

Climate Change-induced Livelihood Insecurity in Narayani-Gandak Basin of Nepal

Chandralal Pandey PhD¹, Prakriti Niraula²
^{1,2}Department of Development Studies, KU.

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Corresponding Author : Chandralal Pandey

E-mail : chandra.pandey@ku.edu.np

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Abstract

Nepal is one of the most disaster-prone countries in the world. Nepal is highly vulnerable to climate risks and disasters. It ranks 4th, 11th, and 13th in terms of vulnerability to climate change, earthquake, and flood risks, respectively. Due to intensive, concentrated, and erratic precipitation, climate change-induced disasters such as 'too much water and too little water' are rapidly increasing in Nepal and the 'too much water' has been affecting riverine communities, significantly, in the Terai region of Nepal. The communities of the Narayani basin have been forced to encounter floods every year due to the perennial Narayani and Rapti including other local seasonal rivers. While these rivers seem to be providing services for irrigation to nurture agricultural products, to some extent, the riparian communities have also been forced to encounter extensive amounts of losses and damages to lives, livestock, crops, and property, which have resulted in losses of livelihoods, and generated serious concerns for communities due to surmounting risks of flood like natural hazards turning into disasters. Employing a mixed-method research approach, we investigated how climate change-induced hazards such as floods turning into disasters have affected the livelihoods of people living in the riverine communities of Chitwan. The two research objectives we explored were i) to examine the impacts of climate change and floods on agriculture and the livelihoods of community people, and ii) to investigate the adaptive methods adopted by local communities to combat climate change-induced flooding for building climate/flood resilient communities. The findings of the research demonstrated that climatic changes have interacted with socio-economic and agricultural practices and significantly affecting livelihood of the communities in Chitwan. In response to changing climatic conditions and unanticipated weather patterns, people in the communities are gradually adjusting their agricultural practices, covering the losses and damages through insurance policies and diversifying the income generating sources.

Keywords: climate change, flood, livelihood, Narayani basin, Nepal

Introduction

South Asia is one of the most disaster-prone regions and Nepal is one of the most disaster-vulnerable countries in the world. Nepal is highly vulnerable to climate risks

and disasters and ranks 4th, and 13th in terms of vulnerability to climate change, and flood risks, respectively (DCA, 2021). It ranked 10th in the Long-term Climate Risk Index in the Global Climate Risk Index (Germanwatch, 2021). Nepal has a diverse topography, varied climatic conditions and distinct geographical features, and as results natural hazards frequently occur affecting communities and the entire nation. The occurrences of natural hazards are now exacerbated by anthropogenic climate change as the average annual maximum temperature in Nepal has been rising by about 0.056°C per year (DHM, 2017). The overall rainfall has decreased over the years but seasonal and erratic rainfall is happening more nowadays compared to previous years (Poudel et al., 2021). Scientific evidence shows that in the future, the temperature will rise and precipitation will intensify and become more frequent which will seriously impact biodiversity, agriculture, water, energy, and overall livelihood aspects of people in communities (IPCC, 2021; MoFE, 2019).

The incidences of climate change-induced floods are increasing in Nepal. The Terai region of Nepal is considered the severest flood-prone region as floods occur every year in this region (Sharma, 2018). The occurrences of prolonged and erratic precipitations due to the changes in climatic conditions have substantially increased the risk of floods. Due to unprecedented changes in climatic system, monsoon flows and rainfall patterns, and river flow systems, the riparian communities have encountered extensive amounts of losses and damages to lives, livestock, crops, and property, which have resulted in losses of livelihoods, and generated serious concerns of living due to floods like natural hazards turning into disasters (Pandey et al., 2023). In this context, we investigated how climate change and change-induced hazards such as floods turning into disasters have affected the livelihoods of people living in the riverine communities of Khairahani Municipality and Bharatpur Metropolis of Chitwan. The two research objectives explored were i) to examine the impacts of climate change and floods on agriculture and the livelihoods of community people, and ii) to investigate the adaptive methods adopted by local communities to combat climate change-induced flooding for building climate/flood resilient communities.

Nexus of Climate Change, Flood, Agriculture and Livelihood

The nexus of climate change and flood and their domino impacts on agricultural practices and livelihood are being experienced deeply and widely across the world. Literature demonstrate that climate change is negatively impacting agricultural sector (Pandey, 2012; Joseph et al., 2022; IPCC, 2022). Nepal is an agricultural country having 66% of people engaged in farming and climate change is affecting agricultural practices and productivity (Malla, 2008; Pandey, 2012; Mishra, 2023). The rapid disappearing

of glaciers and snow from the Himalayas, global temperature rise, irregular monsoon and rainfall patterns, and an increase in the frequency of catastrophic events such as floods, drought, and heatwaves are affecting agriculture massively worldwide where Terai region of Nepal is not an exception. Many rain-fed farmers in Nepal have already been impacted by climatic changes including rising temperatures, delayed monsoons, increased yearly rainfall, and increased frequency of severe rainfall (Pandey, 2012; Bastola et al., 2022;). Changes in average temperatures, erratic rainfalls, climate extremes induced incidents such as floods and droughts, changes in pests and diseases, changes in atmospheric carbon dioxide, changes in the nutritional value of some foods, and changes in the growing seasons are just a few of the ways that climate change affects agriculture (Pandey, 2012; CBS, 2016; Giri et al., 2021). Farmers must deal with unanticipated events like changing rainfall patterns, drought, severe rainfall, floods, and soil erosion which destroy the processes and production of crops. According to the National Climate Change Impact Survey 2016, 60.25% of households reported having observed the emergence of a new disease in crops leading to a reduction in crop yield due to climate change impact (CBS, 2016).

The nexus of climate change and intensive precipitations resulting into floods is increasing in terms of frequency and severity with significant impacts on livelihoods and households that depend on climate-sensitive resources. Literature demonstrate that floods affect communities, worsen the conditions of people due to food and livelihood insecurities (Pandey et al., 2023). Floods damage crops and agricultural infrastructure resulting into greater suffering of all but the marginalized communities suffer the most from disasters due to their greater reliance on climate-sensitive livelihoods (McElwee et al., 2017; Bastola et al. 2020). Adaptation is considered important as it can contribute to adjustment of farming practices and reduce vulnerabilities, and farmers can employ various adaptive and innovative strategies to fight against climate change, and production losses (CBS, 2016; IPCC, 2022). Farmers are required to diversify crop rotations, use climate/flood/drought resistant seeds and crops, alter planting dates, implement more efficient irrigation technologies, minimize pesticides and off-farm flows of nutrients and integrate crop production systems with cattle/livestock rearing (Pandey, 2012). Governments of all tiers also need to integrate climate and development policies with localized agricultural practices to support community resilience (NPC, 2023). Research on potential localized agricultural adaptation either autonomous or planned as suggested by IPCC and other studies for overall community resilience is important to investigate to figure out the realities of the ground, and make better contribution to application aspects of localized farming practices as well as in the policy and academic literature (Pandey, 2012; CBS, 2016; IPCC, 2022; NPC, 2023).

Study Sites and Research Methods

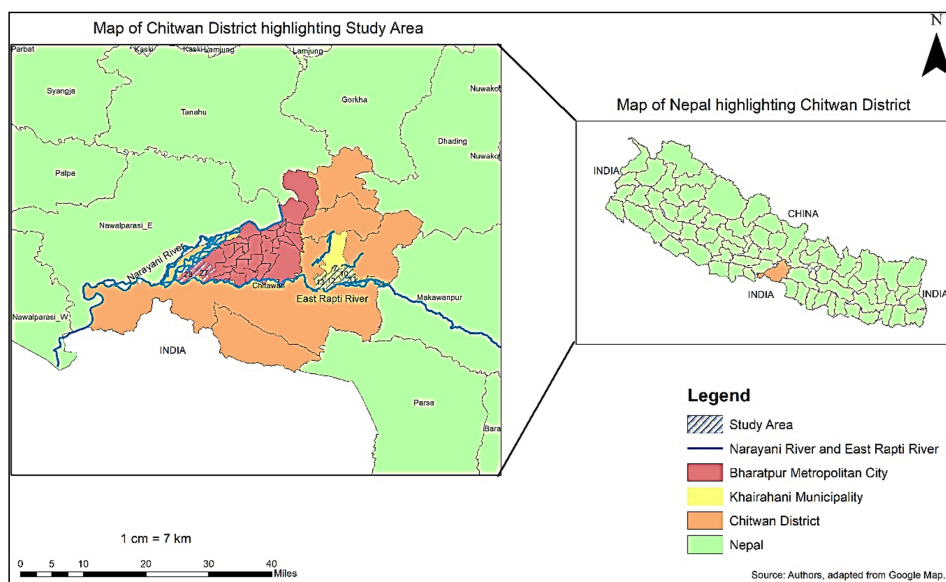
The Narayani-Gandak is one of the significant transboundary rivers shared by Nepal, India, and Bangladesh. The Narayani-Gandak, also called Narayani in Nepal, has provided extensive services to the riparian communities and has brought about both fortune and destruction to the residents living in these riparian transboundary communities. The communities of the Narayani basin have to face the risks of impending floods and water-induced disasters every year as they are sandwiched between the East Rapti and Narayani rivers. In 2021, the Narayani basin was severely affected by floods (*Onlinekhabar*, 27 August 2021; *Naya Patrika*, 27 August 2021). In 2022, the flooded Narayani River crossed the danger mark of 9.8 meters and reached 10.61 meters (*Republica*, 24 September 2022). Likewise, in August 2023, the Narayani River crossed the danger level of 11 meters and reached 11.15 meters (*Republica*, 14 August 2023), threatening the riverine communities of the Narayani River. Likewise, the frequent floods from the East Rapti River have affected the livelihood, property, and resiliency of the surrounding riverine communities of Chitwan.

The two major local bodies frequently being affected by Narayani and Rapti Rivers are Bharatpur and Khairahani in Chitwan (Pandey et al., 2023). Bharatpur is a metropolis located in the central-southern part of Nepal. Bharatpur is situated in Chitwan district and it is also the district headquarters of the district. It is the fifth largest city in Nepal with a population of 199,867 (Bharatpur Municipality, 2023). Bharatpur is one of the fastest-growing cities in Nepal. It serves as a commercial center of the Chitwan district and central region of Nepal. It lies on the left bank of Narayani river and wards 27 and 28 of Bharatpur are the most flood-prone areas. These two wards are not only affected by the Narayani River but also by the Rapti River. Khairahani municipality, comprising 13 wards, is one of the most flood disaster-prone municipalities of Chitwan district due to Rapti and other seasonal rivers. It is located at an altitude of 190 meters from sea level and the Rapti River functions as its southern regional border. The Rapti River has not only been a boon as it is the source of water in the region but also a source of frequent and dangerous floods resulting into flood-induced disasters every year (Khairahani Municipality, 2022).

We employed a convergent mixed-method research design for this study to investigate the impacts of climate change and climate-induced hazards on the livelihood of the community people (Creswell & Creswell, 2018; Creswell, 2014). In 2023, we conducted 111 random household surveys including 70 female and 41 male and 28 key informant interviews (KIIs) in the flood affected areas. Data were collected from 9 communities of five wards of Khairahani Municipality and 4 communities of two wards of Bharatpur Metropolis. The ward numbers and communities included were:

Ward No. 7 (Majhuhi), Ward No. 10 (Kusana & Khairghari), Ward No. 11 (Pidreni & Sundi), Ward No. 12 (Ghogrela & Kumroj), and, Ward No. 13 (Simreni & Harnari) of Khairahani Municipality. From Bharatpur Metropolis two wards: Ward No. 27 (Dadreni) and Ward No. 28 (Golaghat, Jeetpur, and Yogi Tole). The reason behind selecting these communities were two-fold: the first, these communities were the most affected communities by the impacts of climate change and climate induced disasters including floods; the second, these communities had established Community based Disaster Management Committees (CDMCs), which have been working to in areas of building disaster resilient communities.

Map of Study Sites



Findings

In this section, we present our findings of two research objectives introduced in the introduction section. The first objective associates with the nexus of climate change and floods, their domino impacts on agriculture and livelihood practices and the second objective connects to adaptive practices of the communities.

Climate Change and Flood Impacts on Agriculture and Livelihoods

The findings demonstrated that 95.5% of the surveyed individuals noticed climate change. They shared that changes in the climate system have been occurring in the study areas over a long period and also sharply within a relatively short time frame of

just five years. The respondents pointed out various signs of climate change in their region over the past decade as shown in figure 1. These signs encompass unpredictable rainfall, rising temperatures, periods of drought, and the invasion of crops by pests.

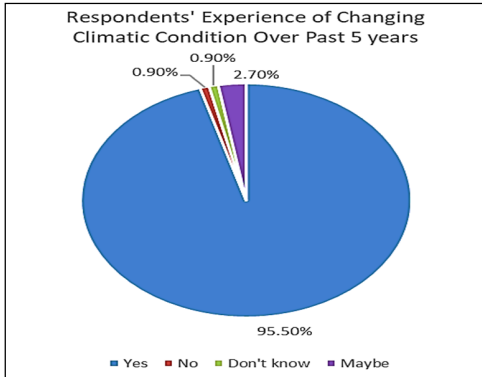


Figure 1: Respondents' Experience of to Climate Change

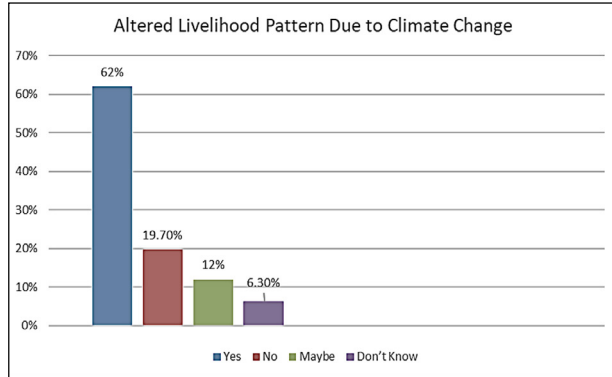


Figure 2: Altered Livelihood Pattern due Changing Climatic Condition

The nexus of climate change and flood is profound in the study sites. Figure 3 demonstrates how climate induced disasters is affecting the lives and livelihood of the people in the communities. One of the participants noted:

Our area is close to the Rapti River. During the monsoon season, continuous rainfall for 3-4 hours leads to flooding, causing significant damage to our crops. Over the past few years, we've observed considerable changes, mainly due to climate change affecting precipitation patterns. Rainfall is irregular, often arriving late, and when it does, it comes down heavily. I'm concerned that we might see more climate extreme vulnerabilities in the upcoming years.¹

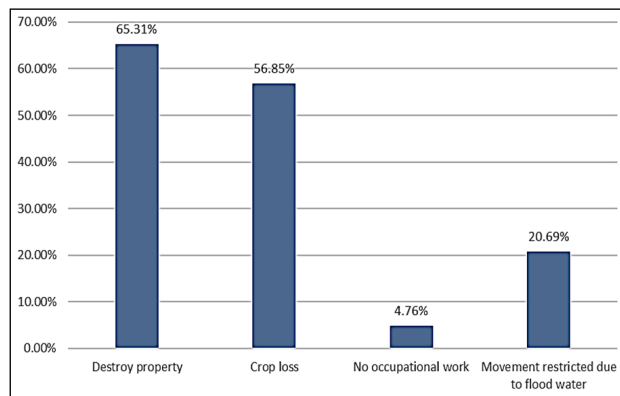


Figure 3. Effects of Floods on Livelihood

1 Interviewee 1, 16 September 2023.

The findings from the study also shed light on the local impact of climate change on water resources. Over eighty-six percent (86.6%) of the respondents noticed worrisome and unseasonable floods on the one hand while the decrease in water levels in wells, ponds and stream flows, indicating the impacts of climate change on water resources as shown in figure 3. Figure 4 shows that eighty-three percent (83%) of respondents observed significant changes in their water sources, illustrating the evolving dynamics influenced by climate change over the last 25 year.

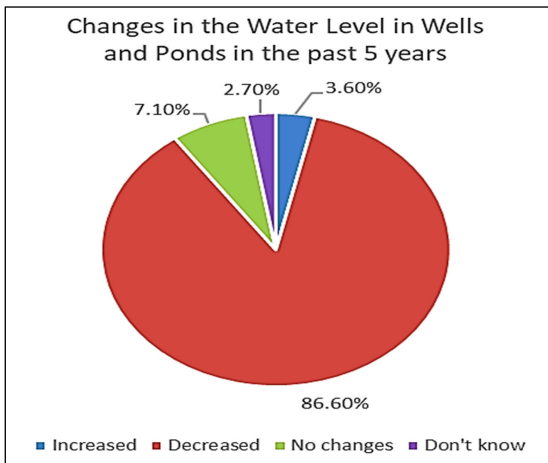


Figure 3: Changes in Water Sources

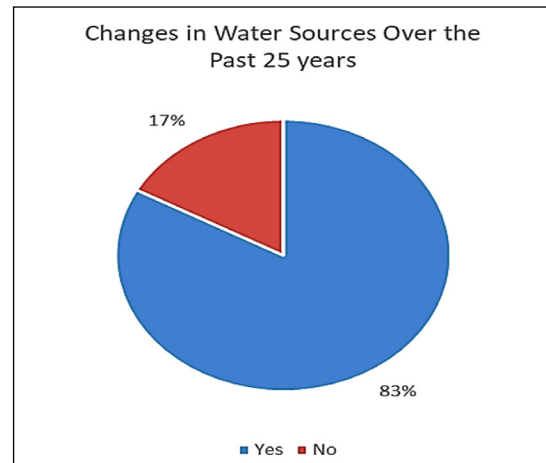


Figure 4: Changes in the Water Level

We found that approximately eighty-eight percent (88.4%) of the respondents reported about the emergence of new diseases affecting crops over the past five years as shown in figure 5. Various crop diseases, including Blight (Daduwa), Fall Armyworms (Fauji Kira), Blast Fungus, and Rice Stem Borer (Gabero), have been reported to be rising and posing significant concerns in the nexus of agriculture, food security and livelihood. These ailments are severely affecting crop yields, jeopardizing both food security and livelihoods within the community. Hence, it is crucial to recognize that climate change is likely to influence crop diseases. Studies confirm that when temperature and humidity shift, they create the right conditions for crop diseases to proliferate and thrive among crops (CBS, 2016; Raza and Bebbber, 2022; Singh et al., 2023; Kaushik et al., 2023;). Therefore, addressing crop diseases becomes integral to building climate and disaster resilience communities in the face of changing environmental conditions.

These findings highlight a concerning trend in crop infestation within the surveyed community. One participant expressed the impact, stating:

The unpredictable rainfall and rising temperatures have adversely affected our crops, leading to poor growth and increased vulnerability to pest infestations.

It's becoming clear that climate change is taking a toll on our livelihoods.²

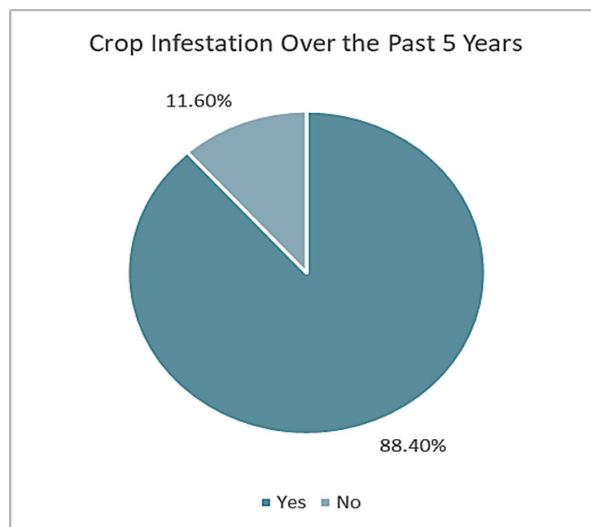


Figure 5: Crops Infestation

Efforts to mitigate the impact of crop diseases, coupled with broader climate/disaster resilience initiatives, are essential to safeguarding the community's agricultural practices and overall well-being. A participant's personal experience reflects the challenges faced:

A few years back, I used to make a good income, nearly a lakh, by selling my paddy. Back then, there weren't any issues with pests harming the crops. However, things have changed drastically. Now, I'm lucky if I can make 20,000 from it. The soil quality has been declining, probably because we're using a lot more fertilizer and pesticides than before. We never faced this problem a few years ago. In the past, we could use the same seeds for a whole year, but now we have to switch them every year. The municipality tried to help by offering us 'Chaite 5' at a 50% discount. Before that, they gave us '14/42' seeds, but that they didn't grow at all. Even though some people came to collect data on ruined crops, we didn't receive any compensation. When our crops get infested, we just use whatever pesticide we can get from the seller. We don't have experts to guide us, and we don't take the infested crops to them to figure out the right pesticide. It's a tough situation, and it seems like climate change is making it harder for us to sustain our agriculture and livelihoods.³

2 Interviewee 4, 16 September 2023

3 Interviewee 9, 17 September 2023

Climate Change Adaptation Strategies in the Study Sites

Climate change continues to pose challenges for farmers globally, affecting temperatures, rainfall patterns, and extreme weather events (Rosenzweig et al., 2020). To tackle these challenges, establishment of CDMCs at the community levels is found to be one of the key pillars to provide necessary gears along with various types of climate and disaster resilient training, simulations and drills. More comprehensive and functional early warning system integrating traditional knowledge system, community based flood early warning system with modern early warning system is found to be in practice in the studied communities (Pandey & Basnet, 2023a). Furthermore, enhancing the marginalized population’s life-styles has also been considered by CDMCs to be another important task of making the communities disaster proof. These communities with funding support from external agencies are practicing a new initiative known as Climate Adaptive Revolving Funds (CARFs) to enhance community resilience to disasters and climate change impacts. These funds typically start with an initial pool of capital used for crucial activities related to disaster preparedness and recovery. The unique feature of CARFs lies in their repayment and reinvestment cycle, where the repaid funds are reused for similar initiatives in cyclic manner. Community-managed CARFs build solidarity and boost local capacity to organize disaster responses (Gentle et al., 2014). With payback rates exceeding 90%, these funds have enabled continued assistance to vulnerable groups during subsequent disasters, avoiding dependence on external aid. Figure 6 shows that 81.60 percent of respondents reported that the CARFs helped them enhance income opportunities and 39.80 percent indicated that it improved their access to credits.

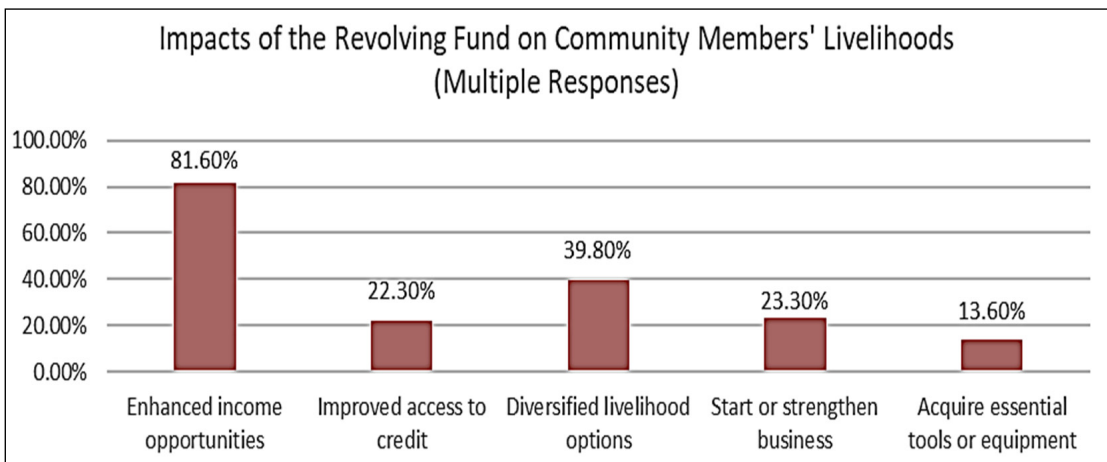


Figure 6: Impacts of CARFs

Our findings reveal the substantial impact of the CARF on community members' livelihoods. The fund's noteworthy impacts include enhancing income opportunities, diversifying livelihoods, initiating/strengthening micro local businesses, improving access to credit, and facilitating the acquisition of essential tools or equipment. One of the participants noted:

I became an active member of the Majhui Disaster Management Committee (DMC). Being part of the DMC has truly changed how I see climate change and justice. I strongly believe that each one of us not only experiences the impacts of climate change but also has a role in advocating for its mitigation. My commitment to resilience goes beyond just understanding. I took a loan of Rs 30,000 from the revolving fund, and I made sure to use it wisely for my business. This investment not only helped me make profits but also allowed me to save for potential future disasters. Every month, I diligently set aside Rs 500 in a microcredit finance account, a practice I learned through DMC training. Recognizing the importance of diversified savings in strengthening resilience, I am actively getting ready for an uncertain future.⁴

Another important adaptive practices include climate-adjusted seeds and crops that can handle heat and drought better, reducing the impacts of extreme temperatures and water stress. Adjusting planting and harvesting times also help align with new growing seasons, preventing losses from early or late-season extremes, and is often a simple and cost-effective solution. Another strategy being utilized in the study sites is agroforestry, which involves planting trees on farmland or vice-versa. By planting trees alongside crops, farmers regulate microclimates and prevent soil erosion during heavy rainfall. Stress-tolerant trees, such as mangoes, are particularly beneficial for mixed smallholder farms contributing to overall sustainability and resilience. In the past five years, significant changes have occurred in both agricultural and livestock practices in Khairahani Municipality and Bharatpur Metropolis. The study results indicate that a substantial portion of the population, 80.4% for agriculture as shown in figure 6 and 73.2% for livestock rearing as shown in figure 7, reported modifications in their practices. Analyzing the driving forces behind these shifts, the data illustrates that 75.9% of respondents identified new technology as a significant influencer, highlighting the evolving and modernizing nature of farming and livestock-rearing practices. Concerns related to climate change (48.2%) and altered weather patterns (37.5%) demonstrate the real impact of environmental changes on agricultural activities.

4 Interviewee 5, 16 September 2023

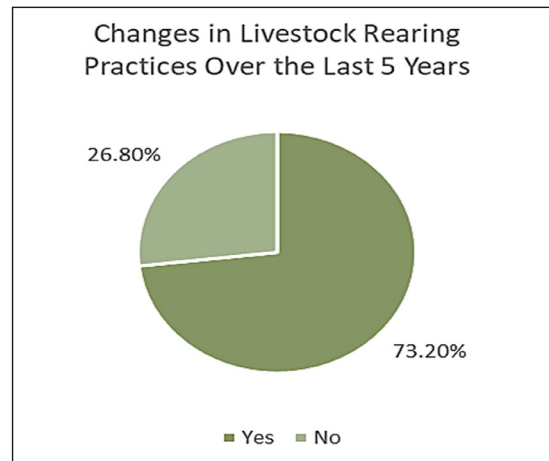
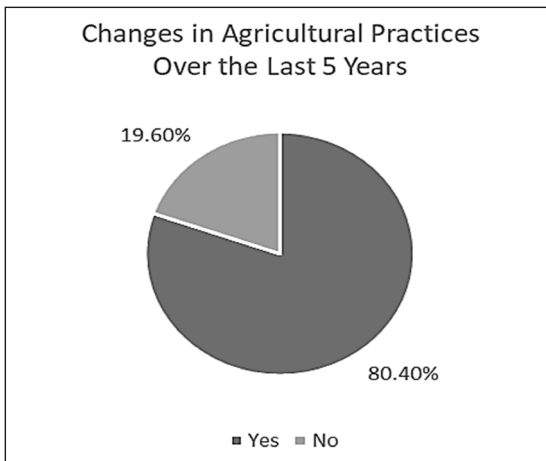


Figure 6: Changes in Agricultural Practices

Figure 7: Changes in Livestock Rearing

Figure 8 shows that economic considerations were mentioned by 43.8%, underscoring the pivotal role of monetary factors in influencing changes in practices. While governance and community activities were mentioned by only 22.3%, it still signifies the relevance of organized group efforts in influencing changes, albeit to a lesser extent. The data clearly portrays a landscape where adaptation in agricultural and livestock practices is prevalent, indicating a community responsive to changing circumstances. The primary driving forces behind these adaptations are technological advancements and environmental changes, emphasizing the multifaceted nature of influences on agricultural practices in the surveyed locations.

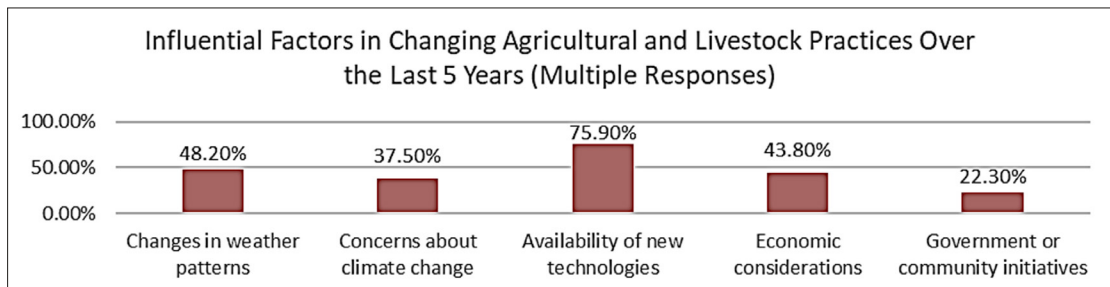
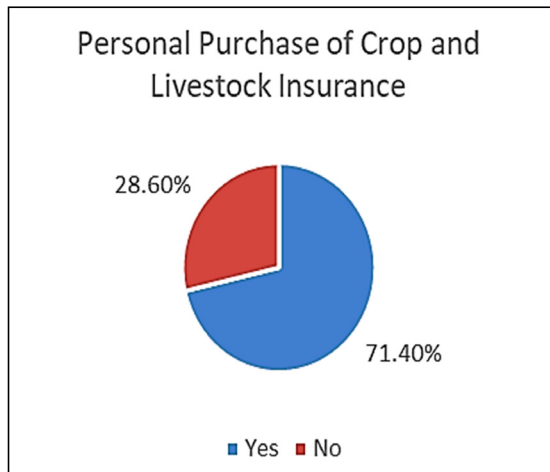
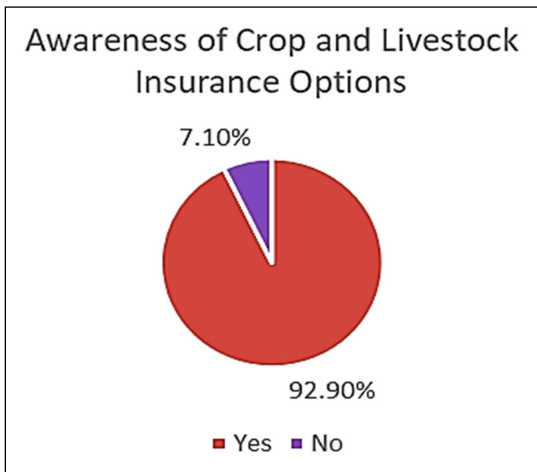


Figure 8: Influential Factors

Research shows that insurance plays a crucial role in supporting farmers by providing stability when faced with production risks (Pandey & Basnet, 2023b). About insurance options, the findings of the study indicate a high level of awareness among the respondents/participants regarding crop and livestock insurance. Impressively,

92.9% of the participants reported being aware of these insurance options as shown in figure 9. Furthermore, figure 10 shows the purchasing behavior, revealing that 71.4% of respondents had purchased crop or livestock insurance. This prevalence of insurance purchases is notable, especially considering that many respondents were engaged in agriculture and animal husbandry. The respondents' perspectives on the benefits of purchasing crop and livestock insurance were diverse. A significant 74.1% mentioned that insurance provided crucial financial protection against losses. Additionally, 40.2% expressed that it brought them peace of mind during uncertain times. For 32.1% of the respondents, insurance had proven to be a valuable tool for enhancing risk management, while 21.4% reported improved access to loans. In essence, the data paints a comprehensive picture of insurance as a multifaceted tool. While primarily valued for its financial protection, it also offers psychological comfort, risk management benefits, and economic opportunities within the surveyed regions. This highlights the nuanced role that insurance plays in the lives of individuals engaged in agriculture and animal husbandry in the studied areas.



Discussion

Climate change and climate induced disasters such as floods threaten agricultural practices, assets of communities the livelihoods of the people because of their reliance on subsistence and income (Pandey, 2014; Hallegatte et al., 2016; IPCC, 2022). There is growing evidence of climate change exacerbating poverty and damaging livelihood assets for vulnerable households through declining farm yields, food insecurity, and housing destruction from extreme weather events (Hallegatte et al., 2016). Rainfed farming communities face disproportionate loss of livelihoods and household capital

from temperature increases, and rainfall variability due to climate change (Bellprat et al., 2015). Increased droughts and floods have harmed croplands and displaced communities (Ahmed & Suphachalasai, 2014). More variable monsoons, prolonged and intensive rainfall patterns resulting in floods and droughts including heat stress, and crop pests are negatively impacting agricultural communities through lower yields, crop losses, and food insecurity and such income uncertainties have exacerbated multidimensional poverty and social marginalization of farmers (Gentle et al., 2018). The findings of the study also confirm that rising temperatures and unpredictable rainfall patterns are disrupting agricultural practices and food production (Malla, 2008; IPCC, 2021). Climate change and climate induced hazards and disasters such as ‘too much water = floods’ are already affecting the agriculture and livelihood nexus. Changing patterns of rainfalls, prolonged dry seasons and unanticipated floods have affected conventional farming practices with serious consequences for agriculture and the livelihoods of people in the communities who primarily depend on good crop yields for their livelihood. The communities of the study sites make a living through agriculture linked to glacial-fed river systems and are encountering acute challenges now due to unanticipated floods and droughts in the future. The observed signs of drying up their own wells and tube wells also emphasize the growing vulnerabilities of water scarcity and the need for proactive water management practices to address the twin challenges of too much and too little water and their domino effects. This underlines the importance of addressing climate change and its multi-layered implications on water-induced disasters, as well as implementing strategies for sustainable water management in the face of evolving environmental conditions.

Adaptation to the impacts of climate change has to be at the forefront of scientific inquiry, policy and practice in the era of anthropocene (Pandey, 2012). Climate adaptation needs to focus on community resilience by addressing the underlying factors that determine chronic poverty, vulnerability and adaptive capacity. The ability of the communities to undertake adjustments against the changing climate systems has to be the center of adaptation. Policy and theoretical discourses have portrayed adaptation as adjustments to climatic changes which focus on reduced damage and more opportunities by being smart in coping with the consequences and the emphasis is on climate proofing to make communities climate and disaster resilient (Brooks et al., 2009; Pandey, 2019). There has to be a greater focus on involving local communities in the process of climate adaptation and disaster management and these actions are considered as a crucial part of making societies climate adaptive and disaster resilient (Pandey & Basnet, 2023a; Pandey et al. 2023).

The study suggested that the approach of forming CDMCs at the

neighborhood/community levels is important to coordinate efforts in reducing risks and making communities resilient. These institutions can be aligned with the Disaster Risk Reduction and Management Act of 2017 which mandated the creation of DMCs at the district, municipal, and ward levels in Nepal (MoHA, 2013; MoHA, 2017). The DMCs are engaged in monitoring risks at the community level, keeping stock of emergency supplies, and updating response plans annually, especially before the monsoon season. These institutions help authorities at the provincial and federal levels to stay informed about any gaps in preparedness, responses and recovery. Studies also highlight that active CDMCs at the community levels have significantly improved capacities related to evacuation processes, providing shelters, and conducting damage and needs assessments following events like floods or landslides ((Pandey & Basnet, 2023b; Pandey, 2019). This study also indicates that CDMCs have engaged in DRR related trainings, drills and simulations, managing EWS, generating awareness about disaster preparedness and mitigation, and bringing in innovative mechanisms such as insurance and CARFs. Also, feedback from people in communities, private sector, academia and government suggest that having more extensive coverage CDMCs and their integration with government DMCs across Nepali communities could further reduce losses from increasingly frequent disasters and make communities climate induced disasters including floods.

Conclusion

Climate change and climate induced disasters including the floods are becoming serious threats to agricultural practices and farmers in the study areas. The nexus of climate change and flood and their impacts on agriculture and livelihood are interconnected and complex. As shown above, due to climate change, there are multiple uncertainties about rainfall patterns, crop selection and good harvest. Although people in the communities have some understanding about climate change and its impacts on their farming practices, they are unsure about the exact consequences on food security and livelihood. Provided uncertainties are there, people are proactive in forming CDMCs, carrying out necessary DRR trainings in the communities. They have also facilitated the micro-finance initiative like CARFs to diversify the income of the most marginalized people and, introduced crop and livestock insurance policies in the communities. The adaptation strategies including gradual shifting to climate/flood resilient crops and seeds and practices of other income diversifying activities appear to be contributing the communities to be climate and flood resilient. More trainings on DRR and innovative agricultural practices and know how sharing can make the communities more multi—hazard resilient.

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