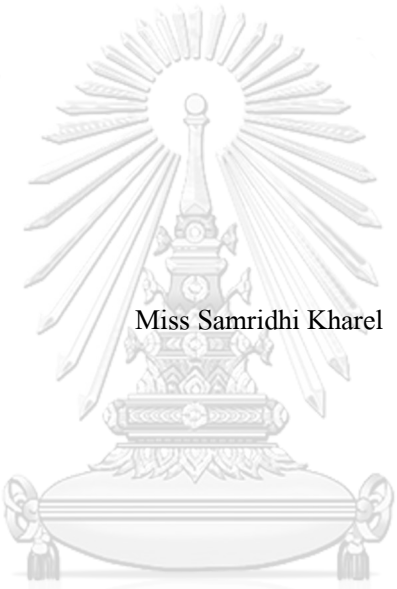
Assessment of municipality roles in adaptation to climate change: A case study from Mangalsen Municipality of Acchham Nepal.

Miss Samridhi Kharel



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การประเมินบทบาทของหน่วยงานระดับท้องถิ่นและการปรับตัวของชุมชนต่อการเปลี่ยนแปลงสภาพภูมิอากาศ: กรณีศึกษามังกอลเซ็น ประเทศเนปาล

น.ส.สัมฤทธิ คาเรล

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรมหาบัณฑิต
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สัมฤทธิ คาเรล :

การประเมินบทบาทของหน่วยงานระดับท้องถิ่นและการปรับตัวของชุมชนต่อการเปลี่ยนแปลงสภาพภูมิอากาศ: กรณีศึกษามังกอลเซ็น ประเทศเนปาล. (Assessment of municipality roles in adaptation to climate change: A case study from Mangalsen Municipality of Acchham Nepal.) อ.ที่ปรึกษาหลัก : ศยามล เจริญรัตน์

วิทยานิพนธ์นี้มีวัตถุประสงค์เพื่อ1)วิเคราะห์ผลกระทบของการเปลี่ยนแปลงสภาพภูมิอากาศต่อการเกษตร2)สำรวจความคิดริเริ่มในการปรับตัวที่กำลังนำไปใช้และวิธีที่เป็นไปได้ในการรับมือกับมัน3)ทำความเข้าใจบทบาทและความพยายามของเทศบาลเมงกาเซ็นในการแก้ปัญหาการเปลี่ยนแปลงสภาพภูมิอากาศและ4)ประเมินความเปราะบางที่ก่อให้เกิดสภาพภูมิอากาศที่ส่งผลกระทบต่อชุมชนเกษตรกรรมระเบียบวิธีในการศึกษาประกอบด้วยการสำรวจ110ครัวเรือนการสัมภาษณ์ผู้ให้ข้อมูลหลัก30คนการสนทนากลุ่ม6ครั้งและการสังเกตการณ์ภาคสนามโดยตรงได้ดำเนินการในเดือนธันวาคมพ.ศ.2564ถึงเดือนมกราคมพ.ศ.2565สำหรับการรวบรวมข้อมูลปฐมภูมิในขณะที่ข้อมูลทุติยภูมิรวบรวมจากวารสารหนังสือพิมพ์และเอกสารการวิจัยการวิเคราะห์และตีความใช้โปรแกรมSPSSและไมโครซอฟเอ็กเซลผลการศึกษาพบว่าประชากรของพื้นที่ศึกษามีความเสี่ยงสูงต่อการเปลี่ยนแปลงสภาพภูมิอากาศเนื่องจากลักษณะทางภูมิศาสตร์สภาพทางเศรษฐกิจและสังคมบริการโครงสร้างพื้นฐานที่ไม่ดีขาดการเข้าถึงตลาดและพึ่งพาการเกษตรและปศุสัตว์สูงในการดำรงชีวิตประชากรในท้องถิ่นยอมรับมาตรการปรับตัวของเทศบาลที่มีความหลากหลายรวมถึงการสร้างความหลากหลายในฟาร์มการกระจายพันธุ์พืชการเพาะปลูกพันธุ์ลูกผสมหรือพืชเชิงพาณิชย์การเปลี่ยนพื้นที่เพาะปลูกและเปลี่ยนแปลงวันที่เก็บเกี่ยวพืชผลรวมไปถึงการอนุรักษ์ที่ดินและแหล่งน้ำเทศบาลยังมีความกระตือรือร้นในการดำเนินโครงการริเริ่มด้านการเปลี่ยนแปลงสภาพภูมิอากาศเช่นการอนุรักษ์แหล่งน้ำในท้องถิ่นโครงการป้องกันการพังทลายของดินและดินถล่มโครงการจัดการความหลากหลายทางชีวภาพด้านการเกษตรเป็นต้นและยังให้ความร่วมมือในการดำเนินงานของคณะกรรมการและโครงการต่างๆอย่างไรก็ตามสิ่งสำคัญคือต้องพิจารณาว่าจะทำให้เกิดการเปลี่ยนแปลงทางสถาบันที่จำเป็นเช่นการระดมทุนและกำหนดกลยุทธ์ที่ยืดหยุ่นสำหรับการปรับตัวต่อการเปลี่ยนแปลงสภาพภูมิอากาศในภาคการเกษตรในระยะยาวได้อย่าง

สาขาวิชา สิ่งแวดล้อม การพัฒนาและความยั่งยืน ลายมือชื่อนิสิต .....

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Samridhi Kharel : Assessment of municipality roles in adaptation to climate change: A case study from Mangalsen Municipality of Acchham Nepal.. Advisor: SAYAMOL CHAROENRATANA, Ph.D.

This thesis aims to 1) analyze the impact of climate change on agriculture, 2) explore adaptation initiatives being applied and potential ways to cope with it 3) understand Mangalsen Municipality's role in solving the climate change issues 4) assess climate induce vulnerabilities which affect farming communities. 110 household surveys, 30 key informant surveys, 6 focus group discussions, and informal direct field observation were undertaken from 1 December 2021-30 January 2022 for primary data collection, whereas secondary data were collected from journals, newspapers, and research papers. SPSS and MS excel were used for data analysis and interpretation. The study area's population is highly vulnerable to climate change due to its geographical features, socioeconomic condition, poor infrastructure services, lack of market access and high reliance on agriculture and livestock for their livelihood. The locals have embraced a variety of municipal-level adaptation measures, including farm and crop diversification, cultivation of hybrid varieties or commercial crops, changing plantation and harvest dates of the crops, and conservation of land and water resources. The Municipality is likewise active in implementing climate change initiatives like conservation of local water resources, soil erosion and landslide prevention projects, agriculture biodiversity management projects etc. and also cooperating on running different committees and projects however, it is critical to consider how to bring about the necessary institutional change, raise funds and establish flexible strategies for long-term climate change adaptation in agriculture.

Field of Study:	Environment, Development and Sustainability	Student's Signature .....
Academic Year:	2022	Advisor's Signature .....

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Samridhi Kharel

TABLE OF CONTENTS

List of Figures

List of Tables

CHAPTER 1

Introduction

Climate change is an infuriating concern, a true reflection and a proven fact (Adger, Arnell et al. 2005). It is a phenomenon caused by greenhouse gas emissions from deforestation, industrialisation, urbanisation and fuel combustion, which brings changes in solar energy, temperature, and precipitation (Upreti 2006). Global warming, rising sea levels, erratic rain patterns and intensities, and weather extremes are the most common effects of climate change (Academics 2022). Between 1880 and 2012, the Earth's temperature rose by 0.85 [0.65 to 1.06] ° C (Stocker, Qin et al. 2013). Between 2006-2015, for the decade, it remained at 0.87° C (Asrar 2019). With the meagre average temperature rise, catastrophic disasters such as drought, heavy rain, and tropical cyclones are predicted to surge in form, intensity, and frequency. They are expected to become more often and severe (Change 2007, Seneviratne, Nicholls et al. 2017). The underlying effects not only count for habitat destruction, people's movement for a better life, loss of human lives and infrastructures and wildlife habitat destruction but also extends to food security, epidemics and decline in quality life aspects(Prevention). Climate change impacts the globe; every state must unite to work collaboratively to withstand this massive problem (CEN 2003). By the 2050s, around a billion Asians will likely experience a water crisis ending in drought and land degradation (Christensen, Hewitson et al. 2007, Cruz, Harasawa et al. 2007, Watts 2018). In up to 65 countries, climate change could diminish agricultural yields, affecting almost 11% of the farming area in developing countries and then about 16% of agricultural GDP (OF 2005). Climate change threatens agriculture in South Asia; hence, adaptation strategies are obliged to ensure agrarian production, minimise susceptibility, and improve the agricultural system's resiliency to climate change (Aryal, Sapkota et al. 2020).

The agriculture industry accounts for 28 % to 33% of Nepal's national GDP (Gairhe, Shrestha et al. 2018, Nepal Rastriya Bank 2018).Nepal is one of the countries most at risk from the threat of climate change (Gautam, Gautam et al. 2007, 2019). Globally it is also ranked fourth in Maple Croft's vulnerability Index 2011 (SJ Thapa 2017, Eckstein, Hutfils et al. 2018). In addition, it is positioned in rank eleventh and thirtieth regarding vulnerability

to earthquakes and floods, respectively (Khadka and Pradhan 2021). Similarly, the Climate-change vulnerability and risk assessment report (MoFE 2021)indicated that in addition to the threat of the impacts of climate change, 50 of the 77 districts ranked high to extremely high (Khadka and Pradhan 2021). Even though Nepal emits only a tiny amount of global greenhouse gas (Rijal 2009, 2019), it is incredibly subtle to the consequences of climate change (Government of Nepal 2004 , Rijal 2009, Government of Nepal 2010) (with 0.13 t per capita CO2 emissions), it has to go through the effects of climate change (Rijal 2009, 2019). The struggling economy, challenging geography, topographical heterogeneity, fragile habitat, microclimate divergence, a vast spectrum of inconstancy in weather and precipitation patterns, heavily reliant on natural assets and insufficient human resources to alleviate and endure climate change are the principal reasons for this (Gautam, Gautam et al. 2007, Karki 2007, Dahal 2009, Gurung and Bhandari 2009, 2019). (Mandal, Yadav et al. 2013) As per AR4, in comparison to the preceding century, Nepal's precipitation rate is anticipated to rise by 15% to 20%, although the country is forecasted to be 0.25 to 3 °C warmer in the summer and 0.04 °C warmer in the winter (Bernstein, Bosch et al. 2008). Nevertheless, because Nepal is a landlocked country, the Global Circulation Model (GCM), often known as the IPCC prediction, indicates that considerable alterations in monsoon precipitation could be witnessed (-14% to + 14%) and the temperature likely to climb by 0.5 to 2 degrees Celsius by 2030 (Team 2009). Farming and animal husbandry are the building blocks of the national economy. Agriculture is the foundation of the country's agrarian economy (Chaudhary 2018).60.4% of the populace is occupied with farming for subsistence for their livelihood (MOAD 2017), and the vast majority of rural lives are reliant on natural resources (water, agriculture, livestock, forest, etc.); thus, the livelihood of this group is under jeopardy, and severe environmental changes will have a detrimental impact on them (Gautam, Gautam et al. 2007, Charmakar and Mijar 2009).

Some studies additionally exhibited that the nation is, as of now, experiencing changed rainfall patterns and warmer weather (Regmi and Adhikari 2007, Chapagain, Subedi et al. 2009, Gum, Singh et al. 2009, Paudel and Kafle 2012).In addition, some other scientific studies show that the state's temperature is rising at a frequency of 0.06 degrees Celsius every year (Dahal, Pokhrel et al. 2011), and this increment in temperature relies on the geographical condition of the country. Mountain areas and the Himalayas have a higher frequency of rise than low-lying Terai, which is 0.08°C and 0.04° C, respectively (Gautam

and Pokhrel 2010). Moreover, Nepal has some of the world's rough and most severe alpine terrain, and around 75% of the country is covered by mountains (Leo E. Rose 2022). In Nepal, divergent societies are grappling with the impacts of climate change in distinct manners (Gautam, Gautam et al. 2007). Climate change impacts every individual, and its repercussions are evident to everyone, regardless of gender and socioeconomic status; in any case, the impoverished, underprivileged individuals and women are the most antagonistically impacted and particularly susceptible (Mitchell, Tanner et al. 2007, Gautam 2007.) since these people's aptitude to cope with it is restricted (Gum, Singh et al. 2009, Paudel and Kafle 2012). Climate change has put the lives of around 2 million people in peril, with the figure expected to climb to approximately ten million in the upcoming year (Durbar and Kathmandu 2010). For nations like Nepal, climate change is not simply an environmental issue yet additionally a socioeconomic and political one (Charmakar and Mijar 2009). The requirement for adaptation was well recognised and earned national attention (Jones 2010). The Local Adaptation Plan of Action (LAPA) has been laid out in 14 districts of the Far-Western development region, including Achham, to implement pilot programs (Government of Nepal 2013, Naresh Sharma 2016).

As we mentioned, most of the country is covered by hills and mountains; rainfall during the monsoon season increases the likelihood of glacial lake outburst floods. As a result, soil erosion worsens, resulting in landslides (Shrestha, Wake et al. 1999), ultimately demolishing agricultural land and crops. Hence, the degree of vulnerability in the farming community to climate change is higher in the mountain region compared to the Terai. The people's socioeconomic status in mountain regions is limited by institutional capacity, which also increases the vulnerability towards climate change in mountain regions (Regmi and Adhikari 2007). Hence, the people of the mountainous regions have a high degree of vulnerability due to their low adaptation capability and high-risk exposure. The magnitude of food insecurity and malnutrition increase is also significantly related to these climatic events (Bailey, Benton et al. 2015). For instance, rainfall patterns change results in lower crop yields and productivity, which contributes to food insecurity in the mountains. Hence it emphasises the need to comprehend climate change on a regional level. Due to a lack of resources to undertake adaptation and diversification initiatives, low-income or rural farmers' communities are projected to be the most affected (Bailey, Benton et al. 2015, UNCCD 2017). Therefore, this research, “Assessment of Municipality Roles in adaptation

to Climate change: A study of Mangalsen Municipality of Achham, Nepal", has been undertaken to investigate the status of human-climate interaction and resulting climate impacts in Farming complex and adaptive measures involved in addressing climate threats and vulnerabilities".

Farmers in Mangalsen Municipality and proximal areas in Far west Nepal have been grappling ever since to deal with the impacts of climate change (Bartlett et al., 1985). The rising riverbeds and heavy rainfall have forced families from their homes and wiped out arable lands and crops (Karki et al., 1970). One of the most significant climate initiatives includes planting Mercy-Crop-like Sugarcane as a counterattack towards mitigating climate change impact (MoFE 2019). However, such an initiative can lower the impacts of climate change to a minimal extent, making it necessary to conduct extensive research frequently while devising strategies and adapting better towards climate change.

1.1 Rationale of the Study

Climate Change impacts not only the Millennium Development Goals (MDGs)7, but all other goals are directly related and impacted by it (Orellana 2010). In addition, sustainable development goal 13 is directly related to climate change and its impacts in the Nepalese context. The other 16 goals are closely related to the 2030 Agenda for Sustainable Development goals (UN). The country signed the Paris Agreement to confine global temperature rise beneath 2 degrees Celsius to withstand climate change (United Nation 2016). As a party to United Nations Framework Convention on Climate Change (UNFCCC), it is paramount for the Government of Nepal to address issues related to climate change and come up with long-term solutions, including adaptive practices, all contributing towards a sustainable future (Ministry of Forests and Environment 2021).

As a party to the United Nations Framework Convention on Climate Change (UNFCC), the Government of Nepal started launching initiatives to build on local and regional practices to strengthen adaptive capacities and resilience to climate change (Agrawala et al., 2003). As a part of the initiative, the National Adaption Plan of Action (NAPA) concept was formulated and implemented across 17 districts in the country (ICEM 2013). The Action plans not only aimed at reducing the impact of climate change but also towards developing climate-resilient communities (World Bank 2019).

Besides, which terai region is often regarded as a food factory for the country (Hibbett 2018),

this implies the importance of enhancing food production to ensure food security. However, ongoing global warming triggered by Climate change has jeopardised farming communities (Malla 2008).

This study thus aims to envisage the extent to which adaptation initiatives have been used and the degree to which the effects of climate change have been mitigated. It intends to work as a bridge to delivering the voices, problems that locals are facing, and the need of the locals to devise and improve the existing adaptation innovations.

Gentle et al.'s (2014) study has shown that the residents in hilly Nepalese areas are susceptible to change and that their socioeconomic status is far lower than in other countries. Lamichhane's (2010) study indicates that climate change has an enormous impact on people's daily lives in hilly areas. However, community adaptation is low because of economic status and unequal access to resources (Sujakhu et al., 2019). Gurung and Bhandari's 2009 findings demonstrate that the high climatic variation significantly impacts people's livelihoods.

The Achham district was chosen for the study because of its diverse agroecology, a good illustration of mountainous ecology, and high hill terrain with pastoralism and integrated farming practices. As mentioned, the Local Adaptation Plan for Actions (LAPA) was implemented in 14 far-western and mid-western, and Achham was one of the piloted districts in the Seti zone. In these circumstances, researching the impact of climate change and community people's adaptation strategies in the Achham district was critical. This study was conducted to extract information on various implications of climate change on agriculture, people's perception of climate change and agricultural adaptation strategies.

1.2 Problem Statement

Climate is changing at an unpredictable rate. Lack of Research, inadequate appropriate adaptive measures from authorities and adequate funding modalities have created a knowledge gap in studying the negative effect of climate change (Gautam et al. 2007, Malla 2008). Nepal has been ranked fourth as the most vulnerable country susceptible to water-induced disasters (Nepal Energy Forum 2013). The unprecedented rate of rainfall, erratic rain pattern and rising riverbeds due to erosion has further increased the vulnerability of people who rely upon agriculture for livelihood (Hibbett 2018, NCCSP 2020, UN 2020). In

addition, the reliability of farmers towards rainfall for agriculture, not having backup income support, and countries' geomorphology that favours landslides and other water-induced disasters have further worsened the situation (UN 2020). Therefore, this study was intended to study the effect of climate change and adaptation practices implemented. This study might help devise adaptive and remedial plans that could help this region's farmers design other adaptive measures to a greater extent.

1.3 Objectives

Understanding climate change and its impact on agriculture in broad and understanding the adaptation methods in the hilly area of Nepal is the vision of this research.

The overall objective of this research project is to assess the roles and responsibilities of the Municipality in helping local communities adapt to climate change. To achieve the general objective, a few specific goals are also developed. The following are the underlying objectives:

1. To understand Mangalsen Municipality's role in supporting community climate change adaptation.
2. To analyse the effect of climate change on agriculture and agriculture products in Achamm, Nepal.
3. To explore ways to adjust agriculture/farming and people's living conditions to climate change.
4. To assess climate, induce vulnerabilities that directly and indirectly affect farming communities.

1.4 Research Questions

The following are the research questions that pertain to our objectives:

- What is the impact of climate change on livelihoods in Mangalsen Municipality, Achham district?
- How do people cope with climate change, and what will be the role of the Municipality in such adaptation?
- What adaptation practices are adopted by people and municipality to cope with climate change impacts?
- What climatic hazards have emerged in the Local government Areas?

- What are the possibilities for NGOs and INGO to collaborate with Local Government agencies in combating climate change?

1.5.1 Scope of the Study

The research helps to generalise the discovery of the district (the condition of Municipality on regards of CC impacts and the adaptation techniques) and also it will help policymakers, NGOs and others to plan and organise their manifestations (the actions accordingly as this research will support to find out barriers for CC adaptation). Farmers and future researchers will also be able to explore possibilities here. As this paper will help them to explore possible impacts and its adaptation measures. In addition, the rural working class has migrated to the surrounding nations, leaving children and older people behind (Dhungana 2013). In the far-west area of Nepal, this is a significant issue. High population increase, minimal scope to expand agricultural lands, underdeveloped irrigation infrastructure, continued high degree of livelihood reliance on agriculture, and virtually static productivity on staple crops have created grave threats to national food security (Dhungana 2013). The need to prioritise agriculture is genuine and significantly boost investments in the sector to prevent the emergence of food insecurity in the district of Achamm. This thesis intended to work as a bridge to delivering the voices of locals to devise and improve the existing adaptation innovations.

CHAPTER 2

Literature Review

“Pilot Program for Climate Resilience Mainstreaming Climate Change Risk Management in Development” (Government of Nepal:Ministry of Science) emphasises conventional and local resilience to climate change in Nepal. However, the Accham district is not included in this assessment. Similarly, one of the early studies outlines climate change and its influence on agriculture, emphasising that people whose livelihoods are based on agriculture are especially susceptible, as well as the impediments to implementing a national adaptation action plan (Karki and Gurung 2012). Nevertheless, the implications on livelihoods and traditional adaption practices still need to be adequately examined. Similarly, the article "Impact of Climate Change on Children in Nepal" depicted precipitation patterns and trends, demonstrating that Ascham is one of the country's heaviest rainy districts (Dr. Dhruba Gautam 2012). however, it made no mention of temperature variations. “Climate Change and Food Insecurity: Institutional barrier to the adaptation of Marginal groups in Far western development region” (Bishokarma and Sharma 2013) delineated that the ramification of climate change is prepotent on disadvantaged groups, the older and women (Ministry of Forest and Environment 2017), furthermore, it highlights Nepal's institutional shortcomings in distant areas, such as ethnic and gender-based jobs, education, non-touch abilities, wage labour, socioeconomic class discrimination, and land tenancy regulations, etc. and mentions that these are some of the critical issues for susceptibility, and suggestions were made to amend these institutional deterrents in improving these populations' ability to deal with the impacts of climate change. This paper attempts to confront the consequences of climate change on food-based livelihoods, as well as the prospects for coping with it and strengthening the capacity to cope with the implications of climate change on food production for its accessibility to marginalized populations and their welfare. Therefore, this article will assist in identifying institutional obstructions to adaptation and determining ways to improve those groups' adaptation capacity. It will also assist in identifying barriers to performing adaptation activities in this region and planning adaptation strategies accordingly. Many researchers, on the other hand, have demonstrated that Nepal is

particularly sensitive to climate change, with its implications apparent in many areas, including people's livelihoods, and have predicted that resilient approaches might shrivel(Sapkota 2016) however, there is still a dearth of study on the magnitude of climate change's repercussions across a multitude of sectors, notably in the fields of livelihood, agriculture, and conventional adaptation initiatives, particularly in the region of my Research (K. Acharya 2015). Given the need for immediate Action, a local adaptation plan of Action (LAPA) was executed nearby in 14 districts between 2013 to 2017 by Nepal Climate Change Support Programme (NCCSP) (NCCSP 2020). Nonetheless, due to a lack of technical cooperation, the fragile economy, unfortunate coordination among government agencies, and a lack of disaster awareness and preparedness at the local level, this initiative could not ensure success (Gum, Singh et al. 2009, Pokhrel and Pandey 2011). Hence this paper will aid in resolving some issues, such as raising knowledge on possible implications of climate change and determining technically feasible and economically viable mitigation and adaptation techniques while also considering traditional adaptation measures.

Despite some detailed findings of climate change, no comprehensive research on vulnerability (K. Acharya 2015) to community livelihoods, meteorological variability, or adaptation and about the role of Municipality in implementing Climate change adaptations has been conducted in this region. Various organisations are concerned about climate change; in any case, they focus on the initiative's execution stage. There is a contracted comprehension of the fundamental issues concerning the severity of climate change's influence on individual livelihood (Ojha 2008.).

As a result, by evaluating the local's degree of comprehension and knowledge of climate change, this research will help to bridge that gap left by prior studies. It will also assist in determining the consequences on livelihoods, the temporal pattern of climate change, the role of municipalities, and whether or not any integrated strategy or technique for climate change adaptation is functioning or deployed at the local level in this area.

2.1. Nepalese Livelihoods

In Southern Asia and the Hindu-Kush area of Nepal, the climate models indicate continuous rises, both in temperature and precipitation. However, these changes are bluntly impacted by high-altitude areas like the hills and mountains of Nepal (Maharjan, 2019). Nepalese rural people rank among the most susceptible climatic groups at higher altitudes, lack access

to infrastructure and markets, and rely heavily on subsistence farming and ecosystem services (NAPA, MOE, 2010). Nevertheless, there is an indication that long-term adjustment could mitigate some of the adverse climate impacts in Nepal (Maharjan, 2019). Though, instruments and resource-based effectiveness of climate adjustment in Nepal need more early investment, which is not easily accessible to poor households. Furthermore, the unusual distribution of physiography and topography of Nepal and the immense variety of climate and ecology add other risks (Gautam, Gautam et al. 2007, Karki 2007, Dahal 2009, Gurung and Bhandari 2009, 2019).

Nepal traditionally has a livelihood based chiefly on agriculture, and over 70% of families depend directly on one or more types of agriculture to fulfil their daily requirements (Merrey et al., 2018). The land is one of the few tangible capitals owned by most families (Hibbett 2018). Rice is the main crop of choice cultivated in Nepal (Pokhrel 1997, Joshi, Maharjan et al. 2011), one-fourth of the country's GDP is accounted for rice, and more than 75 per cent of the population is employed in rice farming for at least half of the year (Pokhrel 1997). Rice production is low and unpredictable, despite its particular importance. Nearly 79% of total farmers rely on rain-fed techniques, which are incredibly susceptible to climatic variations (Pokhrel 1997). Due to the sensitivity and survival of rice yields in the Nepalese economy, the changes caused by climate change in rice production may have catastrophic effects on the security of family food and general health (Hibbett 2018). Since effective collective Action on climate mitigation remains elusive globally, substantial small but positive step obstacles are also present for lower-level commercial and governmental players. First, more research is needed to measure the effect of climate change on farm families' lives in Nepal. Most, i.e., 51 per cent of Nepalese families, have no idea about climate change, reflecting the absence of relevant studies (Ganesh, 2021).

2.2 Climate Change: Impact on People and Nepal Area

Nepal is a landlocked country with diverse geography in South Asia, located between Tibet and India (Agrawala, Raksakulthai et al. 2003, Societies, Gleason; et al. 2021). The high Himalayan Mountains in the north and the low-lying Gangetic Plains in the south lie within a span of fewer than 200 kilometres (Agrawala, Raksakulthai et al. 2003, Societies, Gleason; et al. 2021). As a result, it experiences various climates and catastrophic climatic events (Societies, Gleason; et al. 2021). Furthermore, most of the changes caused by climate

change are not continuous or gradual, with adverse consequences that vary from region to region (Societies, Gleason; et al. 2021). Although Nepal is a country where changes have been relatively less pronounced, there is no doubt that Nepal's climate is changing (Khanal et al., 2018). The country is susceptible to climate change and has already suffered temperature and precipitation alterations quicker than the global average (Climate Links 2017). Droughts, Floods, avalanches, landslides, high and low temperatures, and glacier lake outburst floods(GLOFs) are all common occurrences in Nepal (Societies, Gleason; et al. 2021). The increased frequency of extreme events, rising sea levels, and more frequent droughts have all impacted the lives of millions of people worldwide, including Nepal (Clean Energy Nepal). Moreover, above 80% population is exposed to at least one of those mentioned threats (UNDRR 2019). Climatic-induced natural hazards like floods, landslides, droughts, and other extreme weather events have led to the destruction of lives, livelihoods and property and also caused significant damage to all climate-sensitive regions and the nation's economy (MoFE 2018). Climate change will significantly impact food production, water, and energy resources (Christensen, Hewitson et al. 2007, Cruz, Harasawa et al. 2007, Watts 2018). They are likely to affect incomes, increase malnutrition risk and exacerbate poverty adversely (Malla 2008, Hibbett 2018). Climate change will affect different groups in society depending on their location or level of development, with the poor being the most vulnerable (Gautam, Gautam et al. 2007). The effects will range from reduced crop yields, freshwater availability, biodiversity loss, frequent natural disasters, death due to more extreme weather events, etc. (Ganesh, 2021).

2.2.1 Past Extreme Events of Accham District

Table 1 Past Extreme Events in Accham District

Year	Type of Disasters	VDC/ Municipality	Human loss		Physical loss	Others
			Casualties	Injuries		
1997	Landslide/flood		4			Agricultural lands were washed away.
2002	Fire		4			Destroyed Forest
2006	Landslide/flood		6	5	20 houses and cattle affected	Agricultural lands were washed away.
2007	Landslide/flood		3			Agricultural lands were

						washed away.
2007	Fire				Destroyed shop	Damaged in Lakhs
2008	Fire				Impaired 32 houses	Damaged in Lakhs
2009	Diarrhoea	58	31		31,000 affected	
2009	Landslide	40	19		1200 houses Impaired	Agricultural land swept away
2009	Fire				Destroyed market	Damaged in lakhs
2009	Flood	10	10 and missing	4	Affected family 136 and 12 houses destroyed	
2009	Landslides	1	10		Affected Families 60 and 4 houses destroyed	
2010	Flood	2	2	3	Affected Families 22 and 15 houses were destroyed.	Damaged in lakhs
2011	Flood	4	7 and missing	3		
2012	Storm	1	1	12		
2012	Rainfall	1	2	12	Destroyed one House	
2011-2012	Landslide				Affected 18 houses	
2011-2012	Flood				Affected 3 houses	
2011-2012	Water scarcity				Affected 35 houses	
2011-2012	Earthquake				Affected 30 houses	
2011-2012	Drought				Affected 18 houses	
2011-2012	Forest fire				Affected four houses	
2011-2012	Physical assault				Affected four houses	
2011-2012	Thunderbolt				Affected 2 houses	
2018	Landslide					Blocked Mid Hill Highway
2020	Flood		6 and 11 Were missing	3	Washed away 22 houses Several displaced families still need to be cleared.	Washed away Suspension Bridges Ambulance and Micro-hydro projects are

						impaired. Destroyed arable land

Sources: (Dhungana 2013, ICEM 2013)
https://www.adb.org/sites/default/files/project-documents/44168/44168-012-tacr-en_2.pdf *(ICEM 2013).*
https://kathmandupost.com/sudurpaschim-province/2020/08/19/six-dead-dozens-missing-in-floods-in-achham
https://reliefweb.int/report/nepal/one-month-old-baby-dies-two-other-children-injured-bajhang-landslide.
https://floodlist.com/asia/nepal-floods-achham-sudurpashchim-august-2020

2.2.2 Climate Change impact on agriculture

Climate change has harmful impacts on the agricultural sectors. However, it brings opportunity and revolution in the agricultural field. Due to an increase in temperature and early monsoon, some crops mature earlier, which boosts yields and the possibility of double cropping in some places (MOAC 2018). To some extent, increased temperatures and CO2 emissions aid in some crop production (Malla 2008). It increased agricultural productivity, for example, via improving water use efficiency, photosynthetic processes, shortening the soil microbial activities, and physiological period (Malla 2008).

Nevertheless, it reduced grain filling timeframe due to increased respiration process, fertiliser use efficiencies, increase in insect pest number, a shift in an agricultural region, increased soil erosion, desertification, evapotranspiration, and promoted malnutrition by depleting protein and mineral nutrients content in various crops (Malla 2008). Moreover, agriculture is vulnerable to short-term weather variations that affect crop yield (Malla 2008). On the one hand, inadequate rain and rising temperatures lead to droughts. On the other hand, heavy rainfall over a short period diminishes groundwater recharge by accelerating runoff and generating floods (Malla 2008). However, both Scenarios harm agriculture.

Hence, climate change will potentially result in changes to agriculture, affecting soil fertility, food production, nutrition security, and livelihoods.

2.2.2.1 Impact on the Agriculture of Nepal

Agriculture is the backbone of Nepal's economy. People's heavy reliance on agriculture and tourism renders Nepal's economy extremely vulnerable to climatic conditions (World Bank

2019). Nepal's total area is 147,181 km2, with mountains accounting for 35%, hills for 42%, and Terai for 23%, representing about 33% per cent of the country's total GDP and accounting for 66 percent of jobs (Gairhe, Shrestha et al. 2018, Nepal Rastriya Bank 2018, FAO 2018). Despite this, Nepal became a net food importer in 2008, with a food shortfall of 19 per cent in the mountainous region and 14 per cent in the hilly area (Agri-Business Promotion and Statistics Division 2018, World Bank 2019).

Due to shifting cultivation, some natural vegetation has already been destroyed in the region, including native basmati rice varieties, maize, local wheat, and other agricultural products (Malla 2008). Similarly, in the fiscal year 2012/2013, due to prolonged drought and inadequate rainfall, rice production decreased by 11.3%, maize by 8.3% and millet by 3% (MOF 2013). Likewise, in Nepal, a cold wave in 1997/98 had a detrimental impact on agricultural productivity, resulting in a decrease in crop production, for example, 11.2% in sarson, 27.8% in potato, 36.5% in toria, 37.6% in rayo and 38% in Lentil and chickpeas (Source: NARC annual reports from 1987/88 to 1997/98). People who used to engage in farming practices have been discouraged by climate change and its generated irregular weather patterns; as a result, around 30,845 hectares of land have been left uncultivated throughout the last few decades (CBS 2012). Prolonged droughts, erratic rainfall patterns, landslides, and flash floods, have become more common, all of which have downturned agricultural production in the country. In 2005/06, the early monsoon rain shortfall in eastern Terai resulted in a 12.5 per cent of declination in crop production on a national scale (Regmi 2007).

Similarly, in 2007, 10% of the agricultural land of the hilly region was left barren due to delayed monsoon, while crop productivity in the mid-western Terai was reduced by 30% due to floods caused by severe rain (Regmi 2007). Not only Terai and hilly regions but glacier recession has put the Himalayan region in jeopardy as well. In 2012, The Seti River's Glacier Lake Outburst Flood (GOLF) damaged a 9.5-hectare paddy field, resulting in a nearly US$ 1 million loss. The study was conducted after satellite imagery revealed that 3200 square meters of ice had vanished from Mt. Machhapuchre (OI, HIGAKI et al. 2014). The invasion of invasive species is another significant consequence of climate change. Invasive and exotic weed species harm the local agroecosystem and its functioning (Paudel 2012). Some indigenous crop varieties in Nepal, such as local wheat, maize, and rice, have been wiped out due to the introduction of exotic weeds. When local or indigenous varieties

become extinct, crop productivity suffers (Paudel 2012).

Farmers are also concerned about the impact on livestock, forestry, and fisheries (Anup, 2018).

2.3 Indicators of climate change in Agricultural System

Climate change indicators are parameters that provide easy-to-understand information on current environmental conditions. The organisation for Economic Co-operation and Development (OECD) defines the indicator as" a parameter or value which points or provides information about the state of the phenomenon, environment or area directly associated with a parameter value". Climate change indicators are metrics that provide vital evidence and data about the event that is critical to the environment while also simplifying the intricacies of reality (Smeets and Weterings 1999). The primary goal of these indicators is to give data on climatic conditions based on existing observational data that points to existing environmental issues (Hinkel 2011). There are also some critical indicators in the agricultural system to track climate change. United States Department of Agriculture has identified 20 indicators to monitor climate change. It has grouped them into five categories (physical, crop and livestock, biological, phenological and socioeconomic indicators) which are crucial for agriculture management, with changes in each category being linked to climate change (Walsh 2020).

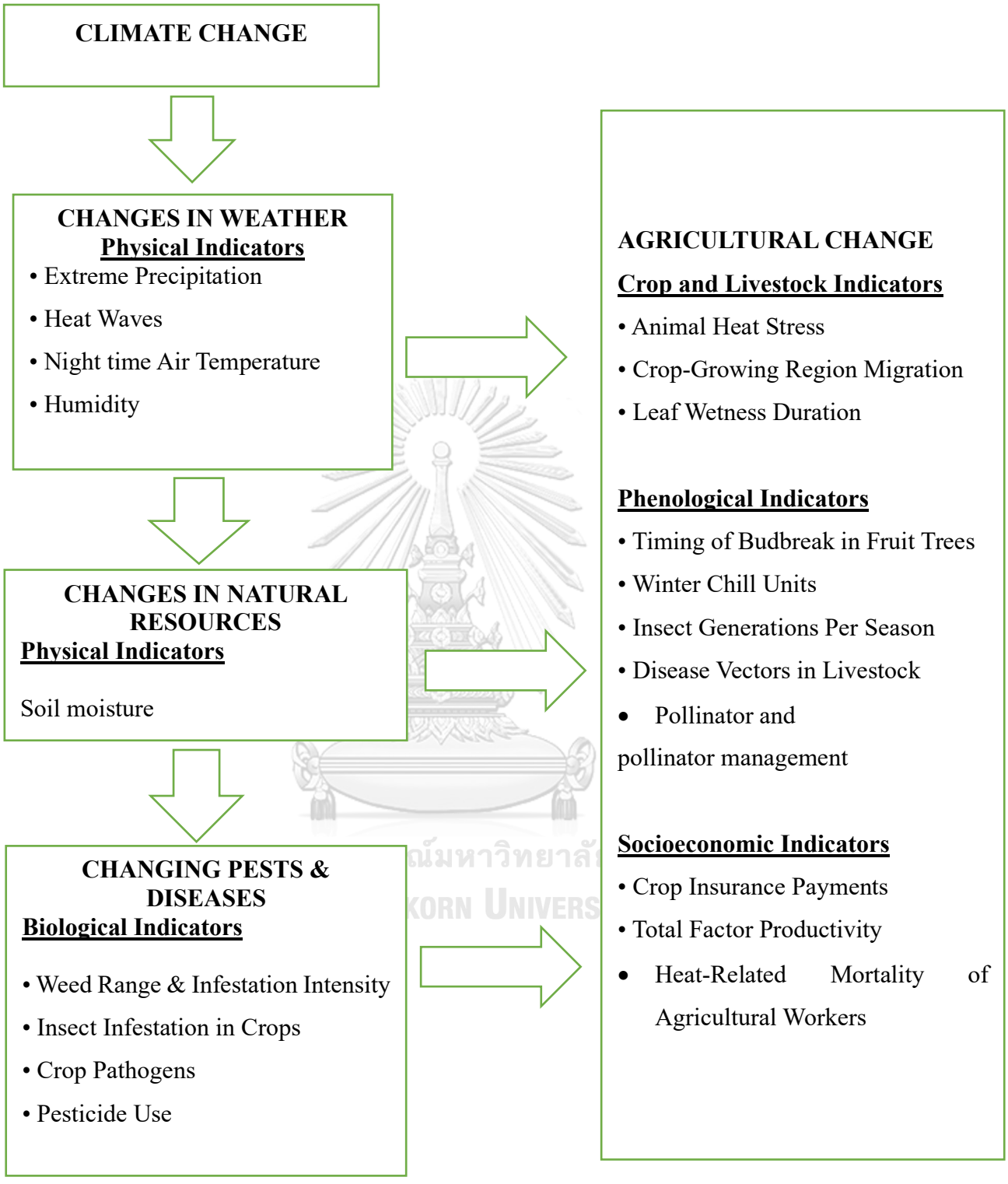


Figure 1 Indicators of Climate Change

*Source:*https://www.usda.gov/sites/default/files/documents/climate_indicators_for_agriculture.pdf
https://www.usda.gov/sites/default/files/documents/climate_indicators_for_agriculture.pdf

2.4 Adaptation in Nepal

Much research has demonstrated how essential adaptation techniques may be used by rural populations to address climate change. Adaptation is a planned strategy focusing on climate change and its influence on ecological and socioeconomic systems (Smit and Pilifosova 2003, Parry, Canziani et al. 2007). Merry et al. (2018) described society's capacity to function collaboratively in generating social capital often regarded as adaptation. Adaptation assessment is the process of identifying alternatives to adapt to climate change consequences and evaluating them in terms of criteria such as availability, costs, benefits, feasibility, effectiveness and efficiency (Regmi 2010). The degree and magnitude of climate change adaptation rely on nature and people being vulnerable to the effects (Smit and Pilifosova 2003). Vulnerability refers to how vulnerable an individual, a household, or a community is to the adverse effects of climate change and how ill-equipped they are to cope with them (Regmi 2010). Adaptive capability varies across nations, between communities, social groupings, individuals, and with time (Smit and Wandel 2006). Vulnerability can be defined as the condition of sensitivity to damage from social and environmental change stress due to a lack of capacity to adapt' (Chapagain et al., 2019). It is a characteristic dictated by physical, social, economic, and environmental elements that make an individual, a community, assets, or systems more vulnerable to the effects of hazards (United Nations Office for Disaster Risk Reduction 2017). The decrease in the susceptibility of society and individuals to climate change is strongly related to reducing poverty since vulnerability and poverty are determining conditions (Abeygunawardena, Vyas et al. 2003). Poverty is generally defined as a lack of access to resources and income opportunities (Yodmani 2001). However, other factors such as geographic location, gender, age, ethnicity, community structure, decision-making processes in the community, and political issues all play a role in determining poor people's vulnerability(Yodmani 2001). According to Maharjan and Maharjan (2020), poverty is linked to poor health, malnutrition, illiteracy, weak social connections, uncertainty, low self-esteem, and inadequacy. Uprety et al. (2017) contend that poverty is also related to social equality and is described as participation inability due to lack of means. A multidimensional poverty viewpoint thus emerges from a more comprehensive picture of poverty, social factors, connections, and structural aspects. Historically, societies rely on weather-dependent natural resources, including fish stocks, crops, forests, cattle, and water supplies (UN 2015, Mugi-Ngenga, Mucheru-Muna et al.

2016, Novita 2009). However, rural communities' adaptation methods aim to respond to shocking occurrences over the short term rather than planned initiatives; autonomous are rather reactive than strategic (Khadka et al., 2018). Documented instances are mostly linked to water management, agricultural diversification, irrigation, insurance, and disaster management. The dangers seen and predicted are more profound, while rural people rely primarily on natural resources. Emerging research shows that adaptation and coping methods are very diverse, and local studies are required in underdeveloped countries for successful development programs. They used existing resources to accomplish goals during and soon after climate-related catastrophes are referred to as coping (Regmi 2010). This study focuses on poverty in remote mountain regions and climate change's effect on rural livelihoods.

There are broadly two types of adaptation frequently mentioned in the literature, and those are autonomous and strategic (Smit and Wandel 2006, Bates, Kundzewicz et al. 2008, Team 2009). (Dixit 2011) Autonomous adaptation is the activities carried out by individuals at the household level to overcome climate change catastrophes or make adjustments that lessen vulnerability to climate changes, despite the existence of government national plans, policies and strategies (Bartlett, Bharati et al. 2010). Although Government approached planned adaptation to climate change, the people in most of the region have been coping autonomously with the calamities (Dixit 2011). Rural households, for example, can adopt various management approaches such as diversification of crops, magnifying cropping intensity, micro level-irrigation, consumption of less water and small-scale storage, or any other practices that enhance the income base's resilience under changing conditions (Bartlett, Bharati et al. 2010).

Strategic adaptation can be attributed to national-level planning, policies, or strategies that deliberately react to the possible implications of climate change (Bartlett, Bharati et al. 2010). Capability building, disaster aid planning, construction and development of infrastructures and a variety of other approaches that strengthen national resilience to the possible impacts of CC on ecosystems and human populations are all examples of this (Bartlett, Bharati et al. 2010).

Most of these consequences in developed and developing countries will be experienced mainly in water resources. Therefore, strategic adaptation planning concerns water

management (Bates, Kundzewicz et al. 2008). As previously mentioned, Nepal's GDP (Gross Domestic Product) and livelihood are primarily reliant on agriculture; hence the effects of climate change on water resources are of essential importance to Nepal (Bartlett, Bharati et al. 2010). Thus, strategic planning will place a greater emphasis on innovative, more sustainable agriculture technologies that consume less water and concentrates those efforts on the restoration of water infrastructure and development through retention and irrigation expansions, as well as analysing water management in light of climate change implications (Bartlett, Bharati et al. 2010).

2.5 Climate Change Adaptation of Agriculture in Nepal

(Smit and Skinner 2002) Adaptation encompasses a wide range of dimensions, such as local, national, and global, as well as forms, such as managerial, technological, and financial, and stakeholders, such as farmers, governments, and industries (Skinner, Smit et al. 2001). Understanding the types and forms of adaptation, their practicality, the stakeholders involved, and the tools and strategies used to achieve them is critical. Smit and Skinner classified agricultural adaptation in 2002 as technical, on-farm adjustment measures, government policy including insurance, and financial management strategies such as diversifying household income sources (Smit and Skinner 2002). If these adaptation measures are not correctly executed, they exacerbate the problem. According to Lobell, if adequate adaptation techniques are not applied, crop production in 12 agricultural systems in Southern Africa and South Asia will decline (Lobell, Burke et al. 2008).

Climate change threatens South Asia's agriculture, including Nepal (Aryal, Sapkota et al. 2020). Farmers in these nations are already taking steps to mitigate the effects by employing traditional and local knowledge, such as seed exchange techniques (Gautam 2008). Adaptation assists farmers in restoring production, revenue, and livelihood security (Kandlikar and Risbey 2000). However, adaptation options should be recognised and classified following the agricultural system (Brklacich and Smit 1992).

According to previous research, farmers have already begun implementing adaptation techniques to cope with climate change. In Makawanpur, for example, the invasion of weeds and crop diseases, as well as outbreaks of insect pests, is causing a problem by deteriorating soil quality. As a response, farmers have begun to use more pesticides and cultivate non-

native varietals resistant to insect pests and high-yielding (Shrestha and Nepal 2016). Farmers in the Panchase region have also changed their cropping patterns, cultivating new varieties and engaging in off-farm activities to sustain their needs and generate income (Adhikari, Baral et al. 2018). Farmers in Nepal are also undertaking some immediate mitigation measures, such as cultivating non-native species and applying more chemical fertilisers, to adapt to the changing climate and its effects (Pradhan et al. 2015).

Farmers are doing their part to reduce the impact, but more than these measures are needed for long-term effects. Nevertheless, inadequate participation of stakeholders and knowledge, inappropriate institutional arrangements, the ambiguous role of community groups, a chasm in the interaction between the grassroots community and Government, and the absence of elected representatives regarding adaptation plan execution are among the primary issues (Dhungana, Khadka et al. 2017).

2.5.1 Factors influencing the choice of adaptation strategies

Farmers' capability to adjust to climate change and fluctuation is primarily determined by a variety of elements ranging from their perception of climate change (Esham and Garforth 2013, Piya, Maharjan et al. 2013) to non-climatic to socioeconomic factors (Abdulla, Eshtawi et al. 2009, Esham and Garforth 2013, Piya, Maharjan et al. 2013, Feola, Lerner et al. 2015, Bhatta, Aggarwal et al. 2016, Mugi-Ngenga, Mucheru-Muna et al. 2016). Climatic and non-climatic factors are recognised to impact response strategy implementation. According to Bhatta et al. (2016), farmers adapt their agricultural techniques to climate change. The household head's age plays a significant role in determining the level of adaptation, with older persons having more experience and being able to employ various adaptation strategies to meet changes affecting farming pursuits (Mugi-Ngenga, Mucheru-Muna et al. 2016). On the other hand, found a negative relationship between age and level of adaptation, suggesting that younger people are more prepared to undertake the risk of embracing new technology in terms of adaptation than older people (Shiferaw and Holden 1998). Younger individuals are also inclined to participate in climate-related activities to mitigate climate change's impact (Salehi, Nejad et al. 2015).

Gender is yet another factor in determining adaptation. In terms of adaptability, however, there is no substantial impact of gender. Because of sociocultural and institutional

constraints, female-headed houses are reported to have a lesser degree of adaptation (Hassan and Nhemachena 2008, Berman, Quinn et al. 2015, Mugi-Ngenga, Mucheru-Muna et al. 2016). While multinomial logit (MNL) and multinomial probit (MNP) models demonstrated that since women conduct most of the agriculture activities in remote regions, female-headed families are more likely to adapt to climate change (Nhemachena and Hassan 2007).

2.6 Future projection of climate change and its impacts on farming communities in Nepal

The Modelling of the global climate change scenario reveals that there will have more severe and profound consequences in high-elevational and complex geographical regions. As mentioned earlier, since Nepal is a mountainous country, climate change disproportionately negatively influences Nepal's mid-hill and mountain regions. Climate change will cause low flows, sedimentation, and flooding in Nepal's over 6000 small and large rivers, becoming even more extreme in the future (Mirza and Dixit 1997). In 2009, five countries, including Nepal, executed a modelling exercise based on emission scenarios; the IPCC report (2007) illustrates that, in non-monsoon seasons, the temperature in Nepal's mid-hills is expected to rise and become a rider. According to forecasts from the Global Circulation Model, Nepal's temperature will undoubtedly rise between 0.5 to 1 °C by 2030 and 1-2.3 °C 2090. Likewise, severe hot days are anticipated to grow 5% from 1970 to 1999, 55% by 2060 and 70% by 2090. Furthermore, scorching nights are expected to rise by 5% between 1970-1999, 77% by 2060 and 93 % by 2090 (Baniya, 2021). When it comes to precipitation, there will be some variation, and the precipitation is expected to fall by 14% and rise by 40% by 2030, then plummeted by 53% and peak at 135% by 2030 (ISET 2008). (Poudel and Kotani 2013)With changes in the origination and development of crop diseases and pests, climate change is projected to promote geographical alterations in land suitability and crop production (Jesus Júnior, Valadares Júnior et al. 2008). Climate change is projected to substantially impact crop productivity, which will vary based on crop variety, growing season, and altitude (Poudel and Kotani, 2013). Therefore, climatic hazards such as flooding and erosion will be more prevalent in the country's mid-hill and terai regions which will also render agricultural land in mountainous terrain and river basin areas at higher risk. However, with a 4-degree Celsius rise in temperature and a 20% increase in precipitation, rice productivity will improve by 0.09 % -7 % (Baniya, 2021).

Because of climate change, the country's general food production loss was predicted to decline by 5.3%, 3.5%, and 12.1% in 2020 and 2050, respectively, while the nation's net agricultural loss was assumed to reach 0.8% of the 2014 GDP every year (IDS-Nepal 2014). Smallholder farmers are expected to shrink due to internal and external migration, increasing vacant land (Joshi and Dongol 2018). Despite the risks posed by climate change, some farmers have transitioned from subsistence to commercial farming with the cooperation of the entire farming community, exhibiting a high level of climate change resilience (Paudel Khatiwada, Deng et al. 2017). Farmers are more likely to adopt high-yielding crops that can withstand extreme weather and innovative ways to increase soil fertility, crop care, and water management practices (Chalise and Naranpanawa 2016), demonstrating excellent resistance to climate change.

2.7 The Action of the Government of Nepal on Climate Change

Nepal formally became a member of the United Nations Framework Convention on Climate Change (UNFCCC) treaty in 1992 during the Rio Earth Summit. It endorsed it in 1994 (Nepal 2019) and enacted it in Nepal in the same year, that is, 1994 (MoPE 2004). It was augmented by the Kyoto Protocol and came into effect in 2005 under the supervision of UNFCCC (Ministry of Environment 2012) as the Convention Party country presented the first document in 2004 (MoFE 2011, GoN 2019).

The Ministry of Environment (former Ministry of Population and Environment), appointed as the national authority, was mandated with fostering developmental projects for Clean Development Mechanisms (CDM). From 1996-2006, the Ministry of Environment (former Ministry of Population and Environment) was proclaimed as a central point to enforce the provisions of UNFCCC. During this time, some initiatives to raise awareness were coordinated; likewise, Nepal's 2003 Sustainable Development Plan and the 2001 Millennium Development Goals strategies have discussed the climate change problem to some degree (MoFE 2011).

Undertaken capacity-building programs to oversee climate change and the environment (MoFE 2011). The National Capacity Needs Self-Assessment Project developed the action plan focusing on capacity building to execute the Rio- Conventions (Climate Change, biodiversity, erosion, etc.) (MoFE 2011). A clean development Project process emerged for approval to make the most of the Kyoto Protocol provisions (MoFE 2011). The (MoFE

2011) Government of Nepal exuded the "Kalapatthar Declaration" in Kalapatthar near the Mount Everest base camp before the 15th meeting of the UNFCCC Parties (COP 15) held, scheduled for 2009 (MoFE 2011). Besides, Nepal prepared the statement report for COP 15. It established a climate change council in 2009 under the Leadership of the Prime Minister to retain policy alignment in climate change (GoN 2019). Moreover, at COP 15, the revered Prime Minister emphasized the exigency to contemplate the threats and risks of climate change in the hilly regions and recommended to the negotiations and decisions of the Convention that this matter be taken very seriously (MoFE 2011). (SAARC 2008, SAARC 2010). Climate change then formed the national development agenda in 2009; besides this, climate change and environmental stewardship challenges were included in Nepal's Interim Constitution (2007) and its Three-Year Interim Plan (2008-2010) (MoFE 2011). In response to the SAARC declaration and Thimphu statement, Nepal aimed to address climate change through organisational measures and reinforcement, strategy formation, agenda formulation, and execution (Environment;MoPE 2016). To meet SAARC Minister's Declaration 3 July 2008 and Thimphu Statement 28-29 April 2010 on climate change, climate change adaptation to safeguard the lives and sustenance of individuals in regards to food, water and energy and developing an intergovernmental climate change expertise panel to formulate concrete policy guidelines for organisational alliance and to build organisational correlations between state institutions regarding climate change challenges respectively (SAARC 2008, SAARC 2010).

Climate Change Management Division was formed at the beginning of 2010 as a convention head in the Ministry of Forestry and Environment and designed the National Adaptation Programs of Action (NAPA), mentioning the national priorities needed for adaptation to mitigate climate change impacts and presenting it at United Nations Framework Convention on Climate Change (UNFCCC) in 2010 and inscribed it on same year on 28 September (Government of Nepal 2010, MoFE 2011). For the implementation of the National Adaptation Plan of Action, the Government of Nepal (GoN) has sanctioned a national outline of the Local Adaptation Plan of Action (LAPA) and national climate change policy in 2011 (Regmi and Star , Regmi and Karki 2010, MoFE 2011, Regmi and Bhandari 2012, GoN 2019). Community-based adaptation Plan was employed in 2011 with support from different level organisations, institutions, etc. (GoN 2019). The Mountain Alliance initiatives were initiated to meet the credentials rendered during COP 15 by the respectable

prime minister, and pertinent reports were prepared through meetings with multinational experts (MoFE 2011). A multi-stakeholder Climate Change Initiatives Coordination Committee (MCCICC) assembled with the presence of delegates from specific governmental and non-governmental bodies etc. (MoFE 2011) to harmonise climate change operations and enact joint projects (GoN 2019).

Moreover, in the fiscal year 2010-11, the National Planning Commission launched climate-resilient planning tools with a strategy to build the national economy and climate-resilient infrastructure (MoFE 2011). Nepal submitted its second national communication report in 2014. It was supposed to submit its third report to the Secretariat of the United Nations Framework Conference on Climate Change in 2019 (GoN 2019), which has probably been presented by now. The Paris Agreement (COP 21, 2016), acknowledging adaptation as a worldwide priority and issue, emphasises encouraging national endeavours and adaptation strategies along with the development and application of National Adaptation Planning and reinforcing institutional configurations(Nepal 2019). Furthermore, this nation is also a party to the Paris Agreement (22 April 2016; became effective on 4 November 2016) (GoN 2019, MoFE 2019), the Sendai Framework and the Sustainable Development Goals and has submitted the roadmap of Nationally Determined Contributions (NDC) on Climate Change as a member to the Paris Agreement (GoN 2019). Besides, Nepal also participated in COP 22 as a UNFCCC member (MoPE 2016, Pashupati Nepal 2019). Besides this, Nepal supported the National REDD+ Strategy in 2018 to modulate REDD+ programs in Nepal, noting the need for low-carbon climate-resilient development approaches (MoFE 2018).

Hence, strategies to mobilise funds to plan climate change programs are in process; however, climate change adaptation projects are conducted by several international and national level non-governmental (INGO, NGOs, etc.) and governmental and community-based organisations and are still ongoing (GoN 2019). Provision has been provided to governmental and non-governmental organisations for direct access to the International climate grant to broaden the adaptation and mitigation programs (GoN 2019). Besides, the private sector and civil society have conducted initiatives and campaigns to raise awareness and foster clean energy (GoN 2019).

2.8 Importance of perception-based study on Climate Change

In the case of climate change, perception is substantially associated with the degree of

induced hazards and opportunities that affect farmers' livelihoods, as well as their adaptation techniques and actions (Adger 2003). Climate change perception is a multidimensional process involving various psychological components such as beliefs, knowledge, attitudes, and concerns regarding whether and how climate change (Whitmarsh and Capstick 2018). Because perception is partly subjective, people in the same neighbourhood may build distinct impressions of climate change despite experiencing the same weather patterns (Simelton, Quinn et al. 2013). Farmers might use their perceived knowledge to improve their farming practices and prepare for future risks and obstacles (Makate, Makate et al. 2017). Perception-based research is critical for understanding the actual phenomenon of climate change at the grassroots level and developing a response strategy (Jianjun, Yiwei et al. 2015). It helps determine the various levels of understanding among individuals or communities and analyze the underlying risk and potential solutions (Abid, Scheffran et al. 2015). Hence, perception might be considered an alternative awareness obtained from local experiences. It is well acknowledged that perception is a prerequisite for adaptation to climate change and unpredictability. It is one of the elements that can impact farmers' judgments on whether or not to adapt to climate change and variability since it influences their agricultural management decisions (Maddison 2007).

2.9 Adaptation Theory

The leading theory is about how people alter the natural environments around them to make a living sustainably. According to Charles Darwin, Adaptation theory, also known as survival theory or survival of the fittest, is an organism's ability to adapt to changes in its environment and adjust accordingly over time (Sciencing and King 2018). The adaptation theory studies how natural environments can be improved/enhanced and changed to make them more habitable for humans (Gregory 2009).

Among the two primary policy solutions to climate change is adaptation; a second is a mitigation, which involves lowering greenhouse gas emissions to address the underlying causes. Adaptation aims to minimize the risks brought on by climatic change's effects (Fisher 2012). Although emissions will be significantly reduced over the next ten years, further warming is still inevitable, and adaptation will be required to cope with the current climatic shifts (Fisher 2012). We must adapt to climate change to safeguard our communities

and ourselves and prevent future losses (destruction of forests, land, water, health, and infrastructure). Climate adaptation is adopting any actions that safeguard an ecosystem and environment from the effects of climate change while simultaneously fostering long-term resilience to changing climatic conditions (McCarthy 2021). Fisher 2012, mentioned that adaptation strategies could help reduce vulnerabilities by minimizing susceptibility or improving adaptive capacity. Climate change is expected to considerably impact agriculture and food security though the effects may vary by region and crop (Anderson, Bayer et al. 2020). Among all, small-scale farmers will experience severe losses in every aspect of their daily lives, from the revenue they gain through their crops to the meals they provide for their families (TechnoServe 2022).

Furthermore, agriculture urgently needs adaptation initiatives to guarantee future food security for this expanding population and improve the livelihood of farmers (Anderson, Bayer et al. 2020, TechnoServe 2022). Hence, this paper will focus on adaptation theory to deal with the vulnerabilities in hilly areas in Nepal, where the effects of global warming are seen. It will study the impact of climate change and the adaptation method. It will provide suggestions for fixing the local barriers to adaptation measures.

2.10 Theoretical framework

Climate Change is a change in a location's typical weather conditions (Administration 2014). This change is about the changes in the climate that are not normal (Mahato 2014). This could be due to a yearly change in the quantity of rainfall received in a specific region (NASA 2014), or it could also be a variation in an area's average temperature over a month or season (NASA 2014) for which long-term averages have been calculated (Organization. 1992.). Global climate change is a change in the long-term weather patterns that characterise the world's region. The phrase "weather" refers to a region's daily (short-term) fluctuations in temperature, precipitation and wind (Mahato 2014). Climate change has led to intense droughts, water scarcity, severe fires, rising sea levels, flooding, shrinking mountain glaciers, melting polar ice, loss of biodiversity, and natural hazards like landslides, floods, hurricanes, etc. (UN 2021/2022).

A greater concentration of human activities on a global scale has been responsible for significant climate changes, which have altered international atmospheric composition or environment over the past few decades (Parry, Canziani et al. 2007). For example, garbage

landfills emit a significant amount of methane. Likewise, deforestation and land degradation emit carbon dioxide; hence, industry, buildings, transport, energy, agriculture and land use pattern and burning fossil fuels like coal, oil and gas are some main greenhouse gas emitters (UN 2021/2022). In addition, the planet's warming over a long period is referred to as global warming (Loza 2019). Global warming is one of the key drivers of climate change. It is characterised by a significant rise in Earth's mean temperatures, which alters weather patterns and ecosystems and has a long-term influence on them (Malhi, Kaur et al. 2021). The greenhouse effect is a natural phenomenon that significantly impacts the world's climate (Mahato 2014). Furthermore, carbon dioxide and methane are examples of greenhouse gas emissions causing climate change (Sutherland Shire Environment Centre 2021).

It is becoming apparent that climate change, the result of global warming, is impacting the world (Mahato 2014). Furthermore, among all other sectors, agriculture is most vulnerable to climate change since environmental factors determine the nature and characteristics of crops and vegetation (Mahato 2014). The three main components of climate temperature, precipitation, and greenhouse gases significantly harm farming (Malhi, Kaur et al. 2021). Globally, agriculture productivity is determined primarily by climate, and climate change poses a worldwide challenge to ensuring food security (Mahato 2014, Malhi, Kaur et al. 2021). A rise in mean seasonal temperature can shorten the duration of most of the crops and therefore reduce their yield (Parry, Canziani et al. 2007). also, it will have a more immediate effect on crop yields in areas where temperatures are already near the physiological maximum. Climate change could impact agriculture in the long term in various ways, including crop quality and quantity in terms of crop productivity, soil fertility, plant physiology, growth rates, moisture availability, transpiration rates and photosynthesis, irrigation resources and so forth (Mahato 2014). The humid and warmer climate induces pest infestation and the origin of many unwanted plants (Malhi, Kaur et al. 2021). Moreover, despite the uncertainties of the future climatic condition and their potential consequences, some studies have presumed that climate change will diminish agricultural output in the coming years (Malhi, Kaur et al. 2021).

Adaptation to climate change includes adjusting to effects that mitigate damage or exploit favourable possibilities in human and natural change concerning current or anticipated climate change (Rojas 2019). Adaptation is an adjustment in a social, economic and ecological system in response to existing or anticipated climatic stimulus and their

repercussions or ramifications (Dixit 2011). Adapting to climate change entails taking precautions to ensure and prevent both the existing and anticipated future effects of climate change (European Commission 2021). Climate adaptation encompasses everything we do to adjust our lives in light of the current climate problem's magnitude and preparation for future disasters (Grist 2021). Its purpose is to make us less vulnerable to the adverse effects of climate change (like increased extreme weather events, rise in sea level, food insecurity, etc.) (NASA 2022). Even though climate change is a global issue, it also affects individuals locally, which is why municipalities and cities are at the forefront of coping with the consequences or adaptation (NASA 2022). Local communities and cities would have focused on tackling their climatic problems without a national or international policy guide (NASA 2022). They strive to reinforce flood defences, prepare for heat waves and rising temperatures, construct water-permeable pavements to manage floods and runoff efficiently, and improve water storage (NASA 2022). Governments are also improving on adaptation at different levels, according to the United Nations Intergovernmental Panel on Climate Change's 2014 report on Climate Change Impacts, Adaptation, and Vulnerability (page 8). Climate change is now being considered in many development initiatives, for example, how can we deal with the increasingly severe disasters we are witnessing, as well as the risks that come along, how to develop resilient crop varieties, how to conserve land and forests more effectively, how to safeguard energy and infrastructure, etc.

To mitigate climate change's detrimental effects on agricultural sustainability, a multitude of mitigation and adaptation measures and technologies have been established, for example, nutrient-smart practices (agricultural residue management, precise nutrient application), weather-smart activities (stress-tolerant varieties), water-smart practices (micro-irrigation, rainwater harvesting, crop diversification, direct-seeded rice, raised-bed planting,), carbon-smart activities (legumes, crop residue management, zero tillage, etc.) and knowledge-smart activities (Extensions of agricultural to boost capacity-building) (Malhi, Kaur et al. 2021). By lowering negative consequences, these strategies significantly attenuate the adverse effects of climate change on crops and increase their climate adaptability (Malhi, Kaur et al. 2021).

Through this case study, the researcher tried to determine how climate change affected people's livelihood in Mangalsen Municipality of Achham district, Nepal and how they have coped with it.

This study focused on livelihood adaptation and municipality actions in the context of livelihood and climate resilience in rural areas. For this purpose, this theoretical framework was characterised into individual household-level adaptation practices, community-level adaptation practices and landscape-level adaptation practices. This study was focused on Mangalsen Municipality, located at a 1362-meter altitude in Achham District (RAP3 2018). However, the secondary analysis will analyse the studies on these three levels to understand the practice gap.

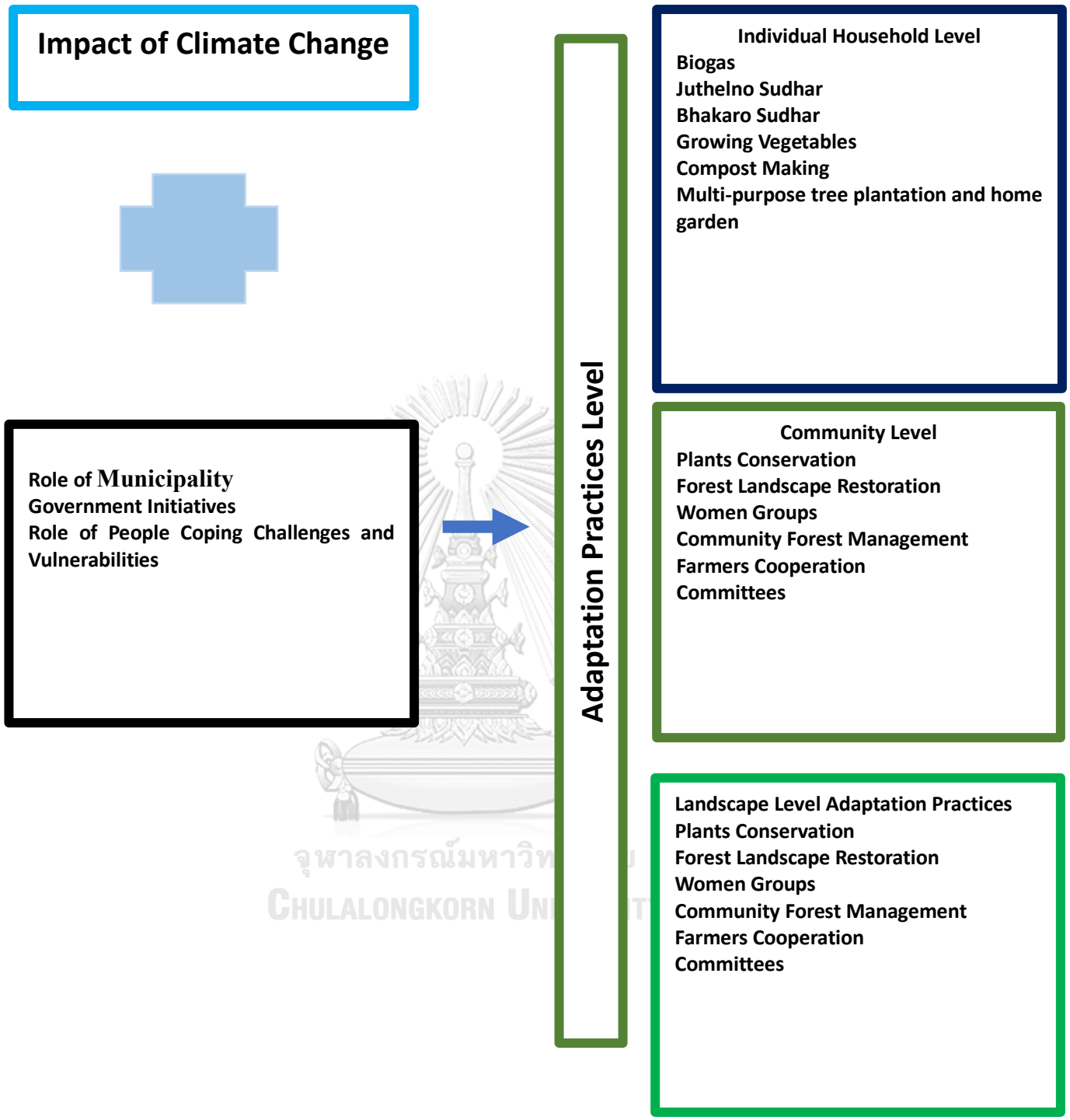


Figure 2 Theoretical Framework

Note:Juthelno Sudhar means utilization of water used for washing dishes, vegetables and clothes in agriculture land by making pathways. Bhakaro (big pot made from mud or bamboo) Sudhar (Improvement) means improving the muddy or bamboo pots for storing rice and grains.

CHAPTER 3

Methodology

The study was carried out within 14 different Mangalsen Municipality of Achham District wards in the Far-Western Development Region. The study has followed both quantitative and qualitative research approaches. Ethnographical approach and descriptive research were observed for the conduction of this research.

3.1 Methodological framework

The methodological framework comprised a mix of both qualitative and quantitative research. The qualitative analysis includes using the ethnographical approach with household surveys while confronting the interviewee in the field. Moreover, the quantitative method comprises statistical analysis of the data collected in the area. In addition, household data was accessed from ward offices inside the municipality.

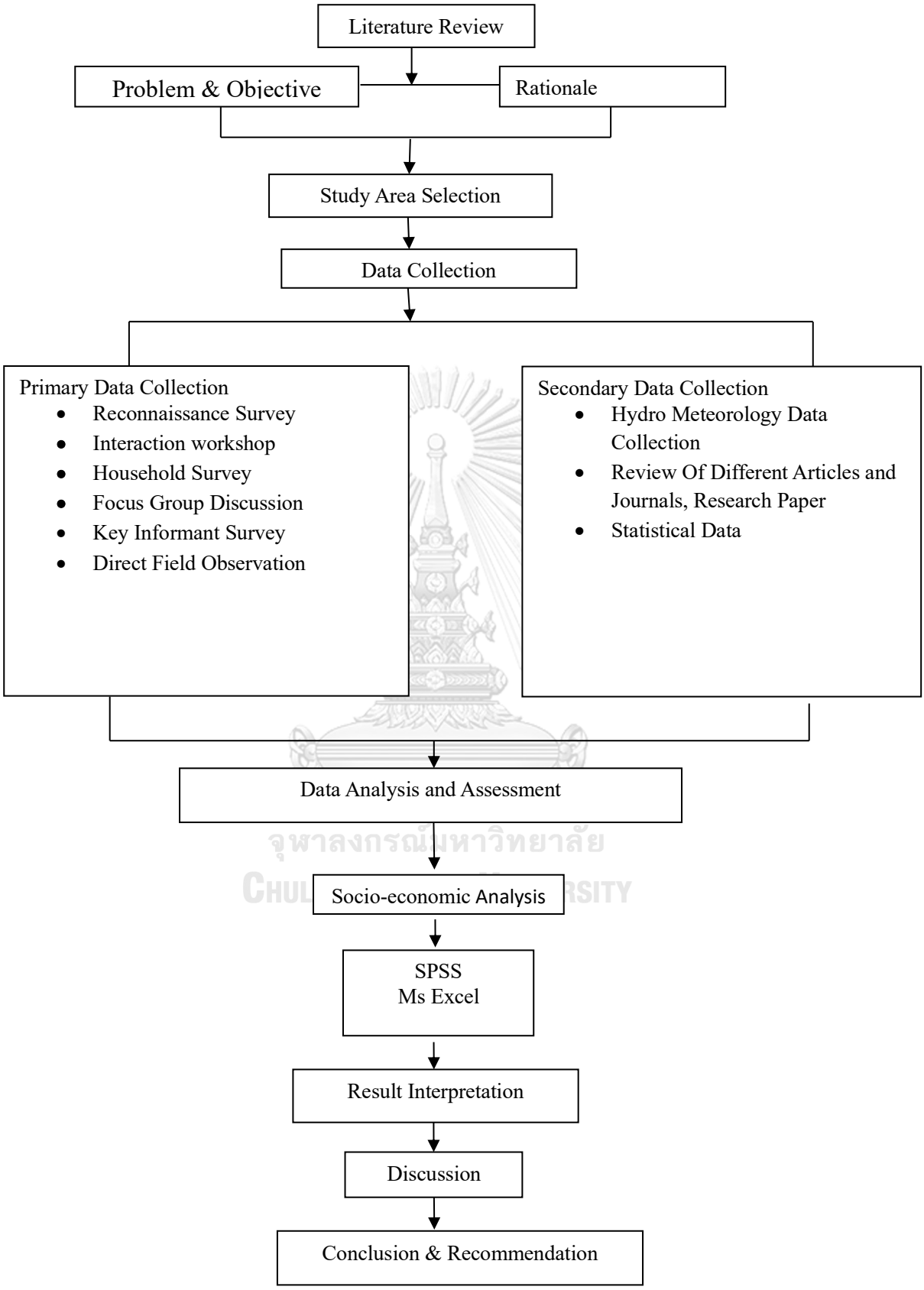


Figure 3 Methodological Framework

3.2 Study Area

This study was carried out in 14 different wards of Mangalsen Municipality of Achham District in the Seti zone of the Far-Western Development Region of Nepal as the representation of mid-hill and which is also the headquarter of this district (Joshi 2013). This district was selected for the research because it is ranked as highly vulnerable according to the overall vulnerability index (Action and Environment 2010), Climate change is an emerging issue in the study area, and an adaptation initiative has been implemented, including local adaptation plans for actions, exposure to different climatic hazards, variation in various aspects like altitude, socio-economic condition, etc., easy to conduct within the time frame and budget limitation.

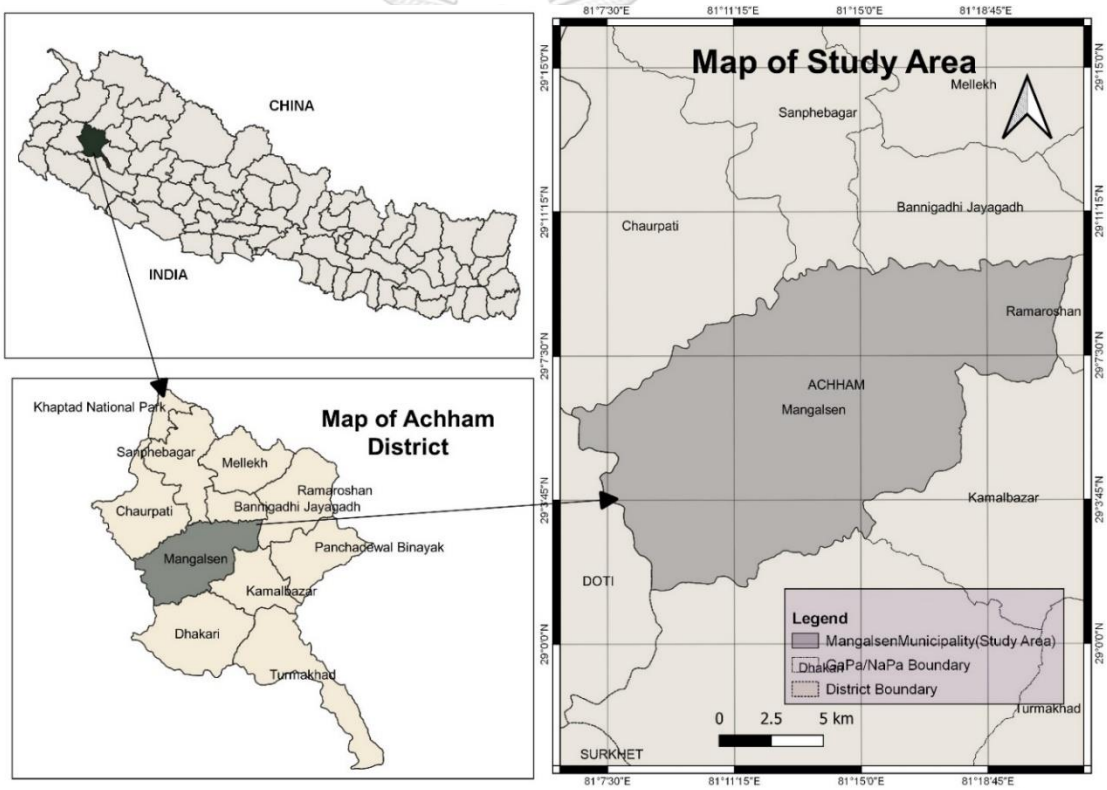


Figure 4 Map of the Accham District showing Mangalsen Municipality
Source:https://www.researchgate.net/figure/Map-of-Achham-district-showing-the-study-areas_fig3_341616639.
https://commons.wikimedia.org/wiki/File:Achham_District_in_Nepal_2015.svg

Dailekh and Kalikot border it in the east, Doti in the west, Bajura and Bajhang in the north and Surkhet and Dailekh in the south (RAP3 2018). The main climate-induced catastrophes like landslides, soil erosion, and drought are focused on in this research. Local inhabitants of this Municipality have observed temperature and severe seasonal and unseasonal

precipitation shifts, leading to climatic catastrophes and disease outbreaks (Malla 2008, Dhungana 2013). The study was carried out to document the extreme cases (in terms of frequency and severity) of climate change impacts and the local people's adaptation to them in the mid-hill region. According to the overall vulnerability index, this district is highly vulnerable (NAPA, MOE 2010).

The budiganga river and several other flash floods flowing through drains and gulley account for the majority of the landslide occurring in the area (ICEM 2013). Likewise, the roadside drains and minor landslides are cleaned regularly (ICEM 2013). Besides, the terrain and geomorphological make out characterize sandy soil with less water-holding capacity, thus triggering climatic catastrophe during wet weather (Mirzabaev, Wu et al. 2019). In Sudurpashchim province, Achham is a district in Nepal and one of the province's nine districts, and this district is ranked as highly vulnerable according to the overall vulnerability index (NAPA, MOE, 2010). The community has a territory of 1,692 square km with a population of 257,477, as reported in 2011(RAP3 2018, Achham Destination Guide 2021).

The altitude ranges from 540 m to 3820 m from the mean sea level (RAP3 2018). Due to variations in altitudes, Achham has four climatic types: Tropical, Subtropical, Temperate and Alpine, and its temperature range from 5 °C to 30 °C (RAP3 2018).The mean annual rainfall is 1794 ml (DADO Report, 2069). The primary source of employment and livelihood for most people, with 61 percent of the active population in this field, is subsistence agriculture or small-scale livestock (Hibbett 2018). Most families suffer a severe food scarcity for much of the year due to their poor agricultural output (Hibbett 2018, RAP3 2018).

3.3 Data collection methods

This study was explorative as well as descriptive types. Both primary and secondary data were collected using Rural Appraisal (RA) techniques.

3.3.1 Primary data collection

3.3.1.1 Reconnaissance Survey:

Before starting the survey, an informal initial field inspection was conducted on the first day of the research (November 25, 2021) to familiarize ourselves with the locale, including its

geographical condition and social organization.

3.3.1.2 Household Survey

A sampling of household survey

At first, before undertaking any other surveys, an interaction an informal workshop was held to define the concept and familiarize communities with climate change, natural calamities, their consequences, livelihood, and properties. The workshop recruited at least thirty participants (from the poor, middle, and upper classes), with an equal number of men and women from each grouping; three locations were chosen and conducted on different days (28-30 December 2021). Several videos and photos were displayed for better understanding.60% of locals were aware of the term climate change and its impacts, and those who weren't aware of it were still familiar with its consequences. Secondly, a structured questionnaire was developed and pre-tested for 5% of households (31 December 2021). Then questionnaires were modified (according to the situation's demand if needed) and finalized and asked face-to-face with the household owners.

Finally, a household survey was conducted with a total estimated household of 110 (due to time constrain and for fruitful data on that limited time) out of the entire 6,604 homes (KARKI 2019) in the study area. Therefore, a household survey was conducted in 14 wards and 9-11 houses in each ward. Purposive sampling was used for the study. The households where adaptation practices have been implemented in the vicinity were given priority. Poor people and farmers were focussed most. Besides, social inclusion was always considered across several socio-economic factors like literacy, possession of the property, gender, education, and access to local governance.

3.3.1.3 Focus Group Discussion

Group discussions were performed to consolidate the data acquired from the household interviews and other sources. Group discussions were conducted to consolidate the data obtained from the household interviews and other sources. Six focus groups were organized (one with mothers and the others with a mix of participants), with 10-15 people in each group for five days. Mainly local farmers were involved, and teachers, labours, job holders, and students were involved in the group discussions.

And learned about the previous and present experiences with climate change, its effects on

livelihoods, the adaption strategies used, and the long-term mitigation plan. Hence, this discussion offered details on attitudes that differed across social groups, the effects of climate hazards, adaption strategies, and local adaptation plans in the research area.

3.3.1.4 Key informant survey (KIS):

About 30 key informants from various industries were selected and approached for interviews. It was carried out for about six days. Local leaders (6 persons), teachers (3 persons), the chairperson of the CFUG and other members (8 persons), the heads of government agencies like the DFO (1 person), DADO (2 persons), and FECOFUN (3 persons) as well as NGOs, and INGOs (7 persons) were consulted for checklist-assisted interviews to gather information concerning climate variability, climate change, impacts, and adaption measures. It is found that critical informants observed changes in the volume and duration of rain and experienced some climatic variations (winter getting warmer, short winter and longer summer days, and temperature rise). And the scenarios of recent and historical climatic experiences, vulnerabilities, and tremors brought about by changes were found.

3.3.1.5 Direct Field Observation

At last, to double-check the information (such as the adaption technique) acquired from the survey, a transect walk survey (filed visit) for observation and evaluation was undertaken with the participation of the local key person. It was conducted on the last three days (28-30 January 2022) of research after completing all survey and workshop programs. The answers obtained from the locals regarding the adaptation measure were found to be true.

3.3.2 Collection of secondary data

Secondary data was obtained from published or unpublished documents, journals, articles, websites, thesis, maps, user committees' records from NTNC, buffer zone office and other organizations, etc. For this, libraries of relevant institutions and organizations were visited.

3.3.3 Data Analysis

Table 2 Data Analysis

Primary data for	Data collection	Data analysis
Status of climate change and adaptation practices and obstacles to adaptation to climate change.	Household surveys, Key informant surveys, Focus group discussions, Close-ended questions, open-ended questions and Semi-structured questionnaires	Quantitative data was analyzed using SPSS (version -15) MS EXCEL, whereas Qualitative data were represented with descriptive terms.

All quantitative data were analysed using the statistical software SPSS (Statistical Package for Social Science) version 15.0. Each questionnaire was assigned an identifying number before being entered into Microsoft Office Excel. Every question and the responses were coded. These codes were saved in the same file's next sheet (MS Excel). After completing the data entry into the “Excel sheet”, the data was imported into SPSS. Before analysing anomalies, typing errors and missing information were corrected by comparing the original data sheet (protocol) with the frequency output table of SPSS. Data were analysed using descriptive statistics (mean, standard deviation, percentage, frequency and range). Results are presented in bar diagrams, frequency tables and pie charts.

CHAPTER 4

Result and Discussion

4.1 Socio-economic characteristics of the respondent

Age, sex, education, occupation, and general well-being are socioeconomic characteristics of the individuals, which also help to understand the outlook of the study region. The expected results examined data about general understanding and impact on livelihood. Analyses of the demographic characteristics are shown in the table below.

Table 3: Socio-economic characteristics

S. N	Variable		Percent (%)
1	Sex	Male	36
		Female	64
2	Well-being	Rich	12
		Medium	54
		Poor	34
3	Education	Literate	51
		Illiterate	49
4	Food sufficiency	Up to 3 months	25
		Up to 6 months	50
		Up to 9 months	20
		Up to 12 months and more	5

4.1.2 Gender of the respondents

The total sampled household was 110. Of the sampled households, 64% were female, while the remaining 36% were male. The household heads who would be interviewed for the survey were meant to be adults and elderly. However, gender has little to no bearing on adaptation

4.1.3 Age-categorization

The study placed a greater emphasis on experienced and mature participants for questionnaire surveys (household and focus group discussion) as they could better discriminate between climate change and simple inter-annual variance of weather situations. Hence,32 % of the respondents were young (20 to 40 years), 55% medium aged (41 to 60) and the remaining 13% elderly aged (61 to 90). As mentioned by Mugi-Ngenga 2016, the level of adaptation is significantly influenced by the age of the household head, with older people having more experience and being able to apply a variety of adaptation tactics to address changes affecting farming activities. However, a negative correlation between age and range of adaptability was discovered, indicating that younger people are more willing to take the risk of implementing new technologies and want to try new techniques to

improve crops.

4.1.4 Education Status

Out of the sampled households, about 51 % were literate, and 49 % were illiterate. The respondents who completed their school (School leaving Certificate; SLC) were considered literate, and below class 10 were considered illiterate. And it was found that the respondents' education levels affected their overall perceptions of climate change.

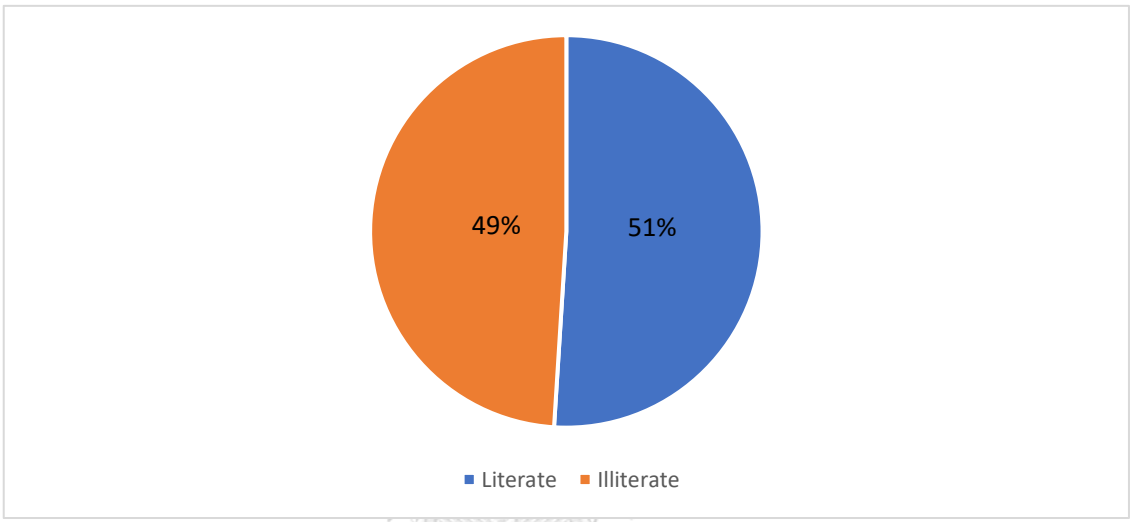


Figure 5 Education Status

4.1.5 Well-being ranking

From the discussions with the farmers, elderly people of the village women groups and VDC officials, three different wealth categories of farmers were determined. 54% of the respondents were assessed to be average, while 34% were found to be poor. 12 % of households were found to be rich.

The well-being ranking was estimated by the availability of the land they hold (7-10 ropani land rich, 4-7 ropani medium, less than 4 ropani poor or no land), type of house they owned (concrete house, Khar (grass) terrace house, wooden house, etc.), type of job (agriculture, labour, office, etc.) they held, amount of salary they receive and comparing it with the number of family members they have and minimum need of money to meet their monthly needs, and type and number of cattle they have (cow, buffalo, goat). Mostly oxen were found in everyone's house as it is used in the field ploughing, and the one who held only one cattle was found to have cow or buffalo.

(Note: 1 ropani= 5476 square feet= 0.125acre)

4.1.6 Occupation of the respondents

Agriculture is the main occupation of Accham district, where from the total sampled household, 59 % of the people were found to be engaged in agricultural activities. Even those who claimed not to be farmers were occasionally involved in small-scale farming activities. Besides agriculture, some people were also engaged in other occupations like business, public service, labour and foreign country. Integrated farming dominates the livelihood in this region, as it does in the rest of Nepal. Livestock is both a source of manure and a mode of transportation. Rearing of livestock and crop production is very strongly inter-linked.

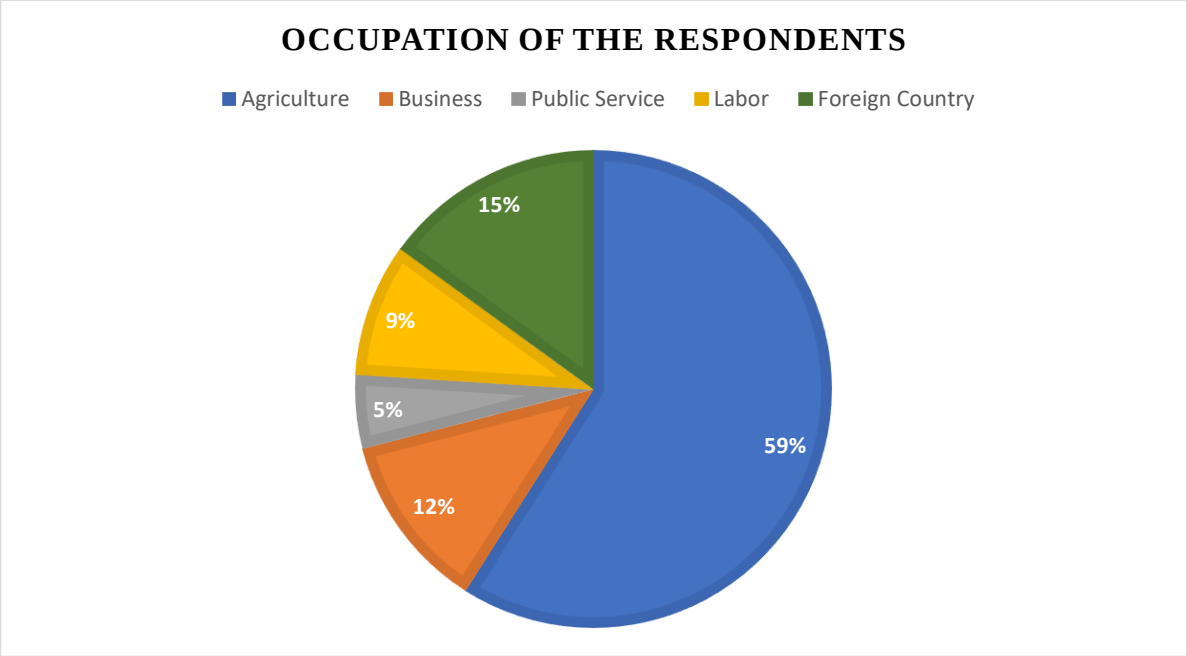


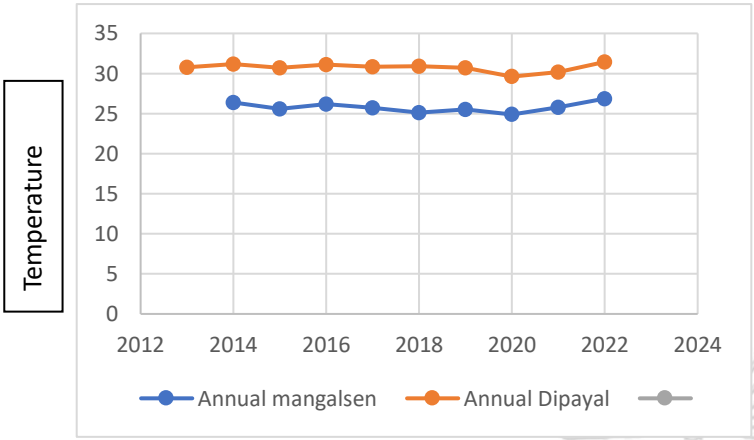
Figure 6 Occupation of the respondents

4.1.7 Food Security

According to the household survey, 25% and 50%of the respondents had food sufficiency for only three months, and up to six months, respectively, which means the food produced from their farm is enough for up to three months and six months. Likewise, 20% of households had food sufficiency for nine months. However, 5% had food sufficiency for 12 months.

4.2Climatic parameter analysis

4.2.1 Temperature



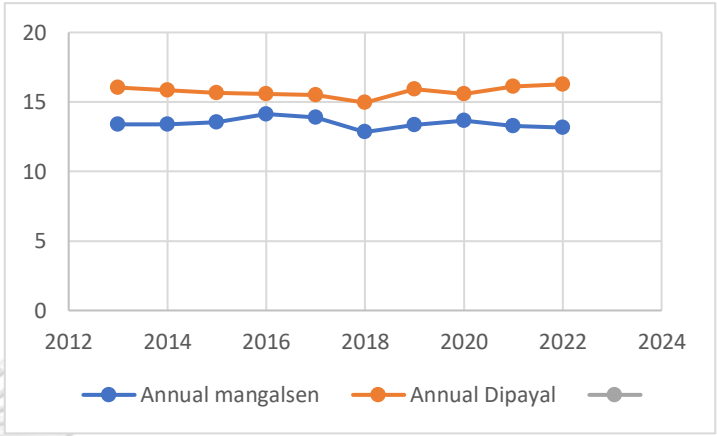


Figure 7 Maximum air temperature **Figure 8 Minimum air temperature**

Source: Figures 7 and 8 Department of hydrology and meteorology

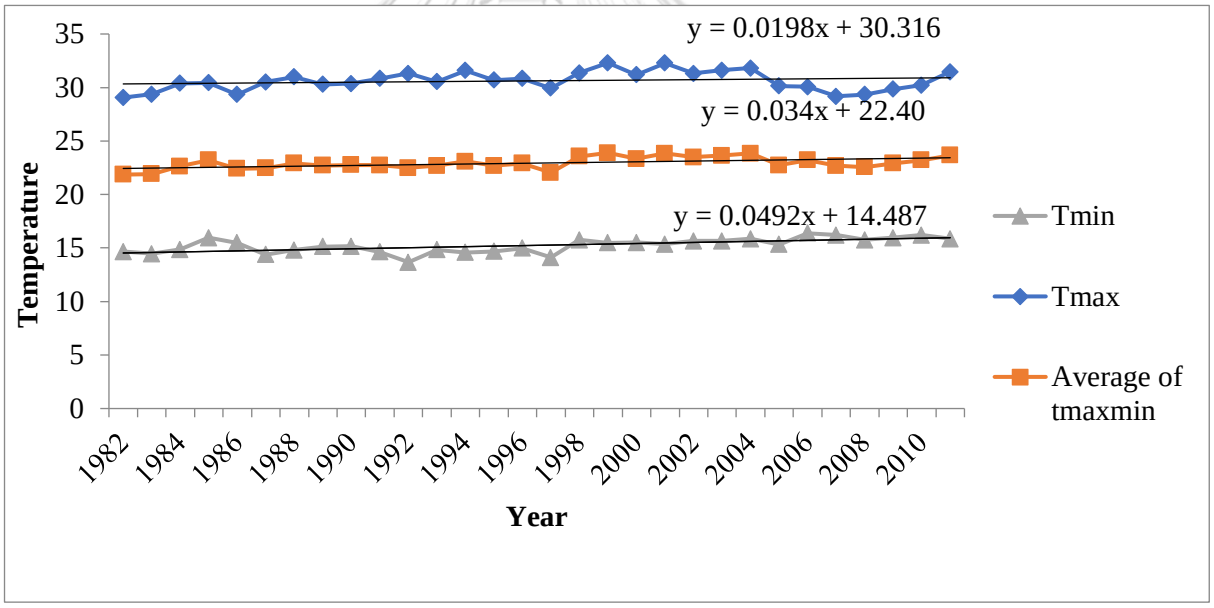


Figure 9 Temperature of Dipayal

Source: Figure 9 (Dhungana 2013)

The figures above present the 40 years of data on the average maximum and minimum temperature of Dipayal and Mangalsen Municipality. Dipayal was presented to compare the obtained data/results of temperature. This study revealed that the maximum and minimum temperature trends varied throughout four decades. The maximum and minimum temperatures had substantially increased by 0.019^0 C and 0.049^0 C, respectively, until 2010,

and the temperature had risen by 0.034^0 C on average. We can observe a significant rise in the minimum and maximum average temperature from 2010 to 2022 (Figures 3, 4 and 5). 96% of respondents(household survey and focus group discussion) stated that the temperature has risen from the past to the present, and data from the meteorological department confirmed this pattern. As a result, these facts were intimately related to people's statements. Also, people in the study area have reported that the duration of summer days is getting longer, and summers are becoming hotter while winters are getting shorter and also warmer. A similar result was obtained from the study conducted in the Mustang district, which indicated (The Marpha Agricultural Research Station's weather data)an upward trend in Mustang District's temperature from 2007 to 2010 (Koirala and Shrestha 2017).

Additionally, researchers discovered that people were experiencing a decrease in the number of cold days and an increase in the number of hot days and warmer days. Another study from Khudi and Gharedhunga (Lamjung district) also represents similar results researcher mentioned that the maximum annual, minimum, and average temperatures had risen significantly from 1987 to 2015 by 0.056°C, 0.01°C and 0.03°C (meteorological data), accordingly (Dhungana, Silwal et al. 2020). Additionally; he said that the pre-monsoon season had a high-temperature trend and the winter season had a low one. This suggests that summer is lengthening and becoming hotter. And the locals have reported a similar statement that winter temperatures were increasing steadily and that winter length was getting shorter. Also, the country's altitude explicitly determines how rapidly the temperature rises (Piya, Maharjan et al. 2019). While Terai experiences an annual temperature increase of $0.01\ ^0$ C, mountains and hills experience a rise of $0.05\ ^0$ C (Piya, Maharjan et al. 2019).

Some other studies have also revealed similar data. The average annual mean temperature of mid-hills rose at a pace of 0.07°C per year (Acharya, Tiwari et al. 2015). In addition, the average yearly maximum temperature climbed by 0.04 degrees Celsius between 1978 and 2015, and the annual average lowest temperature rose by 0.01 degrees Celsius (Piya, Maharjan et al. 2019). Similarly, the Department of Hydrology and Meteorology revealed in 2017 that between 1971 and 2014, the yearly average maximum and lowest temperature increased by 0.056 degrees Celsius and 0.002 degrees Celsius, respectively.

4.2.2 Rainfall

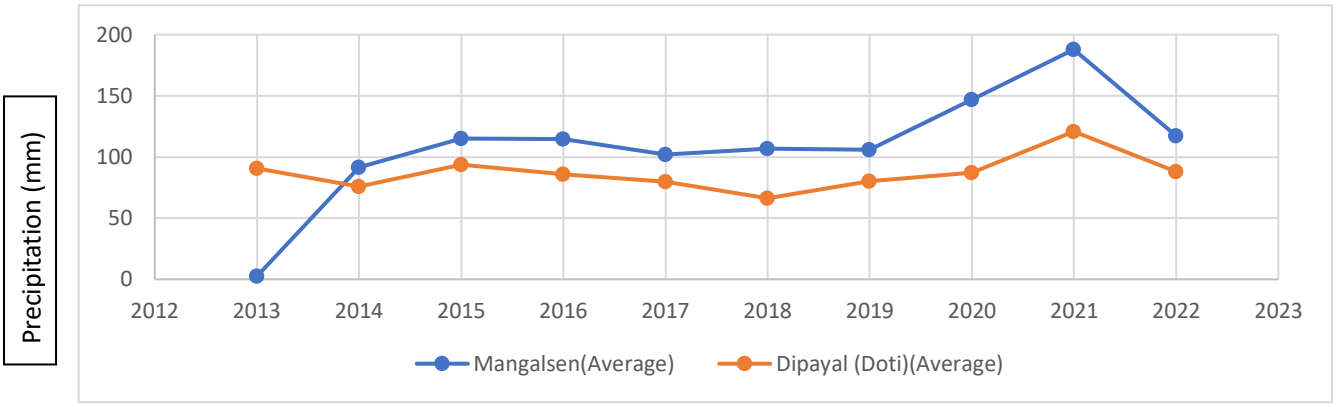


Figure 10 Precipitation of Mangalsen and Dipayal
Source: Department of Hydrology and Meteorology

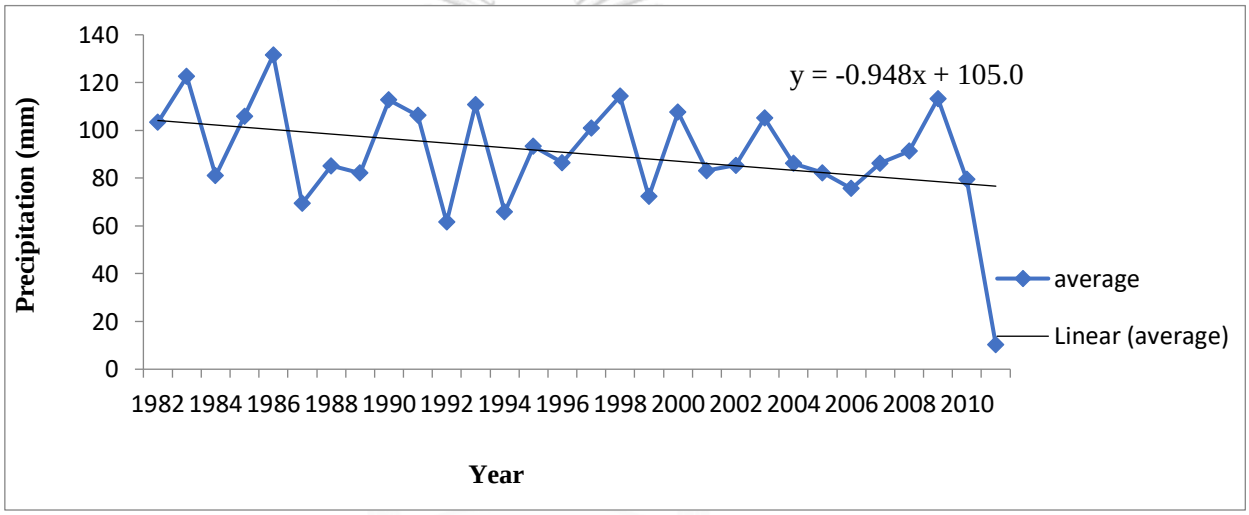


Figure 11 Precipitation of Mangalsen
Source: (Dhungana 2013)

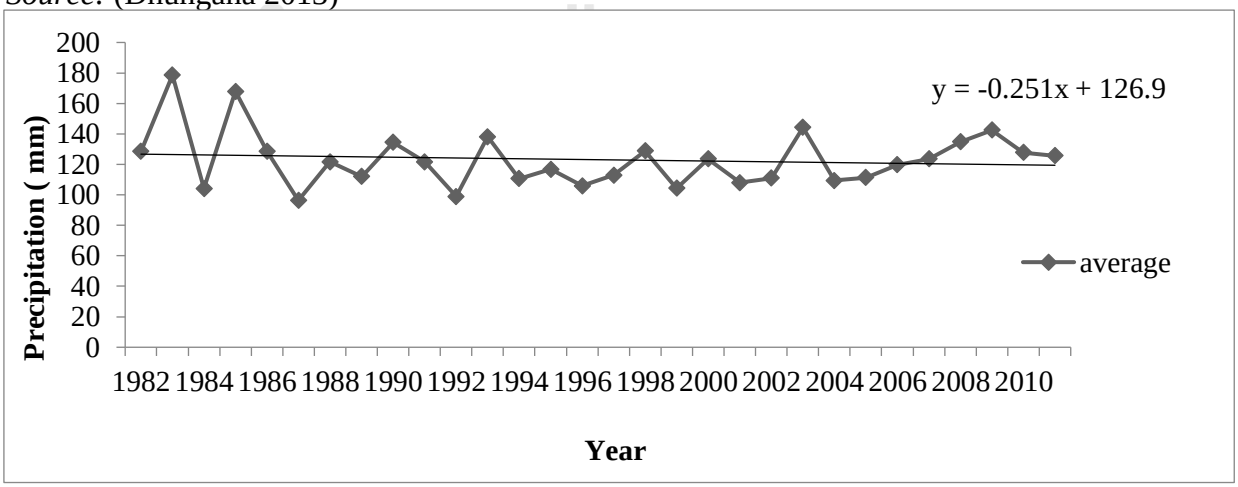


Figure 12 Precipitation of Dipayal

Source: (Dhungana 2013)

Dipayal was presented to compare the obtained data/results of rainfall. The figures above represent the average annual precipitation of two different municipalities, Mangalsen and Dipayal, from 1982 -2022. Graphs represent that the average yearly monsoon rainfall varied in quantity, intensity, and pattern. While talking about the Mangalsen respondents (household survey and focus group discussion), they stated that they had encountered an erratic and unpredictable pattern of rainfall, which is consistent with the meteorological data. Additionally, most of them (85%) mentioned a drop in rainfall patterns, as seen in the graphs if we compare Figures 10 and 11. Despite this, rainfall has reduced in general with some fluctuation. According to Dhungana (2013), Mangalsen's annual rainfall was declining at a rate of 0.251 mm and Dipayal at a rate of 0.948 mm until 2010.

Similar findings from earlier research were the average annual rainfall in the mid-hills was decreasing at a rate of 18.02 mm per year (Acharya, Tiwari et al. 2015). In the Himalayan area of Nepal, temperatures are rising, and rainfall is declining simultaneously (Dhungana, Silwal et al. 2020). Additionally, Khadka & Pathak (2016) found that temperatures are climbing and rainfall is trending downward(Khadka and Pathak 2016). Farmers' experiences and meteorological data showed that the average yearly temperature is rising and that precipitation is getting more erratic, resulting in an adverse effect on the capacity of mountain regions (Adhikari, Prasai et al. 2021).

According to the Department of Hydrology and Meteorology 2017 and Luni 2019, the amount of precipitation varies significantly from region to region and from one year to the next at a rate of 4.78mm, and the yearly precipitation is dropping per year. However, mean annual rainfall is decreasing in all seasons, with the monsoon experiencing the most significant declines (Piya, Maharjan et al. 2019). The researcher mentioned that the drop in precipitation has happened in all three ecological regions. Still, it has been most pronounced in the hills, followed by the mountains and the Terai. The proportion of monsoon rain in yearly precipitation has been rising over time at a rate of 0.03% annually, and this is highest in the mountains where it may also contribute to other natural disasters such as flash floods, landslides, Glacial Lake Outburst floods, etc. (Piya, Maharjan et al. 2019).

4.3. Local perception of climate change

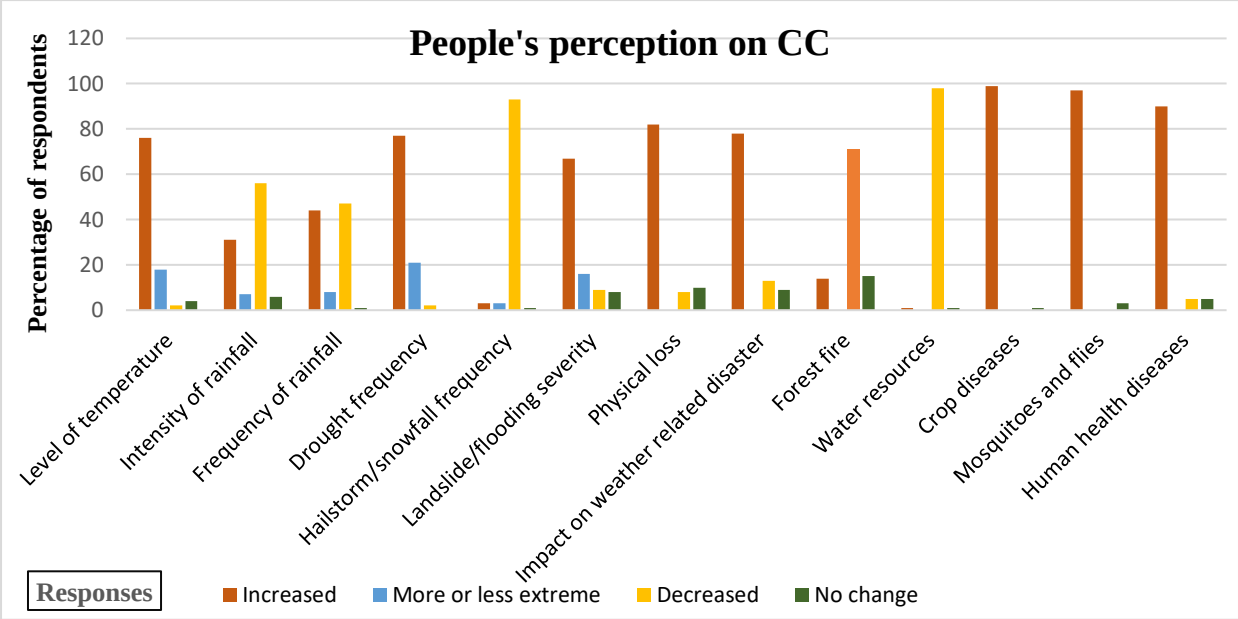


Figure 13 Perception of climate change parameters by the household survey

According to household surveys and focus groups, discussion farmers of Accham district have reported that the region's weather has been very erratic and unpredictable, and the country's weather was proven inconsistent (Malla 2008). The past study mentioned that the typical Jestha and Ashar rains in mid-July had been moved to August/ September in the Kathmandu district (Malla 2008). Figure 11 shows the perception of climate change parameters stated by farmers from 14 wards of *the* Accham district. The parameters were mainly categorized into three major areas, i.e. climate conditions, ecosystem function and biological function. These main areas were further divided into various responses, which were also considered an indicator of climate change. Based on these responses, local perceptions about climate change were studied.

In the household survey, almost all the respondents (97%) answered that they had observed some changes in the local weather. Most of the respondents agreed with the responses like increase in temperature, decrease in snowfall, decrease in the intensity of rainfall, unpredictable frequency of rain, hailstorm or snowfall. In the survey,78% of people reported that the temperature had been increased.

58% reported rainfall intensity has decreased, whereas 79% mentioned that the frequency has increased and that they have noticed a noticeable shift in rainfall patterns. About 80% noted that drought frequency has increased, and 98% mentioned that water availability

(water resources) has decreased and drought conditions have worsened as water sources are drying. Another study from the Himalayan region also indicated the same results. And the paper also mentioned that water resources are drying (Dhungana, Silwal et al. 2020). Locals of the Himalayan region have listed the drought and temperature rise as the first and second indicators, with forest fires coming in third as indicators of climate change, and research has also highlighted the drying of water resources due to climate change (Dhungana, Silwal et al. 2018, Dhungana, Silwal et al. 2020).

Likewise,95% of respondents reported that the frequency of hailstorms and snowfall has decreased. As a result, people near and around the study area did not witness snowfall for more than ten years until 2013. Similar results were also reported by Tiwari *et al.* (2010), which identified that snowfall in the mountain region of Nepal had been gradually decreasing during winter months. Similarly, Macchi (2010) also reported the same result for the hilly region of western Nepal and north-western India, where snowfall is reduced.

Furthermore, not only in production but farmers have also reported the impact of climate change on the physical properties of the soil and water, which is true (Daba, Bazi et al. 2018). Additionally, changes in precipitation and average temperatures will impact soil organic matter, including soil stability and water-holding capacity (Daba, Bazi et al. 2018). Such changes in the soil property mainly include a decrease in soil moisture and nutrition and a reduction in the number of biotas in the water resources. Such changes lead to the degradation of grass land and low grass productivity, which also impacts livestock rearing. Therefore, regeneration measures such as limiting open grazing, enforcing tight norms and regulations, social fencing, and community planting of fast-growing species were carried out. Moreover, the lack of snowfall is directly related to crop production; a decrease in the snowfall means less availability of moisture for winter crops and a reduction in the soil moisture as snow eventually percolates into the ground, enhancing the moisture content of the soil. Hence, the productivity of the winter crop is directly proportional to the amount of snow that falls.

The intensity, growth, and dispersion of pests and diseases are affected by climate change characteristics, including rising temperatures and CO2 (Malla 2008). Respondents have reported many climate change-induced impacts that directly or indirectly affect agriculture and productivity. 99% of respondents noted a rise in invasive species and crop diseases and decreased productivity of local variety and crop failure. The decreasing productivity of the

local type was mentioned as unusual weather patterns, mainly the incidence of drought or continuous rainfall. It is said that such an incidence of unique weather patterns ultimately results in crop failure. More than 90% of the respondents mentioned that they had observed some incidences like the earlier onset of summer, late onset of monsoon, more disasters, early flowering, early crop maturity, change in crop cycles, new weeds, and species shift in the last few decades. Similar results were observed in a hilly area in terai, too, due to climate change hazards (Regmi 2007) reported that early monsoons caused a rain shortfall in eastern terai in 2005–2006, and agricultural production nationwide decreased by 12.5%. Likewise, due to a dearth of rain, over 10% of agricultural land was left barren, while the terai experienced significant rainfall and flooding, which lowered productivity by 30% for the year. A similar result was observed in one of the studies from Ethiopia. Due to flooding and excessive rain, the nation loses over 1.5 billion tons of fertile soil annually. If this soil hadn't been lost, the country's food production might have improved by 1.5 million tons (Tamene 2008).

Around 65% indicated that landslides flood has increased; therefore, approximately 81% said that the rate of physical loss has increased. And 70% reported an increase in a forest fires. And according to 99%, 98% and 95%of respondents, crop diseases, the number of mosquitoes and flies, and diseases in humans have proliferated, respectively.

4.4 Impact of Climate Change

4.4.1 Impact of Climate change on Agriculture

Data for the impact of climate change on agriculture was mainly collected by household surveys and focus group discussions from 14 wards of the Accham district. Farmers were the primary focus of the study, and they noticed changes in their local weather patterns. The farmer's observations and data from the meteorological stations were closely agreed upon. The respondents mainly describe the changes like early flowering, crop maturity and change in crop cycle affected the various forms of crop infestation, thereby reducing the quality and quantity of crop yield and describe that as the impact of climate change. Similar results were observed in Kumaltar that climate change had caused physiological growth stages such as flower bud initiation, fruiting, flowering, and physiological maturity to shorten (Malla 2008). Tropical fruits (banana, mango, papaya, etc.) have been cultivated in the middle hills, and off-season flowering has been seen in higher altitudes like apple, peach and pear fields

(Malla 2008).

The production of sweet oranges has changed, according to farmers from 11 wards. Sweet oranges, which once thrived at elevations of 1200–1300 meters, now only provide withered fruits. Conversely, at high altitudes, they began to develop more effectively. Furthermore, mango tree and fruit production increased, whereas citrus fruit production decreased, and fruits were frequently shrivelled, dry, and of lower quality than in previous years.

Farmers relate the yield of traditional crops to unusual weather conditions (such as *Vigna umbellate* (Siltung), *Macrotyloma uniflorum* (Gahat), *Lens culinaris* (Musuro), and *Glycine max* (Seto Bhatta) and reported decrease in their production. They also reported that this crop used to yield in tones (*Muri)* but is now limited to kilograms (*Pathi)*. However, one study found that at higher CO2 conditions compared to field conditions, tomato productivity increased by 279 percent and the number of fruits by 205 percent in the mid-hill (Malla 2008). They also noted that due to the unpredictable weather pattern, the increased frequency of extreme events such as extended dry periods, unpredictable rainfall/ hailstorm, flood and landslides incidence of crop failure had been raised. Due to these reasons, farmers have experienced the origination and development of invasive weeds, an overall rise in pests with drought periods and damage in the farmland by flood and landslides. More than 85% of the respondents have reported the introduction of invasive weeds in the recent period, and they considered that a result of increased temperature. The respondent noted changes, including rice root damage from beetles, crop damage from green caterpillars, and damage to cauliflower and potato crops from red ants during dry circumstances. Crop diseases that lower productivity have become more common.

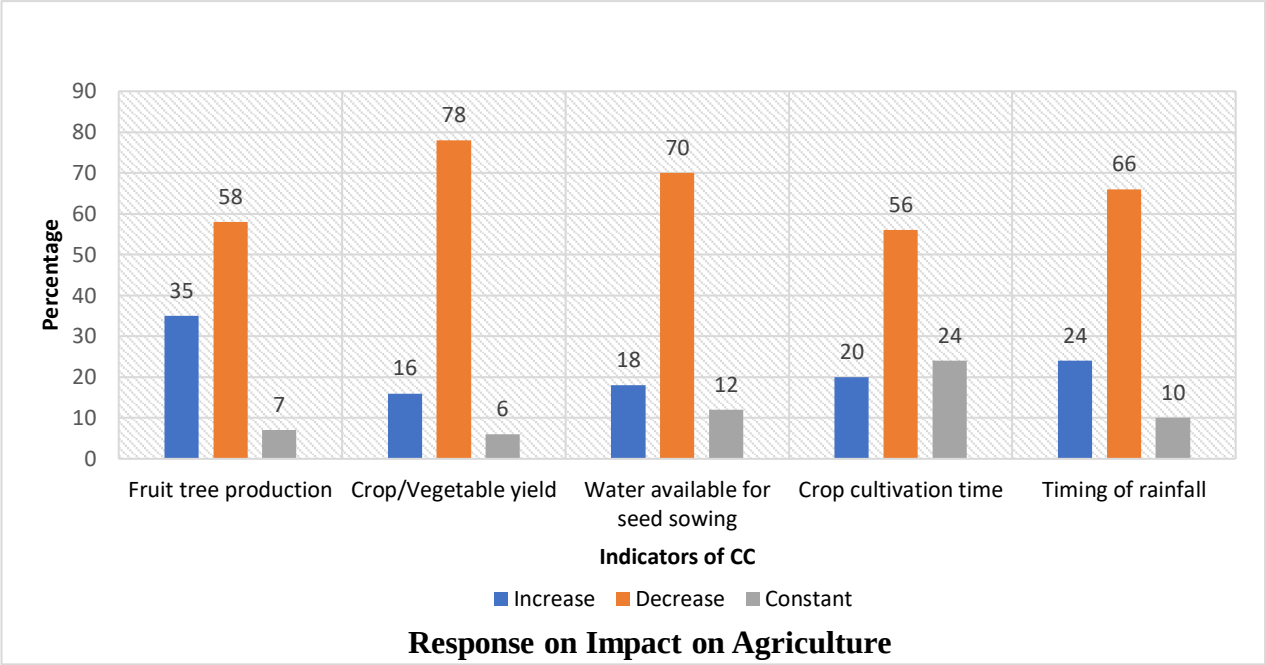


Figure 14 Response on Impact on Agriculture

Global, regional, and local food stability and quality are expected to be impacted by climate change (Brown, Antle et al. 2015), And similar results were obtained from the study area. About 58% noticed a decrease in fruit production, 78% noticed decreased crop or vegetable production yield, 70% noticed a reduction in water availability for agricultural activities, 56% noticed a change in the crop cultivation timing, and 66% reported a decrease in the timing of rainfall. This one is comparable to the Jumla study, which found that the most dangerous risks were unpredictable rainfall trends and drought, significantly impacting rain-fed agricultural techniques and leading to a significant decline in agricultural output (Gupta 2012). Due to declining productivity, agriculture is one of the primary sectors susceptible to climate change (FAO 2018).

Additionally, these findings show that in the case of Nepal's agriculture, the effects of climate on agricultural productivity vary among crop types, growing seasons and altitudes (Poudel and Kotani, 2012).

4.4.2 Impact of Climate Change on Livestock

Agriculture not only includes plants and their products; it also includes livestock. Livestock includes poultry, cattle, buffaloes, sheep, goats and pigs, and dairy products. During household surveys and focus group discussions, farmers have reported that the prevalence of animal diseases has increased in recent decades. 92% of respondents believed cattle

rearing had dropped and become problematic. 55% also mentioned a new type of disease in cattle, such as increasing livestock temperature, animal infertility, skin diseases, etc. Some assumed it could be due to the changing weather, quantity and quality of forage crops, favouring the environment for pest and livestock diseases and ending to death. Villagers have reported that these new livestock diseases result from increasing temperatures that were not observed in the past. The respondents from Mustang district also claimed that the reason behind the increase in cattle diseases might be due to growing competition between humans and livestock for food, a decrease in the supply of fodder and grass, lack of use of veterinary services and veterinarians, overgrazing of native pastures, ignorance of pasture development and use, poor quality of grass, a decline in agricultural productivity, growth of livestock parasites and vector-borne diseases, etc. (Koirala and Shrestha 2017). Locals from Mangalsen mentioned that all these impacts adversely affect animal productivity, including meat and milk, its population, etc. A 2°C rise in temperature would result in lower-quality milk and meat, less-capable fowl eggs, and a higher risk of cattle disease, making vector-borne diseases more likely to occur in society (Malla 2008, Nejash and Kula 2016). Hence, livestock and other living things suffer from illnesses and other effects due to the rapid rise in CO2 (Malla 2008).

The study from the Mustang district also showed that more than 50% of the respondents reported an increase in diseases in livestock and one of which was skin disease (Koirala and Shrestha 2017). And 15% reported a decrease in animal products (meat, milk, offspring, etc.) and were not physically fit like during their parent's time (50 years ago), 13% didn't observe any change, while 7% observed decreased in animal diseases. And the rest 10% hesitate to share the reason behind it.

The loss of numerous livestock species due to unusual climate changes and variability, including increasing temperatures, unpredictable monsoons, precipitation, and inconsistent rainfall, negatively impacts marginalised individuals' livelihood and food security (Koirala and Bhandari 2019). However, livestock disease can be controlled by the taking appropriate caring and feeding of livestock by individuals; utilizing and expanding the veterinary services; proper management and dumping of cattle waste, favouring appropriate temperature as far as possible, by raising awareness among people (Koirala and Shrestha 2017). But all these depend on the socio-economic condition of the people.

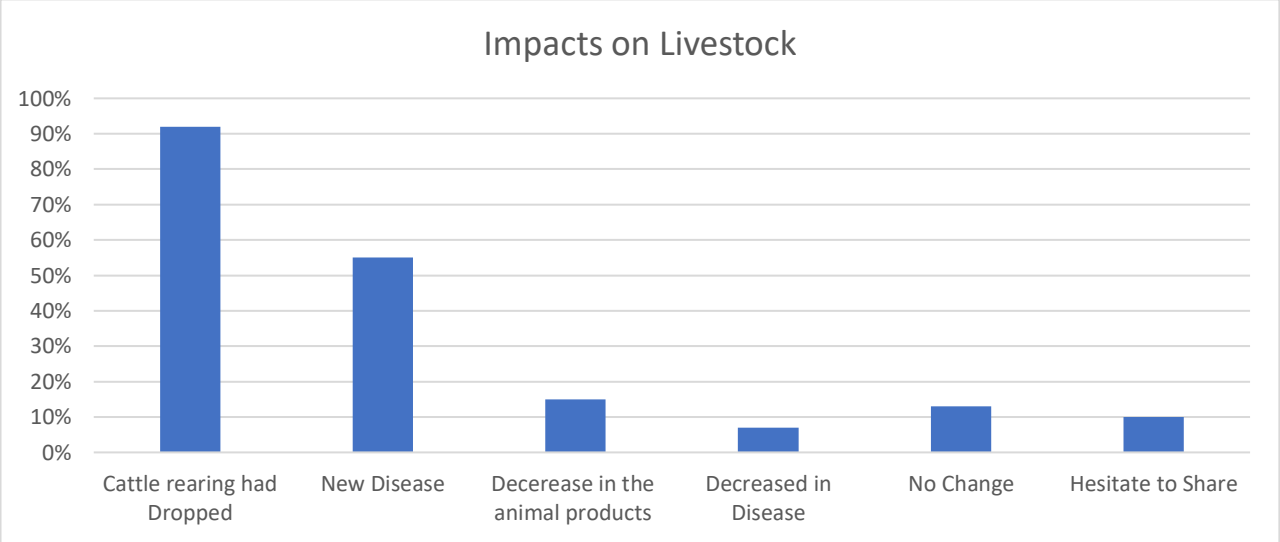


Figure 15 Impacts on Livestock

4.5 Climate risk and hazard

From the reporters (household survey and focus group discussion), it is said that the climate-induced disasters mainly reported are landslides, debris flow damage to farmland, flood, drought in the dry season, decreased productivity in agricultural products and animal products and an increased in livestock diseases. The forest is a significant water supply for people and cattle in the research region. People and livestock suffer more throughout the summer because of the severe drought. According to one of the assessments, the middle Marshyangdi hydro project is now only producing about 50 megawatts of energy, down from its initial output of about 70 megawatts, due to a reduced flow and diminished water level, particularly in the winter and summer (Acharya and Bhatta 2013). The respondents claim they now need to spend between two to eight hours (in various wards) to get a certain

amount of drinking water as they had 10 to 15 years ago.

The respondents (78%) in the upper area mainly reported landslides, erosion and flooding as the significant disasters, while respondents in the lower region (93%) reported flooding as the major disaster. During the study period, almost all, i.e., 96% of respondents, reported that the frequency and magnitude of climate-induced risks and hazards are increasing, becoming more common and more severe; they also reported that the severity of such hazard's impact has increased in recent decades. Locals claimed that the tendency toward prolonged droughts had increased the likelihood of fires, adversely impacting people, the forest, and water sources. Floods, landslides, and debris flows have caused significant damage to agriculture, crops, infrastructure, roads, water supply systems, and buildings in the study region.

Locals stated that in the last 30 years, the frequency of climate disasters such as extended droughts, floods, landslides, thunderstorms, and forest fires has increased. About 93 percent of those surveyed considered that for 30 years ago, the severity of the prolonged drought had risen, followed by physical assault, forest fires, and thunderstorms.

The perception of respondents on increased risks and hazards is explained in figure 13.

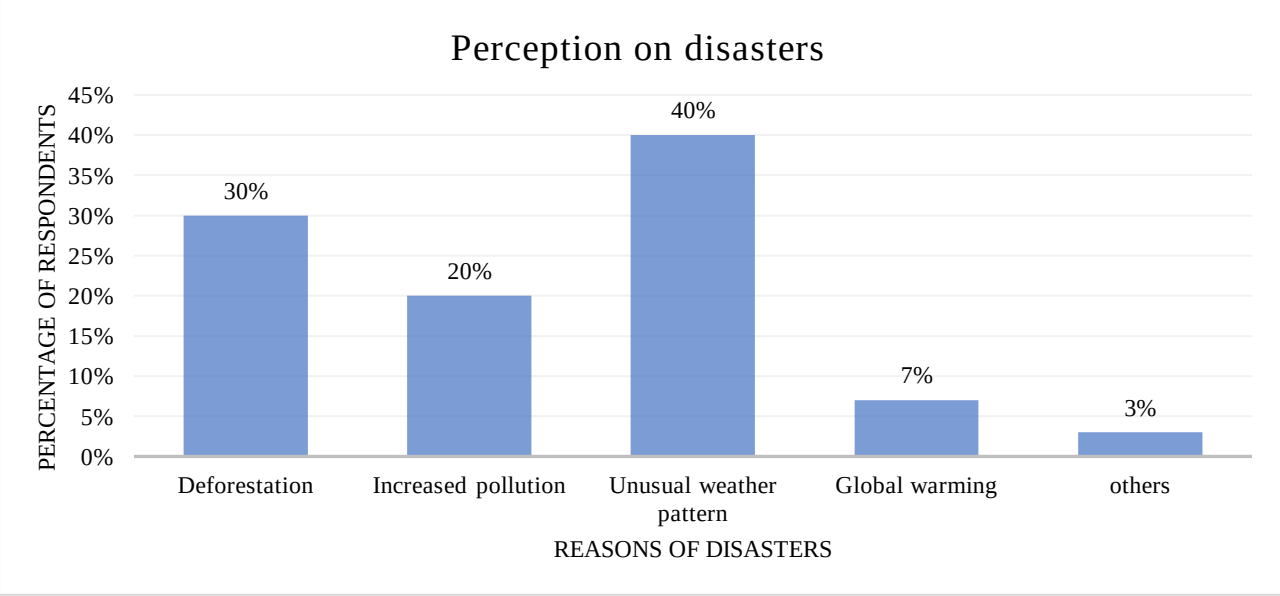


Figure 16 Perception of respondents on reasons for disasters

In the survey, 40% of the respondents from the household survey reported that the reason behind the increasing number of disasters is the unusual weather pattern followed by deforestation, increased pollution, global warming and other reasons.

4.6 Adaptation measures to cope with climate change

Data were collected from the household survey and reconfirmed in focus group discussions and field visits.

Consequences of climate change are being experienced in all parts of the country. Thus, their livelihood must learn how to adjust to these effects. Adaptation is a determined change process in response to stress and external stimuli, either in advance or afterwards (Nelson, Adger et al. 2007). Adaptation implies planned and organized actions either anticipating a hazard or avoiding its effects, inferring some level of positive achievement, success or consistency of response. In recent years, adaptation has gained significant attention from the scientific and policymaking sectors and has become a major topic in the multilateral climate change debate (MOE 2010). In Nepal, the importance of local technologies in adaptation has been studied. Some studies mentioned that those novel technologies, which some farmers in the hills utilise, have built and strengthened community resilience (Regmi, Paudyal et al. 2009). In Nepal, farmers and their assisting organizations are developing and co-devising climate-sensitive innovations (Chhetri, Chaudhary et al. 2012). However, a comprehensive strategy must educate people about climate change's reasons, effects, and solutions. Adaptation takes more than one intervention to complete. Instead, it is a spectrum that necessitates a comprehensive strategy that includes initiatives ranging from those that address the root cause of vulnerability to those created specifically to address the effects of climate change (Jones, Jaspars et al. 2010). In all surveyed wards, 90% of respondents feel that the vulnerability to and due to climate change must be addressed immediately in that region, along with identifying its adaptation measures. Hence, more research is required to develop efficient and suitable adaptation approaches (Corp 2012).

Concerning the risks and threats brought on by climatic circumstances, farmers and locals have discovered and created some localized adaptation and coping mechanisms, which are discussed below.

4.6.1 Local Adaptation Measures

In the research area, various adaptation practices were discovered. Substantial adaptation practices still rely heavily on traditional knowledge and technology in many circumstances (Acharya, Tiwari et al. 2015). Farmers in the Accham district are using different adaptation

measures to minimize the adverse impact of climate change by using their skills and local knowledge. The municipal level coping strategies used by the majority of locals, i.e., 98%, in response to changes they had to deal with daily were conserving water sources, preventing landslides, safeguarding riverbanks, planting fodder grass, practising conservation farming, terrace farming and enhancing terraces, restoring degraded land and forest conservation. Likewise, regeneration measures include limiting open grazing, enforcing tight norms and regulations, social fencing, and community planting of fast-growing species. Previous studies have also mentioned the similar adaptation program being carried out in the mid-hills and Himalayan of Nepal, including the construction of bioengineered structures and planting of fast-growing species (providing higher yield), establishment of community forestry, controlled grazing, fodder plantation bamboos plantation in the region to restore the degraded land. Despite the flood, they endured for a few years, and grass plantation in a degraded and barren land, fruit and mixed species plantation and all these practices have reduced the velocity of the disasters like flood, landslides, drought etc.

Additionally, locals of Mangalsen have started conserving natural forests as community forests and implemented them in other regions of the nation (Acharya, Tiwari et al. 2015, Dhungana, Silwal et al. 2020), which might strengthen community resilience by meeting the need for forest goods. However, these coping mechanisms that groups have developed to deal with climate extremes have limitations. The range and capability of coping are determined by a community's ability and resources and the extent of climate hazards to responding individually to it (Regmi and Bhandari 2013). Unpredictability of the effects of climate change and the extent of the destruction renders the local techniques ineffectual.

Various adaptation tactics were being used locally to lessen the climate change effects on crop output, such as forecasting monsoon rains and modifying crop planting dates accordingly. Similarly, Acharya, Tiwari et.al 2015 discovered that the inhabitants used traditional methods for managing forest resources, raising livestock, and farming in other parts of the mid-hills of Nepal, which was also observed in Mangalsen. Farmers are modifying their cultivation and harvest timings in response to changing weather patterns which were also carried out in the Himalayan region of Nepal (Adhikari, Prasai et al. 2021). More than 96% of respondents changed the harvest date and plantation date.

The practice of mixed cropping has also been used by some of the farmers in Mangalsen, as it reduced the possibility of crop failure (Acharya, Tiwari et al. 2015, Dhungana, Silwal et

al. 2020, Adhikari, Prasai et al. 2021). Both of these practices make some scientific sense because to accomplish crop productivity, the proper environmental condition is also required. Mixed cropping has many benefits to the soil as it helps maintain soil moisture and aeration and also helps to minimize the risk of crop failure. Also, rural residents adopted an integrated strategy that combined conventional and modern practices.

A similar adaptation was being adopted by the people in the Himalayan region of the country. The main adaptation strategies used by the locals in the Himalayas included artificial pond building, weed and insect management, changing plantation and harvest timings, and altering cropping patterns (Adhikari, Prasai et al. 2021).

Some other measures farmers adopt on farms are re-sowing, using bio-pesticides, and relocating animal sheds to a less landslide-prone location. At the same time, some farmers have migrated to the terai region.

4.6.1.1 Farm Diversification

Farm diversification is one of the most used adaptation practices to mitigate the effect of climate change by the farmers of the Accham district. 94% of the farmers have diversified their farmland as they were not satisfied with the productivity of the traditional varieties. Although many were not eager to abandon their conventional farming traditions in favour of off-season agricultural practices, the shifting climate had forced them to. Similar results were obtained from the study in the other parts of the mid-hill of Nepal (Acharya, Tiwari et al. 2015). Some individuals have been attempting to decrease the area of land they use for rice and replace it with vegetables instead of crops since they are more drought-resistant, and similar results were obtained from the Himalayan region of Nepal (Acharya, Tiwari et al. 2015, Adhikari, Prasai et al. 2021). Due to climatic zone shifts, some native crop species like local wheat and its varieties, maize, local basmati rice varieties, etc., have been wiped out (Malla 2008). Due to the low productivity and very high risk of loss, they have changed the types of cereal crops, vegetables, fruits and even in livestock. Hence those are rice, wheat, barley, legumes, maize, millet, soya, lentils, potato, brinjal, gourds, chilli, onion, cauliflower, cucumber, carrot, cabbage, mango, banana, guava, walnut etc. Conveying or mixed cropping is frequently used in the hills to guarantee crop production. Groundnuts and beans are also used as relay crops for maize, millet and soybeans, commonly conveyed in Mangalsen and other mid-altitude (Malla 2008). In the past, they don't use to grow these

crops and vegetables. Now, they growing short-season crops as a catch crop to prevent losses due to lack of or excessive rainfall. During a crisis, livestock is a vital source of food. Most of the communities were impoverished, generally lacking irrigation, and had small, fragmented plots of land that limited their ability to embrace various planting methods and crop production systems successfully. There was no question that there were significant and dangerous climatic changes occurring based on observation and survey results for cropping patterns, vegetation, and way of life. Despite the failure of some technologies and more erratic rainfall patterns, and shifting agricultural environment, several remarkable examples of successful inventions were made to adapt to the changing conditions.

4.6.1.2 Cultivation of hybrid varieties or commercial crops

The unpredictable weather pattern has introduced different impacts on agricultural productivity, due to which farmers practice cultivating hybrid or commercial varieties in Mangalsen. This technique has been implemented by 92% of farmers. It was discovered that they had altered their cropping routine and had planted hybrid crops in the Mangalsen and also on other parts of mid hills (Acharya, Tiwari et al. 2015). Despite the difficulties, farmers prefer hybrids in the study area because they provide superior yields, and hybrid crops help boost revenue by providing higher outcomes (Augustin 2022). Hybrid varieties are one of the most commonly used adaptation measures, which are very effective and help cope with the effects of climate change. Some of the hybrid types that the farmers of Accham district were using were; *Brassica oleracea* ***(Cauliflower)***- snow-crown, snowball 16, silver cup 60; *Brassica oleracea* **(Cabbage)-** green coronet; *Solanum Lycopersicum* (***Tomato)***- BSS 20, Suraksya, Roma; *Solanum tuberosum* ***(Potatoes)***_ cardinal, dijire, Solanum tuberosum (Kufrijyoti); *Cucumis sativus (**Cucumber)***- Malini, Kusle, ninja; *Oryza sativa*/ Early rice (***Chaite dhaan)***_ Judi series, PR 101; *Oryza sativa /Main season* ***(Barkha dhaan)***_ Sugandha, chhomrong dhan, Khumal 2, lumle2, radha2, Khumal 4; *Triticum* (***Wheat)***- BL 1022, 1473, Bhrikuti, NL297, WK1204, Gautam etc.; Cereals like IAL 7723, *Lens culinaris*/ Red lentils (Khajura1/Musuro), *Glycine max*/hardy (Bhatmas), PT 303 *Brassica nigra* (Tori). Additionally, local crop varieties were being replaced, and the cropping system was being altered to boost yield. Farmers were being trained by various NGOs. More advanced approaches and inventions were being adopted more and more frequently-those comprise better seed production, sustainable soil management practices, water and food harvesting

and storage technologies, compost collection, replacing agro-chemicals with improved farmyard manure, the collection and use of buffalo and cattle urine as a plant tonic and liquid fertilizer and preparation of biofertilizer using animal urine as a base, the use of new high yielding varieties of the staple grain crops.

4.6.1.3 Conserving Water Resources

Agriculture in Nepal is hugely dependent upon groundwater for irrigation purposes. The growing population has increased the pressure on agricultural land, demanding a higher yield from Nepal's limited resources. This, in turn, has led to the overexploitation of non-renewable water, making it inaccessible and out of reach for small and marginal farmers. Similarly, in the Accham district, water resource trends are also depleting. As a result, traditional kuwa (lake) was lost in many places. One previous study mentioned that water resources like springs, wells, etc., have dried in Dhading district (Sagun 2010). Similarly, in other parts of mid hills, the old water ponds are progressively disappearing, and some water ponds were lost recently (Acharya, Tiwari et al. 2015).

But recently, the protection of water resources in many places has been started. 97% of locals are involved in this program. Lake (*Kulo)* is being constructed to irrigate agricultural land in drought periods. Stone walls are built to prevent landslides, fencing, tank construction, pipe distribution, pipe installing, formation of the user group, plantation along with planting different plant species around the water source and doing puja in the water source to make the source sacred are some other adaptation measures used to protect the water sources. Many strict rules, such as turn-wise monitoring (*Alo Paalo*), are also set for water source protection.

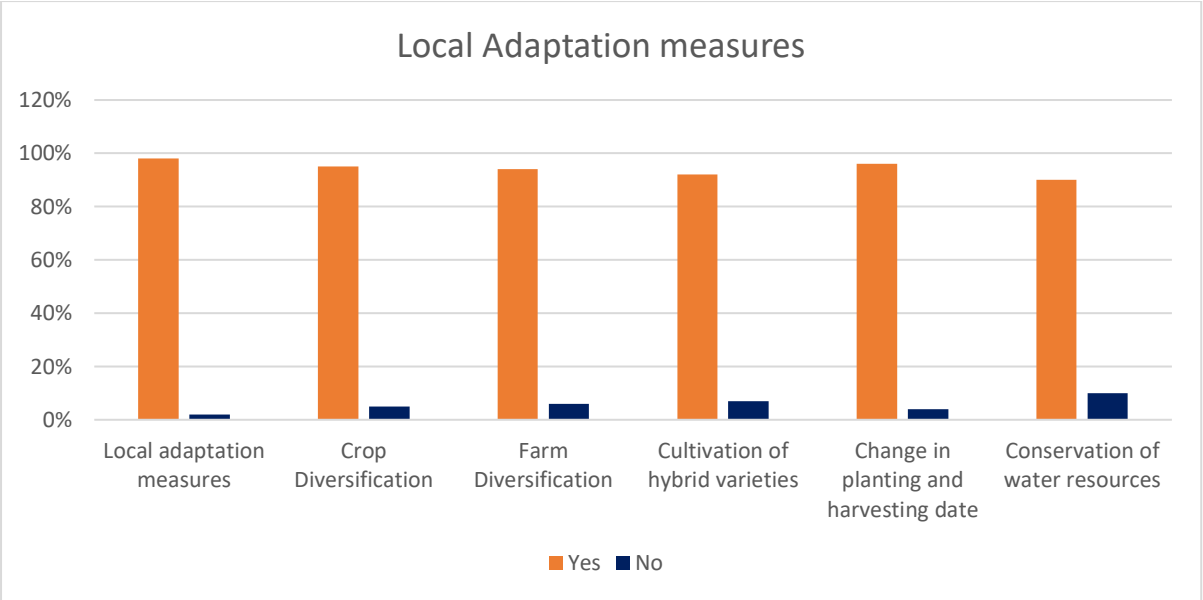


Figure 17 Local Adaptation measures

4.6.2 Adaptation measures at the HH level

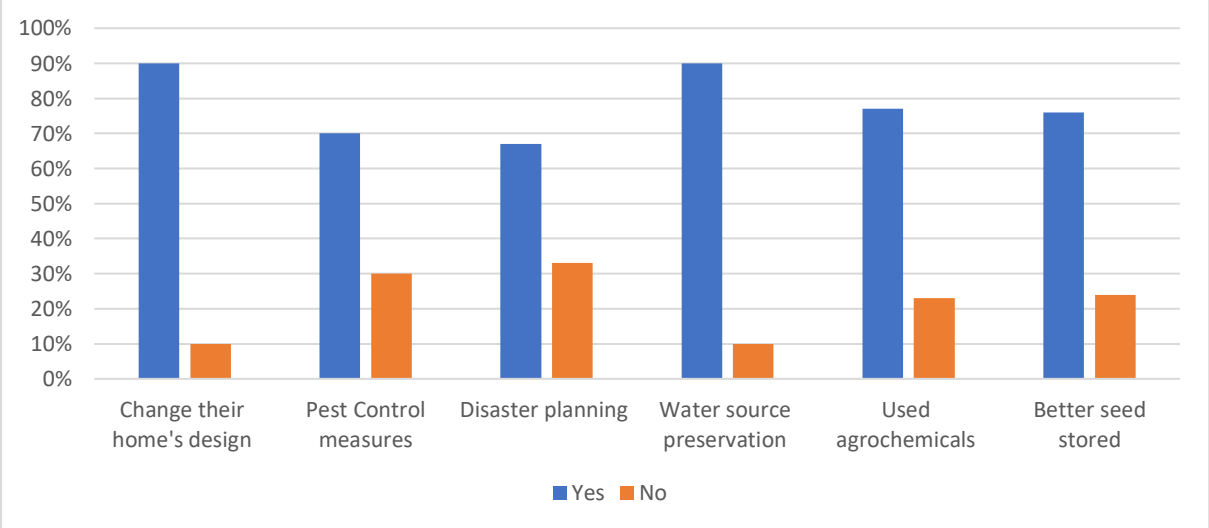


Figure 18 Adaptation measures at the HH level

More than 89 percent of respondents said they had altered their home's design (from Khar/ grass species to slate, tiles, tins, etc.) to confront climate change. Likewise, 70% of respondents said they were engaging in pest control measures, and disaster planning was mentioned by almost 67% of respondents. 90% of respondents have said they are actively involved in water source preservation (Fencing/ tar-bar, Plantation, pipe installing, tank construction, etc.). Additionally,77% of respondents used agrochemicals for pest management, and better seeds were stored using current techniques.

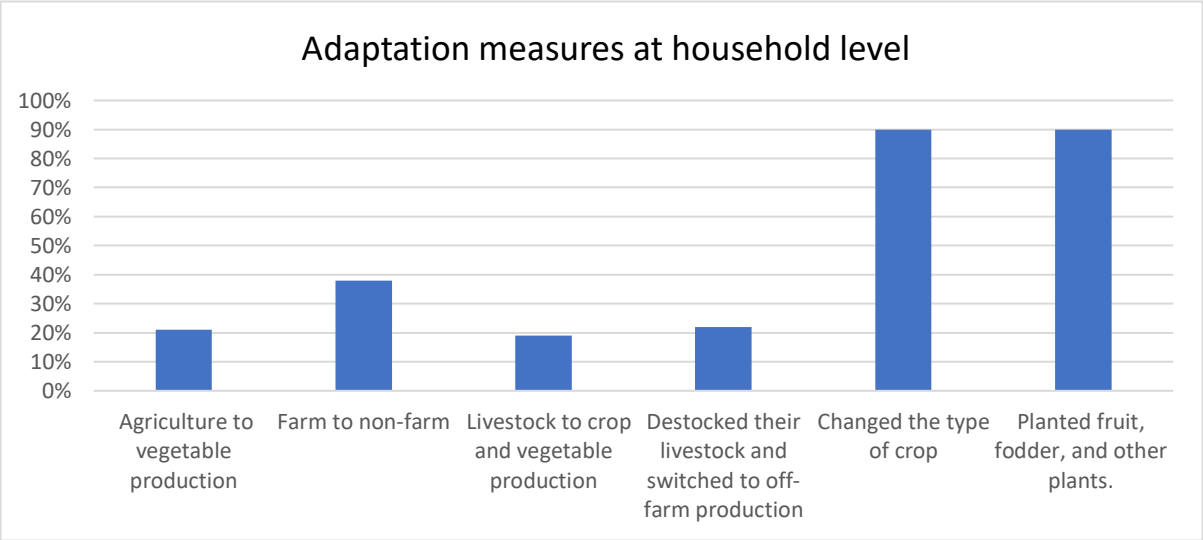


Figure 19 Adaptation measures at household level

90% of respondents said they had changed the type of crop. Similarly, 21% switched from agriculture to vegetable production, 38% from farm to non-farm, 19% from livestock to crop and vegetable production, and 22% destocked their livestock and switched to off-farm production. Similarly, 90% of respondents reported planting fruit, fodder, and other plants. Most key informants stated that the organization in the study region granted the locals some financial and technical assistance. However, according to a survey, the adaptation strategies employed to lessen the adverse effects of climate change did not boost agricultural productivity or technology. Because they were relatively new, people had not yet begun utilizing modern techniques. Therefore, most respondents (90%) are looking for new and satisfactory measures because they are not content with the present ones.

4.6.3 Integrated approach to adaptation plans

Intentionally or unintentionally, the local people have used various adaptation techniques. Communities can create plans for coping with climate change by learning about the environment and climate and discussing their perspectives.

To prepare the community for the effects of climate change, various organizations like governmental and non-governmental organizations have gotten involved. However, conventional strategies towards climatic variations may not consistently be adequate when long-term changes in precipitation and temperature are anticipated. Government policies at the local and federal levels are thus required to aid communities in setting and accomplishing their objectives.

Regarding climate change adaptation measures, 90 percent of those surveyed claimed to have implemented adaptation tactics. In comparison to conventional adaptation approaches, which were used by 50% of respondents, almost 40% used both types of adaptation techniques. As a result, just 10% of people embraced modern adaptation strategies.

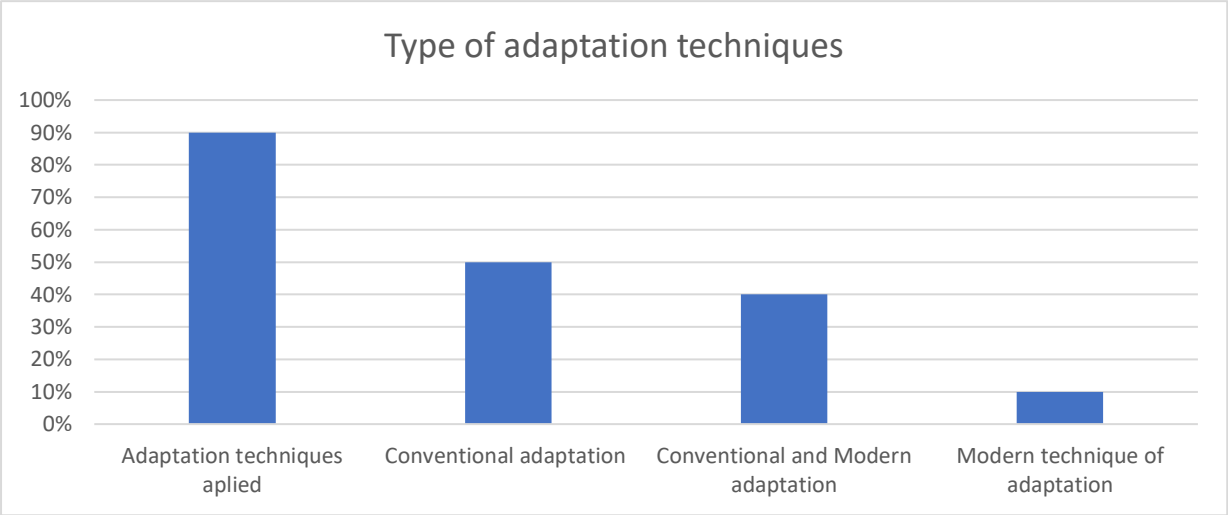


Figure 20 Type of adaptation techniques

In addition, 70% of respondents (household survey) said they knew of an organization operating in the climate and environment sector, while 4% reported that no organisation was involved and 26% were confused of if organisation involved or not. Members of the community engaged in a variety of initiatives as part of an integrated adaptation strategy. They are:

- Adaptation to water resources via conserving watershed areas, conserving water sources, building conservation tanks, collecting water through pipes, and forming drinking water users' groups.
- Agricultural adaptation strategies like conservation farming and adopting more suitable and resistant cultivars (crop diversification, soil mulching, fodder/grass plantation, mixed cropping, agroforestry, etc.). Improved seed interchange, insurance coverage, integration of various farmer groups and farmer schools, and Agriculture- Forest and Environment Committees (Krishi Ban Thata Batabaran Samiti).
- River bank protection (check dam, embankment, spur), landslide rehabilitation, gully control, degraded land restoration, planting of bamboo and grass, and

bioengineering are a few examples of adaptation to climate-induced catastrophes.

- Farmland conservation, watershed management, forest protection/management, fire line construction and management, improved cooking stoves, land degradation control, fodder grass plantation, awareness program, Poverty Alleviation Fund (Garibi Niwaran Kosh), and programs are some instances of adaptation to forests and biodiversity.

4.7 Factors affecting adaptation measures

The study examined obstacles to locals employing different adaptation strategies. The findings showed that the majority of farmers faced significant barriers in adopting different adaptation measures, including a lack of experience, information access, lack of market access, sufficient land and animal power, a lack of education, and financing facilities. Farmers' access to the tools and technology needed to modify their operations in response to changing climatic circumstances is hampered by a lack of capital, inadequate inputs, and education. The previous studies obtained a similar result in Lamjung and Mustang districts in Nepal by Dhungana et, al 2020 and Adhikari et al. 2021 that insufficient funding, knowledge, labours, and technical resources are the main obstacles to functioning climate change mitigation and adaptation and other paper mentioned that absence of obligatory policy, lack of technology, lack of understanding, lack of time (Regmi and Bhandari 2013, Dhungana, Khadka et al. 2017) are additional barriers and which was also observed in Mangalsen. Furthermore, papers stated that further challenges in the context of community forestry were the operational plan's low priority for climate change adaptation and the allotment of forest income for the execution of climate change adaptation strategies and similar reasons were also mentioned by the locals in the Himalayan region (Dhungana,

Silwal et al. 2020)

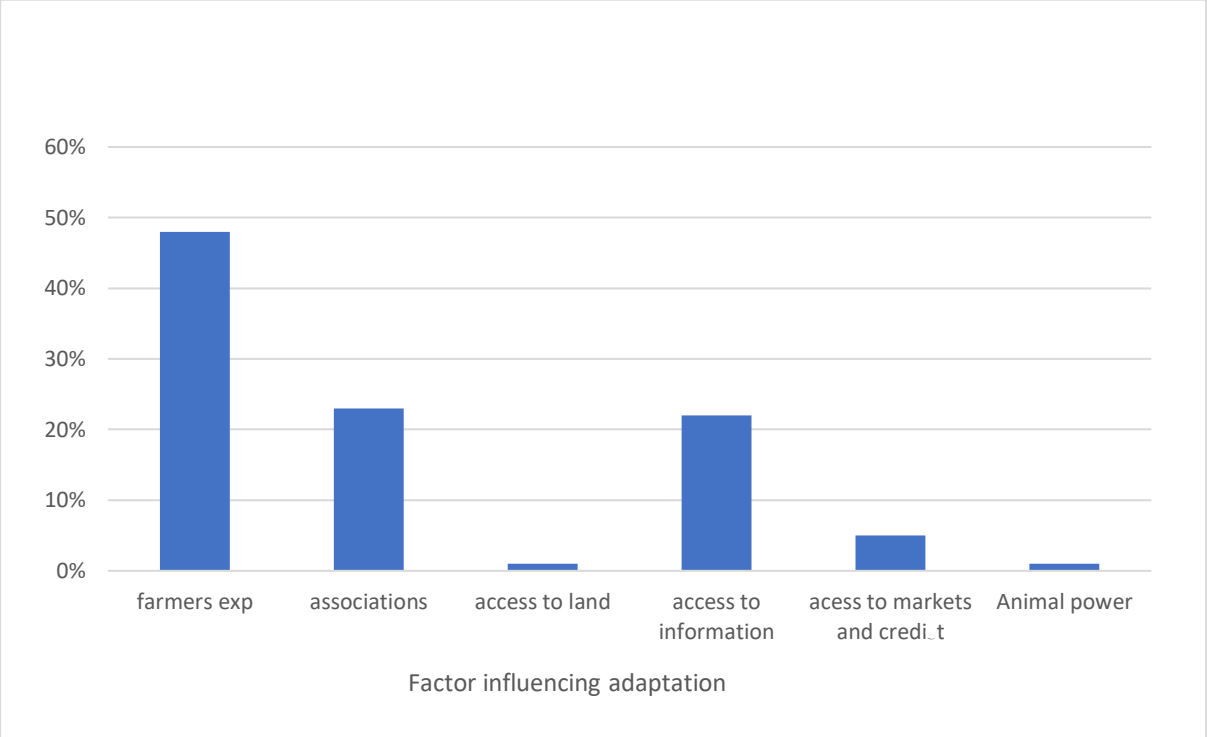


Figure 21 Factors affecting adaptation measures

In a household survey, 48% of respondents named having little or no experience (education, age, gender, labour, no access to inputs such as seed, fertilizers etc.) as one of the hurdles to implementing adaption strategies. In addition, 23% mentioned that not having participating in associations, associations as a challenge. Likewise, 2% claimed that not having enough land or a farm, access to electricity, irrigation, transportation, small animals' power, farm revenue, and non-farm income are other obstacles to adaptation. Similarly, 21% described that not having access to information such as weather forecasts, information on climate change and its adaptation, and free extension services (like guidance, monitoring and evaluation) is yet another hurdle. Similarly, 5% of residents said that access to formal institutions like the market, credit and public institutions (government or government offices, schools, colleges, etc.) was another barrier to adaptation.

AASTHA Nepal, Red Cross, FECOFUN, CARE Nepal, and other organizations and departments like the District Development Council (DDC), District Forest Office (DFO), Department of Agriculture Development (DADO), etc., are reportedly striving to lessen the effects of climate change, according to key informants.

Perception of locals to adaptation to climate change

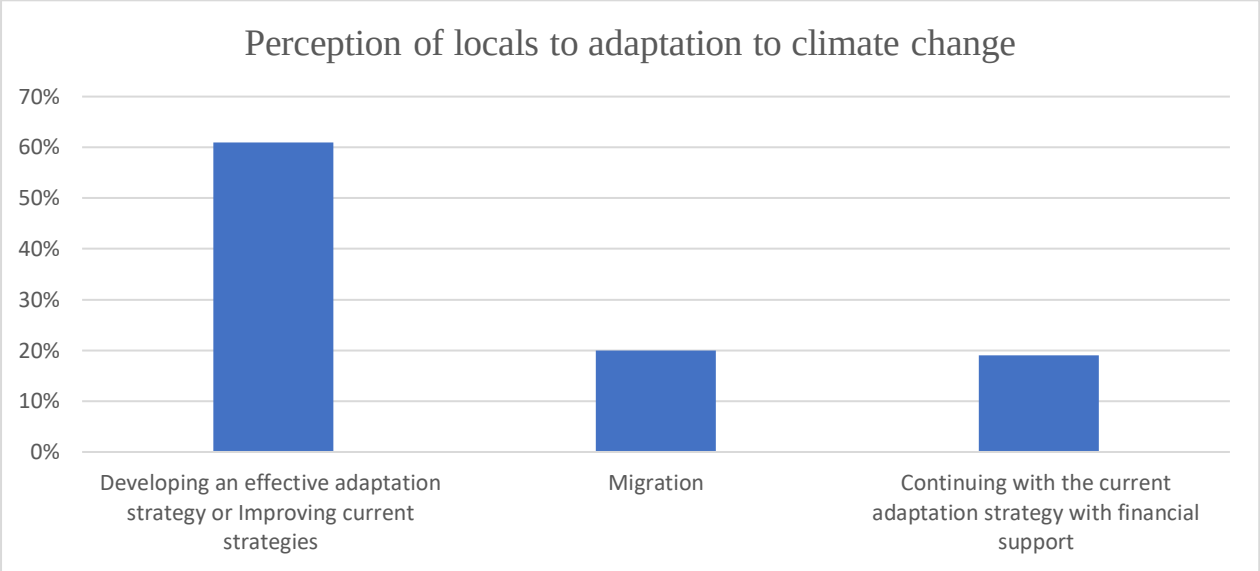


Figure 22 Perception of locals to adaptation to climate change

61% of the respondents from the area supported developing an effective adaptation strategy or improving current strategies and putting it into practice to lessen the negative effects of climate change. 20% proposed migration, and the remaining few percentages of respondents suggested continuing with the current adaptation strategy with financial support as a possible way to mitigate the effects of climate change. According to the research, these plans indicated increasing mechanisms for ensuring coordinated and integrated adaptation actions at local levels within the already-existing planning process. The other LAPAs can be utilized to increase cross-sectoral coordination and interdependences and enhance sectoral programs. A determined, integrated, collaborative endeavour is urgently needed to support these most susceptible villagers.

Hence, to mitigate the effects of climate change, the GoN agencies, local and national NGOs, rural development projects and programmes, related research organizations, and international and national donors must all provide proactive and participatory intervention.

4.8 Role of Municipality to support community climate change adaptation

Cities that meet specific minimal requirements for infrastructure and population are designated as municipalities by the Government (UN 2022). Local governments, also known as local bodies or entities, include rural municipalities, municipalities, sub-metropolitan cities, and metropolitan cities. These independent governmental entities can

significantly enhance livelihood by leveraging local resources for infrastructure development, planning, economic development, recreational, and other services (Koirala 2022). In addition, the local bodies existed in this country even when the nation had not yet been established (Koirala 2022). Local Government, like municipality, continues to be a branch of Government with modest legislative authority and power that functions within a definite geographic and legal jurisdiction (Koirala 2022). The ability to pass laws within the specified area distinguishes local Government (Pretoria 2019/2020). Local Government is composed of different local bodies. Because the central Government cannot handle all the specific needs of society that government institutions must meet, local authorities were established to provide services in designated geographic areas (Pretoria 2019/2020). Local Government, like municipalities, played a crucial role in maintaining the relationship between locals and the Government due to its geographic confinement and closer proximity to the people affected by problems (Pretoria 2019/2020). This makes it possible for the local Government to comprehend and resolve these issues quite effectively.

According to Nepal's Constitution's Part 17, a mayor leads the Municipal Executive, which is in charge of the municipalities. The constitution's Schedules 8 and 9 deal with the authority that the local executive can employ, independently or concurrently, with the federal and provincial governments. The deputy mayor, ward chairpersons appointed from each municipality's ward, five women elected by the Municipal Assembly among themselves, and three representatives from Dalit (lower caste) or other minority groups make up the Municipal Executive (Nepal Law Commission 2020). According to Nepal's Constitution, Part 18, the Municipal Assembly is the only body with legislative authority inside a municipality. It comprises the mayor, deputy mayor, ward chairpersons, and four members appointed from each municipality's ward, at least two of whom must be female. One member of the Dalit minority communities selected for the Municipal Executive is also a member of the Assembly (Nepal Law Commission 2020a). Additionally, Part 17 has provisions for a Judicial Committee, which is led by the deputy mayor and is composed of two other individuals chosen by the Municipal Assembly jointly (Nepal Law Commission 2020).

The study explored that every Municipality of every district has to allocate some budget for climate change, environment, forest and disaster sectors, which is mandatory. The provincial and federal governments provide local authorities funding (Koirala 2022). The government

of Nepal implemented National Adaptation Plan (NAP), which was endorsed in 2010 (Rai, Gurung et al. 2015). The main aim of this national plan is to decrease the country's climate change susceptibility, which also aids in integrating climate change adaptation into strategies, policies, and initiatives at all levels and sectors (MoPE; Bishokarma 2016). Then, to implement NAPA and incorporate climate change resilience into local to national development planning methods and outcomes, the local adaptation plans of action(LAPA) framework was developed and authorized by GoN in 2011 (Rai, Gurung et al. 2015). So, the government at the national level is playing the role of guardian and helps all those organizations who are working for the minimization of climate change impacts. The most fundamental and suitable political units for incorporating climate change adaptation into regional and governmental development planning procedures are the VDC, and the Municipality was recognized (Rai, Gurung et al. 2015). Therefore, the municipality in this district has been involved in disaster recovery activities and has been collaborating with some NGOs and INGOs. Likewise, various regions of the country have seen various development agencies implement climate change adaptation initiatives.

Some pioneer programs like Britain Nepal Medical Trust (BNMT) and Nepal Climate Change Support Programme (NCCSP) were started in the Accham districts. LAPA programs have also been implemented in that area. Other organizations like the Rural Development Centre (RUDEC), The Federation of Community Forestry Users, Nepal (FECOFUN), and Malika development association (Malika Bikas Sangh) conducted the LAPA program in Accham districts through Multi -Stakeholders Forestry Programme (MSFP). Not only that, NCCSP had initiated the LAPA in five Municipalities to avert and develop a system of adaptation planning to climate change with the financial support of Nepal Climate Change Support Unit (NCCSU)(Plus:GCCA+ 2018), and Achham is the first pilot district for LAPA (Bhatt 2014). With the active participation of a multi-stakeholder team, including the vulnerable communities, the LAPA was prepared locally (Dharam Uprety 2016). The authorized LAPA highlighted local adaptation and concentrated on measures to increase resilience and decrease localized climate risk (Acharya 2022). Likewise, according to UNEP, Ecosystem-Based Adaptation (EBa) encompasses a variety of ecosystem management actions to improve resilience and lessen the susceptibility of people and the environment to climate change. It performs disaster risk reduction and sustainable water management to allow for water storage and flood control services (Bhatt 2014). With assistance from locals

and local resources, MSFP also commenced the LAPA program in the Mangalsen municipality and 25 additional municipalities (was VDCs then) (Rai, Gurung et al. 2015). Besides these, six committees coordinated their efforts and served as an integrated platform for the district's overall development and to deal with climate change.

The Jalasrot tatha Vumi Samiti (Water Source and Land Committee) featured drinking water projects, waste disposal sites, embankments, conservation of local water resources, soil erosion and landslide prevention projects, and human resource development and skill improvement initiatives.

The Purbadhar tatha Sanrachana Bikas Samiti (Infrastructure and Infrastructure Development Committee) was active in projects to improve infrastructure, promote tourism, and provide road access to 75 VDCs (now municipalities) and rural areas, rural access program (RAP).

Department of Forest- Introduction of the CFUG, the Comprehensive Plantation Initiative, the National Forest Development Program, the Leasehold Forestry and Livestock Development Program, the Multi-Stakeholder Forestry Program (MSFP)(in the past), and the climate change and forest area monitoring, evaluation and information management. Similar to this, Krishi ban tatha Batabaran Samiti (Agriculture Forest and Forest Management Committee) comprised organizations like the Department of Agriculture Development Office (DADO), District Livestock Development Office and Department of Forest and Programs included by DADO; Irrigation canal (Mangalsen 1,2) citrus bee development program, fruits pocket area development project, ginger and cardamom production project, and agriculture bio- diversity management project. District Livestock Development Office (DLDO) programs offered included those for livestock health, knowledge and awareness, conservation of genetic resources (Achhami cattle), and climate change adaptation.

The Janasankhya tatha Samazik Samiti (Population and Social Committee) offered elderly people security and various forms of social support. District Health Office (DHO) served as the team leader for Swathe tatha Posan Samiti (Health and Nutrition Committee). It was responsible for the overall nutritional health of the children and women. Sangathan tatha Prasasan Samiti (Organization and Administration Committee) was in charge of the administrative procedures and the institutions.

All these committees and organisations must be registered in the municipality and renewed

annually. And those who were registered in the District Development Office should be renewed on time every year. They should submit the annual report and program documents to the municipality. The committee didn't need to submit the formal report, while the organisation required to submit their formal report to the municipality. The committees get grants from the District Development Office and municipality to run the programs.

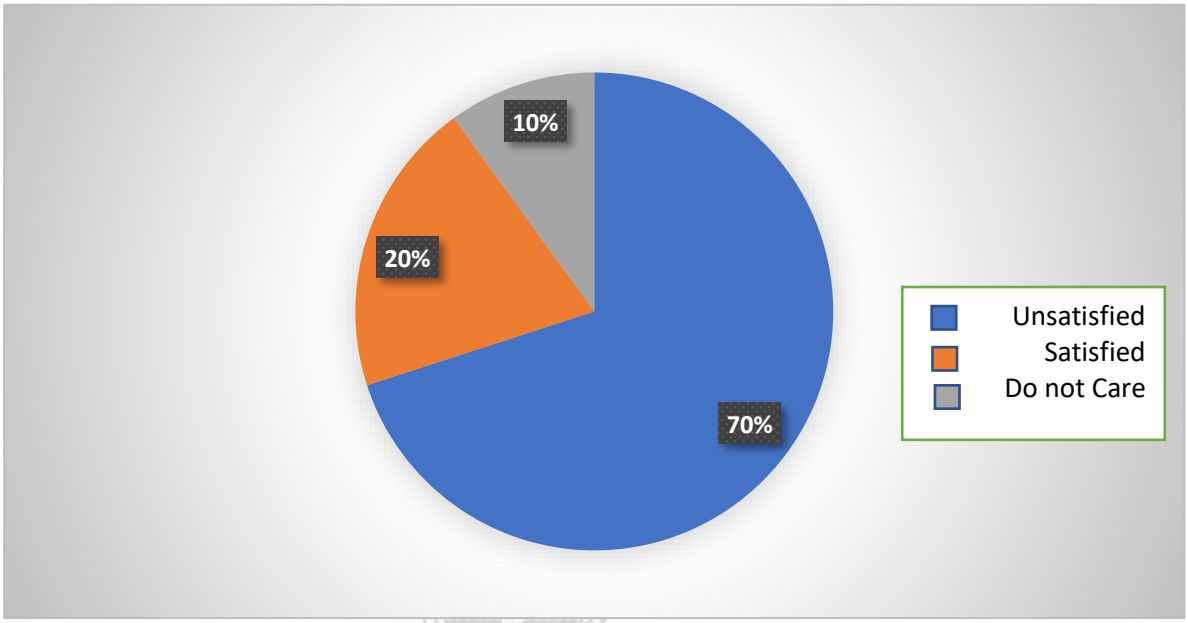


Figure23 Satisfaction level of respondents regarding the performance of the municipality

During the study, about 70% of the respondents (household survey) wanted more from the working of Accham municipality regarding climate change adaptation measures. The local governments' planning and service delivery need to meet society's expectations to the same extent (Koirala 2022). Hence, they are unsatisfied with the planning and services the municipality provides. Their high expectations and desire for compensation from new technologies for crop losses led to their dissatisfaction. The majority look forward to receiving immediate advantages and services that would raise their income and give them financial security. Locals were also expecting a small number of loans and jobs from the Government and organizations. Since they may go to their profession or field and earn money for the day at that moment, some respondents feel that participation in the training and awareness program is a waste of time.

Lastly, Accham is a rural district with a lack of facilities and services for the locals. Like market access, transportation, road, and income opportunity. How can the local

administrations carry out everyone's aspirations? The primary query is this.

Only 20% of respondents were satisfied with their local government's performance in coping with climate change risks and hazards. In comparison, the remaining 10% said that they don't care about the performance of governmental institutions.

Farmers of Accham districts reported mainly five roles of the municipality regarding climate change adaptation measures that are; initiation of climate-smart agriculture, development of early warning system (but not satisfied), training or awareness about water conservation techniques, a conservation initiative for wetlands, formulation of plans and policies regarding climate change impacts.

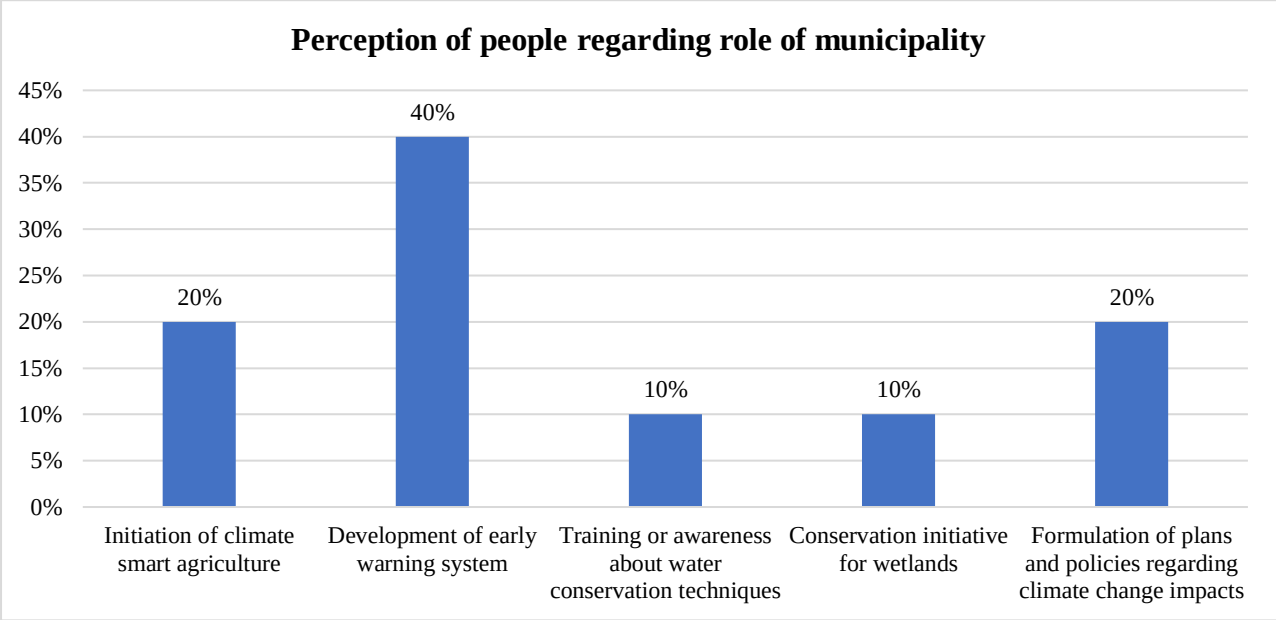


Figure 24 Perception of people regarding the role of the municipality

40% of respondents (focus group discussion) reported that the municipality's role is to develop an early warning system about climate risks and hazards. 20% of people reported formulating plans and policies regarding climate change impacts, and the same percentage with the initiation of climate-smart agriculture. 10% claimed to conduct training or awareness about water conservation techniques, and the rest 10% stated that to develop initiation programs for wetland conservation.

CHAPTER 5

Conclusion

5.1 Conclusion

Most of the inhabitants in this district rely on agriculture and livestock as a primary source of income, which the effects of climate change have adversely impacted. Most respondents stated that the temperature has risen from the past to the present, and data from the meteorological department confirmed this pattern. Locals indicated that rainfall has decreased and encountered an erratic and unpredictable way of precipitation, which is consistent with the meteorological data. Moreover, the duration of summer days is getting longer, and summers are becoming hotter while winters are getting shorter and also warmer. Changes like early flowering, crop maturity and change in the crop cycle, various forms of crop infestation, origination and development of invasive weeds and pests, and crop failure have been observed, reducing the quality and quantity of crop yield. Besides damage in the farmland by floods and landslides due to the unpredictable weather pattern. The increased frequency of extreme events such as prolonged dry periods, erratic rainfall/ hailstorm, and flood and landslides. Fruits, crops and vegetable production has decreased, and decreased availability of water for agricultural activities, depletion of water resources, and change in crop cultivation timing due to climate change have impacted the farmers' earnings.

Likewise, in recent decades, the prevalence of animal diseases has increased. Cattle rearing had dropped and had become problematic. New type of diseases, such as the increasing temperature of livestock and incidence of increasing infertility in animals, skin diseases, etc., has been observed, resulting in poor quality and decreased quantity of animal products, including meat and milk, and its population, etc. Losing numerous livestock species due to unusual climate changes and variability, including increasing temperatures, unpredictable monsoons, precipitation, and inconsistent rainfall, has harmed marginalized individuals' livelihood and food security.

In addition, the frequency and magnitude of climate-induced risks and hazards are increasing, becoming more common and severe. The tendency toward prolonged droughts

has increased the likelihood of fires. Damage has been caused to agriculture, crops, infrastructure, roads, water supply systems, and buildings by floods, landslides, and debris flows.

Furthermore, farmers have also reported the impact of climate change on the physical properties of the soil and water, which is true (Daba, Bazi et al. 2018). Additionally, changes in precipitation, snowfall and average temperatures will impact soil organic matter, including soil stability and water holding capacity (Daba, Bazi et al. 2018).

To cope with such impacts of calamities, locals have adopted several municipal-level adaptation techniques like changing house design, conserving water sources, preventing landslides, safeguarding riverbanks, planting fodder grass, practising conservation farming, terrace farming, modifying the cultivation and harvest timings of crops in response to changing weather patterns, mixed cropping, restoring degraded land and forest conservation. Likewise, regeneration measures include limiting open grazing, enforcing tight norms and regulations, social fencing, and community planting of fast-growing species. Some others adaptations measures are i) Farm diversification: farmers have diversified their farmland. Some farmers have decreased the area of land they use for rice and replaced it with vegetables instead of crops. Mixed cropping has been adapted. However, the socioeconomic condition of the communities has restricted their ability to embrace various planting methods and crop production systems successfully. ii) Cultivation of hybrid varieties or commercial crops: Some farmers have been cultivating hybrid varieties because they provide superior yields and boost revenue by providing higher outcomes(Augustin 2022). Hence, local crop varieties were being replaced, and the cropping system was being altered. Although there is a common link between climate vulnerability and poverty and food insecurity, not all measures to reduce poverty results in a decrease in climate sensitivity, and not all adaptation innovations immediately improve food security (FAO 2011), people residing in the study area is highly vulnerable to the climate change due to its geographical conditions, fragile and unstable landscape, socioeconomic situation, lack of access to infrastructure and markets, and heavy reliance on farming and livestock. They have the terrible economic condition and are ill-equipped to deal with climate change. Their sole holdings are their farmland and livestock, both vulnerable to climate change. Farmers, livestock holders, fishermen, and people who depend on the forest for their livelihoods face significantly more significant production risks due to climate change. They are already

facing water scarcity and high exposure to climatic extremes like floods, landslides, storms, and poverty.

The VDC and the Municipality were identified as the most fundamental and appropriate political units for integrating climate change adaptation into regional and governmental development planning procedures (Rai, Gurung et al. 2015). According to the analysis, it is required that each municipality and district set aside money for the areas affected by disasters, the environment, and climate change. As a result, the municipality in this district has been actively participating in disaster recovery efforts and has partnered with a few NGOs and INGOs. In addition, six committees coordinated their activities and provided a platform for the district's general development and adaptation to climate change.

Most farmers had substantial challenges when implementing various adaptation methods, including a lack of experience, information access, market access, poor infrastructures, scarce land and animal power, and a lack of education and financing facilities. Consequently, awareness of climatic threats and efforts to mitigate issues have expanded globally; however, there are huge discrepancies between the adaptation measures undertaken and what is required in many countries (IPCC, Change et al. 2022). The statistics demonstrated that a continued adaptation plan was insufficient to lessen the harmful effects of climate change. Additionally, it emphasized the need to improve the mechanisms by which the current planning procedure can guarantee integrated adaptation practices at local levels. One of the essential findings is that agricultural methods that aid climate change adaptation in farmland are accessible but that the institutional framework for executing and promoting those technological solutions needs to be reinforced. Several adaptation initiatives have been formed across the country, but there are still insufficient funding sources to implement them.

5.2 Recommendations

Community Level

A livelihood diversion program from agriculture, livestock and resource-dependent to another source of income should be implemented. The different organisations and governments should plan and implement income-generating programs and training. Activities that promote economic growth and sustainability ought to be supported. Ecotourism would, to some extent, benefit from that. The local governments should

establish and operate areas of income generation according to their peculiarities. Roads are merely tracks; they are not like actual roads, and the local governments should work on this. There needs to be more knowledge about climate change and its impacts in the rural mountainous region of Nepal (Dhungana, Silwal et al. 2020, Adhikari, Prasai et al. 2021). So, local and national bodies must conduct awareness programs at the community level (Adhikari, Prasai et al. 2021). A compensation scheme (granting some grants) from the program holder for attending the program may help implement the program effectively. Institutions must therefore develop the measures and programs to help the local population deal with the inevitable effects of climate change. The mechanism for forecasting crops must be improved by the government or through local or national-level projects. Raising awareness of farm conservation, new and improved technology, and its urgency and importance among grass-roots promoting youths, women, and disadvantaged groups are essential to provide a long-lasting solution. Responsible bodies should introduce modern technology at the local level to be aware and enable people to adapt. Establishing and expanding a seed collection centre and gene bank at the local level is necessary. Local variety ought to be encouraged.

The municipality must be able to provide timely service to the communities. Moreover, a compensation scheme should be delivered in case of loss of time and crops from the governmental and non-governmental agriculture adaptation projects. In addition, livestock insurance is offered, but not for crops. Crop insurance should therefore be guaranteed.

A crop-satisfactory relief fund or crop insurance plan (in a simple process) can positively affect people's attitudes toward adopting new technologies. Schedule crop field monitoring must be done in the study area to maintain a consistent attitude (locals) of gratitude for the programs and program holders.

Furthermore, because a large portion of crop agriculture is rain-fed, irrigation canals and investments are needed to help farmers adjust to prolonged and unpredictable droughts. Applying water harvesting and collection methods could help with the problem of water scarcity.

Even though there were more than 30 INGOs and NGOs in the municipality, they still needed to coordinate and integrate to operate as one to combat climate change. Therefore, adequate integration is required. In addition, more clusters and organizations are needed, such as Agriculture Forest and Environment Management Committee (Krishi Ban Tatha

Batabaran Samiti), the District Bio-diversity Conservation Group, and Disaster Reduction Preparation Group. Activities relating to climate change must be addressed by the budgetary mandate and Plan (Yojana) in government buildings.

The provincial and federal governments provide local authorities with restricted funding. The needs of the community might still need to be fulfilled. The municipal authorities should prioritize planning and economic independence. Thus, internal income mobilization must be improved.

National Level

The government administration of these regions is not adequately performing its role; as a result, farmers lack access to technology and emergency aid. Mostly underprivileged farmers are affected by the whims of climate change and its catastrophes. The policies and strategies did not adequately address the farmers' voices and requirements (Adhikari, Prasai et al. 2021). It was discovered that the inhabitants were using traditional methods and utilizing their skills and knowledge for managing forest resources and farming. However, most of them are temporary solutions for managing resources sustainably and dealing with the adverse effects of climate hazards (Adhikari, Prasai et al. 2021). To avoid becoming even more wretched, the government at national and local levels and policymakers must assist farmers in developing long-term and location-specific adaptation methods. Adaptation techniques now in use are insufficient. Instead of focusing solely on agricultural techniques, it is critical to consider how to bring about the necessary institutional change, raise funds to invest in these improvements, and establish flexible strategies for long-term climate change adaptation in agriculture. Numerous adaptations programs have been developed throughout the nation, but there are still not enough sources of finance to put them into action (Rai, Gurung et al. 2015). Hence this implies that setting aside a sufficient budget is essential for carrying out the "adaptation activities" (Rai, Gurung et al. 2015). However, we may achieve the desired objectives if we study, communicate, establish policies and programs accordingly, develop long-term goals, manage the budget, and advance by assuring planning.

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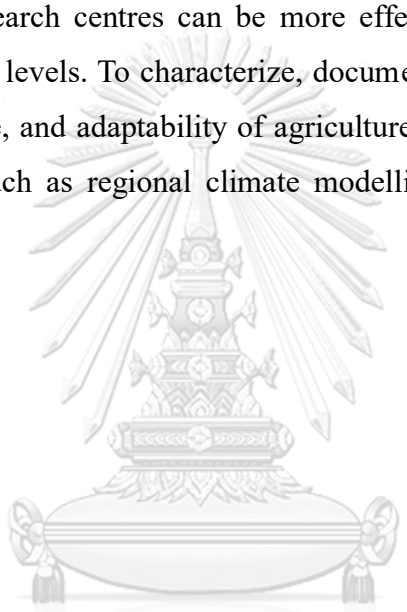
of climate change. Additionally, it emphasized the need to improve the mechanisms by which the current planning procedure can guarantee integrated adaptation practices at local levels.

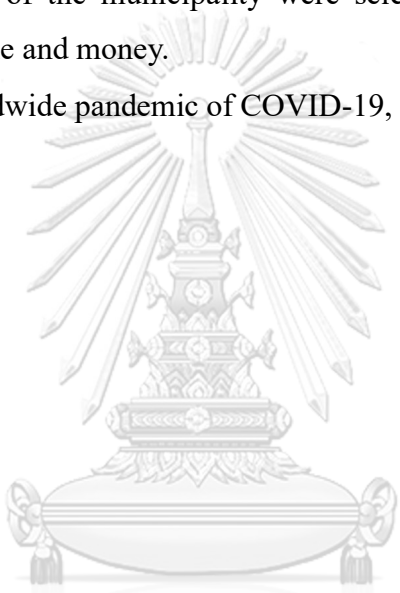
Few weather forecasting stations are established in the far-western region, causing a massive gap regarding climate change's impact among policymakers and people. Hence, a considerable number of meteorological stations should be established to monitor climate patterns. It is also critical to incorporate climate change-related problems into the planning and design of the developmental programme. Strategies like crop insurance, seed bank establishment, and research centres can be more effective in minimising the effects of climate change at local levels. To characterize, document and validate the climate change susceptibility, influence, and adaptability of agriculture in Nepal's mountain region, more specialized research such as regional climate modelling, adaptation studies, and so on should be undertaken.



LIMITATION

This research was conducted in a remote part of Far-West, Nepal. First, many works have been going on in the Achham district regarding climate change and addressing its effects. However, documentation, including data records, articles published and result sharing to broader communities, seems too scarce. This area lacks baseline data previous data on climate change, its impacts and crop productivity. Some other limitations are:

- Only 14 wards of the municipality were selected for the study due to the limitation of time and money.
- Due to the worldwide pandemic of COVID-19, some interviews were taken via online media.



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Appendixes

Appendix - 1

Focus Group Discussion Checklist

1. What type of climate change do you foresee in your area?
2. What other problem/challenge do you face in adapting to environmental impacts?
3. What are CC adaptations implemented by the Municipality in your area?
4. What kind of support do you expect from Municipality to make CC adaptation sustainable in your area?
5. What techniques helped you in adopting these vulnerabilities?
6. How can Municipality take steps for livelihood adaptation if it will be impacted by climate change?
7. How can the Municipality prevent adverse impacts on livelihoods?
8. What strategies have the Municipality adopted to take care of climate change?
9. What are the other problems that the Municipality faces?
10. What is the priority area for the Municipality in adaptation to climate change?
11. What steps have been taken so far by the Municipality to take care of climate change? What more can be done?
12. How have your working strategies been affected by climate change?

Appendix-2

Key Informants Interview/institutions checklist

Name of the Respondent..... Institution……

1. What role is played by your institution in cc adaptations?
2. Which institution applies modern technologies?
3. What challenges does your institution face in implementing the cc adaptation strategies due to climate change?
4. What strategies will be practical/suitable for CC adaptation?
5. How did your institution support these adaptation processes to be sustainable and effective simultaneously?
6. What are the policies incorporated in adapting livelihood activities by your institution in your area?
7. What are the other problems that your institution faces?
8. What is the priority area for your institution in adaptation to climate change?
9. What steps have been taken so far by your institution to take care of CC? What more can be done?
10. How have your working strategies been affected by climate change? Why?
11. How will your institution progressively take care of these impacts?
12. What problems/challenges do you face in adapting to environmental impacts?
13. What strategies have been adopted by your institution to take care of climate change?
14. How will your institution progressively take care of these impacts?

S.N	Activities	Supported	Not Supported
1	Plant production/ Plantation/ Weeding/Pitting		
2	Forest protection		
3	Financial support		
4	Fireline/ inspection path/road construction		
5	Water pond/source protection		
6	Awareness Programs related to CC		
7	Employment generation activities		

8	Construction of dams		
9	Workshop and training		
10	Coordination and support in VDC activities		
11	Silvicultural operations		
12	Others		

Appendix -3

Household Survey Checklist

Household background information

Household Number…….

Household Head……

District.....

VDC……

Village……..…….

Ward……..

Demographics Characteristics

Name of the Respondent……

Sex:…….

Age: ……..

Occupation:……..

Ethnicity:

Education of HH head:

Please describe the occupation of your family members.

Occupation	Female (No)	Male (No)
Student		
Agriculture		
Local off-farm activities		
Business		
Public services (Teaching, Office, NGO)		
Outside work (Foreign country)		
Other specify:		

Resource Ownership

SN	Resources type	Before ten years	Present	Remarks
1	Khet			
2	Bari			
3	Pakho			
4	Others			

Please explain the cropping pattern and crop production on your land.

Land type	Name of Crops/Vegetable	No crops in a year	Before 10 yrs		Current		Reason for change
			Area	Prod.	Area	Prod.	
Bari	1. 2. 3. 4.						

	5.						
Khet	1. 2. 3. 4. 5.						

Do you have any problems with crop production? If yes, please indicate the issues.
a. Yes b. No
Whether your farm production is sufficient for your annual household consumption?
a. Yes b. No
If not, are months of farm production enough for household consumption?
a. three months b. six months c. nine months d.12 months and more

Do you have livestock? a. Yes, b. No

If yes, please give detail of your livestock composition and herd size.			Any problems in livestock farming	Reason change livestock farming
Livestock species	Current	before ten years		
Buffaloes				
Cattles				
Goats				
Pigs				
Poultry Chicken and Ducks				

Forest Resource collection in farming

Forest Resources	Bhari/Yr		% supply for agriculture and HH
	Current	Before ten years	
Fuel-wood			
Fodder			
Litter			
Timber (Cft)			
Others			

Dependencies on forest resources
a. increasing b. decreasing

Have you noticed any of the difficulties in rearing livestock?

Occurrence diseases/parasites	Increased	Decreased	Remarks
Availability fodder/forage			
Quality of grazing lan			

Availability of water			
Others			

Source of income

Farm Source	Rs.	**Off-farm sources**	Rs.
Sale of food grains		Business	
Pulses/Oilseed		Salary	
Vegetable		Off-farm wage	
Fruits		Remittance	
Livestock sale		Pension	
Livestock products		Bank interest	
NTFP		Bonus	
Other		Other	

Knowledge and Perception of Climate Change

Have the following activities stayed the same, increased or declined over the last ten years?

Activities	Increased	Decreased	More or l extreme	No change	Don't kno
Temperature level					
Intensity of rainfall					
Frequency of rainfall					
Drought frequency					
Hailstorms/Snowfall Amount & severity					
Landslide/flooding Severity					
Landslide//flooding Frequency					

Extreme events in your experiences

Extreme event	Year	Number	Remarks
Rainfall			
Hailstorms			
Fire			
Diseases			
Landslide			
Drought			

The reason behind the increasing number of disasters is

a. Unusual weather b. Deforestation c. Increased pollution d. Global warming, e. Other

reasons.

Are there any micro-enterprises in your area?

a. Yes b. No

If yes, please list

SN	Name of organization	Priority work sector	Working sin	Are you benefit		Your involveme	
				Yes	No	Yes	No
1							
2							

How have the micro-enterprises helped your livelihood status?

SN	Name of enterprises	Related to which sec	Direct benefit	Remarks

Indicators of Climate Change

SN		Increase	Decrease	Constant	Reason
1	Fruit tree productio				
2	vegetable yield				
3	Crop				
4	Water available seed sowing				
5	crop cultivation tim				
6	Timing of rainfall				

Time of flowering and fruiting, and harvesting:

a. Early b. Late c. Constant

Is any new insect\ pest occurrence in the farmland? If yes, which crop damage?

a. Yes b. No.

Impacts of CC in various areas

Area of impacts	Condition comparisons to 20 years ago					Mean
	Highly	Slightly	Same	Highly	Slightly	

	Increased	Increased	Before	Decreased	Decreased	
Agriculture production						
Weather-related disasters						
Physical loss						
Forest fire						
Mosquitoes and flies						
Human health diseases						
Invasive species						
Crop diseases						
Animal diseases						
Wild animals						
Water resources						
Wild Plants						
Birds						
Reptiles and amphibians						

Are you affected by these shocks?
a. Yes, b. No

Have you practised any types of strategies to adapt CC variability?
a. Yes b. No c. Don't know
You carry out which types of adaptation strategies?
a. Traditional b. Modern c. Both

Adaptation measures
List down the different adaptation practices at your farm level in response to perceived change.

S.N.	**Traditional adaptation practi (Autonomous)**	**Improved adaptation practices (Planned Adaptation)**

List down the different adaptations' practices at your community level.

S.N.	**Traditional adaptation practi (Autonomous)**	**Improved adaptation practices (Planned adaptation)**

Is any change in house structure or position?
a. Yes b. No
Change in variety
a. Yes, b. No. If yes, why?
Change in technology

a. Yes b. No. If yes, why?
Irrigation management
a. Yes b. No.
Water source protection and improvement
a. Yes b. No.
Soil conservation activities
a. Yes b. No.
Rainwater harvesting and utilization
a. Yes b. No.
What adaptation strategies are practised by HHs level in response to perceived CC?

Class Adaptation Practices	**Corresponding adaptations**	**Practices you**	**From when**	**Institution**
Mobility	Wage labour migration			
	Moving animal			
Storage	Dam construction for irrigation			
	Food storage (crops, seeds)			
	Animal/Live Storage			
	Pest Control			
	Preserving trees around the wa source			
Diversification	Crop diversification			
	Change crop variety			
	Changing crop type			
	Change the planting date a harvesting date			
	Agriculture crop to vegetable			
	Changing from farm to non-fa activities			
	Increased use of water			
	Change from livestock to crop			
	Introduction of new crops			
	Change from crop to livestock			
	Drought resistant varieties			
	Decrease no. of livest (Destocking)			
	Diversify livestock feeds			
	Change on use of chemical a fertilizer			
	Increase land under production			
	Use of insurance			
Communal pool	Disaster preparation			
	Planting tree			
	Forest fire control			
	Silvicultural operations			
	Agro-Forestry promotion			

	Information gathering			
	Infrastructure development			
Exchange	Improved market access			
	Insurance provision			
	New products sales			

Are you satisfied with these adaptation measures?
a. Satisfy b. Not satisfied c. don't know
Have you noticed any change in agro-production after the adaptation measures?
a. Increase b. Decrease c. Same as before
Which institutions play essential roles in addressing these obstacles in this area?
i) DFO ii) NGO iii) FECOFUN iv) DDCO
v) DLDO vi) Red Cross vii) DADO viii) others……..

What are their activities/supports?

Institution/supports	**Physical**	**Technical**	**Financial**	**Information**	**Others**
DOF					
DADO					
DDCO					
DAO					
DLDO					
RED CROSS					
DSCIO					
VDC					
SEBAC Nepal					
AASTHA					
GaRDeF(Gangotri)					
Care Nepal					
Helvetas					

In your opinion, what types of assistance can help you to adapt CC impacts smoothly
What barriers have you felt when implementing coping mechanisms at the local level?

Barriers	**Tick the Barriers**	**Ranking of Barriers**
No access to money/credit		
No access /shortage of land		
No access to inputs (seed, fertilizer		
No access to water		
Shortage of labours		
Lack of knowledge of adaptation		
Pests and Diseases		
Soil Type		
Poor Infrastructures		
Education		
Lack of market		
No Barriers		

Other Barriers		

What activities do you suggest to overcome those barriers?

What are the factors that influence the adaptation of the main adaptation strategies?

Class of determinants	**Corresponding determinants**	**Influenced by you**
HHs Characteristics	Farmer experience	
	Education, age, gender, HH size of HHs head	
	Associations membership	
HH resources endowments	Access to land/farm size	
	Access to electricity, irrigation	
	Have animal power	
	Farm income and non-farm income	
Access to information	Weather forecasts	
	Free extension service	
	Information about CC and its adaptation	
Access to the formal instituti	Access to markets and information	
	Access to credit	
	Access to a public institution	
Other	Mean Annual temperature	
	Mean Annual Precipitation	

VITA

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INSTITUTIONS ATTENDED	Tribhuvan University
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