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# Evaluating climatic vulnerability in India: moving from risk to resilience

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**Abstract.** Climate adaptation has been a top priority in the UN climate negotiations due to the increasing frequency of extreme weather occurrences. Assessments of Climate Vulnerability and Risk are crucial for designing adaptation strategies and identifying vulnerable locations and individuals. However, there aren't many development projects or efforts in India that focus on Climate Vulnerability and Risk Assessment (VRA), and investment plans don't include climate resilience. The scopes and methodologies of risk identification and vulnerability assessments that are currently in use in India are evaluated in this article. It then offers recommendations for growing adaptation activities at the federal level, along with methodology based on global best practices.

## 1 Introduction

Despite a 1.1°C increase, climate change causes intense heatwaves, droughts, floods, and sea level rise, threatening food security and living conditions, especially in poor countries. The 2021 Global Climatic Risk Index [1] ranks India eighth for severe weather occurrences due to its big population and geography. More than forty percent of districts have changed, with 75% being severe event hotspots [2]. Previously flood-prone regions now have droughts. Poverty and poor healthcare worsen climatic stress. National climate policies should incorporate climate adaptation, focusing on existing environmental dangers, infrastructure resilience, and resource sustainability. Scaling up vulnerability and risk assessments is crucial for targeted adaptation strategies amid increasing climate-related disaster damage. Risk and vulnerability assessments are crucial for identifying structural flaws, assessing adaptation potential, and prioritizing financing. Anil K. Gupta et.al, Abinash Mohanty and Shreya Wadhawan, Singh & et. al, C. A. Rama Rao et.al., CoDriVE & CRiSTAL has recently published reports on climate change risk and susceptibility, but their theoretical foundations and conclusions have not been thoroughly examined in India. The National Action Plan on

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Climate Change (NAPCC) was introduced in 2008 to promote state-level climate action plans.

Evaluations of climate risks and human adaptation to climate change are crucial for decision-makers. However, due to the complexity of institutional, social, technological, and environmental linkages, these evaluations have not been fully utilized. The study analyses climate vulnerability assessments from IPCC AR4, WGII, and AR5 reports, applying them to both the approaches and compares methodologies and equipment's, aims to assess climate vulnerability and risk frameworks, for national recommendations.The research gap highlighted in this paper is in India Climate resilience isn't included in investment plans, and there aren't many development initiatives or programs in India that concentrate on climate vulnerability and risk assessment (VRA) which are evaluated in the following tables.

## 2 The evolution of climate vulnerability assessments

Vulnerability is a complex concept used in various fields, including psychology, anthropology, engineering, and economics [3]. It is evaluated before and after exposure to hazards, and is influenced by bio-physical effects, future forecasts, and adaptive actions. Vulnerability is particularly relevant for climate change adaptation, as it arises from social, political, and economic mechanisms. Climate vulnerability assessments identify systemic weaknesses, assess adaptation capabilities, prioritize mitigation efforts, and allocate resources. Initially focused on physical vulnerability, they now include social, economic, and ecological sectors by data-driven techniques like mapping help pinpoint susceptible locations.

The climate VRA framework has been utilized in various climate vulnerability assessments across India, including national-level vulnerability assessments and agricultural industry assessments. The revised State Plan of Action on Climate Change also uses this approach to evaluate risks and vulnerabilities in priority sectors, creating adaptation plans.

### 2.1 Present methods for performing assessments

The vulnerability assessment of climate change has two methods: top-down and bottom-up. Top-down methods use simulation models to project future climate consequences, focusing on measurable biophysical impacts. Bottom-up methods, influenced by community development, humanitarian assistance, and catastrophe risk reduction strategies, focus on stakeholders and individuals impacted by climate change. These methods are better suited for local level evaluations, as top-down methods lack the broad geographical scale needed for localized legislation and climate adaptation measures.

### 2.2 Accessible tools and methodologies

A vulnerability and risk assessment in India typically uses an indicator-based technique, such as CRIDA's [4] risk and vulnerability assessment and the DST's framework. This method calculates susceptibility using indices like temperature and precipitation, and socioeconomic factors like poverty and education. Data is collected through surveys, questionnaires, and satellite imagery. The degree of vulnerability is assigned to each indicator, with scores ranging from low to high. Indicators are useful for visualizing vulnerability hotspots, but inconsistent units make comparison difficult across different geographical and temporal dimensions. Bottom-up instruments like CoDriVE [5] and CRiSTAL, [6] involving stakeholder engagement, are used to evaluate climate risks and vulnerabilities. These tools, along with the DST common framework, use a top-down indicator-based methodology. The choice of methodology and tool for VRA assessment is influenced by purpose, outcomes, spatial extension, time, budget, data, and expertise. Tables 1, 2, and 3 evaluate current frameworks and techniques in India.

**Table 1.** Elements Influencing Assessment and Tools in India.

| CRITERIA | | INDICATOR | | | | | |
|---|---|---|---|---|---|---|---|
| Policy assistance | | Focus on susceptible populations, regions, industries, etc. | Assessment of the vulnerability of a system | More details and targeted sectoral assessments | Prioritizing the distribution of resources | Finding adaptive techniques to reduce vulnerability | Finding adaption technique to reduce the risk |
| TDI-A | AR4 | CSA | | CSA | CPBU | CSA | |
| | AR5 | CSA | CSA | CSA | CPBU | CSA | CSA |
| TBUA | | CSA | CPBU | CSA | CSA | CSA | CSA |
| CRITERIA | | INDICATOR | | | | | |
| Strategizing | | Planning for adaptation in projects and programs for development | Evaluations scenarios affecting livelihood sectors. | Evaluation and monitoring | | | |
| TDI-A | AR4 | CSA | CSA | CSA | | | |
| | AR5 | CSA | CPBU | CSA | | | |
| TBUA | | CPBU | CPBU | CPBU | | | |
| CRITERIA | | INDICATOR | | | | | |
| FINANCING INVESTMENT | | Draw funding from specific commercial, bilateral, multilateral, and other climate change-related groups. | | | | | |
| TDI-A | AR4 | CSA | | | | | |
| | AR5 | CSA | | | | | |
| TBUA | | CPBU | | | | | |
| CRITERIA | | | | | | | |
| Acquiring New Information | | Several industry risks and vulnerabilities study | Examining the conventional and experiential knowledge of Indigenous groups in addressing climate change | | | | |
| TDI-A | AR4 | CSA | CPBU | | | | |
| | AR5 | CSA | CPBU | | | | |
| TBUA | | CSA | CSA | | | | |

*Source: Author's own*

Top-Down Indicator- Approach (TDI-A); Vulnerability Framework for IPCC AR4 (AR4); IPCC AR5: Risk and Vulnerability Framework (AR5); Tools for Bottom-Up Automation (TBUA); Can Potentially Be Used (CPBU); Case Studies are Available (CSA)

**Table 2.** Outputs Produced by the Tools in India.

| CRITERIA | | INDICATOR | | |
|---|---|---|---|---|
| Qualitative | | Cartography | Effect Chains | Profiles of Narrative |
| TDI-A | AR4 | CSA | | CPBU |
| | AR5 | CSA | | CPBU |
| TBUA | | CPBU | | CSA |
| CRITERIA | | INDICATOR | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Quantitative | | Scores and Index | | | | |
| TDI-A | AR4 | CSA | | | | |
| | AR5 | CSA | | | | |
| TBUA | | CSA | | | | |
| CRITERIA | | **INDICATOR** | | | | |
| Scale of application | | One Sector | Several Sectors | | | |
| TDI-A | AR4 | CSA | CSA | | | |
| | AR5 | CSA | CSA | | | |
| TBUA | | | CSA | | | |
| CRITERIA | | INDICATOR | | | | |
| Spatial Scale | | Household, watershed, community levels | At the block level | At the district level | At the State level | National level |
| TDI-A | AR4 | CSA | CSA | CSA | CSA | CSA |
| | AR5 | | | CSA | CSA | CSA |
| TBUA | | | CSA | CPBU | | |

**Table 3.** Criteria for Each Tool in the Indian Context.

| CRITERIA | | INDICATOR | | | | | |
|---|---|---|---|---|---|---|---|
| Resources and skills required | | Extra paid software licenses | Geographic information system applications | Skills in modelling | Skilled PRA methods debates, surveys | User support | Industry expertise |
| TDI-A | AR4 | | CPBU | CPBU | CPBU | CPBU | CPBU |
| | AR5 | | CPBU | CPBU | CPBU | CPBU | CPBU |
| TBUA | | | | | CPBU | CPBU | CPBU |
| CRITERIA | | INDICATOR | | | | | |
| Stakeholder engagement | | Surveys, participative workshops, and consultation with stakeholders | | | | | |
| TDI-A | AR4 | CPBU | | | | | |
| | AR5 | CPBU | | | | | |
| TBUA | | | | | | | |
| CRITERIA | | INDICATOR | | | | | |
| Data/input requirements/ demand | | The present level of variability | Forecasts for future projections | Socio-Economic data | Detail Historical catastrophe events | Biophysical info. | Initial gathering of data |
| TDI-A | AR4 | | | CPBU | CPBU | CPBU | CPBU |
| | AR5 | CPBU | CPBU | CPBU | CPBU | | CPBU |
| TBUA | | | | CPBU | CPBU | CPBU | CPBU |
| CRITERIA | | INDICATOR | | | | | |
| Data/input requirements/ demand | | the capacity to get outcomes devoid of any data supplied by the user | The capability for users to modify the tool, add their information, or personalize inputs | | | | |
| TDI-A | AR4 | CPBU | CPBU | | | | |
| | AR5 | CPBU | CPBU | | | | |
| TBUA | | | CPBU | | | | |

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| CRITERIA | | INDICATOR | | | |
|---|---|---|---|---|---|
| Cost/availability | | Cost | Paid/licensed | | |
| TDI-A | AR4 | CPBU | | | |
| | AR5 | CPBU | | | |
| TBUA | | | CPBU | | |
| CRITERIA | | INDICATOR | | | |
| Other requirements | | Time | Technical, financial capacity expansion | Future specialized frameworks for the adoption | Institutional frameworks used to include VR evaluations |
| TDI-A | AR4 | CPBU | CPBU | CPBU | CPBU |
| | AR5 | CPBU | CPBU | CPBU | CPBU |
| TBUA | | | CPBU | CPBU | CPBU |

*Source: Author's own*

## 3 Difficulties in adopting VRA

According to the tools and reports, vulnerability and risk ideas and technologies have improved greatly but not yet been implemented or scaled up, therefore these frameworks are not well-harmonized while considering development projects in India. Below are the primary scalability challenges for these assessments. The granular level lacks high-quality data, which is needed for climate vulnerability assessments. Certain demographics and environment conditions in newly constituted districts or lower government levels make this difficult. Future climate scenarios and projections require better quality and resolution. Secondary data evaluations require less time than primary data assessments, but decision-makers' adoption may need specialized expertise and training, making review challenging and time-consuming. The DST's Climate Vulnerability Investigation for Adaptation Strategy in India is a recent national-level evaluation still lacks a micro-level understanding of climate risk and vulnerability lacks cooperation across departments and sectors. Lack of technical understanding impacts adaptation decisions, as state-line departments often lack experts and financial resources which need special training and specific guidelines are required at the national level.Streamlining the Evaluation Procedure needs licensed automated programs require applicationwhich should allow users to select economic and climatic scenarios, select indicators, execute a model, and evaluate outcomes and the allow users to modify algorithms, use indicators, and change data, facilitating the selection of appropriate methodologies for specific industries. CRiSTAL and CoDriVE are automation tools designed to aid in climate vulnerability assessment helping to identify communities and demographic groups more sensitive to climate change, benefiting NGOs, local authorities, and community planning and execution. Environmental impact assessments now incorporate climate change adaptation and susceptibility, influencing land use, urban planning, marine spatial planning, and insurance policies, promoting investments in mitigating climate risk. Making central and state budgets climate-proof will enhance policy effectiveness, aid in budgeting for climate adaptation, and encourage fresh budget requests for each program. Regular training and capacity-building workshops can increase understanding and improve department planning. Additionally, local actors, such as counsellors and lawmakers, should be made aware of climate-change trends and risks. Intermediaries like higher education institutions, think tanks, and NGOs can help manage climate risks and vulnerabilities. The business sector must strengthen its capacity to prioritize and operational assessments for effective adaptation funding. Kenya's Initiatives for Capacity Building in the agricultural sector provided valuable knowledge on climate change adaptation and susceptibility, benefiting decision-making. Strengthening the capacity of these intermediaries and raising stakeholder awareness can help improve investment decision-making and raise private funds for adaptation finance.

Communication between creators, practitioners, and end consumers should be fostered through diverse channels to improve outreach, distribution, and communication. Workshops on capacity development and dissemination can help discuss best indicators, data points, assessment framework, and output. Customized outcomes can increase relevance to decisions.

## 4 Conclusion

Climate adaptation planning necessitates understanding climate risk and vulnerability assessments to identify vulnerable systems, people, and places in development projects in India. These assessments aid in developing national strategies, ensuring disclosure under Article 9 of the Paris Accord, and may include tailored adaptation strategies. India's climate VRA initiatives are limited, and climate resilience struggles to find a place in investment proposals. This article examines barriers to VRA adoption, highlighting the labour-intensive nature of climate risk assessments, the need for reliable information, and the lack of technical proficiency among decision-makers. Training and capacity development are needed to raise awareness about climate trends and forecasts among local actors. These assessments can be used in development planning, project reports, investment proposals, and climate budgeting. They can identify vulnerable areas, aid in mitigation and adaptation plans, improve transparency, and increase public participation in India.

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