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Assessing social vulnerability and adaptive responses to climate change in agricultural communities: A global synthesis with local perspectives from India

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Abstract

Climate change has emerged as a critical stressor amplifying socio-economic inequalities, particularly in vulnerable rural and agricultural communities. This review explores the evolution, application, and future direction of the Social Vulnerability Index (SVI) as a framework for assessing community-level resilience to climate-induced risks. Drawing on interdisciplinary studies from regions including Zambia, Ethiopia, Vietnam, and India, the paper synthesizes key vulnerability components—exposure, sensitivity, and adaptive capacity—while highlighting the influence of socio-demographic, institutional, and perceptual factors. A focal case study of Kiphire district, Nagaland, underscores the importance of region-specific SVI adaptation, informed by primary data and local context. Through the development of the SV-CRA (Social Vulnerability-Climate Risk-Adaptation) model and an integrative causal diagram, the study proposes a structured lens for analyzing vulnerability pathways and informing policy intervention. Findings advocate for a shift toward granular, participatory, and gender-responsive SVI frameworks that can better guide targeted adaptation strategies across diverse socio-ecological systems. Conflict of Interest declaration: The authors declare that they have no affiliations with or involvement in any organization or entity with any financial interest in the subject matter or materials discussed in this manuscript.

Keywords: Social Vulnerability Index (SVI), climate risk, adaptive capacity, rural communities, model participatory framework policy intervention, gender-responsive adaptation

1. Introduction

Climate change presents multifaceted challenges to human societies, with disproportionate impacts on communities that are socially, economically, and institutionally vulnerable. The escalating frequency and intensity of climate-related hazards—such as floods, droughts, heatwaves, and crop failures highlight the urgent need to assess and address these vulnerabilities. Socio-economic and demographic disparities often dictate how different populations experience and recover from such events, thereby amplifying existing inequalities. This underscores the critical role of understanding social vulnerability as a lens through which to evaluate climate resilience and inform equitable interventions.

Among the various tools developed to quantify and address these disparities, the Social Vulnerability Index (SVI) has emerged as a pivotal instrument. Originally introduced by the U.S. Centers for Disease Control and Prevention (CDC), the SVI aggregates diverse indicators—including income levels, education, health, and access to resources—to assess a community's ability to prepare for, respond to, and recover from environmental stresses. Over time, its applications have expanded beyond public health to disaster

risk management, climate resilience planning, and environmental justice. However, critiques regarding the index's reliability and contextual adaptability suggest the importance of tailoring it to specific regional dynamics and data realities.

This review aims to bridge global theoretical constructs with grounded empirical insights by examining the application of the SVI across diverse geographies. Drawing upon the methodology proposed by Meena *et al.* 2022, this paper synthesizes findings from international case studies—ranging from Zambia to Vietnam and Portugal—and juxtaposes them with the socio-economic conditions. By integrating global literature with local realities, the review seeks to (i) analyze the multidimensional nature of social vulnerability, (ii) evaluate the strengths and limitations of SVI across contexts, and (iii) propose a localized yet adaptable framework for assessing vulnerability and guiding targeted policy responses.

2. Conceptual Foundations

2.1 Defining Core Concepts in Vulnerability Analysis

Understanding community-level responses to climate change requires clarity on four foundational concepts: social

vulnerability, exposure, sensitivity, and adaptive capacity. These interconnected dimensions offer a structured lens for assessing the differential impacts of environmental stressors. Social Vulnerability refers to the susceptibility of individuals or communities to harm due to socio-economic, demographic, and institutional factors. It encompasses barriers to preparedness, response, and recovery in the face of climate-induced or other systemic shocks. Vulnerability is not uniform; it is shaped by income levels, education, gender, and access to support systems (Otto *et al.*, 2017; Tran *et al.*, 2023) ^[34, 51]. Exposure captures the extent to which a community is subjected to climate hazards, such as droughts, floods, or extreme temperatures. In the context of agricultural systems, exposure is often associated with seasonal variability and geographic location (Malakar & Mishra, 2016) ^[26]. Sensitivity is the degree to which a system or population is affected by climate stressors. It reflects aspects like dependence on rain-fed farming, prevalence of crop or livestock loss, and fragile ecosystems, as seen in various regional studies (Cohn *et al.*, 2016; Hatfield *et al.*, 2018) ^[3]. Adaptive Capacity describes the ability of communities to adjust, reorganize, or recover in response to climate impacts. This includes access to climate-smart practices, credit institutions, agricultural extension services, and institutional support structures (Zakari *et al.*, 2022; Jiri *et al.*, 2017) ^[60, 4]. These definitions collectively underpin index-based assessments like the Social Vulnerability Index (SVI), which seeks to quantify vulnerability and highlight areas

requiring targeted intervention.

2.2 Evolution and Critiques of the Social Vulnerability Index (SVI)

Originally developed by the U.S. Centers for Disease Control and Prevention (CDC), the SVI was designed to inform public health preparedness and resource distribution during crises. Its architecture aggregates multiple indicators—including income, education, housing status, and minority status—into a composite measure of vulnerability. Over time, the SVI has been adapted to various domains such as disaster risk management (Flanagan *et al.*, 2011), healthcare equity (Tran *et al.*, 2023) ^[1], and climate adaptation planning.

Key Milestones

Public Health Roots: Used to allocate emergency supplies during Hurricane Katrina.

Expansion: Tailored for urban planning, rural climate vulnerability assessments, and development prioritization.

Localized Adaptations: Studies from Vietnam, India, and Zambia have modified indicator sets based on ground realities and data availability (Nguyen *et al.*, 2017; Dumenu & Takam Tiamgne, 2020) ^[31, 8].

Critiques and Limitations

Table 1: Despite its widespread application, the SVI has faced several methodological critiques:

Challenge	Explanation
Indicator Selection Bias	Arbitrary or inconsistent selection of indicators across regions.
Contextual Mismatch	Overgeneralization may obscure local nuances in social vulnerability.
Data Limitations	Heavy reliance on secondary data, which may be outdated or coarse in scale.
Theoretical Ambiguity	Discrepancies in linking indicators to the conceptual dimensions they represent.
Interpretation Conflicts	Same dataset may produce different outcomes depending on normalization method.

As highlighted by Spielman *et al.* (2020) ^[40], such limitations can lead to misinformed policy decisions if local conditions are not adequately captured or if statistical methods are poorly aligned with real-world systems. Nevertheless, the SVI remains a valuable heuristic device. When thoughtfully adapted using both quantitative and qualitative methods—and complemented by local stakeholder engagement—it can serve as a powerful tool for targeting interventions and guiding climate resilience strategies.

3. Methodological Diversity in SVI Applications

The measurement of social vulnerability through the Social Vulnerability Index (SVI) has evolved across geographies and disciplines, with methodological variations shaped by data availability, local context, and assessment objectives. The literature reflects a rich tapestry of quantitative, qualitative, and mixedmethods approaches to constructing and applying the SVI.

3.1 Quantitative vs. Qualitative Approaches

SVI methodologies range from statistically driven models to participatory community-based frameworks:

Quantitative Approaches: These dominate in large-scale applications, relying on statistical techniques to aggregate indicators. Commonly used methods include:

- Principal Component Analysis (PCA) and Factor Analysis for dimensional reduction
- Index normalization and weighting, as seen in Malakar & Mishra (2016) ^[26]
- Composite scoring frameworks derived from census or geospatial data

Qualitative Approaches: Employed where quantitative data is sparse or where local perception is vital. These methods involve:

- Focus group discussions
- Key informant interviews
- Participatory rural appraisals (PRAs)

Mixed-Methods: As demonstrated by Nguyen *et al.* (2017) ^[31] and Meena *et al.* 2022 ^[7], many studies are now combining both paradigms to balance empirical rigor with contextual sensitivity.

3.2 Data Sources: Primary vs. Secondary

Table 2: SVI construction critically hinges on the type and quality of data

Type	Data Examples	Strengths	Limitations
Primary Data	Household surveys, perception assessments, local consultations	High relevance; tailored indicators	Time-intensive; less scalable; possible response biases
Secondary Data	Census statistics, satellite imagery, national datasets	Broad coverage; comparability; accessibility	May lack granularity; outdated or aggregated at coarse scales

Nguyen *et al.* (2017) ^[31] highlighted the limitations of relying solely on secondary data, particularly in areas lacking updated demographic records. Their study in Vietnam emphasized the value of localized household surveys to develop finely tuned indices.

Meena *et al.* followed a similar path in India's, adapting vulnerability assessments using regionspecific variables and direct household-level data to capture on-ground realities more accurately.

3.3 Regional Customization of Indicators

Standard SVI frameworks often require local adaptation to reflect distinct socioeconomic, cultural, and environmental dynamics:

Nguyen *et al.* ^[31] designed a tailored SVI framework in Vietnam's Mekong Delta by integrating local livelihood patterns, land tenure status, and access to climate information, rather than depending on generalized census metrics.

Meena *et al.* adapted the SVI for by selecting indicators rooted in subsistence agriculture, ethnic vulnerabilities, and infrastructure limitations, demonstrating that indicator choice must resonate with livelihood contexts and adaptive constraints of rural, marginalized communities.

This regional customization ensures the SVI is not just a diagnostic tool but a responsive mechanism for planning localized climate adaptation strategies.

4. Sectoral and Regional Applications of the SVI

The Social Vulnerability Index (SVI) has proven adaptable across diverse geographies and thematic domains, capturing the multifaceted ways communities experience and respond to climate-related stress. This section synthesizes its use in three major application areas—public health and urban risk, agriculture, and demographic sensitivity.

4.1 Public Health and Urban Climate Risks

SVI was originally developed to address public health inequities in crisis situations. Its early use during Hurricane Katrina demonstrated that socially vulnerable communities—particularly low-income, elderly, and racially marginalized populations—suffered disproportionately and faced prolonged recovery timelines (Flanagan *et al.*, 2011). Urban applications of SVI have also gained prominence in the context of heatwaves and climate-linked health risks:

Cutler *et al.* (2018) ^[6] showed how political ideology and socioeconomic status shaped individuals' perception of heat-related risks in U.S. cities.

In India, urban vulnerability studies (e.g., Malakar & Mishra, 2016) ^[26] revealed that Tier-II cities face amplified warming due to both urbanization and infrastructure gaps, making them especially susceptible to heat-induced mortality and service failure.

4.2 Agricultural Vulnerability and Climate Sensitivity

Agricultural communities, particularly in low- and middle-income countries, remain highly susceptible to climate-induced stress due to their dependence on weather-sensitive livelihoods. The SVI has been applied in these contexts to assess both exposure and capacity for adaptation:

In Zambia, Dumenu & Takam Tiamgne (2020) ^[8] employed the SVI to evaluate smallholder vulnerability. Key stressors included low income diversification, lack of access to information, and limited financial capital. Adaptive strategies such as crop diversification and drought-resilient species were recommended.

In Ethiopia, rural agricultural communities exhibited high sensitivity due to biophysical and economic constraints, particularly where access to credit and climate-resilient inputs was limited (Gebrehiwot & Van Der Veen, 2013) ^[12].

In Portugal, fisheries were assessed using a similar vulnerability model, factoring in exposure, sensitivity, and adaptive capacity—all modulated by localized socioeconomic and ecological variables (Pinto *et al.*, 2023) ^[37].

South Asia, including India and Bangladesh, shows broad vulnerability across agricultural sectors, often intensified by changing monsoon dynamics, input costs, and land fragmentation.

4.3 Demographic Sensitivity and Social Inequities

SVI frameworks also emphasize the social dimensions of vulnerability, where demographic attributes intersect with resource access and governance:

Gender: Women often face heightened vulnerability due to limited land ownership, fewer financial resources, and restricted decision-making power—especially in agricultural households (Nelson *et al.*, 2002; Awiti, 2022) ^[30, 2].

Rurality and Remoteness: Populations in isolated or upland areas typically have weaker infrastructure, limited extension services, and fewer SHG or credit linkages, limiting their adaptive capacity.

Marginalized Groups: Ethnic minorities and lower caste communities frequently face systemic exclusion, reinforcing cycles of exposure and sensitivity without proportional resilience-building support.

5. Adaptive Capacity: The Linchpin of Resilience

Among the three pillars of vulnerability—exposure, sensitivity, and adaptive capacity—the capacity to adapt often exerts the most leverage in determining a community's long-term resilience to climate change. Adaptive capacity reflects not only the availability of resources but also the agency and institutional mechanisms that empower individuals and communities to act on climate

knowledge, reduce risks, and embrace change.

5.1 Extension Services, SHGs, Credit, and Climate-Smart Inputs

Access to extension services and institutional support mechanisms plays a transformative role in enabling rural households to adopt climate-resilient practices. Evidence from across Africa and Asia underscores the role of the following factors:

Agricultural Extension: Jiri *et al.* (2017) ^[4] found that in semi-arid Zimbabwe, households with greater exposure to agricultural extension services exhibited significantly better adaptive practices, including adoption of drought-tolerant crops and early warning systems.

Credit Access: In Ghana, Batung *et al.* (2022) ^[3] demonstrated that both formal and informal credit systems enhanced smallholder farmers’ perceived climate resilience. Similarly, Zakari *et al.* (2022) ^[60] showed that credit access in Niger improved food security and allowed investment in adaptive inputs.

Self-Help Groups (SHGs): Though SHG participation remains modest in many regions, it provides a pathway to collective action, financial pooling, and peer-to-peer knowledge transfer, particularly for marginalized groups.

Climate-Smart Agriculture (CSA) Inputs: Use of resilient crop varieties and farm-level water conservation practices has shown measurable improvements in productivity and resilience, yet their adoption is contingent on market access and institutional support (Safdar *et al.*, 2024) ^[29].

Together, these factors create a support ecosystem that enables rural households to move beyond reactive coping and toward anticipatory adaptation.

5.2 Gender and Institutional Access

Gender remains a structural determinant of adaptive capacity, particularly in patriarchal rural economies:

Women, especially those heading households or belonging to marginalized groups, often lack land ownership, market access, and institutional representation.

Studies from Ethiopia and Bangladesh (Rahman, 2013; Goudet *et al.*, 2024) ^[31] emphasize that women’s climate resilience is undermined by socio-cultural norms that limit their decision-making power and access to adaptation services.

Addressing adaptive capacity therefore necessitates gender-sensitive interventions—from targeted training and inclusive SHGs to reforms that promote women’s access to extension,

finance, and leadership in resource management. Without institutional scaffolding that acknowledges and confronts gender-based barriers, efforts to enhance resilience risk reinforcing existing inequalities.

5.3 The Role of Perceptions in Shaping Adaptation

Beyond infrastructure and inputs, farmer perceptions and beliefs critically shape whether and how adaptation occurs. Behavioral and psychological readiness is often the threshold between knowledge and action:

Jellason *et al.* (2019) ^[17], applying the Theory of Planned Behavior in Nigeria, found that farmers’ belief in climate change and its relevance strongly predicted adaptation intentions. Conversely, perceived lack of control—stemming from poverty or uncertainty—dampened proactive behavior.

Zakari *et al.* (2022) ^[60] observed that farmers in Niger who perceived higher risk from climate change were more likely to pursue income-diversifying adaptation strategies, especially where supported by institutional finance.

In rural Ghana, Yahaya *et al.* (2023) ^[57] emphasized that awareness of climate risks and access to reliable climate information were significantly associated with the use of adaptive measures like irrigation and CSA adoption.

These studies reinforce that subjective perceptions can enable or constrain adaptation, even in the presence of objective resources—highlighting the importance of climate communication, localized information services, and participatory planning.

This section reinforces the idea that adaptive capacity is not merely a function of physical assets or exposure levels—but a composite of institutional access, socio-cultural dynamics, and psychological readiness. Enhancing resilience, therefore, demands a multilayered strategy that integrates services, social equity, and farmer agency.

6. Proposed Framework and Visual Synthesis

To consolidate the interdisciplinary insights across public health, agriculture, and demographic studies, this review introduces a novel framework: the Integrated Social Vulnerability-Climate Risk-Adaptation (SV-CRA) Model. This model captures the dynamic interplay between climate hazards, social vulnerability determinants, and adaptive capacity. It provides a structured lens for assessing climate risk and guiding resilience-oriented policy interventions at regional and local scales.

6.1 The SV-CRA Model: Structural Overview

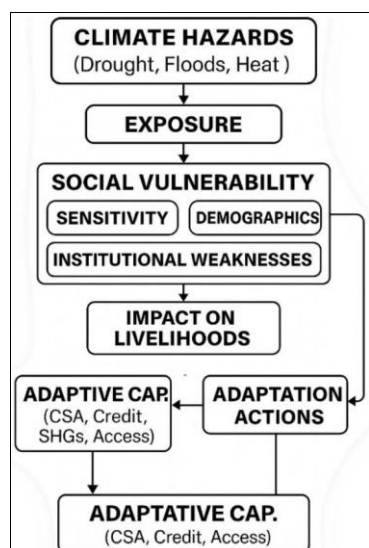
Table 3: The SV-CRA model is built upon three core components:

Core Component	Subdimensions	Examples from Reviewed Literature
Climate Risk	Exposure to hazards	Drought, floods, heatwaves (Malakar & Mishra, 2016) ^[26]
Social Vulnerability	Sensitivity + Socio-demographics + Institutional fragility	Gender disparity, low income, rural remoteness (Otto <i>et al.</i> , 2017) ^[34]
Adaptive Capacity	Access to extension services, SHGs, credit, CSA technologies, perceptions	SHG coverage, credit access in Niger (Zakari <i>et al.</i> , 2022) ^[60]

This framework emphasizes that vulnerability is not a passive state but a composite outcome—shaped by external threats and internal capacities. It aligns with the principles of the CDC-SVI but expands on them by integrating behavioral insights and localized inputs.

6.2 Visual Synthesis: Causal Pathway Diagram

The following diagram illustrates the progression from climate exposure to adaptation outcomes through vulnerability processes.



Interpretation & Utility

- The left-to-right flow denotes the causative progression from environmental stress to socioeconomic impact.
- Bidirectional arrows (e. g., from Adaptation Actions to Adaptive Capacity) imply feedback loops —adaptive actions today reshape future capacity.
- The model will help to visualize how vulnerability is compounded in areas like Kiphire, where climatic exposure intersects with institutional gaps and socio-cultural marginalization.
- It supports localized planning by clarifying where interventions can be most impactful: improving adaptive capacity has the greatest leverage to disrupt this cycle.

This framework not only synthesizes cross-sectoral insights from the literature but also provides a scalable model for real-world application—particularly in regions like the Eastern Himalayas where secondary data alone cannot capture the full landscape of vulnerability.

7. Discussion

7.1 Thematic Synthesis across Sectors and Geographies

The global application of the Social Vulnerability Index (SVI) reveals both its conceptual versatility and its diagnostic strength. Initially developed for public health risk assessment (Flanagan *et al.*, 2011) ^[11], the SVI now spans sectors from urban climate response to agricultural planning and ecological resilience. In urban contexts, infrastructural deficits and heat risk intensification—particularly in Tier-II Indian cities—have made the SVI a critical tool for spatial vulnerability analysis (Malakar & Mishra, 2016; Sethi & Vinoj, 2024) ^[26, 41]. Similarly, geomorphic and climatic changes in western North America and high-relief regions have highlighted SVI's utility in environmental planning. In agriculture, cross-regional applications underscore that vulnerability is not uniformly distributed. Smallholder farmers in Zambia and Ethiopia lack adaptive inputs and face structural disadvantages (Dumenu & Tiamgne, 2020; Gebrehiwot & Van Der Veen, 2013) ^[8, 12]. In South Asia, maize and rice systems exhibit sensitivity to temperature shifts and monsoonal variability, requiring both genetic innovation and adaptive land-use practices (Byjesh *et al.*,

2010; Parida & Bakimchandra, 2015). The Indian Himalayan and Eastern Ghats ecosystems are particularly fragile, experiencing forest degradation, riverine temperature rises, and biodiversity loss due to climate pressures (Tewari *et al.*, 2017; Johnson *et al.*, 2024; Rajesh & Rehana, 2022) ^[19, 50].

The SV-CRA model presented in this review reflects the convergence of these stresses into a causal loop where exposure, vulnerability, and institutional response shape livelihood outcomes. Findings reinforce this dynamic, with region-specific constraints like topographic isolation, credit inaccessibility, and limited SHG coverage amplifying vulnerability (Zakari *et al.*, 2022) ^[60].

7.2 Socio-Demographic and Behavioral Amplifiers

Demographic factors—particularly gender, remoteness, and education—consistently emerge as amplifiers of vulnerability. Studies from Nepal, Nigeria, and the Sahel demonstrate that female-headed households and less-educated farmers have lower access to adaptation resources and participate less in institutional platforms (Poudel *et al.*, 2020; Awiti, 2022; Yahaya *et al.*, 2023) ^[2, 35]. This underscores the call for gender-responsive frameworks that go beyond disaggregated data to institutional empowerment (Giudice *et al.*, 2021; Nelson *et al.*, 2002) ^[30].

Equally important are perceptions and adaptive attitudes. In Ghana, Nigeria, and Pakistan, farmers who perceive climate threats as imminent are more likely to adopt sustainable practices, but barriers such as high input costs, uncertainty, and spiritual beliefs often restrict action (Jellason *et al.*, 2019; Ndamani & Watanabe, 2015; Shah *et al.*, 2024) ^[17, 29]. Behavioral intention, as framed by the Theory of Planned Behavior, is thus integral to the SV-CRA model as both a constraint and an opportunity.

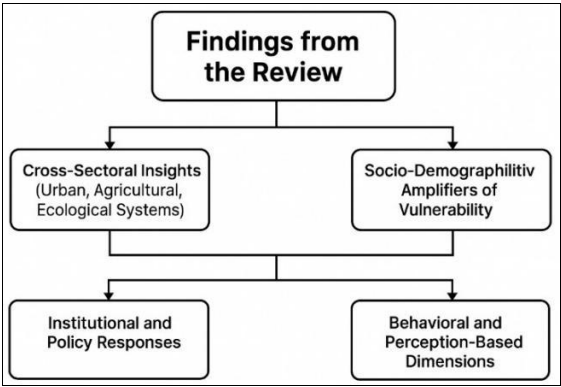
In contrast, passive adaptation—such as altering planting dates without structural investment—is common in eastern Uttar Pradesh and other parts of India (Tripathi & Mishra, 2016) ^[52], highlighting the need for targeted awareness programs and localized extension services.

7.3 Systems, Institutions, and Entrepreneurial Dynamics

Resilience is also modulated by institutional design, entrepreneurship, and systemic support structures. Clean-tech innovation, SHGs, and climate-smart agriculture inputs improve adaptive capacity when embedded within a supportive policy framework (Safdar *et al.*, 2024; Niemann *et al.*, 2019) ^[29]. Startups in developing regions, however, often struggle under macroeconomic and governance challenges such as inflation, corruption, and regulatory gaps (Khan *et al.*, 2023) ^[20].

Green entrepreneurship, in particular, has shown dual benefits—promoting sustainability while offering financial returns (Prokopenko *et al.*, 2024; Yasir *et al.*, 2023) ^[58]. Policymaking must recognize these dualities and create enabling environments for inclusive entrepreneurship, especially in climate-vulnerable areas.

The review also surfaces important policy gaps, such as the need to integrate soil health (Qiao *et al.*, 2022) ^[40], river ecosystem resilience (Van Vliet *et al.*, 2013) ^[21], and biodiversity protection into vulnerability planning. The River Ganga and Western Himalayan rivers serve as case studies of ecological degradation that mirror social neglect.



7.4 Towards Participatory, Scalable SVI Frameworks

The review findings emphasize that while the SVI offers portability across settings—from Wushen Banner in China (Zhang *et al.*, 2020) ^[61] to the Chinyanja Triangle in Africa (Makate *et al.*, 2017) ^[25]—contextual refinement is essential. One-size-fits-all indicator sets risk overlooking dynamic, local vulnerabilities.

To evolve from a descriptive tool to a transformative model for resilience planning, the SVI must:

- Integrate real-time and primary data with remote sensing systems (Spielman *et al.*, 2020) ^[40]
- Embed farmer and community perceptions in indicator design
- Prioritize gender equity and agency as core resilience

- metrics (Goudet *et al.*, 2024) ^[31]
- Localize applications beyond districts to agro-ecological units
- Serve as both diagnostic and decision-support instruments for planning and policy

As climate risks escalate across India's diverse landscapes—from southern plateau maize belts to northeast hill districts—building granular, scalable, and participatory vulnerability indices will be pivotal for just and adaptive governance.

7.5 Strengths and Gaps in the Current Literature
Strengths

1. **Conceptual Robustness:** The SVI incorporates multidimensional constructs—exposure, sensitivity, and adaptive capacity—that allow for interdisciplinary integration.
2. **Global Portability:** The index has been successfully adapted in contexts as varied as Vietnam, Zambia, and Nagaland, proving its trans-contextual value.
3. **Policy Utility:** SVI outputs support disaster response, climate adaptation planning, and health vulnerability mapping—linking data with decision-making.

Gaps and Challenges

Table 4: Case illustrates both the potential and limitations

Category	Description
Data Limitations	Over-reliance on secondary data; lack of temporal depth or local granularity
Indicator Inconsistency	No universally accepted core indicators; tailoring often ad hoc rather than theory-driven
Behavioral Underrepresentation	Farmer perceptions and social norms are underutilized in existing models
Gender Blind Spots	Few assessments embed gender as a central analytical axis
Lack of Validation	Limited cross-verification of SVI outcomes with actual resilience or recovery outcomes

The case illustrates both the potential and limitations of localized SVI construction. While it enhances contextual relevance, it also raises questions of comparability, replicability, and scaling beyond single district analyses.

7.6 Policy Implications and Future Directions for SVI Refinement

To evolve from diagnostic to transformative, the SVI must inform adaptive policies and planning. Key directions include:

- **Local Governance Integration:** Embedding SVI into district- and panchayat-level development plans could help prioritize investments in climate resilience—especially in rural infrastructure, SHG proliferation, and women’s cooperatives.
- **Participatory Indicator Design:** Incorporating community voices ensures that indicators reflect lived vulnerabilities and not just data artifacts.
- **Gender-Responsive Metrics:** Future iterations should integrate variables like land rights, care work burdens, and access to adaptation finance through a gendered lens.
- **Behavioral Insights:** Aligning SVI outputs with farmer perceptions can close the gap between risk recognition and adaptive action (as highlighted in Jellason *et al.*,

- 2019) ^[17].
- **Hybrid Data Systems:** Combining satellite imagery, real-time climate data, and primary survey insights can create dynamic SVIs responsive to shifting climatic and socio-political landscapes.

Ultimately, the SVI’s strength lies in its ability to tell a story about vulnerability—a story that must be grounded in data, shaped by community realities, and framed in a way that informs forward-looking policy and resilience-building strategies.

8. Conclusion

This review underscores the critical role of the Social Vulnerability Index (SVI) as both a diagnostic and strategic tool in the era of climate change. By synthesizing literature across urban risk, agricultural systems, gendered disparities, and regional case studies. The studies highlights that social vulnerability is inherently multidimensional, shaped not only by exposure to climate hazards but also by underlying socioeconomic inequities and adaptive capacity constraints. Globally, the SVI has demonstrated flexibility in diverse contexts, from post-disaster public health assessments in the U.S. to rural adaptation studies in Africa and Southeast Asia. These applications affirm its potential to inform

targeted interventions, particularly when adapted to local realities and enriched through community participation. The proposed SV-CRA framework offers a structured pathway for integrating climate risk, social fragility, and resilience capacity into a single conceptual model—grounded in both theoretical rigor and policy relevance.

From a policy and planning perspective, the findings call for

- Institutionalizing SVI-based assessments into district-level climate resilience planning,
- Strengthening SHG and extension networks in marginalized regions,
- Promoting gender-responsive metrics in adaptation programs,
- And investing in localized data collection to fill gaps in granularity and relevance.

For countries like India—marked by vast socio-ecological heterogeneity and evolving climate risks—the path forward lies in building context-sensitive, participatory, and dynamic SVI frameworks. Future research and policy must emphasize granular vulnerability assessments that move beyond administrative boundaries to the realities of agro-ecological zones and household-level resilience. Only through such refined tools can adaptation efforts truly be inclusive, anticipatory, and equitable.

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