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Adaptive Strategies of Rural Communities in Nepal to Climate Change Impacts

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Abstract

Rural communities in Nepal are increasingly vulnerable to the impacts of climate change, particularly in agriculture-dependent regions like Surkhet District. This study investigates the adaptation strategies employed by these communities to cope with climate variability and associated risks. Findings reveal that households rely on a mix of traditional practices and modern techniques, including crop diversification, water-efficient irrigation, and community-led resource management. The study underscores the critical role of financial, social, and natural capital in shaping adaptive capacity, aligning with the Sustainable Livelihood Framework (SLF) and Community-Based Adaptation (CBA) approaches. Financial capital enables investment in advanced agricultural technologies, while social capital strengthens community resilience through collective action and shared resource governance. Despite these efforts, limited financial support and inadequate institutional backing hinder widespread adaptation, particularly for marginalized communities. This study emphasizes the importance of inclusive climate adaptation policies, enhanced institutional support, and improved financial and technological access to strengthen rural resilience. The insights presented offer valuable guidance for policymakers, development organizations, and local stakeholders in designing sustainable adaptation strategies that address the unique vulnerabilities of Nepal's rural communities.

Keywords

Climate adaptation, Rural resilience, Sustainable livelihoods, Community-based adaptation, Climate policy

Introduction

Climate change is one of the most critical and emerging issues facing rural communities across the globe, especially in those areas highly reliant on agriculture, like Nepal. The Nepalese economy is heavily dependent on subsistence production farming, which is now facing tremendous challenges from the mixture of uncertain monsoons, increasing temperatures, and other extreme climatic events that have become more frequent and intense (Department of Hydrology and Meteorology, Nepal, 2020).

rural communities (Gurung & Sherpa, 2019). As the threat of climate change grows and intensifies, it is extremely crucial to understand how rural communities respond to the climatic variability to formulate an effective and sustainable adaptation strategy to counter these impacts.

The climate of Nepal is largely dominated by the South Asian monsoon, and it plays a major role in the country's annual rainfall, with it contributing almost 80% of the annual rainfall received throughout the year (Shrestha & Aryal, 2012). However, the nation has, in the last few decades, witnessed an elevated trend of more frequent instances of droughts, coupled with abnormally heavy monsoon seasons, along with seasonal climatic pattern changes (Gautam & Pokhrel, 2017). The Surkhet District, the main focus of this specific study, has, in this regard, witnessed irregular rainfall patterns, extended dry spells, and a significant reduction in soil fertility, all of which are serious issues concerning the long-term sustainability of agriculture in the region (Paudel, 2019). As per the findings recorded in the year 2020 by Nepal's Department of Hydrology and Meteorology, the nation's mean annual temperature has witnessed an increasing trend with the acceleration in the rise increasing at a rate of 0.06°C per year, and at higher elevations, it is experiencing an even faster extent of warming trend (Karki & Gurung, 2018). Despite the multitude of studies already conducted on climate change adaptation, there remains an enormous range of knowledge gaps at the community level that are yet to be filled. The available set of studies focuses primarily on national-level policies (Regmi & Bhandari, 2013) or observable macro-level trends (World Bank, 2022), and thus the local adaptation interventions are not well researched and understood. Also, even though there is general recognition that the availability of financial capital and technological innovation are key drivers in enabling adaptation to take place (Pandey & Bardsley, 2015), relatively less attention has been paid to highlighting the role of indigenous knowledge in the formulation of climate resilience at the community level (Chaudhary et al., 2019). It is imperative that these knowledge gaps recognized are filled so that effective and locally defined adaptation policies can be developed. The study is guided by two underpinning theoretical paradigms. The Sustainable Livelihood Framework (SLF) recognizes five fundamental capital assets—financial, human, social, physical, and natural—through which adaptation capacity is strongly influenced. Those households that enjoy greater access to financial capital and infrastructural facilities have a higher chance of implementing modern adaptation interventions, such as the utilization of drip irrigation systems and the cultivation of high-yielding crop. The Community-Based Adaptation (CBA) approach emphasizes community-driven adaptation, highlighting the effectiveness of community-managed irrigation systems, farmer-managed seed banks, and participatory decision-making (Chaudhary et al., 2019).

This study examines how rural communities in Surkhet District adapt to climate variability. Specifically, it investigates what adaptation strategies have been adopted, their effectiveness in sustaining livelihoods, and existing gaps in adaptation measures that require policy and institutional support. It hypothesizes that rural communities in Surkhet integrate both traditional practices and modern climate adaptation techniques to cope with climate variability. Additionally, it is expected that access to financial resources, education, and community networks significantly enhances adaptation effectiveness. By analyzing community-driven adaptation strategies, this study aims to provide practical insights for policymakers, development organizations, and local stakeholders to strengthen climate resilience in Nepal’s rural areas.

Literature Review

Climate change is increasingly affecting rural communities worldwide, with agriculture-dependent regions such as Nepal being particularly vulnerable. The Intergovernmental Panel on Climate Change (IPCC, 2014) has documented that rising global temperatures have led to shifts in precipitation patterns, increased drought frequency, and intensified extreme weather events, all of which significantly impact food security and water availability. In Nepal, where approximately 65% of the population is engaged in agriculture, these climatic disruptions pose serious challenges (Gurung & Sherpa, 2019). Over the past few decades, Nepal has experienced rising temperatures at an annual rate of 0.06°C, with higher altitudes warming faster than lower regions, leading to unpredictable monsoons, prolonged dry spells, and increased flooding (Department of Hydrology and Meteorology, Nepal, 2020). These climatic shifts have resulted in reduced crop yields, soil erosion, and water shortages, particularly in regions such as Surkhet District, where livelihoods are heavily dependent on rain-fed farming systems (Paudel, 2019).

Despite the severity of climate change impacts, rural communities have developed various adaptation strategies to cope with environmental uncertainties. Studies have identified that adaptation measures generally fall into two categories: autonomous (traditional) and planned (modern) adaptation (Chaudhary et al., 2019). In Nepal, farmers have historically relied on traditional ecological knowledge (TEK), including crop diversification, rainwater harvesting, and rotational grazing, to mitigate climate-related risks (Pandey & Bardsley, 2015). However, as climatic conditions worsen, there has been an increasing shift toward modern adaptation techniques, such as drought-resistant crop varieties, agroforestry, and advanced irrigation systems (Regmi & Bhandari, 2013). The success of these adaptation measures is largely influenced by financial capacity, institutional support, and access to climate information (World Bank, 2022).

Comparing Nepal's adaptation strategies with other climate-vulnerable regions offers valuable insights. In the Indian Himalayas, polyhouse farming, which involves cultivating crops in controlled greenhouse environments, has proven effective in reducing the risks posed by erratic weather conditions (Kumar et al., 2020). Similarly, in Bhutan, community-managed water conservation projects have helped farmers maintain sustainable irrigation systems during periods of low rainfall (Sherpa et al., 2018). In the Andean Highlands of South America, indigenous communities have long practiced terracing techniques to prevent soil erosion and retain moisture, a method that remains critical for maintaining agricultural productivity in arid conditions (Gonzales, 2021). While Nepal shares many of the same climatic challenges as these regions, institutional barriers and lack of financial resources have hindered the large-scale implementation of modern climate adaptation techniques (Rai & Nepal, 2017). Many rural adaptation strategies in Nepal remain informal and community-driven, highlighting the urgent need for stronger policy integration and institutional support.

To assess the effectiveness of rural climate adaptation, this study applies two key theoretical frameworks: the Sustainable Livelihood Framework (SLF) and Community-Based Adaptation (CBA). The SLF framework identifies five essential capital assets—financial, human, social, physical, and natural—that shape adaptation capacity (Rai & Nepal, 2017). Households with greater access to financial capital are more likely to invest in advanced adaptation technologies, such as efficient irrigation systems, resilient crop varieties, and modern farming equipment. In contrast, marginalized communities often rely on social capital, such as farmer cooperatives and communal water-sharing systems, to build resilience against climate-related shocks (Ellis, 2000). The CBA approach, on the other hand, emphasizes localized, participatory adaptation strategies that empower communities to develop context-specific solutions to climate change (Chambers & Conway, 1992). In Nepal, CBA-driven initiatives, such as community-led seed banks, decentralized water resource management, and climate-resilient farming practices, have proven highly effective in enhancing rural adaptation capacity (Chaudhary et al., 2019). However, despite their success, these initiatives often lack sufficient funding and institutional support, limiting their scalability.

Although climate adaptation in Nepal has been widely studied, gaps remain in understanding localized adaptation responses at the district level. Most research has focused on macro-level climate policies (World Bank, 2022) or national adaptation plans (Regmi & Bhandari, 2013), with limited emphasis on community-specific strategies. Furthermore, while studies acknowledge the importance of financial, technological, and institutional factors, they often overlook the integration of traditional knowledge with scientific adaptation methods (Karki & Gurung, 2018). This study seeks to address these gaps by analyzing adaptation strategies in Surkhet District, exploring how households combine traditional and modern adaptation techniques to mitigate climate risks. By providing district-specific insights, this research aims to inform more inclusive and practical climate adaptation policies that strengthen the resilience of Nepal's rural communities.

Methodology

This section details the methodological framework employed to analyze the adaptive strategies of rural communities in the Surkhet District of Nepal in response to climate change. The methodology encompasses the study site selection, data collection techniques, sampling strategy, and data analysis approach. A rigorous approach ensures the validity and reliability of the findings, offering valuable insights into climate adaptation strategies in the region.

Study Site Justification

Surkhet District, located in Karnali Province, Nepal, was selected due to its diverse geographic and climatic conditions, which make it highly susceptible to climate change. The district's varied elevation, ranging from 600 to 2,400 meters above sea level, influences different agricultural and livelihood practices, making it an ideal case for studying localized adaptation strategies. The region's reliance on agriculture, including staple crops such as rice, wheat, maize, and millet, highlights its vulnerability to changing weather patterns. Additionally, Surkhet's socio-economic diversity, characterized by a mix of ethnic communities such as Brahmin, Chhetri, Magar, and Tharu, allows for an examination of how different groups respond to similar climatic stressors. Furthermore, the district has been a focal point for multiple governmental and non-governmental climate adaptation initiatives, offering an opportunity to assess the effectiveness of both traditional and institutional adaptation strategies.

Data Collection Methods

A mixed-method approach was adopted, integrating both quantitative and qualitative data collection techniques to provide a holistic understanding of climate adaptation strategies.

1. **Household Surveys**: Structured surveys were conducted with 300 households, covering multiple villages across Surkhet. The surveys comprised both closed and open-ended questions designed to assess the prevalence of adaptation strategies and the socio-economic factors influencing their adoption. A pilot test was conducted in a nearby district to refine the questionnaire, ensuring its relevance and clarity.
2. **Semi-Structured Interviews**: A total of 40 in-depth interviews were conducted with farmers, community leaders, and local agricultural officers. These interviews captured qualitative insights regarding decision-making processes, adaptation challenges, and the perceived effectiveness of various strategies. The interview guide included key themes such as historical adaptation practices, the impact of climate variability, and the role of institutional support.
3. **Focus Group Discussions (FGDs)**: Six FGDs, each comprising 6–8 participants, were organized to facilitate discussions on community perceptions and experiences related to climate adaptation. The groups were stratified by age and gender to ensure diverse representation. Trained facilitators conducted these discussions in local dialects, ensuring participants felt comfortable sharing their perspectives.

Sampling and Recruitment

A purposive sampling technique was employed to ensure representation from different socio-economic backgrounds, genders, and age groups. Special emphasis was placed on including vulnerable populations, such as women, elderly individuals, and marginalized groups, who are often disproportionately affected by climate change. This approach ensured a comprehensive understanding of the varied adaptation responses within the community.

Ethical Considerations

Prior to data collection, all participants were informed about the study's objectives and their voluntary participation. Informed consent was obtained, and confidentiality measures were strictly followed. To protect participants' identities, all data were anonymized during analysis. Ethical approval for the study was secured from the relevant institutional review board, ensuring compliance with research ethics standards.

Data Analysis Techniques

1. **Quantitative Analysis**: The survey data were analyzed using SPSS software. Descriptive statistics, including frequency distributions and cross-tabulations, were employed to examine the prevalence of different adaptation strategies. Inferential statistical techniques, such as regression analysis, were applied to identify key predictors of adaptation choices among households.
2. **Qualitative Analysis**: Interviews and FGDs were transcribed and subjected to thematic analysis. NVivo software was used to code the data and identify emerging themes. Thematic categorization

helped in understanding community-level adaptation narratives, highlighting both traditional and modern adaptation strategies.

3. **Triangulation**: To enhance the reliability and validity of the findings, data triangulation was employed by cross-verifying survey results, interview insights, and focus group discussions. This methodological approach strengthened the overall credibility of the research outcomes.

Methodological Framework

The methodological framework is summarized in Figure 1, illustrating the research process from site selection to data collection, analysis, and synthesis of findings for climate adaptation strategies.

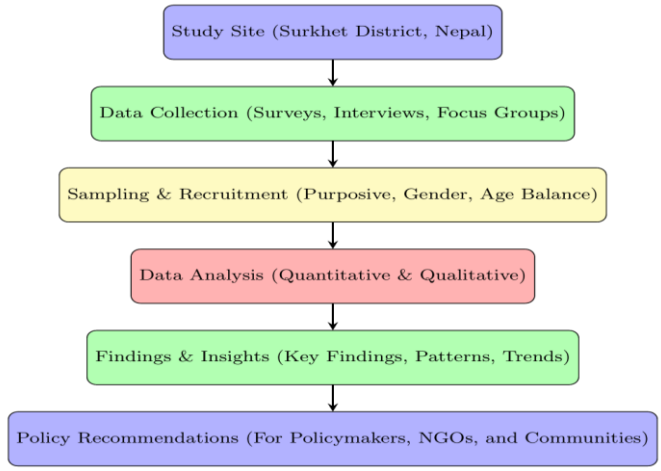

Figure 1: Research Methodology for Climate Change Adaptation in Surkhet

This comprehensive methodological approach ensures a nuanced understanding of climate adaptation strategies in Surkhet, providing valuable insights that can inform future climate resilience initiatives in similar rural settings.

Results and Discussion

This section presents the key findings from the research conducted in Surkhet District and explores their broader implications in the context of established theoretical frameworks. The findings are structured to align with the research questions and methodological approach, with statistical and qualitative insights supported by tables and figures. To better understand the adaptation strategies employed by communities, it is crucial to examine the socio-economic profile of respondents, as summarized in Table 1. The surveyed households had an average household size of 5.2 members, with an average monthly income of 50,000 NPR. The gender distribution was relatively balanced, with 55% male and 45% female respondents.

Characteristic	Value
Average Age	38
Male (%)	55
Female (%)	45
Average Household Size	5.2
Average Monthly Income (NPR)	50,000

A range of climate adaptation strategies were employed by communities in Surkhet, as shown in Table 2. The most common strategies included crop diversification (60%), rainwater harvesting (45%), and soil conservation practices (50%). These findings demonstrate the integration of traditional knowledge with modern climate adaptation techniques.

Adaptation Strategy	Percentage of Households (%)
Rainwater Harvesting	45%

Crop Diversification	60%
Soil Conservation Practices	50%
Drought-resistant Crops	35%
Livelihood Diversification	40%

The study revealed that households with better access to financial capital were more likely to invest in advanced technologies such as water-efficient irrigation systems. Figure 2, mentioned above illustrates the relationship between household income and the adoption of climate adaptation strategies, showing a positive correlation between income level and adaptation scores.

Additionally, social capital played a significant role in adaptation, as community-managed water resources improved resilience to climate-induced water shortages. The variation in adaptation strategies across different municipalities is visually represented in Figure 3. This reinforces the SLF framework's emphasis on multi-capital approaches to adaptation. Adaptation strategies varied across municipalities due to differing access to resources. The heatmap in Figure 3 provides a comparative overview of adaptation strategies adopted in Birendranagar, Bheriganga, and Barahatal.

Overall, the results underscore the need for an integrated approach to climate adaptation, combining traditional knowledge with scientific innovations while addressing financial and institutional barriers. The study found that households with higher financial capital were significantly more likely to adopt modern adaptation measures, such as solar-powered irrigation systems and drought-resistant crops. In contrast, lower-income households primarily relied on social capital and community-led adaptation strategies, such as cooperative water-sharing initiatives and indigenous seed preservation. The limited accessibility to financial credit, subsidies, and training programs emerged as a major challenge preventing marginalized farmers from transitioning to modern climate-resilient techniques. Strengthening policy interventions, improving access to financial resources, and expanding technical support services will be essential in ensuring that rural communities can effectively respond to climate variability. Additionally, fostering community-driven adaptation initiatives in conjunction with targeted government interventions will enhance climate resilience in Surkhet and other vulnerable regions.

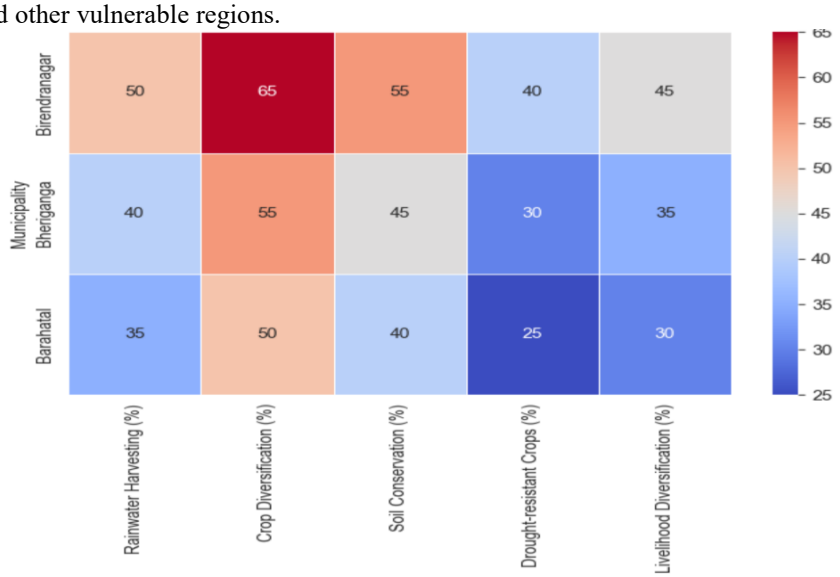

Figure 3: Comparison of Adaptation Strategies Across Municipalities

Findings strongly align with Sustainable Livelihood Framework (SLF) and Community-Based Adaptation (CBA) approaches. Households with greater financial capital invested more in advanced adaptation technologies, while strong social capital improved collective adaptation efforts, particularly in water resource management. Natural capital was also crucial, as sustainable water management practices contributed significantly to climate resilience. The CBA approach was evident in the collaborative

management of water resources, reinforcing previous literature that highlights the importance of participatory decision-making in climate adaptation.

The findings suggest that local and national policies should support community-led adaptation by strengthening governance structures for natural resource management. NGOs should facilitate access to financial resources, technology, and training to enhance adaptation efforts, especially for marginalized groups. Additionally, communities should foster stronger social networks to ensure inclusive and sustained adaptation.

While this study provides valuable insights, its geographical scope was limited to Surkhet District. Future research should conduct longitudinal studies to track adaptation strategies over time, expand the geographic scope to compare adaptation strategies across multiple districts, and integrate psychological and cultural dimensions into climate adaptation research.

This study contributes to the empirical literature on rural climate adaptation in Nepal. Findings emphasize the importance of community participation, financial resources, and social capital in enhancing resilience. Future studies should adopt a broader and longer-term approach to provide more comprehensive insights into climate adaptation strategies.

Policy Recommendations

Based on the findings of this study, several policy measures are recommended to enhance climate adaptation efforts in rural communities. First, financial accessibility should be improved by expanding microfinance programs and providing targeted subsidies for climate-resilient agricultural practices. Government agencies and financial institutions must collaborate to ensure that vulnerable households have access to affordable credit, enabling them to invest in adaptive measures such as water-efficient irrigation and drought-resistant crops. Second, community-based adaptation strategies should be strengthened by fostering participatory decision-making processes. Local governance bodies and non-governmental organizations (NGOs) should facilitate training programs and awareness campaigns that integrate traditional knowledge with scientific advancements. Third, infrastructure development must prioritize climate resilience by improving irrigation systems, building flood-resistant structures, and ensuring reliable access to clean water. Public-private partnerships could be instrumental in funding and implementing such projects. Finally, knowledge-sharing networks should be expanded to bridge the gap between researchers, policymakers, and local communities. Establishing climate resource centers and digital platforms for real-time information exchange can empower farmers and rural households with the necessary tools to make informed adaptation decisions. These policy recommendations, if implemented effectively, will contribute to long-term climate resilience and sustainable development in vulnerable regions.

Conclusion

This study examined the climate adaptation strategies employed by rural communities in Surkhet District, Nepal, emphasizing the role of financial, social, and natural capital in shaping resilience. The findings indicate that households with greater financial access are more likely to adopt modern adaptation techniques, such as water-efficient irrigation, climate-resilient crops, and agroforestry practices, whereas strong community networks facilitate collective resource management and disaster preparedness. The integration of traditional knowledge with modern climate adaptation strategies underscores the adaptability of these communities and highlights the importance of localized adaptation efforts in ensuring long-term resilience. However, disparities in access to financial resources, technical training, and institutional support remain significant barriers to widespread climate adaptation. While wealthier households can invest in climate-smart agricultural techniques, marginalized farmers often rely on traditional coping mechanisms, which may be insufficient in the face of escalating climate risks.

To strengthen climate resilience in Nepal's rural communities, policymakers and development organizations must focus on expanding financial support mechanisms, improving access to climate-resilient technologies, strengthening community-based governance, enhancing climate education, and integrating indigenous knowledge with scientific advancements. Financial resources should be directed toward microfinance programs, agricultural credit schemes, and insurance policies that support vulnerable farmers.

Investment in modern irrigation systems, drought-resistant crops, and early warning systems is crucial to improving adaptive capacity. Encouraging village-level adaptation plans, participatory decision-making structures, and farmer cooperatives can foster sustainable resource management. Additionally, conducting capacity-building programs, farmer training workshops, and knowledge-sharing platforms will help communities make informed adaptation decisions. The most effective strategies will integrate traditional ecological knowledge with modern scientific techniques, creating hybrid adaptation models suited to Nepal's diverse climate zones.

Despite its valuable insights, this study is limited in its geographic scope and cross-sectional nature, which may restrict broader generalizability. Future research should adopt longitudinal studies to track how adaptation strategies evolve over time, while expanding the geographic coverage to compare adaptation strategies across multiple districts and diverse agro-climatic zones. Additionally, research should explore the role of socio-cultural and psychological factors in shaping climate adaptation decisions, as well as assess the effectiveness of existing climate adaptation policies in addressing rural vulnerabilities. A deeper examination of gender dynamics in climate adaptation would also provide insights into how men and women experience climate risks differently and what targeted interventions are needed.

Overall, strengthening local institutions, increasing financial support, and fostering collaborative knowledge-sharing networks will be essential in ensuring sustainable climate resilience for rural communities. A multi-stakeholder approach, involving government agencies, NGOs, researchers, and local farmers, is necessary to develop holistic, context-specific adaptation strategies. By bridging scientific advancements with indigenous knowledge systems, Nepal can build climate-resilient rural communities that are better equipped to withstand future environmental uncertainties.

About Author

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