EFFECTS OF CLIMATE CHANGE ON AGRICULTURE:
A STUDY OF SIGAS RURAL MUNICIPALITY - 02, BAITADI, NEPAL

A Thesis

Submitted to

Faculty of Humanities and Social Science,
Central Department of Rural Development, Tribhuvan University
In Partial Fulfilment of the Requirement for the
Degree of Masters of Arts (MA)
In
Rural Development

Submitted by:

YADAV SINGH DHAMI
Central Department of Rural Development,
Tribhuvan University, Kathmandu

TU Registration Number.: 3-2-418-86-2016
Exam Roll Number: 2830026

January 2025

DECLARATION

I, Yadav Singh Dhami, hereby declare that the thesis entitled **"Effects of Climate Change on Agriculture: A Study of Sigas Rural Municipality - 02, Baitadi, Nepal"** rare entirely my original works have been prepared under the guidance and supervision of my supervisor, Associate Prof. Suman Kharel, PhD. This thesis has not been copied, published, or submitted elsewhere. All sources of information utilized in these studies have been properly acknowledged, cited, and included in the reference sections.

I have followed all research guidelines and ethical standards in conducting and reporting these studies. Any assistance and support received from others has been clearly acknowledged. I assure you that no part of these theses has been presented or published in any form before, nor have they been submitted for the award of any degree or for any other purpose. I take full responsibility for the content of these research studies.

____

Yadav Singh Dhami

T.U. Reg. No.: 3-2-418-86-2016

Date: 2081/09/16

31st December, 2024

RECOMMENDATION LETTER

This is to certify that Mr. Yadav Singh Dhami has completed the thesis entitled **"Effects of Climate Change on Agriculture: A Study of Sigas Rural Municipality - 02, Baitadi, Nepal"** independently, under my guidance and supervision, as part of the requirements for the Master of Arts in Rural Development, Tribhuvan University.

To the best of my knowledge, this study is original and provides valuable insights into the effect of climate change in agriculture. Therefore, I recommend this thesis for final evaluation.

____

Associate Prof. Suman Kharel, PhD

Central Department of Rural Development

Tribhuvan University, Kirtipur, Kathmandu

Thesis Supervisor

Date : 2081/09/18

2nd January, 2025

APPROVAL SHEET

This is to confirm that the thesis entitled **"Effects of Climate Change on Agriculture: A Study of Sigas Rural Municipality - 02, Baitadi, Nepal"** authored by Mr. Yadav Singh Dhami, meets the established standards of scope and quality. The thesis has been thoroughly assessed, approved, and deemed acceptable as part of the requirements for the Master of Arts degree in Rural Development.

Evaluation Committee

____

Associate Prof. Bishnu Bahadur Khatri

Head of the Department, CDRD

____

Assistant Prof. Ramesh Neupane

External Examiner

____

Associate Prof. Suman Kharel, PHD

Thesis Supervisor

Date : 2081/09/23

07th January, 2025

ACKNOWLEDGEMENTS

The study entitled “**Effects of Climate Change on Agriculture: A Study of Sigas Rural Municipality - 02, Baitadi, Nepal”** has been undertaken as a partial requirement for the fulfillment of the Master’s degree in Rural Development at Tribhuvan University.

At the outset, I would like to extend my sincere gratitude to my supervisor, Associate Professor Suman Kharel, for his invaluable guidance, constructive feedback, and unwavering support throughout the research process. His expert supervision provided meaningful insights and significantly contributed to the successful completion of this study. I am equally thankful to Associate Professor Bishnu Bahadur Khatri, Head of the Department, for allowing me the opportunity to conduct this research. Likewise, my sincere gratitude goes to the external examiner Assistant Professor Ramesh Neupane and profound appreciation also goes to all the faculty and administrative member for their cooperation and encouragement during my academic journey.

I am deeply grateful to Mr. Thagendra Singh Air, Ward Chairperson of Sigas - 2, and Junior Technical Assistant (JTA) Mr. Dipen Singh Dhami and Elderly Person Mr. Ram Singh Dhami, as well as Manoj Singh Dhami for facilitating a favorable environment to carry out the fieldwork. I also extend my heartfelt thanks to the respondents of Sigas -2 for their valuable time and willingness to share their perspectives, which were crucial for this research.

I am especially thankful to my dear friend, Mr. Rahul Aryal, for his continuous support and assistance during the research and field survey phases.

Lastly, I express my heartfelt appreciation to my classmates, friends, and family members for their academic and moral support. Their encouragement has been a driving force in completing this thesis. The successful accomplishment of this research would not have been possible without the contributions and support of the individuals mentioned above.

SELF-DECLARATION LETTER

PLAGIARISM TEST REPORT

ABSTRACT

Climate change is a pressing global issue, characterized by major and long-term variations in temperature and precipitation. Climate change is a serious issue that significantly affects security of food and agricultural productivity, particularly in highly vulnerable nations like Nepal. The main aim of this study, entitled "*Effects of Climate Change on Agriculture: A Study of Sigas Rural Municipality - 02, Baitadi, Nepal,*" is to explore how climate change affects agricultural activities and its production in that area. The research aims include examining rainfall and temperature trends, assessing their effects on agricultural production, and investigating the adaptation methods used by locals.

This study used a mixed-methods approach. Using surveys and key informant interviews with local stakeholders, both quantitative and qualitative data were collected. According to the findings, many people in Sigas Rural Municipality depend on agriculture for their livelihood, making them particularly vulnerable to climate changes. The Meteorology data show that climate variables have changed significantly in recent years, with less rainfall and higher temperatures, reducing crop yields and agriculture sustainability.

This study also underlines the issues that farmers face, such as higher insect and disease occurrences, changing cropping timelines, and water problems because of longer dry spells. Farmers adopted a variety of adaptation techniques in response to these problems. However, the effectiveness of these strategies varies according to resource availability and understanding.

Finally, this study also highlights the critical need for targeted actions and policy changes to strengthen agricultural resilience in the present threat of climate change. By combining local knowledge with modern agricultural practices, the study hopes to provide significant insights for policymakers and stakeholders. It can be beneficial to people who are involved in improving adaptive capacities in rural communities affected by climate variation. This study's findings hold significance for maintaining food security and long-term development in Nepal's agricultural sector regarding climate constraints.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS/ACRONYMS

ADB - Asian Development Bank

BBC - British Broadcasting Corporation

CAPA - Community Adaptation Plan of Action

CBS - Central Bureau of Statistics

CIAT - International Center for Tropical Agriculture

CO2 - Carbon Dioxide

CSA - Climate-Smart Agriculture

DFID - Department for International Development

EU - European Union

EUCAP - European Union's Common Agricultural Policy

FAO - Food and Agriculture Organization

GDP - Gross Domestic Product

GHGs - Greenhouse Gases

GoN - Government of Nepal

ICIMOD - International Centre for Integrated Mountain Development

IPCC - Intergovernmental Panel on Climate Change

INDC - Intended Nationally Determined Contributions

JTA - Junior Technical Assistant

KII - Key Informant Interview

LAPA - Local Adaptation Plan of Action

LI-Bird - Local Initiatives for Biodiversity, Research, and Development

MOE - Ministry of Environment

MoALD - Ministry of Agriculture and Livestock Development

NAPA - National Adaptation Programme of Action

NASA - National Aeronautics and Space Administration

NDC - Nationally Determined Contributions

NTNC - Nepal Trust for Nature Conservation

OECD - Organization for Economic Co-operation and Development

SDGs - Sustainable Development Goals

SLA - Sustainable Livelihoods Approach

SPSS - Statistical Package for the Social Sciences

UN - United Nations

UNFCCC - United Nations Framework Convention on Climate Change

US - United States

USDA - United States Department of Agriculture

VDC - Village Development Committee

WB - World Bank

WBG - World Bank Group

WMO - World Meteorological Organization

Chapter I: Introduction

1.1 Background of the Study

Climate change refers to changes in Earth's temperature and weather patterns over an interval of time. It is a natural event and necessary to recognize that human activities have significantly accelerated this process since the mid-1800s. The UNFCCC (1992) defines climate change as: "A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and which is in addition to natural climate variability observed over comparable periods". When analyzing the data of 30 years or more, the average change in various elements of climate (average temperature and average rainfall) is called climate change.

According to the Intergovernmental Panel on Climate Change (IPCC), "Climate change is a change in the climate that lasts for decades or longer, which is determined by the amount of change in the average value through statistical analysis, which is caused by internal natural processes or external factors or human activities in the composition of the atmosphere and land use".

According to the report of the sixth edition of the IPCC 2022, it has been proven that the earth is warming up due to human-made greenhouse gases (GHGs). Due to this, there has been a significant change in the weather and climate indicators. Similarly, global temperature is projected to increase by 1.5 degrees Celsius between the years 2030 and 2052 compared to pre-industrial times. It is predicted that monsoon rains in South Asia will increase after 2041, increasing the incidence of floods.

Due to various human-made activities, excessive growth of population, industrialization, use of minerals and fuels, fires, excessive exploitation of natural resources, etc., due to internal and natural processes or external factors, excessive amounts of greenhouse gases are being emitted, resulting in global warming. As a result, the Earth's regular climate process changes and climate changes happen. Such changes occur over a long period. In recent times, various scientific studies have confirmed that the emission of greenhouse gases has increased due to various human activities and the climate has changed (IPCC, 2023).

According to BBC News (2024), anthropogenic activities are causing the rise in global temperatures which is causing factor for more intense heatwaves and uprising sea levels. The world has become 1.2°C warmer than during the late 19th Century. It has been confirmed now that global warming surpassed 1.5°C across the 12 months between February 2023 and January 2024. This temperature rise was driven by human-caused climate change and advanced by the natural El Nino (warmer-than-average sea surface temperatures) weather phenomenon.

Human actions that release carbon dioxide (CO2) into the atmosphere, such as the burning of fossil fuels, the growth of infrastructure and industry, and conflicts, have contributed to long-term climate change. The released CO2 has increased in the atmosphere by 50 per cent after the Industrial Revolution (NASA, 2018).

The vulnerability situation is high in developing countries, as most of the population in these countries rely on agriculture and their knowledge of technical and financial capability to respond to this variability is low (Barrios et al., 2008). Due to a lack of resources for adaptation, poor nations are predicted to be the most affected, with almost half of the population potentially extremely sensitive to climate change. Governments from different countries signed the Sustainable Development Goals (SDGs) agreement in year 2015 to maintain global warming to 1.5C through net zero emissions by 2050 (BBC, 2024).

Agriculture is one of the major areas impacted by climate change. Agriculture and climate change are entangled together, with each having significant influence over the other. The agricultural sector is highly sensitive sectors to climatic conditions. Crop yields, livestock health, and the frequency of disease and pest infestations are all significantly affected by changes in temperature, precipitation, and extreme weather events. Agriculture significantly contributes to climate change by generating considerable greenhouse gas emissions through practices like deforestation, rice cultivation, and the use of inorganic fertilizers. The agriculture sector significantly contributes to climate change by generating considerable greenhouse gas emissions through practices like deforestation, rice cultivation, and the use of inorganic fertilizers. The interaction between these two factors is a major concern for food security and environmental sustainability (World Bank Group, 2022).

Agriculture's influence on climate change is equally complicated. The sector is responsible for a significant portion of methane and nitrous oxide emissions, both potent greenhouse gases. These emissions arise from the digestion of the animals, manure management, rice paddies, and the application of nitrogenous fertilizers. Deforestation for agricultural expansion further worsens climate change by reducing the number of trees available to extract carbon dioxide. Globally, Climate change is already impacting agricultural productivity. At the present rate of climate change, it will continue to impact (MoALD et al., 2019).

Nepal is among the most prone nations to climate change due to land topography, its reliance on traditional farming practices and monsoon rains. According to the Intended Nationally Determined Contributions (INDC) of Nepal (2016), despite contributing only 0.027 percent to global greenhouse gas emissions (GHGs), Nepal was ranked as the fourth most vulnerable country to the impacts of climate change (R. Sapkota & Rijal, 2016).

Changes in temperature and precipitation patterns and the frequency of extreme weather events are affecting crop yields and farming sustainability. Irregularity in rainfall and increased temperatures are leading factors to reduced crop yields, which is altering the food security and livelihoods of farmers. Climate changes have affected crop calendars and led to extended dry spells, reducing water availability. Increased incidence of pests and diseases has been reported, affecting crop yields (Katuwal & Rijal, 2015).

The global average temperature of the Hindu Kush Himalaya (HKH) section is greater than the global average (Dhimal et al., 2021). The western part of Nepal is more prone to temperature rise than the eastern part. The agriculture sector contributes significantly to Nepal's GDP, though this contribution has been decreasing over the years. Given that 64% of Nepal's cultivable land is rain-fed, the country's agriculture is extremely vulnerable to climate change. Variations in temperature and precipitation patterns have already impacted crop yields, particularly cereals. Increased temperatures lead to higher pest populations and more severe crop diseases (Giri & Dahal, 2021).

Nepal is a developing country which has a population of 25 percent that lives under the poverty line (Pokharel, 2015). In Nepal, agriculture is the dominant sector of the country. Agriculture households account for 62 percent of the total households in

Nepal, and it contributes to 23.9 percent of the nation's GDP (CBS, 2021a). Agriculture is a source of livelihood for most of the rural population. Climate change has caused problems in the national economy by disturbing the agriculture sector.

To reduce and adapt the consequences of climate change, the Government of Nepal (GoN) has put together several programs, policies, and strategies. Local Adaptation Plan of Action (LAPA) and National Adaptation Program of Action (NAPA) are some of the initial works by the government of Nepal towards climate change. NAPA was built on information obtained from in-person interviews with Nepali development specialists as well as qualitative and quantitative examination of publicly available documentation. NAPA presented several observations, analysis, and recommendations for enhancing the LAPA process (Peniston, 2013). The NAPA was endorsed in 2010 for climate adaptation planning and implementation. According to the NAPA, the government plans to directly fund the implementation of specific adaptation projects at the local level with at least 80% of the available money. The NAPA also focuses on ensuring that national adaptation planning provides support for adaptation by local communities, particularly the climate-exposed poor (Peniston, 2013).

Climate change affects everyone’s lives, but it affects more of the people who are economically poor and sensitive to its effects. Various documents and research have shown that climate change impacts the environment biodiversity, water resources, agriculture, health, education and more sectors of Nepal. The individuals whose primary source of income is directly dependent on agriculture are likely to be more affected by it. Few people of Nepal are involved in commercial farming and others are involved in subsistence farming. These individuals who are directly involved in agriculture for a living are the ones who are and will be facing the challenges of climate alteration.

This study was conducted in Sigas Rural Municipality of Baitadi district, Sudurpaschim Province to identify the effects of climate change on agriculture.

1.2 Statement of the Problem

In Nepal, agriculture employs over 60% of the people, and climate change is having a serious negative effect on this sector. The biological diversity of Nepal is already being seriously impacted by climate change. Glaciers are melting, precipitation extremes are happening more often, and the ranges of animals are relocated to higher elevations. Natural calamities like river floods, droughts, heat waves, glacial lake outburst flooding, rising temperatures, shifting precipitation patterns, and an increase in the frequency and severity of extreme weather events are likely to occur in the upcoming days. These calamities will put human life at risk and will have profound implications for crop yields, livestock health, and overall agricultural productivity. Modelling suggested the number of people annually impacted by flooding can double by 2030 due to climate change. Additionally, the financial consequences of river floods may triple (WBG & ADB, 2021).

Vulnerability in hilly regions has forced the rural population to migrate to different areas. The trend of migration from the mountains to the hills or the hilly to the plains or terai regions has been increasing every year. Additionally, due to the remittance-based economy of the country, the inflow of remittances was NPR. 875.03 billion in the fiscal year 2019/20 (MoF, 2021). Nepali individuals of working age, typically 15 years of age or older, are working in more than 110 countries, especially in Gulf countries and Malaysia.

Between 1977 and 1994, Nepal experienced an average annual temperature increase of 0.06°C, with the rate rising to approximately 0.41°C per decade (CARE, 2009). Such changes have led to natural hazards, negatively impacting development and livelihoods. Crop yields are decreased by land degradation, which also puts strain on the remaining fertile land. Rapid evaporation during the dry season leads to droughts, forest fires, pest outbreaks, water scarcity, and deficiencies in soil moisture, all of which reduce crop yields. Locals have observed increased floods, landslides, and changing rainfall patterns (Dahal, 2009). Nepal's climate varies due to its high altitude from 60 to 8,848 meters above sea level, creating diverse agro-climatic zones from subtropical to alpine and tundra. Climate change affects agricultural yields and pressures limited fertile land. In dry seasons, it leads to water scarcity, drought, soil moisture deficits, and forest fires, potentially causing pest outbreaks. Climate change is unpredictable, with South Asia being one of the most vulnerable regions. Temperature fluctuations in mountainous areas have an impact on local activity (Regmi 2013).

Forest fires, floods, landslides, and droughts severely impact rural populations, whose livelihoods depend on climate-sensitive agriculture. While they have adapted using traditional knowledge, the current climate changes are overwhelming. Limited livelihood diversity makes it crucial to understand the impact on rural communities to plan support programs for resilience. Understanding rural knowledge is essential for recommending appropriate climate adaptation techniques (Dhakal et al., 2016). Despite significant temperature and rainfall changes, Nepal lacks detailed studies and publications on specific climate change impacts. Climate change cannot be completely stopped, but its impact can be mitigated through proper awareness and adaptation (Adger et al., 2003). Literacy, awareness and capacity are major barriers, along with a lack of research and credible evidence. Most studies focus on high altitudes and glacial retreats. Educating local communities and utilizing their knowledge for adaptation practices is essential (Adhikari, 2011).

1.3 Research Questions

This thesis study about climate change aims to answer the following critical questions:

1. What is the pattern of rainfall and temperature in the study area?
2. What effects has climate change had on agricultural practices and yields, and what production problems do farmers face?
3. What adaptation measures have farmers implemented to minimize the risk of climate change on cultivation, and how much effective these measures are?

1.4 Objectives of the study

The general objective of the study is to analyze the effect of climate change on agriculture. The study was conducted in Sigas Rural Municipality of Baitadi District, Sudurpaschim province.

The specific objectives of the study are:

1. To examine the trend of climate change in Sigas Rural Municipality -2.
2. To assess the effects of climate change on agriculture production.
3. To analyze the adaptation strategy applied by farmers in Sigas Rural Municipality -2.

1.5 Significance of the study

The importance of this study includes agriculture, the impact of climate change, and climate change adaptation strategies applied by people living in the Mahabharat range of the Far Western region of Nepal. The study aims to provide recommendations at the policy and local levels for readers, stakeholders, state actors, ICIMOD, and policymakers. It is valuable for policymakers, researchers, students, and anyone interested in understanding the characteristics of farmers and their adaptive strategies. Shifts in temperature and rainfall patterns are a leading cause of more frequent crop failures, pasture shortages, and an increase in pests, diseases, and parasites. This study's aim is to identify how climate change affects the agriculture sector in Nepal, how farmers perceive these changes, and the strategies they adopt to cope. Despite Nepal's least contribution to global greenhouse gas (GHG) emissions, Nepal is experiencing alarming temperature increases. This has significantly impacted natural resources like water, forests, and land making local-level studies essential.

As climate change continues to alter rainfall patterns and temperature, agricultural production and productivity are declining, emphasizing the need for urgent local studies to blend traditional knowledge with modern adaptation strategies. This study focuses on the mid-hills of Nepal, an area known for diverse agricultural production, and aims to provide insights into the impact of climate change and the adaptation methods used by farmers.

1.6 Limitations of the study

The study has been affected in several different ways due to several limitations. The following are the construct limitations of this study:

1. This study is based on a descriptive approach under quantitative and qualitative approaches.
2. The study focused on the effects of climate change on agriculture and the adaption measures utilised by local communities.

The construct delimitations associated with this study are as follows:

1. This study was completed in Sigas Rural Municipality -2 of Baitadi.
2. The respondents residing in ward no. 02 were selected purposively.
3. The effects of climate change like drought, flood, climate alteration influence, individual characteristics, society and market functions were also assessed.

Thus, this research investigation has concluded using supervised information acquired from 120 participants or respondents.

1.7 Organization of the Study

This study is organized into five chapters. The first chapter discusses the study's introduction, background, problem of statement, objective, significance, limitations, and organization. The second chapter includes conceptual, theoretical, and empirical reviews, as well as a policy review. The third chapter discusses research methodology, which includes the study area, research design, sources and nature of the study, population and sampling, data gathering procedures and instruments, and data presentation and analysis. The fourth chapter is data analysis and presentation of both primary and secondary data acquired from the field visit and DHM. Finally, the last chapter contains a summary, conclusion, and recommendation.

Chapter II: Literature Review

2.1 Conceptual Reviews

Climate refers to the average weather. It is defined scientifically as the average and variability of important variables over period intervals ranging from months to hundreds or millions of years. The United Nations Framework Convention on Climate Change (1992) defines climate change in Article 1 as follows; "A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and which is in addition to natural climate variability observed over comparable times periods".

Climate change is defined as the fluctuation in average weather and, ultimately, the status of the climate system over a specific time. This fluctuation is typically reflected in changes in mean temperature, precipitation, and rainfall levels, among other indicators. Natural variables such as daylight intensity, volcanic activity, and animal grazing, as well as anthropogenic causes such as fossil fuel combustion, deforestation, and other human activities, can all contribute to climate change (Crate & Nuttall, 2009).

Climate change is related to specific places and regions, which are typically reflected by climatic and non-climatic indicators. People are always aware of the local events in their surroundings, whether they are related to the climate or not, but they achieve it through a concept. The dynamic nature of the human-environment link informs and structures perceptions of climate change; farmers made sense of local climate using categories that were not related to or determined by traditional weather cycles (Vedwan & Rhoades, 2001).

Gas emissions into the atmosphere, industrialization, urbanization, water diversion, pollution of cities and waterways, the building of thousands of dams and lakes, the conversion of grassland or forest to cropland, and agricultural practices are all examples of human activities that have the potential to alter the climate (Garbrecht & Piechota, 2005).

Through variations in rainfall, average temperatures, and climatic extremes, such as disease, pests, and hot waves. The poor and other vulnerable groups will be more at risk of food insecurity because of climate change. Agriculture production is directly impacted by climate change because it is weather-sensitive (Nelson et al., 2014; World Bank, 2005).

The statistical distribution of weather over decades to millions of years is known as climate change. It can also be defined as a long-term change in the earth's climate, or in a specific location, a region, or the entire world. The global temperature has increased in the last few decades since 1850, the global temperature has braised from 0.6 degrees Celsius to 0.7 degrees Celsius approximately (IPCC, 2007).

Without understanding the distinction between the two, people frequently use the phrases weather and climate to refer to the same phenomenon. A location's weather is determined by measuring and characterising the conditions there at a specific moment. In contrast, climate is a vague concept. According to Dash (2007), it is the sum of all atmospheric events at a location within a specific period of the year. Therefore, the average weather conditions seen over extended periods for a particular place are referred to as the climate.

To comprehend climate change, it is vital to distinguish between weather and climate, which are mutually exclusive events with complex effects on human existence and activity on Earth.

Table 2.1 Difference between weather and climate.

Weather	**Climate**
Weather refers to the short-term changes in the atmosphere of a specific location.	Climate refers to the average weather conditions in a certain location over time.
Depending on the season, it may change from morning to afternoon and day to day.	Like the weather, the climate is generally steady over many years rather than changing with the seasons, day, or hour.
For example, being cold or cool in the morning before the sun rises, warm in the middle of the day when the sun is shining, cool instead of warm as the sun shines when there is a strong wind, in the evening, as night falls, it becomes cooler again. In the same way, weather changes month after month according to the season.	For example, last year's winter and this winter (temperature) are almost the same. Similarly, in the experience of winter, summer, rain etc., the characteristics of seasons and months remain the same for years. If there is a global change in climate conditions, it is understood that climate change has occurred, and it becomes a matter of international concern.

Source: Oxfam, 2023

We need to understand each of these five systems to recognize the Earth's climate and how it is shifting (IPCC, 2001):

- The atmosphere is composed of a thin layer of gas that surrounds the Earth.
- The lithosphere includes both natural surfaces like dirt and rocks, as well as man-made structures like highways and buildings.
- The hydrosphere refers to the liquid water on Earth, including the seas, rivers, lakes, and subterranean.
- The cryosphere is composed of frozen water in ice and snow.
- The biosphere layer of the earth includes plants, animals, and humans.

As global temperatures rise, heat waves become more often, the lower atmosphere and deep oceans warm, frosts disappear, and glaciers and snow melt. Climate change was first discovered in the eighteenth and nineteenth centuries. Half a decade after the discovery of global warming in 1967, computer simulations showed that the global temperature may rise by exceeding 15.55 degrees Celsius depending on CO2 saturation. Then, 20 years afterwards, an iceberg sample from Antarctica showed a link between greenhouse gases and temperature that goes back over 100,000 years (IPCC, 2007; Singh & Lal, 2010).

Scientists predict that an increase in greenhouse gas concentrations will raise the average global temperature. Since 1950, records show that the frequency of cold days and nights has decreased, while the total number of extremely hot days and nights has risen. Long-term climate change is observable on a continental, regional, and ocean basin scale due to rising greenhouse gas concentrations, primarily carbon dioxide. Variations in wind patterns, polarizing temperatures, precipitation levels and timings, and extreme weather components such as heat waves, drought, and heavy precipitation are all examples (IPCC, 2007).

According to the WMO survey, the most national records for 24-hour extreme precipitation events have been set in the last two decades, from 1991 to 2010. Global land-surface precipitation averaged from 2001 to 2010 was higher than the 1961-1990 average. It was the wettest decade since 1901, apart from the 1950s. Meanwhile, 2010 was the wettest year in the planet's recorded history. Previous wettest years included 1956 and 2000 (WMO, 2013).

One of the main causes of climate change is believed to be global warming. Scientific study indicates that the increase in greenhouse gas concentrations in the atmosphere has contributed to global warming (AL com and Press-Register staff, 2011). Deforestation and the use of fossil fuels (coal, oil, and natural gas) are the reasons for the increased concentration of carbon dioxide. From 315.98 parts per million in 1959 to 389 parts per million in 2008 and 421.08 parts per million in 2024, the concentration of carbon dioxide (CO2) emerged globally (Gautam, 2010; Tiseo, 2024).

On the positive side, winters will be shorter and high-altitude regions can produce more vegetation. The spread of diseases linked to mosquitoes, including dengue fever, West Nile virus, Ross River virus, and malaria, may be accelerated by climate change (TheClimateInstitute, 2013).

The Nepal Agricultural Research Council (NARC) has warned that crops like wheat and millet would be more severely impacted by rising temperatures brought on by global warming. Higher temperatures would shorten the vegetative state of certain crops, limiting productivity. All these scenarios demonstrate how farming systems may shift in response to climate change (Upreti, 2013; Kandangwa, 2016).

The exponential rise in carbon dioxide along with other greenhouse emissions in the atmosphere is causing climate change (Abouhussein, 2012). Temperature, solar radiation, and precipitation are all climate variables that might affect crop yield. Between 1975 and 2006, the country's temperature increased by 1.80 degrees Celsius on average, with an annual increase of 0.060 degrees. The research on the carbon dioxide enrichment technique at Khumaltar discovered that doubling CO2 improved rice and wheat yields by 26.6 percent and 18.4 percent, respectively, while temperature rise increased them by 17.1 percent and 8.6 percent (Malla, 2009).

Climate change has become a significant and costly concern for climate-vulnerable people and communities as anthropogenic greenhouse gas emissions have increased. Landlocked and mountainous nations like Nepal are most affected by climate change. Climate change poses a significant concern to Nepal. More than 1.9 million people are highly climate-wise vulnerable, and 10 million are at risk, with climate change predicted to significantly increase this number in the coming years (MOE/NAPA Project, 2010). In terms of food security and farming, local people have pointed out climate change as a major contributor to decreased agricultural and livestock productivity. Winter and spring crops suffer when rainfall decreases from November to April (Dawadi et al., 2022). Rice yields are especially vulnerable to climate circumstances, and they may fall in the western region, where a bigger proportion of the poor dwell, jeopardising overall food security (MOE, 2010). It was discovered that the observed rise in anthropogenic GHG concentrations was most likely the cause of the increase in world average temperatures since the middle of the 20th century (Abraham et al., 2014; IPCC, 2007).

In Nepal, temperatures have risen by 1.8 degrees Celsius, with an average increase of 0.06 degrees Celsius over the last 32 years. Also, hilly and higher hills are particularly prone to climate change. The pattern of precipitation is also described as inconsistent and unexpected, with greater levels of rainfall and fewer wet days, resulting in a drought for a brief period and torrential downpours that destroy several lives and properties. Changes in hydraulic cycles and the loss of water sources were the primary concerns facing Nepal in terms of climate change (Acharya & Bhatta, 2013; Malla, 2009).

2.2 Theoretical Review

In this part of the literature review, theories that are relevant to climate change and agriculture are introduced. Theoretical gaze facilitates a researcher to explore fields of knowledge that shape the relationship between local actors, stakeholders, and beneficiaries, including the researchers (Long & Long, 1992). Hence, this study brings theoretical gazes from, vulnerability and adaptation theory, climate-smart agriculture (CSA), and sustainable livelihood approach (SLA).

2.2.1 Vulnerability and Adaptation Theory

The Vulnerability and Adaptation Theory of climate change provides a framework for understanding how agricultural systems are affected by climate variability and how they can adapt to mitigate these impacts. Vulnerability is defined as the degree to which a system is sensitive to harm due to climate hazards, which include extreme weather events, changing precipitation patterns, and rising temperatures. This theory distinguishes between biophysical vulnerability, which relates to the physical impacts of climate hazards, and social vulnerability, which encompasses socio-economic factors that influence a community's ability to cope with these hazards. The IPCC highlights that vulnerability is a consequence of exposure to climate hazards, sensitivity to their impacts, and adaptive capability. Hence, it is critical to consider these dimensions when evaluating agricultural systems' resilience to climate change. (Brooks, 2003; Suranny et al., 2022).

Several sectors face severe obstacles because of climate change, but agriculture is particularly vulnerable. The vulnerability and adaptation theory emphasizes the importance of assessing a system's vulnerability and its resilience to adapt to the shifting climate. The degree to which a system is affected by climate change consequences, such as rising temperatures, shifting precipitation patterns, and extreme weather occurrences, is referred to as exposure. Sensitivity refers to how much a system is influenced by these changes, whether positively or negatively. The ability of a system to adjust to climate change, mitigate potential harm, seize opportunities, or manage impacts is known as adaptive capacity (MHFW, WHO Bangladesh, 2016).

Adaptation strategies in agriculture can take various forms, including technological innovations, changes in farming practices, and policy interventions. For instance, the development and adoption of drought-resistant crop varieties and improved irrigation techniques can significantly enhance resilience to climate variability. Furthermore, agroecological practices, which emphasize biodiversity and sustainability, can help farmers adapt to changing conditions while maintaining productivity. The role of local knowledge in adaptation is vital, as farmers often possess insights into their specific environments that can inform effective strategies. Involving farmers in decision-making processes through community-based approaches can result in adaptation measures. These measures are more tailored to specific contexts and culturally relevant, ultimately improving the adaptive capacity of agricultural systems (Brooks, 2003; Suranny et al., 2022).

The interaction between social and biophysical vulnerabilities is particularly important in agriculture. Poverty, inequality, and limited resources all create social vulnerability. These factors can increase the effects of climatic hazards on agricultural production. For example, marginalized communities may lack the financial resources to invest in adaptive technologies or may have limited access to information about climate risks. This highlights the importance of coordinated approaches that address both social and biophysical deficits (Prescott et al., 2022). Policies that promote social equity, improve access to resources, and enhance education about climate risks are essential for building resilience in agricultural systems. Additionally, external factors, such as market fluctuations and policy environments, can also impact a community's adaptive capacity, highlighting the need for a multi-scale approach to adaptation (Brooks, 2003; Suranny et al., 2022).

Ultimately, the success of adaptation strategies in agriculture relies on a comprehensive understanding of the interplay between vulnerability and adaptation. Policymakers must prioritise incorporating climate change adaptation into agricultural plans and bigger development frameworks. This includes recognizing the specific vulnerabilities faced by different communities and tailoring adaptation strategies accordingly. By tackling the underlying socio-economic factors that contribute to vulnerability and enhancing adaptive capacity, we can develop resilient agricultural systems. These systems will be better equipped to withstand the impacts of climate change, ensuring food security and sustainable livelihoods for future generations (Brooks, 2003; UNFCC, 2007).

2.2.2 Climate Smart Agriculture (CSA)

Climate-smart agriculture (CSA) represents an advanced approach to adapting agricultural practices in response to the challenges posed by climate change. This methodology aims to enhance the resilience of agricultural systems while promoting sustainable development initiatives. The Food and Agriculture Organisation (FAO) of the United Nations established CSA in 2009. It emphasises the interconnection of agricultural advancement, food safety, and climate change (FAO, 2013). It seeks to achieve three key goals: boosting agricultural productivity and incomes in a sustainable manner, adapting to climate change, and lowering greenhouse gas emissions to as much as possible (Lipper et al., 2014). These objectives are interconnected and must be viewed holistically to maximise synergies while minimising trade-offs.

CSA is more than just a set of practices; it is a holistic approach that addresses the challenges at the centre of climate change and agriculture. It incorporates several key components, including a systems approach that looks at challenges in a holistic manner, intentionality in considering how climate change impacts agricultural activities, and the pursuit of multiple benefits by integrating various approaches (FAO, 2013). Additionally, CSA emphasizes context specificity, tailoring practices to relevant geographical, socio-economic, political, cultural, and environmental factors, while also adopting a long-term perspective that acknowledges short-term needs alongside future climate uncertainties (World Bank, 2024).

For developing countries, where farming is often at the mercy of rain and climate variability, CSA's relevance is profound. It's not just about feeding people today but ensuring long-term sustainability. By embedding adaptation strategies into agricultural policies, these nations can better weather climate shocks and cut emissions from traditional farming practices. This dual focus on adaptation and mitigation is a linchpin for sustainable development goals like poverty reduction and environmental sustainability (FAO, 2013; World Bank, 2024).

By implementing CSA practices and technologies that are tailored to specific contexts, the approach aims to achieve a "triple win." The focus is on boosting productivity and incomes while also improving resilience and adaptation to climate change. Additionally, it aims to decrease greenhouse gas emissions and promote carbon sequestration (Lipper et al., 2014, 2018). Some of the practices associated with CSA include adopting climate-resilient crop varieties, utilizing conservation agriculture techniques, implementing agroforestry systems, employing precision farming methods, and improving livestock management strategies (FAO, 2013). Through these integrated efforts, CSA seeks to create a sustainable agricultural future that is resilient to climate change while ensuring food security for all.

2.2.3 Sustainable Livelihoods Approach (SLA)

One concept that has been widely incorporated into development techniques, especially in rural regions of the global south, is the Sustainable Livelihoods Approach (SLA). It was first introduced in the early 1990s and has since become a cornerstone in understanding and addressing poverty and livelihood issues (Eng & DFID, 1999; Natarajan et al., 2022). The SLA promotes a comprehensive and dynamic perspective that centres on the skills, resources, and attempts required for individuals to accomplish favourable livelihood results. It rejects the conventional sectoral approaches, instead involving people in the identification and implementation of activities that enhance their livelihoods (FAO, 2006; Sapkota, 2021).

At its core, the SLA is people-centred, holistic, and dynamic. It recognizes that poverty is a multifaceted issue that goes beyond mere income or consumption levels (Ashley & Carney, 1999). The approach highlights the importance of various assets, including natural, physical, human, financial, and social capital, which individuals and households must combine to achieve sustainable livelihoods (Natarajan et al., 2022). The framework also underscores the need for macro-micro linkages, ensuring that policies and interventions are aligned with the needs and perspectives of local communities (FAO, 2006).

In the context of Nepal, the Sustainable Livelihoods Approach is particularly relevant given the country's significant dependence on agriculture. Approximately 80 percent of Nepali people rely on agricultural activities for their livelihood. This makes farmers crucial to the country's economic orientation (NTNC, n.d.). The SLA in Nepal focuses on enhancing the capabilities and assets of rural households, especially those engaged in subsistence farming. It involves integrating modern scientific methods with traditional practices to improve agricultural capacity and promote market-driven farming systems (NTNC, n.d.). This approach also addresses the challenges posed by climate change, land use changes, and genetic diversity loss in agriculture, aiming to build resilience among smallholder farmers (LI-Bird, 2024).

In Nepal, organizations like the Nepal Trust for Nature Conservation (NTNC) and other development projects have implemented the SLA to improve rural livelihoods. These initiatives involve training and skill-building exercises, material support, and the promotion of agroecological farming practices that conserve biodiversity and adapt to climate change (LI-Bird, 2024; NTNC, n.d.). The approach emphasizes the empowerment of local people, particularly women and marginalized communities, through information sharing and capacity building. By focusing on local strengths and capacities, the SLA aims to contribute to sustainable livelihoods and increase the overall welfare of rural hamlets in Nepal (FAO, 2006; Sapkota, 2021).

2.3 Policy Review

Climate change poses a significant challenge to global agriculture, necessitating comprehensive policies that address both mitigation and adaptation strategies. Various nations and supranational organizations have developed frameworks to tackle the influence of climate change on agricultural systems. The policies aim to enhance resilience, ensure food security, and foster sustainable practices that decrease greenhouse gas emissions.

One notable initiative is the European Union's Common Agricultural Policy (EUCAP) for 2023-2027, which aligns agricultural practices with climate goals outlined in the European Green Deal. The Common Agricultural Policy took on a sustainable kind of farming by offering financial support for practices that will reduce greenhouse gas emissions and favour biodiversity. The Member States should develop strategic plans corresponding to local needs meanwhile contributing to the simple objectives of the climate policy of the European Union (EU). These also include conditionality rules on the linking of payments with environmental standards and eco-schemes that compensate farmers for climate-friendly practices, such as soil health and wetland protection (EU, 2024; OECD, 2023).

In North America, the United States (US) has implemented the Climate-Smart Agriculture (CSA) framework, which focuses on integrating climate considerations into agricultural practices. In this model, farmers are encouraged to adopt technologies and practices that enhance productivity while reducing emissions. The United States Department of Agriculture (USDA) supports CSA through the funding of research and development into practices such as agroforestry and precision agriculture. It is intended that this will generate an agricultural sector at large, resilient to changing climatic conditions, while at the same time contributing to national emission reduction targets (OECD, 2023; World Bank, 2024).

The World Bank (WB) has increased investments in climate smart agriculture (CSA) manifold at the worldwide level, realizing its critical role in meeting the goals of the Paris Agreement. The operational climate change action plan at the Bank stresses the interlinked objectives of increasing productivity, enhancing resilience, and lowering emissions. In that perspective, the alignment of projects with climate goals at the World Bank therefore should aim at helping countries implement Nationally Determined Contributions (NDCs) relevant to agriculture (World Bank, 2024). This holistic approach undergirds the need for a greater, more comprehensive integration of climate consideration within agricultural policy frameworks around the world.

The United Nations Framework Convention for Climate Change (UNFCCC) has a significant part in shaping agricultural policies globally. Reports from UNFCCC have cropped up to underline the centrality of adaptation measures in agriculture, encouraging countries to embark on meaningful strategies that respond not only to immediate but also to long-lasting sustainable impacts. The UNFCCC calls upon all member states to share best practices and collaborate on initiatives about the confrontation of food production to climate change (OECD, 2019, 2023).

Nepal has developed various policies to combat the challenges presented by climate change, particularly in the agricultural sector, which is a key driver of the country's economy. The National Adaptation Programme of Action (NAPA), established in 2010, laid the groundwork for addressing climate vulnerabilities and adaptation strategies. This program identified agriculture as one of the key sectors most vulnerable to climate impacts. NAPA emphasized enhancing farmers' adaptive capacities through training and the introduction of climate-resilient practices and technologies, which are essential for sustaining agricultural productivity under changing climatic conditions (FAO, 2019; MOE, 2010; Thakur, 2018).

The Community Adaptation Plan of Action (CAPA) and the Local Adaptation Plan for Action (LAPA) are two important frameworks that Nepal has created to deal with the consequences of climate change locally. To help incorporate climate resilience into local development planning, with an emphasis on vulnerable communities at the Village Development Committee (VDC) and municipality levels, the Nepalese government formally approved LAPA in 2011 as part of the National Adaptation Programme of Action (NAPA) (Ghimire & Chhetri, 2022; GoN, 2011; Rai et al., 2015). To ensure that local perspectives are included in more comprehensive climate policies, the CAPA supplements the LAPA by providing community-specific adaptation strategies. These plans are significant because they allow communities to prioritize actions that improve resilience and identify climate challenges, thereby linking local adaptation efforts to national climate change policies (Ghimire & Chhetri, 2022; Rai et al., 2015). Even though LAPA and CAPA are critical, there are obstacles to their effective implementation, particularly in terms of obtaining adequate funding and institutional capacity locally (Ghimire & Chhetri, 2022; Peniston, 2013).

In 2011, Nepal adopted the Climate Change Policy, which aimed to incorporate climate change considerations into national development planning. This policy recognized the important part of agriculture in the economy of the country. Agriculture contributed about one-third of the total Gross Domestic Product (GDP) while employing two-thirds of the total population. It called for strategies that promote sustainable agricultural practices while reducing greenhouse gas emissions. The policy also encouraged research and development in climate smart agriculture (CSA). It aimed to boost productivity and resilience among small landholder farmers who are most exposed to climate variability (MoALD et al., 2019; Thakur, 2018).

By 2019, Nepal further refined its approach with the "Integrating Climate Change Adaptation into Agriculture Sector Planning" handbook, which provided detailed guidelines for integrating climate adaptation strategies into farming guidelines and practices. This document outlined specific measures to address vulnerabilities in agriculture, including improving irrigation systems, promoting agroforestry, and enhancing soil management practices. It eased less difficult for local and national agriculture planning processes to better include climate change adaptation (MoALD et al., 2019).

Since the agriculture sector is responsible for more than half of Nepal's greenhouse gas emissions, the effects of these policies are important. The government has recognized that improving practices related to cattle management and crop production is important for both mitigating emissions and adapting to climate impacts. For instance, initiatives promoting stress-tolerant crop varieties and efficient fertilizer use are critical components of Nepal's strategy to enhance agricultural resilience (Acharya & Bhatta, 2013; MoALD et al., 2019).

Addressing the connection between climate change and agriculture necessitates coordinated efforts among nations and international organizations, as illustrated by policies such as the European Union's Common Agricultural Policy (EUCAP), the United States' Climate Smart Agriculture (CSA) framework, and initiatives from the World Bank and UNFCCC. These frameworks reflect an increasing recognition of the need for sustainable agricultural practices that not only adapt to but also mitigate climate change impacts globally, which is vital for ensuring the stability of food and protecting environmental resources for future generations. In Nepal, policies like the Climate Change Policy of 2011 and the National Adaptation Plan (NAP) for Agriculture established in 2019 demonstrate a growing awareness of the complex relationship between climate change and agriculture. By aligning its national strategies with global frameworks set by organizations such as the UNFCCC, Nepal aims to strengthen its agricultural sector against climate-related challenges while contributing to worldwide efforts to combat climate change. These initiatives highlight the importance of comprehensive policy frameworks that address immediate agricultural needs while promoting long-term sustainability in a changing climate. The urgency of these efforts is underscored by Nepal's vulnerability to climate impacts, which threaten agricultural productivity and food security for millions of its citizens.

2.4 Empirical Review

In this section of the literature review, summary and analysis of the past writing from various sources, studies and study findings related to the effects of climate change on agriculture. This section focuses on how previous researchers have approached the subject through empirical methods (e.g., surveys, experiments, case studies etc.).

Aggarwal and Mall (2002) examine rice production in India, focusing on the role of climate variability in influencing rice yields. Their work highlights the uncertainties of modelling future scenarios, particularly in areas with different climate conditions. Challinor with other authors (2007) focused on Africa, where they assessed the exposure of food crop systems to climate change. Their findings emphasize the need to account for climate variability when planning agricultural production in Africa, a region where food insecurity is prevalent.

On a global scale, Fischer et al. (2005) take a collective approach, combining socio-economic factors and climate projections to predict agricultural vulnerabilities up to 2080. They forecast significant challenges for global agriculture, particularly for the world's poorest regions. To address both food security and climate change, Lal (2004) focuses his attention on possible mitigation techniques and promotes the retention of carbon in soil. He claims that crop rotation and other sustainable farming methods can improve soil health and reduce carbon emissions at the same time.

Rosenzweig and Parry (1994) provide a broader perspective on global food production, warning of the risks posed by climate change to crop yields. They predict that without significant adaptation efforts, global food production could suffer, with developing regions facing the greatest threats. Easterling et al. (2007) resound these concerns, particularly for regions like Sub-Saharan Africa and South Asia, where climate change is expected to worsen food security by significantly reducing crop yields. To protect food security in the face of climate change, these findings collectively highlight the necessity of both adaptation and mitigation techniques in agriculture.

The average annual rainfall has dropped by 10.21 mm during the last 30 years, but the average annual temperature has risen by 0.02°C. These changes have affected soil moisture and crop yields despite being statistically insignificant. High-yielding crop varieties, improved irrigation systems, hybrid seeds, and more pesticide use are some ways that farmers have adapted. From 1999 to 2014, these actions resulted in higher yields of important crops, including rice, maize, wheat, sugarcane, potatoes, and lentils. However, the cost of production has risen significantly due to these adaptations. To create successful adaptation plans, the study highlights the necessity of comprehending climate variability and how it affects agriculture (Dhakal et al., 2016).

Nepal, while contributing minimally to global greenhouse gas emissions, stands as one of the most vulnerable nations due to its fragile ecosystem and diverse topography. The country's reliance on critical sectors such as agriculture and hydroelectricity further heightens its sensitivity to the impacts of climate change. The increase in temperature in the country is higher than the average world rise. Temperatures and precipitation unpredictability are seen to rise significantly by the end of this century. This type of change promotes climate-induced hazards like floods, landslides, droughts, and glacial lake outburst floods, hitting directly at the economy of the nation and people's livelihood. Agriculture of Nepal is a vital economic and food security sector and is extremely vulnerable. Climate change is predicted to impact agricultural production by reducing yields and increasing pest and disease occurrence. This leads to direct economic impacts at the farm-scale level, as well as broader socio-economic consequences and adaptation costs. Changes in food production might cause serious financial consequences and threaten the livelihood of a significant proportion of the people (Sapkota & Rijal, 2016).

Climate change significantly threatens agricultural production in Nepal, a sector that is vital for the livelihoods of approximately 66 percent of the population. The diverse geography of the country, which ranges from lowland Terai plains to the towering Himalayas, results in varied climatic conditions that uniquely affect agricultural practices across different regions. Droughts and floods are becoming increasingly common and severe due to changing precipitation patterns and rising average temperatures. These changes disrupt planting and harvesting cycles, jeopardizing crop production, specifically for essential crops like rice and maize. Additionally, soil degradation exacerbated by climate impacts further diminishes fertility and increases susceptibility to pests and diseases. The economic ramifications of these climatic shifts are profound, as reduced agricultural productivity threatens food security and pushes farming households into deeper poverty. To combat these challenges, there is an urgent need for adaptive strategies that enhance the resilience of agricultural systems. This includes improving irrigation infrastructure, adopting climate-resistant agricultural practices, and diversifying crop production. Integrating these adaptation measures into national agricultural policies is crucial for ensuring food security and sustaining rural livelihoods in Nepal amidst ongoing climate changes (WBG & ADB, 2021).

Climate change is a big threat to Nepal's agriculture with rising temperatures, irregular rainfall and unpredictable weather outcomes reducing crop yield and food security. Maize, potatoes, sugarcane, and lentils are expected to yield less. Additionally, livestock farming, essential for 70 percent of agricultural households, will suffer from degraded pastures, heat stress, and disease risks. Climate-induced agricultural loss can lead to 2.2 percent of GDP by 2050 under more severe climate scenarios. Agriculture is a major contributor to greenhouse gas emissions. It accounts for 52 percent of Nepal's total emissions. This contribution primarily comes from livestock and rice cultivation. To address these challenges, Climate Smart Agriculture (CSA) practices are being promoted. Two examples of these practices are the System of Rice Intensification (SRI) and Alternate Wetting and Drying (AWD). These methods can significantly reduce methane emissions. However, barriers like old irrigation infrastructure and limited farmer awareness are hindering wider adoption. This study suggests encouraging climate-resilient cropping systems as a means of enhancing agricultural resilience. It highlights how crucial it is to upgrade livestock systems and infrastructure. Furthermore, it emphasises the necessity of enhancing farmers' access to services, markets, and financial resources (WBG, 2022).

In Nepal, climate-smart agriculture is an important step towards resilience. Farmers who invest in their fields frequently find that the consequences of the land threaten their ability to make a living. They face a variety of irregular obstacles caused by climate change, which includes storms, floods, and droughts. CSA is a stabilizing influence and may nearly be termed as the three-legged stool on which food security, resilience, and greenhouse gas reduction depend for any nation whose GDP relies significantly on agriculture, or which has a large percentage of its population dependent on agricultural employment. Community seed bank development preserves the genetic resources of native plants, while engendering a spirit of cooperation and resiliency among farmers, and youth and women are better equipped with means and skills to address the challenges from a changing climate. Land degradation, however, remains one of the biggest challenges apart from fragmented plots. The Agriculture Development Strategy has thus argued for equal access to land. What is now needed is cohesive policies, for which improved governance and capacity building should ensure that all voices are represented for a harmonious approach. Besides, financial support is also fundamental because most CSA technologies remain unaffordable to smallholder farmers, and access to national and international funding needs to be secured. The storyline in Nepal on CSA epitomizes the people at the centre, their aspirations, the use of ICT to expand the voice of farmers, and awareness and innovation based on experiences shared. Good practices, like solar-powered irrigation systems, have within them the intrinsic innovative solution that enhances productivity and reduces emissions, epitomizing the complexity of the journey. Finally, all of CSA in Nepal is a continuous process of collaboration, innovation, and determination toward the future of prospering farmers, strengthening communities, and thriving land, blessed with an undying spirit of hope and times of change that show the way through (CIAT & WB, 2017).

Paudel (2016) explain that climate change is having a serious effect on agriculture in Nepal. Rising temperatures and irregular rainfall, especially in the hills and mountains, are making it difficult to grow main crops like rice, maize, and wheat. These weather changes have led to decreased crop production and increased risks from pests and diseases, causing serious threats to the country's food security. Additionally, extreme weather events like droughts and floods are damaging farmland and further reducing food production. To deal with these challenges, Nepal is working on creating crop varieties that can survive in harsh environments, and promoting farming practices that are more sustainable, such as growing crops on slopes and using tunnel farming. According to Paudel (2016), the government and farmers are working together to resolve the impact of climate change on agriculture. The government is focusing on developing climate resistant crops, improving farming methods, and establishing early warning systems for natural disasters. Meanwhile, farmers are using techniques like rainwater harvesting, slope stabilization, community-based seed production, and off-season vegetable farming to protect their crops and adapt to the changing climate.

Maximum temperatures in Nepal are rising at a startling rate, according to a review of the country's measured temperatures during the past 30 years (Shrestha et al., 1999). Between 1977 and 2000, the average yearly temperature increased by 0.06 degrees Celsius. In Nepal's high-altitude northern regions, this warming is especially noticeable. In addition, winter warming is more noticeable than in other seasons. Most region of the country has an increasing trend for maximum temperature, except for the western middle mountainous region. The western and western mountainous regions, as well as the eastern parts of the country, indicate a declining tendency in the minimum temperature. Most of the regions, however, are dominated by a rising trend. Another software-based analysis of 36 years' worth of daily temperature data, from 1971 to 2006, reveals that cold days and nights are becoming less common and that both days and nights are getting warmer (Baidya, et al., 2008).

The hilly area of Nepal, which includes mountains covered in snow, is more vulnerable to climate change than the plain area. Previous studies on climate change in mountainous and hilly areas have suggested that considerable warming at higher elevations will result in less snow and ice cover and a higher frequency of catastrophic occurrences like droughts and landslides. Studies on Nepal's temperature trend have found that the yearly mean and maximum temperatures are rising higher at high elevations than at lower elevations (Baidya et al., 2008).

According to the 2016 National Climate Change Impact Survey, climate change has a noticeable effect on agriculture in Nepal’s hilly regions, especially in the far-western areas, where farmers face rising temperatures, unpredictable rainfall, and extreme weather events such as droughts and landslides. In the far west's hilly regions, around 86.1 percent of households reported experiencing drought in the previous 25 years, describing changes in monsoon and winter precipitation that impact planting and irrigation. Increased intensity of rain degrades soil and reduces fertility, while pests and illnesses create a growing threat to crops and livestock. Farmers are responding by increasing crop diversity, strengthening water management, and putting soil conservation techniques into effect. Farmers are responding by increasing crop diversity, strengthening water management, and putting soil conservation techniques into effect. Effective policy implementation is still difficult, nevertheless, due to data limitations and the urgent need for integrated climate resilience initiatives (CBS, 2017).

Over time, notable changes in the climate have been seen in Rasuwa District. Summer monsoon rainfall increased by 19.89 mm between 1980 and 2014, while maximum temperatures increased by 0.07°C annually. On the other hand, winter precipitation declined by 4.89 mm, while winter temperatures decreased by 0.05°C annually. According to surveys, between 1990 and 2014, potato yields increased, because of market demand and warmer temperatures, whereas millet and wheat production decreased. It's interesting to note that farmers in mid-elevation regions reported stronger trends in crop output than those in lower elevations. Many farmers in high-elevation areas have begun modifying their cultivation schedules in adaptation to these changes (Dawadi et al., 2022).

Most regions have seen noticeable changes in climatic conditions, such as rising temperatures, unpredictable rainfall, prolonged droughts, and extreme weather conditions, according to respondents. While perceptions often matched observed meteorological data, there are significant variations around each based on geographic, social, and economic factors. Many Nepalese communities attribute decreased agricultural productivity to erratic monsoon patterns, drying water sources, increased pests and diseases, and extreme weather events such as floods and landslides. More than 80 percent of Nepal's population is vulnerable to climate-related disasters, with agriculture providing a living for more than 65 percent of the population, making these changes particularly concerning. Farmers all over the world face the same fundamental issues: changes in rainfall, lower yields, and increased demand for resources. The community's ability to adapt is measured on a different scale depending on the variables available in terms of resource access, such as credit, technology, and extension services. In general, poor areas are the most disadvantaged. For example, farmers in Canada adapt better because they have more resources, whereas farmers in Africa and Asia have fewer resources. It will be simpler to understand how the community perceives and responds to climate change, develop policies to address such issues and increase resilience among the most vulnerable population groups. In developing nations like Nepal, where livelihoods and economies are at risk, the incorporation into broader policy frameworks would guarantee significant adaptation and mitigation measures (Khatri & Pasa, 2023).

Climate change causes significant positive and negative changes in temperature and precipitation. This situation contributes to a decline in agricultural production, increased crop infestation by pests and diseases, and decreased water availability. These changes have had far-reaching implications for crop yields, livestock management, and overall biodiversity. The study in Panchthar found that the main crop varieties, such as millet, maize and rice are in danger; cattle numbers have decreased due to a lack of fodder. The socioeconomic consequences have been a shift away from traditional agricultural occupations, with only 46.67 percent of households relying on agriculture as their primary source of income. In response to these challenges, local farmers have developed a variety of adaptation methods, including 20 percent reforestation, 13.33 percent crop rotation, 20 percent mix cropping, and 20 percent organic fertilizers. As a result, this study advocates effective adaptation mechanisms and increased climate change awareness as a surefire way to strengthen community resilience for long-term development. These findings highlight the urgent need for targeted interventions or policy measures to help the countryside deal with the difficulties of climate change and its influence on agriculture (Khapangi, 2023).

Climate change poses a significant threat to agricultural productivity and food security in Nepal's Dudh Koshi region. Major crops are expected to experience massive yield losses by 2100: 25 percent for wheat, 42 percent for rice, and 46 percent for maize. Increasing temperatures and shifting rainfall patterns are having a disastrous impact on crop yields. This urgently requires adaptive measures that will ensure food security. For example, vertical farming in high altitudes looks so promising. However, the study warns against over-reliance on maize, either as a food staple or a dominant crop. The food security index will likely drop significantly by 2050 and 2100. Crop yields are no longer predictable, and the increasing demands of an exponentially growing population make the situation difficult to handle. There is a need to develop a set of comprehensive strategies to handle these issues. Environmental, economic, and social factors must be considered to implement new farming practices and resilience strategies. All these efforts are critical to meeting nutritional needs while also effectively managing the effects of climate change on agricultural sectors (Bocchiola et al., 2019).

Climate extremes in Nepal have intensified because of anthropogenic warming, with significant socioeconomic consequences, according to a study that examined 26 climate extreme indices from 90 meteorological stations and found increasing trends in warm temperatures and extreme precipitation, particularly in mountainous regions. Over the last 45 years, Nepal's overall temperature has risen by 0.76°C, causing negative effects on agriculture and infrastructure, as well as increased risks from droughts and floods that disrupt livelihoods. The increasing frequency of extreme precipitation events is associated with shifting monsoon patterns, potentially causing catastrophic flooding, while marginalized communities are disproportionately affected, necessitating targeted interventions. Geographical variations in climate impacts necessitate localized adaptation measures, as parts like the Tarai region may experience flooding while others struggle with droughts. The need for national climate change adaptation and disaster risk reduction policies is urgent. Additional research and high-resolution climate models are necessary to ensure accurate future climate projections (Awasthi & Owen, 2020).

Khatri & Pasa (2023) studied 204 households in Nepal's Mountain and Inner Tarai regions reveals a significant difference in how people are dealing with climate change. Langtang has mostly low-income Janjati communities that rely on tourism and remittances, whereas Madi has mixed castes, a better education, and more people working in farming and wage jobs. Both regions are dealing with issues such as unpredictable rainfall, melting snow, landslides, floods, and a lack of water, all of which have harmed agriculture. To cope, people are experimenting with strategies such as modern and integrated farming, crop rotation, and collaborative risk management. Access to roads, markets, schools, and healthcare facilities has a significant impact on how well people adapt, and Madi performs better in this regard. Communities must use resources efficiently, experiment with new forms of revenue like tourism and farming and provide more support for small farmers. Enhanced farming techniques and more robust strategies are needed to combat climate change.

2.5 Research Gap

The research gaps from the above reviews show three major gaps regarding the study of the effects of climate change on agriculture in Nepal. Firstly, there is a lack of studies that examine trends in climate change variables such as rainfall, temperature, and precipitation shift and their direct effects on agricultural production. Research on the wider effects of climate change on rural livelihoods is lacking. Specifically, there is insufficient information on how changes in agricultural production impact the food security of rural households. Lastly, existing research has not valued the traditional agricultural knowledge and practices into formal adaptation strategies. This gap shows the necessity for research on how farmers use their indigenous knowledge to adapt and build resilience against climate impacts.

Chapter III: Research Methodology

3.1 Research Design

Research methodology describes the methods and procedures applied to all aspects of the study, focusing on data, data collection, and processing and analysis methods. This study was based on a descriptive mixed (qualitative & quantitative) approach with surveys, interviews, questionnaires, and secondary data analysis to address the research issues. The study was based on both primary and secondary data. The primary data were collected by survey and interview methods and analyzed using data analysis software.

3.2 Rationale for the selection of the study area

The research field for this study was Sigas rural municipality which accounts total land area of 245.44 square kilometres (Appendix F). It has a population of 21,814 and a household of 4,114. The research was conducted in Sigas rural municipality ward no. 2. The major population of Sigas municipality are involved in agriculture. They cultivate crops like rice, maize, wheat, millet, barley, buckwheat, mustard, sunflower, lentils, chickpeas, coffee, tea, spices, and various seasonal fruits and vegetables are cultivated. The cattle found in the household of Sigas rural municipality are buffalo, goat/chyangra, sheep, pig/boar, poultry (chicken), etc. (CBS, 2021b).

The study determines the effects of climate change on the agricultural conditions of the Sigas -2 and the people living within the territory. The local people of the study area have land ownership and they people are actively involved in agricultural activities (CBS, 2021b). Climate change is having a direct effect on agriculture production.

This research studies the climate variable patterns like rainfall and temperature, evaluates the effect caused by climate change, and assesses the adaptation measures used by farmers to the current condition of agriculture.

3.3 Nature and Source of Study

This study was completed mainly with the use of primary data and supported by secondary data. Primary data were obtained from the survey through data collection tools and techniques like observation, interviews, unstructured questionnaires, and Key Informant interviews (KII). Similarly, secondary data has also been attained from published related books, newspapers, journals, articles, reports, institutional publications, websites, bulletins, member groups, stakeholders, social workers, NGOs, women groups, youth clubs and previously done dissertations. The fieldwork included both qualitative and quantitative data.

3.4 Universe, Sample and Sampling Procedures

A sample refers to a small, unbiased portion of the population selected for observation and data collection (Taherdoost, 2016). In survey research, it is suggested to have 100 samples for each main subgroup of the population, and between 20 to 50 samples for each smaller subgroup. The researcher utilized the main-minor subgroup criterion to determine the sample size based on the research method (Cohen et al., 2017). Accordingly, this study identified 623 total households in the study area. Out of this, only 120 sample numbers were selected.In so doing, the study followed a simple random sampling method.

Table 3.4 Universe and Sampling of Sigas -2.

S.N.	Professions	Population Households
1	Farm-based Livelihood	278
2	Non-farm-based Livelihood	32
3	Farm + non-farm-based Livelihood	313
	Total Households	623
	Sample Households	120

Source: Field Survey, 2021

A basic random selection procedure was used to select 120 houses, with a 95 percent confidence level and a 5 percent margin of error (Best & Kahn, 2006).

3.5 Data Collection Techniques and Tools

3.5.1 Household Survey

The household survey was used to collect direct understandings from local people on how climate change has affected their agriculture patterns. Different variables like rainfall levels, temperature changes, drought intervals, and water shortages were studied. The study included 120 households in Sigas Rural Municipality-2, reaching out to people of different ages, education levels, and economic situations. Interviews and questions were requested to provide information on both present and past situations of how farming has changed due to climate impacts. The experience of elderly people helped us to understand how adaptation methods in agriculture have shifted over time. Participants from various ethnic groups were included in this study to capture a broad spectrum of perspectives. These details together helped us to get a broader picture of the community's experience.

3.5.2 Key Informant Interviews

Key Informant Interviews (KIIs) were used to get more specific and detailed information on the respondent's adaptations to climate change in farming. The plan was to interview key people in leadership roles and had experience in climate change like local representatives, agriculture officer, civil society member and big farmers. This can help to figure out what new strategies are being undertaken to lessen climate's impacts on agriculture while understanding people's awareness of adaptation measures. The main informants were the ward chairperson, a Junior Technical Assistant (JTA), and a respected elder. These 3 individuals provided us with their take on how agriculture methods have changed and what they know about climate change. Their views provided us with a peek into how aware the community is of climate issues affecting their crops.

3.6 Data presentation and analysis

The data collected during the field visit was analyzed and interpreted according to the research design. Once the field survey was complete, the gathered data was edited and organized into tables to fit the report's structure. The report includes maps, figures, charts, tables and pictures taken during the survey period to enhance clarity and detail.

Additionally, the report is structured into chapters and sub-chapters for easy navigation. For data analysis, we utilized SPSS and Microsoft Excel software. The analysis encompasses descriptive and inferential statistics to highlight the main features of the data. We conducted correlational analysis to explore relationships between variables, while cross-tabulation was employed to examine interactions among different categorical variables.

Data organization, management, and interpretation were carried out using SPSS software in combination with Microsoft Excel. Various visual representations, including pie charts, bar diagrams, column graphs, and line graphs, were created to present the findings in an easily understandable manner, tailored to the nature of the variables involved.

3.7 Ethical Consideration

The questionnaire for this research was designed with careful attention to the prevalent social practices within the Nepalese community, ensuring that no moral values held by individuals are compromised. To gather comprehensive data, we focused research on a one-to-one basis, avoiding group settings to ensure respondents feel comfortable sharing information individually. Additionally, each focus group or participant was provided with detailed information about the study's purpose before the survey. This way, they can choose to participate only after fully understanding and consenting to the study.

During data collection, respondents were informed that they may decline to respond to any question without any pressure to continue. To maintain ethical standards, the researcher upholded privacy, respect participant consent, and actively work to prevent bias (Creswell & Creswell, 2018).

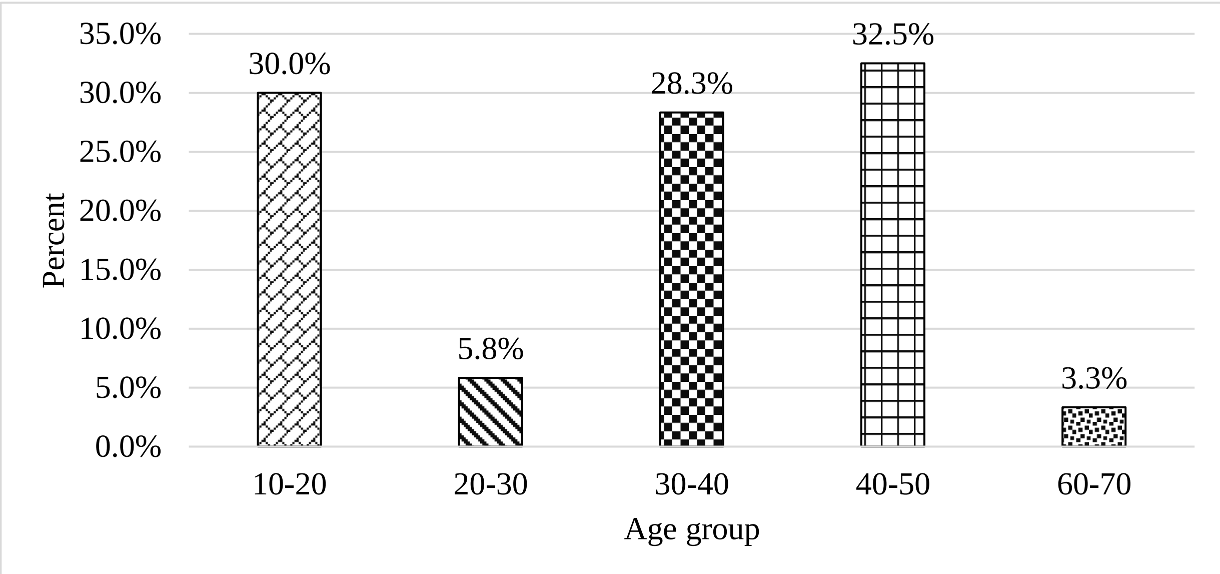
Chapter IV: Data Analysis and Interpretation

This chapter describes the data analysis results gathered from the process of data collection. It focuses on the analysis and interpretation of the primary information obtained from 120 respondents using the questionnaire. The data collected was analyzed using various tools and software. Information gathered from the questionnaire survey was processed through SPSS 27 to examine the effect of climate change on agriculture, changes in temperature and rainfall patterns, challenges faced by farmers due to climate alterations, and the adaptation and mitigation methods respondents have implemented to address these issues. Additionally, meteorological data obtained from DHM were also analyzed using both SPSS and MS Excel.

4.1 Socio-Demographic Profile of Respondents

4.1.1: Age Structure

Figure 1: Bar Diagram for Age of Respondents.



Source: Field Survey, 2024

The bar diagram shows the different age groups of the respondents. The Majority (32.50 Percent) of the respondents were within the age group of 40-50 years. 30 percent of respondents were between 10-20 years followed by 28.33 percent of respondents for the study were aged between 30-40 years. Only 5.83 percent of respondents were aged between 20-30 years. Finally, 3.33 percent of respondents were aged between 60-70 years.

4.1.2: Gender

Table 4.1.2 Gender of the Respondents

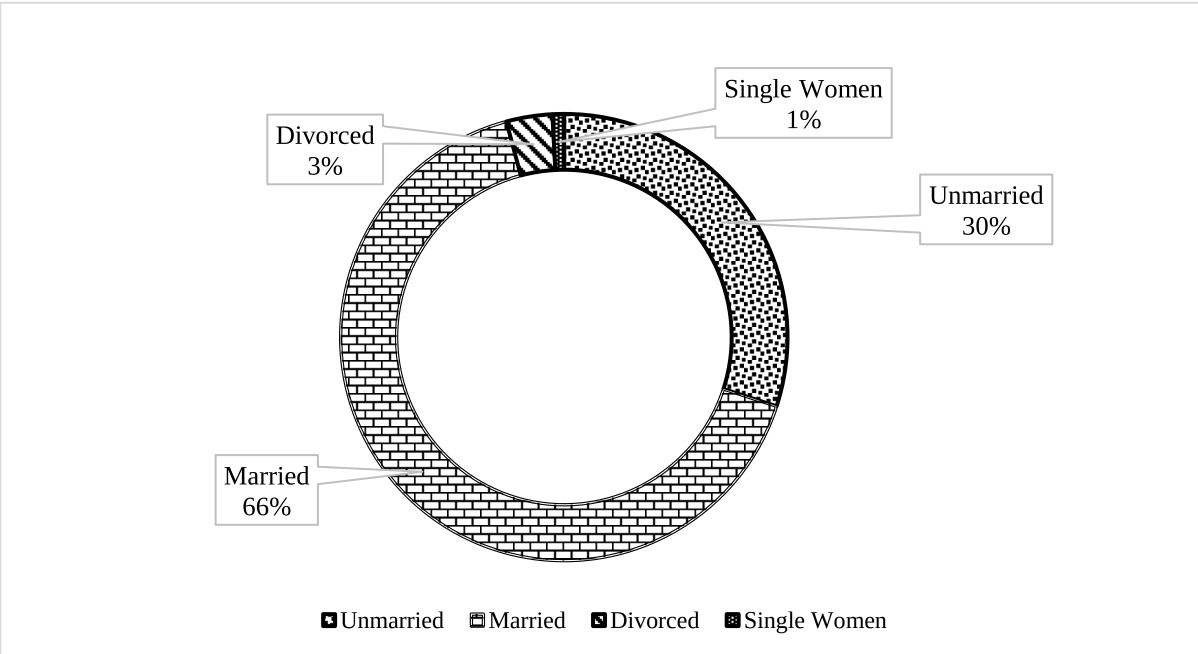
Gender	Number	Percent
Male	68	56.7
Female	52	43.3
Total	120	100

Source: Field Survey, 2024

Table 4.1.2 shows the gender composition of the respondents. It highlights that out of 120 respondents sixty-eight were male and fifty-two were female. Thus, this table shows most of the respondents in this study were male (56.7 Percent) and the minority were female (52 Percent).

4.1.3 Marital Status

Figure 2: Doughnut Pie-chart for Marital Status of the Respondents



Source: Field Survey, 2024

The above doughnut pie chart of the marital status of respondents shows that most respondents were found married, which consists of 66 percent. Similarly, 30 percent of the total respondents were unmarried. Three percent and 1 percent of the total respondents were divorced and single women, respectively. This result shows that most of the respondents in the study are married which indicates the married family members are mostly participating in agriculture.

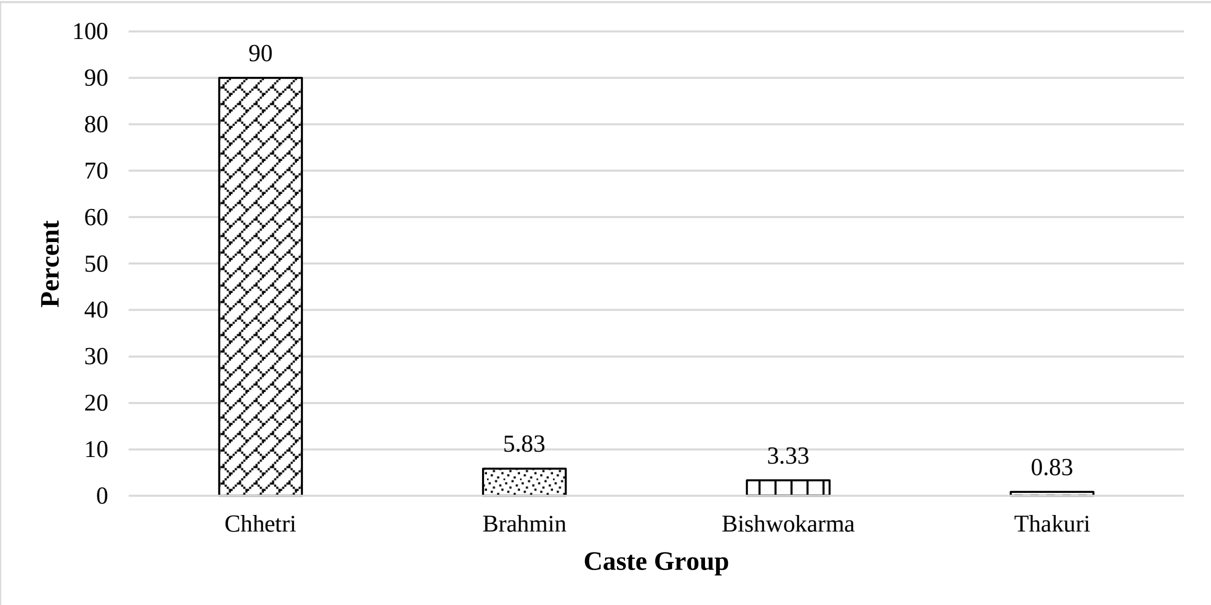
4.1.4 Ethnicity

Table 4.1.4 Ethnicity of the Respondents

Ethnicity	Number	Percent
Chhetri	108	90.0
Brahmin	7	5.8
Bishwokarma	4	3.3
Thakuri	1	0.8
Total	120	100

Source: Field Survey, 2024

Figure 3: Ethnicity of the Respondents



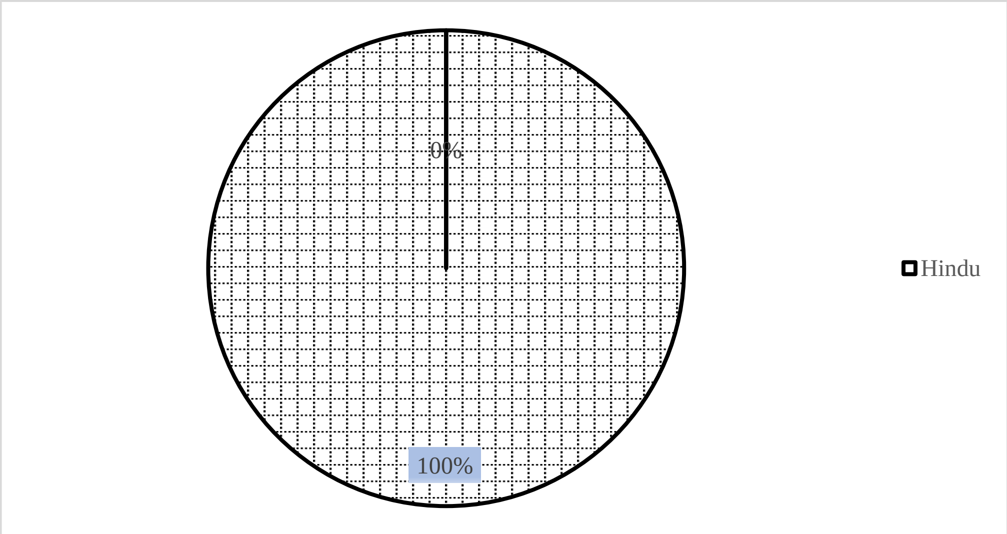
Source: Field Survey, 2024

The Sigas rural municipality-2 has various caste/ethnic groups of people living in the area. Table 4.1.4 and the Bar diagram show that 90 percent of the respondents were from Chhetri, followed by Brahmin 5.83 percent. Similarly, Bishwokarma and Thakuri were 3.33 percent and 0.83 percent, respectively. The above table and bar diagram show the Chhetri caste as maximum and the Thakuri caste as a minimum in Sigas rural municipality-2.

4.1.5. Religious Structure

The religious structure of the surveyed households is presented in the Pie-chart below:

Figure 4: Religion of the Respondents



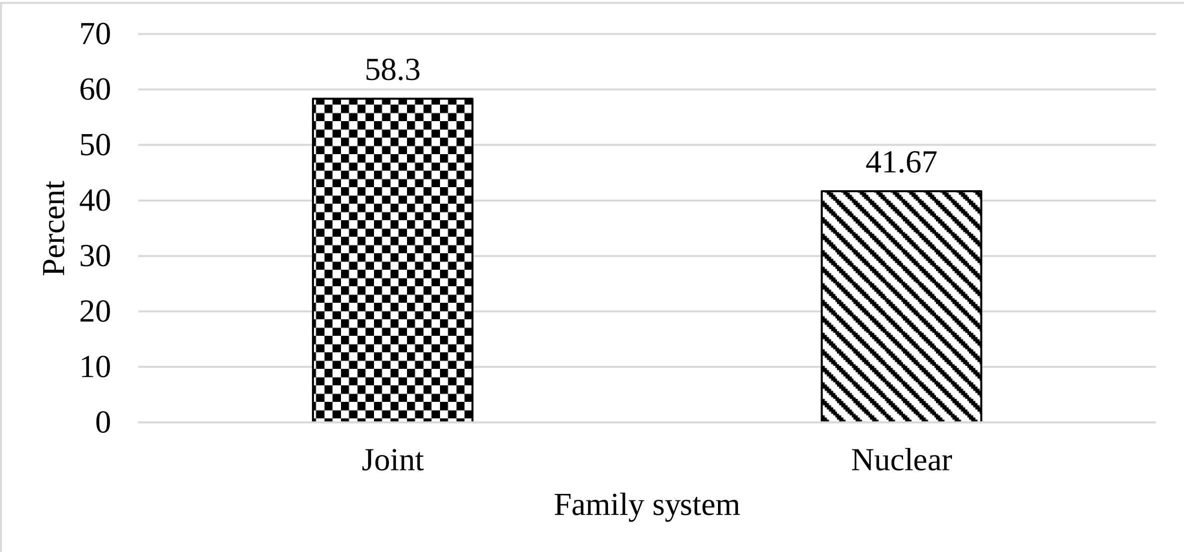
Source: Field Survey, 2024

The above pie chart shows that all the respondents follow only one religion. All the respondents of the study were Hindu. There is a complete absence of other religions in Sigas rural municipality-2.

4.1.6. Family Type

The Family type of the surveyed households is presented in the bar diagram below:

Figure 5: Family type of the respondents.



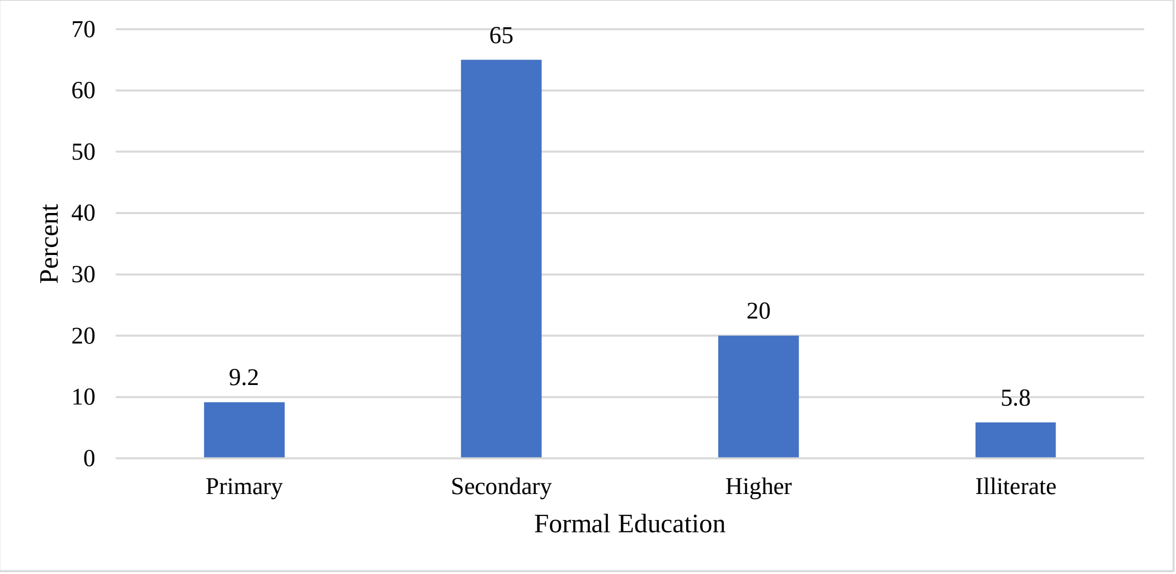
Source: Field Survey, 2024

The above bar diagram shows the family of the respondents are joint which includes 58 percent. Other 42 percent of the respondents live in the nuclear family. This data shows that most of the people in the study area live in joint families.

4.1.7. Education Status

The Education Status of the surveyed households is presented in the bar diagram below:

Figure 6: Education of the Respondents



Source: Field Survey, 2024

This bar diagram shows the breakdown of formal education levels in Sigas rural municipality - 2. Out of a total sample of 120 individuals, secondary education (twelve classes) forms the largest group with 78 respondents (65 percent). Higher education (After twelve) is the second most common with 24 respondents (20 percent), followed by primary education representing 11 respondents (9.2 percent). Seven respondents are classified as illiterate (5.8 percent).

The data suggests this is a relatively well-educated population, with 85 percent having attained at least secondary education. However, there's still a small but significant portion (5.8 percent) who are illiterate.

4.1.8. Schooling for Children

The educational status of children from the surveyed households, currently attending schools and colleges, is shown in the table below:

Table 4.1.8 Education of Children

	Number	Frequency	Percent
School going children	0	5	4.2
	1	12	10.0
	2	35	29.2
	3	32	26.7
	4	18	15.0
	5	7	5.8
	6	7	5.8
	7	4	3.3
	Total	120	100
College going children	0	80	66.7
	1	24	20.0
	2	12	10.0
	3	1	0.8
	4	3	2.5
	Total	120	100

Source: Field Survey, 2024

This study studied 120 households regarding both school and college attendance of their children. For school-going children, the data shows that 29.2 percent (35 respondents) had two children in school, making this the most common category. Respondents with three school-going children closely followed this at 26.7 percent (32 respondents). Respondents with four children in school represented 15 percent (18 respondents), while 10 percent (12 respondents) had one child attending school. There were equal numbers of respondents with five and six children in school, each at 5.8 percent (7 respondents each). Only 4.2 percent (5 respondents) had no children in school, while 3.3 percent (4 respondents) had seven children attending school.

Regarding college attendance, the pattern shows that the majority of respondents (66.7 percent, or 80 respondents) had no children in college. 20 percent (24 respondents) had one child attending college, and 10 percent (12 respondents) had two children in college. Very few respondents had more children in college, with just 0.8

percent (1 household) having three children and 2.5 percent (3 respondents) having four children in college.

The numbers highlight most households had multiple children who go to school, and college-going children were much lower.

4.1.9. Occupations

The occupation and economic status of the respondents in our research field are tabulated as follows.

Table 4.1.9. Occupations of the respondents

Family Occupation	Number	Percent
Agriculture	88	73.3
Business/enterprises	10	8.3
Govt job	15	12.5
Private job	6	5.0
Remittance	1	0.8
Total	120	100

Source: Field Survey, 2024

The study of 120 respondents reveals that agriculture is overwhelmingly the dominant occupation in the Sigas rural municipality - 2, with 73.3 percent (88) engaged in agricultural activities. Government employment represents the second most common occupation at 12.5 percent (15), followed by business/enterprises at 8.3 percent (10). Private sector employment accounts for 5 percent (6) of the respondents. The smallest category is remittance-dependent households, representing just 0.8 percent (1) of the total sample size.

This occupational distribution strongly suggests that the study area is predominantly rural or agricultural in nature, with over three-quarters of households depending on agriculture for their livelihood. The small percentage of private sector employment compared to government jobs indicates limited private sector development in the region. There is minimal presence of remittance-dependent households as people in the study area usually don't consider neighbouring country India as a foreign countries.

4.1.10. Annual Income

The occupation and economic status of the respondents in our research field are tabulated as follows.

Table: 4.1.10. Annual Income of the respondents

Income of the Household (Annual)	**Number**	**Percent**
10000-50000	14	11.7
50001-100000	22	18.3
100001-500000	57	47.5
500001-1000000	22	18.3
1000001-1700000	5	4.2
Total	120	100

Source: Field Survey, 2024

The survey of 120 households reveals that the largest income group falls within the range of 100,001-500,000, comprising 47.5 percent (57) of the total respondents. There is an equal distribution of households in the 50,001-100,000 and 500,001-1,000,000 brackets, with each category representing 18.3 percent (22) of the sample population. The lower income bracket of 10,000-50,000 accounts for 11.7 percent (14) of the respondents. The highest income category of 1,000,001-1,700,000 represents the smallest group, with only 4.2 percent (5) falling in this range.

Most households in the study area are middle class, with nearly half of the population in the 100,001-500,000 range. The data also show that while there is broad economic diversity in the community, relatively few households reach the highest income tier, and a significant proportion remains in the lowest income category.

4.1.11. Annual Expenses

The Yearly expenses of the respondents in our research field are tabulated as follows.

Table: 4.1.11. Annual Expenses of the respondents

Annual Expense of Household	Number	Percent
Below 10000	1	0.8
10000-50000	5	4.2
50001-100000	18	15.0
100001-500000	81	67.5
500001-1000000	12	10.0
1000000 above	3	2.5
Total	120	100

Source: Field Survey, 2024

The study of 120 households shows that the majority of respondents, 67.5 percent (81), have yearly expenses falling within the 1,00,001-5,00,000 range. The second most common expenditure category is 50,001-1,00,000, representing 15 percent (18) of the sample. Households spending between 5,00,001-10,00,000 annually account for 10 percent (12), while those spending 10,000-50,000 represent 4.2 percent (5) of the total. The highest spending category of 10,00,000 and above includes 2.5 percent (3) of respondents, while the lowest spending bracket of 0-10,000 represents just 0.8 percent (1).

This spending pattern is somewhat consistent with the earlier observations about income distribution, wherein the majority of households spend at a moderate level annually. Because there are so many households whose expenses fall between 1,00,001 and 5,00,000, this is likely the normal cost of living for this study area. A small proportion of households fall into both the highest and lowest expense categories, suggesting that extreme spending behaviours are rare in this community.

4.1.12. Food Sufficiency

The food sufficiency of the respondents in our research field is tabulated as follows.

Table 4.1.12 Food sufficiency of the respondents

Food Sufficiency	Number	Percent
<3 Months	2	1.7
3-6 Months	53	44.2
9-12 Months	42	35.0
>12 Months	23	19.2
Total	120	100

Source: Field Survey, 2024

The survey data reveals significant variations in food sufficiency levels across the 120 surveyed households. The largest segment of respondents, comprising 44.2 percent report food sufficiency lasting between 3-6 months. Following this, 35 percent indicate food sufficiency for 9-12 months, while 19.2 report having food security extending beyond 12 months. A small portion of the population 1.7 percent, experiences severe food insecurity with supplies lasting less than 3 months.

The analysis of food security patterns in the study area reveals significant challenges. Nearly half of the study households report food supplies lasting only 3-6 months of the year, indicating widespread vulnerability to food insecurity. While some households maintain stable year-round food security, the majority face considerable variations in their food sufficiency levels throughout the year. Most concerning is the presence of acute food insecurity among a small but notable segment of the population, where households report food supplies lasting less than three months.

4.1.13. Land Holdings

The landholding in the present and 15 years ago of the respondents in the study area is tabulated as follows.

Table 4.1.13. Land Holdings of respondents now and 15 Years ago

Land Type	Now			Then		
	Landholding (in Ropani)	N	Percent	Landholding (in Ropani)	N	Percent
Farmland	<1	3	2.50	<1	5	4.20
	2-5	6	5.00	2-5	19	15.80
	6-9	14	11.70	6-9	11	9.20
	>10	97	80.80	>10	85	70.80
	Total	120	100.00	Total	120	100.00
Rented land	<1	97	80.80	<1	101	84.20
	2-5	9	7.50	2-5	7	5.80
	6-9	3	2.50	6-9	1	0.80
	>10	11	9.20	>10	11	9.20
	Total	120	100.00	Total	120	100.00
Leased out land	<1	101	84.20	<1	105	87.50
	2-5	9	7.50	2-5	7	5.80
	>10	10	8.30	>10	8	6.70
	Total	120	100.00	Total	120	100.00

Source: Field Survey, 2024

Table 4.1.13. shows the comprehensive comparison of property distribution across different land types between the present day and fifteen years ago. In terms of farmland, a significant majority of households currently own more than 10 Ropani (80.8 percent), showing an increase from 70.8 percent fifteen years ago. The data shows that farmland ownership has become more concentrated, with fewer households owning small pieces of land now than before.

Regarding rented land, most households consistently fall into the smallest category (<1 Ropani), with 80.8 percent currently compared to 84.2 percent fifteen years ago. Similarly, leased-out land patterns show minimal change, with most households (84.2 percent now versus 87.5 percent then) having less than 1 Ropani in this category.

These patterns show that farmland ownership has slowly become more concentrated, while other land use types have stayed the same over the past fifteen years. The data shows that most households keep a good amount of farmland but do not rent or lease out much land.

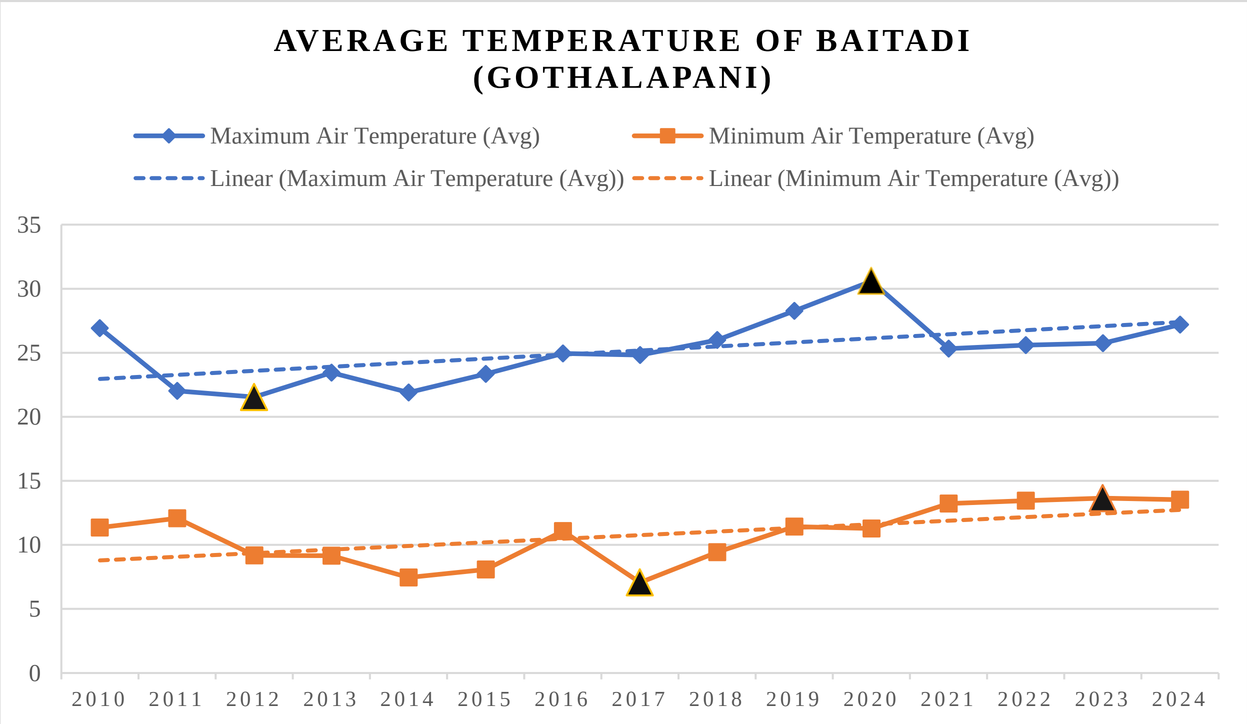
4.2 Trend of Climate Change in the Study Area

4.2.1 Climate Change Assessment

In this data analysis section, we have analysed the data from the Department of Meteorology and Hydrology (2024) to evaluate the variation of Temperature and precipitation in the Baitadi district. Gothalapani Station of Meteorology and Hydrology Department (Index no: 0102) data was used for this analysis as it was the nearest station to Sigas-2.

4.2.1.1 Meteorology Data of Temperature

Figure 7: Minimum and Maximum Temperature of Baitadi in 14 Years



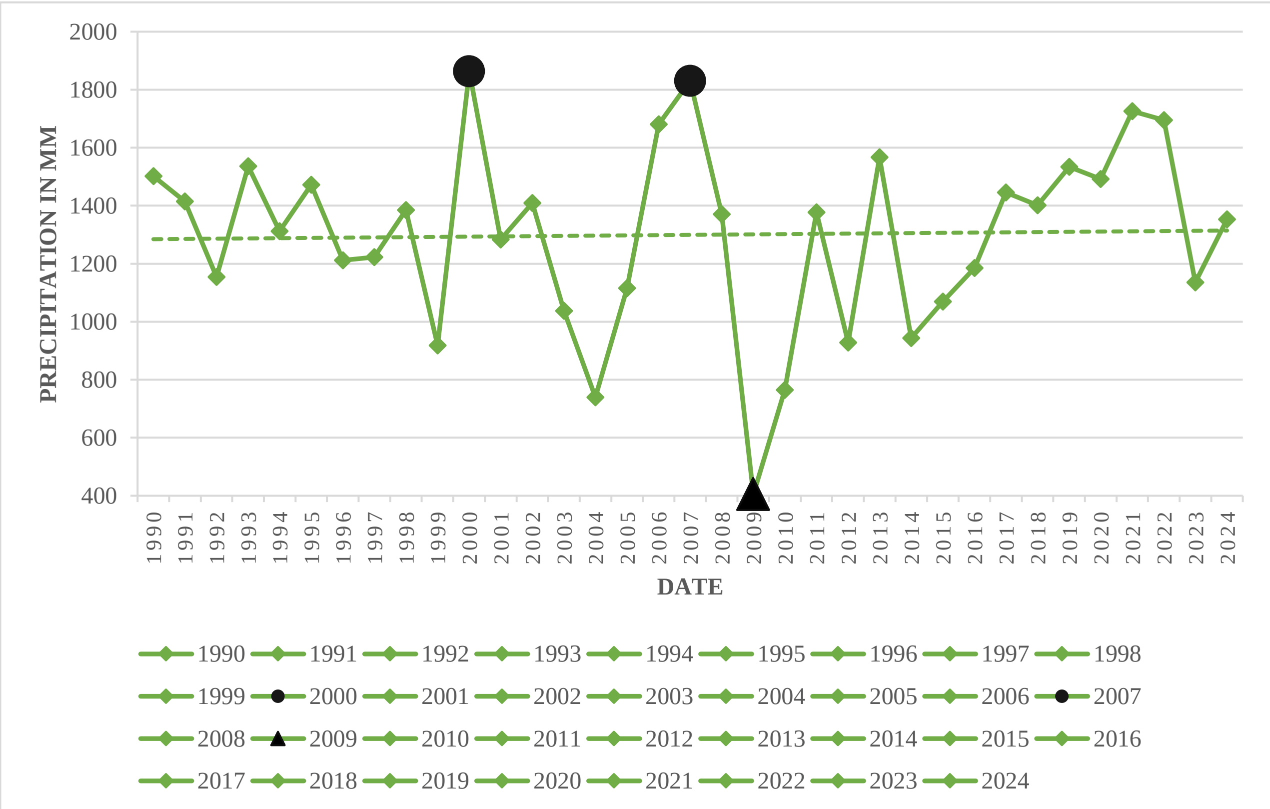
Source: Department of Hydrology and Meteorology, 2024

The meteorological temperature data from 2010 to 2024 highlights significant patterns and variations in maximum and minimum air temperatures. Maximum daily temperatures fluctuated notably, with the highest at 30.592°C in 2020 and the lowest maximum at 21.543°C in 2012. A warming trend marked by a sharp rise from 28.261°C in 2019 to 30.592°C in 2020. Post-2020, temperatures stabilized around 25-27°C, with 2024 recording a maximum of 27.187°C.

Minimum temperatures also showed notable changes. The lowest reading was 7.064°C in 2017, while the highest minimum of 13.651°C occurred in 2023. From 2020 onward, minimum temperatures consistently increased, remaining above 13°C between 2021 and 2024 a marked shift from earlier years, where they often dropped below 10°C. This means that over time, the lowest temperatures recorded (like at night or in colder months) seem to be getting warmer, especially in the more recent years of the data. This indicates significant changes not only in absolute temperatures but also in daily temperature variations across the 15 years.

4.2.1.2 Meteorology Data of Precipitation

Figure 8: Precipitation of Baitadi (Gothalapani) in the last 34 Years



Source: Department of Hydrology and Meteorology, 2024

Baitadi (Gothalapani) precipitation data from 1990 to 2024 shows significant variation in annual rainfall. The lowest rainfall was in 2009 with 405.3 mm and the highest was in 2000 with 1863.4 mm followed by 2007 with 1830.4 mm. The early 1990s had consistent rainfall with most of the years ranging between 1200-1500 mm.

There was a dry spell in the mid-2000s particularly from 2009 to 2010 when the rainfall was way below the average. But the region has recovered well in recent years. 2019 to 2022 had a good rainfall pattern with annual rainfall above 1400 mm. The recent data shows slight moderation with 2023 having 1135.26 mm and 2024 having 1352.87 mm. Throughout the 35 years, the data shows a cyclical pattern with years of heavy rainfall followed by dry years, indicating natural climate variability in the region.

Overall, the trend shows that the precipitation is resilient despite the extreme years. There are big variations from year to year, but the region has averaged between 1000-1500 mm annually with some notable wet and dry years. This long data is helpful to understand the historical precipitation pattern and climate change impacts.

4.2.2 People's views on climate change patterns

This section describes how people view climate change and whether they have experienced any climate-related change. This information was gathered from the field visit and interactions with the respondents of Sigas -2. The Likert scale was used to measure the opinions of the respondents. The scales were Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree. Here, responses 1, 2, 3, 4 & 5 represent Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree respectively.

4.2.2.1 Changes in Temperature and Weather Patterns

Table 4.2.2.1 Changes in Temperature and Weather Patterns

Items	Min	Max	Mean	Std. Deviation	Skewness
Observed changes in temperature over the years.	1	5	4.74	0.587	-3.177
Summers are getting hotter.	1	5	4.19	0.833	-1.261
Winters are becoming colder than before.	1	5	3.78	0.974	-0.475
Changes in Rainfall patterns.	2	5	4.22	0.825	-.808
Unpredictable weather events now.	1	5	4.21	0.934	-1.437

Source: Field Study, 2024

The above table data shows strong agreement regarding observed temperature changes over the years, with a mean value of 4.74 and a standard deviation of 0.587. This high mean score corresponds with a negative skewness of -3.177, indicating a strong leftward distribution. This high negative skewness suggests a high consensus among respondents regarding noticeable temperature shifts. These respondents' perceptions also perfectly match with the meteorological data from 2010-2024. The Meteorology and Hydrology Department (2024) showed significant temperature fluctuations, particularly the marked increase to 30.592°C in 2020.

Regarding seasonal variations, respondents have strongly agreed that summers are becoming hotter (mean = 4.19, SD = 0.833). The perception about winter temperatures showed reasonable agreement (mean = 3.78, SD = 0.974), with a relatively balanced distribution as indicated by the lower negative skewness of -0.475. These observations of people about temperature resemble the meteorological records showing increased minimum temperatures, particularly the constant readings above 13°C from 2021 to 2024.

Changes in rainfall patterns are also noticed by respondents, with a mean score of 4.22 and a standard deviation of 0.825. The evaluation of unpredictable weather events generated similar results (mean = 4.21, SD = 0.934), with a notable negative skewness of -1.437 indicating strong agreement of respondents. The minimum value 2 for rainfall pattern changes suggests that even the most unsure respondents of the study area have acknowledged some degree of variation, correlating with the recognized precipitation changeability in the meteorological data.

A respected elder and ward chairperson from Sigas Rural Municipality -2 has also observed considerable changes in temperature and precipitation patterns and seasonal shifts over the years. They also mentioned that these alternations have become more explicit and frequent, affecting various aspects of daily life and agricultural practices in the area (Dhami, R. S. & Air, T. S., 2024 [KII]). These findings demonstrate a strong correlation between meteorological measurement data and public perception of climate change, suggesting that local communities are acutely aware of and experiencing the documented climatic variations in their region.

4.2.2.2 Climate Change on Environmental and Water Resources

Table 4.2.2.2 Climate Change on Environmental and Water Resources

Items	Min	Max	Mean	Std. Deviation	Skewness
Increase in dry spells/droughts over time.	1	5	4.26	0.903	-1.373
Shift in the rainy season.	1	5	4.20	0.949	-1.252
Fewer cold days in winter than in the past.	1	5	3.69	1.052	-0.718
Changes in flowering and fruiting times.	1	5	4.38	0.980	-1.980
Drying water sources.	1	5	4.59	0.815	-2.719

Source: Field Study, 2024

The above table shows the environmental impact evaluation of climate change and shows compelling evidence of a shift in ecological patterns of Sigas -2. Regarding dry spells and drought, respondents have strongly agreed that they have observed its increased frequency. This reflects in mean score of 4.26 with a standard deviation of 0.903. The negative skewness of -1.373 indicates widespread worry about this trend. This pattern pairs up with the observed fluctuations in temperature over the past fifteen years. *Households and KII individual observations closely mirror the precipitation records of the Department of Meteorology and Hydrology (2024).*

Changes in the timing of rain patterns also have become more noticeable. The above table shows most respondent's agreement regarding shifts in the rainy season (mean = 4.20). Households and KII individual observations closely mirror the precipitation records of the Department of Meteorology and Hydrology (2024). The deviation in responses (SD = 0.949) suggests diverse experiences across different localities of respondents.

Regarding the vegetation, respondents noted significant changes in flowering and fruiting times of flowers and fruits (mean = 4.38, SD = 0.980). *Junior Technical Assistant (JTA) stated he has seen the alteration in the flowering and fruiting times of* *flowers and fruits (Dhami D. S., 2024 [KII]).* Although responses were more diverse (SD = 1.052), there is moderate agreement among respondents as the mean is 3.69 for the perception of fewer cold days in the winter, indicating that variations in winter patterns may not be as consistent throughout Sigas-2.

The findings regarding water resources are particularly alarming. The community's observation of drying water sources has the highest mean score of 4.59. The strong negative skewness of -2.719 reflects strong agreement about this critical issue. *Ward Chairperson and elderly person have also informed that Sigas -2 households experienced their sources of water are gradually running out* (Dhami, R.S. & Air, T. S., 2024 [KII]*)*.

These findings paint a broad picture of environmental change that goes beyond temperature and rainfall measurements. *The data from respondents and KII demonstrates that all neighbourhoods are experiencing major consequences on their water source and natural environment, which are associated with the region's broader climate change patterns.*

4.3 Effects of Climate Change on Agriculture Production

This section analyses people's opinions about the effect of climate change on agriculture production. We have discussed significant findings based on statistical measurements. The data explains noticeable effects across multiple agricultural dimensions, utilizing the Likert Scale. The scales were Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree. Here, responses 1, 2, 3, 4 & 5 indicates Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree respectively.

4.3.1 Effects of Climate Change on Agricultural Practices and Productivity

Table 4.3.1 Effects of Climate Change on Agricultural Practices and Productivity

Items	Min	Max	Mean	Std. Deviation	Skewness
Changes in weather patterns.	1	5	4.23	1.111	-1.505
Climate change affects farming activities.	1	5	4.37	0.819	-1.613
Increment of extreme weather events.	2	5	4.16	0.870	-1.016
Change in weather patterns affects crop yields.	1	5	4.37	0.925	-1.704
Climate change affects soil fertility.	1	5	4.18	0.860	-1.413

Source: Field Study, 2024

This table of data shows the effects of climate change on farming activities, with a remarkably high mean score of 4.37 (SD = 0.819). This finding is supported equally by considerable observations with changes in weather patterns (M = 4.23, SD = 1.111). This shows a close connection between climatic variations and agricultural operations. The data indicates significant negative skewness across all variables. A correlation between weather patterns and agricultural yields (skewness = -1.704) indicates an important inclination for higher-scale responses. *The elderly and ward chairperson also highlighted the correlation between climate variation and agricultural activities. They have also observed the impact of climate change on farming activities* (Dhami, R.S. & Air, T. S., 2024 [KII]).

The analysis further reveals that extreme weather events have become increasingly prevalent, as evidenced by a mean score of 4.16 (SD = 0.870). This observation is particularly noteworthy given the minimum value of 2, unlike other variables which recorded minimum values of 1. This suggests a universal acknowledgement of this phenomenon among respondents. The effect on soil fertility emerges as another critical concern, with a mean value of 4.18 (SD = 0.860). *According to the elderly respected person, he has experienced more frequent extreme weather* *events and a decrease in soil fertility in recent years than in the past.* (Dhami, R.S. & Air, T. S., 2024 [KII]). This highlights the broader sustainable implications of climate change on agricultural systems.

The validity of this data analysis is highlighted by the constant high mean value (range from 4.16 to 4.37) and relatively small standard deviations (0.819 to 1.111) across each category. *There is widespread agreement among respondents and Key Informant individuals about the major effect of climate change on agricultural practices and productivity, as seen by a constant negative skewness value. These findings offer strong statistical support for the broad and significant effects of climate change on agricultural systems. Also, calls for careful evaluation of agricultural policy and adaptation plans.*

4.3.2 Challenges to Agricultural Resources and Costs

Table 4.3.2 Challenges to Agricultural Resources and Costs

Items	Min	Max	Mean	Std. Deviation	Skewness
The availability of irrigation water is unpredictable.	1	5	4.38	0.962	-1.797
Increment of pests and diseases.	1	5	4.03	1.020	-0.937
Increase in cost of farming inputs.	1	5	3.61	1.232	-0.803
Impact on livestock health.	1	5	3.91	1.100	-1.010
Change in types of crops.	1	5	3.55	1.269	-0.728

Source: Field Study, 2024

In Table 4.3.2, the highest mean value is 4.38 (SD = 0.962) of irrigation water availability, which seems to be the most pressing issue in Sigas -2. The data collected shows that water resources vary drastically, which has a big influence on agricultural activities. Regarding the increasing difficulties with water security in agricultural systems, it is noticeable from the strongly negative skewness (-1.797) that respondents regularly considered this as a key worry. *KII also indicate that people are facing water* *unavailability issues in Sigas -2. Also, the water unavailability issue varies in the locality as there are fewer water sources in the neighbourhood* (Dhami, R.S. & Air, T. S., 2024 [KII]).

The frequency of diseases and pests shows a notable trend, with a mean value of 4.03 (SD = 1.020). Even though this number is concerning it's crucial to remember that the standard deviation shows that there is some variation in the responses. Although it is not as evident as the irrigation water challenge, the negative skewness (-0.937) suggests an inclination towards higher assessment. *The KII individuals have also observed a notable frequency of diseases and pests in agriculture* (Dhami, et al. 2024 [KII]).

Livestock health impacts show moderate to high concern levels (M = 3.91, SD = 1.100), with responses ranging from the minimum to maximum values (1-5). The negative skewness (-1.010) indicates a tendency toward a higher scale, suggesting that livestock health represents a significant concern for many agricultural activities, though not as acute as irrigation challenges. *According to the elderly and ward chairperson of Sigas -2, the residents have ceased livestock herding due to the unavailability of fodder in pastureland. Climate variations have negatively affected livestock health, and the prevalence of livestock was better in the past than at present. Consequently, residents now keep fewer livestock at home and have begun herding improved breeds in the area* (Dhami, R.S. & Air, T. S., 2024 [KII]).

The cost of farming inputs, which is part of the economic dimension, has a lower but still noticeable mean value of 3.61 (SD = 1.232). The greater standard deviation indicates that farmers' experiences with input costs are more diversified, likely due to differences in local markets or farming methods. Similarly, changes in crop types show the lowest mean value of 3.55 (SD = 1.269), with the least negative skewness (-0.728), indicating more varied responses and suggesting that crop adaptation pressures may be experienced differently across different agricultural frameworks. *The KII response also suggests similar information towards the cost of farming input and variation in crop types. Locals have faced issues with food insufficiency and had to buy from the local market. The crop types and their cultivation pattern have also changed over time* (Dhami, et al. 2024 [KII]).

4.3.3 Economic Consequences of Climate Change on Farming

Table 4.3.3 Economic Consequences of Climate Change on Farming

Items	Min	Max	Mean	Std. Deviation	Skewness
Decrease in household income from agriculture.	1	5	3.87	1.250	-1.030
Traditional farming methods are no longer effective.	1	5	3.70	1.074	-0.616
Frequent crop failures in recent years.	1	5	3.78	1.055	-0.603
Affected market prices of agricultural products.	1	5	3.75	1.102	-0.752

Source: Field Study, 2024

Table 4.3.3 explains findings about how the climate-related challenges are changing the traditional agricultural economics and household sustainability of Sigas - 2.

With a mean score of 3.87 (SD = 1.250), the decrease in household income from agriculture is the most visible economic impact. While the negative skewness (-1.030) suggests an increase in more severe revenue reductions, the significantly high standard deviation suggests considerable variation in income results among numerous agricultural households. In short, farmers are under a lot of financial strain, and their impact varies widely from household to household. *Ward chairperson and elderly have also confirmed that household income from agriculture has reduced over the years* (Dhami, R.S. & Air, T. S., 2024 [KII]).

In recent years, locals have witnessed an increase in crop failures, as reflected by a mean score of 3.78 (SD = 1.055). This finding is particularly telling when considered alongside the reduced effectiveness of traditional farming methods (M = 3.70, SD = 1.074 & skewness = -0.616. These distinct trends suggest that established agricultural practices are struggling to adapt to changing climatic conditions, forcing farmers to reconsider their agricultural practices. *All the KII individuals have also confirmed the respondent's response regarding crop failures due to alterations in climate over the years* (Dhami, et al. 2024 [KII]).

With a mean score of 3.75 (SD = 1.102), the market dynamics of agricultural products have also been greatly altered. A tendency towards higher ratings is indicated by the negative skewness (-0.752) in market price impacts, which suggests that climate change is causing serious market instability. *This analysis and KII individuals validate that farmers are having trouble maintaining steady revenue streams because of volatile markets in combination with production issues.*

4.4 Adaptation Strategy Applied by Farmers

In this section, we analyzed the type of adaptation strategy applied by the locals of Sigas -2 to mitigate the negative consequences of climate change. This part of the study analyzed the adoption of climate-smart agricultural techniques, climate adaptation education and training, and government, local organizations and non-governmental organization's assistance and programs aimed at tackling climate issues.

We discussed the findings based on statistical measurements. In this study, Linkert Scale was used for collecting the opinions of the respondents. The scales were Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree. Here, responses 1, 2, 3, 4 & 5 represent Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree respectively.

4.4.1. Gender and Adaptation of New Farming Practices

Table 4.4.1 Gender and Adaptation of New Farming Practices

Variables		Adaptation of New Farming Practices					Total
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
Gender	Male	11	9	15	16	16	67
	Female	13	5	4	17	14	53
Total		24	14	19	33	30	120

Source: Field Survey, 2024

Table 4.1.13 examines the relationship between gender and the adaptation of new farming practices to combat climate change. A major tendency to adopt these practices can be seen by the relatively even distribution of responses among the male respondents (n=67), with the highest numbers going into the "Agree" (16) and "Strongly Agree" (16) categories. However, a significant percentage of respondents had divided or unsure opinions, as shown by the 15 males who indicated a neutral viewpoint. Female respondents (n=53) showed a greater tendency for agreement, still with 17 choosing "Agree" and 14 choosing "Strongly Agree." Compared to males, women appear to be more determined and supportive of implementing new farming practices, as seen by the lower number of ambivalent responses (n=4).

Overall, the statistics show a supporting trend in the acceptability of new methods of agriculture across genders, with most participants (63 out of 120) expressing agreement or strong agreement. This demonstrates a widespread willingness to adapt to innovations in agriculture designed to mitigate the consequences of climate change. However, the comparatively higher proportion of males expressing neutrality (22 percent) compared to females (7.5 percent) indicates a potential gender difference in quickness or confidence in these activities. These findings highlight the necessity of addressing gender-specific barriers and views when promoting agricultural adaptation measures in the face of climate change.

4.4.2. Caste and Adaptability to New Farming Practices

Table 4.4.2 Caste and Adaptability to New Farming Practices

Variables		**Adaptability to New Farming Practices**					**Total**
		Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	
Caste	Chhetri	22	14	17	28	27	108
	Brahmin	2	0	2	2	1	7
	Bishwokarma	0	0	0	3	1	4
	Thakuri	0	0	0	0	1	1
Total		24	14	19	33	30	120

Source: Field Survey, 2024

Table 4.1.15 explores the relationship between caste and adaptability to new farming practices. The findings indicate that among Chhetri respondents (n=108), most responses are in the "Agree" (28) and "Strongly Agree" (27) categories, showing a relatively strong desire to adopt new farming practices. However, there is a significant population in the "Strongly Disagree" (22) and "Disagree" (14) categories also. This demonstrates that some Chhetri respondents are resistant or hesitant about new farming activities. The "Neutral" category (17) indicates notable unwillingness or a lack of clarity regarding the issue.

Regarding Brahmin respondents (n=7), the distribution is less inconsistent with only two agreeing, 1 strongly agreeing, and 2 neutral. This reflects a small study size but suggests a less marked willingness to adopt new farming methods than Chhetri participants. The Bishwokarma (n=4) and Thakuri (n=1) respondents have even lower levels of agreement, with only a small fraction supporting the adoption of new farming practices. These statistics demonstrate a substantial difference in adaptability among caste groups, with Chhetri respondents agreeing the most and others demonstrating more resistance or indifference. Cultural, sociological, or economic considerations may influence how different castes perceive and respond to new farming practices.

4.4.3. Education and Use of Drought-Resistant Crop Varieties

Table 4.4.3 Education and Use of Drought-Resistant Crop Varieties

Variable		**Use of Drought-Resistant Crop Varieties**					**Total**
		Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	
Education	Primary	1	2	1	5	2	11
	Secondary	8	9	21	22	18	78
	Higher	6	3	4	6	5	24
	Illiterate	1	2	0	2	2	7
Total		16	16	26	35	27	120

Source: Field Survey, 2024

Table 4.1.17 explores how formal education levels correlate with the use of effective drought-resistant crop varieties for climate change adaptation. Most respondents with secondary education (n=78) held positive opinions, with 22 agreeing and 18 strongly agreeing. This group also had some neutral replies (21) and moderate levels of disagreement (8 strongly disagreeing and 9 disagreeing). This diverse range of replies indicates that secondary school provides individuals with both awareness and critical perspectives on climate adaptation measures.

Respondents with primary education (n=11) and higher education (n=24) gave different opinions. Among those with primary education, 5 agreed, with 2 strongly agreeing, suggesting a positive viewpoint despite their little formal education. Those with higher education were more divided, with 6 agreeing and 5 strongly agreeing, as well as a significant number (6) strongly disapproving, indicating that opinions vary even within this group. Among the illiterate respondents (n=7), views were overwhelmingly positive, with two agreeing and two strongly agreeing, while one strongly disagreed and two disagreed. Overall, findings indicate that, while formal education plays an important role in establishing a positive attitude towards the use of drought-resistant crops. People with little or no education are also familiar with the advantages of using drought-resistant crops.

4.4.4 Adoption of Climate-Smart Agricultural Practices

Table 4.4.4 Adoption of Climate-Smart Agricultural Practices

Items	Min	Max	Mean	Std. Deviation	Skewness
Adopted new farming practices.	1	5	3.26	1.464	-0.362
Use of drought-resistant crops.	1	5	3.34	1.325	-0.411
Changed planting/harvesting schedules.	1	5	3.62	1.258	-0.372
Access to climate-related information to improve farming.	1	5	3.57	1.307	-0.408
Invested in water-saving irrigation.	1	5	3.56	1.358	-0.544
Implementation of soil conservation techniques is effective.	1	5	3.28	1.270	-0.233

Source: Field Study, 2024

Table 4.4.1 presents the adoption of various climate-smart agricultural practices among farmers, focusing on five key areas: adoption of new farming practices, usage of drought-resistant crops, modifications in planting/harvesting schedules, access to climate-related information, and investment in water-saving irrigation techniques.

With a mean value of 3.62, a standard deviation of 1.258 and a skewness of -0.372, farmers expressed the least amount of opposition to changing planting and harvesting times, suggesting widespread embrace and important levels of support. A mean value of 3.57, standard deviation of 1.307 and a skewness of -0.408 indicate that farmers constantly looked for climate-related information to improve their farming methods.

Significant investments in water-saving irrigation techniques, which had the largest negative skewness of -0.544, a mean value of 3.56, and a standard deviation of 1.358, showed that water conservation had become a top priority. With a mean score of 3.34, standard deviation of 1.325, and skewness of -0.411, the adoption of drought-resistant crops demonstrated moderate implementation levels. The adoption of general climate-adaptive farming practices was also moderate, with a mean of 3.26, a standard deviation of 1.464, and a skewness of -0.362.

The above table also indicates that implementing soil conservation techniques has been effective. With a mean score of 3.28 and a standard deviation of 1.270, this technique had modest adoption levels among the respondents. A varying but generally consistent adoption pattern is observed. The skewness value of -0.233 also suggests a tendency towards higher adoption rates.

The negative skewness values of all these practices, which ranged from -0.362 to -0.544, showed a strong tendency towards higher adoption rates. The consistent standard deviation values, which cluster around 1.3, suggest similar divergence in adoption trends across various methods. *The KII individuals also support the opinions of the respondents in Sigas -2.*

4.4.5. Education and climate-related information on improving farming

Table 4.4.5 Education and climate-related information on improving farming

Variables		Access to climate-related information on improving farming.					Total
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
Education	Primary	2	0	2	2	5	11
	Secondary	4	17	17	18	22	78
	Higher	2	5	5	3	9	24
	Illiterate	0	0	0	2	5	7
Total		8	22	24	25	41	120

Source: Field Survey, 2024

Table 4.1.16 explores the correlation between formal education levels and how access to climate-related information affects farming decisions. It highlights how educational level affects farmers' perceptions and decisions to use climate-smart methods. Those with secondary education (n=78) make up the largest group of respondents and are more inclined to say that climate-related information has helped them make better farming decisions. Specifically, 18 agreed and 22 strongly agreed, making up most of this category. However, 17 respondents with secondary education remained uninterested, whereas 17 disagreed, indicating a range of responses within this group.

Respondents with higher education (n=24) expressed a variety of opinions, with 9 strongly agreeing and only 3 agreeing while remaining neutral (5). Respondents with only primary education (n=11) or illiteracy (n=7) demonstrated significant agreement with a smaller proportion of participants (5 in both categories), despite their limited education levels. This shows that formally educated individuals may benefit from having access to climate-related knowledge to help them make informed decisions. Overall, the findings highlight that, although education plays a critical role in shaping farmers’ ability to use climate information effectively, even those with minimal or no formal education can find value in such information.

4.4.6 Access to Information and Training for Climate Adaptation

Table 4.4.6 Access to Information and Training for Climate Adaptation

Items	Min	Max	Mean	Std. Deviation	Skewness
Access to Climate-related information improves farming decisions.	1	5	3.57	1.307	-0.408
Received training on climate-smart agriculture.	1	5	2.69	1.383	0.320
Use of weather forecasts for farming.	1	5	3.25	1.324	-0.340
Regularly seek advice from agricultural extension services.	1	5	3.48	1.378	-0.474

Source: Field Study, 2024

Table 4.4.2 analyses the access to information and training for climate adaptation across multiple dimensions. With a mean value of 3.57 and skewness of -0.408, farmers show a noticeably positive priority for climate-related information as a tool for decision-making. This high average indicates that farmers understand the importance of climatic data for improving their farming practices.

This study found an alarming absence of training in climate-smart agriculture, which contrasts sharply with the positive reception of climate information. Many farmers still lack professional guidance in climate-adaptive methods, as seen by the much lower mean of 2.69 and standard deviation of 1.383 for training obtained, along with a positive skewness of 0.320.

Farmers have a relatively positive level of engagement with weather forecasting tools, as indicated by the weather forecast analysis's mean score of 3.25, indicating that these resources are being used. There is significant variance in how different farmers approach and use weather forecast information, as indicated by the standard deviation of 1.324. More farmers are grouped towards the positive end of the spectrum in their use of weather forecasts, as indicated by the negative skewness value of -0.340, which also shows a minor tendency towards higher scores.

Agricultural extension services were identified as a relatively well-utilized resource, evaluating 3.48 on average and standard deviation of 1.378. The negative skewness value of -0.474 for extension service usage indicates that, while many farmers actively seek professional help, there is still space to grow these crucial assistance groups.

Ward Chairperson and JTA had highlighted that new adaptation techniques related to training, awareness programmes, and informal education is being provided by the local level government and local organizations. Most of the involved individuals in these programmes are female members of the area. They also stated that the situation is gradually showing improvement in the agriculture patterns of the locals (Air, T. S. & Dhami, D.S. 2024 [KII]).

4.4.7 Government Support and Programs for Climate Adaptation

Table 4.4.7 Government Support and Programs for Climate Adaptation

Items	Min	Max	Mean	Std. Deviation	Skewness
Government programs aid farmers in climate adaptation.	1	5	3.08	1.493	-0.222
Government support is crucial in adaptation to climate change.	1	5	3.21	1.506	-0.272
Community-based adaptation strategies are effective in adaptation.	1	5	3.42	1.200	-0.310

Source: Field Study, 2024

Table 4.4.3 analyze the government support and programs regarding Climate Adaptation in Sigas -2. Although government aid programs are beneficial, their efficacy may not be perceived by everyone, as seen by the modest agreement among respondents (mean = 3.08). The standard deviation of 1.493 indicates some variation in viewpoints. This indicates that variables such as location, accessibility, or implementation quality can highly influence how well such programs operate. The negative skewness (-0.222) suggests that respondents had a generally positive attitude towards these initiatives, leaning more towards agreement than dissatisfaction

Strong government support in addressing climate concerns is necessary. This obtained a significantly higher level of agreement, with a mean of 3.21. The high standard deviation (1.506), however it suggests that respondents' opinions were highly diverse, possibly reflecting variations in how adequate government initiatives were viewed in different sectors and geographical areas. Despite being relatively, a little disappointing, the skewness (-0.272) indicates an increase in respondent's agreement, demonstrating the widespread recognition of the role of the government in adaptation efforts.

With the highest mean value of 3.42, community-based adaptation solutions are successful in adaption. This number indicates that respondents strongly agreed that localised community-based initiatives are effective. A more consistent viewpoint among respondents is indicated by the smaller standard deviation of 1.200, which implies that these tactics are widely seen as useful and practicable. This pattern of behaviour is further supported by the skewness number (-0.310), which shows that most respondents agree with the statement.

The Ward Chairperson of Sigas -2 has mentioned that the government had provided aid to the locals through different programmes and various local organizations have helped the local government to distribute improved seeds and organize various programmes (Air, T. S., 2024[KII]). The respected elderly have slightly different opinions regarding this. He said "*I have not participated in any programmes organized by the government. I don't know of any such initiatives taken by the government. But yes, I have seen some organizations conduct such programmes in the neighbourhood.*" *He further described that there are few community-based organizations in the area and people are using Indigenous knowledge to combat climate change than modern knowledge* (Dhami, R.S., 2024 [KII]).

4.4.8 Diversification and Support through Collaborative Efforts

Table 4.4.8 Diversification and Support through Collaborative Efforts

Items	Min	Max	Mean	Std. Deviation	Skewness
Invested in water-saving irrigation techniques.	1	5	3.56	1.358	-0.544
Joined farmer groups to support in adapting to climate change.	1	5	3.48	1.283	-0.417
Diversified the income sources for risk reduction.	1	5	3.19	1.239	-0.318

Source: Field Study, 2024

Table 4.4.4 reveals significant insights regarding agricultural adaptation strategies through diversification and collaborative initiatives.

Amongst the measured parameters, the use of water-saving irrigation methods shows the greatest mean value (3.56) with a standard deviation of 1.358. A significant unequal distribution weighted towards higher values is indicated by the notable negative skewness (-0.544), which suggests that respondents strongly prefer this adaption strategy. The perceived relevance of technical solutions in agricultural water management is highlighted by this finding.

With a mean value of 3.48 and a standard deviation of 1.283, the data on farmer group engagement for climate adaptation shows the same upward trend. Although not as significant as irrigation techniques, the negative skewness value (-0.417) indicates a distribution pattern supporting positive results. This suggests that the importance of teamwork in tackling climate issues is widely acknowledged.

Although the income-source diversification strategy has a positive mean value of 3.19, it has the lowest average among others. While the negative skewness (-0.318) indicates a significant inclination towards higher ratings, the standard deviation of 1.239 indicates very consistent response patterns. According to this study's findings, although diversification of income is acknowledged to be advantageous, some people may view it as difficult to use or less beneficial immediately than other approaches.

Chapter V: Summary, Conclusion and Recommendation

The research findings are summarized in this chapter. This chapter has three sections. The first is a summary of the study which provides general background of the study and provides a general background on research. The second section is the conclusion of the study, and the third section delivers the recommendations.

5.1 Summary of Findings

The general objective of the study was to analyze the effect of climate change on agriculture in Sigas rural municipality. The specific objectives of the study were to examine the trend of climate change, to assess the effects of climate change on agriculture production, and to analyze the adaptation strategy applied by farmers in the Sigas rural municipality, Baitadi.

A mixed approach was applied to gain an insightful understanding of this study. For the qualitative approach, the Key Informant Interview (KII) was used for data collection. The household survey was conducted to collect quantitative data from the field. The data was analyzed and presented by combining the findings obtained with both approaches.

The study involved 120 respondents. Most respondents were aged 40-50 years (32.5 percent), with a higher percentage of males (56.7 percent) than females (43.3 percent). The respondents involved in this study were mostly married (66 percent) and from the Chhetri ethnic group (90 percent). All respondents in the study were Hindu, and 58 percent lived in joint families. Agriculture (73.3 percent) is the dominant occupation followed by government jobs (12.5 percent) of the locals and the education level of Sigas-2 was high, with 65 percent of respondents having secondary education.

Meteorological data from 2010 to 2024 obtained from the Department of Hydrology and Meteorology (2024) showed significant temperature fluctuations, with a warming trend in recent years. Precipitation data from 1990 to 2024 indicated repeated patterns with years of heavy rainfall followed by dry years. Respondents have also observed noticeable changes in temperature and weather patterns, with summers getting hotter and winters becoming colder. They also noted shifts in rainfall patterns and an increase in unpredictable weather events.

In this study, it has been determined that there exists a strong agreement among respondents about the increase in dry spellings, shifts in the rainy season, changes in flowering and fruiting times, and drying of water sources. Climate change has significantly affected agricultural practices and productivity. Similarly, Respondents also reported that there are changes in weather patterns, increased extreme weather events, and impacts on soil fertility and crop yields.

Data analysis and field survey found that the availability of irrigation water was unpredictable, and there was an increase in pests and diseases. The cost of farming inputs had risen, and livestock health was impacted. Household income from agriculture had decreased, traditional farming methods were less effective, and crop failure incidents had increased over the years. Due to this, the market prices of agricultural products were also affected.

To combat these variations in climate, locals of Sigas -2 adopted new farming practices, used drought-resistant crops, changed planting/harvesting schedules, and invested in water-saving irrigation techniques. They also sought climate-related information and training, although access to training was limited. Government programs and community-based adaptation strategies were seen as crucial for climate adaptation. However, the effectiveness of these programs has contrasted.

5.2 Conclusion

This study explores how climate change exerts a serious threat to the agricultural sector in Sigas Rural Municipality-2. It draws attention to major environmental changes such as changing weather patterns, an increase in the frequency of extreme weather events, and changes in precipitation and temperature. These variations have shown a significant decline in agricultural production, the health of the soil, and the availability of water supplies. The study results demonstrate that people are prone to various climate-related problems, including water scarcity, irregular irrigation schedules, and a rise in disease and pest outbreaks. These changes directly affect food security, household incomes, and overall development in the region.

Local farmers have demonstrated resilience in dealing with these challenges by applying community-based adaptation techniques and indigenous knowledge. They have adopted CSA principles, such as using water-saving irrigation methods and drought-resistant crops. Despite the potential of these approaches, their full implementation is somehow limited by a lack of resources and expertise. To deal with unstable markets and growing input prices, farmers are using new farming techniques and diversifying their sources of income. Furthermore, incorporating indigenous knowledge with modern farming practices and developing institutional support systems are critical for increasing agricultural sustainability. Furthermore, this study also advocates for collaborative partnerships between local governments, organizations, and farming communities to build resilience and promote sustainable agricultural practices. To address the short-term and long-term effects of climate change on agriculture, an integrated approach is essential for maintaining long-term agricultural sustainability and enhancing livelihood outcomes.

5.3 Recommendations

To address the negative impact of climate change on agriculture in Sigas Rural Municipality-02, Baitadi, some strategic measures have been proposed. These recommendations aim to enhance agricultural resilience, foster climate adaptation, and promote sustainability.

The recommendations include,

- Promote drought-tolerant crop varieties and foster crop diversification for year-round productivity.
- Implement strategies to combat pest invasions and crop diseases driven by climate change.
- To ensure fair water distribution, set up water collection systems, use water-saving irrigation techniques, and involve the community in managing the resources.
- Organize training programs on climate-smart agriculture and facilitate peer-to-peer knowledge exchanges among farmers.
- Improve government program effectiveness through collaboration among agencies, local groups and organizations, and communities.
- Allocate resources for developing infrastructure like roads and storage facilities to enhance market access and minimize post-harvest losses.
- Support small-scale agro-processing ventures and explore eco-tourism opportunities to diversify income sources.

These recommendations aim to ensure food security and resilient livelihoods for the people of Sigas Rural Municipality.

References

Abou-hussein, S. D. (2012). Climate change and its impact on the productivity and quality of vegetable crops (review article). *The Journal of Applied Sciences Research*, 4359–4383.

Abraham, J., Cook, J., Fasullo, J., Jacobs, P., Mandia, S., & Nuccitelli, D. (2014). Review of the consensus and asymmetric quality of research on human-induced climate change. *Cosmopolis*, *2014*, 3–18.

Acharya, S. P., & Bhatta, G. R. (2013). Impact of Climate Change on Agricultural Growth in Nepal. *NRB Economic Review*, *25*(2), 1–16. https://doi.org/10.3126/nrber.v25i2.52682

Adger, W. N., Huq, S., Brown, K., Conway, D., & Hulme, M. (2003). Adaptation to climate change in the developing world. *Progress in Development Studies*, *3*(3), 179–195. https://doi.org/10.1191/1464993403ps060oa

Adhikari, S. D. (2011). *Impacts of climate change on rural livelihood and its adaptation practices: A case study from fulkharka vdc of dhading district, nepal* [Tribhuvan University]. https://hdl.handle.net/20.500.14540/12952

Aggarwal, P. K., & Mall, R. K. (2002). Climate Change and Rice Yields in Diverse Agro-Environments of India. II. Effect of Uncertainties in Scenarios and Crop Models on Impact Assessment. *Climatic Change*, *52*(3), 331–343. https://doi.org/10.1023/A:1013714506779

AL com and Press-Register staff. (2011, January 14). *2010 wettest year on record; tied with 2005 as hottest year on record, NOAA says*. Al. https://www.al.com/live/2011/01/2010_wettest_year_on_record_ti.html

Arora, N. K. (2019). Impact of climate change on agriculture production and its sustainable solutions. *Environmental Sustainability*, *2*(2), 95–96. https://doi.org/10.1007/s42398-019-00078-w

Ashley, C., & Carney, D. (1999). *Sustainable livelihoods: Lessons from early experience*. https://api.semanticscholar.org/CorpusID:44220778

Awasthi, R. P., & Owen, J. S. (2020). Observed Climate Extreme in Nepal. *The Geographic Base*, *7*, 1–14. https://doi.org/10.3126/tgb.v7i0.34262

Baidya, S. K., Shrestha, M., Sheikh, M. M., Shrestha, M. L., & Sheikh, M. M. (2008). *TRENDS IN DAILY CLIMATIC EXTREMES OF TEMPERATURE AND PRECIPITATION IN NEPAL*. https://api.semanticscholar.org/CorpusID:131943022

Barrios, S., Ouattara, B., & Strobl, E. (2008). The impact of climatic change on agricultural production: Is it different for Africa? *Food Policy*, *33*(4), 287–298. https://doi.org/10.1016/j.foodpol.2008.01.003

Bast, J. L. (2010). *Seven Theories of Climate Change*. Heartland Institute. https://books.google.com.np/books?id=b3LDZwEACAAJ

BBC. (2024). *What is climate change? A really simple guide*. https://www.bbc.com/news/science-environment-24021772

Best, J. W., & Kahn, J. V. (2006). *Research in Education*. Pearson/Allyn and Bacon. https://books.google.com.np/books?id=xgliQgAACAAJ

Bocchiola, D., Brunetti, L., Soncini, A., Polinelli, F., & Gianinetto, M. (2019). Impact of climate change on agricultural productivity and food security in the Himalayas: A case study in Nepal. *Agricultural Systems*, *171*, 113–125. https://doi.org/10.1016/j.agsy.2019.01.008

CARE. (2009). *Climate change impacts on livelihoods of poor and vulnerable communities and biodiversity conservation: A case study in Banke, Bardia, Dhading, and Rasuwa districts of Nepal*. SAGUN Program, CARE Nepal.

CBS, C. B. of S. (2017). *National climate change impact survey 2016: A statistical report* (pp. 38–120). Government of Nepal, National Planning Commission Secretariat, Central Bureau of Statistics. https://climate.mohp.gov.np/downloads/National_Climate_Change_Impact_Survey_Report_2016.pdf

CBS, C. B. of S. (2021a). *National Agricultural Census 2021*. https://www.agricensusnepal.gov.np/category/40

CBS, C. B. of S. (2021b). *National Population and and Housing Census 2021*. https://censusnepal.cbs.gov.np/results/population?province=7&district=72&municipality=10

Challinor, A., Wheeler, T., Garforth, C., Craufurd, P., & Kassam, A. (2007). Assessing the vulnerability of food crop systems in Africa to climate change. *Climatic Change*, *83*(3), 381–399. https://doi.org/10.1007/s10584-007-9249-0

CIAT, C., & World Bank, L.-B. (2017). Climate-Smart Agriculture in Nepal. CSA Country Profiles for Asia Series. In *The World Bank; CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS); Local Initiatives for Biodiversity Research and Development* (Vol. 26). LI-BIRD.

Cohen, L., Manion, L., & Morrison, K. (2017). *Research Methods in Education* (8th ed., p. 944). Routledge.

Crate, S. A., & Nuttall, M. (2009). *Anthropology and Climate Change: From Encounters to Actions*. Left Coast Press. https://books.google.com.np/books?id=55mHNAAACAAJ

Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications.

Dahal, N. (2009). *Impact of climate change on forests and livelihoods: Issues and options for Nepal*. Livelihoods and Forestry Programme.

Dash, S. K. (2007). *Climate Change: An Indian Perspective* (1st ed.). Foundation Books. https://www.cambridge.org/core/product/identifier/9788175968837/type/book

Datta Sapkota, B. (2021). *Sustainable Livelihoods Approach: Alternative to Rural Development* (Triyuga Academic Journal, Vol. 2, pp. 39–39).

Dawadi, B., Shrestha, A., Acharya, R. H., Dhital, Y. P., & Devkota, R. (2022). Impact of climate change on agricultural production: A case of Rasuwa

District, Nepal. *Regional Sustainability*, *3*(2), 122–132. https://doi.org/10.1016/j.regsus.2022.07.002

Dhakal, S., Sedhain, G. K., & Dhakal, S. C. (2016). Climate change impact and adaptation practices in agriculture: A case study of Rautahat District, Nepal. *Climate*, *4*(4). https://doi.org/10.3390/cli4040063

Easterling, W., Aggarwal, P., Batima, P., Brander, K., Erda, L., Howden, M., Kirilenko, A., Morton, J., Soussana, J.-F., Schmidhuber, S., & Tubiello, F. (2007). Food, fibre and forest products. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, & C. E. Hanson (Eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 273–313). Cambridge University Press.

Eng, L., & DFID, T. D. F. O. R. I. D. (1999). *SUSTAINABLE LIVELIHOODS GUIDANCE SHEETS*. https://bit.ly/4hITpGt

EU. (2024, July 18). *Climate change—European Commission*. Agriculture and Rural Development. https://agriculture.ec.europa.eu/sustainability/environmental-sustainability/climate-change_en

FAO. (2006). *Building on Gender, Agrobiodiversity and Local Knowledge – A Training Manual*. https://www.fao.org/4/y5956e/Y5956E04.htm

FAO (Ed.). (2013). *Climate-smart agriculture sourcebook*. FAO.

FAO. (2019). *Strengthening climate resilient agriculture in Nepal*. https://www.fao.org/partnerships/resource-partners/investing-for-results/news-article/en/c/1277472/

Fischer, G., Shah, M., Tubiello, F. N., & Velhuizen, H. van. (2005). Socio-Economic and Climate Change Impacts on Agriculture: An Integrated Assessment, 1990-2080. *Philosophical Transactions: Biological Sciences*, *360*(1463), 2067–2083.

Garbrecht, J. D., & Piechota, T. C. (2005). *Climate Variations, Climate Change, and Water Resources Engineering*. American Society of Civil Engineers. https://ascelibrary.org/doi/book/10.1061/9780784408247

Gautam, N. P. (2010). *CLIMATE CHANGE SCENARIO GENERATION USING STATISTICAL DOWNSCALING*. http://shodhbhagirathi.iitr.ac.in:8081/jspui/handle/123456789/3197

Ghimire, P. (2024). ApEx Explainer: How are our climate-related laws? *The Annapurna Express*. https://annapurna-express.prixa.net/story/50074/

Ghimire, R., & Chhetri, N. (2022). Challenges and prospects of Local Adaptation Plans of Action (LAPA) initiative in Nepal as everyday adaptation. *Ecology and Society*, *27*(4), art28. https://doi.org/10.5751/ES-13630-270428

Giri, M., & Dahal, D. R. (2021). Impact of Climate Change on Agriculture in Kavre District, Nepal. *Journal of APF Command and Staff College*, *4*(1), 106–119. https://doi.org/10.3126/japfcsc.v4i1.34141

GoN, G. of N. (2011). *National Framework on Local Adaptation Plans for Action*. Government of Nepal, Ministry of Environment, Singhdurbar. https://climate.mohp.gov.np/downloads/National_Framework_Local_Adaptation_Plan.pdf

IPCC. (2001). *Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change* (R. T. Watson & The Core Writing Team, Eds.). Cambridge University Press.

IPCC. (2007). *Climate change 2007: Impacts, adaptation and vulnerability: Contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge university press.

IPCC, I. P. O. C. C. (2023a). *Climate Change 2021 – The Physical Science Basis: Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (1st ed.). Cambridge University Press.

https://www.cambridge.org/core/product/identifier/9781009157896/type/book

IPCC, I. P. O. C. C. (2023b). *Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (1st ed.). Cambridge University Press. https://www.cambridge.org/core/product/identifier/9781009325844/type/book

IPCC, Lee, H., Calvin, K., Dasgupta, D., Krinner, G., Mukherji, A., Thorne, P. W., Trisos, C., Romero, J., Aldunce, P., Barrett, K., Blanco, G., Cheung, W. W. L., Connors, S., Denton, F., Diongue-Niang, A., Dodman, D., Garschagen, M., Geden, O., … Péan, C. (2023). *IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland.* (First). Intergovernmental Panel on Climate Change (IPCC). https://doi.org/10.59327/IPCC/AR6-9789291691647

Kandangwa, D. P. (2016). *Impact of Climate Change in Agriculture: A Case Study of Chhtedhunga VDC in Terhathum, District* [Faculty of Rural Development]. https://hdl.handle.net/20.500.14540/15896

Katuwal, S., & Rijal, D. (2015). Climate change impacts in agriculture: A case of Makrahar Village, Rupandehi, Nepal. *Nepal Journal of Environmental Science/Nepal Journal of Environmental Science*, *3*, 43–49. https://doi.org/10.3126/njes.v3i0.22734

Khapangi, M. K. (2023). *Impact of Climate Change and Adaptation Practice in Agriculture: A Study of Phalelung Rural Municipality Ward No.5, Panchthar, Nepal* [Department of Rural Development]. https://hdl.handle.net/20.500.14540/20692

Khatri, B. B., & Pasa, R. B. (2023a). Climate Change Adaptation Strategies of the Communities in Bagmati Province, Nepal. *Pravaha*, *29*(1), 89–102. https://doi.org/10.3126/pravaha.v29i1.71409

Khatri, B. B., & Pasa, R. B. (2023b). People's Perception on Climate Change: The Context of Local and Global Discourse. *Asian Journal of Population Sciences*, 68–79. https://doi.org/10.3126/ajps.v2i1.51091

Lal, R. (2004). Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. *Science*, *304*(5677), 1623–1627. https://doi.org/10.1126/science.1097396

LI-Bird. (2024). *Scaling up Climate Resilient Agriculture for Sustainable Livelihood of Smallholder Farmers in Nepal (CRA)*. Local Initiatives for Biodiversity, Research and Development (LI-BIRD). https://libird.org/projects/cra/

Lipper, L., McCarthy, N., Zilberman, D., Asfaw, S., & Branca, G. (Eds.). (2018). *Climate Smart Agriculture: Building Resilience to Climate Change* (Vol. 52). Springer International Publishing. https://doi.org/10.1007/978-3-319-61194-5

Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Bwalya, M., Caron, P., Cattaneo, A., Garrity, D., Henry, K., Hottle, R., Jackson, L., Jarvis, A., Kossam, F., Mann, W., McCarthy, N., Meybeck, A., Neufeldt, H., Remington, T., … Torquebiau, E. F. (2014). Climate-smart agriculture for food security. *Nature Climate Change*, *4*(12), 1068–1072. https://doi.org/10.1038/nclimate2437

Long, N., & Long, A. (1992). *Battlefields of Knowledge: The Interlocking of Theory and Practice in Social Research and Development*. Routledge. https://books.google.com.np/books?id=ZOftAAAAMAAJ

Malla, G. (2009). Climate Change and Its Impact on Nepalese Agriculture. *Journal of Agriculture and Environment*, *9*, 62–71. https://doi.org/10.3126/aej.v9i0.2119

MHFW & WHO Bangladesh. (2016). *Bangladesh Health National Adaptation Plan (HNAP)*. Ministry of Health and Family Welfare, WHO Country Office of Bangladesh. https://www.who.int/publications/m/item/hnap-bangladesh

MoALD, FAO, & UNDP. (2019). *Integrating Climate Change Adaptation into Agriculture Sector Planning of Nepal A Handbook*. Food Security and Food Technology Division, Ministry of Agriculture and Livestock Development. https://bit.ly/4hAjSG9

MoF, M. O. F. (2021). *Economic Survey 2020/21*. https://bit.ly/Ecosurvey20-21

MoPaE, M. of P. and E. (2016). *INTENDED NATIONALLY DETERMINED CONTRIBUTIONS (INDC)*. https://bit.ly/INDCS2016

MPPN. (2021). *Nepal Multidimensional Poverty Index 2021 MPPN*. https://www.mppn.org/nepal-multidimensional-poverty-index-2021/

NASA, N. A. and S. A. (2018). *What Is Climate Change? - NASA Science*. What Is Climate Change? https://science.nasa.gov/climate-change/what-is-climate-change/

Natarajan, N., Newsham, A., Rigg, J., & Suhardiman, D. (2022). A sustainable livelihoods framework for the 21st century. *World Development*, *155*, 105898–105898. https://doi.org/10.1016/j.worlddev.2022.105898

National Adaptation Programme of Action (NAPA) to Climate Change., 96 (2010). https://www.fao.org/faolex/results/details/en/c/LEX-FAOC169509/

Nelson, G. C., Valin, H., Sands, R. D., Havlík, P., Ahammad, H., Deryng, D., Elliott, J., Fujimori, S., Hasegawa, T., Heyhoe, E., Kyle, P., Von Lampe, M., Lotze-Campen, H., Mason d'Croz, D., Van Meijl, H., Van Der Mensbrugghe, D., Müller, C., Popp, A., Robertson, R., … Willenbockel, D. (2014). Climate change effects on agriculture: Economic responses to biophysical shocks. *Proceedings of the National Academy of Sciences*, *111*(9), 3274–3279. https://doi.org/10.1073/pnas.1222465110

NTNC, N. T. for N. C. (n.d.). *Livelihood and Food Security*. Livelihood and Food Security. Retrieved September 4, 2024, from https://ntnc.org.np/thematic-area/livelihood-and-food-security

OECD. (2019). *Enhancing the Mitigation of Climate Change though Agriculture: Policies, Economic Consequences, and Trade-offs*. OECD.

https://www.oecd-ilibrary.org/agriculture-and-food/enhancing-the-mitigation-of-climate-change-though-agriculture_e9a79226-en

OECD. (2023). *Agricultural Policy Monitoring and Evaluation 2023: Adapting Agriculture to Climate Change*. OECD. https://www.oecd-ilibrary.org/agriculture-and-food/agricultural-policy-monitoring-and-evaluation-2023_b14de474-en

Oxfam. (2023). *Climate Change and Disaster Management Resource Book*. Oxfam in Nepal. https://nepal.oxfam.org/latest/publications/climate-change-and-disaster-management

Paudel, M. N. (2016). Consequences of Climate Change In Agriculture and Ways to Cope Up Its Effect In Nepal. *Agronomy Journal of Nepal*, *4*, 25–37. https://doi.org/10.3126/ajn.v4i0.15514

Peniston, B. J. (2013). *HIGH MOUNTAINS ADAPTATION PARTNERSHIP A Review of Nepal's Local Adaptation Plans of Action (LAPA)*. https://bit.ly/2Le9jcd

Pokharel, T. (2015). Poverty in Nepal: Characteristics and Challenges. *Journal of Poverty, Investment and Development*, *11*, 44–55.

Prescott, S. L., Logan, A. C., Bristow, J., Rozzi, R., Moodie, R., Redvers, N., Haahtela, T., Warber, S., Poland, B., Hancock, T., & Berman, B. (2022). Exiting the Anthropocene: Achieving personal and planetary health in the 21st century. *Allergy*, *77*(12), 3498–3512. https://doi.org/10.1111/all.15419

Rai, J. K., Gurung, G. B., & Pathak, A. (with ForestAction (Organization) & Rural Reconstruction Nepal). (2015). *Climate change adaptation in MSFP working districts: Lessons from LAPA and CAPA preparation and implementation in the Koshi hill region*. ForestAction Nepal and RRN.

Regmi, S. D. (2013). *IMPACT OF CLIMATE CHANGE ON LIVELIHOODS OF RURAL COMMUNITIES A Case Study of Shankar Pokhari VDC, Parbat District* [Tribhuvan University]. https://hdl.handle.net/20.500.14540/9758

Rijal, R. (2010). *Climate Change and its Impact on Agriculture (A Case Study of Mangalbare VDC, Ilam)*.

https://elibrary.tucl.edu.np/bitstream/123456789/4478/1/All percent20Thesis.pdf

Rosenzweig, C., & Parry, M. L. (1994). Potential impact of climate change on world food supply. *Nature*, *367*(6459), 133–138. https://doi.org/10.1038/367133a0

Sapkota, B. D. (2021). Sustainable Livelihoods Approach: Alternative to Rural Development. *Triyuga Academic Journal*, 39–45. https://doi.org/10.3126/taj.v2i1.45619

Sapkota, R., & Rijal, K. (2016). *CLIMATE CHANGE AND ITS IMPACTS IN NEPAL*. https://bit.ly/4fFM20I

Shrestha, A. B., Wake, C. P., Mayewski, P. A., & Dibb, J. E. (1999). Maximum Temperature Trends in the Himalaya and Its Vicinity: An Analysis Based on Temperature Records from Nepal for the Period 1971–94. *Journal of Climate*, *12*(9), 2775–2786. https://doi.org/10.1175/1520-0442(1999)012<2775:MTTITH>2.0.CO;2

Sidiropoulos, M. (2023). *TEN THEORIES OF CLIMATE CHANGE*. 12–12.

Sigdel, L. (2022, January 8). *Climate change and its impact on Nepalese Agriculture*. Agriculture Student Liaison Forum. https://aslframpur.wordpress.com/2022/01/08/climate-change-and-its-impact-on-nepalese-agriculture/

Singh, A., & Lal, D. (2010). Preparation and characterization of activated carbon spheres from polystyrene sulphonate beads by steam and carbon dioxide activation. *Journal of Applied Polymer Science*, *115*(4), 2409–2415. https://doi.org/10.1002/app.31340

Taherdoost, H. (2016). Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research. *International Journal of Academic Research in Management*, *5*, 18–27. https://doi.org/10.2139/ssrn.3205035

Thakur, S. B. (2018). Climate change related policy environment in agriculture and food security in Nepal. *Journal of Agriculture and Environment*, *18*, 120–130. https://doi.org/10.3126/aej.v18i0.19897

The World Bank Group & The Asian Development Bank. (2021). *Climate Risk Country Profile: Nepal (2021)*. WBG and ADB. https://hdl.handle.net/10986/36374

TheClimateInstitute. (2013). *Climate of the Nation*. ClimateInstitute.com.au

Tiseo, I. (2024, May). *Atmospheric CO2 ppm by year 1959-2023*. Statista. https://www.statista.com/statistics/1091926/atmospheric-concentration-of-co2-historic/

UNFCCC. (1992). *United Nations Framework Convention on Climate Change*. https://bit.ly/defccUNFCC

United Nations. (1992). *UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE*. The United Nations Framework Convention on Climate Change (UNFCC). https://unfccc.int/

Vedwan, N., & Rhoades, R. E. (2001). Climate change in the Western Himalayas of India: A study of local perception and response. *Climate Research*, *19*, 109–117.

Villacis, A. H., Alwang, J. R., & Barrera, V. (2021). Linking risk preferences and risk perceptions of climate change: A prospect theory approach. *Agricultural Economics*, *52*(5), 863–877. https://doi.org/10.1111/agec.12659

WMO. (2013). *The Global Climate 2001 – 2010 a Decade of Climate Extremes Summary Report.* World Meteorological Organization. https://bit.ly/3YQtaVF

World Bank. (2005). *World Bank annual report 2005: Main report*. World Bank. https://bit.ly/wb-report-2005

World Bank. (2022, October 17). *Climate Explainer: Food Security and Climate Change*. World Bank Group. https://bit.ly/wb-blog-2022

World Bank. (2024, February 26). *Climate-Smart Agriculture*. World Bank Group. https://www.worldbank.org/en/topic/climate-smart-agriculture

World Bank Group. (2022). *Nepal Country Climate and Development Report*. World Bank. https://hdl.handle.net/10986/38012

Appendix A: Recommendation Letter from the Department

TRIBHUVAN UNIVERSITY

त्रिभुवन विश्वविद्यालय

CENTRAL DEPARTMENT OF RURAL DEVELOPMENT

ग्रामीण विकास केन्द्रीय विभाग

विभागीय प्रमुखको कार्यालय
कीर्तिपुर, काठमाडौं, नेपाल।
Office of the Head of Department
Kirtipur, Kathmandu, Nepal.

Ref. No. :......................

Date मिति २०८१।०८।१०

त्रिभुवन विश्वविद्यालय ग्रामीण विकास केन्द्रीय विभाग कीर्तिपुर

जो जससँग सम्बन्ध छ।

यस विभागमा स्नातकोत्तर तहमा अध्ययनरत रोल नं. ०७ का श्री यादव सिहं धामीले चौथो सेमेस्टर पुरा गरी Effect of Climate Change on Agriculture.विषयमा शोध कार्य गरिरहनु भएकोले अनुसन्धान तथा खोजकार्यका लागी निज विद्यार्थीलाई आवश्यक सहयोग गरिदिनु हुन अनुरोध गर्दछु।

सह-प्रा.बिष्णु बहादुर खत्री

विभागीय प्रमुख

Tel.: 977-1- 4333581, 977-1- 4331383, Website: www.cdrd.edu.np, E-mail : contact@cdrd.edu.np

Appendix B: Household Survey Questionnaire

Namaskar!
Dear respondent, this study is completely an MA dissertation work, and it does not carry any official record. This study will rely on your valuable responses. The information obtained from you during this study will not be used for any purpose other than research. Your responses will be kept confidential according to the data protection regulations of 2018.

\- Yadav Singh Dhami (The Researcher)

Section A: Household Characteristics

1. Name:
2. Age:
3. Sex of the respondent: ☐ Male ☐ Female ☐ Others
4. Marital Status: ☐ Single ☐ Married ☐ Divorced ☐ Widowed ☐ Single Woman ☐ Single Man
5. Caste/ethnicity: ☐ Chhetri ☐ Brahmin ☐ Bishwokarma ☐ Thakuri ☐ Other
6. Religion: ☐ Hindu ☐ Bouddha ☐ Kirat ☐ Others, then please specify..................
7. Your formal educational status: ☐ Primary ☐ Secondary ☐ Higher ☐ Illiterate
8. Your subject specification in higher education: ☐ Management ☐ Education ☐ Arts and Humanities ☐ Sciences and Technology ☐ Health ☐ Engineering ☐ Agriculture ☐ Forestry ☐ Animal Science/Veterinary ☐ IT ☐ Others
9. Family system: ☐ Joint family ☐ Nuclear family
10. Total numbers of female members................. and Total numbers of male members ....
11. Number of school-going children: Government school ……………
    Private school……………
12. Number of college-going children:
    Government college/university ……….. Private college…………
13. Family occupations: ☐ Agriculture ☐ Enterprises ☐ Business ☐ Govt. job ☐ Private job ☐Remittance
14. Food Sufficiency: ☐ <3 months ☐ 3-6 months☐ 9-12 Months☐ >12 Months
15. Land Holdings status:

Items	Present (In Ropani)	15 Years Ago (In Ropani)
Farmland		
Pastureland		
Non cultivated land		
Rented Land		
Leasehold Land		
Total		

Land Measurement
1 Bigha = 20 Kathha
1 Kathha = 20 Dhur
1 Ropani = 16 Aana
1 Aana = 4 Paisa
1 Paisa = 4 Daam

16. Annual Income and expenditure of your family:

Income	Amount in NRs	Expenditure	Amount in NRs
Agriculture		Daily consumption	
Local Shop		Cloths	
Government Job		Accessories/Gold	
Private Job		Child Education	
Daily Wages		Festival celebration	
Remittance		Medicine	
Others		Others	
Total		Total	

17. Section A: Trend of Climate Change in the Study Area

Measurement Scales: 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree

S. N.	Items	Response				
		1	2	3	4	5
1	I have observed changes in temperature over the years.					
2	Summers are getting hotter than before.					
3	Winters are becoming colder compared to past years.					
4	Rainfall patterns have changed noticeably.					
5	There are more unpredictable weather events now.					
6	I have seen an increase in dry spells/droughts over time.					
7	The start and end of the rainy season have shifted.					
8	There are fewer cold days during winter than in the past.					
9	I have noticed changes in the flowering and fruiting times of plants and trees.					
10	Water sources like rivers, streams, and wells are drying up faster.					

18. Section B: Effects of Climate Change on Agriculture Production

Measurement Scales: 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree

S. N.	Items	Response				
		1	2	3	4	5
1	I have noticed changes in the weather patterns in the past few years.					
2	The timing of seasons has shifted, affecting my farming activities.					
3	Extreme weather events like floods and droughts have increased recently.					
4	Crop yields have decreased due to changing weather patterns.					
5	Soil fertility has been affected by climate change.					
6	The availability of water for irrigation has become more unpredictable.					
7	Pests and diseases have increased due to climate change.					
8	The cost of farming input has risen due to climate-related challenges.					
9	Climate changes have impacted livestock health.					
10	I had to change the types of crops I grew because of the changing weather.					
11	Climate change has led to a decrease in my household income from agriculture.					
12	Traditional farming methods are no longer as effective due to changing climate.					
13	I have experienced more frequent crop failures in recent years.					
14	The market prices of my agricultural products have been affected by climate change.					

19. Section C: Adaptation Strategy Applied by Farmers

Measurement Scales: 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree

S. N.	Items	Response				
		1	2	3	4	5
1	I have adopted new farming practices to cope with climate change.					
2	Using drought-resistant crop varieties has helped me adapt to changing climate.					
3	I have altered planting and harvesting schedules due to climate change.					
4	Access to climate-related information has improved my farming decisions.					
5	I have invested in water-saving irrigation techniques.					
6	Joining farmer groups has provided support for adapting to climate change.					
7	I have received training on climate-smart agricultural practices.					
8	The government has carried out programs that aid farmers in adapting to climate change.					
9	Government support has been crucial in helping me adapt to climate change.					
10	I have diversified my income sources to reduce risks from climate impacts.					
11	Implementing soil conservation techniques has been effective in adaptation.					
12	I use weather forecasts to plan my farming activities.					
13	The use of organic farming methods has helped me adapt to climate change.					
14	Community-based adaptation strategies have been effective in dealing with climate change.					
15	I regularly seek advice from agricultural extension services to adapt to climate change.					

Appendix C: Key Informant Interview Questions

1. What changes in weather patterns have you seen that could be linked to climate change?
2. Have farmers changed the types of crops they grow or the way they farm because of these weather changes?
3. How have weather-related changes affected farmers' income?
4. What challenges have climate change raised to agriculture in this region?
5. Have there been more extreme weather events like droughts or floods? If yes, how have these affected farming and the community?
6. What new methods are farmers using to deal with the effects of climate change?
7. Can you talk about any support from the community or government that has helped farmers adapt to climate change?
8. How well do you think these new methods are working to reduce the impacts of climate change?
9. What do you think is needed to prepare for future weather changes?
10. What do you think the role of local leaders, business owners, civil society, and big farmers is in tackling climate change and supporting Agriculture?

Appendix D: List of selected Participants for KII

Name	Designation
Thagendra Singh Air	Sigas-2 Ward Chairperson
Dipen Singh Dhami	Junior Technical Assistant (JTA)
Ram Singh Dhami	Respected Elderly Person

Source: Field Survey, 2024

Appendix E: Data from the Department of Hydrology and Meteorology

Table 1: Precipitation data (in MM) of Baitadi, Gothalapani

Year	Baitadi (Gothalapani)
1990	1501.9
1991	1415
1992	1154
1993	1535.7
1994	1312.6
1995	1472.6
1996	1212.1
1997	1222.9
1998	1385.1
1999	917.8
2000	1863.4
2001	1283.2
2002	1408.7
2003	1036.9
2004	739.1
2005	1115.2
2006	1680.3
2007	1830.4
2008	1370.8
2009	405.3
2010	764.9
2011	1376.9
2012	927.7
2013	1567
2014	943.5
2015	1068.9
2016	1185.6
2017	1445.1
2018	1401.4
2019	1534.1
2020	1492.5
2021	1725.76
2022	1695.26
2023	1135.26
2024	1352.87

Source: Department of Meteorological and Hydrology, 2024

Table 2: Average Temperature of Baitadi, Gothalapani

Date	Maximum Air Temperature (Avg)	Minimum Air Temperature (Avg)
1/1/2010	26.922	11.353
1/1/2011	22.031	12.09
1/1/2012	21.543	9.17
1/1/2013	23.444	9.157
1/1/2014	21.902	7.462
1/1/2015	23.352	8.07
1/1/2016	24.938	11.081
1/1/2017	24.819	7.064
1/1/2018	25.985	9.439
1/1/2019	28.261	11.42
1/1/2020	30.592	11.271
1/1/2021	25.312	13.228
1/1/2022	25.594	13.461
1/1/2023	25.743	13.651
1/1/2024	27.187	13.529

Source: Department of Meteorological and Hydrology, 2024

Appendix F: Sample Size determination

Table for Determining Sample Size from a Given Population

N	S	N	S	N	S
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368

140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note:
N is population size.
S is sample size.

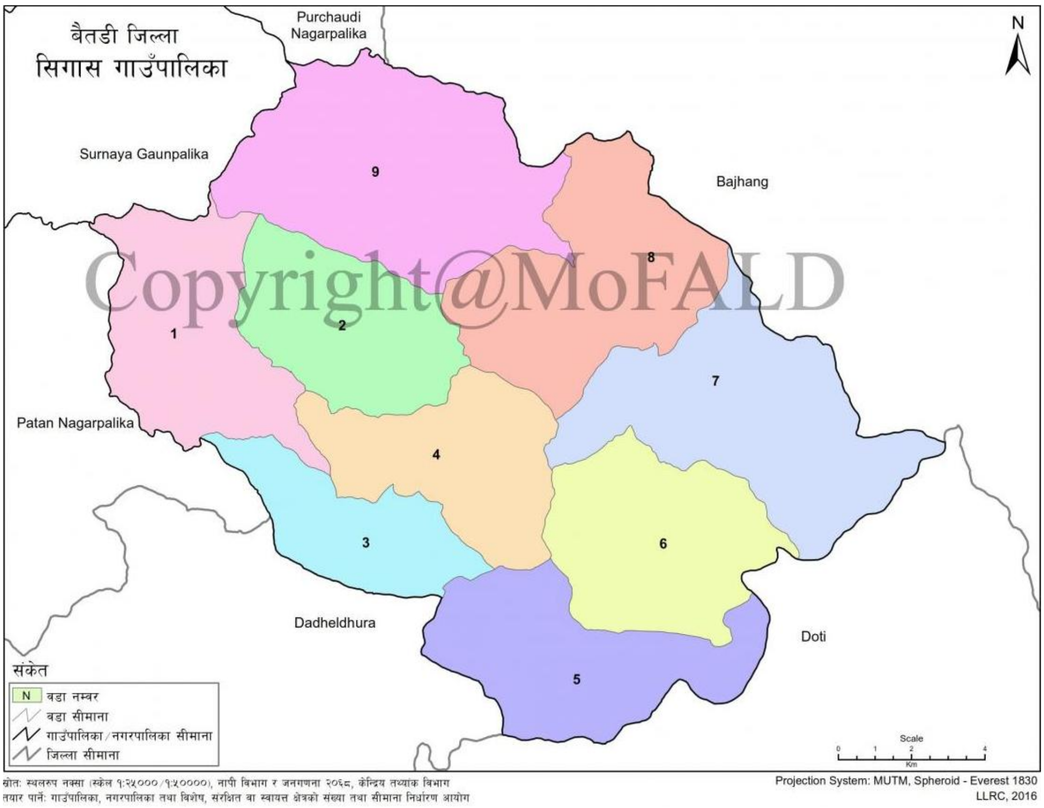
POPULATION SIZE KNOWN:

$$\text{SIZE} = \frac{X^2 NP(1-P)}{d^2(N-1) + X^2 P(1-P)}$$

X^2 = table value of Chi-Square @ $d.f. = 1$ for desired confidence level
.10 = 2.71 .05 = 3.84 .01 = 6.64 .001 = 10.83
N = population size
P = population proportion (assumed to be .50)
d = degree of accuracy (expressed as a proportion)

Appendix G: Map of Sigas Rural Municipality

Figure 9: Map of Sigas Rural Municipality.



Appendix H: Photo Gallery

Pictures during Field Survey

Pictures of Sigas -2