Economic&PoliticalWEEKLY

ISSN (Online) - 2349-8846

How Vulnerable are India’s Himalayan Region States to Climate Change?

ANAMIKA BARUA
VISHAKA GULATI
TAPASYA CHANGAKAKATI
RUPAM BHADURI
SHYAMASREE DASGUPTA
SURBHI VYAS
ALAM KHURSHEED
KRITISHNU SANYAL
TASHINA ESTEVES
INDU K MURTHY
N H RAVINDRANATH
JAGAMOHAN SHARMA

Anamika Barua* (anamika.barua@gmail.com), Vishaka Gulati, Tapasya Changakakati, and Rupam Bhaduri are with the Indian Institute of Technology Guwahati. Shyamasree Dasgupta, Surbhi Vyas, Alam Khursheed, and Kritishnu Sanyal are with the Indian Institute of Technology Mandi. Tashina Esteves, Indu K Murthy, and N H Ravindranath are with the Indian Institute Science, Bengaluru. Jagamohan Sharma is with the Government of Karnataka. *Anamika Barua is the corresponding author.
A longer version of this article was published as a report (J Sharma 2018). ArcGIS software has been used to develop the figures.

In 2018, a group of academic institutions initiated a project to build capacities of the 12 Indian Himalayan Region (IHR) states through robust assessments of climate change vulnerability, adaptation planning, and implementation. A standardised assessment of

Economic&PoliticalWEEKLY

ISSN (Online) - 2349-8846

vulnerability allows stakeholders to compare vulnerability across states, probe what has caused their vulnerability, and investigate how they might address these vulnerabilities.

Studies across the world have found substantial evidence that the climate is changing (IPCC 2014, 2018). This change is adversely affecting both biophysical systems (mountains, rivers, forests, wetlands, etc) and socio-economic systems (hill communities, coastal communities, agriculture, animal husbandry, etc). The impact of climate change, however, is not uniform across space and time. It varies within the same region due to differences in the exposure and vulnerability of various ecosystems, economic sectors, and social groups (IPCC 2014; O'Brien and Leichenko 2000). Therefore, one of the critical steps to identify appropriate adaptation measures to combat climate change is assessing the vulnerability of systems.

A study by Wester et al (2019) found that there has been a rising trend in extreme warm events, a falling trend of extreme cold events, and a rising trend in extreme values and frequencies of temperature-based indices (both minimum and maximum) in the Hindu Kush region over the past five to six decades. Further, the study reports that the region is experiencing increasing variability in western disturbances and a higher probability of snowfall in the Karakoram and western Himalaya regions. These changes are likely to contribute to increases in glacier mass in those areas. Realising the high vulnerability of the Indian Himalayan Region (IHR) with respect to climate change, the Government of India launched the National Mission for Sustaining the Himalayan Ecosystem (NMSHE) under the National Action Plan on Climate Change in 2010. One of the key areas identified by NMSHE was to build the capacity of 12 states in the IHR in conducting robust assessments of their vulnerability to climate change, developing plans to adapt to climate change, and effectively implementing these plans. The 12 states include Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Sikkim and the hilly districts of West Bengal in the eastern part of the IHR and Himachal Pradesh, Uttarakhand and Jammu and Kashmir in the western part of the IHR.

With this objective in mind, in 2018, a group of academic institutions initiated a project titled "Capacity Building on Climate Change Vulnerability Assessment in the States of Indian Himalayan Region."[1] The methodological framework considered under the project was based on the guidelines of the Fifth Assessment Report of Intergovernmental Panel on Climate Change (IPCC 2014). A common set of indicators was used. This set of indicators helped produce comparable vulnerability maps. The project aimed to develop maps, vulnerability profiles, and potential drivers of vulnerability at the district and state level for the chosen states. In addition, IHR states were ranked using a vulnerability index.

The assessment is unique because for the first time, all 12 states have used a common methodological framework. The assessment's coordinated approach between states in the region has the potential to facilitate promotion of resilience to climate change. This is vital since several adaptation interventions will require coordinated efforts across administrative

Economic&PoliticalWEEKLY

ISSN (Online) - 2349-8846

boundaries. Comparable outcomes are useful for government officials, implementers, decision-makers, adaptation project developers, adaptation funding agencies and development experts for several reasons. A common understanding on vulnerability allows stakeholders to compare vulnerability across states, probe what has caused their vulnerability, and investigate how they might address these vulnerabilities.

Concepts

IPCC (2014) developed a climate change risk-impact framework consisting of three components—hazard, exposure and vulnerability. Vulnerability is conceptualised as an internal property of a system; it is "the propensity or predisposition of a system to be adversely affected" (IPCC 2014). Therefore, vulnerability of a natural ecosystem or socio-economic system is assessed as a function of its sensitivity or susceptibility to harm from a first order impact of a hazard/stressor on the system and its lack of adaptive capacity to overcome or cope with such situations.

While there can be several types of vulnerabilities, they can broadly be classified into two categories: biophysical and socio-economic (including institutional). Biophysical vulnerability considers the extent to which a natural system is susceptible to damage from climate change, for example, forests, grasslands, etc. The socio-economic dimension is referred to as "a region's capacity to recover from extreme events and adapt to change over the longer term" (Füssel 2007). While the project has incorporated a few biophysical indicators, it has mainly assessed socio-economic vulnerability because the economies of the IHR states are highly dependent on natural resources.

The IPCC (2014) concluded that reducing vulnerability to the risks from current climate variability is the first practical step to curtail economic, social, and environmental harm. Reducing vulnerability to risks would be a reliable and "no-regret" approach to reduce current vulnerability and build long-term resilience from climate change. Specifically, a vulnerability assessment helps us:

- rank the biophysical or socio-economic units using an index,
- assess the extent of vulnerability,
- identify the drivers of vulnerability,
- identify the areas/systems/communities that are vulnerable,
- create demand among stakeholders for adaptation action and plan adaptation strategies, and
- create awareness among the stakeholders.

A Common Framework

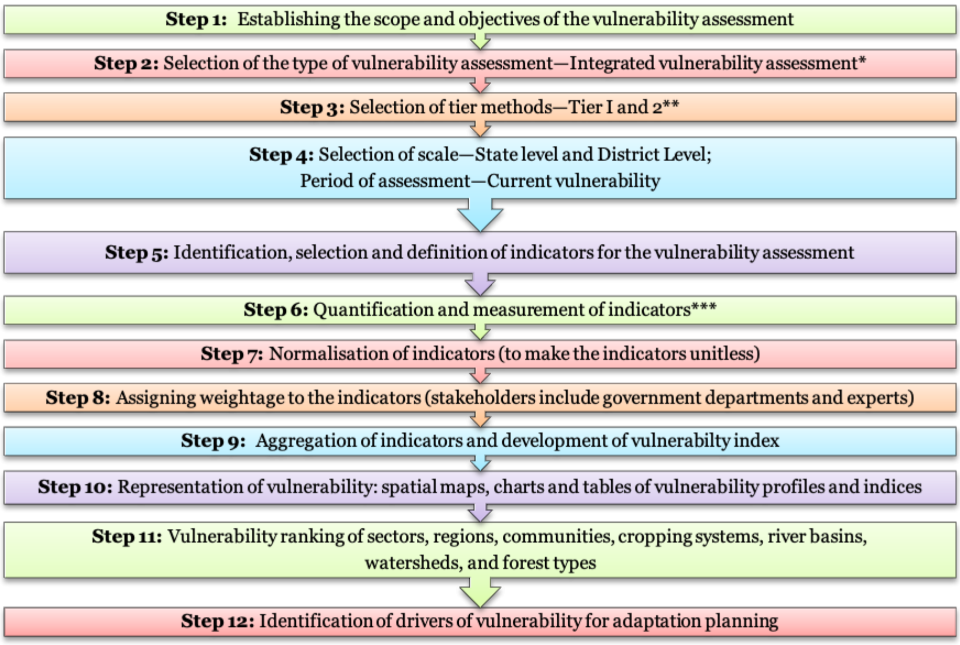
Prior to our research, while most of the IHR states had developed vulnerability profiles, these profiles were not comparable because the methods and indicators used by the states varied. Many of the states used the IPCC (2007) definition and framework of "vulnerability," which focused on assessing the future vulnerability to climate change rather than understanding the current vulnerability. The newer IPCC 2014 framework brought several

Economic&PoliticalWEEKLY

ISSN (Online) - 2349-8846

modifications and an increased level of scientific understanding. For example, exposure is no longer a component of vulnerability, but it has been categorised as a separate component of risk.

Figure 1: The Common Methodological Framework for Vulnerability Assessment



*Integrated vulnerability assessment is a combination of biophysical and socio-economic vulnerability assessment.
** For state level tier 1 approach (secondary data) and for district level tier 2 approach (secondary and primary data) was used.
Source: Sharma et al 2018

The final set of common indicators and their weights (or importance) were selected through discussion and debates during the workshops held with IHR state government representatives and experts. There are four broad categories of indicators used in the assessment based on those discussions. Each of these broad indicators have two to six sub-indicators. The expert consultation ensured that the indicators selected comprehensively represent the inherent socio-economic and biophysical systems of the 12 IHR states. The indicators are as follows:

- “Socio-economic, demographic status and health indicator is composed of six sub-indicators: population density; percentage marginal farmers; livestock to human ratio; per capita income; the number of primary health care centers per 100,000 households and percentage of women in the overall workforce” (Sharma J et al 2018).
- “The sensitivity of agricultural production is captured by considering three sub-

Economic&PoliticalWEEKLY

ISSN (Online) - 2349-8846

indicators—percentage area under irrigation; yield variability and percentage area under horticulture crops" (Sharma J et al 2018).
- "Forest dependent livelihood is represented by percentage area under open forests and area under forests per 1,000 households. It tries to capture the extent of degradation of forest resources in each state and the competition for this resource" (Sharma J et al 2018).
- "Access to information, services and infrastructure is represented by five sub-indicators, namely; percentage crop area insured under all insurance schemes; percentage farmers taking loans; average person days per household under MGNREGA; average percentage area with >30% slope; and road density" (Sharma J et al 2018).

District-level Vulnerability Assessment

For district-level assessments, the states selected eight state-specific indicators similar to those used in the state-level assessment. These indicators are:

- Percentage of area under slope greater than 30%
- Percentage area under forest cover
- Yield variability of foodgrains
- Population density
- Female literacy rate
- Infant mortality rate
- Percentage of below poverty line (BPL) households or per capita income[2]
- Average person-days under the Mahatma Gandhi National Rural Employment Guarantee Act, 2005 (MGNREGA)

The weights assigned to each indicator were first discussed during the methodology workshop,[3] and were finalised by the states after consultations with relevant departments back in their respestive states. The project team used the average of the weights communicated by the states for each indicator to compute the vulnerability index and develop vulnerability profiles of each state.

Ranking and Drivers of Vulnerability

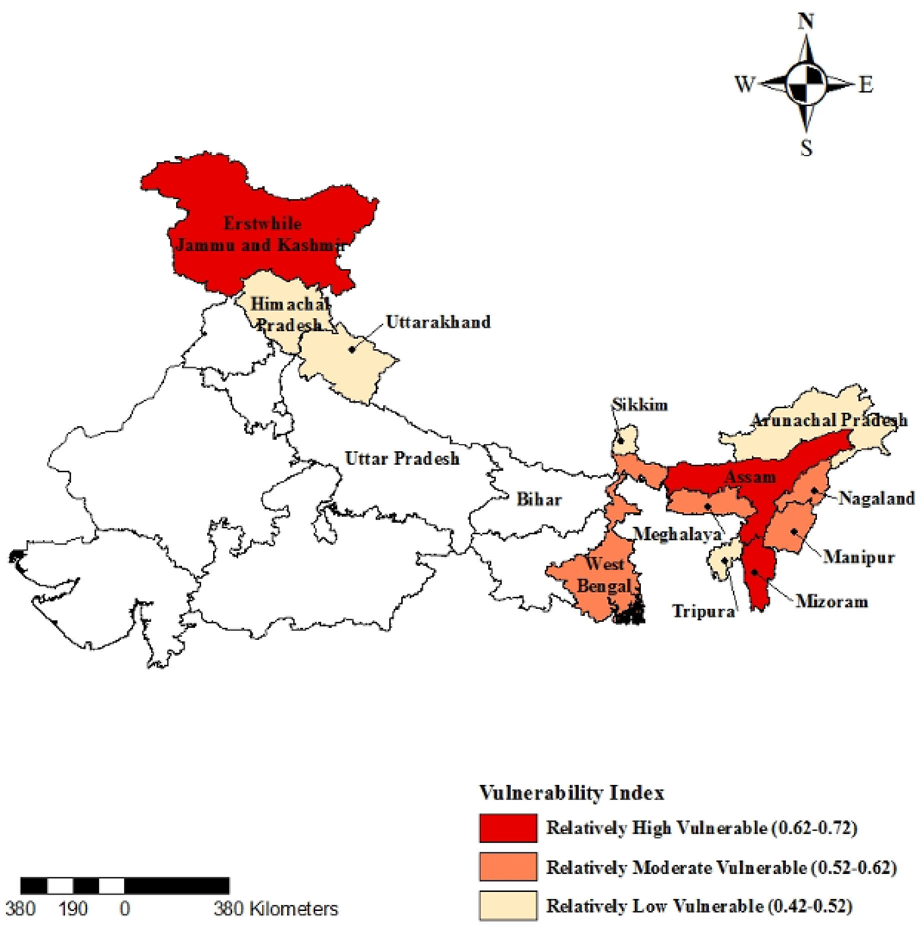
The geographic, climatic, socio-economic or demographic factors varied significantly across the IHR states. The states have been ranked from highest to lowest vulnerability based on composite vulnerability index values. The vulnerability index is highest for Assam (0.72) and Mizoram (0.71), followed by Jammu and Kashmir (0.62), Manipur (0.59), Meghalaya and West Bengal (both 0.58), Nagaland (0.57), Himachal Pradesh and Tripura (0.51 both), Arunachal Pradesh (0.47) and Uttarakhand (0.45). Sikkim is the least vulnerable state, with an index of 0.42. However, it is important to note that all these states are vulnerable to climate risks and the fact that vulnerability is a relative measure implies that this

Economic&PoliticalWEEKLY

ISSN (Online) - 2349-8846

assessment does not portray Sikkim, Uttarakhand or Arunachal Pradesh as having no or lower vulnerability in an absolute sense. These states are less vulnerable relative to the other IHR states, but also have several inherent drivers of vulnerability that need to be addressed. From the above-mentioned drivers of vulnerability, the most important drivers for the IHR states are low per capita income, and low open forest area per 1,000 households, lack of irrigation coverage, lack of availability of healthcare centres, high yield variability of food crops, and higher proportion of marginal farmers.

Figure 2: Vulnerability Map of the IHR States



Source: IHCAP 2018

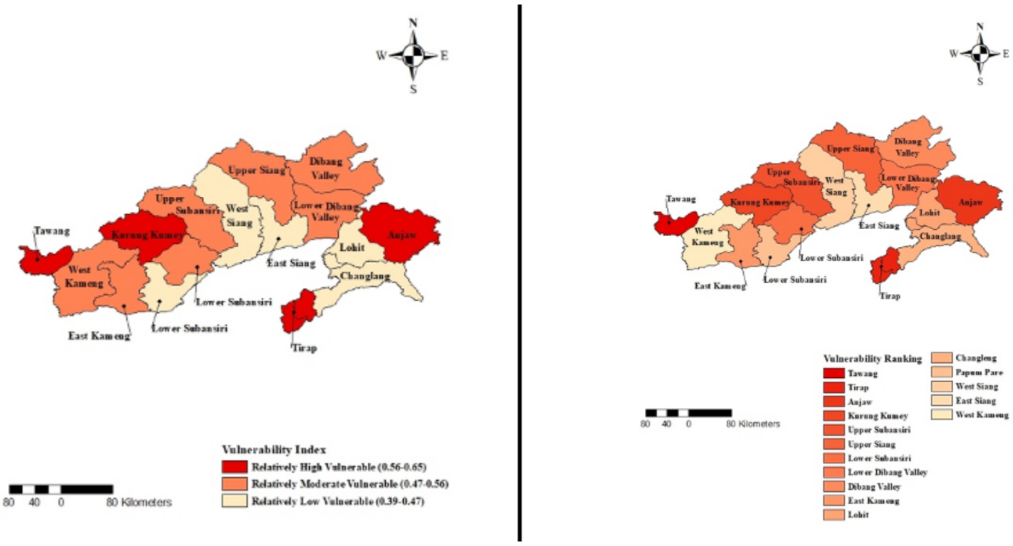
It was important to assess the severity and types of vulnerability at the district level because of variations in geographic, climatic, socio-economic, and demographic conditions within states. Thus, states constructed composite vulnerability indices at the district level. In some cases, state representatives used a few specific indicators to capture characteristics unique to their state. This led to the collection of more accurate and context-specific information,

Economic&PoliticalWEEKLY

ISSN (Online) - 2349-8846

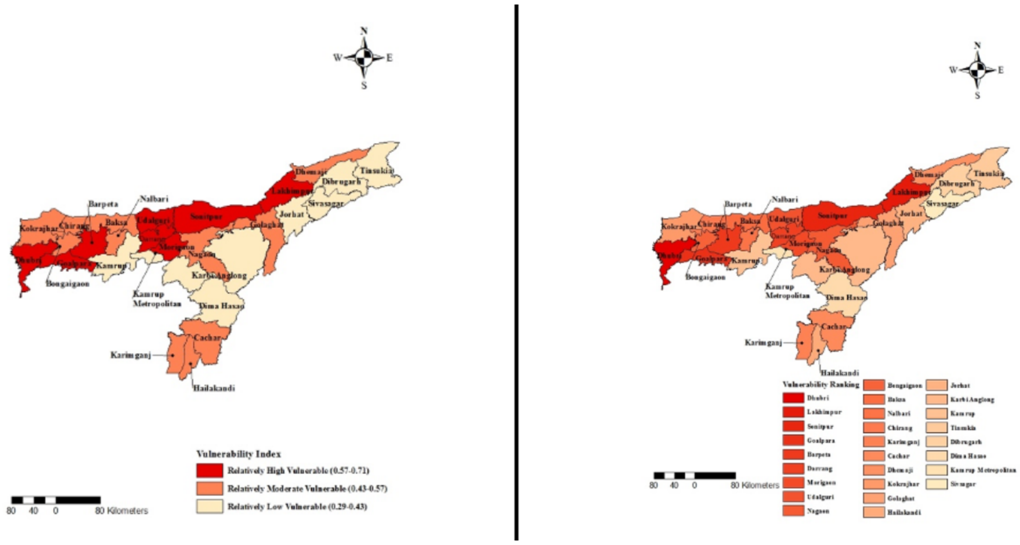
which is key for policymakers. Figures 3–12 show the district-level vulnerability ranking maps for each state followed by a list of the major drivers of vulnerability and they were generated based on data presented in the report "Climate Vulnerability and Risk Assessment: Framework, Methods and Guidelines" (IHCAP 2018). The vulnerability profile and ranking and classification as high, medium, or low and, in some cases, very high or very low are state-specific.

Figure 3: Vulnerability Category (Left) and Vulnerability Ranking (Right) of Arunachal Pradesh



Low female literacy, high percentage of BPL households, steep slope, and poor medical facilities are the main drivers of high vulnerability.

Figure 4: Vulnerability Category (Left) and Vulnerability Ranking (Right) of Assam

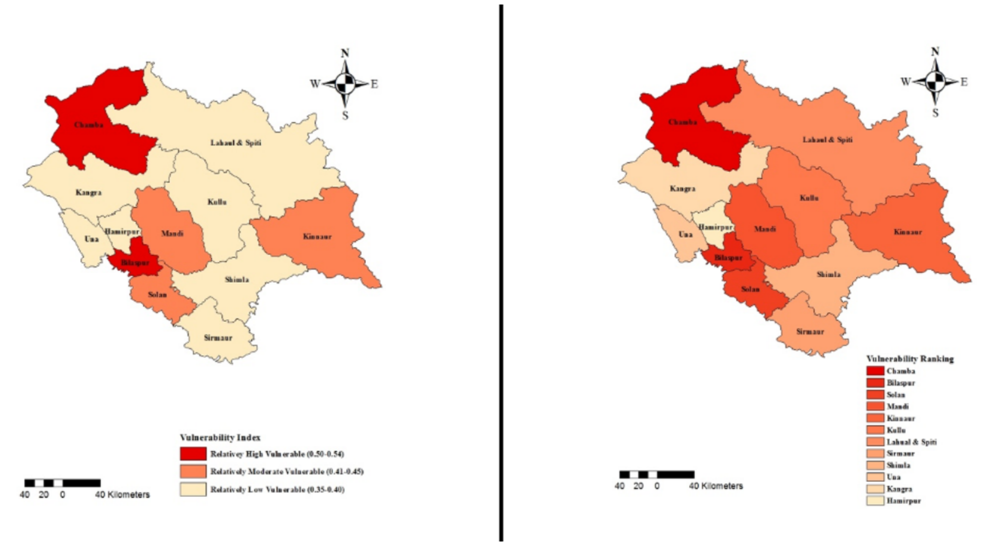


Economic&PoliticalWEEKLY

ISSN (Online) - 2349-8846

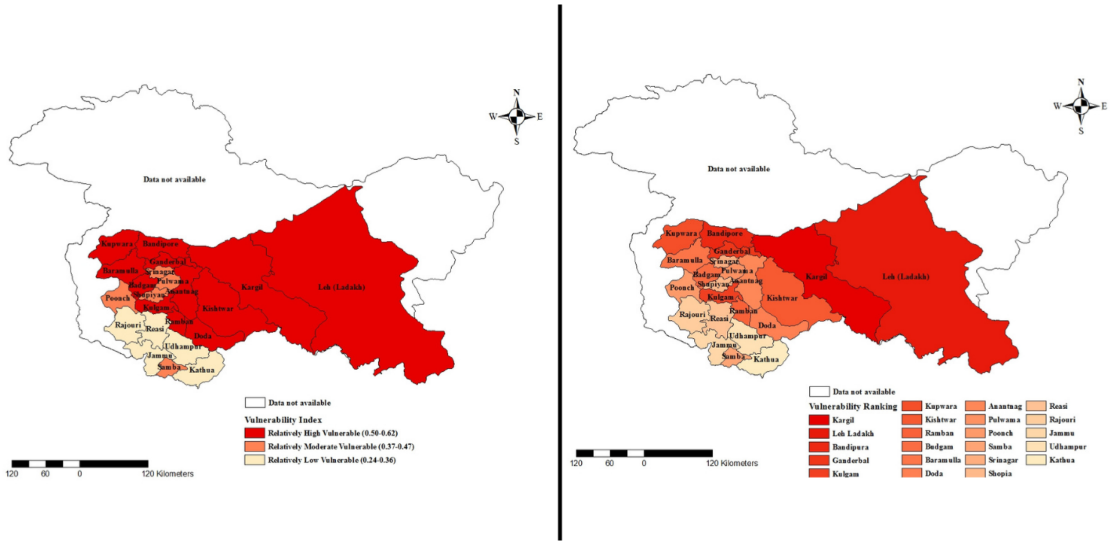
The major drivers of vulnerability are deforestation, low per capita income, low implementation of MGNREGA, and low female literacy rate.

Figure 5: Vulnerability Category (Left) and Vulnerability Ranking (Right) of Himachal Pradesh



Steep slope, high population density, high yield variability, low female literacy rate, and poor healthcare are the main drivers of vulnerability.

Figure 6: Vulnerability Category (Left) and Vulnerability Ranking (Right) of Erstwhile Jammu and Kashmir

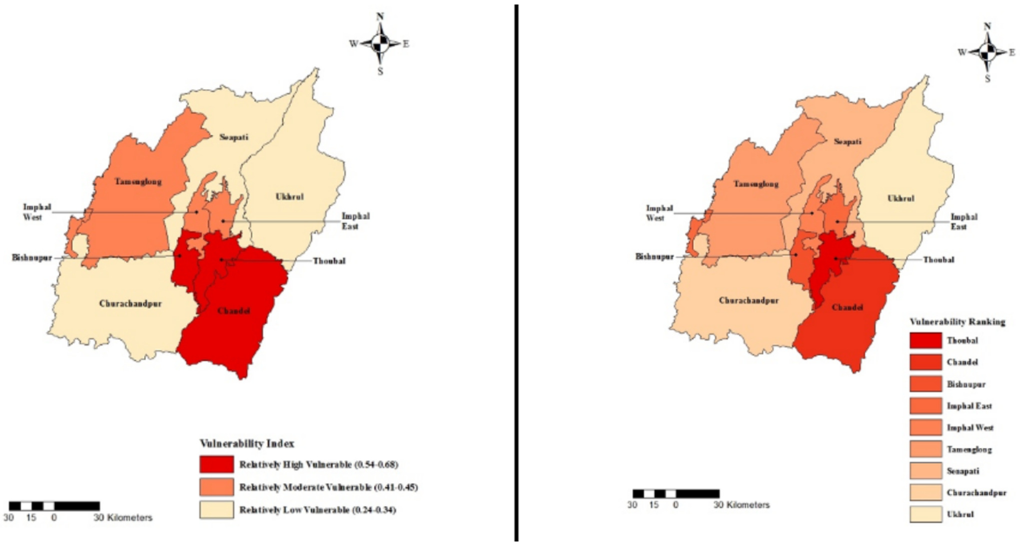


Low per capita income, relatively higher percentage of area under slope, high infant mortality rate, low female literacy rate, and lower MGNREGA participation are significant contributors.

Economic&PoliticalWEEKLY

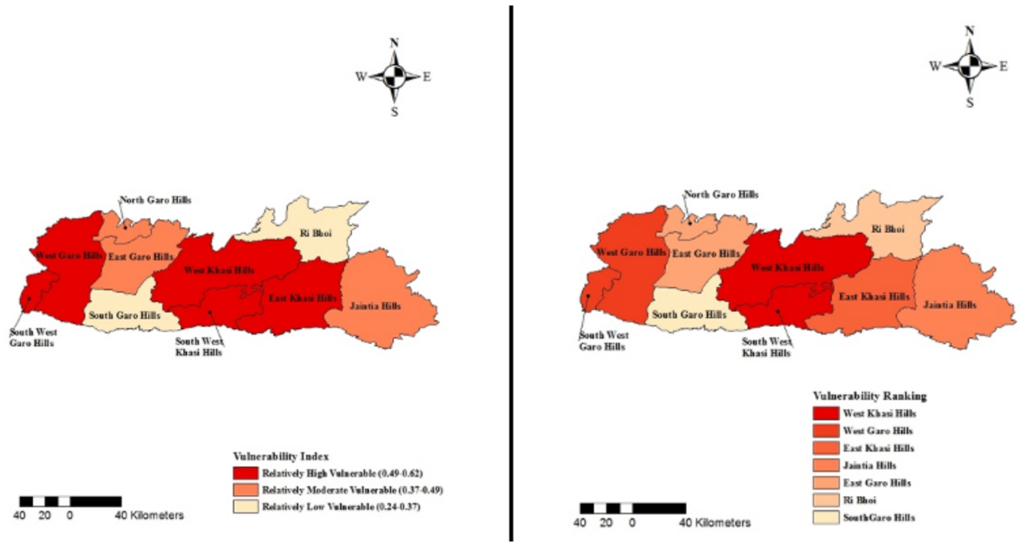
ISSN (Online) - 2349-8846

Figure 7: Vulnerability Category (Left) and Vulnerability Ranking (Right) of Manipur



High yield variability and high percentage of population under BPL are two main drivers for vulnerability.

Figure 8: Vulnerability Category (Left) and Vulnerability Ranking (Right) of Meghalaya



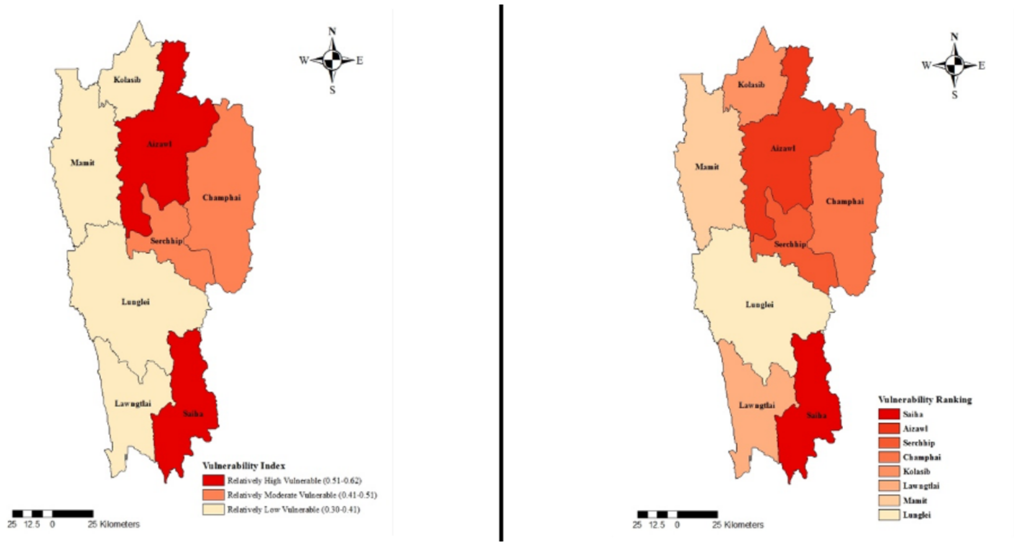
High yield variability, high percentage of households living under BPL, and lack of area under forests are the three major drivers of vulnerability.

Figure 9: Vulnerability Category (Left) and Vulnerability Ranking (Right) of

Economic&PoliticalWEEKLY

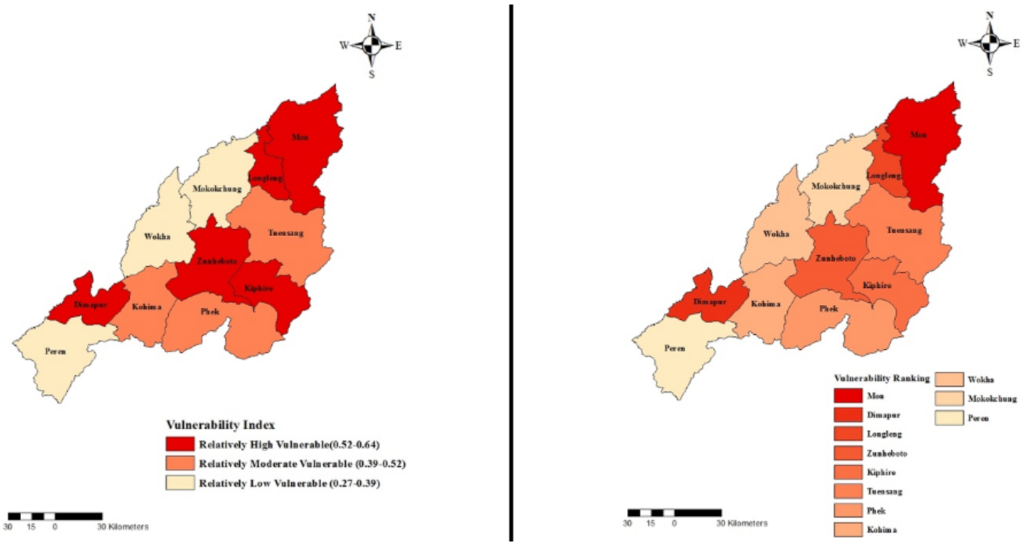
ISSN (Online) - 2349-8846

Mizoram



Lack of forest cover, steep slope and lack of person days under MGNREGA are the major drivers of vulnerability. Greater forest cover makes regions less vulnerable.

Figure 10: Vulnerability Category (Left) and Vulnerability Ranking (Right) of Nagaland

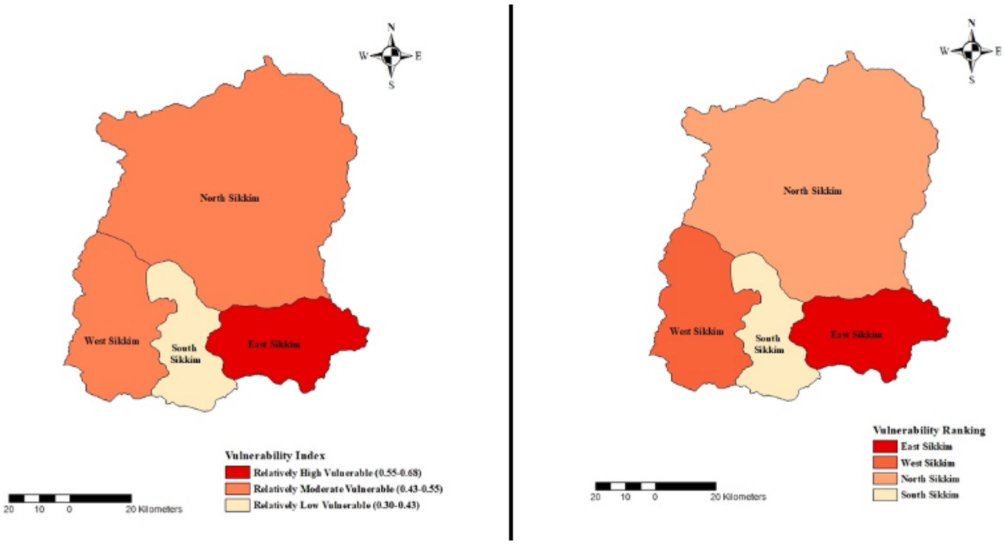


Loss of forest cover, steep slope and high yield variability are the major drivers of vulnerability.

Figure 11: Vulnerability Category (Left) and Vulnerability Ranking (Right) of Sikkim

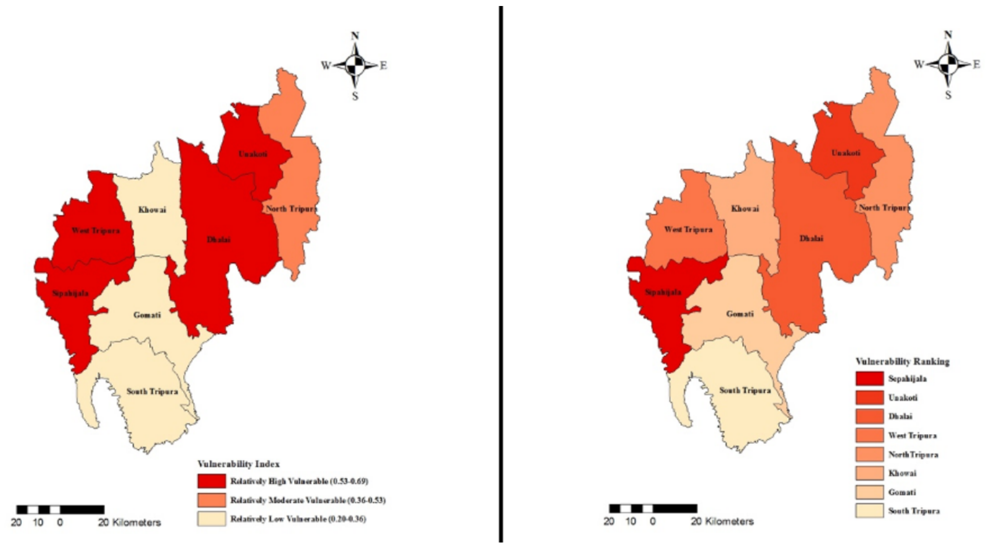
Economic&PoliticalWEEKLY

ISSN (Online) - 2349-8846



High population density and high slope are the main drivers of vulnerability. High yield variability and low income are significant drivers in some areas.

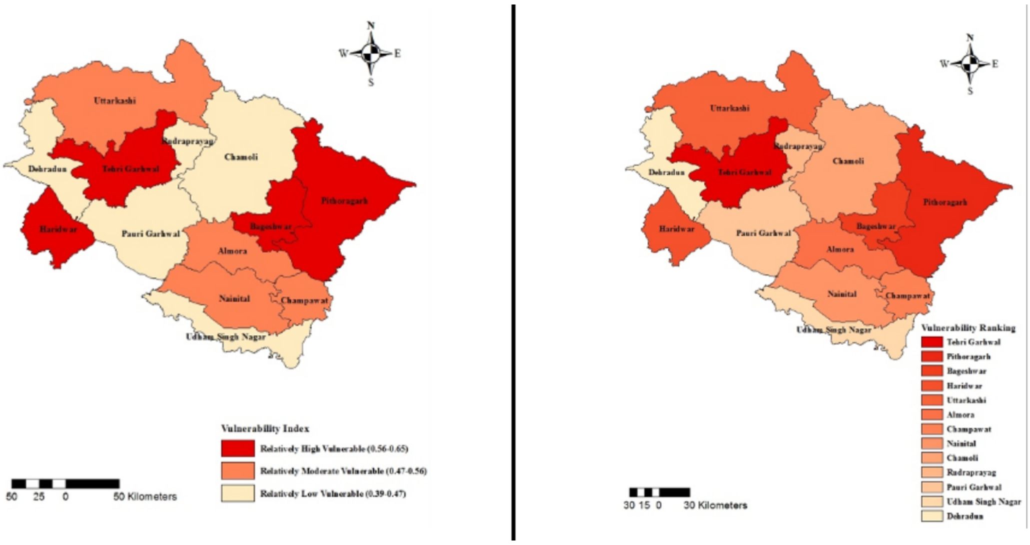
Figure 12: Vulnerability Category (Left) and Vulnerability Ranking (Right) of Tripura



High yield variability is basic major driver. Low forest cover and high IMR is also responsible. Low population density and higher forest cover reduces vulnerability in some regions.

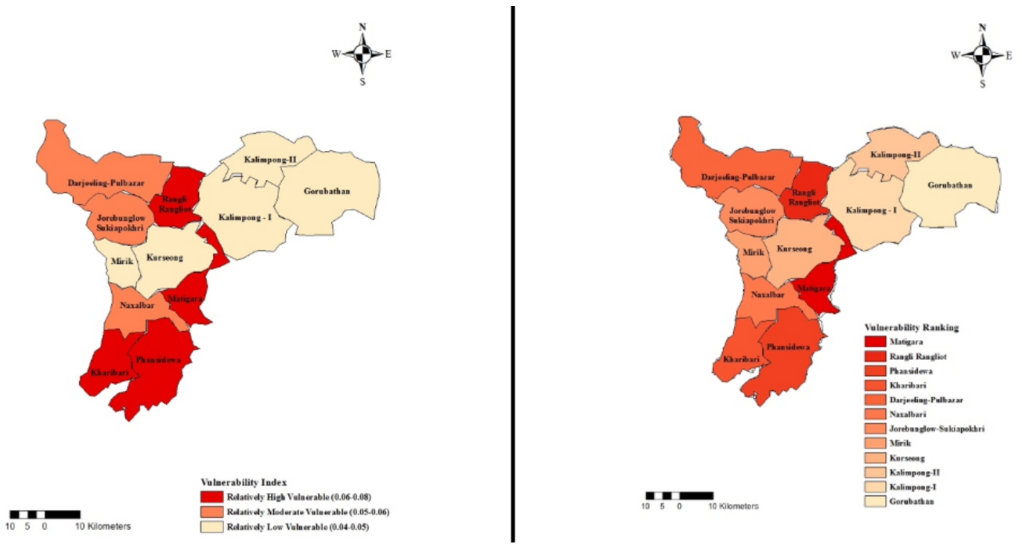
Figure 13: Vulnerability Category (Left) and Vulnerability Ranking (Right) of Uttarkhand

ISSN (Online) - 2349-8846



Steep slope, high population density, high yield variability, low female literacy rate, and poor healthcare are the main drivers of vulnerability. In some regions, low forest cover also drives vulnerability.

Figure 14: Vulnerability Category (Left) and Vulnerability Ranking (Right) of West Bengal



Two relevant districts, Darjeeling and Kalimpong come under vulnerability assessment as they fall in the IHR. Block-level vulnerability assessment found high population density, lack of participation in MGNREGA and high degree of slope are major drivers of vulnerability.

The Way Forward

The assessments carried out under this project should be seen as the beginning of a process of vulnerability assessment and not the end. Our vulnerability assessments are primarily

Economic&PoliticalWEEKLY

ISSN (Online) - 2349-8846

based on a tier-I approach, which used district-level secondary data. In the future, states are encouraged to carry out assessments following tier II and III approaches involving greater consultation with the primary stakeholders and use of primary data and spatial maps. It will also be important to conduct sectoral (agriculture, water resources, forest, etc) vulnerability assessments based on the unique characteristics of each of the states. There is a need for further and continued capacity-building support to the state climate change cells to upgrade and revise their state action plan for climate changes as per the state-of-the-art methodology and models. However, vulnerability assessments is inherently a data-intensive process. The project developed an understanding of the requirement and availability of secondary data to carry out such assessments. It shows the need for regular reporting of data for different sectors at various resolutions including district, block and panchayat level for more targeted micro-level assessments. Several states, as a result of this exercise, have identified the need for better data availability, storage and dissemination, and its accessibility. The next step to assess vulnerability is to incorporate it in adaptation planning and project development since the ultimate goal is to reduce vulnerability and promote resilience and adaptation to climate change. This will require the development and dissemination of toolkits and guidelines to enable states to undertake adaptation actions.

End Notes:

[1] Department of Science and Technology (DST) and the Swiss Development Corporation (SDC) supported the project titled "Capacity Building on Climate Change Vulnerability Assessment in the States of Indian Himalayan Region." The Indian Institute of Technology Guwahati (IIT Guwahati), Indian Institute of Technology Mandi (IIT Mandi) in collaboration with Indian Institute of Science (IISc Bengaluru) implemented the project.

[2] Depending on the data available for IHR state, we used either statistics for those below poverty line or per capita income (not both).

[3] Eighty-eight state representatives from all 12 IHR states attended the methodology workshop held at IIT Guwahati in September 2018. The aim of the workshop was to introduce the participants to the methodological steps involved in district-level vulnerability assessment.

References:

Füssel, H M (2007): "Vulnerability: A Generally Applicable Conceptual Framework For Climate Change Research," *Global Environmental Change*, Vol 17, No 2, pp 155–67.

Indian Himalayas Climate Adaptation Programme (IHCAP) (2018): "Climate Vulnerability and Risk Assessment: Framework, Methods and Guidelines," IHCAP, India, https://www.himalayageoportal.in/wp-content/uploads/Knowledge_Resources/....

Economic&PoliticalWEEKLY

ISSN (Online) - 2349-8846

IPCC (2018): "Global Warming Of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat Of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty," Geneva: World Meteorological Organization, https://www.ipcc.ch/sr15/chapter/spm/.

— (2014): "Summary for Policymakers. In: 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," Cambridge: Cambridge University Press, https://www.ipcc.ch/report/ar5/wg2/.

— (2007a): "Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change," Cambridge: Cambridge University Press, https://www.ipcc.ch/report/ar4/wg2/.

O'Brien, K L and R M Leichenko (2000): "Double Exposure: Assessing the Impacts of Climate Change within the Context of Economic Globalization," *Global Environmental Change,* Vol 10, No 3, pp 221–32.

Wester, Philippus, Arabinda Mishra, Aditi Mukherji and Arun Bhakta Shrestha (2019): The Hindu Kush Himalaya Assessment—Mountains, Climate Change, Sustainability and People, Springer Cham, https://doi.org/10.1007/978-3-319-92288-1.

Sharma, J, Indu K Murthy, T Esteves, Payal Negi, Sushma S, Shyamasree Dasgupta, Anamika Barua, G Bala and N H Ravindranath (2018): "Climate Vulnerability and Risk Assessment: Framework, Methods and Guidelines for the Indian Himalayan Region," National Mission for Sustaining the Himalayan Ecosystem and Swiss Agency for Development and Cooperation.

Image-Credit/Misc:

Image courtesy: Canva