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The Implications of Climate Variability on the Livelihood of Local Communities of Melamchi Municipality

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Abstract

Climate change is humanity's most serious concern, with far-reaching and severe consequences for people, ecosystem services, and the environment. The study aims to evaluate the implications of climate variability on the livelihood of local communities of Melamchi municipality. The study collected primary data through focus groups, interviews, and observations and analyzed 31 years of precipitation and temperature data. The study assessed participatory vulnerability to climate change using indicators of exposure, sensitivity and adaptive capacity. Analysis of precipitation data showed decreasing annual rainfall trends at Dubachaur and Baunepati stations, while Sarmathang station showed an increasing trend. The maximum average annual temperature has shown a rising trend in all three stations. The RAI analysis showed that 2009 had the highest negative value, with an RAI of -4.87, classified as extremely dry from the rainfall data collected from the Baunepati station. Respondents reported severe climate change impacts on livelihoods, including increased temperatures, shifting rainfall, drought, water shortages, and invasive species. The study recommends urgently enhancing local climate adaptation efforts by integrating considerations of water security, food systems, and disaster risk reduction into development planning.

Keywords: adaptation, exposure, livelihood, perception, sensitivity

Introduction

Climate change is associated with a change in the state of the climate system over time, whether caused by natural or man-made factors. Climate change is one of the century's most pressing global issues. The past several decades have seen a marked rise in climate variability and seasonal unpredictability as a result of rising atmospheric greenhouse gas (GHG) emissions, which have led to a decline in agricultural production (Calzadilla et al., 2013; Ray et al., 2019; Wiebe et al., 2019). It is anticipated that Nepal will warm more rapidly than the average region. Nepal is projected to warm by 1.2^{0}C to 4.2^{0}C by the

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2080s relative to the 1986-2005 baseline period under the most extreme emission scenario, RCP8.5 (WBG & ADB, 2021).

Nepal is particularly vulnerable to geological and climate-related disasters due to its diverse topography and social fragility. Recent years have seen an increase in the intensity and impact of soil erosion, landslides, flash floods, and droughts across the nation, posing a greater threat to the lives and livelihoods of the Nepalese (Ahmed & Suphachol, 2014). Agriculture, which includes crops, livestock, and fisheries, is a major economic sector in Nepal, providing the primary source of income and livelihood in rural areas as well as significant revenue through agricultural exports. In 2019/20, the sector contributed approximately 27.65% of Nepal's GDP (Nepal Rastra Bank, 2020), and approximately 66% of the country's population worked in the agricultural sector (GoN, 2021). Rising temperatures, changes in precipitation, and increased extreme weather events have impacted agricultural productivity. The sector is vulnerable to climate change because it relies on small-scale, rain-fed agriculture and dryland farming (Paudel et al., 2016).

According to MoFE (2019), the average temperature of sindhupalchowk for the reference period of 1981 to 2010 is 7.8 ^{0}C. Likewise, the average precipitation for the reference period of 1981 to 2010 is 2241 mm. Climate change has far-reaching consequences, indicating a complicated and cross-cutting subject. This can influence communities' socio-economic status, hinder progress toward development goals, and pose a general danger to long-term development in developing countries with a higher reliance on natural resource-based livelihoods (IPCC, 2007). Every year, climate-induced disasters take a significant toll in terms of both lives lost and property damage. The Melamchi Bazaar was devastated by severe flash floods on June 15, 2021, from two tributaries, the Melamchi and Indrawati Rivers, causing several fatalities and significant property damage.

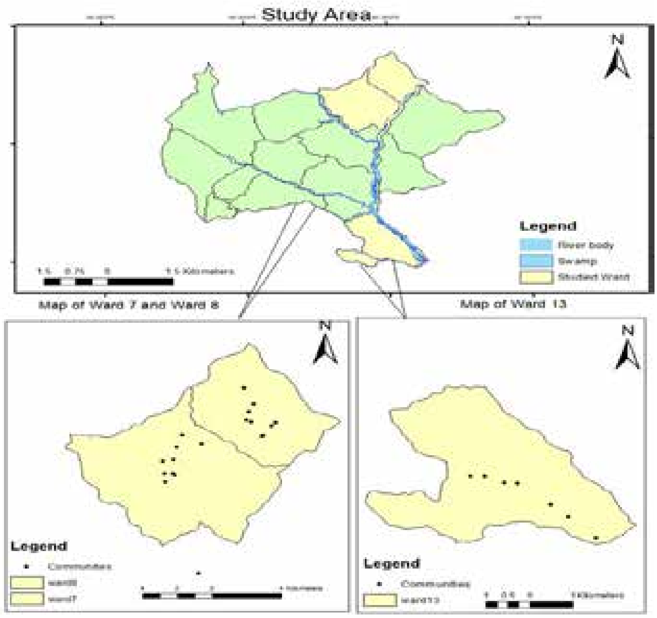
Consequently, it is vital to analyze climatic variability, its effects on livelihood, and adaptation measures to better deal with climate calamities. Melamchi municipality is well known for agriculture, as 98.82 (11,692 HH) percent of families are involved in agriculture, covering 65.44 percent of arable land. However, the recurrent flood has wreaked havoc on Melamchi Municipality, severely disrupting agricultural activity and the livelihood of the local population. It is critical to understand how people on the ground and at the local level are dealing with climate change-related events to educate the public about the potential implications of climate change and effective solutions for dealing with these effects. This study is intended to evaluate the climatic variability and people's perceptions of the effects of climate change on agricultural productivity, which is the primary source of livelihood.

Methods

Study Area

Melamchi Municipality is located southwest of Sindhupalchowk District in Bagmati Province. It covers an area of 160.63 km^2. The municipality has a population of 41,170, of which 20,073 are male and 21,097 are female (CBS, 2021). Melamchi Valley's upper portion has a Cool Temperate climate, while the lower portion has a Sub-Tropical climate. Rainfall in the upper section of Melamchi Valley is greater than in the lower part. The study was carried out in three different Wards: Ward 7 (Dubachaur), Ward 8 (Kyurani), and Ward 13 (Fatakshila).

Figure 1
Map of Study Area



Methods of Data Collection

This study adopts a sequential explanatory mixed-methods model, which implies collecting and analyzing quantitative (climate data) and then qualitative (FGD/key informant interview) information in two consecutive phases within one study that connect quantitative and qualitative data to reveal integrated results (Ivankova et al., 2006).

The primary data was collected through techniques like Key informant surveys, focus group discussions and direct field observation. Participatory tools, including FGD, KII, and other group discussions, were used to collect quantitative and qualitative data from the field. PRA methods were exercised to understand various facets of the communities under study.

The focus group discussion was carried out in a total of 22 communities to get information about their perception of climate change, changes in their livelihood due to climate change impact, changes in cropping patterns, past and present hazard events, changes in seasonal patterns, condition of available resources, changes in activities for livelihood, impact on agriculture due to climate change events, impact on community people due to climate changes events and adaptation strategies which they are adopting for the livelihood. Stakeholder consultation meetings were done in key informant interviews. Stakeholders were elected bodies, representatives from wards, local governments, planning officers, agriculture officers, and the private sector.

Climate data was used for the analysis of the temporal pattern of temperature and precipitation, i.e. the ground station (point station) data from the Department of Hydrology and Meteorology (DHM). The precipitation data covers 31 years of data (1990-2021), and temperature data covers 11 years (2011-2021).

Sampling Procedures

Snowball and purposive sampling were used to select sampling units in this study. Purposive sampling was used to select communities for focus group discussions to collect information about community perceptions and vulnerability levels of the communities. Similarly, snowball sampling was used for stakeholder consultation to conduct key informant interviews to collect information, which was validated with information obtained from focus group discussions. Data was gathered from participants from November 29 to December 10, 2022.

Data Analysis

The data gathered was examined using both qualitative and quantitative techniques. Statistical analysis was conducted on temperature and rainfall information sourced from various stations. Parametric (linear regression) and non-parametric (Mann Kendal test & Sen's slope estimator) tests were used to analyze the climate data. Also, the RAI, developed by Van-rooy (1965), is used to categorize rainfall anomalies into positive and negative severities. Periods of dryness and wetness in the area were depicted using the Rainfall Anomaly Index (RAI). In this study, the exposure, sensitivity, and adaptive capacity data-driven indicators were chosen with an equal quantity and weight of indicators for each component for assessing the vulnerability.

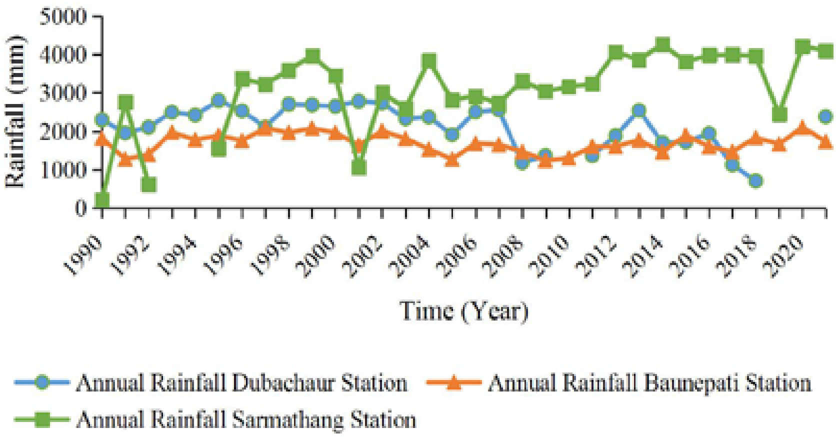
Results

Precipitation Trend

The recorded precipitation data from 1990 to 2021 were used to analyze the trend of precipitation in the study area. The figure 2 shows the rainfall is in decreasing trend from the data obtained from Dubachaur and Baunepati stations similarly, the line chart of the data obtained from Sarmathang station shows the rainfall is in increasing trend.

Figure 2

Precipitation trend Dubachaur, Baunepati, and Sarmathang Stations



Temperature Trend

From the analysis of temperature data, the average annual maximum temperature was found to increase at a rate of 0.13^0C per year while the average minimum temperature was decreasing at 0.13^0C per year in Bahrabise station. The maximum average annual temperature recorded in the study period was 29.52^0C in 2017, and the minimum average annual temperature in the study period was 12.25^0C in 2015. Likewise, the average annual maximum temperature increased to 0.8^0C per year while the average annual minimum temperature increased to 0.34^0C in Chautara station. The maximum average annual temperature recorded was 27.61^0C in 2011, and the minimum average annual temperature in the study period was 6.36^0C in 2012. The average annual maximum temperature increased at 0.8^{0}C per year, while the average annual minimum temperature increased to 0.42^{0}C per year in Sarmathang station. The maximum average annual temperature recorded in the study period was 16.68^{0}C in 2016, and the minimum average annual temperature in the study period was 5.46^{0}C in 2012.

Table 1

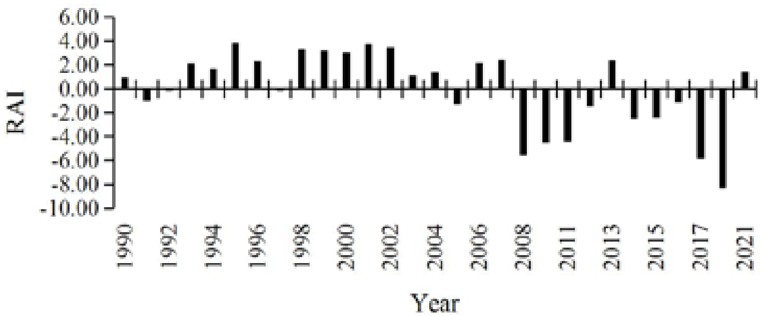
Trend Analysis of Annual Average Temperature Using Mann-Kendall Test and Sen's Slope Estimator for Different Meteorological Stations

Test		Bahrabise Station		Chautara Station		Sarmathang Station	
		Min Temp	Max Temp	Min Temp	Max Temp	Min Temp	Max Temp
Mann-Kendall	P-value (two-tailed)	0.276	0.119	0.891	0.783	0.244	0.837
	Mann-Kendall stat (S)	-15	21	-3	5	18	4
	Kendall's tau	-0.273	0.382	-0.046	0.0763	0.273	0.0606
	Alpha	0.05	0.05	0.05	0.05	0.05	0.05
	Var (S)	165	165	211.667	211.667	212.667	212.667
	Test Interpretation	Accept H_0	Accept H_0	Accept H_0	Accept H_0	Accept H_0	Accept H_0
	Sen's slope	-0.225	0.129	-0.057	0.121	0.141	0.037
	Trend	Decreasing	Increasing	Decreasing	Increasing	Increasing	Increasing

3.3 Rainfall Anomaly Index (RAI)

Figure 3

Annual Rainfall Anomaly Index (RAI) of Dubachaur Station



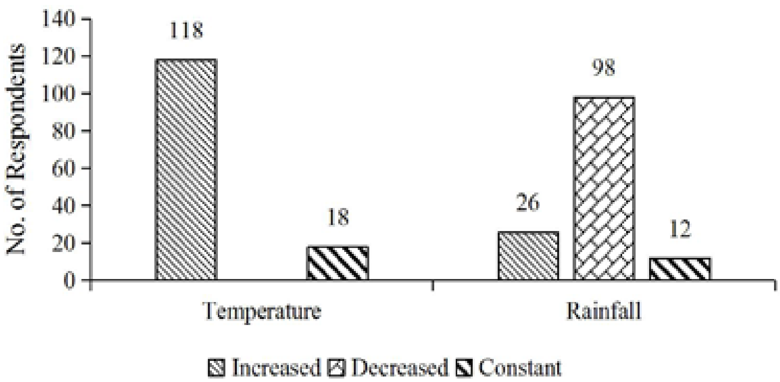
From the analysis of precipitation data of Dubachaur station, more rainy years were found than drought ones, similar to the result from Sarmathang station. 2018 was the year with the highest negative value, with an RAI of -8.30, classified as extremely dry. The year of greatest positive value was 1995, with an RAI of 3.87, being therefore classified as extremely wet. On the other hand, there were equal numbers of rainy years to drought ones found in the Baunepati station data.

Community Perception of Change in Climatic Variables in Study Area Over 30 years

Local people in all the studied wards (i.e. Ward 7, 8, and 13) reported that the temperature in the summer has risen and winter has become colder. Regarding the rise in temperature, 118 participants in the focus group discussion perceived that the temperature had increased, and none reported a decrease in temperature. At the same time, 18 respondents said there was no change in temperature. Likewise, 98 respondents claimed decreasing rainfall, 26 reported increasing precipitation, and 12 participants perceived no change in rainfall.

Figure 4

Community Perception on Climatic Variables

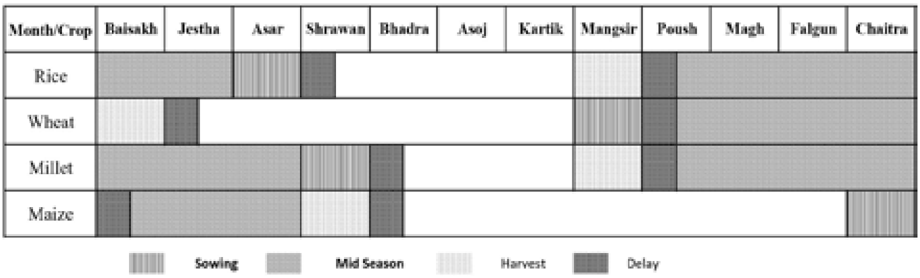


Climate Change Impact on Agriculture

As per the response from the local communities, Melamchi municipality's crop calendar has undergone significant alteration (Figure 5). According to the respondent, the harvesting and planting times for crops have shifted compared to previous years. The shift in the rainfall pattern impacted the seasonal plantation of the crops. With the delay in one crop plantation time, the planting season of other agricultural crops was also delayed. With these facts in hand, it makes sense to say that climate change has impacted agricultural production.

Figure 5

Changes in Crop Calendar in Melamchi Municipality in the Last 30 Years



Adaptation Practices

Local communities were found to be participating in climate change adaptation and mitigation efforts, knowingly or unknowingly. The adaptation approach is used solely by local communities based on agriculture and its linked activities to boost productivity directly and indirectly, i.e., crop diversification, use of green, compost, and chemical manure, and shift in planting and harvesting time. To prevent insects, community people are using ash in vegetables and fertilizers on agricultural land. Some communities have been found using wood ash along with pesticides and applying it to the vegetables and agricultural land for the prevention of pests. To address water scarcity, members of the community have built a water storage tank that they use during the dry season, especially in the months of Chaitra and Baisakh when water sources run dry. Gabion walls were constructed to protect their land and road from landslides and floods.

Similarly, community people have established group committees (i.e. Aama Samuha and other committees) for weekly or monthly meetings to discuss the problems in the communities and also give different types of training to other people. The committee provides rotational water supply for household and irrigation purposes. Different organizations and institutions have worked/working in the communities to implement adaptation strategies.

Figure 6 shows the different institutions and organizations, along with local community groups, that have worked directly and indirectly to uplift communities and provide support in building their adaptive capacity. The length of the arrow determines the level of influence in the communities as the institutions and organizations that have worked closely with communities were near to the communities, and the institutions and organizations that have not much influence in the communities were far from the communities.

Figure 6

Stakeholder Role Map in the Communities

Discussion

Precipitation Trend

Most previous research done in various regions of Nepal shows that temperatures are rising and precipitation is declining (Paudel et al., 2021; Shrestha et al., 2019). Likewise, the analysis of the 31 years (1990-2021) of precipitation data obtained from Dubachaur and Baunepati stations shows that the annual precipitation trend was decreasing, and the data obtained from Sarmathang stations shows an increasing trend.

Temperature Trend

Almost all station data shows a positive temperature trend except for the minimum average annual temperature of Bahrabise and Chautara stations. All three stations observe the highest positive maximum temperature trend in the winter season. The seasonal and annual temperature showed an altitude-dependent trend, with a higher positive trend in higher places and a negative trend or modest positive trend in lower altitudes (Ghimire, 2019). In 2015, the Department of Hydrology and Meteorology (DHM) released a report titled "Study of Climate and Climatic Variation over Nepal" that examined the country's overall weather patterns and climate trends. From 1971 to 2012, trend analyses of precipitation and air temperature were conducted. The analysis discovered an upward tendency for maximum temperatures across all seasons, which were significantly higher than minimum temperatures. Similar results have been observed in this study as well.

Rainfall Anomaly Index (RAI)

In Nepal, drought is primarily recognized by meteorological occurrences brought on by a late monsoon or an inadequate rainfall distribution (Adhikari, 2018). Most of the country's districts have been affected by the winter 2008–2009 drought, which drastically reduced crop yields (Ghimire et al., 2010). A similar result has been obtained in our study, where 2009 was the year with the highest negative value, with an RAI of -4.87, classified as extremely dry from the rainfall data collected from the Baunepati station. Similarly, 1990 and 2018 were the years with the highest negative values, with an RAI of -9.45 and -8.30, respectively. This also reveals an extremely dry year from the analysis of rainfall data collected from Sarmathang and Dubachaur stations. Nepal experienced many climatic droughts between 1970 and 1990, and winter droughts between 2002 and 2004 were primarily responsible for a 50% decrease in precipitation (Adhikari et al., 2018).

Climate Change Impact on Agriculture

The most significant impact on crops is caused by the slow onset and widespread drought among all hydro-meteorological risks in Nepal. According to Bhatta et al. (2016) and Chaudhary and Aryal (2009), drought and the slow monsoon onset cause planting to be delayed, which in turn causes poor crop germination, flowering/grain production, and fruit set, as well as a decline in productivity. Locals have noticed changes in their immediate surroundings. Flowering and fruiting times have changed. Similar to this, invasive species and weeds were introduced while native species went extinct. The respondents claim that they couldn't plant on schedule because of a change in rainfall timing. According to UNDP (2009), weather hazards impact crop yield most, which declines by up to 90%. Climate change has been shown empirically to have a bigger influence on agricultural production in underdeveloped nations (Stern, 2006).

Adaptation Practices

The majority of people surveyed during the field study reported using various adaptive measures to cope with climate change. According to studies, socio-economic components and factors may significantly impact how people adapt to climate change (Deressa et al., 2009). According to (Owusu et al., 2011), communities with low adaptive ability farmers have low financial and human capital scores and vice versa. A highly educated farmer is more likely to use modern technology (Adesina et al., 2000; Tiwari et al., 2008). According to Bocchiola (2017) and Regmi and Bhandari (2013), a larger percentage of respondents used less expensive, traditionally used methods at the household level in their production technology as adaptation measures. The communities at the research site mostly focus their adaptation efforts at the household level. Adoption of adaptation strategies is more probable when individuals are aware of the problem of climate change and its solutions. One of the key determinants in the research region has been knowledge and awareness of the changing climate. People aware of climate change are more likely to respond to observed changes by implementing adaptation measures (Maddison, 2006). Different institutions and organization have involved local communities in the upliftment and improvement of the livelihood of the communities, but that is limited till the contract period of the organizations. However, the findings of study sites show that the fundamental adaptation strategies have not yet happened.

Conclusion

Climate change is gradually becoming a major issue for all countries, including Nepal. This study examined climate variability and its implications on the livelihood of the local communities of the Melamchi municipality. The Climatic data analysis results show variation in climatic trends. Overall, the result shows the annual rainfall is decreasing trend and the result of temperature data analysis reveals that the maximum average annual temperature has shown an increasing trend in all the station data while the minimum average annual temperature has shown an increasing trend in two stations (i.e. Chautara and Sarmathang) except in Bahrabise station. However, no significant trend is observed for all stations' maximum and minimum annual average temperatures. The communities' perceptions and experiences of climatic variations convey the reality of climate change. The key indicator of climate change is the pattern of rainfall and temperature. Local communities have noticed an increase in temperature, pests/diseases, flooding/landslides, drought, and a drop in rainfall and production compared to previous years. The majority of respondents report a decrease in the number of rainy days, an increase in the number of hot days, an increase in summer heat, and a decrease in the number of cold days. The survey results show similarities with the research area's climate data. Local communities are still lacking knowledge regarding adaptation practices however, they are still practicing traditional ways as per their knowledge. The difficulty or inability to implement new and appropriate adjustments is primarily due to a lack of government support and access to meteorological information that is out of reach for the community's people. The financial and technical support from the government seems to be one of the important aspects of the better adaptation approach in the Melamchi region. Based on their traditional climate change adaptation strategies, proper training and awareness programs on the impact of climate change and its trend for improving agricultural practices are essential.

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