Climate Change Vulnerability of Livelihoods of People Residing in Kaski District of Nepal

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ABSTRACT

This study assesses the climate change vulnerability of livelihoods across altitudinal gradients in the Kaski district of Nepal. A sample of sixty-five households from four different communities in municipalities (Annapurna rural municipality and Machhapuchchhre rural municipality) was selected through random sampling and surveyed at various elevations. The Principal Component Analysis (PCA) approach and the Composite Index Method (CIM) were employed to evaluate and determine IPCC-VI. To derive Adaptive capacity, Sensitivity, and Exposure, the components such as Social Demographic Profile (SDP), Social Networking (SN), Livelihood Strategies (LS), Health (H), Water (W), Food (F), Natural Disaster and Climate Variability (ND CV) were used. The trend of the temperature and rainfall were analyzed and it was found that the mean annual maximum temperature is increasing at a rate of 0.036°C per year and the annual rainfall is decreasing at 14.532 mm per year. Among the communities, Melache (2210m), in Annapurna Rural Municipality exhibited the highest vulnerability (IPCC-VI: 0.118), whereas Hudu (1490m) showed a lower vulnerability index (0.025). In Machhapuchchhre Rural Municipality, Dhampus upper region (1660m) displayed moderate vulnerability (IPCC-VI: 0.043), with the Dhampus lower region (1360m) showing the least vulnerability (-0.011). So, all the communities demonstrated intermediate vulnerability levels indicating a need for tailored adaptation strategies across the elevation levels. Effective adaptation efforts could improve community resilience by addressing local climate challenges, ensuring sustainable livelihoods, and reducing future vulnerability risks.

Keywords: IPCC-VI, Altitude, Livelihoods, Climate Change

1. Introduction

The term "climate change" describes long-term alterations to the Earth's climate system, such as variations to its properties and patterns, brought about by both natural and man-made processes that affect the atmosphere's composition (Pachauri et al., 2014). There are both short-term and long-term risks for Nepal because of its extreme vulnerability to natural hazards and climate change. The nation is susceptible due to its complex mountainous geography, unpredictable monsoon-driven climate systems, chaotic population patterns, and inadequate infrastructure (World, 2022)

1.1. Climate change vulnerabilities and its multifactorial approaches

Vulnerability refers to the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt Pachauri et al. (2014). Every year, Nepal faces the repercussions of heavy rainfall, which triggers devastating floods, landslides, and erosions, and causes extensive damage to crops and livestock. These calamities not only disrupt livelihoods but also deteriorate the overall environmental and human health conditions of the affected areas (Acharya et al., 2021). The estimated per capita income of Nepali citizens for the fiscal year 2023/24 is projected at approximately USD 1,400 (MoF, 2021). It reflects modest economic growth and the challenges Nepal faces in sectors such as agriculture, industry, and tourism, which are key to economic expansion efforts by the government.

The ability of the Nepalese people to cope with natural disasters brought on by climatic fluctuation or climate change is limited. Because of its insufficient capital, the federal government fails to give both the adaptation factors and the targeted farmers top priority. According to the Climate Risk Index (CRI), Nepal is placed fourth, indicating a high degree of vulnerability. Its mortality rate is 0.559 fatalities per 100,000 people, and its economic losses as a percentage of GDP are 2.412% Eckstein et al. (2019).

The IPCC Sixth Assessment Report (IPCC AR6) provides IPCC-VI tools for assessing the vulnerability of communities to climate change impacts through three primary approaches:

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a) Exposure: Exposure refers to the presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected Pachauri et al. (2014).

b) Sensitivity: Sensitivity is the degree to which a system or species is affected, either positively or negatively, by climate alterations. Changes in crop yields in response to variations in average temperatures or fluctuations in temperature are examples of direct effects of this. On the other hand, it may have an indirect impact, such as harm from more frequent coastal floods brought on by sea level rise Houghton et al. (2001). The sensitivity of a specific program or development plan to various hazards may differ across different locations, as the climate sensitivity of a plan or program is specific to each study area NPC (2011).

c) Adaptive Capacity: Adaptive capacity refers to the ability of systems, institutions, humans, and other organisms to adjust to potential damage, take advantage of opportunities, or respond to consequences Houghton et al. (2001).

2. Study Area

Annapurna as well as Machhapuchchhre rural municipalities in Kaski District, situated in the Gandaki province of Nepal, experience a warm, temperate monsoon environment at elevations between 1200 and 2100 meters with the GPS location :28°16'00" N and 83°58'06" E in latitude and longitude as shown in Figure 1.

The climate changes to a freezing temperate monsoon climate as the elevation climbs to 3300 meters. The area embraces a tundra ecosystem at 3500 meters and above. The vegetation in Machhapuchchhre Gaupalika exhibits a blend of deciduous and evergreen plants, forming a diverse forest ecosystem with characteristics. Machhapuchchhre rural municipality has a population of 27,873 people who live there, with women making up 48.66% of the population (13.564) and men making up 51.34% of the population (14.309) (NSO, 2021). The area covered by the municipality is 545.52 square kilometers. Its population density is 51 people per square kilometer, and it is split into nine wards. Annapurna rural municipality is covered by a municipality, which is 417.74 square kilometers and has 11 wards with 23,417 of the total population (NSO, 2021).

3. Materials and Methods

3.1. Sampling process

The sample size formulae compute the sample size of a respondent community, as it was a crucial step in the research with the known population size (Kothari, 2004). The sample size of respective ward's community was calculated using equations 1 and 2 as given:

$$n = \frac{Z^2.N.p(1-p)}{(N-1).e^2 + Z^2 p(1-p)} \tag{1}$$

where, N= Size of Population, n = Size of a sample, e = acceptable error (the precision) (error 5% = 0.05 which is relevant with a confidence level of 95% so the error is 5%), p = Estimate of a proportion of the Population (So, the highest proportion cannot be more than 50% = 0.50), Z = Standard variate of a confidence level at 95% (so, Z-score is 1.96).

$$s = \frac{H.R.C}{N} * n \tag{2}$$

where, s = Sample size for respondent community or Sample size (n) for the community, H.R.C = Total number of households in the respondent community, N = Total finite population size of respective ward, n = Sample size of respective wards. The calculation of sample size for a known population is given as an example of the Upper Region in Melache is illustrated in Table 1:

3.2. Data collection

65 household surveys were conducted in four distinct locations situated at different elevations using the random sampling method. 21 households in Annapurna Rural Municipality, in the upper region of Melache (2210m), and 13 houses in the lower region of Hudu (1490m), were surveyed. Likewise, in Machhapuchchhre Rural Municipality, 17 households were surveyed in the upper region (1660m) and 14 households in the lower region (1360m) of Dhampus ward number 7. The primary data collection process took approximately 12 days, between June 25, 2023, and July 6, 2023. The primary data were gathered through household surveys and key Informant Interviews (KII). The secondary data were gathered from multiple sources, including the Wards and Municipality websites. The population structure data was obtained from the National Population and Housing Census of 2021 (NSO, 2021), ensuring up-to-date and accurate information. Additionally, climate-related data were taken from the nearest station operated by the Department of Hydrology and Meteorology (DHM, 2017).

3.3. Data Analysis

The data analysis employed in this study incorporated both the Principal Component Analysis (PCA) method and the Composite Index Method (CIM). PCA was employed in data processing and feature extraction to ensure that all variables within a dataset were on a consistent scale. This is particularly useful when dealing with data that are either highly correlated or contain large datasets. CIM is a statistical approach used to condense multiple variables or

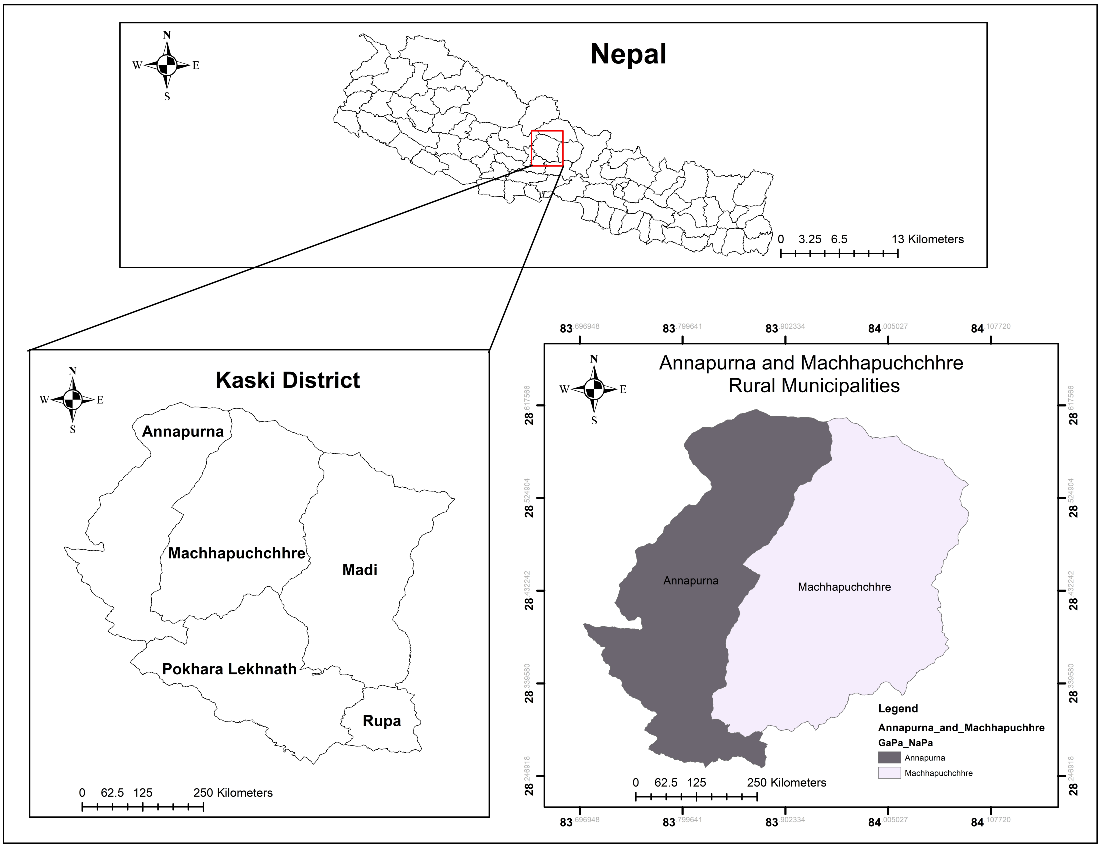

Figure 1. Map of Study Area.

Table 1. Calculation of sample size using the equation 1 and 2 of Melache (Annapurna Rural Municipality).

SN	Annapurna Gaupalika Ward 11 Melache upper region of Ghandruk
1	N = 444 (Total Number of HH in Ward 11)
2	Z- Score = 1.96
3	p = 0.5
4	e = 0.05
5	n = 206.16 ≅ 206
6	H.R.C = 45
7	s = 20.89 ≅ 21

indicators into a single numerical index(Hahn et al., 2009; Mainali and Pricope, 2017).

Importantly, no prior assumptions were made concerning the significance of individual factors, as most values exhibited a normal distribution within the composite index. Additionally, the analysis included trend analysis using linear regression, allowing for an examination of trends and relationships within the data, for which Microsoft Excel software and SPSS were used.

3.4. Analysis of the Climatic Data

Climatic data were analyzed to understand variability in climate, specifically concerning changes in temperature and precipitation (Figures 2 and 3). This analysis helped to identify extreme weather events, such as landslides and droughts, in the survey region. These events directly impacted crop yields, water availability, and the health of the local population, as illustrated in Tables 2 and 3. So, to determine a linear trend, the data were subjected to a basic linear regression analysis using Equation 3, where the linear relationship between the time-series data (Y) and the time (t) can be seen(Dhungana et al., 2021).

$$Y = a + bt \tag{3}$$

where, Y=Temperature or Rainfall (Yearly/Monthly/Daily), t=Time (Yearly) & a and b both are constant.

3.5. Calculation of LVI (Livelihood Vulnerability Index)

Seven key elements make up LVI: Social Demographic Profile (SDP), Livelihood Strategies (LS), Social Networks (SN), Health (H), Food (F), Water (W), Natural Disaster (ND), and Climatological Variability (CV). These key components, sub-components, and methodologies, were employed as the requirements of the research.
Step 1: Maximum value was set at 100 and minimum value at 0, other sub-components were set according to requirements, for example, months = 12, the ratio in 1:2 format

$$\text{Index}_{S_c} = \frac{S_c - S_{\min}}{S_{\max} - S_{\min}} \tag{4}$$

where, S_c = Original sub-component for a community, Smax and Smin = Maximum and Minimum values of Sub-components from the community after a survey.
Step 2: After normalizing the value in equation 4, the sub-components were averaged (Standardization) to calculate the major components of a respective community (Mc).

$$\text{M}_\text{C} = \sum_{\text{i}=1}^{\text{n}} \frac{\text{Index}_{\text{S}_\text{c}\text{i}}}{\text{n}} \tag{5}$$

where, M_c = Major components, n = The Total number of sub-components available in the major components, $\text{Index}_{\text{S}_\text{c}\text{i}}$ = Normalized or balanced weight calculation of each sub-component indexed by i from equation 4.
Step 3: Adaptive Capacity, Sensitivity, and Exposure were calculated from the normalized and average standardization data obtained from equations 4 and 5, as shown in below equations 6,7,8, and 9.

3.5.1 Adaptive capacity

The core concept of this approach is a combination of sociodemographic profile (SDP), social network (SN), and Livelihood Strategies (LS).

$$\text{Adap. cap.} = \frac{W_{A_1} \cdot SDP + W_{A_2} \cdot LS + W_{A_3} \cdot SN}{W_{A_1} + W_{A_2} + W_{A_3}} \tag{6}$$

The weights of the three major components, W_{A_1}, W_{A_2}, and W_{A_3}, as well as the total number or weight of their sub-components, are indicated.

3.5.2 Sensitivity

Equation 7 below illustrates the equation of sensitivity and the overall weightage of the three main components, health (H), food (F), and water (H), as well as their subcomponents.

$$\text{Sen} = \frac{\text{W}_{S_1}\text{H} + \text{W}_{S_2}\text{F} + \text{W}_{S_3}\text{W}}{\text{W}_{S_1} + \text{W}_{S_2} + \text{W}_{S_3}} \tag{7}$$

where W_{S_1}, W_{S_2}, and W_{S_3} represent sensitivity with the weighted average of its three principal components.

3.5.3 Exposure

Equation 8 below shows the overall weightage of the two major components, Natural Disaster (ND), and Climatic Variability (CV), as well as their sub-components.

$$Ex. = \frac{W_{E_1}ND + W_{E_2}CV}{W_{E_1} + W_{E_2}} \tag{8}$$

Here, WE1, and WE2, are the exposure with the weightage of three major components and their sub-components.

3.6. LVI-IPCC approach

The IPCC vulnerability index concept is incorporated into the LVI-IPCC strategy. According to the IPCC definition, outcome (or endpoint) vulnerability is the result of a system's exposure to and sensitivity to climatic stimuli as well as its ability to adapt to their (unfavorable) impacts (Pachauri et al., 2014). The LVI-IPCC approach was developed by Hahn et al. (2009) and applied in two villages in Mozambique with varying socio-economic and environmental conditions, where it effectively captured differences in community-level climate vulnerability.
Step 4: Exposure, Sensitivity, and Adaptive Capacity are the three contributing factors (CF) identified by the IPCC-VI; each has a unique set of major components and sub-components that are computed using Equations 6, 7, and 8.

$$CF_c = \sum_{i=1}^{n} \frac{W_{mi}\ M_i}{W_{mi}} \tag{9}$$

Here, CF is the contribution factor (Exposure, Sensitivity, and Adaptive Capacity) Mi and Wmi are the numbers of subcomponents and the weightage of major components. After calculating the CF, the three CF combine to calculate IPCC-VI as shown in equation 10.

$$LVI - IPCC_c = (\ e_c - a_c) * \ s_c \tag{10}$$

ec stands for exposure of a community, ac stands for adaptive capacity of a community and sc stands for sensitivity of a community.

4. Results and Discussion

4.1. Climatic data trend

a) Precipitation Lumle, station index 0814, situated in Annapurna Gaupalika has the highest amount of rainfall in the entire country. From the analysis period of (1992-2022) the annual average rainfall was 5497.015mm which the highest rainfall in all around the country but it has been dropping on average at a rate of 14.532 mm per year in or around the Lumle area as illustrated in the timeline graph "Figure 2". So, in a similar study of Lumle station from (2001 to 2017) analyzed the decreasing trend in rainfall, at the rate of 12.53mm per year (Basnet et al., 2020). A phenomenal 95% of respondents said people have seen changes in the climate during the previous 30 years. However, the study also showed that these locals had difficulties correctly estimating the timing, amount, and patterns (Shrestha et al., 2019)

b)Temperature The highest average maximum temperature was recorded in 2012, reaching 22.04°C. Conversely, the lowest average maximum temperature occurred in 1997, with a value of 18.69°C. In all other years, the maximum temperature ranged between 18°C and 22°C. Notably, there is an observed increase in the mean annual maximum temperature at a rate of 0.036°C per year, as shown in Figure 3. The highest annual mean minimum temperature was recorded in 1999, reaching 13.02°C. Subsequently, it gradually decreased to 12°C in 2000 and further to 11°C in 2001. From 2001 onwards, there has been a consistent fluctuation, with the mean annual minimum temperature remaining in the range of 12°C to 11°C until 2022 (Figure 3). This indicates a minimal decrease in the minimum temperature over this period, occurring at a very gradual rate of approximately 0.0005°C per year. Compared to the minimum and maximum average annual temperatures, the minimum temperature has shown only minimal changes in the rate over the past 30 years. However, the maximum temperature has accelerated, which has affected the health of the people and increased the risk of natural disasters, as shown in Table 2.

4.2. Major components and sub-major components of LVI

The primary components of LVI were derived from the IPCC reports (Houghton et al., 2001) and the sub-components have been adapted from Hahn et al. (2009). According to the requirements of the study area and geographical considerations, the average of sub-major components was calculated using multiple factors as given in Tables 2 and 3.

Calculation of Sub-components and Major Components (Example of Dhampus Lower Region)

Step 1: Calculation for sub-components (repeat for all sub-components)

$$\text{Index (Health)} = \frac{\text{Observed value - Minimum value}}{\text{Maximum value - Minimum value}}$$

$$= \frac{2-1}{9-1} = 0.125$$

Step 2: Calculation for major components (repeat for all major components)

$$\text{Health} = M_{\text{Dhampus Lower Region}} = \frac{\sum_{i=1}^{n} \text{Index}_{\text{Sc}^i}}{n}$$

$$= \frac{0.124 + 0.429 + 0.143}{3} = \frac{0.693}{3} = 0.232$$

Step 3: Calculation for contributing factors (Adaptive Capacity, Sensitivity, and Exposure)

$$\text{Adaptive Capacity}_{\text{Dhampus Lower Region}} = \frac{W_{S_1}H + W_{S_2}F + W_{S_3}W}{W_{S_1} + W_{S_2} + W_{S_3}}$$

$$= \frac{(3)\cdot 0.232 + (3)\cdot 0.127 + (6)\cdot 0.238}{3+3+6} = 0.208 \tag{11}$$

Step 4: Calculation for all study areas

$$\begin{aligned} \text{IPCC-VI}_{\text{Dhampus Lower Region}} &= (e_c - a_c)\cdot s_c \\ &= (0.458 - 0.513)\cdot 0.208 = -0.011 \end{aligned} \tag{12}$$

The area of Melache-11 in Ghandruk, situated at an elevation of 2210 meters, exhibits the highest IPCC-VI (Intergovernmental Panel on Climate Change Vulnerability Index) which stands at 0.118, which falls into the moderate vulnerability range. Despite this, Melache-11 is more vulnerable when compared to three other communities. Meanwhile, Hudu-10 is less vulnerable than Melache-11 but still highly vulnerable overall. The Dhampus lower region stands out as the least vulnerable among the four communities, while the Dhampus upper region exhibits a higher LVI. These disparities in vulnerability can be attributed to various contributing factors. According to Table 3, the vulnerability level of four distinct communities falls under the range of 0.118 to -0.011 which is moderately vulnerable. Melache has 0.118 IPCC-VI which also falls under the moderate vulnerability level but it is near the high vulnerability range. This can be compared the study conducted in Ladakh, India, which identified their susceptibility to climate change-induced natural disasters, the value in Panamik regions of Ladakh was much lower (0.007) (Tashi and Sudan, 2022) than that of Melache, making Melache vulnerable in all aspects, including sensitivity and adaptive capacity. The vulnerability level for Dhampus Upper-ward 7 is 0.043, which is somewhat more sensitive

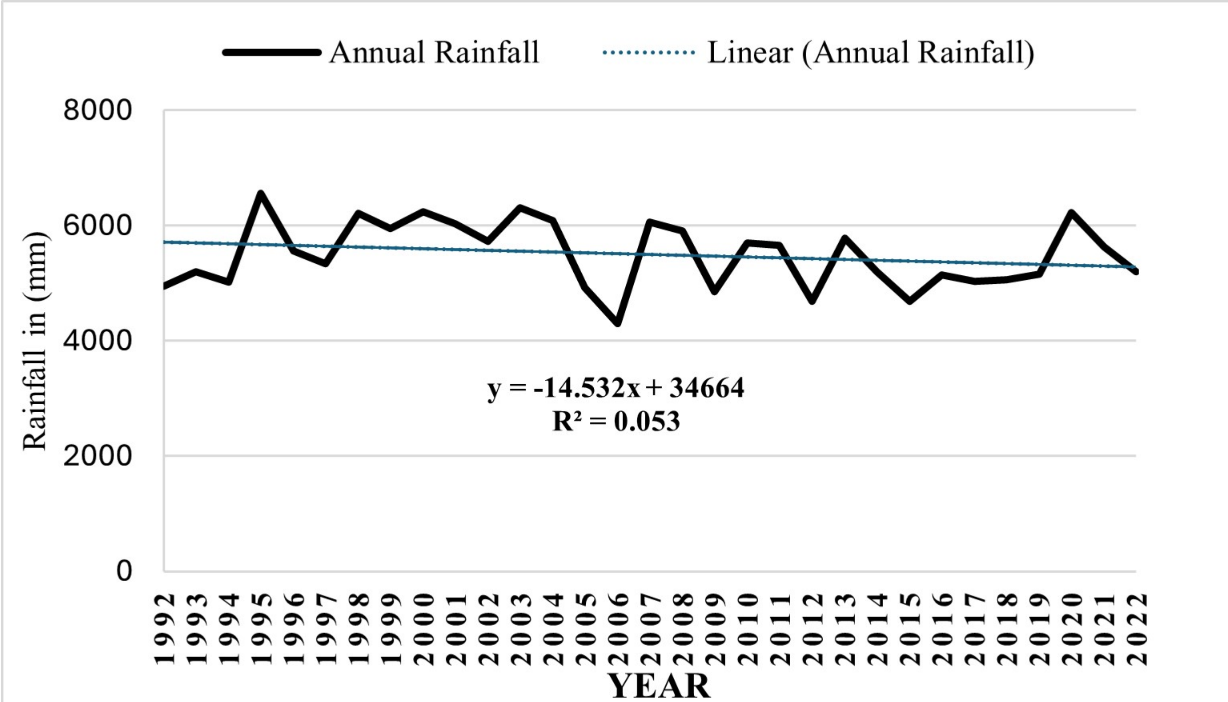

Figure 2. Annual trend analysis of rainfall data .

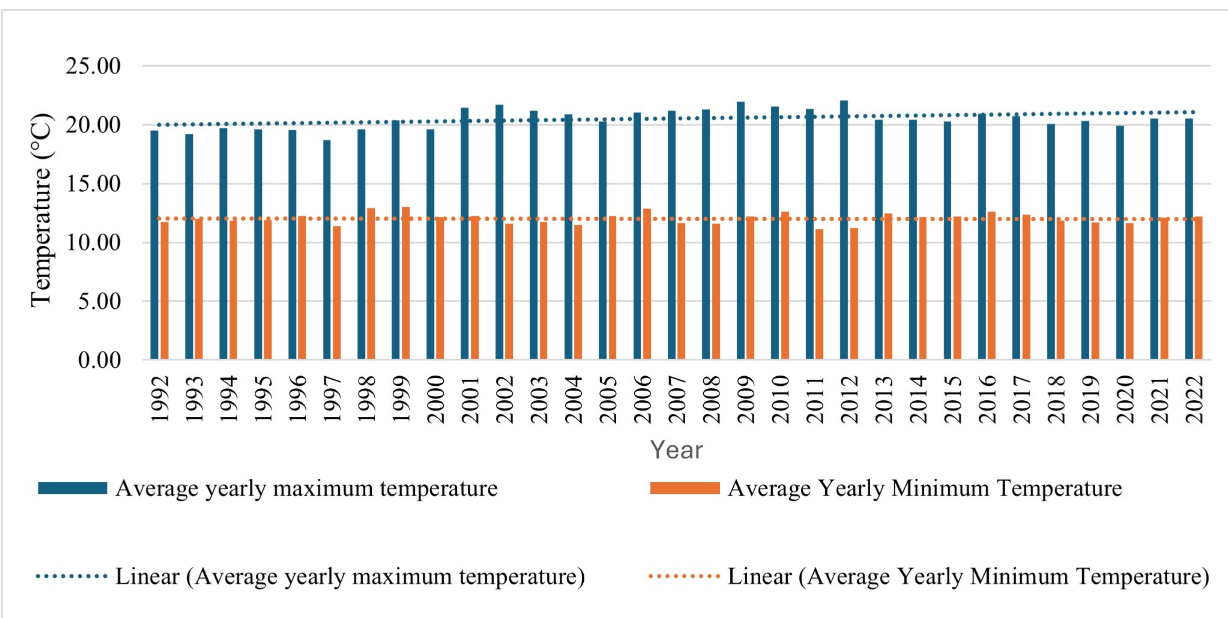

Figure 3. Average yearly minimum and maximum temperature.

than Hudu-10 (0.025). This is because the region's sensitivity to food and health issues was a little greater. Dhampus Lower- Ward 7 is less vulnerable (-0.011) than the other three communities because it has high adaptive capacity, less sensitivity and exposure. A comparison study with Bhutan showed that the livelihoods of potato farmers were vulnerable to the climatic variability. So, IPCC-VI was -0.005 to 0.030at a distinct district (Rai et al., 2022) but it

Table 2. LVI major components, sub-major components, and average of sub-major components for four distinct locations.

Major Components	Sub-Major Components	Melache	Hudu	Dhumpus Upper	Dhumpus Lower
Socio-Demographic Profile	Dependency ratio % of women headed HH % of family heads without primary education % of orphans	0.18	0.311	0.235	0.408
Livelihood Strategies	% of HH solely depends upon Tourism % of HH that rely solely on agriculture for their income % of HH where members seek external sources of income The Agricultural Livelihood Diversification Index (0.20 to 1)	0.402	0.567	0.487	0.575
Social Network	Average receives help ratio from others (0-15) % of individuals not helping the community or local government Average number of HH individuals lending money (0.5 - 2)	0.372	0.428	0.413	0.573
Health	Average distance to nearest health post (Minutes) % of HHs with chronic diseases % of students missing school due to illness	0.498	0.292	0.355	0.232
Water	Average time to reach water resource (Minutes) % of HHs dependent on natural resources % of HHs reporting water conflicts	0.33	0.247	0.204	0.127
Food	Average number of HHs with food scarcity per month (0-12) % of HHs dependent on family farms Crop diversity index (0 to 1) % of HHs not saving seeds Average crop loss from natural calamities % of HHs not saving harvested crops	0.593	0.367	0.426	0.238
Natural Disaster and Climate Variability	Average number of natural disasters (0-7) % of HHs lacking early warning systems % of HHs experiencing death or injury in 10 years Average daily maximum temperature (mean, SD) Average daily minimum temperature (mean, SD) Average monthly precipitation (mean, SD)	0.549	0.514	0.497	0.458

Table 3. IPCC-VI with contributing factors for four communities.

Contributing factors	LVI Contributing factors value			
	Melache	Hudu	Dhumpus Upper	Dhumpus Lower
Adaptive Capacity	0.313	0.436	0.375	0.513
Sensitivity	0.500	0.316	0.352	0.208
Exposure	0.549	0.514	0.497	0.458
IPCC-VI	0.118	0.025	0.043	-0.011

is still less vulnerable than the Hudu and Dhampus upper region. Figure 3 takes the form of a triangle and serves as an illustrative depiction of values derived from seven significant components: SDP, LS, SN, H, F, W, and ND and

CV. These components are integral factors contributing to the Livelihood Vulnerability Index (LVI) and the calculation is illustrated in Table 3. It can be further categorized into three key aspects: Adaptive Capacity, Exposure, and Sensitivity. The analysis is presented for four distinct communities: Melache, Hudu, Dhampus Upper, and Dhampus Lower regions. Within the triangular diagram, it is evident that Melache exhibits the highest vulnerability. This is evident through its lower Adaptive Capacity score, which stands at 0.313, and its elevated Sensitivity (0.500) and Exposure (0.549) in comparison to the other three communities. Conversely, the Dhampus Lower region emerges as the least vulnerable, boasting an Adaptive Capacity score of 0.513, lower Sensitivity (0.208), and reduced Exposure (0.458) when contrasted with the other communities.

Hudu and Dhampus Upper regions fall into the intermediate range of vulnerability compared to Melache and Dhampus Lower regions. Notably, Hudu displays a slightly higher vulnerability due to higher Exposure (0.514) than Dhampus Upper (0.497). However, Dhampus Upper has higher Sensitivity (0.352) than Hudu (0.316). In terms of Adaptive Capacity, Hudu slightly outperforms Dhampus Upper with a score of 0.436 versus 0.375.

To sum up, the triangular diagram represents a range of values falling within 0 to 0.6 range for all the components, encapsulating the vulnerability assessment of these communities.

4.2.1 Adaptive Capacity (AC)

The value of Adaptive Capacity (AC) ranges from 0.513-0.313, which shows the high gap between the lower region and the upper region. Melache has the lowest AC compared to the other three communities because it has a lower value in Social Demographic Profile, Social Network, and Living Strategies. Additionally, none of households were led by women, and 43 percent of individuals lived outside of the village in search of other sources of income. Because the income is so low, people won't be able to adapt to climate change in the future; farming needs modern technology but still, people are using indigenous knowledge, and also it was discovered that people use local knowledge, such as using bamboo nets to cover crops and vegetables, harvesting before rainy and snowy seasons, storing potatoes and other vegetables in deep holes to keep moisture out of the crops, and using Artemisia vulgaris, also known locally as Titepati, to control insects similar to the findings in Solukhumbu district by (Lama and Devkota, 2009). The average number of loans per family is significantly greater (42%). Because it has a lower SDP (0.235), only 11% of households are headed by women, and more people rely on tourism than agriculture for a living, the Dhampus Upper region is also extremely vulnerable in terms of adaptive capacity. However, this is unsustainable because of the region's extremely high exposure. Additionally, 50% of respondents reported having received a loan from a bank or relative. Hudu and Dhampus Lower region has a bit higher AC of 0.436 and 0.513 respectively compared to that found by Zhang and Fang (2020) for Sindhuli district, 52% of HH do not have any savings for future needs, and the poverty threshold is extremely low. People are dependent on the local government for financial assistance in 44% of cases, relatives in 52 percent of cases, and NGOs and INGOs in the remaining cases (Zhang and Fang, 2020). This is due to the district's resident's vulnerability to financial or capital losses because of agricultural farms being damaged by landslides and soil erosion (Zhang and Fang, 2020).

4.2.2 Sensitivity

The sensitivity of lower region is 0.208 and the higher region is 0.500. This indicates that the higher altitudes have somewhat more acute sensitivity than lower altitudes. In Melache, residents are particularly concerned about their health and food since there is no transportation and they can only access their farms' produce for 5 months of the year and when they get sick, they must walk 3 hours. However, the Dhampus Upper region's sensitivity (0.352) is also greater due to the area's low food production and lack of contemporary technology, which would allow them to sustain themselves for a year. This is because of the region's vulnerability to harsh weather. Hudu has a sensitivity value of 0.316 and is sensitive to health; it takes over an hour to walk to the closest clinic, and it takes over three hours to get to the hospital. Since there are more residences in the neighborhood and food can be produced in hotter weather, Dhampus Lower is less sensitive to health, water, and food issues. They can also easily access a health post that is 5 minutes away by foot. Nepal is currently facing serious climate change challenges because of an unprecedented rise in heat and natural disasters like flooding, landslides, and vector-borne illnesses. Additionally, there are social and environmental differences within the nation and a lack of adaptability in the health system (Dhital and Koirala, 2016).

4.2.3 Exposure

Melache has a high exposure value of 0.549 compared to other communities, making it even more difficult for inhabitants in their daily lives due to natural disasters including landslides, cold waves, and snowfall. There are no early warning systems in Annapurna and Machhapuchchhre Rural Municipalities, which make it impossible for people to get early warning information on rainfall, hail, or snowfall because of abrupt seasonal weather changes. Climate change vulnerability study in Langtang by (Mandal and Khanal, 2019) have shown that a lack of early warning system which causes them to lose their growing crops as well as crops during harvesting time. KIIs were conducted with

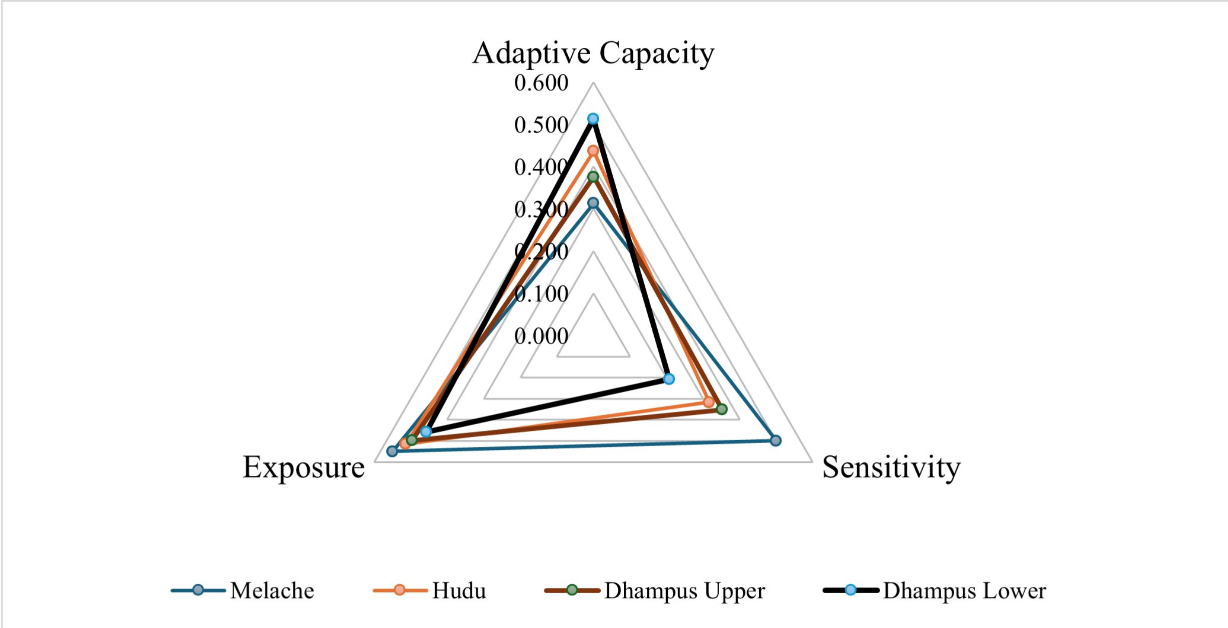

Figure 4. Contributing factors of LVI for Annapurna and Machhapuchchhre Rural Municipality.

ward representatives to assess the exposure. The participants confirmed that there is no such early warning system at the local or provincial level and people are suffering from natural disasters, landslides, and floods. All communities have high exposure scores, and Hudu (0.514) is no exception. In Hudu, roughly 30.46% of HHs had experienced a fatality or injury in the last ten years. Similar study in the Ladhak region of India on vulnerability and exposure due to the effects of natural disasters at varying levels, showed that most of the specific locations are vulnerable due to climate change-induced natural disasters (Tashi and Sudan, 2022). However, in this study, the exposure rate increased as the altitude increased, and Dhampus Upper had an exposure rate of 0.497, making it more susceptible for the population when compared to the other four communities.

5. Conclusions

The Vulnerability analysis of four distinct communities of Annapurna Rural Municipality (Melache and Hudu) and Machhapuchchhre Rural Municipality (Dhampus upper and Lower region) were analyzed according to elevation ranging from (1360-2210m). The Vulnerability was obtained from IPCC-VI approach. The research showed that the Melache which is situated at 2210m altitude is the most vulnerable community and the Dhampus Lower region situated at 1360 m is the least vulnerable among the four study areas. The study concluded that the vulnerability increased with the increasing elevations.

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