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Impacts of climate change on the livelihood of people and their adaptive strategies

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ABSTRACT

Climate change has been a significant threat to rural peoples' natural resources and livelihoods. A comparative case study on climate change impacts and adaptation strategies adopted by two communities (externally supported Ramnakot Pachaljharna Rural Municipality-4 and the non-supported community of Raskot Municipality-3, Kalikot district) conducted to assess climatic variables, their impacts, and adaptation strategies. Primary and secondary information is collected through household surveys, focus group discussions, key informant interviews, direct observation, and the review of meteorological data and climate change impacts and adaptation-related publications. Collected data were analyzed using SPSS (Statistical Packages for Social Science) and MS-Excel (Microsoft Excel) and presented in this report. In total, 81% and 91% of the total respondents in Raskot Municipality and Ramnakot Rural Municipality, respectively, were dependent on rain-fed agriculture for their livelihood The average summer temperature of study areas has been on the rise in recent years, and rainfall patterns are unusual and abnormal, with a growing number of days having rainfall of 100 mm and above a day. The torrential rainfall has severely impacted agricultural fields, forests, and irrigation canals in the region. The study found that the effects of changing rainfall patterns were similar in Raskot-3 and Ramnakot-4 villages, but Ramnakot-4 respondents, with the support of CAFS- Karnali and HuRENDEC Nepal/WFP, designed and implemented Climate Smart Village (CSV) approaches focusing on growing high-value cash crops, fruits and vegetables along with maize, wheat, millet, barley, and paddy for food security and nutrition, as well as income and employment generation. They focused on improving soil fertility using organic manure, including green manure and mulching, and irrigation canal and drinking water supply systems were also improved, resulting in an increase in cropping intensity of respondent households from 68% to 91% following CSV activities. It is revealed that the respondents of externally supported Ramnakot-4 were more resilient to climate change vulnerability than those of the respondents of Raskot-3. The study indicates that to raise awareness among farmers in Raskot-3 and their stakeholders about climate change issues, it is necessary to develop and implement adaptation measures, awareness programs, and information-sharing initiatives.

Keywords: Climate change, Climate Smart Village, Livelihood, adaptive strategies

1. INTRODUCTION

The climate of the earth has been changing rapidly, which has direct effects on natural resources as well as on the livelihood of rural peoples. Natural variability or anthropogenic activities induce it (GIEC, 2021). In addition, population growth and environmental degradation have intensified climate change and its impacts on people. Climate change has been expected to cause serious environmental, economic, and social impacts in the Hindu Kush Himalayan region, affecting rural farmers whose livelihoods depend on using natural resources (Eriksson et al., 2009). Poverty, environmental degradation, natural resource depletion, shrinking water resources, desertification, and climate change also challenge the area (Schild, 2008). The mean annual temperature climbed by 0.06 degrees Celsius between 1977 and 1994 and may rise by another 1.5 degrees Celsius by 2030 if it continues at the current rate (IPCC, 2021).

This increase will likely cause more floods and glacial lake outbursts, devastating irrigation and water supply systems, roads, bridges, communities, and agricultural land. Industrial activity has increased greenhouse gases in the atmosphere, significantly raising the global temperature. Nepal, a mountainous landlocked country in South Asia, is located in the Himalayas between India and China, with only 17% of its area consisting of plains. Subsistence agriculture is a mainstay of Nepal's livelihood. The climate is influenced by the Himalayan Mountain range and the South Asian monsoon, with an annual rainfall of approximately 1600 mm. The monsoon rain is most abundant in the east and gradually decreases as it moves southeast. Temperature trends increase from north to south and decrease with altitude (Bishwokarma et al., 2021; Baniya et al., 2021).

Nepal is highly vulnerable to climate change impacts, with recent studies by the Asian Development Bank suggesting that Nepal could lose 2.2% of its annual GDP due to climate change by 2050. Nepal's third National Communication to the identifies the country's energy, agriculture, water resources, forestry and biodiversity, and health sectors as the most at risk from climate change. Rural communities, particularly in mountainous regions, are the most vulnerable to climate change and variability, struggling to cope with extreme weather events like landslides, erosion, and drought. In lowland regions, flooding, sedimentation, and drought pose significant threats (IPCC, 2021). Karnali Province is the most vulnerable to climate change in Nepal. Its topography and living conditions play a vital role in this vulnerability.

Harsh climatic conditions occur in Karnali due to changing environmental situations. Many areas have very little development and poor livelihoods, making it even harder for people to cope with climate change. Most sectors, like agriculture, forestry, and water resources, are affected, resulting in socio-economic problems, including sickness and livelihood-related issues for the people (Regmi and Adhikari, 2007). Climate change can be exceptionally hard-hitting for small, underdeveloped countries that rely heavily on natural resources for their economy and livelihoods. Nepal is one such country, being landlocked with diverse physiographical characteristics within a relatively small territory and rugged terrain. Poverty is widespread, and the capacity of people and the government to cope with climate change impacts is low.

The government is dominated by the Asian monsoon system. The effects of climate change can be much more significant for Indigenous communities and people living in the more remote and ecologically fragile zones of Nepal, who rely directly on their immediate environments for subsistence livelihoods. Most areas of Karnali Province are remote and fragile but rich in floral diversity. The high-altitude rangelands of this province are abundant in medicinal and aromatic herbs. The collection and sale of these valuable alpine medicinal species are among the most important and unique aspects of the local economy. Kalikot is worst hit by water-induced disasters every year. During the 2077 monsoon season, landslides caused the deaths of 44 people, with seven still missing. According to the District Natural Disaster Management Committee, landslides destroyed 685 houses and partially damaged 1,771 homes (Kathmandu Post, 2077).

Additionally, people face issues related to drought, loss of soil fertility, reduced crop yields, illness, food insecurity, and multi-dimensional poverty. Climate change impacts various sectors such as agriculture, forestry, biodiversity, water sources, and energy, affecting people and their communities. Climate change threatens human, social, natural, physical, and economic assets of livelihoods. This thesis focuses on comparing adaptive strategies adopted by two communities to provide insights for future climate change-related projects and programs. The study employs both primary and secondary methods to achieve its objectives. It documents climate change baseline data, its impacts on local livelihoods, and the adaptive strategies implemented at the community level. The research is

conducted in Ramnakot-4 and Raskot-3 in Kalikot District, Nepal. Ramnakot is supported by external NGOs and INGOs working to improve conditions affected by climate change.

2. MATERIALS AND METHODOLOGY

Study Area

The proposed study sites are in the Kalikot district of Karnali province. The district covers an area of 1,741 km2 (672 sq mi) with a total population of 105,580 in 2001, 136,948 in 2011, and 144,917 in 2021 (Figure 1). Local communities in the study areas are experiencing the impacts of climate change and are taking steps to adapt to it. Their efforts focus mainly on protecting freshwater supplies, safeguarding infrastructure and communities against flood, erosion, and severe weather events, modifying agricultural patterns, and planning for water shortages and droughts. There are certain adaptation practices applied by locals. Still, they are not sufficient to cope with the rapid changes in climate and catastrophes.

Sustainable land management can contribute to reducing the negative impacts of multiple stresses, including climate change, on ecosystems and societies. In Kalikot district, there are five Rural Municipalities and four Municipalities. This study was conducted in ward no. 4 of Pachaljharna Rural Municipality and ward no. 3 of Raskot Municipality. The total population of the Pachaljharna Rural Municipality according to the 2011 and 2022 census was 12,343 and 13,683 individuals respectively. Raskot Municipality has a population of 16,272 and 16,468 individuals as of the 2011 and 2022 census respectively. This study was conducted in these two areas to assess climate change, its impacts, and adaptation measures used by local people.

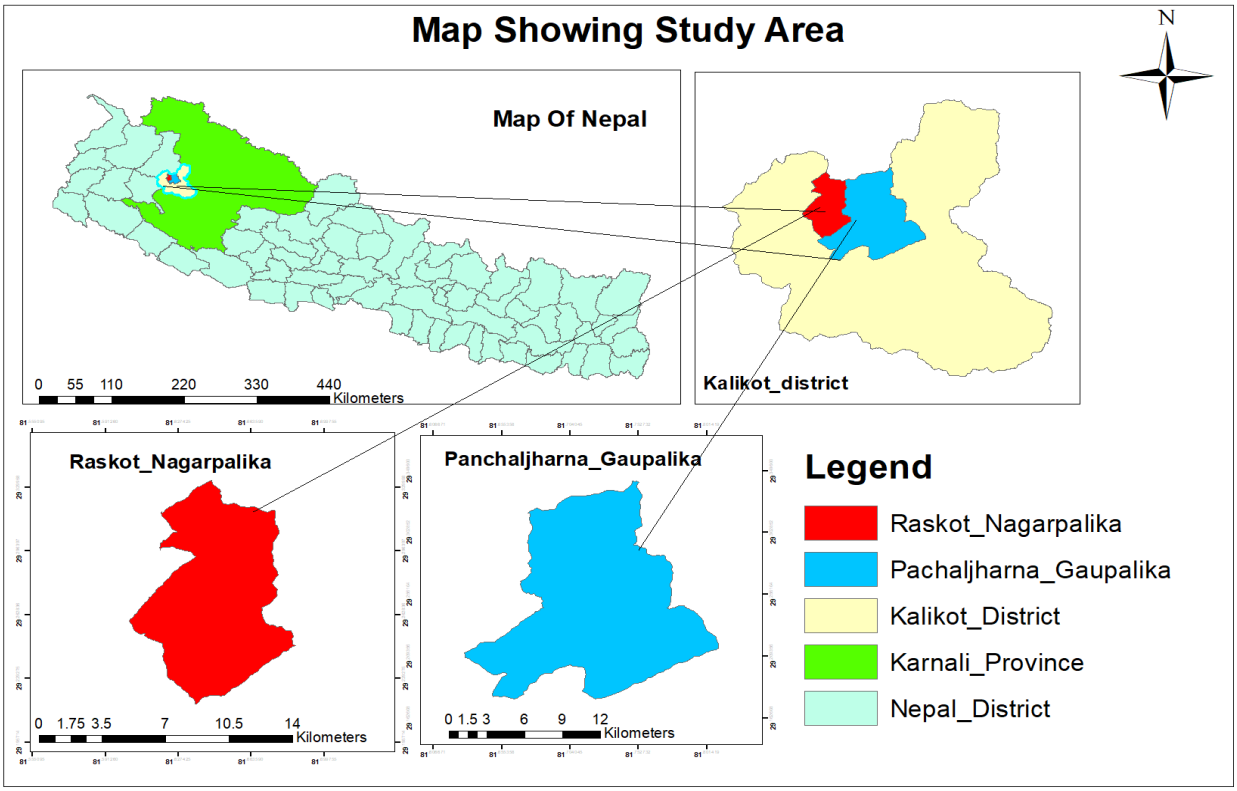

Figure 1 Map showing study Area.

Data Collection

During the household survey, respondent households of both study sites were selected using a simple random sampling. Cochran formula 1997 was used to calculate the number of sample households for the survey. The Cochran formula allows us to calculate an ideal sample size given a desired level of precision, desired confidence level, and the estimated proportion of the attribute present in the population. Cochran's formula is considered especially appropriate in situations with large populations. A sample of any given size

provides more information about a smaller population than a larger one. Therefore, we can apply a 'correction' to reduce the sample size calculated by Cochran's formula when dealing with a relatively small total population.

$$n = \frac{\mathrm{N} * Z^2 * \mathrm{P}(1-\mathrm{P})}{\mathrm{N} * d^2 + Z^2 * \mathrm{P}(1-\mathrm{P})}$$

Where,

N= Population size

P= Proportion of sample on population estimated (sample size as 5% of the population size)

d= required level of precision (0.05%)

Z= confidence Interval chosen (c= 1.96 for 95% confidence)

Both primary and secondary information were collected using Participatory Rural Appraisal (PRA) tools and techniques, which are as follows:

Primary data collection

Participatory Rural Appraisal (PRA) tools and techniques used for collecting primary data were questionnaire survey, key information interview focus group discussion, and direct observation.

Questionnaire survey

Using the Cochran 1977 formula, the number of sample households were calculated. The households from different economic groups such as rich, medium, and poor were selected using simple random sampling. Then, the questionnaire was prepared and after a few pilot surveys, it was finalized. To collect data, a questionnaire survey was conducted in selected households from different economic groups to assess their socio-economic conditions and general level of awareness about climate change. During the survey, questions about how climate change-related events have affected residents, which aspect of their livelihoods are most impacted, and what remedial measures each household has taken were asked and recorded.

Key informant interviews

For the interview, key informants like senior citizens, village leaders, Human Rights and Environment Development Center (HuRENDEC) members, teachers, elected local ward members, and technical personnel working in Rural Municipality and Municipality and DFO staff were interviewed using a checklist (Appendix 2). The interviews were conducted to assess existing climate change-related events and their impacts on local livelihood assets and adaptation measures used in study areas.

Focus group discussion

Focus group discussion was carried out separately with the selected user group members including groups of rich, medium, and poor members of different ethnic groups, women groups, Dalits, and groups of people with socio-economic backgrounds affected by climate change-related events such as floods, landslides, drought, and fire. Important data on climate change and its impacts and adaptation measures used by local people was collected. A checklist (Appendix 1) was prepared and used for the discussion.

Direct observation

Direct observation of areas affected by climate change events was conducted and data on different adaptation measures used by farmers in farmlands, forests, and community lands was recorded during field visits with farmers, user group members, and concerned line agencies to observe and gather information on social and physical features for getting insight view of the consequences of disasters and local measures adopted by people to cope with floods, drought, and other climate change-related events.

Secondary data collection

The secondary data related to temperature and rainfall of the study areas was collected from the Department of Hydrology and Meteorology (DHM), Kathmandu, and other publications of district line agencies, and literature related to climate change and its effects on people's livelihoods were also reviewed. Secondary data on climate change, its impacts on community and household levels, and

adaptation measures applied by community members and farmers for this study were collected to supplement primary data. Essential information on climate change and its impacts was also downloaded from related websites.

Data Analysis

The primary data gathered from the household survey, key informant interview, focus group discussion, direct observation, and data collected from secondary sources regarding climate change, its impacts, and adaptation practices was compared and analyzed using statistical packages like SPSS (Statistical Packages for Social Science) and MS Excel. The information obtained after analysis is presented in the result using tables, and figures such as pie charts and diagrams.

3. RESULTS AND DISCUSSIONS

This chapter presents the study's findings and discusses their implications. It includes an analysis of the socioeconomic and educational status of the respondents, their perceptions of climate change, its impacts on livelihoods, and the adaptive measures employed by both externally supported and non-supported communities.

Gender of the Respondents

During this study, 100 respondents from Raskot-3 and 68 respondents from Ramnakot-4, representing different well-being ranks and genders, participated in a household-level questionnaire survey. Men's participation was higher, with 80% in Raskot and 70% in Ramnakot, compared to women's involvement, which was 20% and 30%, respectively.

Ethnicity of the Respondents

Dalit participation was higher in Raskot-3, followed by Yogi/Giri/Puri, Chettri, and Brahmin (Table 1). Similarly, in Ramnakot-4, the Chettri population was higher, followed by Dalit, Brahmin, and Giri/Puri/Yogi. The major Chettri subcastes were Khadka, Oli, and K.C., while the major Dalit subcastes were Kami, Damai, and Sarki. These diverse groups are effectively managing forests and other natural resources, such as water sources, to cope with the impacts of climate change.

Table 1 Ethnicity of the respondents

Community	Ethnic groups				Total HHs
	Brahmins	Chettri	Giri/Yogi/Puri	Dalit	
Raskot (%)	2	13	25	60	100
Ramnakot (%)	17	57	1	25	68

Well-being rank of the respondents

The respondents were categorized into three economic groups—rich, medium, and poor—in both communities based on their human capital, houses, land holdings, livestock population, food sufficiency, and income from business and services within and outside the country. Most respondents in both communities were poor. Raskot-3 had a better education status, with a 95% literacy rate compared to Ramnakot-4's 75% literacy rate. Despite the high literacy rates in both communities, most people lacked awareness of climate change, its effects, and the adaptation measures that local communities can use.

Occupational status

Agriculture is the main occupation of respondents in both communities, followed by wage labor, service, and business. Ten years ago, they focused entirely on agriculture, but now many have shifted to business, livestock rearing, and wage labor. Some have even started going to India for labor work rather than farming their land, making agriculture a secondary occupation. The majority (86%) of respondents reported that agricultural production in their communities is highly vulnerable to climate change. Increasing temperatures and uneven rainfall distribution have reduced yields of main crops such as maize and rice while encouraging the growth of weeds and pests.

Source of household income

The average annual income of respondent households was Rs 50,000 in Raskot-3 and Rs 40,000 in Ramnakot-4. In Raskot-3, 45% of the total annual income came from on-farm sources, while 55% came from off-farm sources. On-farm income sources included the sale of pulses, oil seeds, vegetables, fruit, livestock, and products such as meat and milk. Off-farm income sources included business, salaries, and remittances. In Ramnakot-4, 71% of the total income came from on-farm sources, while 29% came from off-farm sources.

Livestock population

More than 80% of households in Raskot-3 and 90% in Ramnakot-4 had livestock such as buffalo, cattle, goats, and poultry (Table 2). These livestock were a significant source of income and a way of life for the studied households. The goat population in these households has increased in recent years in both communities, while the number of buffalo and cattle has decreased because they require more feed compared to goats. However, in Raskot-3, the number of goats and sheep has also decreased due to insufficient feed.

Table 2 Livestock population of the study households

Livestock	Raskot-3		Ramnakot-4	
	Before five years	Now	Before five years	Now
Buffalo	112	61	79	53
Cattle	214	191	309	241
Goat	412	579	365	423
Poultry	89	504	82	197
Rabbit	2	12	0	20

Land Holding

All respondents from both communities owned land, though the size of their holdings varied. Comparatively, rich and middle-class people owned more land than poor and Dalit families (Table 3).

Table 3 Shows the landholding size of the respondents of both communities.

Size of land holding	Households in Raskot	Households in Ramnakot
Landless	7	10
1-3 Ropani	70	44
4-6 Ropani	15	12
7-10 Ropani	5	1
More than 10 Ropani	3	1
Total households	100	68

Food Sufficiency

The study area was not very productive due to its geographical features and soil fertility. The figure 2 shows that the food security situation of the households in the study area has been worsening in recent years. The main reasons for this are drought during the crop-growing season, increased insect, pest, and disease attacks on crops, lack of irrigation facilities, and reduced farmyard manure production due to a declining buffalo and cattle population. Consequently, all the studied households experienced food security problems. They managed this issue by generating income from alternative sources such as the sale of pulse crops, oil seed crops, vegetables, fruit, livestock, and their products (meat and milk), as well as off-farm income from business, salaries, remittances, and labor.

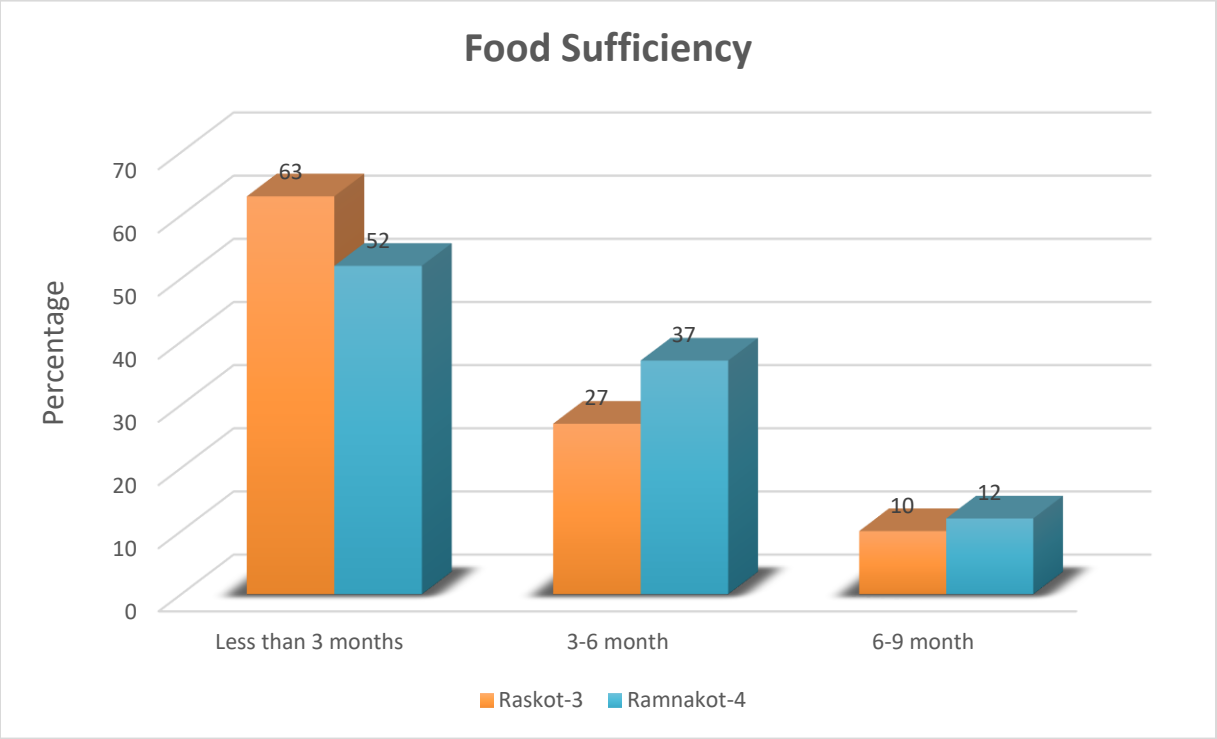

Figure 2 Food Sufficiency situation of the respondents

Cropping pattern

The majority (65%) of respondents in both studied areas have changed their cropping patterns over the last 30 years. Previously, they grew local varieties of rice, maize, millet, buckwheat, and barley. The current cropping pattern includes a diverse range of crops such as improved varieties of rice, wheat, and maize, and income-generating cash crops like potatoes, tomatoes, onions, garlic, black cardamom, and various fruits, indicating a significant shift in cropping practices. The primary constraints for growing crops in the study areas are the lack of irrigation facilities and unpredictable rainfall. In Raskot, people have relatively large land holdings and grow wheat, rice, and maize for their consumption, as well as cash crops for income. In contrast, the small land holdings in Ramnakot force residents to rely on hybrid or improved crop varieties provided by several NGOs and INGOs to adapt to the climate and topography.

Trees on Farms

Almost all respondents in both communities have planted trees on their farmlands. The majority (45%) have grown Utis (*Alnus nepalensis*) trees. Other tree species grown on their farmlands include *Pinus wallichiana, Dalbergia sissoo, Melia azedarach*, Paiyu (Wild Himalayan Cherry, *Prunus ceramides*), kaki, and banjh (*Quercus leucotrichophora*). On average, 36 bhari (1080 kg) of fuel wood was obtained from farm trees, contributing 47% of the total household fuel wood requirements. Additionally, each household produced about 160 bhari (4800 kg) of fodder per year from their farmlands. Consequently, trees grown on farmlands have reduced the pressure on nearby forests for fodder and fuel wood.

Climatic situation of the study area

Temperature and rainfall data from the Department of Hydrology and Meteorology were used to analyze the effects of climate change on the study areas. The study revealed that temperature and precipitation have varied over the last ten years. Summer temperatures have shown an increasing trend in recent years, while precipitation patterns have become erratic, creating problems for local livelihoods. These findings are presented in the following section:

Temperature

The majority (83%) of respondents reported temperature fluctuations in their communities, noting colder winters and hotter summers compared to eight years ago. According to temperature data from the Department of Hydrology and Meteorology (Figure 3), the average maximum temperature in the study areas varied, with the highest average temperature recorded at 25°C in 2014 and the lowest at 21.5°C in 2021.

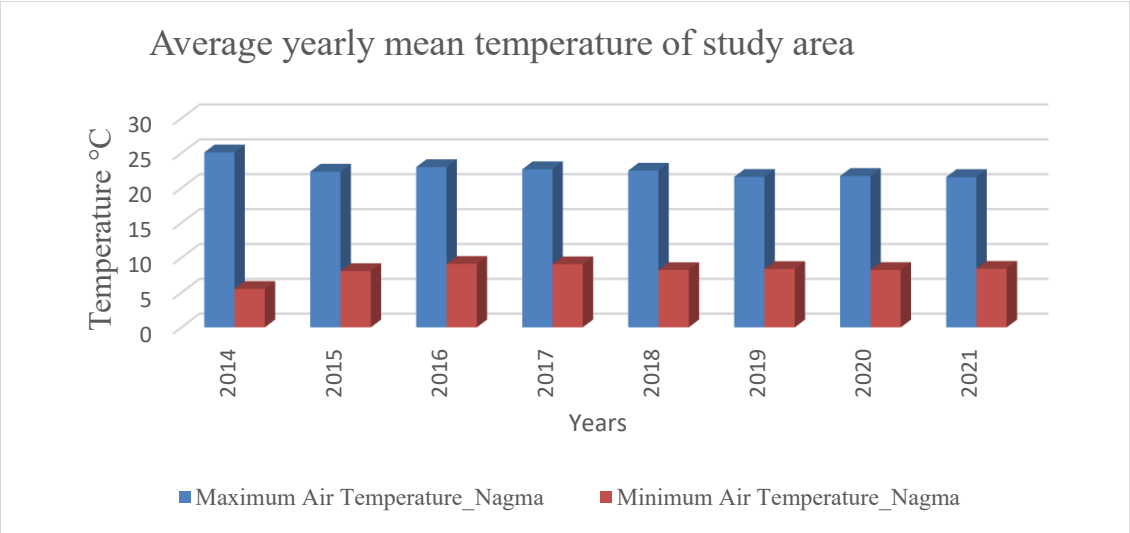

Figure 3 Average yearly mean temperature of study areas

Summer temperature

Figure 4 shows the average summer temperatures in the study areas from March to August, indicating an increasing trend in recent years. Approximately 39% of respondents from both communities attributed this rise in temperature to climate change, while the remaining 61% believed that abnormal weather patterns were the primary cause of the temperature increase in the study areas.

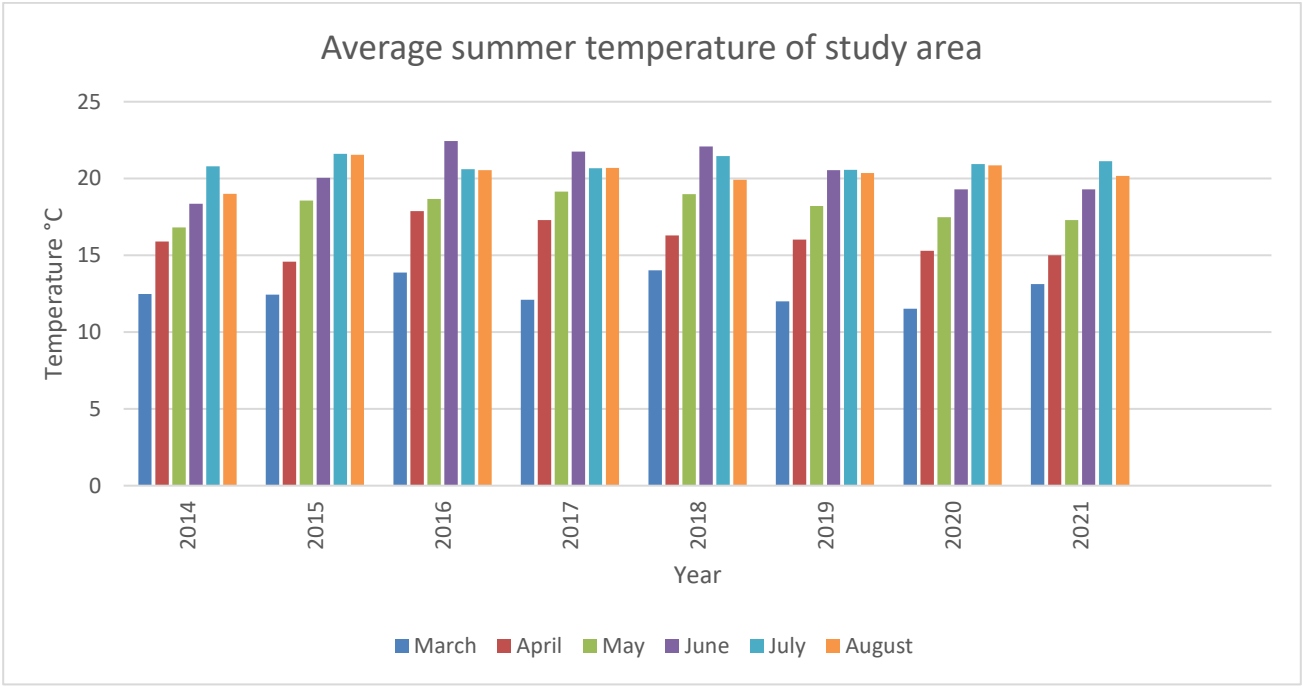

Figure 4 Summer temperature of study areas from March-August months

In July 2014, the highest recorded temperature was 32.17°C, while the lowest was -5.87°C in January 2015. This temperature data aligns with respondents' perceptions during the survey. They noted a decrease in cooler days and a rise in extremely hot days compared to ten years ago. As a result, these higher temperatures indicated periods of drought, which affected human health, water sources, and agricultural production. The majority (91%) of respondents reported that the major impact of temperature fluctuations was a change in rainfall patterns. This change led to drought or water scarcity during the maize growing season, resulting in a decline in maize yields in the study areas.

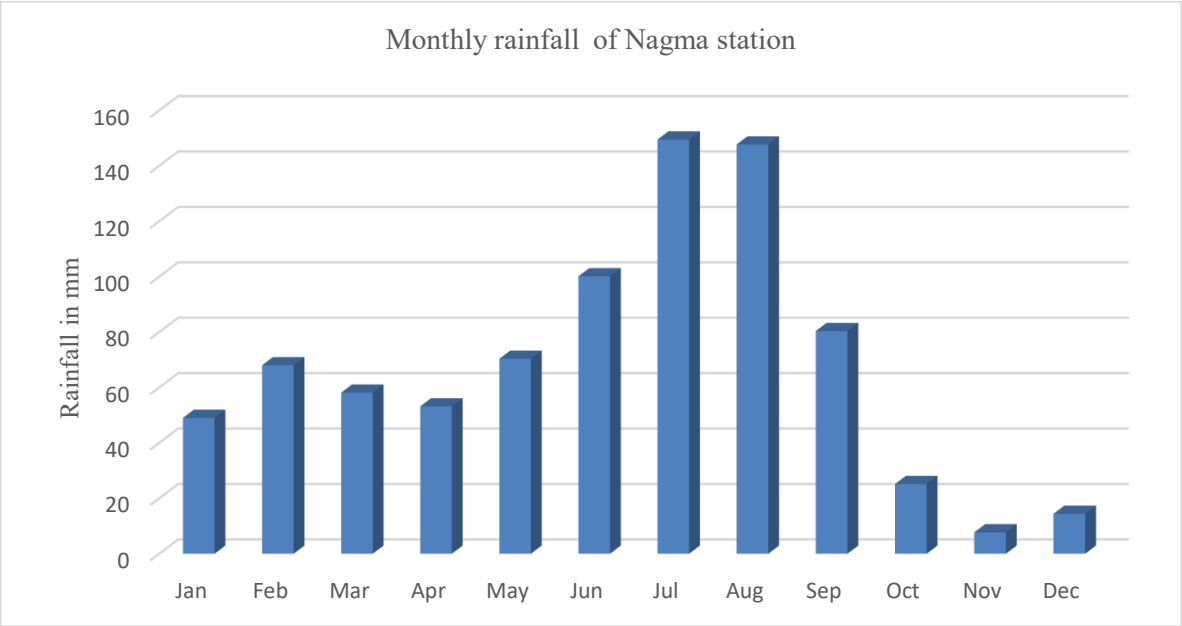

Figure 5 Average Monthly Rainfall of Study Area from1990-2021

Analysis of average monthly rainfall showed the highest rainfall was nearly 149.48 mm in July, while the lowest was about 7.73 mm in November (Figure 5). Rainfall began to drop from August to December. May and June are considered pre-monsoon months, while September and October are post-monsoon months. The monsoon season for paddy growing is July and August, and wheat grows well in December due to the rain. June and July provide optimal rainfall for paddy cultivation. The Nepalese climate calendar indicates that June and July are ideal for the monsoon season. However, the graph shows a shift in monsoon rainfall to August, indicating that the paddy farming season has been impacted by this change in rainfall.

Crop calendar

Agricultural production in the study areas is impacted by changes in rainfall patterns due to climate variability, inadequate irrigation facilities, and irrigation systems damaged by flooding during heavy monsoon rains. Additional factors include underutilization of available farmland, a shortage of young and energetic labor in villages, soil fertility loss from erosion reduced use of farmyard manure, and frequent occurrences of livestock and crop-related insects, pests, and diseases. The alterations in the crop calendar and climate risk calendar indicate that climate change has occurred in the study areas (Tables 4 & 5). To adapt, farmers have modified their planting schedules.

Table 4 Change in crop calendar.

Crops	Year	Baisakh		Jestha		Ashad		Shrawan		Bhadra		Ashoj		Kartik		Mangsir		Poush		Magh		Falgun		Chaitra	
Maize	2010	■	■	■	■	■	■	■	■	■															
	2021				■	■	■	■	■	■	■	■													
Paddy	2010			■	■	■	■	■	■	■	■	■	■	■	■	■	■								
	2021					■	■	■	■	■	■	■	■	■	■										
Wheat	2010														■	■	■	■	■	■	■	■	■	■	■
	2021	■	■	■	■											■	■	■	■	■	■	■	■	■	■
Barley	2010														■	■	■	■	■	■	■	■	■	■	■
	2021	■	■													■	■	■	■	■	■	■	■	■	■

Table 5 Climate risk calendar of study areas

Risks	Time	Baisakh		Jestha		Ashad		Shrawan		Bhadra		Ashoj		Kartik		Mangsir		Poush		Magh		Falgun		Chaitra	
Drought	Before 10 years	■	■	■																				■	■
	Now	■	■	■	■	■	■															■	■	■	■
Landslide	Before 10 years					■	■	■	■	■															
	Now							■	■	■	■	■	■												
Insect on crop	Before 10 years														■	■	■	■	■	■	■	■			
	Now												■	■	■	■	■	■	■						

People's perception of climate change

The general perception of the respondents about temperature and rainfall pattern variation was studied. Table 6 shows that most respondents were aware of the changing climate and its variables. Most of the total respondents revealed that the temperature was on an increasing trend and the rainfall trend was unpredictable.

Table 6 People's perception of climate change

Responses	*Increased (%)*	*Same (%)*	*Decreased (%)*
Rainfall	10	-	90
Temperature	85	10	5
Length and rainy days duration	5	-	95
Flood and landslides	85	5	10
Drought	86	9	5

The majority (90%) of respondents from both communities reported that May's rainfall was less than in previous decades, leading to reduced maize production. Additionally, the lack of rain in May increased human and animal diseases and reduced water sources in villages. Around 95% of respondents said that the increase in rainy days with more than 100 mm of rainfall caused soil erosion, landslides, and flooding in the study areas. As a result, people faced problems with crop cultivation, livestock rearing, loss of

biodiversity, and soil nutrient depletion due to the erratic rainfall pattern. People perceive that temperatures in May are rising while rainfall is decreasing, indicating the impacts of climate change.

Respondents in Raskot were less aware of climate change and its effects on livelihoods compared to those in Ramnakot. Many in Raskot do not take climate change and its consequences seriously. However, some educated individuals believe that climate change has caused natural disasters in their villages and that climate resilience measures are needed to reduce vulnerability. In Ramnakot, respondents were unaware of climate change, its causes, and impacts 5-6 years ago. However, as its effects became severe, their community received training, workshops, and information from the local government and HuRENDEC, raising awareness about climate change and adaptation measures. In recent years, this community has taken climate change variations and impacts seriously, and adaptation measures have been implemented to reduce vulnerability.

Adaptation Measures

Prolonged droughts during the winter months and in March and April, followed by forest fires, torrential rainfall in July and August causing landslides and floods, and the spread of invasive species in forests and community lands, along with pests and diseases in crops and livestock, have caused significant problems for respondent households. However, when asked about adaptation measures, the majority (76%) claimed they have developed and used various indigenous strategies to cope with climate change impacts. A significant portion (70%) of respondents from both communities reported changes in their cropping patterns, followed by altering cropping times, practicing home gardening, planting trees, protecting water sources, mulching maize fields, using chemical fertilizers, and adopting improved farming systems that include cash crops like vegetables (Devkota et al., 2018).

For water management, respondents utilized drums to collect water and improved irrigation channels. To protect soil and water sources, they constructed check-dams along the Karnali riverside and breast walls in landslide-prone areas. A one-house-one-tap system was implemented to provide drinking water after constructing water supply systems in both villages. Both communities face similar climate change-related problems and impacts, but their adaptation measures differ. Raskot-3, the externally non-supported community, and Ramnakot-4, the externally supported community, each have distinct approaches, which are detailed in the following section.

Discussion

The study was conducted in two communities in the Kalikot district to assess climate change, its impact on people's livelihoods, and adaptation strategies used by local people in response to climate change. Mainly, the increase in farmers' inclination toward vegetable farming and, or cash crops in the study area suggests that farmers are already responding to the influence of climate change on their rain-fed agriculture. Dawadi et al., (2022), Jaquet et al., (2016) reported that farmers in Nepal were shifting from cereal crops to vegetables as a response to low production resulting from increased temperature and erratic rainfall. Altering the plantation and harvesting time and moving to vegetable farming and cash crops by farmers to deal with the climate variability concurs with other studies in Pakistan, India, and Ethiopia.

A recent assessment report from the Hindu Kush Himalayan (HKH) regions by reported that transitioning from subsistence agriculture to a commercial, cash-crop-based economy is prevalent in the HKH region which supports the findings of this study. Pant, (2012) reported that an increase in temperature leads to drought, resulting in a shortage of water in paddy fields and consequently decreasing rice productivity. Similarly, Hurlbert and Gupta, (2016) reported a reduction in agricultural production due to drought during crop-growing months. Karki et al., (2020) noted that agriculture is negatively affected by both climatic and non-climatic factors, such as social, economic, and political factors. The decrease in the interest of young people in farming was due to being relatively unproductive and unprofitable and has resulted in either migrating or seeking other economic opportunities.

The increasing international migration of men, mainly youth, seeking labor opportunities or better prospects was highly evident in the study area. This has created a burden on agriculture and household labor for women, further lowering production and decreasing food security (Tamang et al., 2014). The increase in invasive species in forests and community lands reduces fodder and forage, affecting livestock production. In addition, infestations of insects, pests, and diseases pose problems for farmers to grow crops. Farmers, on the other hand, adopted a variety of ecologically sound and environmentally acceptable adaptation strategies to cope with and adapt to climatic changes. The respondents of Ramnakot-4 were cultivating high-value crops such as fruits and garlic, onion, leafy vegetables, and potato, and increasing land productivity utilizing various technologies such as green manure and mulching.

These adaptation strategies were adopted by communities' people based on their local knowledge, skills, and judgment, which varies according to their agroecological region, vulnerability, available technology and resources, and institutional and organizational support. Studies by Bhandari et al., (2019) and Uddin et al., (2021) also show similar adaptation strategies being employed in the mountain regions of Nepal and other countries in the Hindu Kush Himalayan region. Adaptation is easier and more effective if there is some appropriate external support for rural households. They were provided with one tap water per house through a CSV system. Because of this water facility, cropping intensity also increased from 68.475 % to 91%. People began to make organic manure and were also aware of and able to make bio-pesticides and insecticides. Farmers have begun cultivating drought-resistant varieties of rice, maize, sorghum, millets, wheat, and barley.

They have also received instruction and training in poultry farming, focusing on promoting the Giriraj breed, and in livestock management, particularly raising hybrid goats for income and employment generation. Finally, both communities of Raskot and Pachaljharna faced similar climate change impacts, but adaptation measures used by externally supported ward 4 of Pachaljharna municipality were found more effective compared to Raskot ward no. 3. Locals should develop multidisciplinary approaches to respond to the challenges created by climate change. However, Regmi and Bhandari, (2013) reported that climate change adaptation is largely local and contextual. Therefore, local governments, along with local communities, and affected households need to work together to plan and implement climate change adaptation strategies at the regional level.

Moreover, the finding of the study on climate change and its impacts on agriculture and household food security found that most households perceived changes in temperature and rainfall patterns, the timing of seasons, incidents of drought, and water availability perceived mixed impacts on the production of significant crops: A decline in the production of rice, wheat, and barley, and an increase in the production of potato and local beans. The study done by Thapa and Hussain, (2021) also supports the finding that climate change affects people's livelihoods by decreasing crop production. This study suggested key strategies to improve local food security in the face of climate change in the study areas.

4. CONCLUSIONS

A comparative study was conducted in the communities of Ramnakot and Rajkot to assess the impacts of climate change and the effectiveness of adaptation measures. Findings revealed that both areas experienced adverse effects such as erratic precipitation, temperature fluctuations, and climatic hazards like droughts and floods, significantly impacting livelihoods, agriculture, and water resources. Ramnakot-4 exhibited better adaptation outcomes than Raskot-3, attributed to external support facilitating the implementation of effective measures such as crop diversification, water management systems, and technological interventions.

Indigenous practices were more prevalent in Rajkot, albeit with lesser effectiveness due to lower external support. Common adaptation strategies included agroforestry, water conservation, crop diversification, and livestock management. The study underscores the pivotal role of NGOs, INGOs, and governmental organizations in promoting successful adaptation through policy advocacy, research, capacity building, and material support, highlighting the importance of external assistance in enhancing resilience to climate change impacts.

Ethical approval

Not applicable.

Informed consent

Written & Oral informed consent was obtained from individual participants included in the study.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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Data and materials availability

All data associated with this study are present in the paper.

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