Original Research Article

Impact of Climate Change on Livestock-Centric Rural Development: Adaptive Strategies for Sustainable Agriculture

Krishna Prasad Gyawali[1]
[1]Assistant Professor, Faculty of Humanities and Social Sciences, Saptagandaki Multiple Campus

Sharad Mani Kharel[2]
[2]Research Student, MA (RD), Saptagandaki Multiple Campus

Abstract

This study investigates the impacts of climate change on livestock-centric rural development in Gaindakot Municipality, Nepal. Livestock farming is the primary livelihood for most households, with 61% maintaining 20-40 animals and 25% owning large-scale operations with over 60 livestock. However, small landholdings (1-5 Kattha) present challenges to economic stability, underlining the need for support to improve productivity. Climate change has significantly impacted livestock health, with 42.9% of households reporting moderate effects and 35.7% experiencing severe impacts, leading to declines in livestock productivity. The study highlights the adoption of water conservation methods, such as drip irrigation, and climate-resilient practices, including drought-resistant fodder and resilient livestock breeds. However, barriers to the broader adoption of these practices, such as a lack of awareness and limited access to resources, were noted. The study also emphasizes stronger policy support and further interventions to promote sustainable agricultural practices. These findings underscore the importance of adapting to climate change through improved livestock management, resource conservation, and enhanced policy frameworks to safeguard rural livelihoods and food security.

Keywords: *Climate change, Livestock farming, Rural Development, Food Security, Sustainable agriculture*

Introduction

Rural development is a transformative process aimed at enhancing all aspects of rural social life. It involves building infrastructure, commercializing agriculture, effectively using and mobilizing resources, ensuring food security, creating new

[1]*Corresponding author:* gyakrish_kp@yahoo.com

opportunities, fostering inclusive social growth within rural communities, and advancing the modernization of society as a whole (Acharya,2008). Rural development aims to improve the economic and social conditions of the rural poor, particularly benefiting small-scale farmers, tenants, and the landless. This strategy must address three key issues: First, the transition from low-yield agriculture to more profitable sectors has been slow, largely due to the limited expansion of the modern sector in developing countries. Second, poverty levels remain high in rural areas and may worsen with rapid population growth and restricted resources, technology, and institutional support. Third, rural areas have valuable resources, including labor, land, and some capital, which, if mobilized effectively, could reduce poverty and enhance quality of life. To achieve this, it is essential to optimize current resources, build infrastructure, adopt new production technologies, and establish new institutions. Together, these efforts can support sustainable development and drive progress in rural communities (World Bank 2024)

Climate represents the long-term average of temperature, humidity, and rainfall patterns across a region or globally, observed over seasons, years, or even decades. Unlike weather, which can shift within hours, climate evolves over extended periods. Climate change specifically refers to substantial shifts in these average conditions, such as warming, increased rainfall, or drought, that develop over multiple decades or more. This extended trend distinguishes climate change from natural fluctuations in daily weather (World Bank, 2024). Climate change can be described as enduring changes in temperature and weather patterns that can naturally result from factors like solar variations or significant volcanic eruptions. However, since the 1800s, human activities—primarily the burning of fossil fuels such as coal, oil, and gas have become the main contributors to climate change. This fuel combustion releases greenhouse gases that envelop the Earth, trapping the sun's warmth and driving up global temperatures (UN, 2023). Climate change leads to long-term shifts in temperature and weather patterns. These variations can happen naturally, influenced by factors like solar activity or major volcanic eruptions. Essentially, climate change represents substantial changes in average weather over decades. Today, it stands as a critical issue for both developed and developing nations, including Nepal (Shreshta, 2023). Emissions of methane, a potent GHG from natural ecosystems are rapidly rising, due to increases in temperature and rainfall. Antarctic sea temperatures have been at record highs in 2024, even as sea ice is at an all-time low, reducing the reflectance of solar radiation (ADB, 2024).

Climate change's impact on agriculture has directly affected both the economy and the lives of people, especially in rural communities. (Chaudhary, Maharjan, & Pallapu, 2020). Human activities, primarily through greenhouse gas emissions, have undoubtedly driven global warming, with global surface temperatures rising to 1.1°C above the 1850–1900 levels by 2011–2020. From 2010 to 2019, greenhouse gas emissions continued to grow, reflecting unequal contributions over time due to unsustainable energy use, land use changes, and consumption and production patterns across and within countries, regions, and even individuals. Human-driven climate change is now impacting weather and climate extremes globally, resulting in widespread negative effects on food and water security, human health, economies, and society, as well as causing extensive losses to ecosystems and communities. Particularly affected are vulnerable populations who have historically contributed the least to climate change, bearing the most disproportionate impact (UN, 2023). Livestock production accounts for around 40% of the global agricultural GDP. It supplies 33% of the world's protein and contributes 17% of the total calories consumed globally (Cheng McCarl & Fei, 2022). The effects of climate change are evidently affecting people's livelihoods across the globe. As a result, building human capacity to adapt to these changes has become a pressing necessity (Khatri, & Pasa, 2023). The interplay between ongoing climate change and the rising demand for livestock production creates challenges in boosting production while reducing climate impacts and greenhouse gas (GHG) emissions. Tackling these issues requires insight into how climate change affects livestock production, along with the effects of adaptation and mitigation strategies (Cheng McCarl, & Fei, 2022).

Climate change in Nepal affects food and agricultural systems differently across national, regional, and district levels. These impacts can vary, being positive, negative, or neutral depending on geography, so spatial data is essential for designing effective adaptive policies. For Nepal, a developing country, adaptation is more practical than mitigation. However, it is important for Nepal to advocate globally about the costs it incurs, such as increased pesticide use, altered rainfall patterns, natural disasters, and biodiversity loss, all linked to climate change. (Acharya & Bhatta, 2013). Mountain regions are particularly vulnerable to climate change and are expected to experience even greater impacts in the years ahead. Farmers observe that, on average, annual temperatures are increasing, and precipitation patterns are becoming more unpredictable, which adversely affects mountain livelihoods (Adhikari, Prasai,

Lamichhane, Gautam, Sharma & Acharya,2021). The negative impacts of climate change are escalating, affecting all aspects of life and jeopardizing quality of life in both urban and rural areas. The influence of climate change is evident across various parts of daily life, posing a significant threat to the urbanization process. These adverse effects, both direct and indirect, are impacting public health, leading to a rise in mortality rates(WHO,2018) .Climate change triggers a chain of risks, affecting ecosystems, agro-ecosystems, agricultural production, and food chains. These impacts extend to incomes and trade, influencing the economy and society, and ultimately threatening livelihoods, food security, and nutrition (FAO (2015). Rural communities, which often experience the impacts of climate change most directly, serve as crucial early warning indicators for society. These communities deserve support, not only for their intrinsic value and the well-being of their residents but also for their importance to all life on Earth (Christopher , Atkinson and Atkinson 2023). Climate change primarily threatens food and nutrition security. As Nepal's economy grows increasingly fragile, with agriculture as its foundation, the nation faces a high risk of experiencing the severe impacts of climate change (Dhungel, 2024).Climate change has notably impacted the Tarai and Gangetic Plain regions, with over 80% of GRB farmers observing shifts in temperature and precipitation. Floods frequently affect mountain areas, while droughts are common in the Gangetic Plain. Additionally, 74% of farmers reported climate-related crop diseases and pests, and vegetation cover was most affected in mountainous regions (Rai, Zhang, Paudel , Yan & Khanal,2023) .Terai districts have greater exposure due to their extensive agricultural lands, larger populations of livestock and poultry, and increased fishery activities. Districts in Mechi, Madesh, and Bagmati Provinces have higher exposure compared to other regions, whereas all districts in Karnali Province show very low or low exposure (GoN,2021).

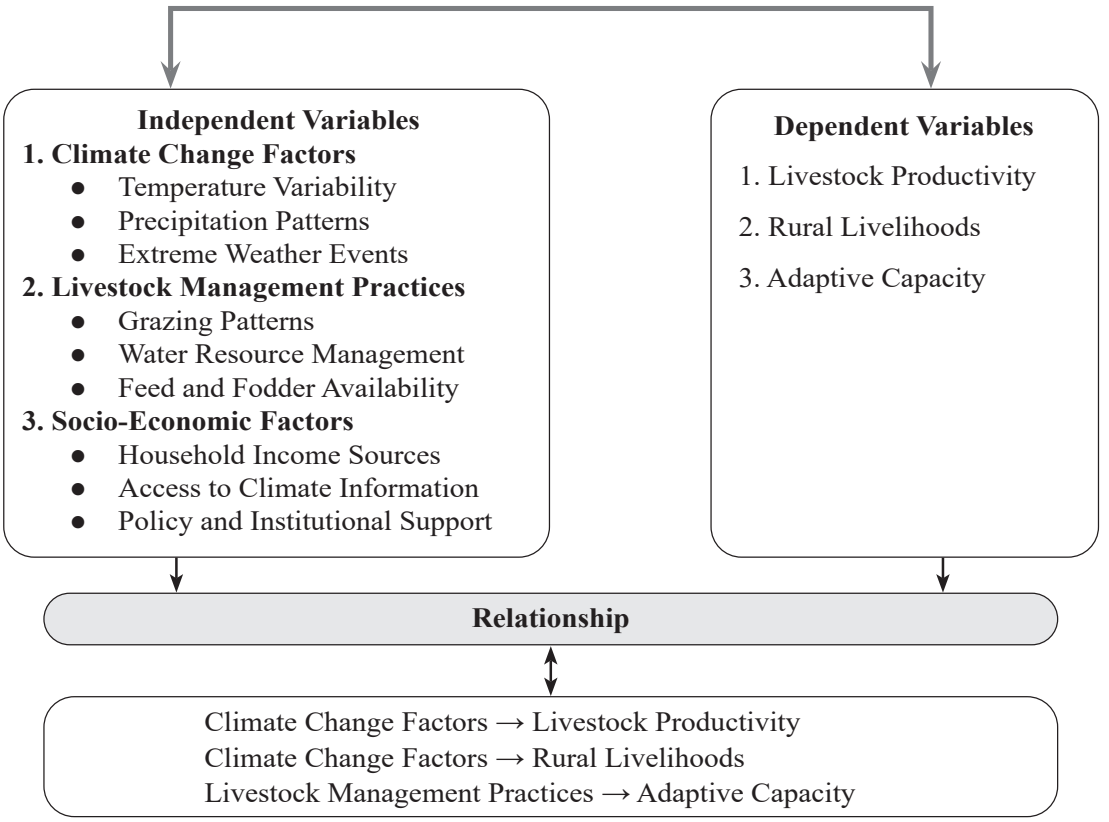
Climate change threatens livestock-centric rural development by disrupting livestock health, reducing productivity, and increasing disease prevalence. Erratic weather patterns and extreme climatic events undermine livelihoods and food security, leaving rural households highly vulnerable. Addressing these challenges is crucial for safeguarding the sustainability of livestock-dependent communities. This research seeks to address the knowledge gap by evaluating the impacts of climate change on livestock and examining the resilience of adaptive strategies. It aims to provide evidence-based recommendations for promoting sustainable agricultural practices, ensuring the long-term viability of livestock-dependent rural communities in the face of climate change.

Objective of the Study

- To assess the impact of climate change on livestock health, productivity, and the livelihoods of rural communities dependent on livestock farming.
- To identify adaptive strategies and best practices currently employed by livestock-centric rural communities to mitigate the adverse effects of climate change.
- To analyse the effectiveness of sustainable agricultural approaches in enhancing resilience among livestock-dependent rural communities, focusing on resource management, technological adoption, and policy support.

Conceptual Framework

The conceptual framework outlines the relationship between climate change and its effects on livestock-centric rural development, with a focus on crafting adaptive approaches for sustainable agriculture. The framework identifies key independent and dependent variables that drive the interaction between climate change and rural livelihoods, particularly those centered on livestock.



This conceptual framework provides a structured approach to understanding how climate change influences livestock-centric rural development. By identifying and analyzing the relationships between independent and dependent variables, the framework aims to guide the development of adaptive strategies that ensure sustainable agriculture in the face of climate change.

Literature Review

The study by Kangalawe and Lyimo (2013) reveals that most households rely on agriculture as their primary livelihood, making them highly vulnerable to climate change impacts on food security and overall well-being. Diversification into non-agricultural activities enhances adaptive capacity, providing crucial support when agriculture is negatively affected. Declining crop productivity is attributed to both climate-related factors, such as late rainfall, increased temperatures, and frequent droughts, and non-climatic issues like land shortages, low soil fertility, and inadequate extension services.

Another study by Koirala & Shrestha (2018) investigates climate change in Mustang's Jomsom and Kagbeni and concludes that it has caused disease outbreaks, increased parasites, reduced forage availability, and pasture degradation, leading to a decline in livestock numbers and income. Consequently, residents are shifting to alternative professions to sustain their livelihoods.

Chaudhary, Maharjan, & Pallapu, (2020). Local governments play a crucial role in addressing climate change impacts through policies, budgets, and social safety nets. Strengthening weather forecasting, advanced research, and awareness-building are essential for protecting vulnerable farmers. An interdisciplinary approach is vital for developing effective solutions to mitigate climate challenges in Nepal.

According to Verma and Sudan (2021), marginal and small farmers are highly vulnerable to climate change due to their reliance on agriculture and limited resources. Adaptation is essential to enhance resilience, secure livelihoods, and sustain agriculture under changing climatic conditions. Climate-smart agriculture emerges as a vital approach to adapt, ensure food and livelihood security, and mitigate greenhouse gas emissions.

In Dey's (2023) findings, climate change has severely impacted Bangladesh's livestock industry through increased disease, heat stress, and reduced productivity due

to higher temperatures and excessive rainfall. Mitigation requires improved livestock management, resilient breeds, and alternative feed. Collaborative efforts among policymakers, institutions, and organizations are essential to promoting climate-smart practices and supporting farmers in adapting to these challenges.

A study by Food and Agriculture Organization of the United Nations (2023) estimates the impacts of climate change on livestock systems, particularly cattle and buffaloes, which are essential for milk and meat production. It projects significant losses due to heat stress, with meat production potentially dropping by up to 22% and milk production by up to 21% by 2085, depending on climate scenarios (RCP 2.6 and RCP 8.5).

According to Singh, Leua, and Nidhishree (2024), climate-induced disasters have a direct impact on farmers' livelihoods since they rely on agriculture and animal husbandry, all of the respondents agreed that a drop in animal-agricultural production weakened the local economy. Because livestock is and will continue to play a significant part in the rural economy, it is critical to find appropriate solutions to mitigate the negative effects of climate change on livestock output.

Imelda and Hidayat (2024) in a study on climate change in Indonesia highlights four key findings. First, most studies focus on crop farming (60%), followed by fisheries (23%) and general agriculture (17%), with Java as the primary geographic focus. Second, Climate Change Adaptation and Mitigation (CCAM) strategies fall into ecological, economic, and social categories, emphasizing a balanced approach to sustainable agriculture. Ecological adaptations include technology adoption, economic strategies involving livelihood diversification, and social measures using indigenous knowledge. Third, socioeconomic factors like gender, education, and resource access influence adaptive capacity. Finally, CCAM strategies may involve short-term trade-offs, such as reduced productivity and high initial investments.

Methodology

Research Design

A mixed-methods research design was used for the study. The quantitative aspect involved surveys and structured data collection to assess the impact of climate change on livestock health, productivity, and rural livelihoods. Measurable indicators such as livestock mortality rates, productivity changes, and income shifts were

analyzed using statistical methods. These data allowed for a numerical evaluation of how climate change affected livestock-dependent communities. In parallel, qualitative methods such as interviews, focus groups, and case studies explored the adaptive strategies employed by rural communities. These methods provided deeper insights into the adoption of water conservation techniques, climate-resilient livestock breeds, and sustainable feeding practices. Additionally, qualitative data helped understand the perception of policy support and the effectiveness of resource management practices and climate-smart agricultural technologies. By combining these approaches, the study not only measured the direct impacts but also uncovered the underlying social, cultural, and policy factors that influenced the effectiveness of adaptive strategies, thus providing a more holistic understanding of climate change adaptation in livestock-centric rural development.

Source of Data

The research utilized both qualitative and quantitative data to gain a comprehensive understanding of the topic. Primary data was collected through surveys, interviews, and field observations, providing firsthand insights. Secondary data was sourced from existing reports, research papers, and official records, allowing for a broader context and supporting the study's analysis.

Sampling Method and Sample Size

Gaindakot Municipality, comprising 18 wards, has been purposively selected as the study area. Among these, five wards (1, 8, 10, 11, and 14) have been identified for detailed analysis. The selection of these specific wards was based on their relevance to the research objectives. Within these selected wards, there are a total of 94 firms. To ensure focused and meaningful data collection, 28 firms were purposively chosen from this pool. This sampling strategy allows for an in-depth examination of the study variables, ensuring that the selected firms provide rich insights aligned with the research's primary objectives. The sample structure is presented in the following table:

Table 1

Sampling Method and Sample Size

Wards	Population					Sample Size					Total sample Size
	Cow Firms	Goat Firms	Pig Firms	Hatchery Firms	Hens Firms	Cow Firms	Goat Firms	Pig Firms	Hatchery Firms	Hens Firms	
1	6	-	-	-	5	1				1	2
8	6	1			2	1	1			1	3
10	52	1			1	6	1			1	8
11	27	1	3		2	5	1	3		1	10
14	3	1		1	9	1	1		1	2	5
Total	94	04	03	01	19	14	04	03	01	06	28

Data analysis

Data analysis for this research was conducted using both quantitative and qualitative methods. The quantitative data, collected through surveys, were analyzed using statistical tools to assess the impact of climate change on livestock health, productivity, and rural livelihoods. Descriptive statistics, such as frequencies and percentages, were used to examine the adoption of adaptive strategies like water conservation techniques and climate-resilient breeds. The qualitative data from interviews and focus groups were analyzed thematically to explore the effectiveness of resource management practices, technological adoption, and policy support for sustainable agriculture. This combined approach provided a comprehensive understanding of climate change impacts and adaptation strategies.

Results and Discussion

Caste Composition of the Respondents

The caste composition of Gaindakot Municipality in Nawalparasi District showcases the rich ethnic and cultural diversity of Nepal. The predominant castes in this area include Brahmin, Chhetri, Magar, Tharu, Dalit, Newar, and Tamang (Municipal Profile,2081).

Table 2

Caste Composition of the Respondents

S.N	Caste	Frequency	Percent
1.	Brahman	17	60
2.	Magar	4	14
3.	Newar	2	7
4.	Tharu	2	7
5.	Gurung	1	4
6.	Chhetri	1	4
7.	Dalit	1	4
	Total Households	28	100

Source: Field survey, 2022

Table 2 shows that the Brahman caste constitutes a significant majority, accounting for 60%. This dominance suggests a strong presence of Brahman culture and practices in the community, potentially influencing local governance, education, and social norms. The next largest group is the Magar caste, making up 14%. Their presence indicates that indigenous cultures are also part of the community's fabric. However, the low representation of other castes, such as Newar (7%), Tharu (7%), Gurung (4%), Chhetri (4%), and Dalit (4%), highlights a disparity in representation. The caste composition of households in Gaindakot Municipality illustrates a significant imbalance, with the Brahman caste overwhelmingly represented. While there is some diversity, the low numbers of other castes indicate potential issues of marginalization. Recognizing these dynamics is crucial for promoting inclusivity and equity in community development efforts.

Food Sufficiency

Food security is present when every person has stable physical and financial access to adequate, safe, and nutritious food that fulfills their dietary requirements and personal choices, supporting an active and healthy lifestyle. (World Bank,2024). Food sufficiency refers to the condition where a population or community has an adequate and stable supply of food to meet its nutritional needs without relying heavily on imports or external assistance. It emphasizes the ability of local agricultural production,

resources, and systems to provide enough food for the people within a specific area. Achieving food sufficiency involves ensuring that food is not only available but also accessible, affordable, and culturally acceptable to the population, thus contributing to overall food security and the well-being of individuals and communities.

Table 3

Food Sufficiency

Food Sufficiency	Frequency	Percent
6-12 month	16	57
Surplus	12	43
Total Households	28	100

Source: Field Survey, 2022

Table 3 indicates that all 28 households surveyed are either able to sustain their food supply for 6-12 months or have a surplus, demonstrating a generally positive state of food security within the community. The majority, 57% (16 households), report having food sufficiency for 6-12 months. This suggests that these households can adequately manage their food resources for a significant duration, reflecting effective agricultural practices, good food storage strategies, or a consistent income that supports food purchasing. A notable 43% (12 households) report having surplus food. This surplus indicates not only food security but also the potential for economic benefits through the sale or sharing of excess food. Households with surplus can contribute to local markets and enhance community resilience by providing food to those who may experience shortages in the future. The combined data suggests a robust community framework for food production and management. The presence of both food-sufficient and surplus households can foster a supportive environment where food security is reinforced through shared resources and community cooperation. The surplus reported can stimulate local economic activities. Households that produce more food than they need may engage in selling their surplus, thus promoting local trade and potentially increasing household incomes. This could contribute to overall economic stability in the area. The data presents a favorable picture of community food security, with over half of the households able to sustain their food needs for 6-12 months and a significant portion reporting surplus production. This situation reflects a resilient

agricultural community that can support itself and contribute to local economic activities. Continued attention to food security practices and the support of vulnerable households will be crucial for maintaining this positive trend.

Livestock Holding of the Respondents

Livestock holding plays a crucial role in the local economy and agricultural practices. The predominant livestock includes cattle, buffaloes, goats, and poultry, which serve various purposes such as providing meat, milk, and eggs, as well as contributing to household income.

Table 4

Livestock size of the Respondents

Livestock	Frequency	Percent
10-20	2	7
20-40	17	61
40-60	2	7
60 and above	7	25
Total	28	100

Source: Field Survey, 2022

Table 4 presents the distribution of livestock sizes among the 28 surveyed households in Gaindakot Municipality, revealing insights into livestock farming practices in the area. The most common category is households with 20-40 livestock, comprising 61% (17 households). This suggests that a majority of the respondents engage in moderate to substantial livestock farming, which may be a significant aspect of their livelihood and economy. Households with 60 or more livestock represent 25% (7 households). This group, while smaller, indicates the presence of larger-scale livestock operations, which can provide more substantial income and food security benefits. These households may have greater resources and better access to markets, impacting their overall economic stability. The categories of 10-20 and 40-60 livestock each account for only 7% (2 households each). This low representation could suggest that few households opt for very small or moderately large livestock holdings, possibly reflecting market dynamics, resource availability, or a preference for larger herds to maximize productivity. The distribution of livestock sizes among respondents in

Gaindakot Municipality illustrates a significant engagement in livestock farming, with a majority of households maintaining moderate herds of 20-40 animals. This suggests that livestock farming is an essential component of their livelihoods. The presence of households with larger herds indicates economic potential, while the low number of households with very small or moderately large holdings could suggest a need for support and resources to enhance livestock productivity and sustainability in the community.

Landholding Size

Land is a key resource in determining people's wealth and social status. Families with larger landholdings are typically considered higher class, while those with smaller holdings are seen as lower class. Additionally, the fertility and irrigation potential of the land influence a family's status, with fertile, irrigated land being more valuable. The size of a household's landholding directly affects its reliance on forest resources: those with more land depend less on forests, whereas households with less land tend to rely more heavily on these resources. The following table presents landholding sizes among respondents in the study area.

Table 5

Landholding Size of the Respondents

Land (In Kattha)	Frequency	Percent
1-5	12	43
6-10	2	7
11-15	11	39
Above 15	3	11
Total	28	100

Source: Field Survey, 2022.

The largest group of respondents, 43% (12 households), falls within the 1-5 kattha range. A close second, 39% (11 households), own land in the 11-15 kattha range. The 6-10 kattha category shows very low representation at 7% (2 households), while 11% (3 households) have landholdings above 15 kattha. The analysis of landholding size reveals a predominance of small landholdings (1-5 kattha), suggesting challenges for many households in achieving sufficient agricultural output and economic stability.

While a significant proportion of households possess moderate landholdings (11-15 kattha), the overall distribution indicates limited opportunities for larger-scale farming. Addressing the needs of small landholders through support services and cooperative initiatives may be crucial in enhancing agricultural productivity and ensuring food security within the community.

Plants, Fodder and Grazing Lands

Access to plants, fodder, and grazing land is crucial for local survival. In developing countries like Nepal, animal husbandry significantly contributes to economic development. In the study area, livestock graze primarily in forests rather than on private or public grazing lands, as there is no dedicated public grazing area. Fodder, essential for livestock, is mostly gathered from community forests and private lands. Although the region has low agricultural yields, it is rich in forest resources, supporting a high density of livestock farming. Locals rely on animal husbandry and vegetable farming for survival, gathering fodder, fuel wood, and leaves year-round. The table below outlines grazing land access and fodder collection patterns.

Table 6

Access of Collect of Plant, Fodder, and Grazing Land

Name of grazing land	Frequency	Percent	Fodder collection in different seasons	Frequency	Percent
Forests	7	25	Summer	7	25
Own land	19	68	Winter	3	11
Public grazing land	2	7	Summer/Winter	18	64
No access to grazing land	0	0			
Total	28	100		28	100

Source: Field Survey, 2022

Table 6 illustrates access to plant collection, fodder, and grazing land among households in the study area. A significant majority, 68% (19 households), access their own land for grazing, while 25% (7 households) utilize forests, indicating a reliance on privately owned resources. Public grazing land is less common, used by only 7% (2 households). Regarding fodder collection, 64% (18 households) gather fodder in both

summer and winter, suggesting adaptability in managing seasonal changes. In contrast, only 25% (7 households) collect fodder solely in summer, and 11% (3 households) do so in winter. This data indicates a strong capacity among households to secure necessary fodder year-round, which is vital for livestock sustainability and overall agricultural productivity. Such access supports livelihoods, enhancing food security in the community.

Impact of Climate Change on Livestock Health

The impact of climate change on livestock health is becoming increasingly evident. Rising temperatures and erratic rainfall patterns contribute to the prevalence of heat stress, which adversely affects livestock productivity and reproductive performance. Additionally, changing climate conditions can exacerbate the spread of diseases and parasites, posing significant risks to animal health. Water scarcity further complicates the situation, limiting access to clean drinking water and quality forage. Farmers face challenges in managing their herds, leading to reduced livestock productivity and increased economic vulnerability.

Table 7

Impact of Climate Change on Livestock Health

Impact Level	Frequency	Percent
Severe Impact	10	35.7
Moderate Impact	12	42.9
Mild Impact	6	21.42
Total	28	100

Source: Field survey, 2022

Table 7 shows that 42.9% (12 households), report a moderate impact, while 35.7% (10 households) experience severe effects on their livestock. Only 21.4% (6 households) indicate a mild impact. This distribution highlights that over three-quarters of the respondents perceive notable challenges due to climate change, which may affect livestock productivity, health, and overall agricultural sustainability. These findings underscore the need for targeted interventions to mitigate climate impacts and enhance livestock management practices in the community.

Impact of Climate Change on Livestock Productivity

Climate change significantly impacts livestock productivity, affecting the livelihoods of local farmers. Altered weather patterns, including increased temperatures and unpredictable rainfall, lead to reduced forage availability and lower nutritional quality, directly influencing livestock growth and milk production. Heat stress in animals decreases reproductive performance and increases mortality rates, further diminishing productivity. Additionally, the rise in livestock diseases due to changing climate conditions poses a threat to herd health, compounding the issue.

Table 8

Impact of Climate Change on Livestock Productivity

Impact Level	Frequency	Percent
Significant Decline	9	32.1
Moderate Decline	11	39.3
Minor Decline	8	28.57
Total	**28**	**100**

Source: Field survey, 2022

Table 8 shows that, 32.1% experienced a significant decline, 39.3% a moderate decline, and 28.57% a minor decline. This indicates that climate change is having a substantial negative impact on livestock productivity in the surveyed area. A substantial portion (32.1%) of respondents experienced a significant decrease in livestock productivity. This suggests that climate change is severely affecting the health, growth, and overall yield of livestock in the region. A considerable number of respondents (39.3%) reported a moderate decline in productivity. This indicates that climate change is negatively impacting livestock, although to a lesser extent than the significant decline group. While a smaller proportion (28.57%) experienced only a minor decline, it still highlights the widespread impact of climate change on livestock productivity. Even a minor decline can have economic and social consequences for farmers and communities reliant on livestock. Climate change is posing a substantial threat to livestock productivity in the surveyed area. This has implications for food security, rural livelihoods, and the overall economy of the region.

Impact of Climate Change on Livelihoods of Rural Communities

Climate change poses significant threats to the livelihoods of rural communities, particularly those dependent on agriculture and livestock. Erratic weather patterns, including increased temperatures and unpredictable rainfall, disrupt farming schedules and reduce crop yields, leading to food insecurity. Livestock health is compromised by heat stress and the spread of diseases, diminishing productivity and income. Additionally, limited access to water resources exacerbates these challenges, making it difficult for farmers to sustain their operations.

Table 9

Impact of Climate Change on Livelihoods of Rural Communities

Impact on Livelihoods	Frequency	Percent
High Impact	13	46.4
Moderate Impact	9	32.1
Low Impact	6	21.42
Total	**28**	**100**

Source: Field survey, 2022

Table 9 shows that, 46.4%, reported a high impact on their livelihoods. This suggests that climate change is a major challenge for these communities, affecting their ability to sustain their livelihoods. Additionally, 32.1% of respondents reported a moderate impact, indicating that climate change is still a significant concern for a substantial portion of the rural population. Only 21.42% of respondents reported a low impact, highlighting the widespread nature of the issue. These findings underscore the urgent need for targeted interventions and policies to help rural communities adapt to the challenges posed by climate change. Such interventions could include climate-smart agriculture practices, improved access to water resources, and social safety nets to protect vulnerable populations.

Adoption of Water Conservation Techniques

The adoption of water conservation techniques is crucial for sustainable agriculture and livestock management. Farmers are increasingly implementing methods such as rainwater harvesting, drip irrigation, and water recycling to optimize water usage amid changing climate conditions. These techniques help improve crop

yields and ensure livestock health by providing a reliable water supply.

Table 10

Adoption of Water Conservation Techniques

Strategy	Frequency	Percent
Drip Irrigation	9	32.14
Improved Irrigation Systems	5	17.85
Water Reuse	3	10.71
No Water Conservation	8	28.57
Constructing Gabion Walls	3	10.71
Total	**28**	**100**

Source: Field survey, 2022

Table 10 summarizes the adoption of water conservation techniques among 28 respondents. Drip irrigation is the most widely adopted technique (32.14%), highlighting its perceived efficiency in minimizing water wastage. Improved irrigation systems follow with 17.85%, showing moderate adoption and suggesting potential barriers like cost or accessibility. Water reuse and constructing gabion walls are both adopted by 10.71% of respondents, indicating limited uptake, possibly due to practical challenges in implementing these methods. A notable 28.57% of respondents do not engage in any water conservation methods, underscoring a gap in resources, awareness, or support. This segment points to an opportunity for interventions to encourage sustainable water practices. Overall, while drip irrigation shows popularity, the presence of respondents with no conservation strategies highlights a need for further outreach and assistance in promoting water-saving techniques.

Use of Climate-Resilient Livestock Breeds

The use of climate-resilient livestock breeds is becoming essential for adapting to the impacts of climate change. Farmers are increasingly selecting breeds that can withstand heat stress, resist diseases, and thrive in variable environmental conditions.

Table 11

Use of Climate-Resilient Livestock Breeds

Strategy	Frequency	Percent
Adapted Livestock Breeds	10	35.7
Mixed Breeding Techniques	7	25.0
Traditional Breeds	6	21.4
No Specific Breeding Strategy	5	17.9
Total	**28**	**100**

Source: Field survey, 2022

Table 11 shows that 35.7%, are utilizing adapted livestock breeds that are more resilient to climate-related challenges such as heat stress, drought, and disease. This suggests a growing awareness of the importance of genetic adaptation in livestock production. Mixed breeding techniques, adopted by 25% of respondents, involve crossbreeding traditional breeds with more resilient ones to improve their overall performance. This approach can enhance the adaptability of livestock to changing climatic conditions. 21.4% of respondents continue to rely solely on traditional breeds, which may be less resilient to climate change. Additionally, 17.9% of respondents have no specific breeding strategy, which could further exacerbate the negative impacts of climate change on livestock. To mitigate these challenges, it is crucial to promote the adoption of climate-resilient livestock breeds and breeding techniques. This can be achieved through education, training, and access to quality breeding stock. By investing in sustainable livestock practices, farmers can enhance their resilience to climate change and ensure long-term food security.

Implementation of Sustainable Feeding Practices

The implementation of sustainable feeding practices is vital for improving livestock health and productivity. Farmers are increasingly adopting techniques such as rotational grazing, utilizing local feed resources, and supplementing diets with nutrient-rich forage. These practices not only enhance animal nutrition but also promote soil health and reduce environmental impact.

Table 12

Implementation of Sustainable Feeding Practices

Practice	Frequency	Percent
Use of Drought-Resistant Fodder	11	39.3
Supplementary Nutritional Feeding	9	32.1
Seasonal Grazing Adjustments	5	17.9
No Sustainable Feeding Practice	3	10.7
Total	**28**	**100**

Source: Field survey, 2022

Table 12 shows that 39.3%, are utilizing drought-resistant fodder, demonstrating a proactive approach to mitigating the impacts of climate change on livestock feed availability. Supplementary nutritional feeding, adopted by 32.1% of respondents, can help maintain livestock health and productivity, especially during periods of feed scarcity. Seasonal grazing adjustments, practiced by 17.9% of respondents, can help optimize livestock grazing and reduce pressure on pasturelands. However, a concerning 10.7% of respondents have not implemented any sustainable feeding practices, which could compromise the health and productivity of their livestock. To enhance the resilience of livestock systems, it is essential to promote the adoption of sustainable feeding practices. This can be achieved through education, training, and access to quality fodder and feed supplements. By adopting these practices, farmers can ensure the well-being of their livestock and contribute to sustainable agriculture.

Effectiveness of Resource Management Practices

Effective resource management practices are crucial for enhancing agricultural sustainability. Farmers are implementing techniques like water conservation, soil management, and crop rotation. These practices improve productivity, mitigate climate impacts, and promote efficient use of local resources, ultimately contributing to the resilience and livelihoods of the rural community.

Table 13

Effectiveness of Resource Management Practices

Practice	Frequency	Percent
Efficient Water Use	10	35.7
Soil Conservation Techniques	8	28.6
Crop-Livestock Integration	6	21.4
No Resource Management	4	14.3
Total	**28**	**100**

Source: Field survey, 2022

Table13 shows that 35.7%, are implementing efficient water use techniques, demonstrating a growing awareness of the importance of water conservation in agriculture. Soil conservation techniques, adopted by 28.6% of respondents, can help protect soil quality and prevent erosion, which is crucial for long-term agricultural productivity. Crop-livestock integration, practiced by 21.4% of respondents, can enhance nutrient cycling, improve soil fertility, and reduce reliance on external inputs. However, a concerning 14.3% of respondents have not adopted any resource management practices, which could lead to resource degradation and reduced agricultural yields. To promote sustainable agriculture, it is essential to encourage the adoption of effective resource management practices. This can be achieved through education, training, and access to appropriate technologies. By implementing these practices, farmers can improve their livelihoods, protect the environment, and ensure food security for future generations.

Adoption of Climate-Smart Agricultural Technology

The adoption of climate-smart agricultural technology is gaining momentum among local farmers. Techniques such as improved irrigation systems, precision farming, and resilient crop varieties enhance productivity while reducing environmental impact.

Table 14

Adoption of Climate-Smart Agricultural Technology

Technology Type	Frequency	Percent
Digital platforms	4	14.29
Renewable energy use	3	10.71
No technological adoption	6	21.43
Agroforestry	4	14.29
Integrated pest management (IPM)	3	10.71
Crop diversification	4	14.29
Soil testing and fertility management	2	7.14
Improved storage facilities	1	3.57
Crop insurance	1	3.57
Total	**28**	**100**

Source: Field survey, 2022

Table14 illustrates the adoption rates of various climate-smart agricultural technologies among respondents, providing insight into sustainable farming practices in the study area. Digital platforms, agroforestry, and crop diversification each account for 14.29% of the adoption, indicating a balanced interest in tools that enhance resource efficiency and ecosystem resilience. However, the notable rate of "no technological adoption" (21.43%) highlights a significant barrier to broader adoption of climate-smart practices, suggesting potential issues such as lack of awareness, access, or affordability. Lower adoption rates are evident in soil testing (7.14%), improved storage (3.57%), and crop insurance (3.57%), which are vital for long-term agricultural sustainability but appear underutilized. Renewable energy and integrated pest management (10.71% each) show moderate adoption, reflecting an emerging interest in eco-friendly practices. The data indicate a gradual shift towards climate resilience, with some technologies more widely accepted than others, yet with area for improvement in comprehensive adoption.

Perception of Policy Support for Sustainable Agriculture

Perceptions of policy support for sustainable agriculture vary among farmers. Many appreciate government initiatives aimed at promoting sustainable practices, while others express concerns about inadequate resources and implementation.

Table 15

Perception of Policy Support for Sustainable Agriculture

Level of Policy Support	Frequency	Percent
Highly Supportive	4	14.28
Moderately Supportive	10	35.7
Minimally Supportive	8	28.6
No Policy Support	6	21.42
Total	**28**	**100**

Source: Field survey, 2022

Table15 shows that 35.7%, perceive moderate levels of support, suggesting that some policies are in place to promote sustainable practices. However, 28.6% perceive minimal support, indicating a need for more targeted and effective policies. A concerning 21.42% of farmers feel there is no policy support for sustainable agriculture, highlighting a gap in policy implementation and outreach. While 14.28% perceive high levels of support, further investigation is needed to identify the specific policies contributing to this perception. To enhance the adoption of sustainable agriculture, it is crucial to strengthen policy support. This includes developing clear and coherent policies, providing adequate financial incentives, and ensuring effective implementation and monitoring. By addressing the perceived gaps in policy support, governments can empower farmers to transition to more sustainable practices and contribute to environmental conservation and food security.

Effects of Climate Change on Livestock-Centric Rural Development

Climate change adversely affects livestock-centric rural development through declining animal health, reduced productivity, and increased vulnerability to diseases. Erratic weather patterns disrupt grazing and feed availability, threatening food security and livelihoods.

Table 16

Effects of Climate Change on Livestock-Centric Rural Development

Effect of Climate Change	Frequency	Percent
Decreased Livestock Health	12	42.9
Reduced Productivity	10	35.7
Increased Livelihood Challenges	9	32.1
Altered Feeding Practices	8	28.6
Increased Livestock Diseases	11	39.3
Economic Instability	7	25.0
Changes in Resource Availability	10	35.7
Total	28	100

Source: Field survey, 2022

Table 16 highlights the significant negative impacts of climate change on livestock-centric rural development. A substantial proportion of respondents, 42.9%, reported decreased livestock health due to factors such as heat stress and disease outbreaks exacerbated by changing climatic conditions. Reduced productivity, affecting 35.7% of respondents, is another major consequence, as climate change can lead to lower milk yields, reduced weight gain, and decreased fertility in livestock. This, in turn, impacts the livelihoods of rural communities heavily reliant on livestock. Increased livelihood challenges, reported by 32.1% of respondents, are a direct result of these factors. Altered feeding practices, increased livestock diseases, economic instability, and changes in resource availability further compound these challenges. To mitigate these impacts, it is crucial to implement climate-resilient livestock practices, such as improved breeding, vaccination, and feeding strategies. Additionally, policies and programs should be designed to support rural communities in adapting to climate change and building resilience.

Conclusion and Implication

The study reveals that climate change is significantly impacting livestock-centric rural development. A majority of respondents reported moderate to severe impacts on livestock health, productivity, and overall livelihoods. This underscores the urgent need for adaptive strategies to mitigate these challenges. The findings highlight

the importance of adopting climate-resilient practices. These include promoting the use of climate-resilient livestock breeds, improving water management through techniques like drip irrigation, and implementing sustainable feeding practices to ensure adequate nutrition for livestock. Additionally, strengthening policy support and promoting the adoption of climate-smart agricultural technologies are crucial for building resilience in rural communities. By addressing these issues, it is possible to mitigate the negative impacts of climate change, enhance livestock productivity, and ensure the sustainability of rural livelihoods. Further research and continuous monitoring are necessary to refine adaptation strategies and support the long-term resilience of livestock-based systems.

Implications

The findings of this study have significant implications for policymakers, development practitioners, and researchers:

- There is an urgent need for targeted interventions to mitigate the adverse effects of climate change on livestock-centric rural development. These interventions should focus on enhancing the resilience of livestock systems, improving livestock health, and increasing productivity.
- Promoting the adoption of climate-smart agricultural practices, such as improved breeding, vaccination, and feeding strategies, is crucial to enhance the resilience of livestock systems.
- Strong policy support is essential to facilitate the transition to sustainable livestock practices. Governments should develop and implement policies that incentivize climate-resilient agriculture, provide financial support, and create enabling environments for farmers.
- Investing in capacity building and knowledge transfer is crucial to empower farmers and communities to adapt to climate change. This includes training programs on climate-smart agriculture, access to information and technology, and financial literacy.
- Continued research and monitoring are necessary to understand the evolving impacts of climate change on livestock systems and to refine adaptation strategies.

References

Acharya, B. (2008). Dimension of rural development in Nepal. *Dhaulagiri Journal of Sociology and Anthropology, 2*, 1-14.

Acharya, S. P., & Bhatta, G. R. (2013). Impact of climate change on agricultural growth in Nepal. *NRB Economic Review, 2013*, 1-20.

Adhikari, D., Prasai, R., Lamichhane, S., Gautam, D., Sharma, S., & Acharya, S. (2021). Climate change impacts and adaptation strategies in Trans-Himalaya region of Nepal. *Journal of Forest and Livelihood, 20*(1), 1–13.

Asian Development Bank. (2024). *Asia-Pacific climate report 2024: Catalysing finance and policy solutions*. Mandaluyong City, Philippines: Asian Development Bank.

Atkinson, C. L., & Atkinson, A. M. (2023). Impacts of climate change on rural communities: Vulnerability and adaptation in the global South. *Encyclopedia, 3*, 721–729. https://doi.org/10.3390/encyclopedia30100721

Chaudhary, D., Maharjan, S., & Pallapu, A. V. (2020). The effect of climate change on rural livelihood in Nepal. *IOSR Journal of Humanities and Social Science (IOSR-JHSS), 25*(10), 21-30. https://doi.org/10.9790/0837-2510022130

Cheng, M., McCarl, B., & Fei, C. (2022). Climate change and livestock production: A literature review. *Atmosphere, 13*, 140. https://doi.org/10.3390/atmos13010140

Dey, S. (2023). Climate change effects on livestock production in Bangladesh and its economic impacts. *South Asian Journal of Agriculture, 21*(2). https://doi.org/10.3329/sja.v21i2.68030

Dhungel, H. B. (2024). Impact of climate change on the farming community of Bhaktapur district of Nepal. *Baneshwor Campus Journal of Academia, 3*(1), 50–62.

Food and Agriculture Organization of the United Nations. (2023). *An analysis of the effects of climate change on livestock.* FAO.

Food and Agriculture Organization. (2015). *Climate change and food security: Risks and responses*. Food and Agriculture Organization of the United Nations.

Gaidakot Municipality. (2081). *Municipal profile*. Gaidakot: Gaidakot Municipality.

Government of Nepal, Ministry of Forests and Environment. (2021). *Vulnerability and risk assessment and identifying adaptation options*. Kathmandu : Government of Nepal.

Hidayat, I. R. (2024). Climate change impacts, adaptation and mitigation in the agricultural sector. *Global Journal of Environmental Science and Management.* Retrieved from http://creativecommons.org/licenses/by/4.0/

Kangalawe, R. Y. M., & Lyimo, J. G. (2013). Climate change, adaptive strategies and rural livelihoods in semiarid Tanzania. *Natural Resources, 4*(3), 66–78. https://doi.org/10.4236/nr.2013.43034

Khatri, B. B., & Pasa, R. B. (2023). People's perception on climate change: The context of local and global discourse. *Asian Journal of Population Sciences, 2*(1), 68–79.

Koirala, A., & Shrestha, K. B. (2018). Effects of climate change on the livestock population in Mustang District, Nepal. Retrieved from https://www.researchgate.net/publication/329962349

Maharjan, R. K. (2024). Impacts of climate change on farm-based livelihood: A study of Panchkhal. *Journal of APF Command and Staff College, 7*(1), 16–50.

Paudel, M. N. (2016). Consequences of climate change in agriculture and ways to cope with its effect in Nepal. *Agronomy Journal of Nepal, 4*, 1–9.

Rai, R., Zhang, Y., Paudel, B., Yan, J., & Khanal, N. R. (2023). Analysis of farmers' perceptions of climate changes and adaptation strategies in the transboundary Gandaki River Basin. *Land, 12*(1)

Shrestha, S. K. (2023). Climate change and adaptive strategies for agriculture in Panchkhal Municipality. *Journal of Geography, 23*, 47-65.

Singh, N., Leua, A. K., & Nidhishree, R. (2024). Climate change impacts on livestock for sustainable production: A Ricardian approach. *International Journal of Agriculture Extension and Social Development, 7*(1), 16–22.

United Nations. (2023). *Climate change 2023 synthesis report*. United Nations.

Verma, S., & Sudan, F. K. (2021). Impact of climate change on marginal and small farmers' livelihood and their adaptation strategies: A review. *Regional Economic Development Research.* Retrieved from http://ojs.wiserpub.com/index.php/REDR/

World Bank. (2024). *Rural development: Sector policy paper*. Washington, D.C.: World Bank Group.

World Bank. (2024). *What is climate change?* World Bank. https://www.worldbank.org/en/topic/climatechange/overview

World Bank. (2024). *What is food security?* Washington, D.C.: World Bank Group. https://www.worldbank.org/en/topic/agriculture/brief/food-security

World Health Organization. (2018). *COP24 special report: Health and climate change*. Geneva: WHO.