UNIVERSITY OF COPENHAGEN

Practicing Interdisciplinary Field Research on the Environment

# Climate Change and Adaptation Strategies of Smallholder Farmers in Chilaha and Ratawal, Nepal

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# Abstract

As the impacts of climate change become increasingly evident, the implementation of effective adaptation strategies is also crucial. Developing countries like Nepal are particularly vulnerable due to their dependence on agriculture, water resources and limited capacity to cope with environmental changes. This study, conducted in the villages of Chilaha and Ratawal in Kawasoti Municipality, Nepal, aimed to identify and analyze the adaptation strategies used by smallholder farmers to cope with Climate-Related Changes (CRCs). Using a mixed-methods approach, the research integrates primary and secondary data to identify key environmental changes, the perception of farmers, adaptation strategies, and barriers to implementation. The study applied a transect walk with Key Informants, followed by household surveys (N=27) using systematic random sampling, along with Key Informant semi-structured interviews (N=9) and one focus group discussion. Findings reveal that rising temperatures, declining rainfall, and water scarcity are the most pressing CRCs affecting farmers in the study area. To address these challenges, farmers have adopted individual-led, community-led, and State-led adaptation strategies including shifting planting dates, increasing fertilizer and pesticide use, constructing deep-boring wells, embanking rivers, and using improved seeds, among others. However, the research also concluded that the adoption and effectiveness of these measures are influenced by specific factors, including financial constraints, limited access to information, technology, and institutional support. These insights underscore the need for targeted interventions to enhance farmers' resilience and adaptive capacity in rural areas of Nepal.



**Keywords:** Climate change, farming, agriculture, developing countries, Nepal, perception of climate change, adaptation strategies, barriers.

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# List of acronyms

| | |
|---|---|
| AKC | Agricultural Knowledge Center |
| AO | Agricultural Officer |
| AS | Adaptation Strategies |
| BZC | Buffer Zone Committee |
| CFG | Community Forest Group |
| CRCs | Climate-Related Changes |
| EPA | Environmental Protection Agency |
| FGD | Focus Group Discussion |
| IPCC | Intergovernmental Panel on Climate Change |
| LAPA | Local Adaptation Plans for Action |
| NAP | National Adaptation Plan 2021-2050 |
| NASEM | National Academies of Sciences, Engineering, and Medicine |
| NTFPs | Non-Timber Forest Products |
| SIPs | Solar Irrigation Pumps |

## List of figures and tables

## 1. Introduction

Over the past few decades, climate change has become one of the most pressing challenges on the international agenda, due to the far-reaching impacts on both human societies and ecosystems. As awareness of this global phenomenon grows, there has also been a significant increase in research exploring its potential drivers, effects on human livelihoods and ecosystems, and more recently, strategies for adaptation and mitigation. Previous studies, such as the ones conducted by Mertz et al. (2009) and Ranabhat et al. (2023), argue that the effects of climate change are disproportionately affecting developing countries due to their high reliance on agriculture and watershed resources for their livelihoods, and the often limited economic and technological capacities to cope with environmental variation.

In this context, Nepal is among the world's most vulnerable countries to climate change, ranking 10th in the Global Climate Risk Index 2021 for weather-related damages such as floods, storms and heatwaves (German Watch, 2021). Over the past 40 years, events like floods and landslides have become more frequent, and climate change is expected to exacerbate these hazards (World Bank Group, 2022). Temperature in Nepal is expected to rise by approximately 0.9°C between 2016 and 2045, winters are predicted to become drier, while monsoon summers could experience a threefold increase in rainfall. Moreover, “climate variability is already a major driver of food insecurity and poverty in Nepal and warming temperatures exacerbate inequities across the country” (World Bank Group, 2022, p.12).

The effects of climate change in Nepal are particularly severe due to its reliance on agriculture. The majority of farmers practice rain-fed farming (Paudel et al., 2019), and agriculture is considered the backbone of the country’s economy, contributing 28% to the national GDP and providing 64.54% of employment opportunities (Ranabhat et al., 2023). The impacts of climate change in Nepal are geographically diverse.

While there has been extensive research on Nepal’s climate change adaptation at the national level, there is a significant gap in micro-level studies focused on local areas. The absence of localized research hinders the understanding of specific adaptation efforts, challenges, and strategies employed by farmers in these communities. Furthermore, there is a lack of insight into how these strategies are implemented and what factors influence farmers' decisions. Studies have shown contrasting perspectives on climate change impacts at the local level, with some communities recognizing its effects while others do not (Nash et al., 2019).

This variance in perception plays a critical role in shaping the implementation of adaptation strategies, as communities may prioritize different issues or respond to climate-related challenges in unique ways.

Despite ongoing adaptation efforts implemented by farmers in Nepal, significant barriers[1] persist (Rijal et al., 2022). Institutional support mechanisms, such as government-subsidized crop insurance programs, have been established to mitigate financial risks (Budhatoki et al., 2019). However, the utilization of these schemes has been low, suggesting that financial constraints and/or knowledge-based barriers may be hindering broader adaptation. This highlights the need for further investigation into the multidimensional limitations that affect farmers' abilities to adapt effectively to the long-term effects of climate change.

Given this context, this research aims to understand the key factors influencing the adaptation strategies used by smallholder farmers to cope with CRCs in two specific villages of Ward no. 10 of Kawasoti Municipality. Therefore, the overarching research question guiding this study is: *What are the adaptation strategies used by farmers to cope with Climate-Related Changes in Chilaha and Ratawal?* To provide a comprehensive answer to this, the study also explores the relationship between main CRCs experienced in the study area, how farmers perceive those changes in the environment, the adaptation strategies they have implemented, and the main barriers that prevent farmers from effectively adapting to long-term climate impacts.

By using the term *"Climate-Related Changes"* instead of "climate change," the research emphasizes both climate-induced disasters (such as floods, storms, and heatwaves) and the gradual environmental changes perceived by local communities. This conceptual approach is chosen to capture the local socio-economic and cultural context of the study area, and with the objective of obtaining specific insights that could inform policy-making and reflect the local perspectives and knowledge of the communities.

Ultimately, understanding climate change adaptation in developing countries requires a context-specific approach, where local socio-economic conditions, governance structures and access to resources play a crucial role. By analyzing localized adaptation measures, this study

[1] Defined as "factors, conditions or obstacles that reduce effectiveness of farmers adaptation strategies" (Devkota et. al, 2018, p. 283)

seeks to bridge the gap between farmers' perceptions, adaptation measures, and policy interventions, offering insights into how climate resilience can be strengthened in rural areas in Nepal.

## 2. Literature review

In this section, a literature review is outlined following three themes: *climate change impacts on Nepal, adaptation strategies to climate change*, and *barriers to effective adaptation*.

### *2.1 Climate change impacts on Nepal*

Climate change poses a significant challenge to Nepal, with rising temperatures, erratic precipitation patterns and increasing number of extreme CRCs threatening agricultural productivity and rural livelihoods (Ranabhat et al., 2023; Government of Nepal, 2021; Karki et al., 2019; Thapa et al., 2023). Nepal's vulnerability is compounded by its reliance on subsistence agriculture, weak institutional support, and limited access to financial and technological resources (Rijal et al., 2022; Dhakal et al., 2016).

Precipitation trends are highly variable, with monsoon season rains accounting for over 80% of annual rainfall (Karki et al., 2016). Extreme weather events, including floods, landslides and droughts, have intensified (Baidya et al., 2008), exacerbating food and water insecurity (Government of Nepal, 2021; IPCC, 2022). The Terai region, where agriculture is highly dependent on monsoon patterns, has experienced prolonged dry spells and severe flooding, disrupting cropping cycles, and reducing yields (Karki et al., 2016; Paudel et al., 2013). Increased temperatures and shifting precipitation patterns have also contributed to the spread of pests and crop diseases, further threatening food security (Dhakal et al., 2016; Rijal et al., 2022; Shrestha et al., 2023).

### *2.2 Adaptation strategies to climate change*

Farmers in Nepal employ various short-term and reactive adaptation strategies, including adjusting planting schedules, using drought-resistant crop varieties and increasing the reliance on chemical inputs such as fertilizers and pesticides (Dhakal et al., 2016; Rijal et al., 2022). Many farmers have also turned to irrigation improvements, such as rainwater harvesting and small-scale irrigation systems, to mitigate water shortages (Regmi et al., 2023; Ranabhat et al., 2023; Rijal et al., 2022; Dhakal et al., 2016). At the community level, adaptation measures include afforestation programs, watershed conservation efforts, and cooperative-led initiatives that promote knowledge-sharing and resource pooling (Government of Nepal, 2021; Ranabhat et al., 2023). However, these initiatives remain limited in scope and implementation due to financial and institutional constraints (Rijal et al., 2022).

The Nepalese government has developed several climate adaptation policies, including the National Adaptation Plan (NAP), the Local Adaptation Plans for Action (LAPA), and the National Climate Change Policy (Government of Nepal, 2021; Rijal et al., 2022). These policies aim to integrate climate adaptation into national and local development strategies. The NAP 2021-2050 provides a comprehensive framework addressing climate change vulnerabilities, focusing on agriculture, water resources, biodiversity, and disaster risk reduction (Government of Nepal, 2021). Locally, the LAPA framework "ensures that the process of integrating climate adaptation and resilience into local and national planning is bottom-up, inclusive, responsive and flexible" (Government of Nepal, 2011, p. 3).

### *2.3 Barriers to effective adaptation*

Despite these efforts, several studies have found the scope and implementation of national adaptation policies limited. According to Rijal et al. (2022) and Budhathoki et al. (2019), the effectiveness of policy implementations is hindered by weak governance, lack of coordination among agencies and limited financial resources. Further, adaptation planning in Nepal has been largely reactive rather than proactive, with limited involvement of local communities in decision-making processes (Ranabhat et al., 2023).

Financial limitations act as a major barrier to adaptation for smallholder farmers, who often lack access to credit and insurance schemes (Budhathoki et al., 2019; Gautam et al., 2018). Additionally, most farmers are unable to afford climate-resilient seeds, irrigation technologies or infrastructure improvements, making them highly vulnerable to climate shocks (Rijal et al., 2022).

Nepal's adaptation policies suffer from fragmented implementation, with poor coordination among different government agencies and donor organizations. The lack of knowledge dissemination further limits farmers' ability to adopt effective adaptation strategies (Nash et al., 2019; Regmi et al., 2023).

Socioeconomic factors, including gender inequality and labor shortages, influence climate adaptation in Nepal. Women tend to take the main responsibility of household chores, but due to climate change they must take on additional agricultural work, increasing their burden of labor (Ranabhat et al., 2023). Moreover, local knowledge is often overlooked in formal policy frameworks, and several studies have found that combining modern technology with traditional knowledge would enhance adaptive capacity and foster greater community engagement in climate adaptation planning (Race et al., 2016; Rijal et al, 2022; Ranabhat et al., 2023). As noted, the literature underscores the pressing need for climate adaptation strategies in Nepal's agricultural sector.

## 3. Meteorological data

To contextualize farmers' perceptions of CRCs an analysis of temperature and rainfall data of the last ten years (2014-2023) has been conducted. This meteorological assessment serves two purposes: identifying climate trends and establishing a baseline to analyze adaptive strategies.

### *3.1 Variability in temperature and precipitation*

Climate data has been collected by the station in Dumkauli, located 14 km from the village of Chilaha (Fig. 1). Given its proximity, it is used as a reliable reference for analyzing temperature and rainfall data of Chilaha and Ratawal villages and comparing data with farmers' perception.

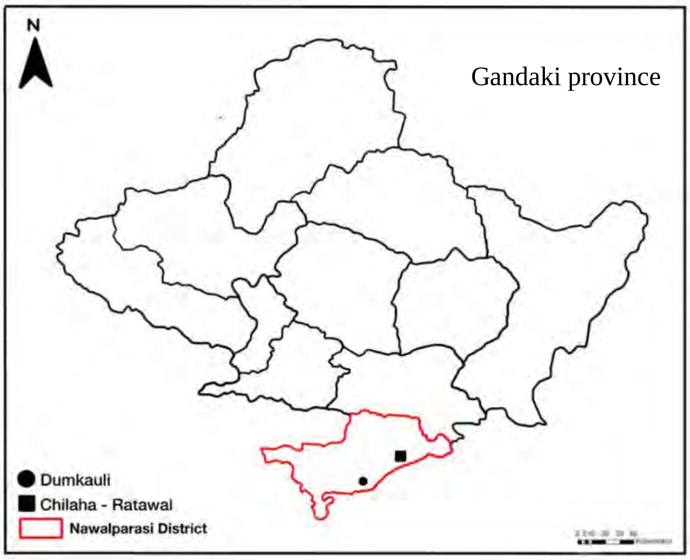



Fig. 1 Location of the meteorological station used in the study

### *3.2 Temperature analysis*

An analysis of temperature trends from 2014 to 2023 shows fluctuations in both maximum and minimum temperatures over the observed period. The mean annual maximum ranged from 30.54°C in 2014 to 33.99°C in 2016, while the mean annual minimum temperature varied between 18.84°C in 2020 and 19.69°C in 2022. The overall mean temperature, calculated as the average of the maximum and minimum, followed a similar pattern, fluctuating between 24.73°C and 26.59°C (Table 1).

| Year | MAX (°C) | MIN (°C) | MEAN (°C) |
|---|---|---|---|
| 2014 | 30.54 | 18.93 | 24.73 |
| 2015 | 32.99 | 19.14 | 26.07 |
| 2016 | 33.99 | 19.19 | 26.59 |
| 2017 | 33.57 | 19.26 | 26.41 |
| 2018 | 32.68 | 18.85 | 25.77 |
| 2019 | 32.96 | 19.46 | 26.21 |
| 2020 | 31.66 | 18.84 | 25.25 |
| 2021 | 32.71 | 19.29 | 26.00 |
| 2022 | 33.12 | 19.69 | 26.41 |
| 2023 | 33.35 | 19.50 | 26.42 |

Table 1. Annual variation in temperature from 2014 to 2023 at Dumkauli station.

The data reveal a rise in maximum, minimum, and mean temperatures over this period, with an average annual increase of 0,2345°C/yr, 0,04712°C/yr, and 0.14081°C/yr, respectively (Fig. 2), suggesting a gradual but consistent warming trend. While year-to-year variations are present, the overall trajectory aligns with broader climatic shifts observed in the region by other studies potentially linked to global and local environmental changes (Upadhayaya, 2019; Upadhayaya et al., 2020; Adhikari et al., 2023; Sharma et al., 2024).

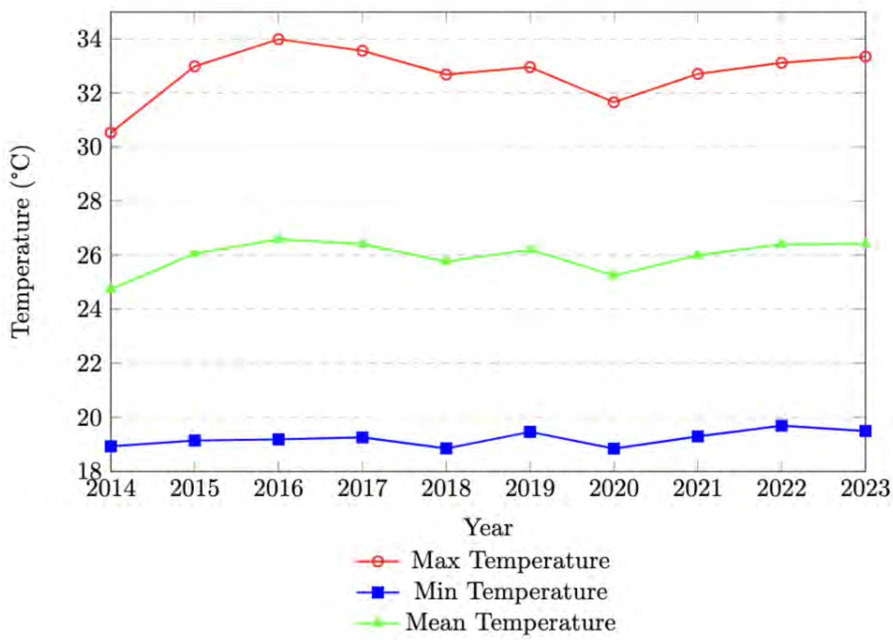



Fig. 2 Annual variation in temperature from 2014 to 2023 at Dumkauli station

### *3.3 Rainfall analysis*

Analyzing rainfall patterns over the past decade reveals significant seasonal variations. The monsoon months (June–September) consistently contribute to the majority of annual precipitation, ranging from 74% to 89% each year. In contrast, the period from October to February remains the driest, accounting for only 1% to 14% of the annual rainfall (Tables 2 and 3).

| Season | Months | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fall/Winter | Oct-Feb | 153 | 108.2 | 68.5 | 125 | 18 | 94.2 | 43.01 | 127.91 | 404.02 | 192.23 |
| Pre-Monsoon | Mar-May | 98.8 | 211 | 523.7 | 392.5 | 382.9 | 233.8 | 480.19 | 541.03 | 284.48 | 80.54 |
| Monsoon | June-Sept | 2068.7 | 1790 | 1931.3 | 1443.8 | 1373.7 | 1441.9 | 3268.74 | 2648.32 | 2148 | 1685.54 |

Table 2 Seasonal rainfall data (mm) from 2014 to 2023

| Season | Months | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fall/Winter | Nov-Feb | 7% | 5% | 3% | 6% | 1% | 5% | 1% | 4% | 14% | 10% |
| Pre-Monsoon | Mar-May | 4% | 10% | 21% | 20% | 22% | 13% | 13% | 16% | 10% | 4% |
| Monsoon | June-Sept | 89% | 85% | 77% | 74% | 77% | 81% | 86% | 80% | 76% | 86% |

Table 3 Seasonal rainfall distribution (%) from 2014 to 2023

The annual rainfall trend exhibits fluctuations, with a notable decline in precipitation from 2014 to 2019, followed by a sharp increase in 2020 and 2021. The year 2020 recorded the highest annual rainfall (3791.94 mm), while 2019 and 2018 experienced some of the lowest values (1769.9 mm and 1774.6 mm, respectively). However, post-2021, a decreasing trend re-emerges, with 2023 registering a lower total (1958.31 mm) (Fig. 3).

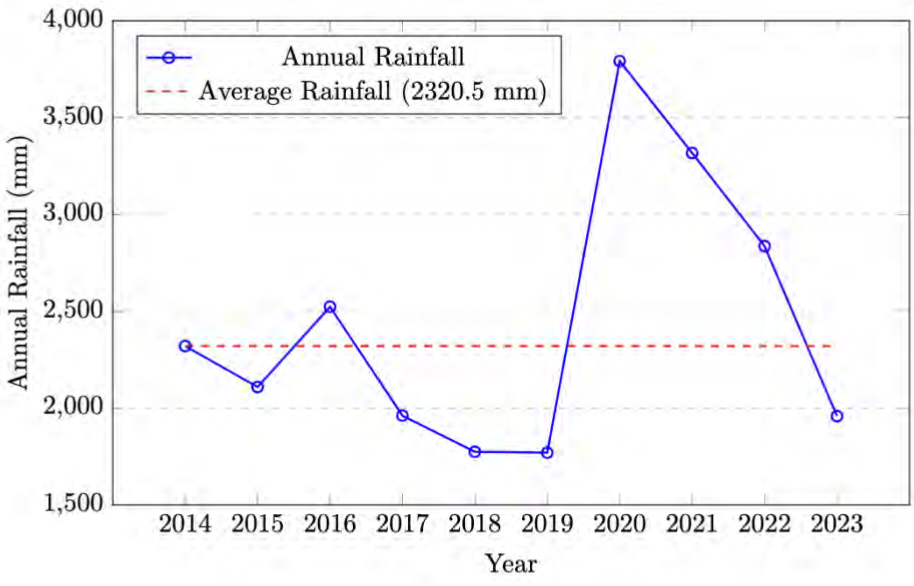



Fig. 3 Annual variation in precipitation (mm) from 2014 to 2023 at Dumkauli station

Given its significant contribution to total annual precipitation, monsoon rainfall trends further confirm variability, with notable declines observed between 2014 and 2019, followed by peaks in 2020 and 2021. The pre-monsoon season also reflects year-to-year variations, with 2016 and 2021 experiencing increased rainfall compared to other years. While winter rainfall typically remains minimal, the anomalous 2022 peak deviates from this pattern, underscoring both the unpredictability of seasonal precipitation and potential shifts in intra-annual rainfall distribution (Fig. 4).

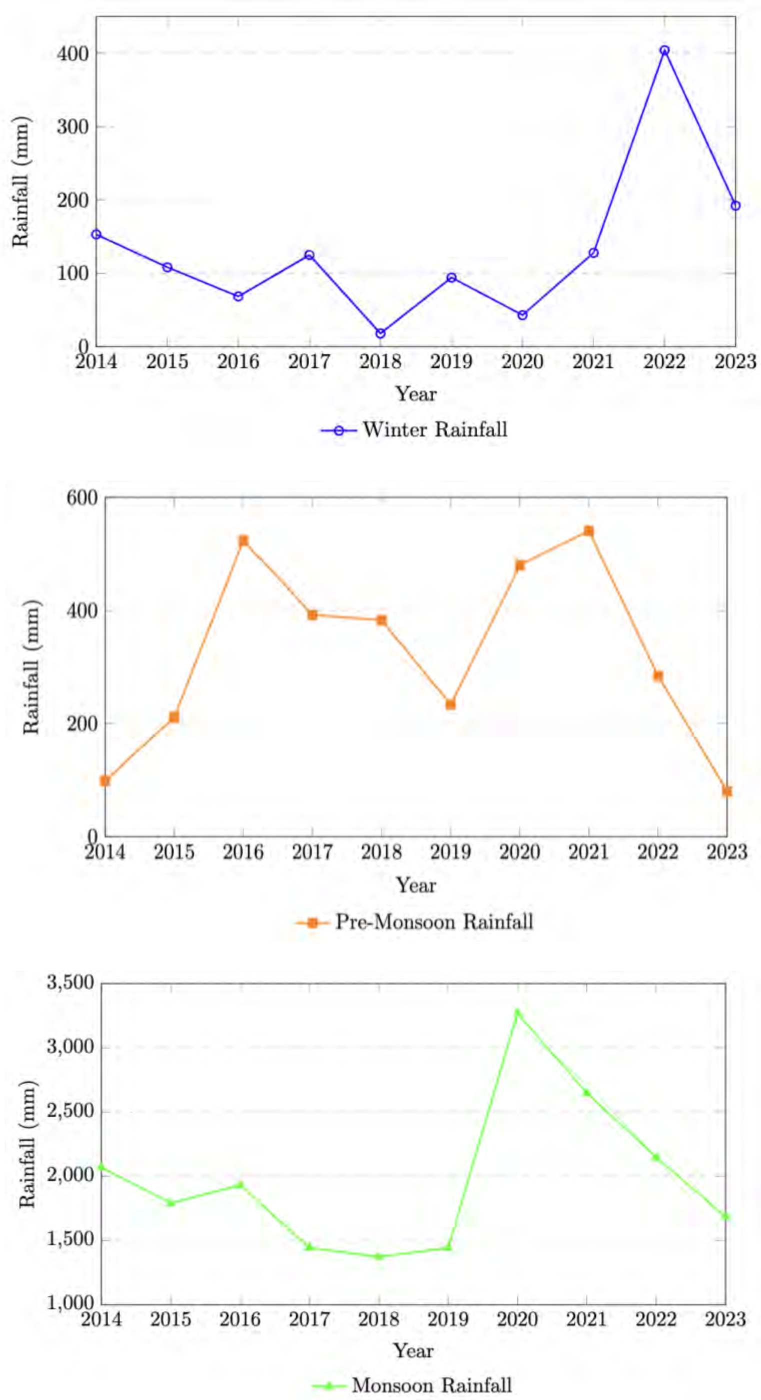



Fig. 4 Seasonal variation in annual precipitation (mm) from 2014 to 2023 at Dumkauli station

## 4. Theoretical framework

Adaptation to climate change operates within a complex, multi-dimensional context that considers temporal, economic, and governance factors. In order to analyze the adaptation strategies observed in the study area, this research aimed to develop a new framework (Fig. 5) relying on the IPCC[2] definition of “adaptation” and the contributions of Neil Adger (2005) to assess adaptation measures. Although Adger’s framework was originally designed to assess the “success” of adaptation strategies, this study uses it instead as a guiding lens to interpret results by identifying connections between variables and trying to understand the complexity of implementing adaptation strategies. The IPCC defines “adaptation” as the:

> *Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation* [...] (IPCC, 2001, p. 982).

This definition is relevant as it considers the multiple dimensions of climate change adaptation strategies. It includes the **time dimension**, distinguishing between short-term and long-term responses. Secondly, the choice of a specific adaptation strategy inherently involves trade-offs between harms and benefits, introducing the dimension of **cost-opportunity** and incorporating issues of procedural and distributional justice[3] which are fundamental for a just climate change adaptation (Venn, 2019). Lastly, it highlights the **actors dimension**, recognizing different types of adaptation (private/public, autonomous/planned) and their role in complex decision-making processes related to adaptation strategies.

These dimensions also align with Neil Adger's (2005) framework for evaluating adaptation strategies, which is based on the criteria of *effectiveness*, *efficacy*, and *equity/legitimacy*. ***Effectiveness*** is interpreted in terms of achieving a set objective on the basis of the time frame considered, linking it to the time dimension. ***Efficacy*** considers costs and benefits (economic and non-market based), aligning with the cost-opportunity dimension.

[2] Intergovernmental Panel on Climate Change (IPCC)

[3] Procedural justice is intended as justice that results from fairness of the process rather than fairness of the outcome itself (Fraser, 2007).
Distributional justice is intended as justice that results from fairness in distribution of costs and benefits across members of a society (Lamont & Favor, 2017; Kaufman, 2012).

***Equity and legitimacy*** address social acceptance, justice, and decision-making, connecting them to the actors dimension and highlighting who bears the consequences of adaptation decisions.

In light of this complexity, Adger (2005) highlights the importance of **scale** in adaptation, considering space and institutions. The spatial scale identifies the local, regional, national and global level of action, while the institutional scale focuses on actors such as individuals and communities, local, regional and national governments, and international organizations. As observed, the consideration of the **context** is essential because of cross-scale dynamics that mutually influence each other. Therefore, in this study, adaptation strategies need to be classified considering multiple levels of complexity arising from an environmental and socio-economic context that comprises different hierarchical structures and institutional processes. Agents involved in decision making processes have different interests and different power structures which are fundamental to consider in the interpretation of the results.

Another fundamental concept for the analysis is **vulnerability,** which is defined as a system's exposure, sensitivity, and adaptive capacity to climate change (IPCC, 2001). As noted by Adger (2006) vulnerability manifests itself at different levels, and the author highlights that marginalization in decision-making both results from and reinforces vulnerability. Ultimately, successful adaptation depends on how well policies, institutions, and communities navigate these interconnected challenges, ensuring that adaptation is not only effective but also sustainable, inclusive and just.

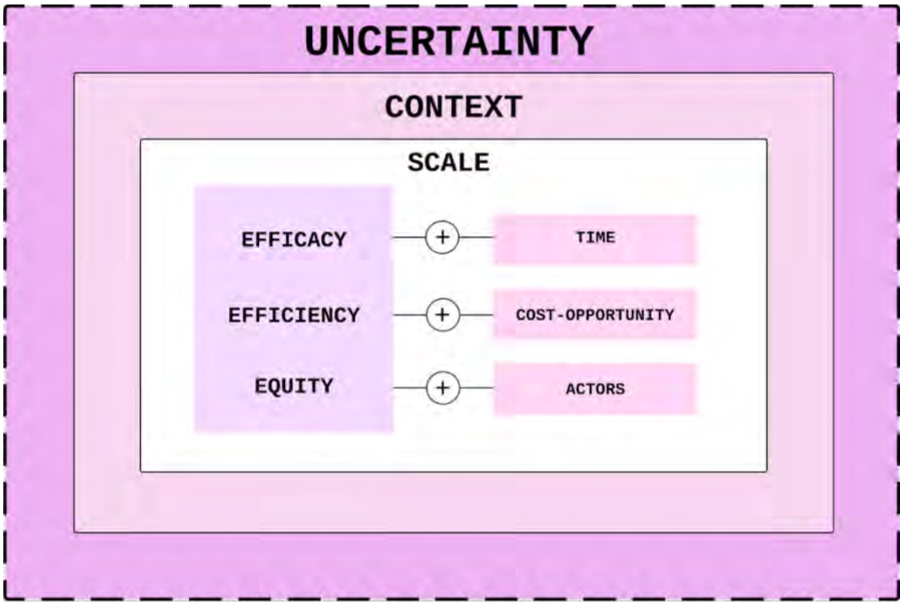



Fig. 5 Conceptual map of the framework used

## 5. Methodology

The following section outlines the methods adopted in this study. Utilizing a mixed-methods approach, this research integrates a qualitative approach to capture in-depth narratives, contextualized understandings and nuanced perceptions, and a quantitative analysis to explore potential relationship between farmers' level of concern of CRCs and other influencing factors (Bryman, 2006). This approach allows for cross-verification which will increase the validity of the findings (Creswell, 2009).

### *5.1 Study site*

The study was conducted in the villages of Chilaha and Ratawal, which, together with Magarkot, form Ward no. 10 of Kawasoti Municipality in Nawalpur District, located in the South-Central region of Nepal (Fig. 6). Lying in the Terai region, a lowland area bordering the Chitwan National Park to the East, the villages extend over an area of approximately 1.16 km², with their boundaries ranging from 27°35’32’’ N to 27°36’43’’ N in latitude and 84°06’47’’ E to 84°07’37’’ E in longitude.

Situated at an altitude of approximately 170 meters above sea level, the area is predominantly agricultural, with an estimated[4] 75% of land used for farming, 15% for natural landscapes and 10% for residential settlements. As reflected in its land use distribution, agriculture represents the primary economic activity. A notable geographical feature is the Kahahre Khola river, which runs along the western side of the villages. On the Eastern side, the Bad Khola river serves as a natural boundary before converging with the Kahahre Khola river South of Ratawal. These rivers play a crucial role in shaping local water availability, influencing irrigation practices and seasonal water distribution for agriculture.

As part of Chitwan National Park’s buffer zone, Chilaha and Ratawal benefit from diversified livelihood opportunities. Tourism (e.g., homestays, guided tours) and collection of non-timber forest products (NTFPs) supplement agricultural incomes, enhancing local resilience (Kandel et al., 2024; Stræde & Treue, 2005).

[4] Derived from Google Earth satellite imagery

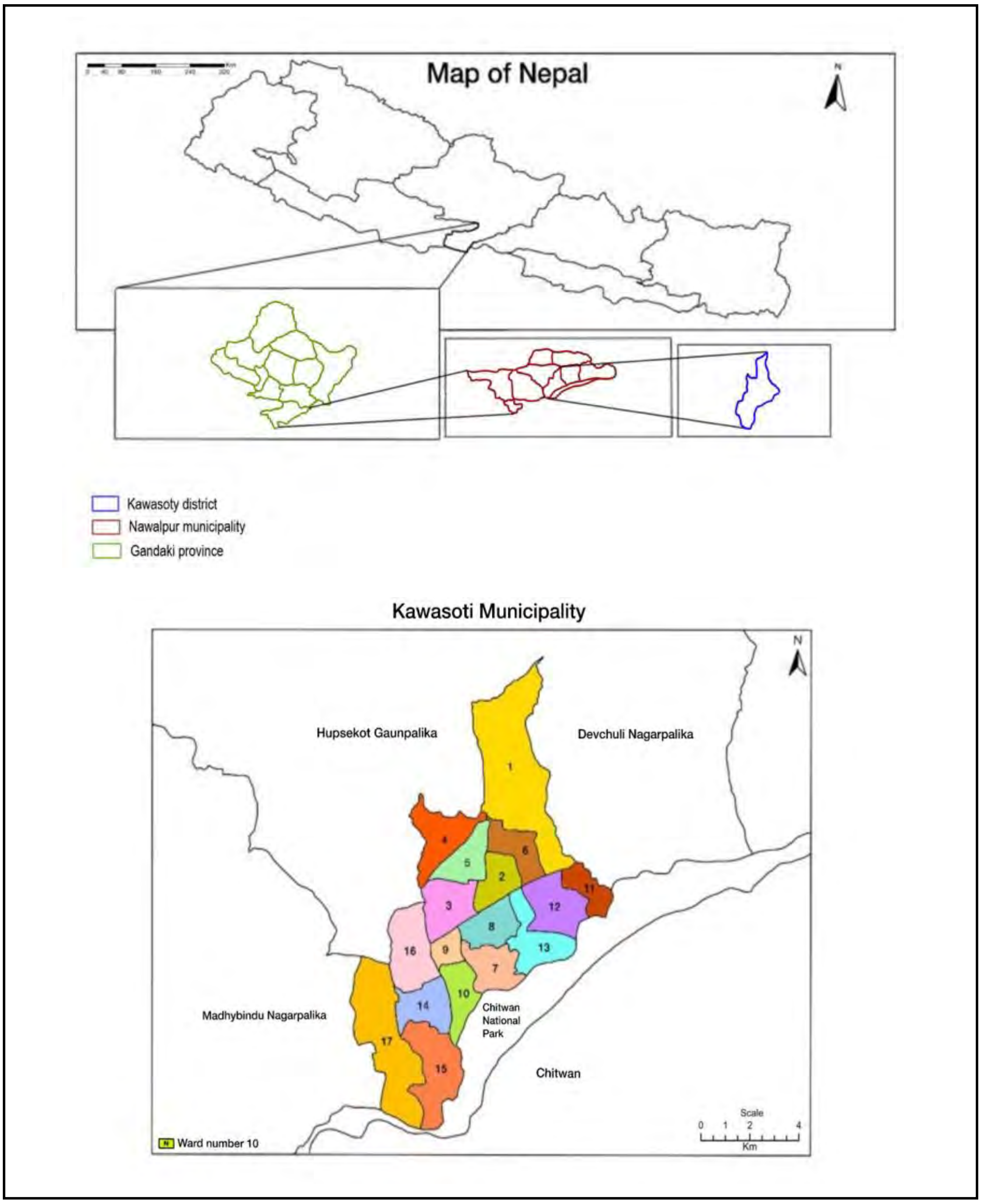



Fig. 6 Maps of the study area

### *5.2 Defining Climate-Related Changes and their connection to climate change*

Before delving into the methodological framework of this study, two important clarifications must be made. First, it is essential to note that individual weather events in the village might not necessarily serve as direct evidence of climate change (Trenberth, 2012; NASEM[5], 2016). "Weather" refers to short-term atmospheric conditions at a specific time and place (e.g., rainfall, temperature), while "climate" encompasses not only average temperature and

[5] National Academies of Sciences, Engineering, and Medicine

precipitation but also the *frequency*, *duration*, and *intensity* of weather events (EPA[6], 2025). As Trenberth (2012, p. 283) points out, “no single event can be solely caused by climate change". Instead, all weather events are influenced by climate change to some extent because “the environment in which they occur is warmer and moister than it used to be” (Trenberth, 2012, p. 289). This distinction between weather events and climate change is crucial for providing a more nuanced analysis of the observed environmental shifts.

Secondly, it is pivotal to clarify the term ‘Climate-Related Changes’ (CRCs), which is used to describe the observed environmental shifts in the village in this study. CRCs encompass climate-induced shocks, such as floods and heat waves, as well as more gradual, incremental changes in the local environment, as perceived by the community. It should be noted that the aim of this research is not to establish a direct causal relationship between CRCs and climate change, but rather to examine how farmers perceive and adapt to the changes in the environment. Therefore, the specific questions guiding this research cover four main themes and are structured as shown in Fig. 7:

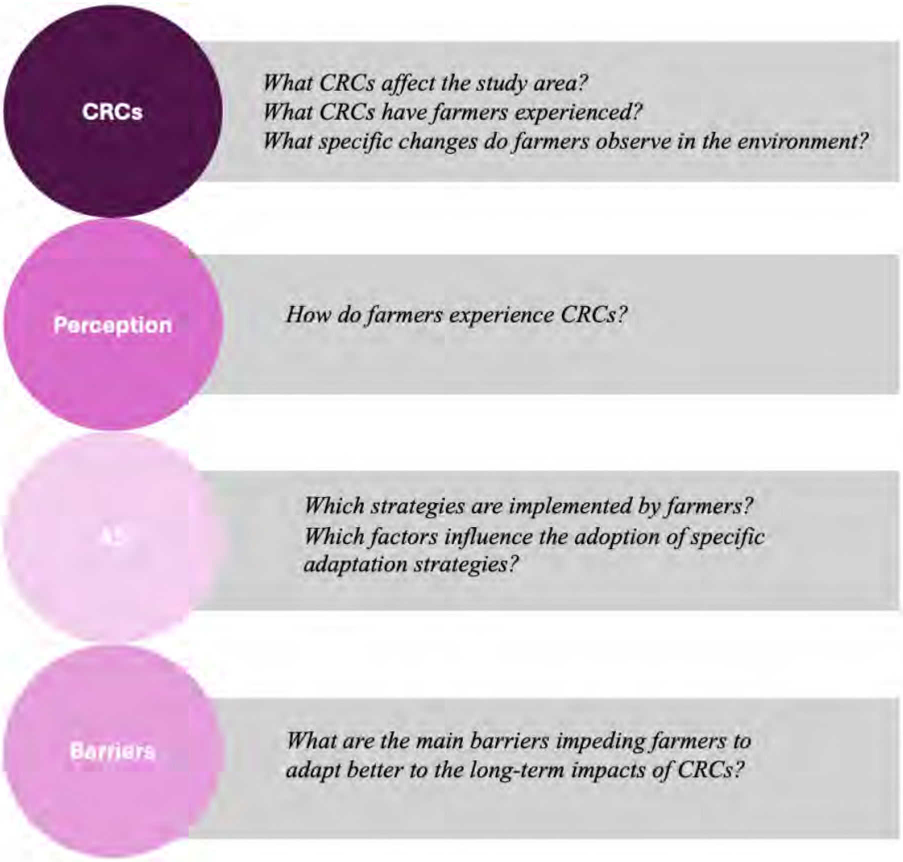



Fig. 7 Sub-research questions for the study

[6] Environmental Protection Agency

The methodological choice of using the term Climate-Related Changes is driven by the following considerations (Fig. 8):

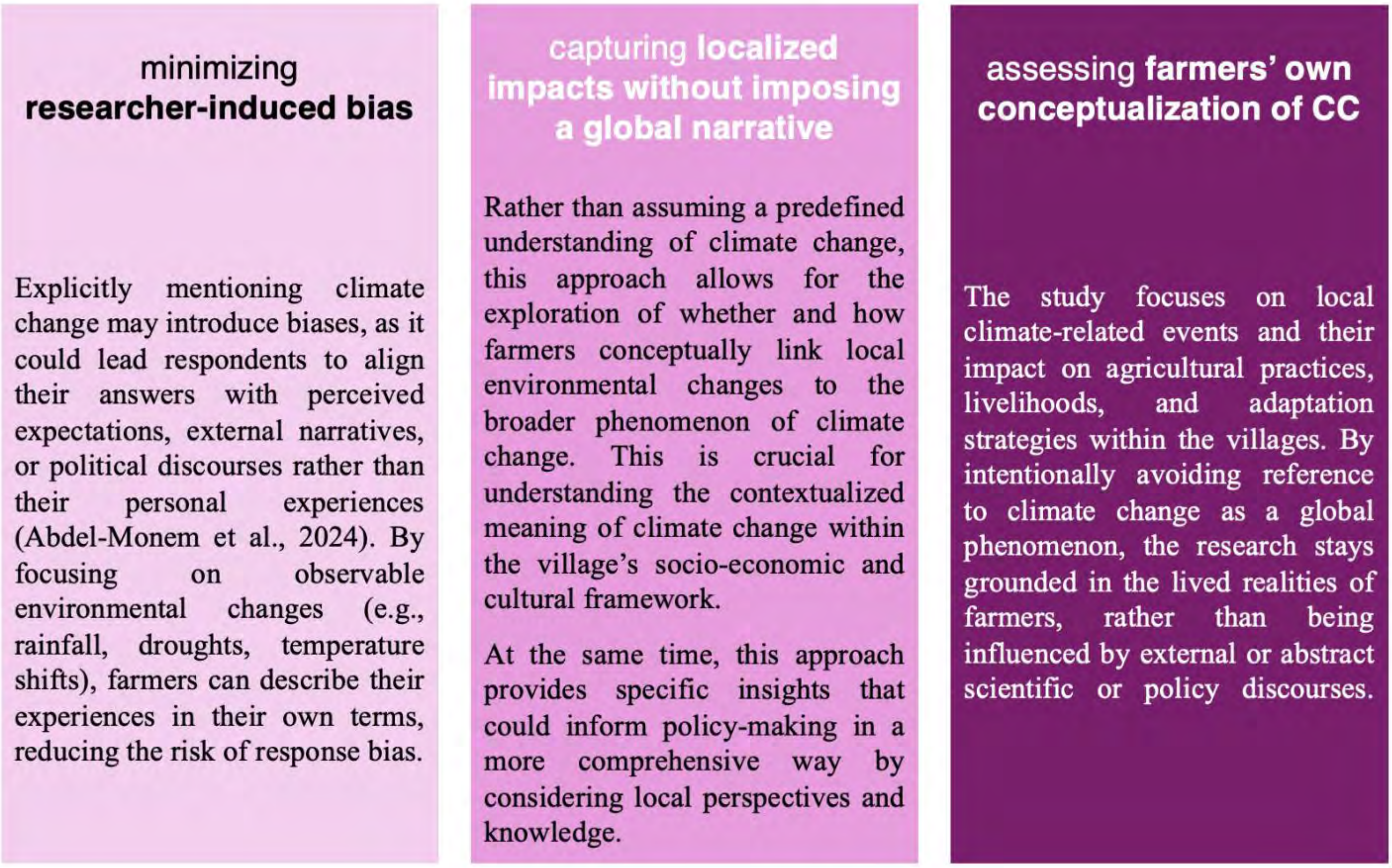



Fig. 8 Methodological Justifications for the use of 'Climate-Related Changes' (CRCs)

### *5.3 Methodological framework*

The research process was divided into stages, each employing specific methods to ensure comprehensive data collection and enable the triangulation of findings. The diagram below provides an overview of these stages, and the methods applied at each step (Fig. 9):

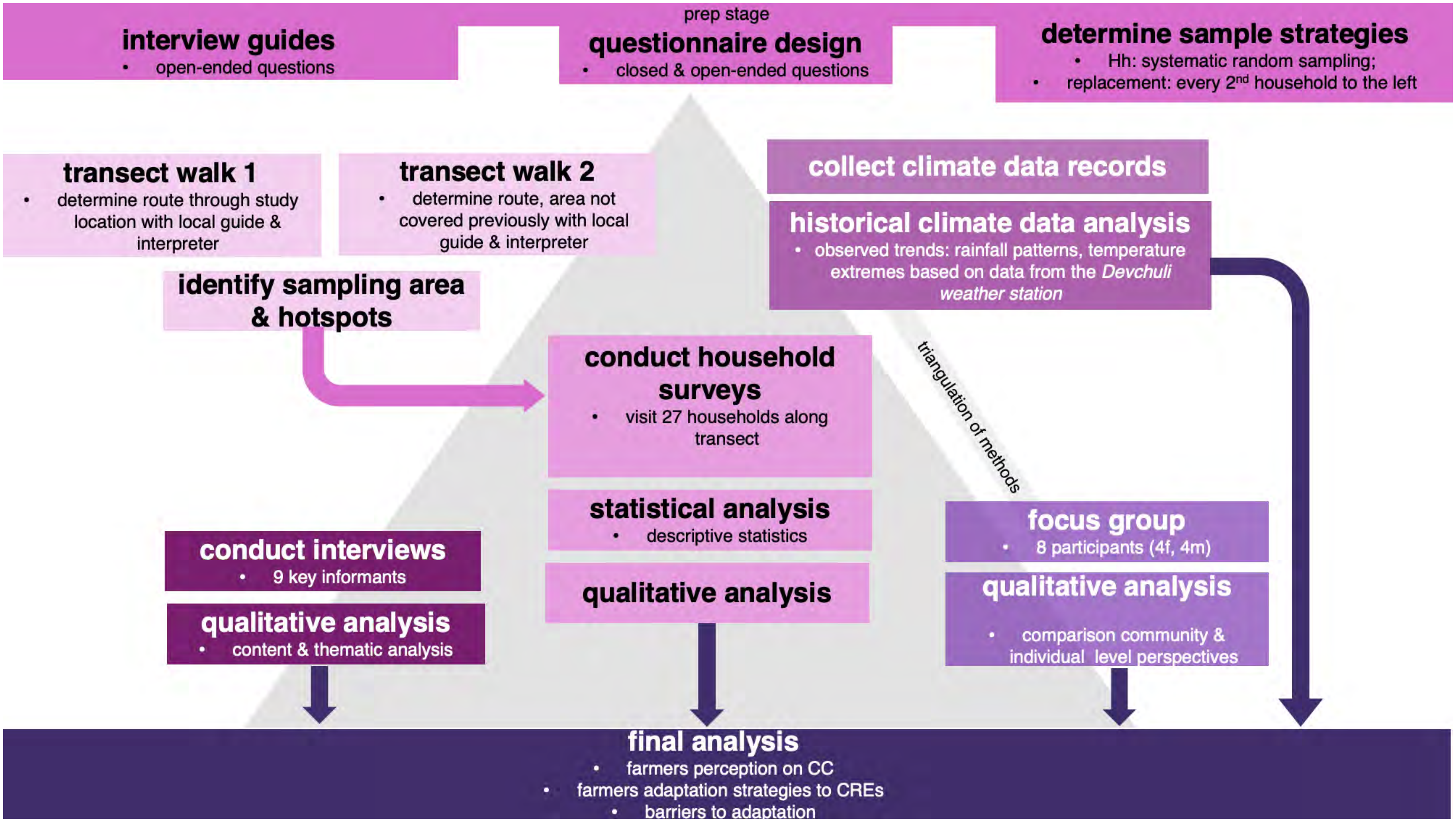



Fig. 9 Methodological Framework used for the research

### *5.4 Preparation stage*

An interview guide for semi-structured farmer interviews was developed and refined on-site for local officials, the Agricultural Knowledge Center (AKC), and community groups. A comprehensive survey with closed-ended, open-ended, and ranking questions was also designed and adjusted after on-site testing for clarity and effectiveness.

### *5.5 Sampling strategies*

During preparation, sampling strategies for interviewee and household selection were developed and refined on-site. The sampling area was determined through transect walks on the first two days, guided by locals through Ratawal and Chilaha, covering key environmental hotspots like rivers, deep borewells, and remote households.

The decision to exclude Magarkot from the sampling area was done due to its distance from the primary study site and its proximity to the city, which could provide farmers with better market access, infrastructure, and alternative livelihoods, making it less comparable to other sites. Initial survey attempts found few farming households, and based on these observations and local guide recommendations, Magarkot was ultimately excluded.

Focusing on Ratawal and Chilaha allowed the study to capture the experiences of communities more vulnerable to CRCs, reflecting the challenges faced by exposed, agriculturally dependent farmers. Additionally, the sampling area's proximity to Chitwan National Park had key implications. The forest may influence local microclimates, mitigating temperature extremes and affecting water availability (Ellison et al., 2017). Farmers here might also prioritize adaptation to human-wildlife conflict over climate change, unlike those in more deforested or urbanized regions (Dhungana, 2017).

Ratawal has approximately 150 households and Chilaha around 100, totaling an estimated 250[7]. To achieve an approximate 10% sample size, 27 surveys were targeted, with a higher proportion in Ratawal due to its larger population. Household selection followed systematic random sampling among farming households to ensure an unbiased process. While diversity in gender, age, caste, education, and income was considered, the lack of a comprehensive demographic list prevented stratified random sampling. Such a list would have allowed for stratified random sampling, which would have provided a more balanced

[7] This data was retrieved from a local expert (Bikash Adhikari) due to the absence of official statistics

representation of the population. The process began with a randomly selected household in Chilaha, surveying every $8^{th}$ household along the main road. As a replacement strategy, if a household had already been surveyed, did not farm, or declined participation, every second house on the right was selected instead, ensuring consistency in data collection.

To strengthen the rigor of the findings, purposive sampling was used for interviews and focus group discussions (FGD), selecting key informants from both farmers and institutions. Farmers were chosen based on their knowledge of local agricultural practices, adaptation strategies, ensuring diversity in age, gender, and CRC experience. Institutional informants were selected from local government, the Agricultural Knowledge Center (AKC), and community groups like the Buffer Zone User Committee (BZC) and Community Forest Group (CFG). This approach provided a balanced understanding of both local knowledge and institutional perspectives, offering insights into community experiences and available support systems.

### *5.6 Ethical considerations*

Prior to data collection, informed consent was obtained from all respondents. Each participant was provided with a clear explanation of the study's purpose and how their responses would be used. Survey data was securely stored and accessed only by the research team. Explicit consent was sought before taking any photographs, audio or video recordings.

### *5.7 Data collection stage*

The second stage involved collecting data through a combination of methods to ensure a comprehensive and nuanced understanding of the research topic.

#### *5.7.1 Meteorological data*

As presented in the meteorological data section, climate data obtained from Dukali station was analyzed to assess differences between farmers' perceptions and scientific observations.

#### *5.7.2. Transect walk*

As aforementioned, two transect walks were conducted on the first and second days with different local guides. Transect walks are a valuable exploratory tool for identifying community issues and mapping key hotspots (Kumar, 2014). Initially, snowball sampling was planned to include one or two additional participants alongside the guide to address knowledge gaps, but practical constraints limited this to one main guide per transect. This reliance may have introduced bias by narrowing community perspectives and reducing viewpoint diversity. Additionally, the guides' observations influenced hotspot identification. However, interactions with locals provided valuable insights, including an English teacher and a former farmer who abandoned his fields after repeated floods.

### *5.7.3. Surveys*

The survey aimed to gather initial information on participants, including demographics, experiences with CRCs, risk perceptions, and adaptation strategies implemented. It consisted of 48 questions, divided into four sections: *Introductory Information, Household and Livelihood, Knowledge and Perception of CRCs,* and *Implementation of Adaptation Strategies*. The survey format was designed to quantify responses for statistical analysis and to identify patterns in CRCs experiences and adaptations. While most questions were closed-ended, some open-ended questions allowed "respondents to provide more detailed answers and explore alternative perspectives" (Bryman, 2012, p. 247). To ensure accuracy, a local interpreter assisted in translating questions from English to Nepali.

A total of 27 surveys were completed. The survey data was digitized and processed using tools available in SurveyXact. Later, statistical analyses were performed using R and Microsoft Excel to identify patterns or trends in the responses. Descriptive statistics were used to summarize demographic data, providing an overview of the study population. To explore relationships between variables, t-tests, correlation analysis, and chi-square tests were conducted. These analyses helped determine potential associations between demographic characteristics, risk perception, and adaptation strategies. The outcomes of these tests are presented in the 'Results' section.

A key limitation intrinsic to the nature of the survey method is the lack of depth in responses. While some open-ended questions were included, most were closed-ended, which may have restricted participants from fully expressing their experiences. This presents a twofold challenge: on one hand, the survey allowed for quantifying responses across a larger sample but lacked detailed insights; on the other hand, leaving questions open sometimes led to missing information, as participants did not always recognize their actions as adaptation strategies. To address this, interviews with key informants were conducted to gain deeper insights.

Another limitation is the relatively small sample size (27 respondents), which restricted the ability to conduct more robust statistical tests and may have limited the representativeness of the findings. A larger sample size could have provided more reliable and generalizable results. Additionally, having only one interpreter reduced time efficiency, as it limited researchers to conducting only one survey at a time.

Recall bias also posed a challenge, as participants had to rely on their memory of past events, meaning some details may have been forgotten or misremembered, affecting data accuracy. Misinterpretation and translation issues could also have been a factor. The survey was originally in English and translated into Nepali, thus, even with careful translation, some differences in meaning might have led to misunderstandings, which could have affected how participants interpreted and answered the questions.

Despite these challenges, the combination of structured questions, open-ended responses, and statistical analysis still provided useful insights into participants' experiences with CRCs and their adaptation strategies.

#### *5.7.4. Semi-structured interviews*

To develop a more comprehensive understanding and complement the quantitative survey findings, nine semi-structured interviews were conducted. This approach, based on predefined open-ended questions, provided the flexibility to explore farmers' perceptions of CRCs and their adaptation strategies in greater depth (Bryman, 2012).

Photo elicitation was initially intended to evoke deeper discussions by prompting memories and emotions (Harper, 2002, p. 13). However, it became clear that farmers did not document CRCs through photographs, with such images primarily captured by local journalists, limiting the use of participant visuals for discussion. While the selection process explored earlier carries the potential for selection bias, efforts were made to mitigate this through triangulation, incorporating information from multiple sources and ensuring the inclusion of diverse perspectives. Triangulation strengthens the validity, reliability, and interpretative depth of the study while minimizing investigator bias (Thurmond, 2001).

Interviews were conducted in person, either in English or Nepali, with the assistance of an assigned interpreter. The interviews typically ranged between 45 minutes and one hour. To maintain consistency, each interview began with introductory questions about the participants' background, followed by focused discussions on topics of interest for the research, including perceptions of CRCs, adaptation strategies, and barriers to adaptation.

A key challenge faced during the interviews was the language barrier. In cases where an interpreter was required, there were concerns that some of the nuances of participants' responses may not have been fully captured. Similarly, the inability to communicate directly with participants hindered building a closer rapport and establishing trust during the interview process. However, despite this limitation, the participants were generally open and receptive to the questions, which significantly facilitated the data collection process. While the semi-structured interview format allowed flexibility in exploring topics, this also posed challenges in ensuring consistency across interviews. The interviews conducted in English were transcribed using the Good Tape transcription software, while those in Nepali could not be transcribed. Instead, notes were taken during the interviews. Both the transcripts and notes were then coded using thematic analysis.

#### *5.7.5. Focus group discussion*

A focus group was discussion (FDG) also conducted to explore farmers' adaptation strategies to cope with CRCs. A group of eight farmers (four female and four males) discussed their experiences with CRCs, adaptation measures taken and needed, and barriers to adaptation. Given the language barrier, this discussion was initiated through a structured threefold ranking exercise. Ranking and scoring are "particularly relevant tools for analysis of difference, unequal relationships and prioritization, and to assess people's expectations, beliefs, judgements, attitudes, preferences, and opinions" (Mikkelsen, 2012, p. 2). This participatory approach enabled the researchers to understand which strategies are most valued by the community and which barriers prevent their implementation.

The activities carried out were brainstorming and ranking exercises, designed for both individual and collective discussion. First, participants individually identified CRCs in the past ten years and ranked them based on their impact on agricultural production. Measures taken in response to these changes were first identified openly, followed by the introduction of additional options to ensure all strategies were considered. A collective discussion then focused on determining the most needed community-level measures for future adaptation, ranking them alongside existing strategies.

Then, the next activity explored barriers to adaptation, beginning with individual brainstorming and followed by a collective discussion, where participants ranked the most to least relevant obstacle they were facing. Additionally, two seasonal calendars, one reflecting five years ago and another for the present, were prepared to assess changes in rice cultivation.

Due to time constraints, this activity was conducted later during a cooperative meeting attended only by women.

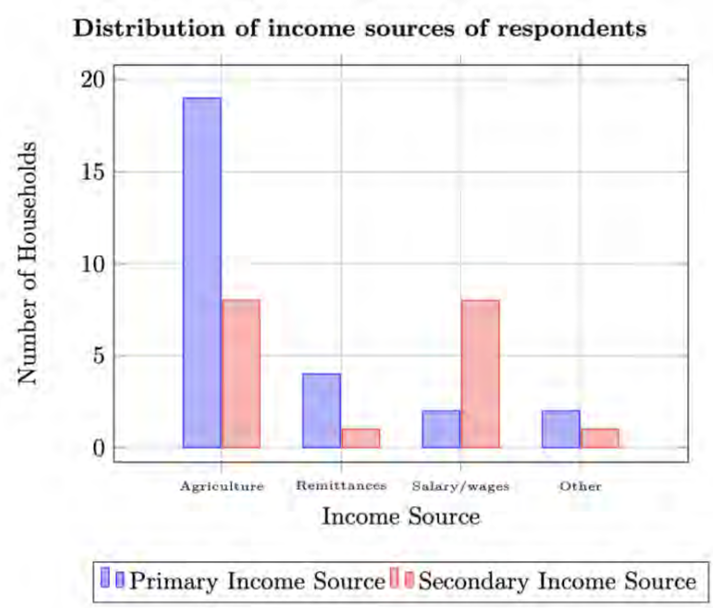
FDGs provide a space for farmers to share their perspectives free from external narratives, while the ranking exercise highlights locally preferred strategies and constraints (Caillaud et al., 2022). Certainly, there are some limitations to consider. First, more vocal participants may have dominated the discussion, potentially overshadowing quieter voices (Caillaud et al., 2022). Upon arrival, participants naturally sat in gender-divided groups, with men on one side and women on the other. Overall, both men and women actively engaged with the discussion prompts. However, one man was particularly outspoken, while one woman, who attended with her child, was partially distracted and less involved. These factors may have influenced the results.

# 6. Results

This section presents and analyzes key findings from the different methods used. Beginning with an overview of the survey participants' socio-demographic characteristics, providing essential context for the study, followed by an analysis of four core themes: the main CRCs farmers experience, their perceptions of these changes, current adaptation strategies, and barriers to these efforts. The section aims to identify connections between these themes by triangulating data from different sources, highlighting common patterns, and explaining discrepancies in the findings.

### *6.1 Socio-demographic characteristics of the sample*

After conducting a total of 27 household surveys, it was possible to obtain key socio-demographic characteristics of the surveyed population, which are shown in Fig. 11. The sample presented a higher representation of females (59%) compared to males (41%). Education levels varied, with 41% having no formal education, 52% attaining a lower level of education[8], and only 7% reaching higher education[9]. Agriculture was the primary source of income for most respondents (70%), followed by remittances (15%) and wage labor (8%). Regarding irrigation systems, participants usually relied on nature-based sources (30%) and mixed systems (30%), followed by the "boring system"[10](26%).




[8] Lower education level refers to completing primary and secondary education.
[9] Higher education refers to obtaining a bachelor's degree.
[10] Boring system: this term was commonly used by local people to refer to a borewell, which is a drilled well that reaches deep into the ground to access groundwater usually for agricultural irrigation, drinking water supply, and industrial purposes (Seethadevi Borewells, 2023).

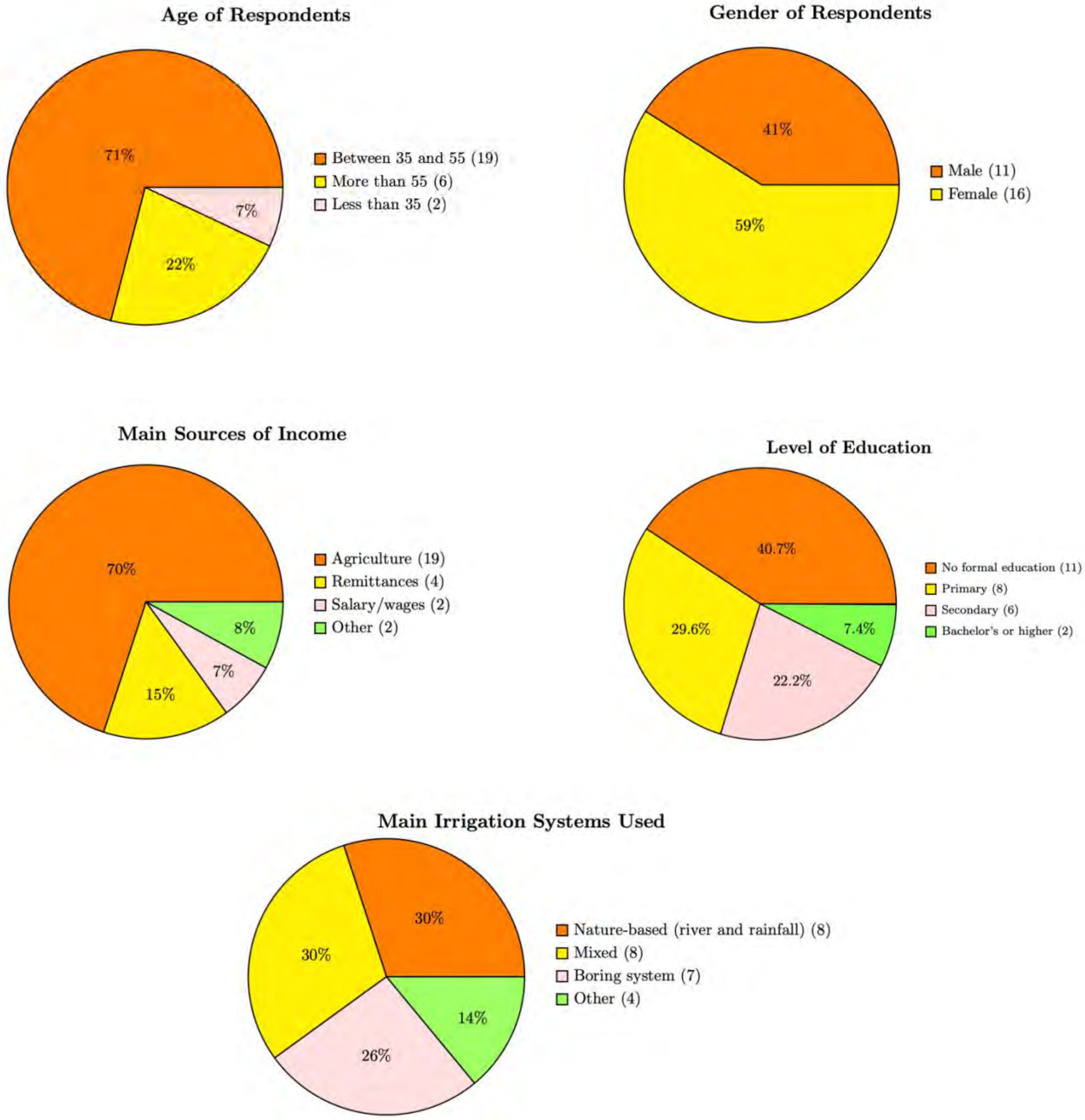



Fig. 11 Key socio-demographic characteristics of the respondents (results from survey, n=27)

### *6.2 Climate-Related Changes*

To identify specific areas experiencing CRCs in the past, the transect walks initially conducted enabled the determination of relevant areas for agriculture where significant environmental changes took place. The map below (Fig. 12) in combination with the Table 4 showcase the area covered and key hotspots identified:


Hotspots identified: *Riverbank (1), Riverbed (2), Area close to the river (3), Agricultural land/ex-swampy areas (4), and Boring system (5)*

Fig. 12 Map of combined transect walks with identified hotspots

| **Hotspot** | Riverbank (1) (River: Kahahre Khola river) | Riverbed (2) (River: Kahahre Khola river) | Area close to the river (3) (River: Bad Khola) | Ex-swampy now agricultural land (4) | Boring system (5) |
|---|---|---|---|---|---|
| **Village** | Ratawal | Ratawal | Chilaha | Chilaha | Chilaha and Magarkot |
| **Land use** | Abandoned ex-farming land | Seasonal river<br>Abandoned farming land | River | Agricultural land<br><br>Houses | Agricultural land<br><br>Houses |
| **Observed CRCs** | Landslide from monsoon flood | Flood | - | Drought/Land change from swampy wetland to agricultural land | - |

| | | | | | |
|---|---|---|---|---|---|
| **Local people's perception of changes in climate** | The risk prone area extended to the close by banana fields<br><br>Warmer temperatures in all seasons<br><br>Erratic rainfall | Floods always happened, extreme in the past 2/3 years<br><br>Forced displacement of people<br><br>Abandoned land is attracting wildlife (grass as hiding spots)<br><br>Lower level of water in the dry season (attracting less wild animals)<br><br>Warmer temperatures in all seasons<br><br>Erratic rainfall | Flood is not a threat<br><br>Warmer temperatures in all seasons<br><br>Erratic rainfall | Decreasing underground water<br><br>Degreasing spring water<br><br>Warmer temperatures in all seasons<br><br>Erratic rainfall | More mosquitoes<br><br>Warmer temperatures in all seasons<br><br>Erratic rainfall |
| **Adaptation strategies** | Abandoned land | Gabion wall<br>Wild sugar cane | - | Boring well | - |
| **Challenges with the adaptation strategies** | Loss of agricultural land | Government budget is limited, not allowing to complete the project fast enough to make a change | - | Decrease in underground water level | Decrease in underground water level |
| **Additional observations** | - | - | Canal system from river water | - | Boring well |

Table 4. Key findings from the transect walk

Additionally, a short video a walk through ward 10 was created to capture the visual aspects of the environment and key locations (Fig. 13).


Fig. 13 Cover of “A Walk Through Ward 10” video

As a general finding, and by triangulating the results obtained across all methods employed, this research identified increased temperatures, decreased rainfall, and water scarcity as major CRCs perceived by farmers in the study area. Regarding the results from surveys, a total of 85% of respondents have observed increased temperatures, while 100% of farmers mentioned a decrease in rainfall as a relevant change in the environment, and 89% highlighted a decreased level of water availability. Fig. 14 shows a summary of the CRCs identified by farmers:

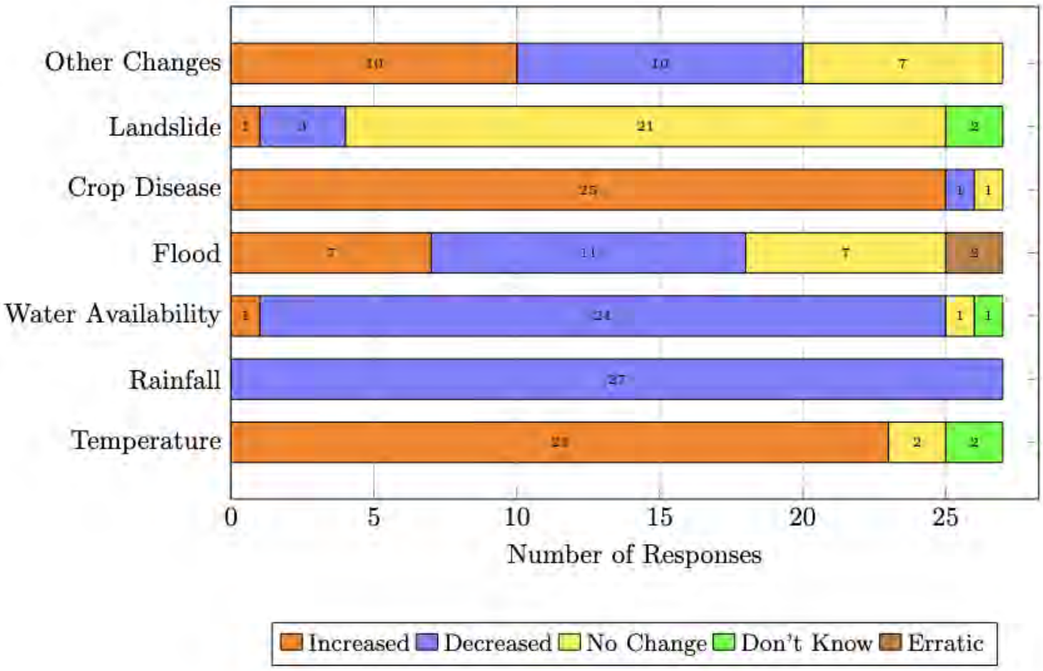



Fig. 14 Main Climate-Related Changes perceived by farmers (survey, n=27)

Likewise, during the interviews with local authorities, they recognized decreasing rainfall and prolonged dry periods, reinforcing farmers' observations. Specifically, an official from the Agricultural Knowledge Center (AKC) stated: *"Last year we got rain after 9 months. So you can imagine the rain will stop in September then we will get rain in June again – very long duration"* [Interviewee I]. Consistently, this observation is supported by climate data, which shows a decline in pre-monsoon rainfall between 2021 and 2023, indicating prolonged dry periods before the onset of the monsoon (Fig. 4). Similarly, during the interview with the Agricultural Officer (AO), he emphasized the impact of climatic variations on agriculture: *"As there is a change in climate, the production and productivity of agriculture has changed. There is untimely rain, untimely increasing temperature, as a great negative effect in agriculture"* [Interviewee H].

Other studies in the Terai region, such as Khanal et al. (2019)'s research in Chitwan reported contrasting findings. Their results indicate that most respondents noted an increase in rainfall, during the monsoon season. In contrast, the present study found a general perception of decreased rainfall, especially during the monsoon season, along with an overall rise in temperature, including winter. Interestingly, climate data from the past 10 years do not show a decrease in total rainfall. This suggests that farmers' perception of reduced rainfall may be linked to water availability rather than actual precipitation levels. A potential explanation is that rainfall has become more concentrated over shorter periods, meaning the total annual rainfall remains overall stable, but its distribution has changed, coherently with farmer's perception of a shift in monsoon season.

During the FGD, participants were asked to rank CRCs based on how frequently they had experienced them over the past ten years. Table 5 ranks the list according to how many times the CRCs were mentioned, and Fig. 14 reflects the same ranking created, but using a word cloud to visually represent the importance given to the CRCs experienced:

| CRCs | Times Mentioned | Percentage (%) |
|---|---|---|
| Increase in temperature | 8 | 100 |
| Flood | 5 | 63 |
| Water scarcity (reported as drought) | 5 | 63 |
| Crop disease | 4 | 50 |
| Erratic rainfall | 3 | 38 |
| Pest infestation | 2 | 25 |
| Storm | 1 | 13 |
| Decrease in rainfall | 1 | 13 |

*Note:* Ranking created by farmers (n=8) during focus group discussion when asked: "What are the most significant climate-related changes you've observed in the last 10 years?"

Table 5. Ranking of CRCs most frequently experienced (focus group, n=8)

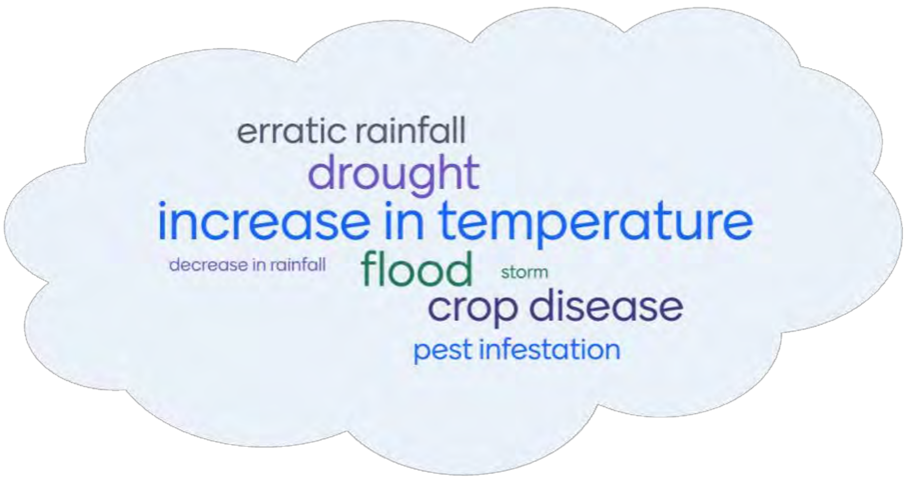



Fig. 15 Word cloud of main CRCs mentioned by participants (focus group, n=8)

Other issues consistently mentioned in all methods are increased crop diseases and pest infestations. For instance, during the FGD ranking exercises, 50% of the participants mentioned crop disease as one the CRCs most frequently experienced; while during the household surveys, 25 out of 27 respondents stated that diseases in their crops have increased during the past ten years. Similarly, about the impact of climate change in agriculture, the AO, mentioned: *"Outbreak of pest. That is another issue, several diseases are seen in crops –basically on rice"* [Interviewee H].

As observed, the different research methods show variations in findings. For example, surveys, with a larger respondent base, offered a broad view of farmers' perceptions, suggesting widespread CRCs. Interviews with local authorities provide deeper insights, aligning with farmers' views on decreasing rainfall and dry periods. This consistency between surveys and interviews enhances the reliability of the identified CRCs. In contrast, surveys pointed to decreased rainfall, crop diseases, and water shortages, while the FGD emphasized increased temperature, floods, and drought. This difference may stem from the more localized, personal experiences shared in FGD, which can reflect specific events or memories not captured in broader survey trends (Bryman, 2012). Farmers may also have different perspectives based on their crops, farming practices, or location, explaining why some CRCs, like rainfall decrease, were ranked lower in focus groups despite being acknowledged in surveys.

### *6.3 Perceptions of Climate-Related Changes*

A key focus of this research was understanding how smallholder farmers perceive environmental changes. When analyzing the findings, it is important to recognize that environmental issues, including climate change, are influenced by social, cultural, and political factors, not just physical phenomena. Nash et al. (2019) highlight that cultural knowledge, through social norms and practices, plays a vital role in shaping these perceptions.

With this in mind, the survey results provide insights into how concerned farmers are about the effects of CRCs on their agricultural activities. The findings reveal that 30% of respondents are "very concerned," while 15% expressed being "not concerned at all," as illustrated in the Fig. 16 shown below:

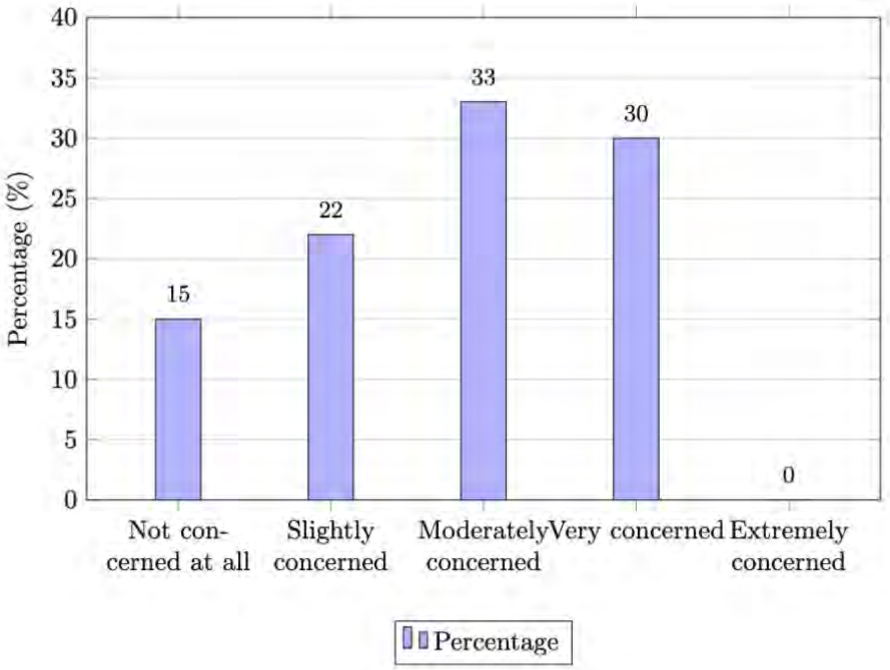



Fig. 16 Level of concern on the impact of Climate-Related Changes expressed by farmers during (surveys, n=27)

When reflecting on the results about perception of CRCs, there are some discrepancies between actors. For instance, while farmers recognize changes in the environment and the effects on their farming practices, they may not necessarily attribute these variations to the global phenomenon of "climate change" and understand the irreversible consequences. This became evident during a conversation with a young farmer, who, when asked whether his father understood the concept of global warming, responded: *"Maybe not the term, but he sees the changes – rising temperatures, unpredictable rain"* [Interviewee D]. Similarly, Khanal et al. (2019) also reported that even when individuals were unfamiliar with the term "climate change," they still acknowledged experiencing shifts in environmental conditions.

This disconnect between observation and attribution is further documented by Budhathoki et al. (2020) study of 496 Nepalese farmers, which found that while 87% of respondents reported changes in rainfall and temperature patterns, none directly attributed shifts in cropping patterns to climate change. Instead, farmers predominantly cited market forces (63%) and technological advancements (20%) as the primary drivers of agricultural changes, suggesting that even when farmers are aware of environmental changes, they tend to interpret these changes through more immediate, practical lenses rather than attributing the cause to climate change. A similar pattern was observed by Nash et al. (2009), who found that climate change was rarely part of community discussions unless introduced by the interviewer.

In contrast, representatives of the local and provincial governments showed greater awareness of climate change and its impacts on agriculture. For instance, the AO mentioned: *"They [farmers] know the impact of climate change, but actually they are not using this knowledge in agriculture. For this particular purpose, farmers have to be aware"* [Interviewee H]. These variations in perceptions also align with findings of previous studies in Nepal, since "in light of other pressing local issues, climate change is yet to penetrate the environmental representations of some communities and there is a need to address the disconnect between local issues and global climate change" (Nash et al., 2019, p. 1).

Interestingly, statistical tests showed no significant links between farmers' socioeconomic factors and climate concern (Table 6), suggesting perception is shaped more by direct experiences than by socio-economic conditions.

| Type of Analysis | Hypothesis | Test | Result |
|---|---|---|---|
| Relationship between income and level of concern | Higher income is linked to lower concern, as more resources help to cope with climate change impacts | Regression analysis: P-value = 0.307 | Hypothesis rejected |
| Relationship between households with agriculture as 1st source of income and level of concern | People with agriculture as 1st source of income have higher level of concern | Chi-square test: P-value = 0.662 | Hypothesis rejected |
| Relationship between level of education (lower/higher) and level of concern | People with higher education are more concerned | Chi-square test: P-value = 0.844 | Hypothesis rejected |

Table 6. CRCs perception statistical analysis[11]

During the FGD, participants also ranked the CRCs experienced according to the impact on their crops. Table 7 shows that decreased rainfall, drought, and increasing temperatures are the most impactful changes perceived:

| CRCs | Points Allocated | Percentage |
|---|---|---|
| Decreased rainfall | 10 | 25% |
| Drought | 9 | 23% |
| Increase in temperature | 9 | 23% |
| Flood | 5 | 13% |
| Pest infestation | 3 | 8% |

*Note:* Ranking[12] created by farmers (n=8) during focus group discussion when asked: "Which Climate-Related Changes have impacted your crops the most over the past 10 years?"

Table 7. Ranking of CRCs most impactful for crops (focus group, n=8)

When comparing the results from surveys and the FGD, there are some interesting differences between ranking of events by impact vs. frequency: farmers participating in the FGD ranked decreased rainfall and drought as the most impactful events for their crops, yet

[11] All data was obtained from surveys. Education was categorized as low (no/primary) or high (secondary). Agricultural dependence was determined by ranking income sources, with farming ranked first indicating primary reliance.

[12] For the ranking exercise, a total of 5 stones were given to each participant so they could allocate stones to the events that impacted their agricultural production the most. They were able to place more than one stone on each event in order to express a greater impact. The ranking was made using a total of 40 stones.

temperature increase was mentioned more frequently in surveys. Additionally, while all methods identify broad categories of CRCs, heat waves and hailstorms were specifically mentioned as impacting events during interviews, with the AO noting heat waves affecting rice crops and a farmer reporting hailstorm-induced harvest loss. These specific events were not as prominently featured in the survey or FGD results, although rising temperatures were generally noted.

These differences in specific experiences highlight the role of localized variations in shaping the perception of CRCs on an individual basis. Overall, the discrepancies reflect the complexity of climate change perception, which varies based on individual experiences, community discussions, and the way questions were framed across different methods.

### *6.4. Adaptation strategies*

In this section, the adaptation strategies employed by farmers in response to CRCs are presented and discussed. The adaptation measures identified during the research can be broadly categorized into *individual-led, community-led,* and *State-led* strategies. This categorization follows the theoretical framework proposed which pays particular attention to the scale of action considered.

#### *6.4.1. Individual-led adaptation strategies*

**a. Shift in planting dates**

Farmers are shifting their sowing and harvesting schedules to adapt to temperature variations, delayed monsoons, and increasingly erratic rainfall, which has disrupted traditional farming cycles. Complaints from farmers about poor harvests have led the Agricultural Office to recommend shifting planting dates as a key adaptation measure. The AO explained: *"When the same variety was planted during a hotter period, it failed to pollinate properly due to high temperatures. That's why we explain to farmers that climate change is the cause and suggest shifting the planting time."* and recommended farmers to *"Plant either a week earlier or later, so the crops aren't exposed during critical periods."* [Interviewee H]. This recommendation suggests that shifting planting schedules can help farmers avoid critical climatic periods, allowing crops to pollinate under more favorable conditions.

Over time, the planting and harvesting periods have shifted in response to these climatic changes. Seasonal calendars from 2076 and 2080[13] reveal clear changes in the timing of key

[13] According to the Nepali calendar (Vikram Sambat), the corresponding Gregorian calendar years for 2020 and 2024.

agricultural activities. Sowing, which previously took place mid-February, has shifted to early/mid-January, while transplanting has moved from mid-March to mid-February. Harvesting now occurs earlier, having moved from early June to mid-May. These shifts suggest that farmers are adjusting the crop cycle to avoid climatic stresses during pollination and maturation periods. Similarly, the timing of irrigation has advanced from mid-September to mid-July to late August, due to changing rainfall patterns and an increased reliance on irrigation to mitigate prolonged dry spells.

These gradual yet deliberate adjustments highlight both experiential learning at the community level and support from local agricultural authorities. The co-created calendars act both as a record of change, and as a practical planning tool for navigating unpredictable climate. The effectiveness of shifting planting schedules ultimately depends on farmers' awareness and ability to adjust agricultural practices, yet challenges remain in ensuring they receive timely and accurate guidance.

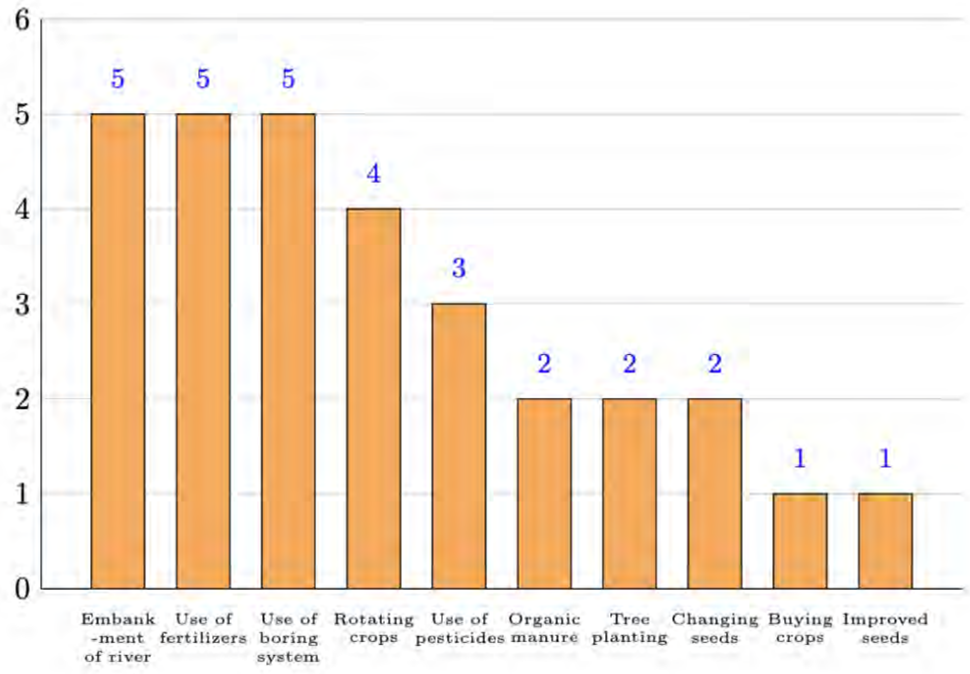



Fig. 17 The main adaptation strategies currently used by farmers (x-axis). Each farmer had 5 stones, and placed them on the adaptation strategies they perceived as the most important (y-axis) (FGDs, n=8)

### b. Increased use of fertilizers and pesticides

The use of chemical fertilizers and pesticides has increased as farmers attempt to counteract declining soil fertility and rising pest infestations. While this practice is largely individual-led, it is supported by State subsidies for fertilizers. However, the AKC discouraged excessive pesticide use due to environmental concerns.

Based on farmers' perception, fertilizer use is often regarded as an adaptation strategy to maintain or enhance crop yields amid changing climatic conditions (Fig. 17). It is frequently used alongside alternative water sources to compensate for dry spells. The results are consistent with existing literature (Khanal et al., 2018), who assess the use of intense fertilizers by farmers as an adaptation strategy to cope with the adverse impacts of climate change.

### c. Use of boring for irrigation

Borings are a key adaptation tool to decreased rainfall and dried out rivers. Of 27 farmers surveyed, 7 rely solely on borings, and 8 use them alongside other water sources. Others cited lack of land-rights (n=3), proximity to a river (n=2), and not necessary (n=3) as reasons for not using them.

Some farmers advocate for expanding borewell infrastructure, *"We rely completely on it [boring] during the winter season. It was built 21 years ago and was the first one in the village, allowing us to grow crops even in winter. A few years ago, others began installing borings thanks to government subsidies. More borings would be useful for other farmers too."* [Interviewee G], whereas community representatives are against it: *"I don't see boring as a long-term solution. I am concerned, but I'm not sure what the alternative is. Instead of building more, we should focus on using the ones we already have—by repairing the damaged ones and installing motors to make them functional again."* [Interviewee C], warning about the long-term sustainability issue.

As mentioned by the AKC: *"If we can't draw water or we can't use the water from the river and the stream, then it is compulsory we have to deep bore."* [Interviewee I]. At the same time, they acknowledge that this is not a long-term solution: *"We bore the land. It is very true that the water level is going down and down."* [Interviewee I]. The AKC has proposed alternative water extraction technologies, such as solar-powered river water lifting systems, but they are still in an early phase and implementation remains limited.

This highlights a tension between short-term adaptation and long-term sustainability. While borings offer immediate relief, overuse risks groundwater depletion. Promoting effective yet sustainable strategies require balancing urgency with ecological concerns, making it vital to develop community-supported alternatives for future resilience.

**d. Abandonment of agricultural fields**

In extreme cases, some farmers have abandoned their fields following extreme flooding which swept away their crops. During one of the transect walks, an area experiencing extreme flooding was identified. According to a local guide, two to three households had to relocate and abandon their fields due to the flooding, which corresponds to survey results, where 7 farmers responded that their crops had been swept away. As one farmer recounted: *"Seven years ago, I was forced to abandon my land after the flood. The soil turned sandy, making it unfit for agriculture"* [Interviewee F].

This outcome highlights the severity of climate-induced agricultural challenges faced by farmers and the long-term consequences of extreme weather events on land usability. The abandonment of fields underscores the lack of viable adaptation options, emphasizing the critical need for improved flood management and sustainable land restoration initiatives.

**e. Quantitative analysis of adaptation strategy determinants**

To test common assumptions about adaptation behavior, we examined two hypothesized relationships: (1) between household income and adoption strategies (H1), and (2) between climate concern and adoption strategies (H2). As shown in Table 8, neither relationship proved significant association, suggesting adaptation decisions cannot be explained by conventional factors alone, but rather by complex, multi-layered determinants.

| Type of Analysis | Hypothesis | Test | Result |
|---|---|---|---|
| Relationship between income and adaptation strategies (yes/no) | Higher income leads to more adoption of adaptation strategies | T-test: P-value = 0.287 | Hypothesis rejected |
| Relationship between level of concern and adaptation strategies (yes/no) | Higher level of concern leads to more adoption of adaptation strategies | T-test: P-value = 0.692 | Hypothesis rejected |

Table 8. Adaptation behavior statistical analysis

### *6.4.2. Community-led adaptation strategies*

**a. Cooperatives**

Membership in cooperatives[14] has played a crucial role in enhancing farmers' resilience to climate induced change. Cooperatives facilitate access to financial loans, agricultural subsidies, and improved market linkages. While not originally designed as a climate adaptation strategy, cooperatives indirectly strengthen farmers' ability to cope with climate risks. Fig. 18 illustrates the significance of cooperatives as a key financial support system for farmers, with 91.7% of surveyed farmers having taken a loan through a community-based group over the past five years. Cooperatives act as a bridge for smallholder farmers, enabling them to invest in improved farming practices and access resources that would otherwise be out of reach.

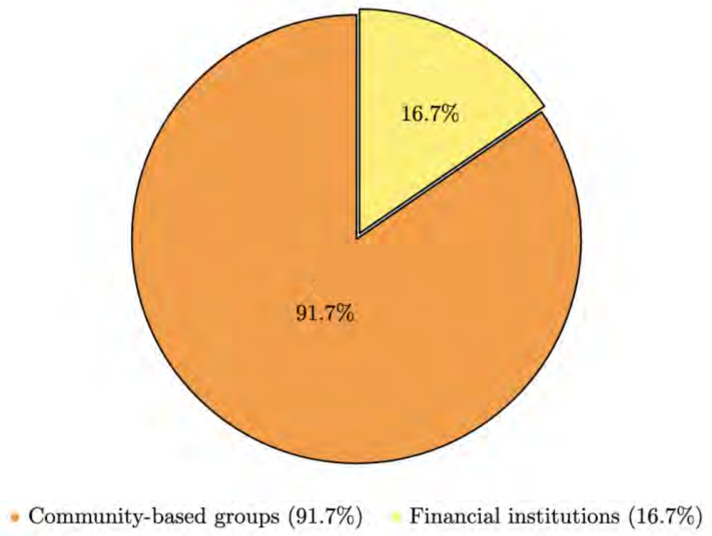



Fig. 18 Source of agricultural loans (survey, n=27)

**b. Afforestation projects**

Afforestation is identified as one adaptation strategy, though implementation remains limited. According to the Chairwoman of the CFG: *"We plan to replace the flowers with trees in the roadside plantation."* [Interviewee B]. These efforts, driven by local authorities, aim to enhance the aesthetic appeal of the region and attract tourism.

Tourism plays a crucial role in shaping land use priorities, with grassland expansion favored over afforestation: *"The grassland expansion is mainly for tourism purposes. As there will be more wildlife sightings in those areas, it will enhance tourism and directly impact livelihood purposes."* [Interviewee B]. This reflects a strategic adaptation decision where

[14] Member-based organizations focused on shared economic or social goals

maintaining and expanding grasslands is seen as more beneficial than planting trees in some locations.

Despite the tourism-driven approach, afforestation projects rely heavily on community support: *"It was done with the concern of all the people in the village, and it was not possible to do without the support of the community. The projects are done for the community by the community, accounting for their needs."* [Interviewee B]. Although afforestation initiatives may not be a primary adaptation focus, those that do occur are shaped by local decision-making and collaboration, as well as indicate an effort to integrate adaptation with economic priorities and environmental sustainability.

#### *6.4.3. State-led adaptation strategies*

**a. Use of improved seeds**

The local government subsidizes improved seed varieties, e.g. rice strains that are more resilient and avoid flowering during critical wet periods. According to the AO, these seeds are particularly valuable in flood-prone areas, as they provide greater resistance to water stress and extreme climatic conditions. While offering potential benefits, some farmers question whether the new varieties yield as much as traditional crops, raising uncertainty about long-term sustainability. This is an issue the local government is aware of: *"At first, farmers were upset, thinking the seeds were poor quality. But once we explained the impact of climate change on production, they began to understand the real cause. Through our training, they realized climate change can be more harmful than they thought."* [Interviewee H].

Despite these concerns, the adoption of improved seeds has contributed to enhanced food security and agricultural resilience (Dwivedi et al., 2021). Government-backed programs ensure that improved seeds are available at subsidized rates, making them a key adaptation tool. Although uptake remains low (Fig. 17), they have been identified as one of the main adaptation strategies. Bridging gaps in awareness and trust in improved seeds is crucial to strengthening resilience in the agricultural sector against CRCs.

**b. River embankment and gabion wall construction**

To mitigate impacts of frequent river flooding, the local government began constructing a gabion wall along the Khahare Khola River, identified during a transect walk. The initiative's aim is to provide protection to the surrounding agricultural land, since river flooding has intensified in recent years. However, progress has been hindered by budget constraints. Farmers report that sections of the wall are damaged by yearly floods, necessitating repairs each year, cutting down the budget to finalize the construction even further. Despite these challenges and structural limitations, Fig. 17 indicates that embankments are widely perceived as an important adaptation measure.

At the national level, NAP 2021-2050 recognizes the importance of river management in reducing climate-induced flood risks. Through the program "Climate-Resilient Flood Control to Protect Livelihoods and Assets at Risk from Climate-Induced Flooding" (Government of Nepal, 2021, P. 68), the government aims to construct climate-resilient infrastructure and safeguarding vulnerable communities, while emphasizing nature-based and sustainable solutions. The program stresses long-term planning, infrastructure development, and coordinated efforts to reduce the impact of flooding exacerbated by climate change.

Importantly, this program illustrates how national adaptation strategies can influence local actions. While plans are developed at the national level, their effectiveness depends on how they trickle-down to village-level implementation. The Khahare Khola gabion wall reflects local manifestation of broader goals, but budget constraints highlight the need for better funding and coordination between levels of governance to ensure that national strategies translate into effective local outcomes.

**c. Capacity-building programs**

The local government offers capacity-building programs to help farmers adapt to CRCs. These sessions focus on key adaptation techniques, such as shifting planting times and utilizing improved rice seeds that avoid flowering during critical weather periods. However, many smallholder farmers remain unaware of these programs. Training was more frequent and perceived as beneficial in the past, as one farmer noted: *"We've received training on agriculture, livestock, and crop diseases, but it's no longer enough. The trainings used to be more helpful in the past, but now they're less frequent and less relevant. We haven't been able to make major changes – we're still farming the same way as before."* [Interviewee C], indicating a decline in information dissemination efforts in recent years. The gap in outreach reduces the effectiveness of these programs, hindering the adoption of key adaptation strategies.

**d. Crop insurance**

The AKC emphasized insurance programs as a key government priority, stating: *"The central government has prioritized programs for insurance, because to protect agriculture we have to* *promote insurance"* [Interviewee I]. At a governmental level, crop insurance is viewed as a viable option for safeguarding farmers' livelihoods, however, this perspective contrasts with farmers' experiences. One farmer shared: *"The compensation is too low – only about 25% of the actual loss. And the process takes too long. A ranger must come from the city just to assess the damage. Insurance could be helpful in the long run, but the whole system needs to change."* [Interviewee G]. The AKC acknowledged these issues: *"Because the insurance companies are not capable, they do not prefer to pay for all this loss. So, there is always a fight between farmers and the insurance company to claim the loss."* [Interviewee I]. This underscores the need for streamlined farmer-friendly insurance policies to enhance financial security against climate risks.

### *6.5. Barriers to adaptation*

Various adaptation strategies have emerged in Nepal, but their implementation is often limited by barriers. This section presents the key barriers to effective climate change adaptation identified.

#### *6.5.1. Financial barriers*

#### a. Limited financial resources

Limited financial resources remain one of the most significant barriers to climate adaptation. On the community level, both farmers and local government representatives noted that they depend heavily on central government funding to implement adaptation strategies. However, budget constraints at the national level often limit what can be achieved, creating a bottleneck for community-scale adaptation projects. As the AO explained: *"The budget is not in our hands; it comes from higher authorities. So there's not much we can do on our side."* [Interviewee H].

At the individual level, farmers prioritize immediate household needs or invest in non-agricultural expenses: *"When farmers start earning more, they usually invest in their children's education – often moving them from local government schools to private ones. They also spend on assets, mainly buying land and building houses."* [Interviewee C]. This leaves little room for long-term investments in adaptation measures.

Survey results indicate most farmers have not received any financial support for climate adaptation (Fig. 19), largely due to limited outreach, high interest rates, and complex application processes. Many remain unaware of existing support schemes or unable to navigate the bureaucratic systems required to access them. While some benefited from cooperatives that offer more accessible credit, others rely heavily on informal lending networks with unfavorable repayment conditions (Rijal et al., 2022).

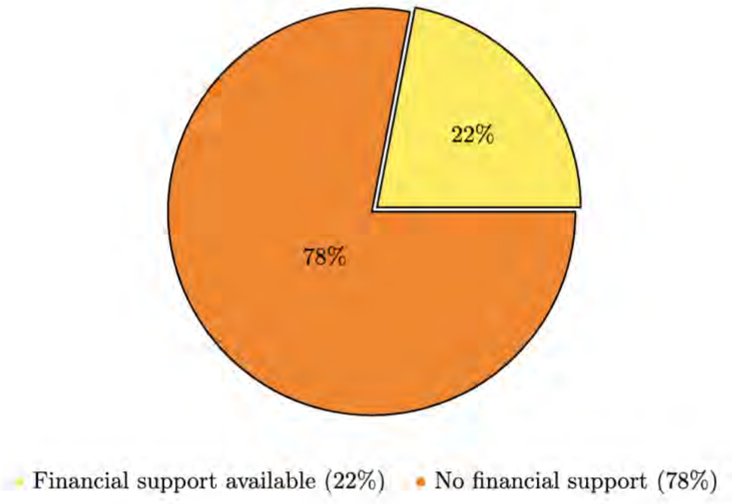



Fig. 19 Financial support received by respondents for climate adaptation over the past 10 years (survey, n=27)

**b. Crop insurance: awareness and accessibility**

Crop insurance is one of the State-led strategies promoted to improve climate adaptation. While the AKC views insurance as a viable long-term solution, they acknowledge flaws in the system. As one AKC representative admitted: *"We are not able to convince all farmers, no, we have to do the insurance"* [Interviewee I] and added: *"If we look at the whole district, less than 1% of the farmers do the crop insurance because they are not very aware"* [Interviewee I]. This aligns with the survey result, where none (n=27) of the farmers have used crop insurance in the past decade.

These findings highlight a disconnection between crop insurance availability and its accessibility or perceived relevance to farmers. Low uptake reflects limited awareness, trust, and support in implementing insurance. Without targeted campaigns, streamlined procedures, and consistent follow-up, crop insurance remain underutilized. To make insurance an effective adaptation mechanism, efforts must focus on awareness-building, simplifying procedures, and increased responsiveness to farmers' concerns.

### *6.5.2. Institutional barriers*

#### a. Weak coordination and fragmented governance

Interviews identified weak institutional coordination as a major barrier to adaptation. As explained by the AKC, Nepal follows a decentralized governance system: *"We operate under a decentralized system. If farmers face problems, they first go to the ward level, where representatives are familiar with the local context. The ward then reports to the municipality. If the issue can't be solved there, it's forwarded to us at the AKC for further support"* [Interviewee I]. While intended to support localized problem-solving, this system often results in delays and inconsistent service due to limited coordination and communication between different levels of government. Despite the existence of national adaptation programs, local implementation remains inconsistent and dependent on available resources and institutional capacity.

Local government representatives cited budget constraints as the main challenge in executing adaptation projects, as the case of the gabion wall: *"The main issue is that the central authorities need to allocate enough budget to build a permanent wall."* [Interviewee H]. These limitations force local authorities to prioritize certain adaptation strategies over others, often delaying or preventing the completion of planned interventions. Subsequently, government interventions are often short-term fixes rather than sustainable solutions.

Financial strain also impacts community-level adaptation, where mistrust and miscommunication further hinder implementation. As explained by the CFG Chairwoman, some community members perceive adaptation projects as money-making schemes: *"There is a misconception that the members receive money without working – that the projects are done for money purposes. Often, the purpose of the projects isn't clearly understood, or even when proposals are accepted, they're sometimes misinterpreted or seen as unsuccessful"* [Interviewee B]. Mistrust can erode participation and reduce the effectiveness of community-led adaptation efforts, underscoring the need for increased transparency, inclusive communication, and stronger alignment between government-led initiatives and local understandings of adaptation.

This institutional gap reflects a broader challenge: effective adaptation depends not only on the existence of policies and plans but also on the capacity and resources of local governance structures to carry them out. Without adequate support from higher government levels, local authorities remain stuck in reactive rather than proactive planning.

**b. Training and extension services**

Farmers expressed the need for more capacity-building programs to support adaptation, particularly among subsistence farmers who feel underserved. Government programs tend to reach commercial farmers more effectively, partly because they are more visible to authorities, have better connections, and are more experienced in engaging with formal institutions. The AKC is aware of this, noting how they have faced criticism of elite capture: *"Some farmers and politicians blame us for that – no, you are just supporting those farmers who are the elite, those farmers who are the political link and those farmers who have knowledge of writing proposals."* [Interviewee I]. Smallholder farmers often lack such access, limiting their support and thus giving fewer chances to improve their adaptive practices. This disparity has significant implications. With less access to resources, markets, and external support, smallholders are more vulnerable to CRCs. Without targeted training, they are less equipped to adopt new techniques, utilize improved seed varieties, or shift planting schedules in response to changing weather patterns.

Another barrier is that farmers have to proactively reach out to local authorities to receive any training: *"They have to approach us."* [Interviewee I]. This places the burden on farmers, many of whom lack awareness or confidence in navigating bureaucratic systems. The lack of systematic outreach excludes those most vulnerable from accessing potentially transformative knowledge and support. The lack of regular, inclusive training represents a missed opportunity for empowering smallholders as key agents of adaptation. By not adequately addressing the needs of this group, current capacity-building efforts risk reinforcing existing inequalities and slowing the diffusion of climate-resilient practices.

#### *6.5.3. Information and awareness barriers*

**a. Discrepancy in awareness between farmers and authorities**

A major barrier to adaptation is the lack of timely and accessible information. While government officials report available support schemes, only 22% of surveyed farmers said they receive information on adaptation strategies from the government (Fig. 20).

The information gap undermines grassroot-adaptation. Without adequate information, farmers may continue to use outdated practices or fail to implement adaptive measures. The lack of communication limits awareness of training, insurance, or subsidies, eroding trust in government programs. When communities are left uninformed, the likelihood of adopting new strategies diminishes significantly, reinforcing cycles of vulnerability. Bridging this gap requires frequent, localized outreach to ensure smallholders' access and understand critical climate-rated support.

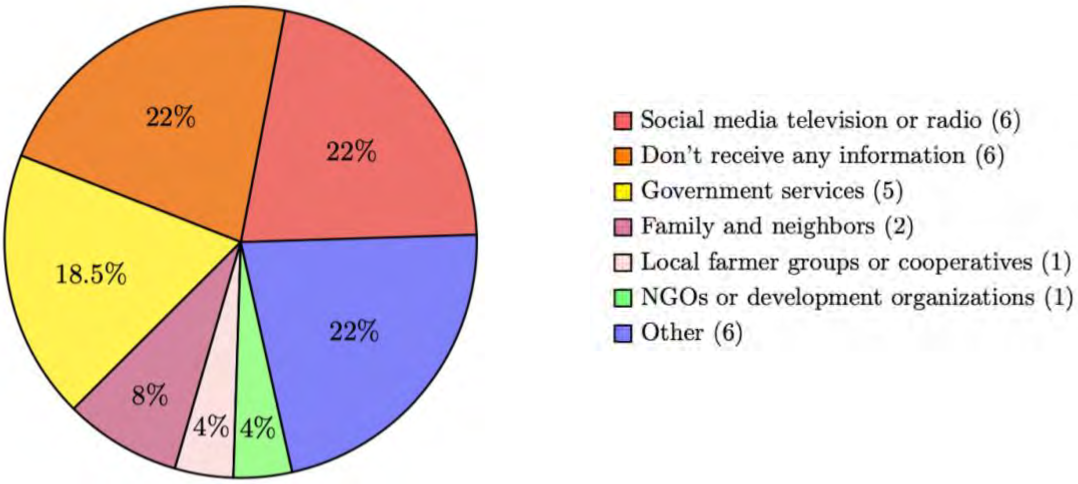



Fig. 20 Sources of information on climate adaptation strategies (survey, n=27)

**b. Access to technology**

Limited access to smartphones and digital platforms restricts farmers' access to information. The AKC uses WhatsApp for outreach: *"We have formed groups of farmers and developed some sort of software here [WhatsApp]. [...] We have been communicating with them, and maybe 100, 200 farmers are involved."* [Interviewee I]. While this approach shows initiative in using digital tools for outreach, its effectiveness is limited by a digital divide.

Many rural farmers lack smartphones or digital literacy to navigate digital platforms. As the AKC acknowledged: *"When you publish a notice, those farmers may be working in the rural area, and they don't have access to Facebook and all these things"* [Interviewee I]. This reveals a mismatch between institutional outreach methods and farmers' access.

Digital tools, while promising, can inadvertently exclude those most in need. Without complementary strategies, e.g. in-person outreach or community radio, the technical divide continues to act as a barrier to inclusive adaptation planning. Bridging this gap requires tailoring communication approaches to the realities of farmers on the ground to support informed, proactive farming decisions.

## 7. Discussion

In the following section, the results will be discussed considering the previously introduced framework and existing literature.

The research objective of this study was to explore how farmers perceive CRCs and to identify the key factors influencing farmers' decisions to implement specific adaptation strategies in Ratawal and Chilaha. Based on the findings from surveys, interviews and FGD the general picture that emerged is that climate change significantly impacts farmers, not only as reduced but also unstable crop production. This affects livelihoods in terms of food security and income stability, which is supported by existing studies (Devkota et al., 2018; Adhikari et al., 2023). A recognizable trend from interviews and surveys is that for many smallholders, farming has shifted from being a relatively stable source of income to one of subsistence. While climate change is a significant driver of this shift, other structural factors—such as economic pressures, or insufficient institutional support, might influence it as well.

As presented earlier in the framework, **vulnerability** is strictly linked to the adaptation capacity of a system, namely the extent of the variations of climate determines the consequent adaptation strategies (IPCC, 2001). However, it is not just the epistemic and ontological uncertainties regarding climate change that affect adaptation strategies, as socio-economic dynamics play a fundamental role (Foley, 2010). From the presented results it is possible to categorize adaptation strategies in **individual-led**, **community-led** and **State-led**. This categorization follows the importance of recognizing different **scales**, as decision-making and implementation dynamics vary across spatial and institutional levels, impacting final outcomes. In this case study, common patterns in the adaptation strategies on the three different scales are identified using the concepts of *efficacy* (achievement of objectives over time), *efficiency* (cost-opportunity trade-offs) and *equity/legitimacy* (social acceptance and justice implications).

Regarding the dimension of *efficacy*, **individual-led** adaptation strategies often achieve their short-term objectives by tackling immediate shocks such as floods or droughts, but their reactive nature, focused on addressing immediate stressors rather than enhancing long-term resilience, suggests that they may be classified as coping strategies rather than adaptive ones (IPCC, 2001). This may not always be effective in the long-term and could lead to maladaptation, therefore be counter-productive due to unforeseen side effects of unplanned strategies as previous studies has shown (Asare-Nuamah et al., 2021; Rijal et al., 2022;

Adhikari et al., 2021). For example, soil acidification may cause an increased use of fertilizers (Zhang et al., 2022), or underground water depletion due to the overreliance on boring wells, affecting wetlands and rivers as well as leading to water shortages in the long run (Prajapati et al., 2021). It could be inferred that this short-term approach is a consequence of the discrepancy between the local experience of climate change and its framing as a global long-term phenomenon with irreversible consequences (Adhikari et al., 2021). At the same time, literature shows that perception of climate variability does not always translate into long-term adaptation strategies as may be influenced by other determining factors, such as education, location, and economic status (Khanal et al., 2019).

Linking the dimension of *efficacy* to *efficiency*, the urgency faced by farmers, driven by the lack of institutional support, results in a trade-off between addressing immediate crop loss and preventing long-term environmental degradation (Meyfroidt, 2018). Interviews indicated that some of these effects are already perceived by farmers, and they are destined to worsen without proper planning; a finding also supported by Rijal et al. (2022).

Additionally, the dimension of *equity/legitimacy*, which addresses the (un)fair distribution of costs and benefits, plays a crucial role in evaluating the cost-opportunity trade-offs of these strategies. Literature shows that, due to bureaucratic and awareness barriers, even when subsidies target smallholders, applicants tend to come from more privileged groups, while marginalized actors remain overlooked (Kafle et al., 2022). For example, research has found that the use of improved seed varieties is increasingly promoted by government programs across climate-vulnerable regions to enhance agricultural resilience in the face of climate change (Dwivedi et al., 2021). Despite the benefits of improved seeds, their adoption is often influenced by broader socio-economic and institutional conditions. The literature shows that factors such as limited access to extension services, lack of awareness, institutional inefficiencies, and limited willingness to pay can hinder widespread uptake (Mishra & Joshi, 2019; Ransom et al., 2003). If the costs of climate change impact continue to be borne by already vulnerable actors without adequate institutional support, it will inevitably result in increased instability and a loss of trust in institutions (Touch et al., 2024). The failure to address these disparities not only undermines adaptation efforts but also deepens existing inequalities, further limiting the resilience of those who are already most at risk (Kafle et al., 2022).

Moving to **State-led** adaptation strategies observed in the study area, particularly regarding their *efficacy,* these measures can generally be classified as ineffective since they fail to achieve their objectives. For instance, the river embankment lacks sufficient funding for completion and, while intended to prevent floods from damaging agricultural fields, it falls short in practice. Similarly, training programs remain inaccessible due to bureaucratic obstacles, preventing farmers from acquiring essential knowledge—an issue also highlighted in findings from similar studies (Rijal et al., 2022; Adhikari et al., 2023). This ineffectiveness also extends to crop insurance programs, which are not perceived as a feasible strategy to adopt by smallholders in the study area due to multiple barriers that limit farmers' access and participation (Gautam et al., 2018).

In terms of *efficiency*, some of these strategies could present an opportunity to benefit the most vulnerable people and bring structural change at a relatively low cost, such as training programs, which could foster capacity-building and enhance resilience. Other strategies have higher investment costs, like the river embankment, but would decrease the long-term costs of annual reconstruction (Ishiwatari et al., 2023). Beyond individual financial barriers, challenges such as limited public funding, institutional constraints, and lack of awareness could be more effectively addressed through participatory decision-making. Therefore, as suggested by Rijal et al. (2022) institutionalizing farmers' voices into the adaptation planning process is pivotal. This would lower costs for coordination and awareness raising while ensuring equity and legitimacy in the process, which is currently lacking, as interviews revealed a perceived top-down approach that places vulnerable farmers in disadvantaged positions (Adger, 2006).

**Community-led** adaptation strategies, such as cooperatives and afforestation projects, present the most *effective*, *efficient* and *equitable/legitimate* scale of action. They reach their goal of expanding the financial capital of smallholders, ensuring more stability and resilience. This is done by providing loans with low interest rates. In terms of *efficiency,* this is not an externalization of risk but a sharing of it, creating a balanced trade-off where participation now helps mitigate future hardships (Adger, 2003). This kind of community-based adaptation could provide more procedural and distributional justice, ensuring resilience building (Reid et al., 2009; Forsyth, 2017). The high participation rates of farmers in cooperatives could suggest a widespread trust in these organizations. A dedicated study is necessary to get a more in-depth understanding of the mechanisms in place of cooperatives to confirm or reject these hypotheses.

In sum, the framework application highlighted trends such as the need for inclusive decision-making, multi-scale coordination, and long-term sustainability. Policies should focus on overcoming financial, institutional, and awareness barriers, ensuring equitable strategies, and bridging the gap between institutional support and farmers' needs through participatory context-sensitive adaptation that integrates both scientific and local knowledge.

## 8. Conclusion

This study explored how smallholder farmers in Chilaha and Ratawal perceive and adapt to CRCs, alongside the key barriers hindering their efforts. Using a mixed-methods approach, the research examined how local communities are using individual-led, State-led and community-led responses to adapt to the perceived environmental changes. The findings show that farmers share consensus in perceiving increased temperatures, decreased rainfall, and water scarcity as the most pressing CRCs affecting their agricultural production.

Farmers mainly adjust by shifting planting dates, adopting irrigation systems—mainly boring systems, and using improved seeds. However, structural barriers such as financial limitations, lack of institutional support, and knowledge gaps constrain their ability to implement long-term adaptation strategies. Moreover, while State-led adaptation initiatives such as crop insurance, subsidies, and training programs exist, their accessibility and effectiveness remain limited, especially for smallholders.

The findings reveal critical trends across individual, community and State-levels, emphasizing the need for inclusive decision-making, multi-level coordination, and long-term sustainability in adaptation planning. For instance, practical interventions like low-cost water meters for boreholes, or small-scale solar irrigation pumps (SIPs) can provide accessible alternatives where institutional barriers limit large-scale climate financing (Kafle et al., 2022). Implementation of institutional reforms, such as Kawasoti's adoption of the Local Adaptation Plan of Action (LAPA), is essential to align governance with local needs. Furthermore, knowledge-sharing programs and dissemination of climate information could bridge awareness gaps, enriching farmer's opportunities to adapt.

Moreover, alternative research should explore the role of international organizations in complementing the efforts of local communities in supporting the implementation of adaptation strategies. As pointed out several times before, the lack of resources is hindering people's adaptive capacity. International organizations could provide broader support, facilitating small-scale interventions increasing climate community resilience.

As an overall reflection, a critical task is to fairly balance the right to preserve local knowledge and the need to adjust practices according to the changing environment. Working within this tension could be daunting as the risk of missteps may lead to inaction. The goal is not to choose between preservation and modification, but rather to thoughtfully integrate both, ensuring that adaptation efforts respect and build upon traditional knowledge while addressing current and emerging challenges. For this reason, all interventions or alternatives proposed need to be carefully designed, ensuring they are grounded in local perspectives.

Moving forward, collaboration between policymakers, researchers, and communities will be vital to ensure adaptive strategies are both sustainable and just. To create truly inclusive and effective solutions, adaptation efforts must prioritize the voices of those directly affected. By centering farmer perspectives and scaling participatory approaches, these efforts can better respond to the evolving climate crisis.

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# APPENDIX

# I. Authors

| Section | Author | Co-author |
|---|---|---|
| Introduction | Krystel | Jyoti |
| Background and Framework | Sara: Literature review<br>Matteo: Meteorological data<br>Francesca: Framework | Ester |
| Methodology | Ester: Surveys; FGD<br>Jyoti: Transect walk; Interviews; Sampling | Francesca |
| Results | Krystel: CRCs; Perception of CRCs<br>Sara: Adaptation Strategies; Barriers<br>Matteo: Integrating quantitative analysis | ALL |
| Discussion | Francesca<br>Jyoti | ALL |
| Conclusion | Ester<br>Matteo | ALL |

## II. Overview of applied methods

| **Method** | **Description** |
|---|---|
| Transect Walk | 2 transect walks with local guides and interpreter |
| Household Surveys | 27 respondents selected through a systematic random sampling strategy. Use of SurveyXact to manage data |
| Semi-structured interviews | 9 interviews with Key Informants; including farmers and stakeholders of local governments and community groups |
| Focus group | 1 focus group discussion with 8 participants: 4 females and 4 males. |
| | 1 focus group discussion producing seasonal calendar with approximately 20 female participants part of a cooperative |

## III. Original synopsis

Group 7: Climate Change and Agriculture Research Synopsis

Practicing Interdisciplinary Field Research on the Environment

Field Site: Magarkot Village,

Nepal Dates: 24th February - 07th

March 2025

***Research topic: Climate Adaptation Strategies implemented by Farmers in Magarkot Village***

Word Count: 2,484


Ester Rossi

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# Introduction

*The Case*

Nepal is among the countries most vulnerable to climate change impacts, ranking 10th in the Global Climate Risk Index 2021 for weather-related damages such as floods, storms and heatwaves (German Watch, 2021). However, climate changes do not affect all regions of Nepal uniformly. The mountain regions are experiencing more significant temperature increases than the lowlands, contributing to variable climatic effects across the country (Karki et al., 2019). Seasonal variations have become increasingly pronounced, with prolonged dry spells in winter leading to water shortages for drinking and irrigation, while excessive rainfall during the monsoon season causes frequent flooding in the Terai region (Tiwari et al., 2014). Additionally, cold waves, a relatively new phenomenon in the Terai, have begun to significantly impact agriculture, affecting both crop yields and livestock productivity (Shrestha et al., 2023).

The effects of climate change on agriculture are particularly concerning given Nepal's high dependence on agriculture as a livelihood source. Studies have shown that while some local communities do not perceive climate change as an immediate problem (Nash et al., 2019), others have reported significant water shortages and an increase in pest infestations, particularly in hotter conditions (Ghimire et al., 2023). Climate-related risks in Nepal are diverse, all of which significantly impact agricultural productivity. Key challenges include Climate-Related Events (CREs): fog, heat waves, pest infestations, hailstorms, floods, droughts and rising temperatures. In this study "climate-related events" are intended as both climate induced disasters (such as floods, hurricanes, heat waves, etc.), but also the specific gradual/incremental changes in the environment perceived in the village.

In response, farmers have implemented various adaptation measures, such as rainwater harvesting, improved irrigation systems, crop diversification and agroforestry. Additionally, climate-smart agriculture (CSA) practices and access to weather information have been adopted to help manage climate-related risks (Rijal et al., 2022). However, these adaptation strategies have not always been effective in addressing climate variability, often resulting in increased production costs despite stable yields (Rijal et al., 2022; Dhakal et al., 2016).

In spite of these adaptation efforts, barriers persist. Institutional support mechanisms, such as government-subsidised crop insurance programs, have been established to mitigate financial risks, with the Nepalese government covering 75% of insurance premiums for farmers (Budhatoki et al., 2019). However, uptake of these schemes have been low, suggesting that financial or knowledge-based barriers may be hindering broader adaptation. This highlights the need for further investigation into the multidimensional constraints that affect farmers' ability to adapt effectively.

*Research Problem and Objectives*

Although research on climate change adaptation in Nepal at the national level has been conducted, there is a notable gap in micro-level analysis focusing on small villages such as Magarkot, where this research will take place. This lack of localized research means that the specific adaptation efforts, challenges and strategies of farmers in these communities remain understudied. Consequently, it becomes difficult to design targeted policy interventions that address the unique constraints and opportunities faced by these farmers. Thus, understanding climate change adaptation requires a context-specific approach, particularly at the village level, where socio- economic conditions, governance structures and access to resources play a crucial role. Analyzing localized adaptation measures can provide valuable insights into how farmers respond to climate variability, including the socio-economic constraints that hinder effective adaptation and the role of governance in shaping adaptation efforts.

While various adaptation strategies have been identified, there remains a gap in understanding how farmers implement these strategies and what factors influence their decisions. Studies have shown contrasting perspectives on climate change impacts at the local level, with some communities recognising its effects while others do not (Nash et al., 2019). Although adaptation strategies have been documented, their effectiveness and sustainability in different agro-ecological contexts remain insufficiently analysed. Moreover, financial constraints, policy insufficiencies and knowledge gaps might hinder adaptive capacity, raising questions about the role of institutional support and local governance in facilitating agricultural adaptation.

Thus, this study aims to explore the adaptation strategies used by farmers to cope with CREs in Margakot village while accounting for barriers that may constrain these efforts. The overarching research question, with its sub-questions, guiding this study is:

1. *What are the adaptation strategies used by farmers to cope with climate-related events in Magarkot village?*

   1.1. *Climate-related events*

      1.1.1. *What CREs affect the village area?*

      1.1.2. *What CREs have farmers experienced?*

      1.1.3. *What specific changes do farmers observe in the environment?*

   1.2. *Adaptation strategies*

*1.2.1. Which strategies are implemented by farmers? Why or why Not?*

*1.2.2. Which factors influence the adoption of specific adaptation strategies?*

*1.3. Perception of climate change by farmers*

*1.3.1. How do farmers experience climate-related events?*

By investigating the intersection between CREs, adaptation strategies and influencing factors, this study seeks to provide insights that can inform policy intervention aimed at strengthening climate adaptation in small communities within Nepal's agricultural sector. Addressing these challenges requires a multi-dimensional approach that integrates local knowledge, technological innovations and supportive governance structures to enhance farmers' adaptive capacities in the face of climate change.

## Methodology

This study employs a mixed-methods approach: a qualitative approach is prioritized to capture in-depth narratives and contextualized understandings, while a quantitative analysis is used to examine the relationship between farmers' risk perception of CREs and the adaptation strategies implemented (Bryman, 2006).

One methodological clarification to emphasize is that individual weather events experienced in the village might not necessarily be direct evidence of climate change. "Weather" usually refers to short-term atmospheric conditions at any given time and place (e.g. rainfall, temperature). In contrast, "climate is defined not only by average temperature and precipitation but also by the type, frequency, duration, and intensity of weather events" (Environmental Protection Agency, 2025). Acknowledging this distinction will provide more nuances to assess whether observed changes in the local environment are explained by the increasing frequency of climate change effects. In this study, we deliberately avoid framing our investigation directly under climate change, instead we use the term 'Climate related-events'(CREs).

Also, important to clarify that the objective is not to establish a direct, causal link between the observed CREs and climate change. Instead, the research aims to examine relevant climate trends and assess whether future occurrences are likely to increase, decrease, or remain at a similar level. The methodological choice is driven by the following considerations:

1. *Minimizing researcher-induced bias:* Explicitly mentioning climate change may introduce biases, as it could lead respondents to align their answers with perceived expectations,

external narratives, or political discourses rather than their personal experiences (Abdel-Monem et al., 2024). By focusing on observable environmental changes we allow farmers to describe their experiences in their own terms, reducing the risk of response bias.

2. *Assessing farmers' own conceptualization of climate change:* Rather than assuming a predefined understanding of climate change, this approach enables us to explore whether and how farmers conceptually link local environmental changes to the broader climate phenomenon. This is crucial for understanding the contextualized meaning of climate change within the village's socio-economic and cultural framework, and for obtaining specific insights that could inform policy-making and consider the local perspectives and knowledge.

3. *Capturing localized impacts without imposing a global narrative:* Our primary focus is on the local manifestations of climate-related events and how they affect agricultural practices, livelihoods, and adaptation strategies of the inhabitants of the village. By not explicitly referring to climate change as a global phenomenon, we ensure that the research study remains grounded in farmers' lived realities rather than being shaped by external/abstract scientific or policy discourses.

According to the proposed time plan, we implement various research methods in the following order:

1. Secondary data collection of historical records of CREs
2. Transect Walk
3. Surveys
4. Semi-structured interviews
5. Focus groups + ranking exercise

*Secondary data collection of historical records of CREs*

To assess the impact of climate-related events on farmers' perceptions, this study first examines historical climate events in Magarkot. Data will be collected from both official sources (e.g., government reports, scientific journals) and farmers' personal experiences through a transect walk. Official sources provide scientifically validated climate data, which serve as a baseline for understanding long-term trends in CREs, and provide background knowledge to interpret how farmers perceive and respond to them (Electric Power Research Institute, n.d.). These sources include: government reports, meteorological data, scientific literature and remote sensing data.

*Transect Walk*

Transect walks are conducted in a transect, a defined path, together with local informants in order to collect information about the problems and relevant areas of the community then used to draw a diagram or map (Narayanasamy, 2009). Transect walks are a useful tool to implement at the beginning of a research as a way to explore the field, identify problems for the community and create a participatory map of hotspots (Kumar, 2014). In the case of the present research the aim of the transect walk is to identify areas relevant for agriculture where CREs took place and investigate the social meaning assigned to them. Regarding the actors involved in the transect walk, identified as a key informant is the local guide/interpreter, considered to be a person with thorough knowledge of the village. In addition, following the snowball sampling technique, one or two other people willing to participate could take part in the walk to complement knowledge gaps and foster aid to memory.

Additionally, GIS mapping will be implemented during the walk in order to create a digital map of the hotspots to compare with historical records to identify possible patterns. As for limitations, this tool requires cooperation and is time consuming, in addition to possible memory gaps and lack of knowledge of the actors involved. The most prevailing biases could be social desirability bias, selection bias and group dynamics bias. Nonetheless, through our multifold methods approach we aim to minimize them.

*Survey*

The survey is aimed to gather initial information about participants, including demographic details, experiences with CREs, risk perception and any adaptation strategies they have implemented. We have structured the survey into four sections: Introductory Information, Household and Livelihood, Knowledge and Perception of CREs, and Implementation of Adaptation Strategies. We chose a survey format to quantify responses, allowing us to perform statistical analyses and identify patterns in experiences and adaptation to CREs. Although most of the questions are closed-ended, we have also included some open-ended questions so the participants can provide their own answer (instead of being guided by a predefined set of options) and elaborate on any alternative perspectives, themes, or issues we may have overlooked. As Bryman (2012, p. 247) points out, open-ended questions are useful to tap the levels of knowledge and understanding of issues of the respondents, and to explore new areas in which the researcher has limited experience or knowledge. For instance, in section 'Implementation of Adaptation Strategies', we initially ask an open-ended question to allow respondents to answer freely, then we follow it with predefined options to guide participants, who might not have considered certain aspects, while also facilitating quantitative analysis.

For our sampling strategy, we intend to focus on farmers. Participants will be identified through a transect walk, where we locate geographical hotspots most impacted by CREs. Households in these areas will be randomly selected from the identified hotspot, every fifth household, forming the basis for our stratified sampling approach if we find relevant farming households. For the stratified sampling approach, we hope to be able to reflect the diversity of the population in relation to gender, age, caste, level of education and income, etc; however this will be highly dependent on the type of data obtained through the research. If a randomly selected household is not engaged in farming, not able or willing to take the survey, we will implement a systematic replacement method to maintain consistency in data collection. In such cases, the replacement will follow a structured approach, selecting the next household to the right to ensure systematic and unbiased sampling. This method ensures that our survey aims for a balanced representation of farming communities affected by CREs.

*Semi-structured interviews*

To develop a more comprehensive understanding and complement the quantitative survey findings and participatory methods, we conduct ten semi-structured interviews. This semi-formal approach, based on predefined open-ended questions, allows for flexibility to explore farmers' perceptions of CREs and their adaptation strategies in greater depth (Bryman, 2012). In addition, we use photo elicitation to "evoke deeper elements of human consciousness" and facilitate richer discussions by prompting memories, emotions, and personal interpretations that might not emerge through verbal questioning alone (Harper, 2002, p. 13). CREs with deeper impacts may have been photographed to capture the extent of the damage, helping farmers recall the event more easily and articulate their experiences in greater detail.

To strengthen the rigor of our findings, we employ a purposeful sampling strategy to identify specific actors of the community that could provide us with the insights and information required for this research, based on the results of the survey. Additionally, to reinforce a diverse, relevant and feasible sample the ten farmers will be selected based on the following factors: experience with climate events, reliance on farming, land ownership type, adaptation strategies and barriers and financial and institutional access, to ensure a diverse and relevant sample.

While this approach may introduce selection bias, we mitigate this by triangulating the findings with data from other sources as well as taking diverse voices into account. The triangulation method will allow us to "increase the validity, strength, and interpretative potential of the study, decrease investigator biases, and provide multiple perspectives" (Thurmond, 2001).

Finally, all participants will provide informed consent, and ethical guidelines will be followed to ensure confidentiality and respect for participants' experiences.

*Focus groups and ranking*

Lastly, the focus groups and ranking exercise will also explore farmers' adaptation strategies to cope with CREs. Groups of 6-10 participants will discuss their experiences with climate variability, challenges faced and adaptation measures. Following this, a ranking exercise will help identify the most valued adaptation strategies and barriers to their implementation, as ranking and scoring are "particularly relevant tools for analysis of difference, unequal relationships and prioritization, and to assess people's expectations, beliefs, judgements, attitudes, preferences, and opinions" (Mikkelsen, 2012). This participatory approach and methods will enable the researchers to understand which strategies are most valued by the community and which barriers prevent their implementation.

However, there are also limitations. Discussions may be dominated by vocal participants, potentially sidelining quieter voices (Caillaud et al., 2022). Translation bias could lead to misinterpretation, and memory recall issues may result in inconsistent data. To mitigate these limitations, we will implement several strategies. To ensure balanced participation, we should actively encourage quieter participants to share their perspectives, using direct prompts and structured turn-taking. To reduce translation bias, local interpreters will be used and cross-checking of key terms will be conducted with participants. To ensure diverse representation, a stratified sampling approach will be used, selecting farmers based on landholding size, socio-economic status, gender, and age (Rea & Parker, 2014). This will help capture perspectives across different farming scales, social backgrounds, and generations.

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# IV. Research matrix

| **Research objective** | To identify the key factors influencing farmers' decisions to implement specific climate adaptation strategies, and explore how farmers perceive climate-related events in Magarkot village. | | | | | |
|---|---|---|---|---|---|---|
| **Research Question** | What are the adaptation strategies used by farmers to cope with climate-related events in Magarkot village? | | | | | |
| **Research themes:** | **Research Sub-Questions** | **Data Required (Variables)** | **Data Collection Methods** | **Data Analysis Method** | **Inputs** | **Important & Critical Assumptions** |
| Climate-Related Events | What CREs affect the village area?<br><br>What CREs have farmers experienced?<br><br>What specific changes do farmers observe in the environment? | Observed climate-related events (CREs) – Types and frequency | Review of historical climate records<br><br>Transect walk (Key Informant) and GIS mapping<br><br>Survey (stratified sampling) – use of SurveyXact | Descriptive statistics<br><br>Triangulation of data obtained from historical records and specific experiences<br><br>Thematic analysis Coding of answers – use of NVivo | Participants: Local guide/interpreter<br><br>Clipboards; Notebooks; Pens; Tablet<br><br>Recording device<br><br>Camera<br><br>GPS devices and mapping tools | Availability of historical climate records;<br><br>Willingness to participate;<br><br>Inaccuracy of one's memory |

| | | | | | | |
|---|---|---|---|---|---|---|
| Adaptation strategies | Which strategies are implemented by farmers? Why?<br><br>Which factors influence the adoption of specific strategies? | List of adaptation strategies used<br><br>Adaptation strategies categorization – based on effort level<br><br>List of enabling factors<br><br>List of barriers | Survey (stratified sampling)<br><br>Semi-structured interviews (purposeful/snowball sampling)<br><br>Focus groups + ranking exercise (stratified sample) | Descriptive statistics<br><br>Thematic analysis Coding of answers – use of NVivo<br><br>Statistical analysis – use of Excel | Participants:<br>Interpreter<br><br>Venue,<br>Ranking tokens<br>Scorecards<br>Pens<br>Markers<br>White board<br>Notebooks | Willingness to participate;<br><br>Inaccuracy of one's memory;<br><br>Bias due to dominant voices and group dynamics ;<br><br>Translation bias |
| Perception of climate change by farmers | How do farmers experience climate-related events? | Socio-demographics<br><br>Livelihood sources<br><br>Socio-economic consequences of CREs<br><br>Past CREs experienced<br><br>Risk perception of CREs | Survey (random / stratified sampling) – use of SurveyXact<br><br>Semi-structured interviews (purposeful/snowball sampling)<br><br>Photos elicitation | Descriptive statistics<br><br>Statistical analysis (depending on the data available) – use of Excel<br><br>Thematic analysis Coding of answers – use of NVivo | Participants:<br>Interpreter,<br><br>Consent form<br><br>Interview guides<br><br>Participant-generated images<br><br>Recording device | Willingness to participate;<br><br>Inaccuracy of one's memory;<br><br>Translation bias;<br><br>Subjectivity of risk perception;<br><br>Social desirability bias |

**Survey draft**

Link SurveyXact: https://www.survey- xact.dk/LinkCollector?key=TKYA1NTMU63J

Four sections:
1. Introductory information/demographics
2. Household information: income, land, size of family, etc
3. Perception of climate events and variation
4. Adaptation strategies of farmers

**DEFINITIONS:**

- Household: “A household is defined as a group of people (normally family members) living under the same roof, and pooling resources (labour and income)” (PEN, 2007)
- Climate-related events: “Climate-related events” refer to both climate induced disasters (such as floods, hurricanes, heat waves, etc.), but also the specific gradual/incremental changes in the environment perceived in the village.
- Adaptation strategies: “The array of strategies and measures that are available and appropriate for addressing adaptation. They include a wide range of actions that can be categorised as structural, institutional, ecological or behavioural” (IPCC, 2022).
- Adaptation: “In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects” (IPCC, 2022).

**Consent**

We are a group of students from the University of Copenhagen conducting research in Magarkot village with the aim to better understand your agricultural practices, how climate- related events affect you, and the strategies you use to adapt. Your insights will be invaluable to our study.
This survey will take approximately 20-25 minutes to complete. The purpose is purely educational, and it is not linked to any institution or organization other than the University of Copenhagen.
Your names will not be mentioned in the final report, meaning your answers are anonymous. The data will be stored safely, where only us, the students and the teachers will have access, and it will be deleted once we are finished with this course.

Are you willing to proceed with this survey?
☐ Yes
☐ No

**Introductory Information**

**1. Name of Respondent**

________________

**2. Name of Household Head**

________________

**3. Relationship to the Household Head** *(Select one)*
☐ Self (Household Head)
☐ Spouse
☐ Son/Daughter
☐ Parent
☐ Sibling
☐ Other (please specify): ___

**4. Gender** *(TBC)*
☐ Male
☐ Female
☐ Other
☐ Prefered not to say

**5. Age**
______years

**6. Caste/Ethnicity** *(TBC)*

______________________

**7. Education Level** *(Select the highest level completed)* (TBC)
☐ No formal education
☐ Primary
☐ Secondary
☐ Diploma
☐ Bachelor's degree or higher

**8. Time residing in the village** *(In years)*
______years

**9. Occupation over the past 12 months** *(Select all that apply)*
☐ Farmer
☐ Wage laborer
☐ Business owner

☐ Salaried employee (government/private sector)
☐ Livestock farming
☐ Remittance-based income
☐ Other (please specify): ___

---

**Household and Livelihood Household Composition**
How many members live in this household?
______(Write the number)

---

**Livelihood Sources**

What were the main sources of livelihood for your household in the past 12 months? *(Rank in order of importance, 1 being the highest)*
☐ Agriculture (farming, livestock, etc.)
☐ Salary/wages (employment)
☐ Non-agricultural business (trade, small enterprise, etc.)
☐ Remittance (money sent from family members abroad)
☐ Other (please specify): ___

---

**Agricultural Land Ownership**

Does your household own agricultural land?
☐ Yes
☐ No

If **Yes**, what type of land do you own? *(Select all that apply) —> TBC*

☐ Irrigated farmland
☐ Rainfed farmland
☐ Pasture/grazing land
☐ Orchard/plantation land
☐ Other (please specify): ___

---

**Household Access to Social and Economic Services**

**a. Cooperative Membership**
Are you or any of your household members part of a cooperative or social network?
☐ Yes
☐ No

**b. Savings in Cooperatives**
Have you or any of your household members regularly saved money in a savings group or cooperative in the past 12 months?
☐ Yes
☐ No

**c. Agricultural Loans**
Have you or any of your household members taken a loan for agricultural purposes over the past 5 years?
☐ Yes
☐ No

If **Yes**, from which type of organization?
☐ Community-based group (cooperative, savings group, informal lender)
☐ Financial institution (bank, microfinance, government credit program)
☐ Other (please specify): ___

**d. Community Organization Participation**
Are you or any of your household members part of a community organization related to agriculture?
☐ Yes
☐ No

---

**Household Income Sources (Past 12 Months)**

What crops did you grow in the past 12 months?

______________________________

How much did you earn in cash from these crops in the past 12 months? NPR ____(Specify amount)

Apart from agriculture, did you have additional income sources in the past 12 months?

☐ Yes
☐ No

If **Yes**, what are your additional sources of income?

____________________

How much did you earn in cash from each one of these sources in the past 12 months? NPR ______(Specify amount)

---

**Knowledge and Perception of CREs**

**1. Observed Changes in Weather Patterns**

Have you noticed any changes in weather over the last five years? *(Select one option for each factor)*

| Weather Factor | Increased | Decreased | No Change | Don't Know |
|---|---|---|---|---|
| Temperature | ☐ | ☐ | ☐ | ☐ |
| Rainfall | ☐ | ☐ | ☐ | ☐ |
| Drought | ☐ | ☐ | ☐ | ☐ |
| Flood | ☐ | ☐ | ☐ | ☐ |
| Landslide | ☐ | ☐ | ☐ | ☐ |
| Other (Specify) | ______ | | | |

---

**2. Climate Events Affecting Your Area**

What are the main climate events that have impacted this area in the past five years? *(Select up to 5 and rank them in order of severity, 1 being the most severe)*
☐ Drought
☐ Forest fire
☐ Fire in the village

☐ Flood
☐ Windstorm
☐ Heavy rain
☐ Sporadic rain
☐ Landslide
☐ Heatwave
☐ Crop disease outbreak
☐ Pest infestation
☐ Water scarcity
☐ Other (please specify): ___

---

**3. Household Experience with Climate Events**

Have you or any of your household members personally experienced a climate event in the past five years?
☐ Yes
☐ No
☐ Don’t remember

If **Yes**, which events did you experience?

______________________________________________

---

**4. Impact of Climate Events on Household**

Indicate the level of impact of the climate events on your household *(Tick one for each selected event)*

| Climate Event | Very Low | Low | Moderate | High | Very High |
|---|---|---|---|---|---|
| _____________ | ☐ | ☐ | ☐ | ☐ | ☐ |
| _____________ | ☐ | ☐ | ☐ | ☐ | ☐ |
| _____________ | ☐ | ☐ | ☐ | ☐ | ☐ |
| _____________ | ☐ | ☐ | ☐ | ☐ | ☐ |
| _____________ | | | | | |

_______ ☐ ☐ ☐ ☐ ☐

---

### 5. Impact on Agricultural Production and Livelihood

How concerned are you about the impact of climate-related events on your farming activities?
Likert Scale (1-5):

☐ 1 - Not concerned at all (Climate-related issues are not a major concern)
☐ 2 - Slightly concerned (Minor challenges, but manageable)
☐ 3 - Moderately concerned (Challenges that require adjustments)
☐ 4 - Very concerned (Significant impact on farming and livelihood)
☐ 5 - Extremely concerned (Threatening farming viability)

Have you experienced the impact of climate events on your agricultural production?
☐ Yes
☐ No

☐ Don’t know

If **Yes**, how has it affected your farming?

________________________________________

---

### Implementation of adaptation strategies

Have you or any of your household members taken any measures to cope with climate-related events in the past 5 years?
☐ Yes
☐ No
☐ Don’t know

If **yes**, can you describe any measures you've taken?

________________________________________________

If **Yes,** what are the main factors influencing your decision to adopt adaptation measures? (Select all that apply)

☐ Past experiences with climate events
☐ Advice from agricultural experts or extension workers
☐ Recommendations from fellow farmers
☐ Financial costs and expected returns
☐ Availability of government or NGO support (e.g insurance schemes, subsidies etc…)
☐ Other (please specify): ___

If **No**, what are the main barriers preventing you from implementing adaptation strategies? *(Select all that apply and rank them in order of relevance, 1 being the most relevant)*

☐ Financial constraints/lack of access to credit
☐ Limited information or awareness
☐ Lack of access to modern technology or inputs
☐ Land or water scarcity
☐ Lack of government support or policies
☐ Social or cultural barriers
☐ Other (please specify): ___

Have you received any financial support over the past 5 years (e.g., subsidies, grants, or loans) for climate adaptation or agricultural investments?

☐ Yes
☐ No

What initiatives do you think would be most needed for you to adapt better to climate-related events?

______________________________

What is your main source of information on climate adaptation strategies? *(Select all that apply)*

☐ Government agricultural extension services
☐ Local farmer groups or cooperatives

☐ NGOs or development organizations
☐ Social media, television, or radio
☐ Family and neighbors
☐ Private sector input suppliers (e.g., seed or fertilizer companies)
☐ Other (please specify): ___

Are you considering adopting new adaptation measures in the next 5 years?
☐ Yes
☐ No
☐ Not sure

**Draft of Interview Guide**

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**Objective:** Understand how farmers experience climate-related events, their consequences, and their responses.

**Warm up**

- Introduction and the purpose of the research
- explanation of photo discussion
- Confirmation of consent for the interview and photo use.

1. **Farming Background**

- How long have you been farming here?
- What crops do you grow?
    - Has this changed over the years in terms of quantity?
    - And in terms of varieties?
- What is the biggest challenge in farming for you right now? (suggestion: such as in terms of family, health, subsistence etc.)

2. **Personal Experience of Climate-Related Events**

- Can you tell me about this photo? What's happening here? (identifying the event)
- Has this kind of situation always happened, or is it something new? (perception of CC)
- What did you do when this happened? (adaptation)
    - Why?
- Can you describe what this day was like?
- How has this (referred to the CRE in the picture) affected your farm or your daily work? (socio-economic consequences)
- Does this still have an effect on your farm or your daily work today? How? (socio-economic consequences)

*(if no photos)*

- From the survey we understand that you experienced x (insert the specific climate-related event), can you tell us more about it?
    - When was it?
- Are there any other climate-related events that you remember?

- Have you noticed that some seasons are different from when you were younger? In what way (suggestion: maybe colder, warmer, longer, shorter, wetter, drier)? (perception of CC)
- Do certain crops struggle more than in the past?
    - What about animals?
    - How?
    - Why do you think that is? (perception of CC)

**3. Socio-Economic Consequences (adaptation)**

- If a season is bad, how do you manage? (enabling factors)
    - Do you borrow money, reduce expenses, or find other work?
    - Why don't you use other strategies? (barriers)
- Have you had to make changes to your farm because of these difficulties?
    - What are these changes?
- Has there been a time when you lost a big part of your harvest due to a CRE?
    - What did you do? Why?
- What strategies do you use when water is scarce/there's a flood/when there are extreme temperature?
- Have you tried different crops or techniques to protect your harvest?
- What *makes it difficult for you to adapt to these* events? (Factors)
    - *Why? (Suggestion: Lack of money, lack of knowledge, lack of support?)*

*(Crop Insurance-Specific Questions)*

- Have you heard of agricultural insurance?
- Have you ever considered getting insurance? Why or why not?
- If you are insured, has it helped you? In what way?
- What would make insurance more useful or accessible to you?

**5. Perceived Risk (Quantifying the Experience)**

- Based on the survey: can you tell us the reason behind the score you chose?

**6. Closing the Interview**

- Is there anything else about farming challenges or solutions that you want to share?
- If you could ask for one thing to make farming easier, what would it be?
- Confirm whether they are comfortable with their photos being used in research.

## Quantitative analysis

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**Research question for quantitative analysis:**
How do past climate shocks and risk perception (as a combined factor) influence farmers' adaptation strategies in Magarkot village?

The core idea of this analysis is to investigate the relationship between farmers' adaptation strategies and two key factors: past exposure to climate-related shocks and risk perception. Specifically, we propose merging these two factors into a categorical variable to explore their combined impact on adaptation strategies. The general assumption underlying this approach is that farmers' past experiences with climate shocks, as well as how they perceive the risks associated with future CREs, shape their decisions regarding adaptation strategies. It is hypothesized that:

1. **Farmers with past climate shocks experienced are more likely to adopt proactive strategies**
2. **Farmers who perceive CREs as a risk to their livelihood are more likely to adopt proactive strategies**
3. **The interaction between past climate shocks and risk perception may influence the level of adaptation effort**

### Climate shocks experienced and risk perception (Independent variable)

The methodological choice of combining past climate shocks experienced and risk perception in a single variable has two main justifications:

1. **Interaction effect: understanding the relationship between past shocks and risk perception:**

If we kept past climate shocks and risk perception as separate variables, we wouldn't see how one influences the other.
By creating four categories, we can test if past shocks actually shape risk perception (Do people who experienced past shocks perceive risk? Or is risk perception independent of past experience?)

2. **Clearer comparison of adaptation strategies:**

Instead of testing two separate effects (past shock and risk perception) on adaptation strategies, merging them allows us to directly compare behavioral patterns across groups. For example, do farmers who experienced past shocks and perceive risk behave differently from those who perceive risk without past shock exposure?

**The four categories**

1. No past climate shock and does NOT perceive risk
2. No past climate shock but perceive risk
3. Past climate shock but does NOT perceive risk
4. Past climate shock and perceive risk

**Informations gathered through two separated questions (in order not to add useless complexity to respondents)**:

1. Have you experienced any climate-related shocks (e.g., droughts, floods, storms) in the past? Yes/No
2. Do you perceive future climate-related events (e.g., droughts, floods, storms) as a risk to your livelihood? Yes/No

**Potential limitations of this approach (combination of PCS and RP)**

1. **Assumption of equal weighting:**

Merging the two variables assumes that past climate shock and risk perception are of equal importance in shaping adaptation strategies, which may not be the case. For example, past shocks might have a stronger influence on adaptation decisions than risk perception

2. **Methodological carefulness in accounting for barriers**:

Focusing solely on this relationship may be misleading, as other factors also influence adaptation strategies. Therefore, it is essential to consider how barriers impact and interfere with this relationship -> barrier index

**Adaptation strategies score (Dependent Variable)**

Farmers' adaptation strategies are measured based on the specific actions they take to cope with climate-related risks. These actions can vary in terms of effort, ranging from short-term, reactive responses to more long-term, transformational adaptations.

**Survey question for adaptation strategies:**

*"Which of the following adaptation strategies have you used in response to climate-*related *challenges?"* (Check all that apply)

**A. Low-effort strategies (short-term, reactive responses)**

☐ No action taken

☐ Relying on food aid or external support

☐ Reducing farm investments (e.g., buying fewer inputs)

☐ Selling livestock/assets as a coping mechanism

**B. Moderate-effort strategies (incremental adjustments)**

☐ Changing planting dates

☐ Adoption of agriculture insurance schemes

☐ Increasing use of irrigation

☐ Improved seeds and crop varieties

☐ Mechanized tools (tractors, threshers, etc.)

**C. High-effort strategies (transformational adaptations)**
☐ Diversifying crops and livelihoods
☐ Shifting to alternative farming systems (e.g., agroforestry, organic farming, others)
☐ Migrating or permanently relocating farming activities
☐ Investing in large-scale infrastructure (e.g., water storage)
☐ Greenhouse farming

☐ Other (we decide how to categorize the strategy during the analysis)

-> create activity to let farmers decide strategies based on effort

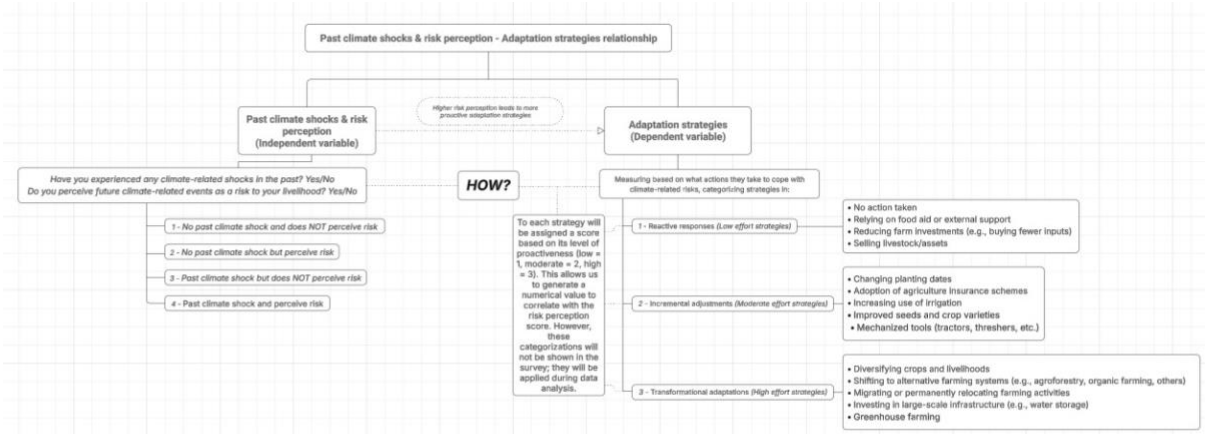
Each strategy will be assigned a score based on its level of proactivity and resource intensity, for example:

- Low-effort strategies = 1
- Moderate-effort strategies = 2
- High-effort strategies = 3

After data collection, these scores will be used to quantify the adaptation efforts. Importantly, the survey will not present these categories to respondents; they will simply check the strategies they have used, and the categorization will occur during the data analysis phase, this mainly because categories could make farmers feel judged or pressured to choose certain responses. By not assigning categories upfront, the survey avoids social desirability bias and allows farmers to select strategies based on their actual experience.

**Limitations of this approach:**

1. The approach assumes that the strategies farmers adopt are driven by climate-related challenges. However, farmers may adopt certain strategies for reasons other than climate risks, such as economic factors, market trends, social influences, or traditional practices. This analysis does not consider these other factors and it assumes a linear relationship between the two variables.
2. Difficulting in assessing the level effort displayed, many variables interact + effectiveness can be proven implementing low effort strategies




**Data Analysis Plan**

Once the data is collected, the relationship between risk perception and past climate shocks variable and their adaptation strategies is planned to be analyzed using ANOVA:

- **Example Analysis:**
  - **Null Hypothesis ($H_0$):** There is no significant difference in adaptation strategy scores across the four groups.
  - **Alternative Hypothesis ($H_1$):** At least one group shows a significant difference.
  - **Test:** One-way ANOVA

**Example:**

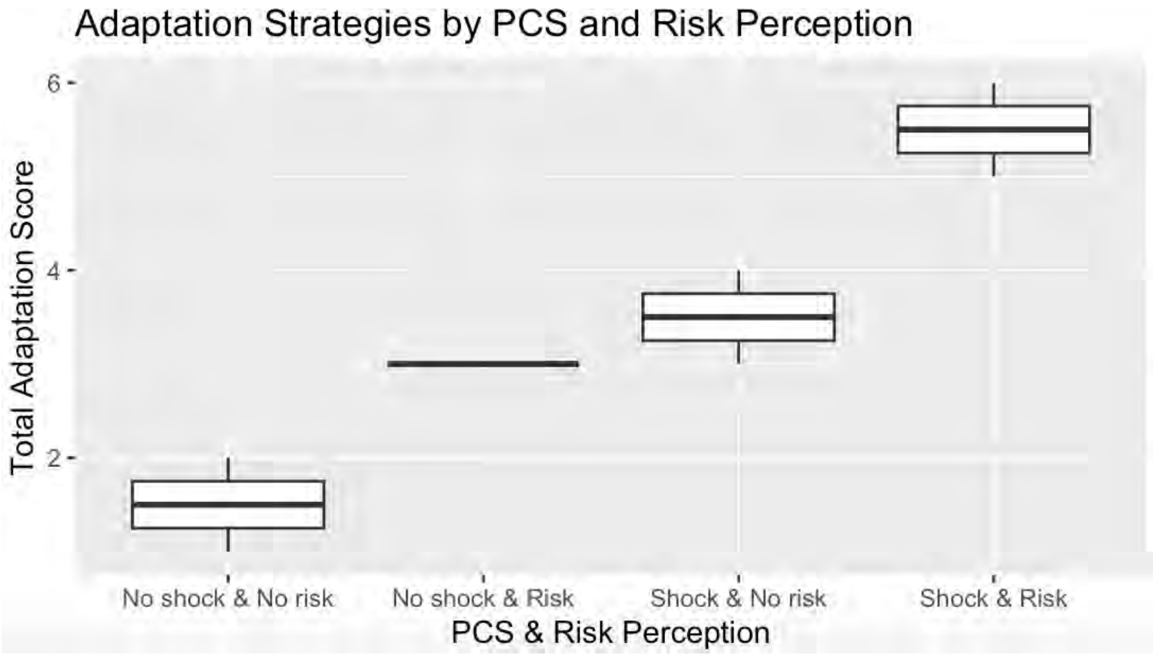
| farmer_id | past_shock | risk_perception | PCS_RP_combined | total_adaptation_score |
|---|---|---|---|---|
| 1 | Yes | Yes | Shock & Risk | 5 |
| 2 | No | Yes | No shock & Risk | 3 |
| 3 | Yes | No | Shock & No risk | 4 |
| 4 | No | No | No shock & No risk | 2 |
| 5 | Yes | Yes | Shock & Risk | 6 |
| 6 | No | Yes | No shock & Risk | 3 |
| 7 | Yes | No | Shock & No risk | 5 |
| 8 | No | No | No shock & No risk | 1 |

Build R script:

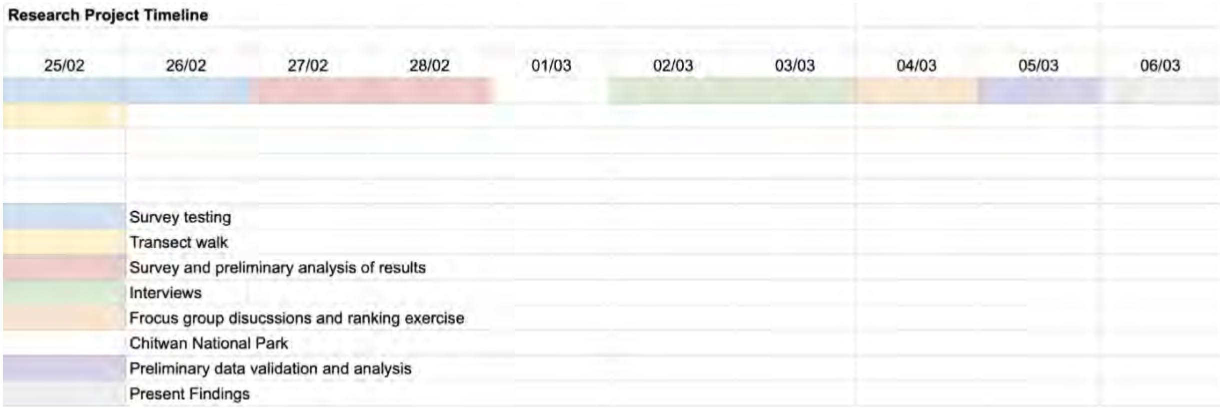
# Load necessary libraries library(ggplot2)

# Example dataset where adaptation score has been pre-calculated

```
farmers_data <- data.frame( farmer_id = c(1, 2, 3, 4, 5, 6, 7, 8),
past_shock = c("Yes", "No", "Yes", "No", "Yes", "No", "Yes", "No"),
risk_perception = c("Yes", "Yes", "No", "No", "Yes", "Yes", "No", "No"), PCS_RP_combined
= c("Shock & Risk", "No shock & Risk", "Shock & No risk", "No shock & No risk",
"Shock & Risk", "No shock & Risk", "Shock & No risk", "No shock & No
risk"),
total_adaptation_score = c(5, 3, 3, 2, 6, 3, 4, 1)
)
# Run the ANOVA to test for differences in adaptation scores across PCS-RP categories
anova_result <- aov(total_adaptation_score ~ PCS_RP_combined, data = farmers_data) # View
the ANOVA table
summary(anova_result)
# Visualize the results with a boxplot
ggplot(farmers_data, aes(x = PCS_RP_combined, y = total_adaptation_score)) +
geom_boxplot() +
labs(title = "Adaptation Strategies by PCS and Risk Perception", x = "PCS & Risk Perception",
y = "Total Adaptation Score")
```



**Time Plan**




| Date | Activities | Details | Estimated Time |
|---|---|---|---|
| **Feb 24 (Day 0)** | **Arrival & Initial Preparation** | - Travel to Magarkot, meet local contacts<br>- Finalize logistics (interpreters, permissions)<br>- Set up data storage and backup plan<br>- Initial exploration for sampling | Full day |
| **Feb 25 (Day 1)** | **Transect walk Survey Testing & Adjustments** | - Conduct 2–3 transect walks with key informants<br>- Observe climate-related impacts, take photos, GPS mapping<br>- Conduct initial test surveys with a small sample of farmers<br>- Identify potential issues with wording, clarity, or structure<br>- Collect feedback from participants and enumerators<br>- Revise survey as needed | 9:00 – 13:00 (4 hrs): Transect walk<br>14:00 – 16:00 (2 hrs): Test surveys<br>16:00 – 17:00 (1 hrs): Survey review & adjustments |

| | | | |
|---|---|---|---|
| **Feb 26 (Day 2)** | **Survey Testing & Finalization** | - Implement revised survey with another test group<br>- Final adjustments based on findings<br>- Finalize survey questions for full-scale implementation | 9:00 – 13:00 (4 hrs): Test surveys<br>14:00 – 17:00 (3 hrs): Final modifications |
| **Feb 27 (Day 3)** | **Survey on Perception & Experience of Climate Change (15 people)** | - Conduct first half of surveys | 9:00 – 13:00 (4 hrs): Surveys<br>14:00 – 17:00 (3 hrs): Data entry & review |
| **Feb 28 (Day 4)** | **Survey on Perception & Experience of Climate Change (15 people)** | - Complete remaining surveys (30 total)<br>- Verify data quality & address inconsistencies | 9:00 – 13:00 (4 hrs): Surveys<br>14:00 – 17:00 (3 hrs): Data entry & review |
| **March 1 (Day 5)** | **Chitwan National Park** | | |
| **March 2 (Day 6)** | **Semi-Structured Interviews + Photo Elicitation** | - Conduct first 10 interviews (purposeful/snowball sampling) | 9:00 – 13:00 (4 hrs): Interviews<br>14:00 – 17:00 (3 hrs): Transcription & coding |
| **March 3 (Day 7)** | **Semi-Structured Interviews + Photo Elicitation** | - Complete remaining interviews (10 total) | 9:00 – 13:00 (4 hrs): Interviews<br>14:00 – 17:00 (3 hrs): Transcription & coding |

| | | | |
|---|---|---|---|
| **March 4 (Day 8)** | **Focus Group Discussions + Ranking Exercise (6-10 people per group)** | - Identify adaptation strategies used by different groups<br>- Rank strategies based on effort, barriers & enablers | 9:00 – 12:30 (3.5 hrs): Focus group discussions<br>14:00 – 17:00 (3 hrs): Data coding & ranking analysis |
| **March 5 (Day 9)** | **Preliminary Data Validation + Analysis Start** | - Organize, transcribe, and code initial findings<br>- Share early insights within the research team | 9:00 – 12:30 (3.5 hrs): Internal review<br>14:00 – 17:00 (3 hrs): Data cleaning & initial analysis |
| **March 6 (Day 10)** | **Community Feedback Session** | - Present findings to the community<br>- Collect feedback, clarify results | 9:30 – 12:30 (3 hrs): Presentation<br>14:00 – 16:00 (2 hrs): Community discussion & adjustments |
| **March 7 (Day 11)** | **Departure & Final Data Backup** | - Thank participants, finalize notes, store data securely | Full day: Departure & final review |