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Understanding Differential Climate Vulnerability: A Comparative Analysis of Two Tharu Communities in Chitwan District, Nepal

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Abstract

Climate-related hazards are disproportionately affecting rural communities in developing countries like Nepal, where livelihoods depend heavily on climate-sensitive sectors. This study employed a mixed-methods approach to assess exposure, sensitivity, and adaptive capacity, guided by the Intergovernmental Panel on Climate Change (IPCC) vulnerability framework and applying the Community-Based Vulnerability Assessment (CBVA) tool in two indigenous Tharu communities, Telauli and Jitpur, located in the Meghauli Buffer Zone of Chitwan District, Nepal. Data were collected from a total number of 200 households: 130 in Telauli and 70 in Jitpur that represents about 30% of each community. The study further utilized 31 years of meteorological data to validate community perceptions of climate change. The climate trend analysis revealed relatively stable rainfall and temperature patterns, with no statistically significant variations over time. Despite these statistically insignificant results, household perceptions reveal increasing climate stress from irregular rainfall, prolonged dry spells, and temperature extremes, resulting in heightened risks of water scarcity, flash floods, crop loss, and changes in farming practices. This is due to the fact that, short term variability affected livelihoods in contrast to long-term statistical trend situation. Both communities exhibited high exposure to climate-related hazards, with scores of 2.04 in Telauli and 2.08 in Jitpur, the latter experiencing slightly higher flood exposure. Sensitivity levels were also elevated with recorded score of 2.3 in Telauli and 2.7 in Jitpur. However, a notable difference was observed in adaptive capacity, which was higher in Telauli (2.3) compared to Jitpur (1.5). This is due to better infrastructure, market access, stronger saving groups and more diversified livelihood. Overall, the vulnerability was found to be high in both settlements but greater in Jitpur. The findings highlight that climate vulnerability is largely determined by the availability of community resources and, critically, by how effectively these resources are utilized to adapt and enhance the climate resilience.

Keywords: *Adaptive capacity, climate vulnerability, exposure, resilience, sensitivity*

1. Introduction

Changes in hydrological regimes have become a significant environmental challenge, affecting both natural systems and human societies under changing climatic conditions. Scientific evidence indicates noticeable changes in global temperature, precipitation patterns, and the increasing frequency of extreme weather events over recent decades (Haden et al., 2012; Shikuku et al., 2017; Upreti, 2023). The Intergovernmental Panel on Climate Change defines climate change as long-term shifts in climate conditions, including changes in average temperature and rainfall variability that persist for decades or longer (IPCC, 2022). Human activities, particularly greenhouse gas emissions, have contributed to approximately 1°C increase in global temperature above pre-industrial levels, posing serious risks to ecosystems, livelihoods, and human health (Han & Ahn, 2020; IPCC, 2018). Climate change impacts vary across sectors, including agriculture, water resources and public health. Irregular rainfall, floods, droughts, heatwaves reduce agricultural productivity, disrupt water availability, and increase the spread of climate-sensitive diseases such as malaria, cholera, and Japanese encephalitis (Shivanna, 2022). These sectoral disruptions directly affect rural livelihoods by understanding food security, income sources, and overall economic stability, particularly in communities dependent on climate sensitive occupations (Kabir et al., 2023).Developing countries are more vulnerable to climate change due to the interaction of economic, geographic, and social factors that create a vulnerability trap, including poverty, limited resources, and high dependence on agriculture and natural ecosystems (Burton et al., 2006; Moser, 1998). Nepal, despite contributing minimally to global greenhouse gas emissions, is considered highly vulnerable to climate change because of its fragile mountain ecosystem, geographic diversity, and socio-economic constraints (Pokhrel et al., 2025). Agriculture and forestry support the livelihoods of a large proportion of the population, making rural communities highly sensitive to climatic variability (Garg et al., 2007). Climate related hazards such as floods, landslides, droughts, and erratic monsoon patterns are already affecting millions of people in Nepal and are expected to intensify in the future (Hobbs, 2009). Both hydro-meteorological and socio-ecological aspects are important to understand the climate vulnerability in its specific context (Sharma et al., 2025).

Recognizing these challenges, the Government of Nepal has implemented adaptation policies such as the National Adaptation Programme of Action (NAPA) and Local Adaptation Plans of Action (LAPA), which emphasize identifying vulnerable communities and promoting climate-resilient development through participatory approaches (GoN, 2011). Community based vulnerability assessments are widely used to understand how climate change affects livelihoods and to design locally appropriate adaptation strategies (Agrawal, 2008; Smit & Wandel, 2006). Such approaches help evaluate exposure, sensitivity, and adaptive capacity, which together determine climate vulnerability at the local level (Burton et al., 2002).

Indigenous communities such as the Tharu, who traditionally depend on agriculture, forests, and natural resources, are particularly sensitive to climate variability. In areas such as the Meghauli Buffer Zone of Chitwan National Park, communities have experienced irregular rainfall, floods, droughts, and other climate-related hazards in recent years (Chaudhary et al., 2018). Although traditional knowledge has helped these communities adapt in the past, rapid environmental changes may exceed their coping capacity. Therefore it is essential to understand local perceptions, livelihood challenges, and adaptation practices for developing effective climate resilience strategies.

In this regard, this study aims to assess and compare climate vulnerability in two Tharu communities of the Meghauli Buffer Zone, Chitwan District, Nepal, using Community-based Vulnerability Assessment (CBVA) tool. This study focuses on climatic variability assessment incorporating exposure and its sensitivity and Tharu community's adaptive capacity to climate change. It further conducts a comparative analysis of index-based vulnerability between two communities to enhance understanding of differential climate vulnerability in the study area.

2. Materials and Methods

2.1 Study Area

The study was conducted in Meghauli buffer zone of Chitwan National Park (CNP) in western Chitwan District, Nepal. Meghauli lies along the Rapti and Narayani rivers, approximately 25 km from Narayangadh, and covers an area of 77.18 km². According to the Central Bureau of Statistics (CBS, 2021), the area has a total population of 14,699 in 2,598 households, including about 5,730 Tharu individuals living in nearly 879 households. The area is highly dependent on agriculture and forest resources, making local livelihoods sensitive to climate variability and flood hazards (MoE, 2010). For comparative analysis, two Tharu communities, Telauli (Ward No. 27) and Jitpur (Ward No. 28) of Bharatpur Metropolitan City were selected based on differences in settlement patterns and resources exposure (2231 HH and 1659 HH, where total number of Tharu households is 616 and 263 respectively). The confluence of the Narayani and Rapti rivers at Golaghat also lies within this ward.

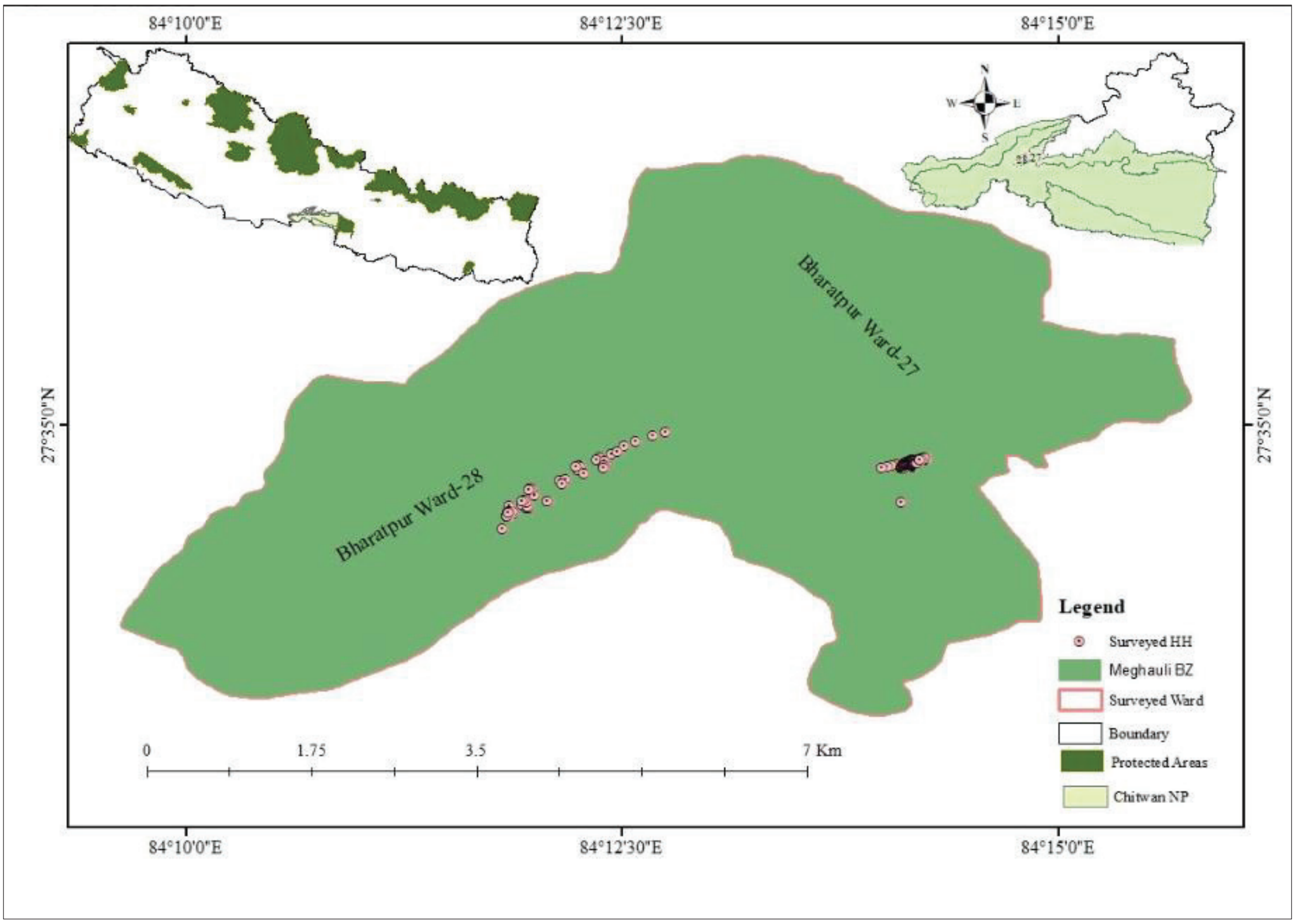

Figure 1: Study area map showing Meghauli Buffer Zone, Chitwan National Park, Nepal

2.2 Research Design and Data collection Methods

This study is based on participatory as well as exploratory research design to assess community level vulnerability to climate change. The approach combined both qualitative and quantitative methods to understand the level of exposure, sensitivity, and adaptive capacity by following the IPCC framework for climate change vulnerability and applied the CBVA tool (MoEST, 2012). Each community was sampled separately for the socio-economic survey and to gather perceptions on climate change, using a purposive sampling method (Acharya et al., 2013).

2.2.1 Primary Data Source

2.2.1.1 Semi Structured Questionnaire survey: A combination of both quantitative and qualitative information was gathered from both communities using a semi-structured questionnaire based on MoEST (2012) Guidelines. Out of total 200 HHs (households), a total of 130 households from Telauli and 70 from Jitpur communities were selected representing about 30% of the total households of Tharu in each community. The interview was conducted at each household most preferably with the head of the house so as to collect all the required data at the household level during the time period of 31st January to 9th of February, 2025.

2.2.1.2 Key Informant Interview: Interviews were conducted with five key personnel; community leader, chairman of the ward office and Meghauli users' communities. These key informants shared insights on the community's available social resources, the effects of climate change on local livelihoods, existing status of climate change awareness and potential strategies taken for the adaptation.

2.2.1.3 Community Transect Walk: The community transect walk was conducted as a primary field observation technique to evaluate community assets, infrastructure, and climate risk. This method allowed for the direct assessment of local conditions, serving as a crucial tool to triangulate and validate findings gathered through household surveys, and key informant interviews. In Jitpur, the transect walk was carried out from 6-7 February 2025, covering an area approximately 1 km north of the Narayani-Rapti River confluence. In Telauli, the transect walk was conducted from 28-29 January 2025, covering an area approximately 1 km west of the ward office.

2.2.2 Secondary Data Source

Secondary data of temperature and rainfall, over 31 years, were gathered from Department of Hydrology and Meteorology (DHM), Government of Nepal from Rampur stations (Index: 0902) while population data was gathered from the Central Bureau of Statistics (CBS, 2021). In addition, government reports, research papers, and scientific journals were further used to obtain other demographic and literature information.

2.3 Data Analysis

2.3.1 Community Level Vulnerability Assessment

Based on the theoretical framework of the vulnerability function provided by the IPCC, the CBVA tool (MoEST, 2012) was used to assess the vulnerability level of the communities through a participatory approach. The three components of the vulnerability equation, exposure (E), sensitivity (S), and adaptive capacity (A), were empirically estimated by averaging the ranks of their respective sub-components (Table 1).

The indicators for each subcomponent were graded as Low (1), Medium (2), High (3), and Very High (4). The resulting sub-indices were subsequently averaged to drive the indices of the three major components Exposure (E), Sensitivity (S), and Adaptive Capacity (A). Vulnerability index was calculated by using the equation (i),

$$\text{Vulnerability (V)} = f\left(\frac{E*S}{A}\right) \quad \text{..........................} \quad (i)$$

Based on the CBVA paradigm, the computed vulnerability indices were also divided into four levels: low (<1), medium (1-2), high (2-4), and very high (>4) to compare community vulnerability patterns systematically (Pudasaini, 2015).

2.3.2 Socio-economic and Meteorological Analysis

Household data from questionnaires were categorized into exposure, sensitivity, and adaptive capacity to support CBVA analysis, while socio-economic insights from key informant interviews and transect walks were also integrated. Results were shown using graphs and tables by using Excel 2016. To assess climate trend, the temperature and

Table 1: Displaying the CBVA framework's components and subcomponents in description

Components	Subcomponents	Subcomponent's Description
Exposure(E)	Temperature	Rising and falling temperature in summer and winter season
	Precipitation	Monsoon; winter rainfall
	Hazard	Drought; flood
	Indicator plants	Flowering and fruiting behavior of indigenous plant
Sensitivity(S)	Natural Assets Physical Assets Social assets Human Assets Financial Assets	Five livelihood assets are impacted by the climate induced threats that are given top priority in the livelihood impact matrix (Table 4/5)
Adaptive Capacity (A)	Natural Assets Physical Assets Social Assets Human Assets Financial Assets	Access, viability, potentiality, and availability trend of five livelihood assets are shown in the livelihood resources matrix (Table 6)

rainfall data spanning from 1994 to 2024 from Rampur stations (Index: 0902) were collected and Mann-Kendall test and Sen's Slope estimator were applied in R-studio (4.5.2) to test whether the data are statistically significant.

3. Results and Discussion

3.1 Socioeconomic and Demographic Data

Communities from Telauli and Jitpur showed clear demographic differences, with Tharu households forming the majority (60% and 40%), varying family structures, and distinct age distributions, including a notable share of elderly respondents, especially in Telauli. Both communities were predominantly agricultural, with similar landholdings, high engagement in farming, and agriculture and foreign employment serving as the main income sources, supported by livestock rearing and small-scale crop and vegetable production (Table 2).

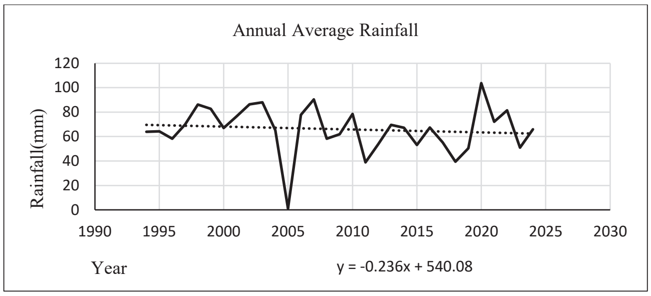

Figure 2: Trend of Average Annual Rainfall in this study location

Seasonal rainfall was also found in decreasing trend. Similarly, the gap between monsoon and non-monsoon rainfall was also found to decline (Mk tau: -0.187, Slope: -0.299mm/yr.), However, the trend was not statistically significant (p: 0.1438 (Figure 3).

Table 2: Showing socioeconomic and demographic data of study area

S.N	Indicators	Telauli (%)	Jitpur (%)
1	Tharu Population (of total population)	60%	40%
2	Joint Family	40%	59%
3	Single Family	60%	41%
4	Male	57%	56%
5	Female	43%	44%
6	Majority of respondents with respect to age range	27% (40-50 age)	41% (30-40 age)
7	Avg. landholding per HH (Hectors)	1.28	1.30
8	Farming	64%	75%

3.2 Exposure Assessment

3.2.1Temperature and Rainfall Trend Change

3.2.1.1Rainfall Trend: The average annual rainfall was found to be 65.98 with a decreasing trend (MK tau: -0.11), which is further supported by Sen's Slope (Slope: -0.378 mm/year). However, the trend is found with no statistically significance (Z: -0.8498, n= 31, p= 0.396) (Figure 2).

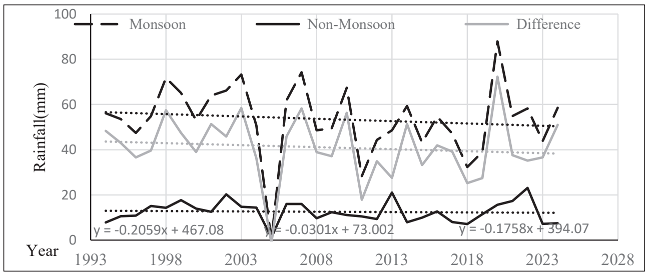

Figure 3: Rainfall during and after the monsoon season

3.2.1.2 Temperature Trend: The average annual maximum and minimum temperatures were recorded to be 30.88 °C and 17.81 °C, respectively. Results depicted a slight decreasing trend in annual average temperature (MK τ: -0.191; Sen's slope: -0.0142 °C/year), but the change was not found to be statistically significant (p: 0.1347) (Figure 4).

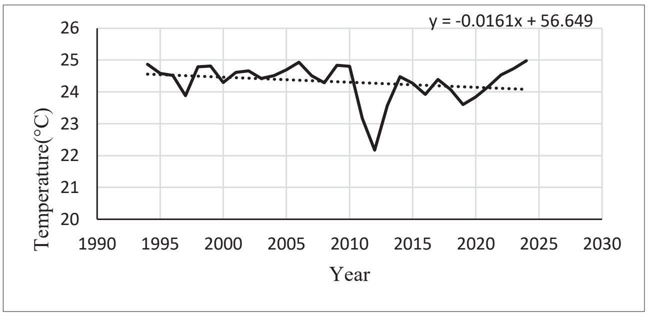

Figure 4: Annual average temperature in the Rampur station of study area

Seasonal extreme temperature (max summer temperature/min winter temperature) show minor warming (Sen's Slope: 0.0086 and 0.0087°C/yr), but the variation between highest and lowest temperature over the course of a year decline (–0.0087°C/yr), however none of these trends are statistically significant (p: 0.634, 0.865 and 0.61) respectively (Figure 5).

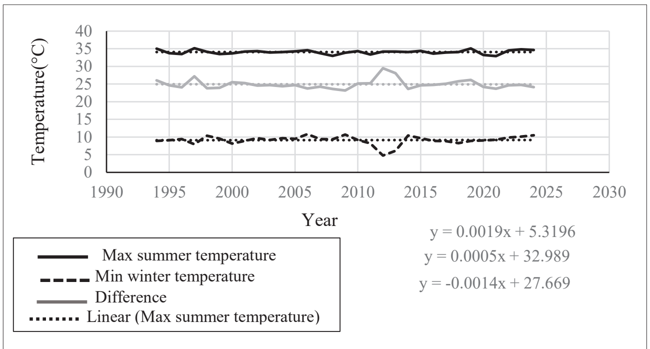

Figure 5: Annual trends in maximum and minimum temperature variations showing temporal changes in the highest and lowest recorded temperatures

3.2.2 Household perception of exposure

From 1 (low) to 4 (very high), the exposure index was evaluated according to the perceived changes across these four indicators (temperature, precipitation, indicators plant and hazard event). The findings indicate that both Telauli and Jitpur exhibited similarly high levels of exposure with index value of 2.04 and 2.08, respectively (Figure 9; Table 3). Although Jitpur recorded a slightly higher exposure score, the difference between the two communities was minimal.

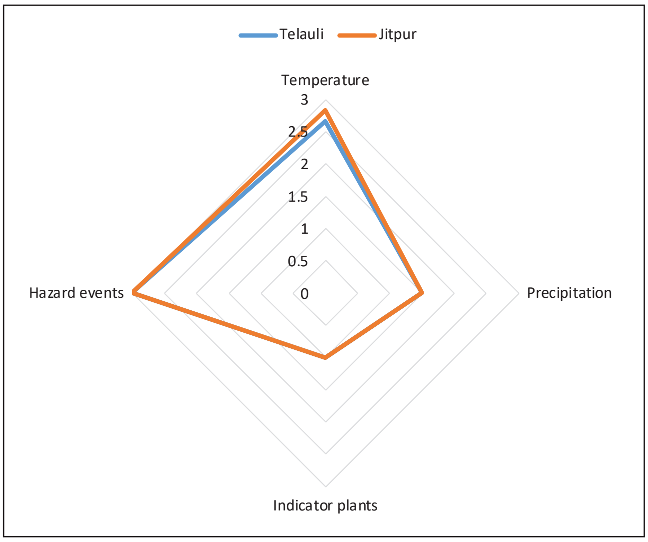

Figure 6: Radar chart showing overall exposure level of both communities

Despite statistically insignificant trends in rainfall and temperature, household perceptions indicate increasing climate stress from irregular rainfall, prolonged dry spells, and temperature extremes, leading to greater exposure to water scarcity, flash floods, crop loss, and altered farming practices, consistent with findings that climatic variability significantly increases livelihood stress (Kamalvanshi, 2022).

Table 3: Household level Perception of exposure in two Tharu communities

Subcomponents and its description	Perceived change Telauli	Perceived change Jitpur	Score index Telauli	Score index Jitpur
1.Temperature				
*All HH from both community perceived that increased temperature in both summer and winter season with a bit more rising patterns (since last 8-9 years); 3% HH from Telauli and 43% HH from Jitpur.	3	3	2.66	2.83
*57% HH from Telauli and 63% HH from Jitpur perceived hot waves in their area with 10-30% increasing patterns.	3	3		
*43% HH from Telauli perceived cold waves and 100% HH from Jitpur did not perceive such cold waves in their region	2	2.5		

2. Precipitation *All HH from both communities observed changes in monsoon rainfall with 56 % HH from Telauli and 71% HH from Jitpur perceived 30-50% decreasing patterns.	2	2	1.5	1.5
*Winter rainfall (74% HH from Telauli and 83% HH from Jitpur) perceived decreased winter rainfall with more than 50% fall				
3. Indicators plant	1	1		
* Majority of the respondents from both the communities do not observe any changes in the local plants in regard to flowering, fruiting, shredding and spurting season	1	1	1	1
4. Hazard events * Drought event (Almost respondents perceived increased duration and frequency with advancement by 8-15 days in Telauli and 21 days in Jitpur with 30% increasing patterns.	3	2	3	3
* Flood (Majority of the respondents perceived increased incident in flood at 30-50% rate from both the communities; 90% HH from Telauli and 100% HH from Jitpur perceived flood problem in their area.	3	4		
Average exposure index	High	High	8.16/4= 2.04	8.33/4=2.08

3.2.3 Sensitivity of Livelihood Resources to Climate Risks

According to Pairwise hazard ranking Metrix, Telauli is most sensitive to drought, while Jitpur showed highest sensitivity to floods (Appendix 1; Table A1 and Table A2). Natural assets (such as forest, water, agriculture) are highly sensitive in both communities, with stronger impacts in Jitpur as 71.14% of communities exposed to flood risk, which is more than double of Telauli (Figure 7), raising annual damage which is significant with financial stress (Rathod et al., 2024).

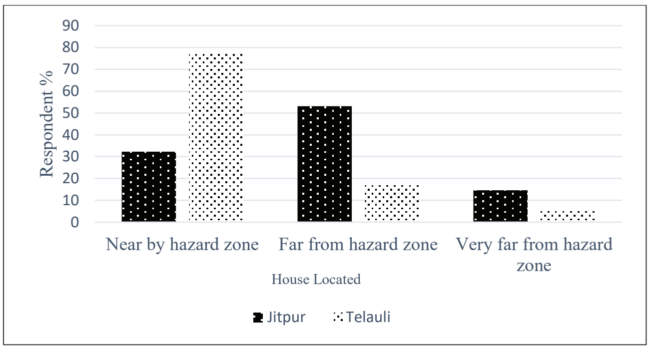

Figure 7: Distance of settlement from the flood effect zone

Telauli also showed higher sensitivity in food and water sectors, whereas Jitpur was found to be more sensitive in infrastructure, health, and forest sectors (Figure 8).

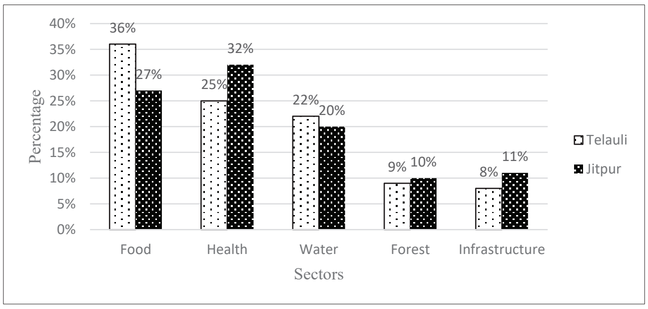

Figure 8: Perception of sensitivity by sector in both Telauli and Jitpur community

Across all five livelihood resources, both communities had high sensitivity to climate hazards, with Jitpur being more sensitive (S: 2.7) than Telauli (S: 2.3) (Figure 9; Table 4 and 5).

Table 4: Livelihood impact matrix results for the four main climatic hazards of Telauli

Livelihood Resources	Drought	Insects/pest/weeds	Hot/cold waves	Unseasonal rain	Sub index	Sensitivity index(S)
Natural Asset	4	3	2	2	2.75	2.3 (High)
Physical Asset	1	1	2	2	1.25	
Social Asset	1	1	2	2	2	
Human asset	3	3	3	3	2.75	
Financial Asset	3	4	2	3	2.75	
Avg. Sensitivity	2.4	2.4	2	2.4	2.3	

Table 5: Livelihood impact matrix results for the four main climatic hazards of Jitpur

Livelihood Resources	Flood	Drought	Insects/pest/weeds	Unseasonal rain	Sub index	Sensitivity index(S)
Natural Asset	4	4	3	2	3.25	2.7 (High)
Physical Asset	4	1	1	2	2	
Social Asset	3	1	1	3	2	
Human asset	3	3	3	3	3	
Financial Asset	4	3	3	3	3.25	
Avg. Sensitivity	3.6	2.4	2.2	2.6	2.7	

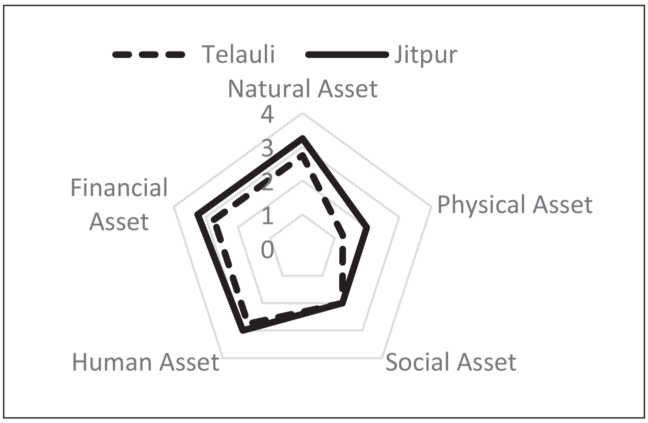

Figure 9: Five livelihood asset's overall sensitivity level is displaying in a spider web graph

3.2.4 Adaptability with Respect to Livelihood Resources

Better infrastructure and market access make Telauli more adaptable. Stronger saving groups in Telauli enhance resilience and coping capacity which is also align with the findings of CBVA by (Pudasaini, 2015). Human and financial capital were also higher in Telauli than Jitpur and as per (Wu et al., 2023), higher education and diversified incomes depicts the increased adaptive capacity. (Sharma et al., 2023) also highlighted to emphasize the natural capital for better adaptive capacity that ultimately enhance the community resilience. In this study, Jitpur had relatively better access to forest and water resources, whereas Telauli had comparatively better access to agricultural land and sand/gravel (mineral) resources. These contrasting advantages create a balance in overall natural capital between the two communities, despite generally limited resource available in both areas. Consequently, the livelihoods asset evaluation matrix shows an equal index value 2 for natural assets in both communities. According to the results of the livelihood asset, evaluation matrix (Table 6), Telauli recorded an adaptive capacity score of 2.3, which is notably higher than Jitpur's score of 1.5 (Figure 10)

Table 6: Livelihood asset evaluation Matrix regarding Adaptive capacity

Livelihood Resources	Sub-indices Telauli	Jitpur
Natural Assets	2	2
Physical Assets	2.5	1.5
Social Assets	2	1
Human Assets	3	2
Financial Assets	2	1
Avg. Index	2.3 (High)	1.5(Medium)

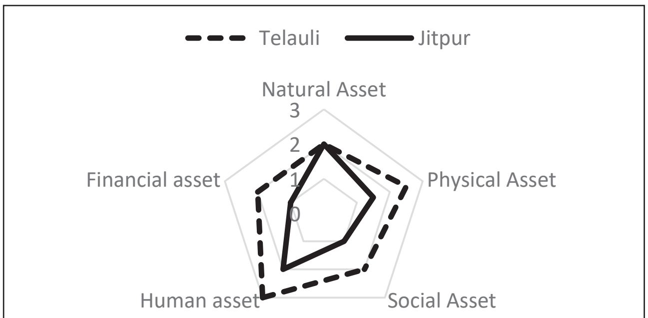

Figure 10: A spider web graph that displays the communities' ability to adapt

3.3 Climate Change Vulnerability of the Communities

Based on the CBVA paradigm, by using this functional representation (Equation i) vulnerability index was calculated.

$$\text{Vulnerability (V)} = f\left(\frac{E*S}{A}\right)\text{...... (i).}$$

The computed vulnerability indices were also divided into four levels: Low (<1), Medium (1-2), High (2-4) and very high (>4). So, with respective scores of 2.04 (High) and 3.8 (High), it was determined that Telauli and Jitpur had high vulnerability indices. In comparison to Telauli Jitpur's vulnerability scores were marginally higher (3.8), suggesting that Jitpur is more vulnerable due to its low adaptive capacity (Table 7; Figure 11). Higher adaptive capacity in Community Telauli corresponds to lower climate change vulnerability, as supported by literature (Jones et al., 2010; Pudasaini, 2015).

Table 7: Measurement of total vulnerability in Telauli and Jitpur communities

Telauli			Jitpur		
Components	Index	Vulnerability index	Components	Index	Vulnerability Index
Exposure	2.04	2.04	Exposure	2.13	3.8
Sensitivity	2.3		Sensitivity	2.7	
Adaptive capacity	2.3	(High)	Adaptive capacity	1.5	(High)

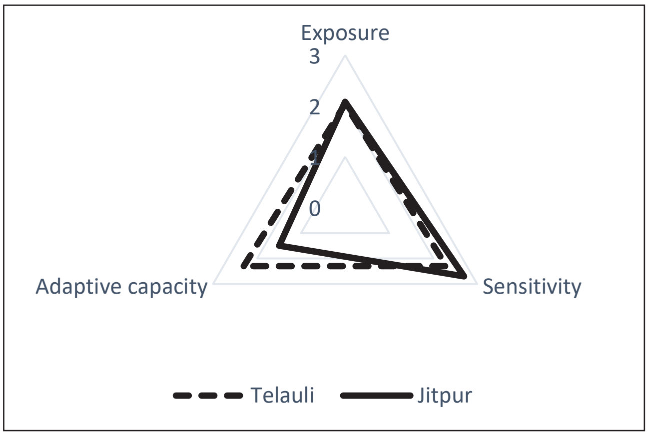

Figure 11: Triangle diagram of vulnerability illustrating its three main elements in both Telauli and Jitpur communities

4. Conclusion

The study reveals that, despite statistically insignificant long-term trends in rainfall and temperature, the Tharu community clearly perceived increasing climatic variability manifested through irregular rainfall, flash flood, prolonged dry spells, and temperature extremes. Both Telauli and Jitpur experienced high exposure to climate-related stressors, with Jitpur being more prone to flooding due to its geographical and settlement characteristics. Sensitivity was also found to be high in both communities, particularly in relation to financial and natural livelihood assets, with Jitpur exhibiting slightly greater sensitivity than Telauli. A key distinction lies in adaptive capacity: Telauli demonstrated relatively high adaptive capacity, while Jitpur is medium. This disparity significantly influenced overall vulnerability, as stronger adaptive capacity can offset the impacts of exposure and sensitivity more effectively. Consequently, while both communities are highly vulnerable to climate change, Jitpur is considerably more vulnerable than Telauli. These findings underscore that climate vulnerability and resilience are not solely determined by climatic factors, but are strongly shaped by the availability of local resources, and more importantly, their effective utilization. The study highlights the importance of integrating long-term climate data for improved detection of localized trends, alongside strengthening community-based adaptation strategies for both communities. Additionally, promoting both wet and drought-resilient crop varieties, and rainwater harvesting practices can play a vital role in community Telauli. In this study, the Tharu community's local knowledge and practices, such as traditional farming methods and understanding of seasonal changes, help them to cope with climate-related challenges. These local practices can support resilience and help them adapt to future climate uncertainties.

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Appendix A: Pair wise hazard ranking in two Tharu communities

Table A1: Pair wise hazard ranking for Community -Telauli

Climatic Hazards	Flood	Drought	Hot/ Cold waves	Insects/pest/ weeds	Unseasonal rain	Hail	Strom	Fire	Ranks
Flood	*	Drought	Hot/ Cold waves	Insects/pest/ weeds	Unseasonal rain	Hail	Flood	Flood	2
Drought	*	*	Drought	Drought	Unseasonal rain	Drought	Drought	Drought	6
Hot/cold waves	*	*	*	Insects/pest/ weeds	Unseasonal rain	Hot/Cold waves	Hot/Cold waves	Hot/cold waves	4
Insects/pest/ weeds	*	*	*	*	Insects/pest/ weeds	Insects/ Pest/Weeds	Insects/pest/ weeds	Insects/pest/ weeds	5
Unseasonal rain	*	*	*	*	*	Unseasonal rain	Unseasonal rain	Fire	3
Hail	*	*	*	*	*	*	Hail	Hail	3
Strom	*	*	*	*	*	*	*	Fire	0
Fire	*	*	*	*	*	*	*	*	2

Table A2: Pair wise hazard ranking for community -Jitpur

Climatic Hazards	Flood	Drought	Hot/Cold waves	Insects/pest /weeds	Unseasonal rain	Hail	Strom	Fire	Ranks
Flood	*	Flood	Flood	Flood	Flood		Flood	Flood	7
Drought	*	*	Drought	Drought	Drought	Drought	Drought	Drought	6
Hot/cold waves	*	*	*	Insects/pest/ weeds	Unseasonal rain	Hail	Hot/Cold waves	Hot/ cold waves	2
Insects/ pest/ weeds	*	*	*	*	Insects/ pest/weeds	Insects/ Pest/ Weeds	Insects/pest/ weeds	Insects/ pest/ weeds	5
Jnseasonal rain	*	*	*	*	*	Unseason al rain	Unseasonal rain	Unseasonal rain	2
Hail	*	*	*	*	*	*	Hail	Hail	2
Strom	*	*	*	*	*	*	*	Fire	0
Fire	*	*	*	*	*	*	*	*	1
Fire	*	*	*	*	*	*	*	*	2