In the Shadow of Climate Change: Exploring Livelihood Vulnerability in the Juang Communities of Keonjhar

Jena Damodar[1], Das Shusrisangeeta[1]*, Mishra Priyanka[2*], Kar Brajaballav[3], Patnaik Sonali[1] and Panda Itishree[1]
1. KIIT School of Rural Management (KSRM), KIIT Deemed to Be University, Bhubaneswar, Odisha 751024, INDIA
2. KIIT School of Architecture and Planning, KIIT Deemed to be University, Bhubaneswar, 751024, Odisha, INDIA
3. KIIT School of Management, KIIT Deemed to be University, Bhubaneswar, 751024, Odisha, INDIA
*shusri.das@gmail.com; prof.priyankam@gmail.com

Abstract
Climate change has a disproportionate impact on communities that rely on natural resources, especially those in vulnerable, disaster-prone regions like Odisha, India. This study evaluates the climate vulnerability of the Juang tribes in Keonjhar district, using the Livelihood Vulnerability Index (LVI), which is based on the Intergovernmental Panel on Climate Change's model. Data were collected from 200 households, whose livelihoods primarily depend on agriculture and natural resources. Secondary data were also integrated to enhance the findings. The analysis identified "livelihood status" (0.56) and "social status" (0.53) as the most vulnerable components among the seven vulnerability factors assessed. These results indicate that economic conditions and social networks are key factors in determining the community's resilience to climate impacts.

This study demonstrates that the LVI can serve as an effective tool for policymakers to prioritize interventions, to plan long-term strategies and to enhance climate resilience in vulnerable tribal communities. By providing a quantitative measure of vulnerability, the study underscores the importance of context-specific adaptation strategies to mitigate the effects of climate change. Ultimately, the LVI framework can guide sustainable development initiatives, ensuring that the needs of marginalized communities like the Juangs are addressed in climate adaptation policies.

Keywords: Climate change vulnerability, Livelihood Vulnerability Index (LVI), Tribal communities, Adaptation strategies, Socio-economic resilience.

Introduction

The impacts of climate change vary across regions, countries and even among communities [2]. The multifaceted impacts of climate change include rising temperatures, erratic precipitation and natural disasters, which affect agriculture, ecosystems and human health [1,33]. The most vulnerables to these impacts are poor and agrarian communities in developing countries[24,29] where fragile ecosystems are particularly sensitive to even minor climatic variations[13]. The vulnerability of the agricultural sector is a global concern, with irreversible weather fluctuations threatening food production and supply. This, in turn, disrupts global feeding patterns, particularly in countries where agriculture forms a critical part of the economy and overall productivity[1,8].

Assessing the factors that contribute to the vulnerability of livelihoods is the primary step in developing climate change adaptation and mitigation strategies[11,16]. It is equally important that these findings are communicated to policymakers to inform the planning of climate-related programs[18]. Although there is no consensus on how vulnerability should be measured[14], scholars argue that any assessment must integrate and examine the interactions between human and social-ecological systems[7].

Recent studies on livelihood vulnerability to climate change in India employ diverse methodologies and reveal critical findings (Table 1). Das et al[9] used the livelihood vulnerability index (LVI) and spatial modeling in Manikchak, Gangetic plain, highlighting high vulnerability near rivers due to floods and erosion. In Arunachal Pradesh. Rehman et al[33] adopted IPCC's LVI framework, identifying gaps in rural adaptive capacity due to health and socio-economic stressors. Kumbrottil et al[22] assessed Wayanad farmers' vulnerability to erratic weather and reduced agricultural productivity using LVI. Jatav[19] evaluated Bundelkhand's exposure to floods and droughts, emphasizing challenges among Scheduled Tribes.

Joshi and Rawat[21] integrated biophysical and socio-economic indicators to assess agro-pastoral vulnerabilities in the Himalayas. Latha and Babu[24] applied LVI with stratified sampling in Andhra Pradesh, finding significant dependency on agriculture and limited access to healthcare, education and infrastructure among tribal communities. These studies underscore the unique vulnerabilities posed by climate change and highlight socio-economic stress in different regions, emphasizing the need for adaptation strategies tailored to the specific conditions of affected populations. Solutions must address local exposure to climate hazards, resource dependency and adaptive capacity, ensuring effective measures aligned with the real challenges faced by these communities.

Building on the indicator-based approach for vulnerability assessment[12,19,35,37], this study focuses on the Juang tribe in Keonjhar district, Odisha, a particularly vulnerable tribal group (PVTG) marked by distinct socio-economic and cultural traits[5,17,28]. Odisha has experienced numerous natural disasters[27] and despite the increasing impact of

climate change, there is a lack of comprehensive data on how these events specifically affect tribal communities like the Juangs. This study aims to fill this gap by using a livelihood vulnerability index (LVI) tailored to these communities, evaluating the vulnerabilities they face.

The research explores the multifaceted effects of climate change on the Juang tribe, focusing on key vulnerability drivers like limited access to resources, low adaptive capacity and high exposure to natural disasters. The LVI is employed as a tool to evaluate the sensitivity of tribal livelihoods to climate change, assessing critical areas such as livelihood status, food security, health, social networks and disaster exposure. By quantifying vulnerability, the LVI provides a clearer understanding of the vulnerable areas and supports evidence-based decision-making for policymakers. The study highlights the importance of resilience-building and the need for sustainable development in marginalized communities.

The research explores how climate change impacts the Juang tribe, focusing on key vulnerability drivers such as limited access to resources, low adaptive capacity and exposure to natural disasters. The LVI is employed to assess critical factors like livelihood status, food security, health, social networks and disaster exposure, providing a quantifiable measure of vulnerability.

Table 1
Summary of recent studies on livelihood and climate vulnerability across various regions in India

Location	Methodology	Key Findings	Indicators
Manikchak block, Gangetic plain	LVI, Moran's I Index, Getis-Ord G*; 240 households sampled[9]	Vulnerability due to riverbank erosion, floods and lack of basic services.	• Exposure indicators include proximity to the river and frequency of floods and riverbank erosion; Sensitivity factors- access to basic amenities, socioeconomic status and dependence on agriculture. • Adaptive capacity- livelihood security, access to infrastructure and the community's ability to adapt to environmental stresses, including floods and erosion.
Arunachal Pradesh	IPCC LVI framework; 450 households surveyed[34]	Yield loss, landslides and adaptive capacity gaps identified in rural areas.	• Exposure: Climate hazards (floods, temperature extremes), Sensitivity: Dependence on agriculture, adaptive capacity: Access to resources, technology and infrastructure.
Wayanad, Kerala	LVI for farmer livelihoods[23]	Erratic weather patterns and reduced agricultural productivity impacted food security and income.	• Exposure: Climate hazards (temperature extremes, rainfall variability), Sensitivity: Dependence on agriculture, Adaptive Capacity: Access to resources, technology, infrastructure.
Bundelkhand Region, Uttar Pradesh	LVI computation for social groups[20]	Scheduled Tribes (ST) communities were most vulnerable due to climate exposure and lack of resources.	• Exposure Index- floods and droughts, along with changes in rainfall patterns and temperature extremes • Sensitivity Index- on climate-sensitive resources such as agriculture and socio-economic factors like income and education • Adaptive Capacity Index- access to essential resources like technology, financial support, education and infrastructure.
Western Indian Himalaya	Integrated LVI for agro-pastoral communities; surveys[22]	Vulnerability linked to climate change and socio-economic challenges.	• Biophysical indicators: rainfall, temperature, crop yield and biodiversity. • Social indicators: income, education, access to services and community capacity.
Ananthagiri Agency Area, Andhra Pradesh	Andhra Pradesh LVI using socio-economic and biophysical indicators; 300 households surveyed[25]	High vulnerability due to inadequate healthcare, education and water access; social capital influenced resilience.	• Socioeconomic: income, asset ownership, occupation, education level. • Agricultural: landholding, crop variety, dependency on agriculture. • Infrastructure: access to water, electricity, healthcare, education. • Social capital: participation in community organizations, social cohesion. • Environmental: exposure to climate risks, water availability, forest resources.

This enables policymakers to make evidence-based decisions and prioritize areas for intervention, promoting resilience-building and sustainable development in marginalized communities.

The primary objectives of this study are to assess the climate change vulnerabilities of the Juang tribe in Keonjhar district and to identify the key vulnerability drivers. By providing actionable insights for policymakers and development organizations, the study emphasizes the need for context-specific adaptation strategies. This research bridges the gap between theoretical vulnerability models and practical applications, equipping policymakers with the necessary tools to design inclusive climate adaptation programs that promote equity, sustainability and resilience. Ultimately, it contributes to the broader discourse on climate change vulnerability, offering a modified composite vulnerability index that reflects the unique challenges faced by indigenous communities.

Study Area

Keonjhar District, located in the northernmost part of Odisha, India, shares borders with Mayurbhanj, Bhadrak districts in the east, Jajpur district in the south, Dhenkanal, Sundargarh districts in the west and West Singhbhum districts of Jharkhand State in the north (Figure 1). The district spans 8,303 square kilometers and is situated between latitudes 21º 1' N to 22º 10' N and longitudes 85º 11' E to 86º 22' E. The Juang tribes, also known as 'Patuas' or 'Patra-Savaras' (meaning "leaf-wearers"), are an indigenous community residing in the Keonjhar district of Odisha [30]. Traditionally semi-nomadic, they build settlements on hilltops, slopes, or valleys, often near rivers or streams for water, making them vulnerable to climate change and flooding. Historically, their livelihoods involved shifting cultivation and hunting-gathering, but modernization, urbanization and government policies have significantly altered their traditional lifestyle and demographics. These changes have led to shifts in their social structure and economic practices.

Material and Methods

Sampling: The structured methodology ensures a comprehensive evaluation of livelihood vulnerabilities and provides insights into the adaptive capacity and resilience of the Juang community in the face of climate variability. A multi-stage sampling technique was employed to select one block and four villages in Keonjhar district (Figure 2).

The study targeted a total sample size of 200 tribal households from the Juang community. To capture in-depth qualitative insights, focus group discussions (FGDs) were conducted with community members to understand their perceptions, lived experiences and challenges related to climate change and its impacts on their livelihoods. Ten FGDs were strategically distributed across different villages to ensure diverse representation and a holistic understanding of the issues faced by the community.

Data analysis: The analysis comprised two pronged-methods: (1) Computation of a Balanced Weighted Average Livelihood Vulnerability Index (LVI) to evaluate the vulnerability of households to climate variability and (2) the formulation of an LVI based on the framework set forth by the IPCC guidelines to integrate vulnerability into climate change impact assessments.

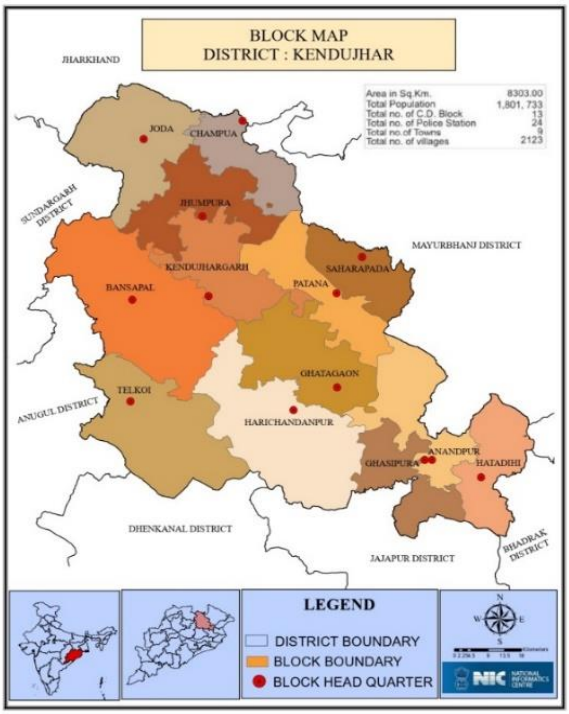


Figure 1: Location map of the study area
(Source: National Informatics Centre, Ministry of Electronics and Information Technology, Government of India)

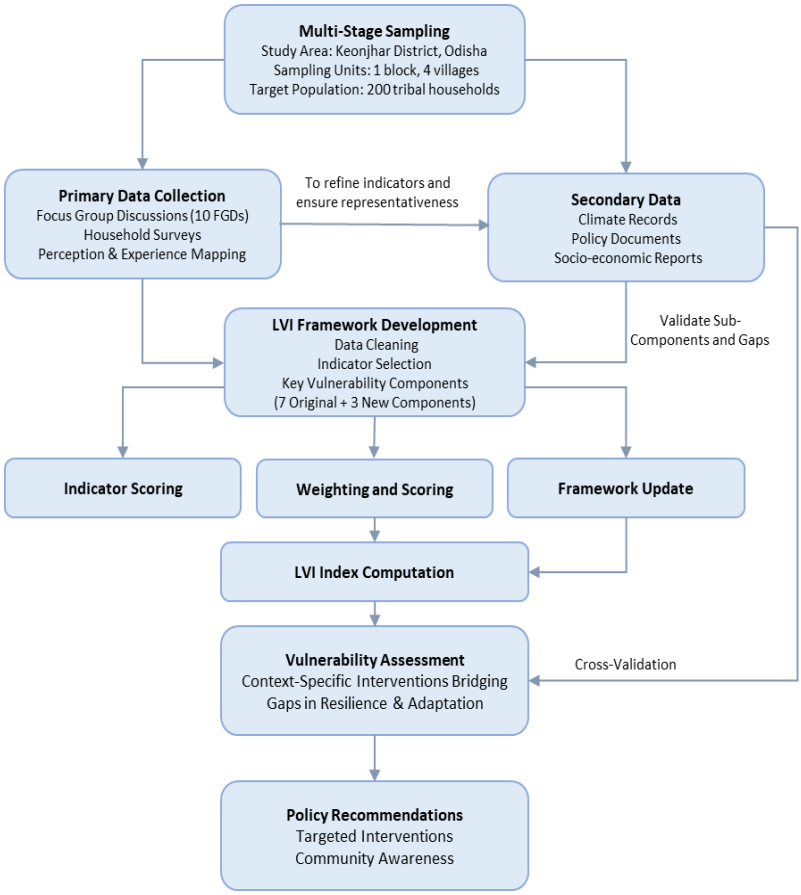


Figure 2: Methodology flowchart for assessing the climate vulnerability of the Juang tribe

Constructing livelihood vulnerability index (LVI): To assess vulnerability to climate variability, this research employed methodologies articulated by Hahn et al[18] and Shah et al[36] with necessary adaptations to suit the context of the current study. Notably, the LVI was expanded to include five additional components beyond the seven originally proposed by Hahn et al[18]. The elements of 'Housing' and 'Land Tenure' were separated into distinct components to facilitate a more detailed and nuanced understanding of household sensitivities specific to each factor. Additionally, a "Knowledge and Skills" component was introduced to address human vulnerability related to climate change adaptation.

Table 2 presents the process used to calculate the LVI, while table 3 outlines the seven main components analyzed in the study. Each component comprises of multiple sub-components, reflecting detailed indicators within broad livelihood domains[34].

The major components of the livelihood vulnerability index (LVI) provide a comprehensive framework to evaluate the susceptibility of households to climate variability and associated challenges[3,21,32]. These components include livelihood status, which assesses the economic stability and resource access of households[6,10] and the socio-demographic profile and vulnerability to climate change[9,21,36], which considers factors such as population characteristics, dependency ratios and exposure to climate risks. Health issues and access to medical services form another critical component, addressing the availability and quality of healthcare facilities as well as prevalent health conditions within the community[6,21].

Food security evaluates access to and availability of sufficient and nutritious food, while social networks explore the support systems and collective resilience mechanisms within the community. Natural disasters and climate change impact assess the frequency and severity of disasters, alongside their effect on livelihoods. Lastly, drinking water and sanitation focus on the accessibility, quality and reliability of water resources and sanitation infrastructure[4,26,39,40,42]. Together, these components offer a detailed and multidimensional assessment of livelihood vulnerabilities, helping to identify areas requiring targeted interventions[15,31].

Weighting and Scoring: Each major component includes several sub-components which provide more detailed measures within each category such as access to healthcare, food availability etc. that contribute to its weight. Components with more sub-components are assigned higher weights in the LVI calculation[41,43]. The overall LVI score is computed by aggregating the weighted contributions of all components. Scores range from 0 (least vulnerable, high resilience) to 0.6 (most vulnerable, significant susceptibility to risks).

Table 2
Calculating the livelihood vulnerability index (LVI)

Formula (1): Sub-component Index Calculation	$S_{ij} = \frac{X_{ij} - Min_{(xj)}}{Max_{(xj)} - Min_{(xj)}}$	**Purpose:** This formula normalizes each sub-component's raw value (X_{ij}) to a scale of 0 to 1. **Variables:** - (x_{ij}): The observed value of sub-component j for household i. - min(x_j) and max(x_j): Minimum and maximum observed values for sub-component j across all households. **Process:** - Subtract the minimum observed value from the actual value to determine the relative position of x_{ij} in the range. - Divide this difference by the range (max - min) to scale the value between 0 (minimum vulnerability) and 1 (maximum vulnerability). **Significance:** This ensures that all sub-components are comparable, regardless of their original units or scales.
Formula (2): Component Index Calculation	$C_i = \frac{\sum_{j=1}^{n} S_{ij}}{n}$	**Purpose:** This formula calculates the average index for a major component of vulnerability (e.g., health, food security). **Variables:** - C_i: The index value for a major component i. - S_{ij}: The normalized value of sub-component j for component i. - n: The total number of sub-components within the major component. **Process:** - Sum the normalized sub-component values (S_{ij}}) within the major component. - Divide the total by the number of sub-components to find the average. **Significance:** This aggregation creates a single score for each major component, summarizing the sub-component values.
Formula (3): Weighted Index Calculation	$M_i = \sum_{k=1}^{m} w_k . C_{ik}$	**Purpose:** This formula accounts for the relative importance of each major component when calculating the overall index. **Variables:** - M_i: Weighted score for a dimension or the overall index. - w_k: Weight assigned to major component k (reflecting its importance). - C_{ik}: Index value of major component k for household i. - m: Number of major components. **Process:** - Multiply each major component index $C_{ik}$by its assigned weight w_k. - Sum the weighted values. **Significance:** This allows for differential emphasis on major components, reflecting their relative contributions to overall vulnerability.
Formula (4): Overall Livelihood Vulnerability Index	$LVI = \frac{\sum_{i=1}^{p} M_i}{p}$	**Purpose:** This formula calculates the final Livelihood Vulnerability Index for the entire population or sample. **Variables:** - LVI: Overall Livelihood Vulnerability Index. - M_i: Weighted index score for household i. - p: Total number of households in the study. **Process:** - Sum all households' weighted index scores (M_i). - Divide by the total number of households to get the average vulnerability score for the population. **Significance:** This final step aggregates individual household vulnerabilities into a single index, representing the overall vulnerability of the study area.

Table 3
The main components of LVI and Its subcomponents

Major components	Subcomponents (indicator)	Unit
Livelihood status	Type of land	Nominal (1: Private land, 2: Communal and clan land, 3: Community land, 4: State-owned land)
	Total land holding, if any	Scale: Acre
	Total income from farm sources, if any	Scale: INR
	Annual produce of crops, if any	Scale: INR
	Orchards/ vegetables, if any	Scale: INR
	Sale animals/ birds & products, if any	Scale: INR
	Income from forest related activities, if any	Scale: INR
	Income from non-farm sources, if any	Scale: INR
	Income from wage Earning, if any	Scale: INR
	Income from Others (Business, Contract Assignments, Old Age Pensions), if any	Scale: INR
	Rainfall quantity	Nominal: 1) Decrease, 2) Increase, 3) Unchanged 4) Can't say
	Rainy days	Nominal: 1) Decrease, 2) Increase, 3) Unchanged 4) Can't say
	Temperature in monsoon	Nominal: 1) Decrease, 2) Increase, 3) Unchanged 4) Can't say
	Temperature in winter	Nominal: 1) Decrease, 2) Increase, 3) Unchanged 4) Can't say
Socio-Demographic Profile and Vulnerability to Climate Change	Sex	0) Male 1) Female
	Level of education	Number
	Size of Family	Number
	Capacity to protect them self from drought	1) Yes, 0) No
Health Issues and Access to Medical Services	Is anybody in your household chronically ill (they get sick very often)?	1) Yes, 0) No
	Has anyone in your household been so sick in the past 6 months that they had to miss work?	1) Yes, 0) No
	Was anyone in your household injured by natural calamities during last 30 years?	1) Yes, 0) No
	Did anyone in your household die due to natural calamities during last 30 years?	1) Yes, 0) No
	Has anyone in your household been so sick in the *past 6 months* that they had to miss work?	1) Yes, 0) No
Food security	Does your household have food for the whole year?	1) Yes, 0) No If no, how many months you suffer from food shortage: Number
Social networks	In the past five years, did any relatives or friends assist you or your household with tasks such as obtaining medical care or medicines, selling animal products or other goods, or taking care of children?	1) Yes, 0) No
	Over the past five years, did you or anyone in your household provide similar assistance to relatives or friends, such as helping with medical needs, selling goods, or childcare?	1) Yes, 0) No
	Have you or your household borrowed money from relatives or	1) Yes, 0) No

	friends at any point in the last five years?	
	In the past five years, have you or your household lent money to relatives or friends?	1) Yes, 0) No
	Did you or your household receive any development support or aid from the government or NGOs during the last five years?	1) Yes, 0) No
Natural disasters and climate change impact	Did you receive a warning about the any natural calamities before it happened?	1) Yes, 0) No
	Do you think change in rainfall effect on your production/land/your occupation/ anything?	1) Yes, 0) No
	Do you think change in temperature effect on your production/land/your occupation/ anything?	1) Yes, 0) No
Drinking water and sanitation concerns	During last 30 years do you have any conflicts over drinking water?	1) Yes, 0) No
	Do you treat water before drinking?	1) Yes, 0) No
	Do you have toilet in your house?	1) Yes, 0) No

(Source: Authors)

Results and Discussion

Livelihood Status (LVI: H1=0.56)

Resource ownership (land) in Keonjhar: Focused group discussions revealed that land ownership in Keonjhar predominantly follows a customary system, regulated by various laws, resulting in a complex classification of land ownership. The study identified four primary types of land as shown in table 4.

Socio-Demographic profile and vulnerability to climate change (LVI:H2=0.33): The socio-demographic profile highlights several factors that exacerbate the climate vulnerability including gender disparities, low education levels, rapid population growth and insufficient capacity to protect vulnerable groups from severe climatic threats like drought. The weighted value of 0.33 underscores the need for enhanced knowledge and preparedness within the community to adapt to and mitigate these impacts.

Health issues and access to medical services (LVI: H3=0.25): In Keonjhar, health issues are a significant contributor to vulnerability, with a weighted score of 0.25. High rates of illness and school absenteeism due to health-related problems emphasize the importance of strengthening institutional healthcare systems and ensuring accessible medical services for the community.

Food security (LVI: H4=0.39): Food security is a pressing concern, as farmers face challenges in accessing food during lean seasons and planting periods. The weighted value of 0.39 indicates a reliance on supplemental food sources due to inadequate farm yields. On average, households in Keonjhar had to supplement their farm produce with food from other sources due to insufficient farm yields. Farmers noted that ensuring the availability of grains and food supplies is the best strategy to mitigate the effects of climatic stress events to enhance resilience.

Social networks (LVI: H5=0.53): The social network component, with a weighted score of 0.53, highlights the crucial role in determining the vulnerability of households and the community to climate change. A strong social network enables better access to credit and support during climate-induced challenges. The high score reflects the need for Keonjhar communities to fortify their social networks to improve their adaptive capacity and resilience.

Natural disasters and climate change impact (LVI: H6=0.16): The vulnerability score for natural disasters and climate change impacts in Keonjhar is 0.16. This reflects the region's high exposure to climatic shocks such as hurricanes and storms, resulting in significant losses of crops, assets and livelihoods. A significant influence of the sub-component value is of farmers who lost more than 50% of their crops or assets due to a climatic disaster.

Agriculture, predominantly rain-fed, is heavily influenced by monsoon rains, which serve as the primary source of water for farming. Through the focus group discussions, changes observed include changes in monsoon patterns including delayed onset, reduced rainfall compared to previous years, fewer rainy days during cultivation alongside rising temperatures and extreme wind events and increased rainfall during harvest, which have severely impacted agricultural productivity.

According to focus group and key informant interviews, paddy, millets and pulses are identified as the most common and important group of crops.

During discussions about how to adapt to these impacts on crops grown in the area, it was noted that some households managed to adapt to these effects due to their social and economic advantages. There was also observed a confusion in making appropriate agricultural decisions, seedling wilting, increased pest attacks, resulting in crop damage and reduced productivity compared to previous years. The impact of climate change on crop cultivation is highlighted in table 5.

Drinking Water and Sanitation Concerns (LVI: H7=0.22): The LVI score of 0.22 highlights issues related to

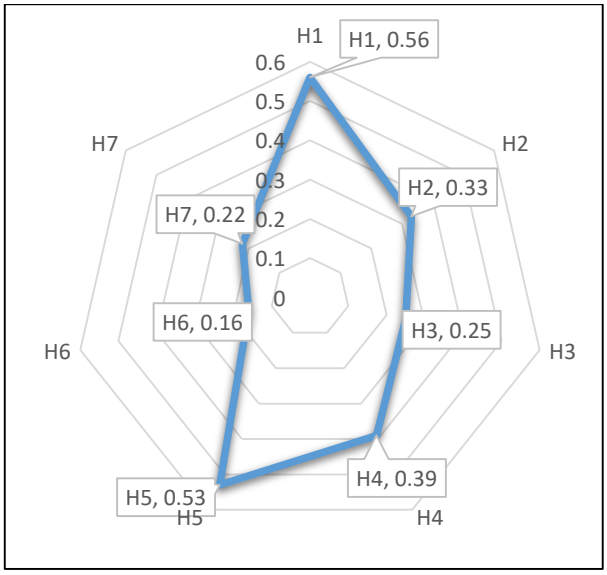
reliance on natural and untreated water sources for drinking which are exacerbated by climatic events. The primary sub-components affecting drinking water and sanitation were households using natural water sources and untreated water for drinking purposes. These challenges underline the need for improved water infrastructure and sanitation facilities, particularly for vulnerable forest-dwelling communities.

Table 4
Types of land ownership, rights and their unique features

Land Type	Ownership and Rights	Key Features
Private Land	Owned by an individual or family, with full autonomy to sell or purchase without government involvement. Distribution follows gender-specific inheritance laws in case of the owner's death.	Complete rights over the property; Not subject to external control unless in case of disputes; Inherited as family property through generations; No revenue payments to the government.
Community Land with User Rights	Regulated collectively by a community or clan. Members have rights to use, occupy and cultivate the land but cannot sell their shares individually. Ownership transfer requires community or clan association approval.	Used for agriculture, grazing and resource collection; Supports tribal livelihoods and cultural practices; Provides essential resources for sustaining traditional ways of life; No individual sale allowed; collective ownership.
Community Land through FRA (2006)	Granted to tribal communities under the Forest Rights Act, 2006. Managed by the community and cannot be transferred or sold. Individual use requires community council approval.	Users lose rights if land remains unused for 3 consecutive years; Land reverts to the local community council for reassignment., Improvements (e.g., planting crops or constructing buildings) may provide transferable rights.; Effective usage allows descendants to inherit but cannot transfer to others; Governed entirely by the community council.
State-Owned Land	Government-owned lands categorized as exchange lands, purchased lands, leased lands, or acquired lands, regulated by specific governmental frameworks.	Acquired, purchased, or leased through detailed regulations; Managed by government agencies for specific purposes; Includes communal lands acquired for development or administrative use; Subject to intricate rules defining ownership and land-use policies.

Table 5
Impact of Climate Change on Crop Cultivation and Farmer Adaptation Strategies in Keonjhar

Crop Type	Primary Insights	Climate Impact	Adaptation Strategies
Paddy Cultivation	• Primary crop for 125 of 200 households. • Cultivated during autumn. Forms a key part of the food basket and economic sustainability.	• Climatic fluctuations causing decision-making challenges for farmers. • Remains resilient as the most significant crop.	Focus on ensuring its sustainability through improved agricultural practices.
Millets Cultivation	• Considered vital for food and economic security. Cultivated on medium-grade lands. Drought-resistant and climate-resilient crop.	• Withstands climatic stress better than other crops. Acts as a reliable income source.	Farmers are willing to adopt new techniques to enhance crop quality and productivity.
Pulses Cultivation	• Planted post-paddy harvest. Primarily used for local consumption, with some surplus sold.	Affected by: • Increased rainfall during harvest. • Decreased rainy days. • Higher temperatures and unseasonal rains. Soil moisture deficit and pest attacks have reduced yields.	Some households show better adaptation by diversifying crops or employing water conservation methods.



Major components	Symbol	Results
Livelihood status	H1	0.56
Socio-demographic profile and vulnerability to climate change	H2	0.33
Health issues and access to medical services	H3	0.25
Food security	H4	0.39
Social networks	H5	0.53
Natural disasters and climate change impact	H6	0.16
Drinking water and sanitation concerns	H7	0.22

Figure 3: Major component of Livelihood Vulnerability Index and the results of analysis

Livelihood Vulnerability Index (LVI=0.35): With an overall LVI of 0.35, categorized as medium vulnerability, the study identifies critical factors: living conditions, access to drinking water, food security and social networks as significant contributors to sensitivity. These factors collectively heighten livelihood and socio-economic vulnerability in Keonjhar, necessitating targeted interventions to enhance resilience against climate change impacts. Table 6 and figure 3 show the seven main LVI components in spider plots, providing a comprehensive representation of the vulnerabilities assessed in the study.

Policy implications: The study offers a framework for understanding and addressing the climate change vulnerabilities of Juang tribes in Keonjhar district, providing actionable insights for policymakers:

Targeted Interventions: The LVI identifies critical areas like livelihood status, food security, social networks and access to healthcare. These insights allow policymakers to prioritize interventions in high-risk areas and urgent community needs.

Evidence based Policy Formulation: Quantitative data helps tailor policies addressing specific issues such as enhancing food security and improving healthcare systems.

Strategic Resource Allocation: The study's weightage insights (e.g. livelihood status: 0.56 vs. health issues: 0.25) ensure efficient resource distribution.

Long-Term Planning: The research underscores the need for resilience-building strategies in tribal communities by improving agriculture, social networks and disaster mitigation for sustained well-being.

Community-Centric Adaptation: The study highlights the importance of understanding socio-economic participatory measures, fostering local ownership and sustainability.

Monitoring and Evaluation: The LVI serves as a valuable tool for monitoring the impact of implemented policies and programs, enabling adjustments for better outcomes.

Replication in Other Regions: The approach offers a replicable framework for assessing climate vulnerability in other regions or communities.

This study equips policymakers with tools for targeted, equitable climate adaptation strategies, ensuring both immediate mitigation and long-term resilience for vulnerable communities.

Conclusion

The study highlights the significant vulnerability of the Juang tribes in Keonjhar District to climate change, particularly through the lens of their livelihood dependency on natural resources and agriculture. By utilizing the livelihood vulnerability index (LVI), the research identified critical areas of sensitivity, with livelihood status scoring the highest (0.56), followed by food security (0.39) and social networks (0.53). These vulnerabilities are exacerbated by factors such as inadequate social support systems, low agricultural productivity, limited access to healthcare (0.25) and challenges in water and sanitation (0.22). The findings emphasize the disproportionate impacts of climate variability on marginalized communities who face delayed monsoon rains, decreased rainfall, increased pest attacks and rising temperatures, resulting in significant crop losses and reduced agricultural yields.

The study provides a detailed account of climate impacts on key crops in the region including paddy, millets and pulses. Paddy, a staple crop, remains the most popular despite significant fluctuations, while millets are recognized for their drought resistance and role in ensuring food security. Pulses, however, face declining productivity due to increased rainfall during harvest and rising temperatures.

The study also documents the high frequency of natural disasters, with 16% of farmers reporting losses of over 50% of crops or assets, reflecting the pervasive risks posed by climatic shocks.

To address these vulnerabilities, the study recommends strengthening social networks to improve resource sharing, enhancing food security through sustainable agricultural practices and improving healthcare and sanitation infrastructure. AI can be applied to risk assessments and vulnerability modeling, to empower communities to make informed decisions by identifying key vulnerabilities related to climate change, infrastructure and social factors. Targeted capacity-building initiatives are critical to equipping communities with adaptive strategies, while policy interventions must focus on integrating these measures into long-term development plan.

The findings not only provide a robust framework for evidence-based policymaking but also highlight the broader applicability of the LVI for assessing vulnerabilities in other regions. By prioritizing resilience-building and socio-economic stability, this research serves as a vital tool for empowering vulnerable populations to navigate and adapt to climate uncertainties, ensuring sustainable development and improved quality of life.

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