892 | 0.818 | 0.164 | 0.173 | 0.241 | 0.614 | 0.705 | 0.627 | 0.018 | 0.925 | 1.000 | 0.473 | 0.884 | 0.099 | 0.989 |
| 14 | Sailutar | 0.650 | 0.205 | 0.136 | 0.400 | 0.047 | 0.620 | 0.185 | 0.595 | 1.000 | 0.848 | 0.235 | 0.986 | 1.000 | 0.264 | 0.829 | 0.227 | 1.000 |
| 15 | Palsang | 0.024 | 0.000 | 0.765 | 0.000 | 0.065 | 0.677 | 0.023 | 0.357 | 0.968 | 0.986 | 0.172 | 0.919 | 1.000 | 0.288 | 0.815 | 1.000 | 1.000 |
| 16 | Hmunnghak | 0.878 | 0.491 | 0.836 | 0.317 | 0.064 | 0.966 | 0.126 | 0.733 | 1.000 | 0.475 | 0.597 | 0.541 | 0.000 | 0.412 | 0.693 | 0.014 | 0.750 |
| 17 | Sawleng | 0.485 | 0.233 | 0.003 | 0.196 | 0.151 | 0.832 | 0.188 | 0.164 | 0.827 | 0.694 | 0.287 | 0.924 | 1.000 | 1.000 | 0.826 | 0.011 | 0.995 |
| 18 | East Phaileng | 0.613 | 0.191 | 0.755 | 0.423 | 0.016 | 1.000 | 0.051 | 0.426 | 0.988 | 0.728 | 0.169 | 0.954 | 0.600 | 0.215 | 0.864 | 0.160 | 0.656 |
| 19 | Kepran | 0.497 | 0.087 | 0.825 | 0.576 | 0.083 | 0.102 | 0.092 | 0.458 | 0.981 | 0.725 | 0.140 | 0.982 | 1.000 | 0.459 | 0.784 | 0.000 | 0.979 |
| 20 | Lailak | 0.370 | 0.477 | 0.915 | 0.227 | 0.080 | 0.634 | 0.054 | 0.491 | 0.984 | 0.695 | 0.057 | 0.391 | 1.000 | 0.288 | 0.881 | 0.248 | 0.889 |

| Sl. No. | Khawhming | % of individuals within vulnerable age group | % of persons with disabilities | %HH employed only in agriculture | % family living in rented house | % HH run by widow | % BPL family | %marginal land holder | % HH with salaried/stable income | %HH diversified income sources (at least 3) | %HH with better housing quality | %HH with women work force | % reserve forest wrt TGA | % irrigated area wrt total cultivate area | Diversification of educational infrastructure | No of Medical professional per 1000 population | %HH with piped water connection | Water Reservoir share by population in litres |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | North Tinghmun | 0.368 | 0.132 | 0.066 | 0.475 | 0.016 | 0.571 | 0.121 | 0.811 | 0.838 | 0.816 | 0.131 | 0.951 | 1.000 | 0.124 | 0.918 | 0.251 | 0.972 |
| 22 | N. Khawdungsei | 0.409 | 0.468 | 0.755 | 0.218 | 0.032 | 0.820 | 0.083 | 0.486 | 1.000 | 0.811 | 0.037 | 0.956 | 1.000 | 0.483 | 0.610 | 0.000 | 0.332 |
| 23 | New Vervek | 0.129 | 0.255 | 0.119 | 0.367 | 0.163 | 0.835 | 0.865 | 0.629 | 0.842 | 0.206 | 0.032 | 0.981 | 0.757 | 0.296 | 0.818 | 0.019 | 0.911 |
| 24 | Darlawn Chhim Veng | 0.118 | 0.225 | 0.432 | 0.313 | 0.038 | 0.124 | 0.152 | 0.348 | 1.000 | 0.685 | 0.469 | 1.000 | 1.000 | 0.804 | 0.015 | 0.319 | 0.929 |
| 25 | Vaitin | 0.331 | 0.422 | 0.235 | 0.076 | 0.034 | 0.367 | 0.007 | 0.771 | 0.928 | 0.477 | 0.057 | 0.948 | 1.000 | 0.320 | 0.849 | 0.059 | 1.000 |
| 26 | Khawruhlian | 0.000 | 0.136 | 0.183 | 0.395 | 0.024 | 0.912 | 0.461 | 0.316 | 0.941 | 0.673 | 0.075 | 0.831 | 0.786 | 0.216 | 0.788 | 0.154 | 0.988 |
| 27 | N. Serzawl | 0.087 | 0.048 | 0.617 | 0.238 | 0.032 | 0.579 | 0.019 | 0.279 | 0.962 | 0.815 | 0.394 | 0.000 | 1.000 | 0.240 | 0.759 | 0.000 | 0.764 |
| 28 | Pehlawn | 0.566 | 0.000 | 0.690 | 0.310 | 0.000 | 0.000 | 0.278 | 0.284 | 0.000 | 0.856 | 0.018 | 0.946 | 0.695 | 0.336 | 0.881 | 0.080 | 0.884 |
| 29 | Darlawn Vengpui | 0.571 | 0.100 | 0.074 | 0.519 | 0.033 | 0.234 | 0.030 | 0.000 | 0.987 | 0.000 | 0.029 | 1.000 | 0.643 | 0.000 | 0.665 | 0.011 | 0.945 |

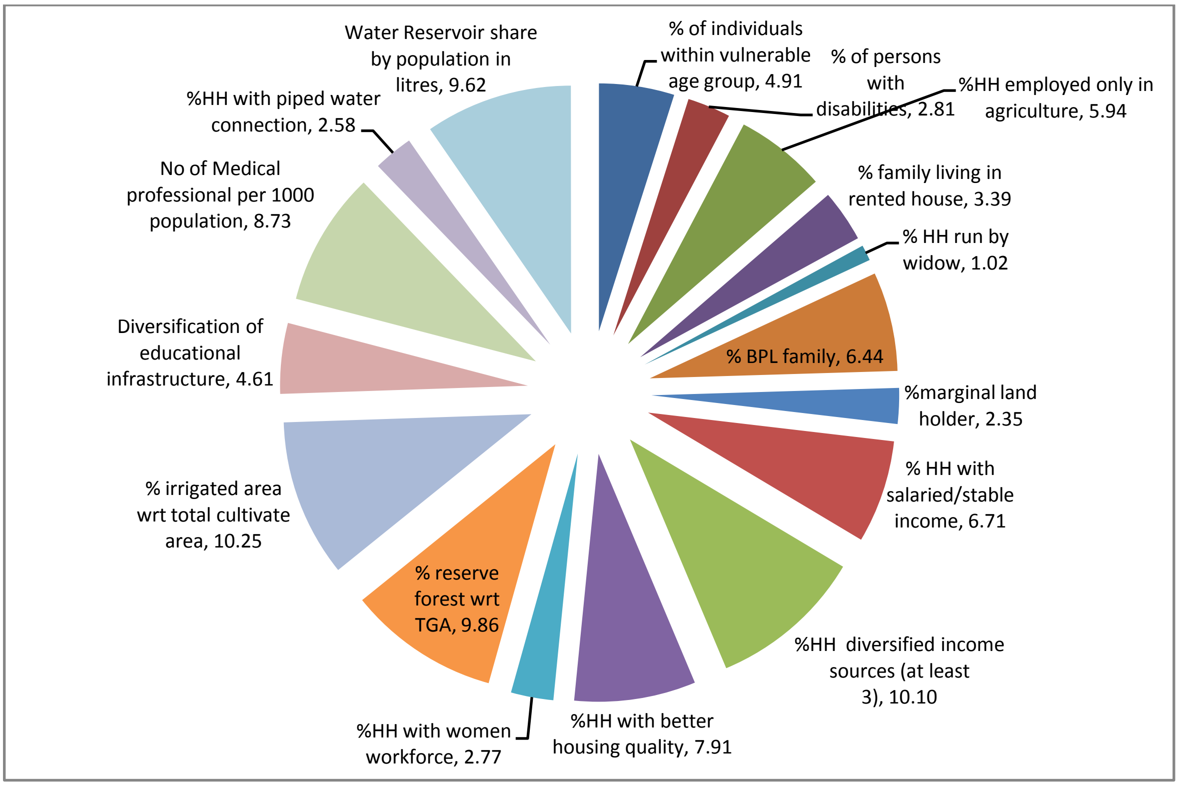


**Figure 2.** Pie Chart showing drivers of vulnerability: indicators (expressed in lack of adaptive capacity) and their corresponding percent contribution to an overall vulnerability against climate change and climate variability for Darlawn block, Mizoram, India

# References


[1] Lindner M, Maroschek M, Netherer S, Kremer A, et al. Climate change impacts, adaptive capacity, and vulnerability of European forest ecosystems. Forest Ecology and Management. 2010; 259: 698–709.

[2] Ministry of Environment, 2010. Indian Network for climate Change Assessment (INCCA). In Climate Change and India, Ministry of Environment and Forests, Government of India, New Delhi, India.

[3] Banerjee R (2014) Farmers' perception of climate change, impact and adaptation strategies: A case study of four villages in the semi-arid regions of India. Natural Hazards 75(3): 2829–2845.

[4] Eckstein, D., Künzel, V., & Schäfer, L. (2021). Global Climate Risk Index 2021. Who Suffers Most from Extreme Weather Events? Weather-Related Loss Events in 2019 and 2000 to 2019. Germanwatch.

[5] Safriel U, Adeel Z, Niemeijer D, Puigdefabregas J, White R, Lal R, McNab D (2005) Dryland systems. In Ecosystems and Human Well-being: Current State and Trends.: Findings of the Condition and Trends Working Group 623-662

[6] IHCAP. Climate Vulnerability Assessment for the Indian Himalayan Region using a Common Framework. Department of Science and Technology (DST), New Delhi (2019)

[7] Pant, S., Tabrez, S. (2024). Exploring the Impact of Climate Change Factors on Landslide in the Himalayan State of Mizoram. In: Sajjad, H., et al. Landslide Risk Assessment and Mitigation in India. LRAMI 2022. Springer Proceedings in Earth and Environmental Sciences. Springer, Singapore.

[8] J.Y. Gerlitz, M. Macchi, N. Brooks, R. Pandey, S. Banerjee, S.K. Jha. The multidimensional livelihood vulnerability index-an instrument to measure livelihood vulnerability to change in the Hindu Kush Himalayas. Clim. Dev., 9 (2016), pp. 124-140, 10.1080/17565529.2016.1145099

[9] Tsering, K., Sharma, E., Chettri, N., Shrestha, A., 2010. Climate Change Impact and Vulnerability in the Eastern Himalayas – Synthesis Report. ICIMOD. ICIMOD 110.

[10] Wester, P., Mishra, A., Mukherji, A. B., & Shrestha, A. B. (Eds.). (2019). The Hindu Kush Himalaya Assessment: Mountains, Climate Change, Sustainability and People. Springer Nature Switzerland AG

[11] Ford, J.D., Pearce, T., McDowell, G. et al. Vulnerability and its discontents: the past, present, and future of climate change vulnerability research. Climatic Change 151, 189–203 (2018).

[12] Bowler D., Böhning-Gaese K. Improving the community-temperature index as a climate change indicator. PLoS ONE. 2017;12:e0184275.

[13] Gruza G., Rankova E., Razuvaev V., Bulygina O. Indicators of Climate Change for the Russian Federation. Clim. Chang. 1999;42:219–242.

[14] Otto, I.M., Reckien, D., Reyer, C.P.O. et al. Social vulnerability to climate change: a review of concepts and evidence. Reg Environ Change 17, 1651–1662 (2017).

[15] Pandey R., Jha S. Climate vulnerability index–measure of climate change vulnerability to communities: A case of rural Lower Himalaya, India. Mitig. Adapt Strateg. Glob. Change. 2012;17:487–506.

[16] Kousik Das Malakar, Manish Kumar, Subhash Anand, Gloria Kuzu. Climate Change and Socio-Ecological Transformation: Vulnerability and Sustainability. July 2023.

[17] Martina Baučić. Household Level Vulnerability Analysis—Index and Fuzzy Based Methods. ISPRS Int. J. Geo-Inf. 2020, 9(4), 263.

[18] Nguyen, C.V., Horne, R., Fien, J. et al. Assessment of social vulnerability to climate change at the local scale: development and application of a Social Vulnerability Index. Climatic Change 143, 355–370 (2017).

[19] Slettebak, R. T. (2013). Climate change, natural disasters, and post-disaster unrest in India. India Review, 12(4), 260–279

[20] Sharma, J., Murthy, I.K., Esteves, T., Negi. P., Sushma, S., Dasgupta, S., Barua, A., Bala, G. and Ravindranath, N.H., 2018. In: Vulnerability and Risk Assessment: Framework, Methods and Guideline, Indian Institute of Science. (Cited 2021 February 8) http://himalayageoportal.in/wp-content/ uploads/Knowledge_Resources/Vulnerability- Manual_ IISC_IHCAP.pdf Tambe, S., Kharel, G

[21] IPCC, 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S.

Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

[22] Mohanty, A. and Shreya, W., 2021. Mapping India's Climate Vulnerability: A District Level Assessment. New Delhi: Council on Energy, Environment and Water.

[23] Department of Science and Technology (DST), Govt. of India, 2018-2019. Climate Vulnerability Assessment for the Indian Himalayan Region Using a Common Framework Under the project Capacity Building on Climate Change Vulnerability Assessment in the States of Indian Himalayan Region. (Cited 2022 July 29) https:// dst.gov. in/sites/ default/files/ IHCAP_Climate%20Vulnerability%20 Assessment _ 30Nov2018 _ Final_aw.pdf.

[24] Department of Science and Technology (DST), Govt. of India, 2019-2020. Climate Vulnerability Assessment for Adaptation Planning in India Using a Common Framework. Under the project Climate vulnerability and risk assessment at the national level using a common framework. (Cited 2022 July 29) https:// dst.gov.in/sites/ default/files/Full%20Report%20%281%29.pdf.