Research report

PILOTING OF LOSS AND DAMAGE ASSESSMENT FRAMEWORK FOR FLOOD AND DROUGHT HAZARDS

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EXECUTIVE SUMMARY

Global climate change is increasingly impacting people and the planet, with effects observed at all levels. Local governments and communities are struggling to adapt to both extreme weather events and slow-onset changes. Given these escalating impacts, it is crucial to document their extent and explore potential measures for mitigation, adaptation, and risk reduction. In this context, this report on Loss and Damage (L&D) assessment presents findings on climate-induced hazards and their associated loss and damage in two municipalities in Nepal: Dullu and Gulariya.

According to the Consolidated Vulnerability and Risk Index of Urban Municipalities (2021), Dullu Municipality faces significant exposure to climate-induced hazards, including floods, landslides, and droughts which is the primary focus of this study. On the othe hand, Gulariya Municipality is comparatively at moderate risk and exhibits a higher capacity to adapt- but has a high recurrence and extensive loss and damage due to flood hazard.

The study employed a mixed-methods approach, incorporating five Focus Group Discussions (FGDs), eight Key Informant Interviews (KIIs), and household surveys conducted with 297 respondents in Dullu and 345 in Gulariya municipalities. Additionally, temperature and precipitation trends were analysed to assess drought and flood hazards in the respective municipalities. The Standardised Precipitation Index (SPI), with a focus on drought, provided a robust basis for understanding local climate hazards and their long-term impacts.

Temperature data from Dullu shows significant warming since the 1990s, particularly in minimum temperatures, which may contribute to increased evaporation and persistent water stress. Precipitation data from Dadimadi station highlights erratic rainfall patterns, characterised by severe droughts and occasional above-average rainfall. SPI calculations reveal frequent drought episodes between 2002 and 2007, with severe negative values in 2012, 2013, and 2014, indicating prolonged drought conditions that likely impacted agricultural productivity and water availability.

Over 99% of respondents in Dullu Municipality reported reduced agricultural productivity, while nearly 97% observed the drying up of local water sources. Key crops like maize and wheat have been severely affected, compelling farmers to adopt drought-resistant varieties or shift to alternative crops, often with limited success. Water scarcity has also led to significant non-economic losses, including health issues and emotional stress, particularly among women and children who spend long hours fetching water. Health concerns, such as waterborne diseases like diarrhoea, were reported by over 87% of respondents, underscoring the urgent need for improved access to clean water.

Households in Dullu reported cumulative losses averaging USD 10,706 in agricultural and livestock income over the past decade due to drought. On average, health-related recovery costs amounted to USD 412 per household. Additionally, households spent an average of USD 152 (with a maximum of USD 559) on livestock treatment to mitigate drought-related impacts. To access basic necessities during droughts, households incurred an average cost of USD 755.

When asked about relocation, 31% of respondents expressed a willingness to pay, with an average contribution of USD 755. Furthermore, if provided an opportunity to restore flood-damaged land, respondents indicated a willingness to pay up to USD 1,566.

Similar cases of L&D were reported in Gulariya, where the 2014 flooding incident resulted in an average economic loss of USD 10,132 per household. Agricultural income losses averaged USD 427, with a maximum of USD 7,450, while total income loss across all sources averaged USD 531. It is important to note that these valuations are influenced by some respondents living on public land without land ownership. Health-related recovery costs were comparatively lower, averaging USD 72 per household.

The report highlights the significant L&D caused by both slow-onset and rapid-onset climate-induced hazards in the two municipalities. To mitigate these impacts, the study recommends heavy investment in adaptation practices related to agriculture and risk reduction such as promoting climate-resilient crops, enhancing water resource management through conservation techniques, and incorporating locally led adaptation practices. Additionally, the report underscores the need for external support mechanisms, such as loss and damage funds or disaster relief funds at both national and international levels, to assist communities in addressing climate-induced losses and damages.

FOREWORD

The increasing effects of climate change, whether through slow or rapid-onset events, are being seen in the form of heat waves, floods, wildfires and droughts. These losses are often considered the most difficult to endure as they are potentially irreversible. These issues gained significance on L&D in international climate policy since the 1990s, as it became more prominent with growing evidence of climate change impacts. In 2021, Nepal formulated the National Framework for Loss and Damage, under the Ministry of Forests and Environment (MoFE), which tried to assess and address the impact of climate change.

DanChurchAid in Nepal (DCA Nepal) conducted a research study titled "Piloting Loss & Damage Assessment and Systems for Climate-induced Hazards" with its partners Social Service Centre (SOSEC), Kamaiya Mahila Jagaran Samaj (KMJS) and technical partner Youth Innovation Lab (YI-Lab) from March 2024 to December 2024.

The study focused on quantitative and qualitative assessments for L&D for extreme events (flood) and slow-onset events (drought) based on the national assessment framework developed by the Government of Nepal. The project aims to integrate Economic Loss and Damage (ELD) and develop a demonstration manual for Non-Economic Loss and Damage (NELD) into the government-owned Bipad Portal, while also co-designing a draft Standard Operating Procedures (SOP) for potential L&D compensation mechanisms at the local level for climate-induced hazards. We have received technical inputs from NDRRMA, MoFE, provincial government representatives- Karnali and Lumbini; and local government representatives from Dullu Municipality and Gulariya Municipality and other Technical Expert Committee members in three phases and have incorporated them.

This report compiles the methodology and results of the assessment for flood and drought hazard in Gulariya and Dullu Municipalities. The study has incorporated both qualitative and quantitative methodology to assess the losses and damages, based on the National assessment framework for climate-induced losses and damages.

I would like to thank Ms. Krity Shrestha, who coordinated this research study together with Ms. Abhilasha Rajbhandari. I would also like to thank our partners from Youth Innovation Lab- Mr. Pradip Khatiwada, Ms. Deepshikha Nepal, Mr. Sabin Dotel; from SOSEC Nepal- Mr. Basanta Shrestha, Mr. Madhav Bhattarai, Mr. Pushkar Sharma and from KMJS- Mr. Anupam Nyaupane; as well as other members of the technical support team- from CRR-Lab : Mr. Binod Parajuli, Ms. Preshika Banskota, Mr Jhalak Paudel and Ms. Somy Bhattarai. I would also like to thank our enumerators from KMJS Nepal and SOSEC Nepal. I would also like to thank the technical review team Mr. Bimal Ghimire, Mr. Lars Jacobsen, Ms. Sidsel Koordt Vognsen, Mr. Rigendra Khadka, Ms. Puspa Chad and Mr. Prabin Man Singh for their constructive suggestions and feedback.

I would like to thank Ms. Nirmala Limbu for her support in proofreading, designing, and finalising the publication. I would also like to thank the representatives from federal ministries- MoHA and MoFE, NDRRMA, and provincial and local governments for their feedback and input from inception to methodology finalisation and during the first draft sharing of this report. We have tried to incorporate their invaluable feedback and suggestions as much as possible. I would like to assure you that this pilot assessment research on loss and damage feedback from our partners and impacted climate-vulnerable communities as well as from the Technical Expert Committee members, will guide us in our future research and advocacy on loss and damage.

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ACRONYMS

°C	Degree Celsius
AOSIS	Alliance of Small Island States
COP	Conference of Parties
CVRI	Consolidated Vulnerability and Risk Index
ELD	Economic Loss and Damage
FGDs	Focus Group Discussions
GBV	Gender-based Violence
GHGs	Greenhouse Gases
IPCC	Intergovernmental Panel on Climate Change
KIIs	Key Informant Interviews
L&D	Loss and Damage
mm	Millimeter
MoFE	Ministry of Forest and Environment
NDRRMA	National Disaster Risk Reduction and Management Authority
NELD	Non-Economic Loss and Damage
NPR	Nepalese Rupees
RCP	Representative Concentration Pathway
SPI	Standardised Precipitation Index
SPSS	Statistical Package for Social Sciences
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WIM	Warsaw International Mechanism
WMO	World Meteorological Organization

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1 Introduction

1.1 Background

Climate change refers to prolonged changes in temperature and weather patterns, occurring naturally or as a result of human activities—primarily the burning of fossil fuels, such as coal, oil, and gas (UN, 2016). These changes have led to rising sea levels, melting glaciers, loss of ice sheets, and more severe weather phenomena, including the increased intensity and frequency of hurricanes, floods, heat waves, and droughts (UNDP, 2023).

In 2023, Asia experienced its second-highest mean temperature, 0.91°C above the 1991–2020 average, triggering severe heat events. These extreme temperatures contributed to over 79 hydrometeorological hazard events, resulting in more than 2,000 fatalities and impacting over 9 million people (WMO, 2024).

In Nepal, significant positive trends have been observed in annual and seasonal maximum temperatures. The annual maximum temperature is increasing at a rate of 0.056°C per year, while the annual minimum temperature also shows a positive trend of 0.002°C per year, though not statistically significant (DHM, 2017).

Human-induced climate change results from the accumulation of greenhouse gases (GHGs) emitted through energy use, land use, lifestyle choices, consumption patterns, and production activities. These changes are already driving more extreme weather events globally, negatively impacting food, water, health, economies, and society. Vulnerable communities, which contribute the least to climate change, are disproportionately affected (IPCC, 2023). The intensification of these extreme weather events underscores the urgent need for enhanced climate preparedness and disaster risk reduction strategies (WMO, 2024).

The United Nations Framework Convention on Climate Change (UNFCCC) defines the impacts of climate change as leading to L&D. Broadly, L&D refers to the actual or potential impacts of climate change that adversely affect human and natural systems. "Loss" denotes irreversible impacts where repair or restoration is impossible, while "damage" pertains to aspects that can be restored but at significant costs (DCA, 2021). Both slow-onset processes and extreme weather events can result in considerable losses and damage.

L&D is typically categorised into two main types: economic and non-economic. Economic L&D refers to income and physical assets, such as resources, goods, and services, that hold monetary value. Non-economic L&D includes goods and services that cannot be traded in the market, covering losses related to life, health, displacement, human mobility, territory, cultural heritage, indigenous and local knowledge, biodiversity, and ecosystem services (MoFE, 2021a; UNFCCC, 2020).

1.2 Loss and Damage in Nepal

In the context of Nepal, according to MoFE (2021a), L&D "represents the actual and/or potential negative manifestations of climate change in the sudden onset extreme events, such as heatwave and extreme rainfall and slow-onset events such as snow loss, droughts, glacial retreat to which people in Nepal's mountains, hills, and Terai are not able to cope with or adapt to as the country's natural ecosystem, infrastructure and institutions are overwhelmed, leading to the loss of lives and livelihoods, including losses of cultural heritage."

In Nepal, significant climate change-related disasters include floods, extreme temperature fluctuations, landslides, droughts, and Glacier Lake Outburst Floods (GLOFs) (Kapri, 2024). Rising atmospheric temperatures disrupt hydrological processes, leading to higher evaporation rates. This can result in either floods or droughts, depending on the specific geographic region (IPCC, 2023). Floods, which are rapid-onset events and droughts which are slow-onset events, pose major threats due to their frequency, the number of people affected, and their overall economic impact worldwide (Pizzorni et al., 2024; UNFCCC, 2020). As a mountainous country, Nepal is particularly vulnerable to slow-onset events like glacier retreat, snow loss, and drought, which place both high-altitude and downstream communities at risk (IPCC, 2023; MoFE, 2021b).

Between 1971 and 2019, an average of 647 people died annually in Nepal due to climate-induced disasters (MoFE, 2021a). Fourteen climatic hazards have been identified in the country, with floods on the rise while drought events are declining. However, localised drought occurrences may still increase in specific regions and districts (MoFE, 2021a). Drought is one of the most widespread disasters in Nepal, particularly impacting crops (MoFE, 2021b). According to data from Em-Dat, droughts affected the far western and midwestern regions—now Sudurpashchim Province and Karnali Province—between 2006 and 2009, due to reduced rainfall, impacting a population of 503,000 (0.5 million). Similarly, flood data from 2000 to July 2024 shows that 3,605,232 (3.6 million) people were affected by floods, resulting in approximately 3,080 fatalities.

The average annual economic loss in Nepal is NPR 2,778 million, which represents approximately 0.08 % of the total Gross Domestic Product (GDP) for the Fiscal Year 2018/19 (MoFE, 2021a). Over the past decade, floods and droughts have accounted for 80-90% of all natural hazards (WHO, 2024). By 2030, up to 700 million people may face displacement due to droughts, and water scarcity is expected to affect 40% of the global population (WHO, 2024). An assessment of L&D from the Melamchi Flood in two municipalities reported economic impacts of around USD 436 million for Melamchi Municipality and USD 62 million for Helambu Rural Municipality (Parajuli et al., 2023).

1.3 Loss and Damage (L&D) in Climate Discourse

The issue of L&D is a top priority for climate-vulnerable developing countries like Nepal, which are increasingly impacted by climate-induced disasters. The UNFCCC process has recognised loss and damage as a key component of climate negotiations. The concept was first introduced in 1991, spearheaded by the Alliance of Small Island States (AOSIS), highlighting the need for a risk transfer mechanism to address issues beyond adaptation and mitigation. L&D was formally recognised during COP16 in 2010, held in Cancun, where the issue was acknowledged for the first time. The establishment of the Warsaw International Mechanism (WIM) in 2013 further marked a significant milestone in enhancing the understanding of L&D and advancing the momentum for addressing these challenges.

The momentum was further solidified in 2015 with the recognition of L&D as a key climate agenda in the Paris Agreement. Article 8 of the agreement urges parties to "recognise the importance of averting, minimising, and addressing L&D associated with the adverse effects of climate change, including extreme weather events and slow-onset events, and the role of sustainable development in reducing the risk of L&D." This article underscores the importance of international cooperation and the urgency of addressing climate-induced L&D. The formal recognition within the Paris Agreement marked a significant step forward; however, the financing and implementation mechanisms are yet to be finalised.

After 2015, the establishment of the Santiago Network at COP25 in 2019 created a platform for facilitating technical discussions and providing assistance. The discussions continued at COP26 in Glasgow, which emphasised the need for increased financial support for L&D. A dedicated L&D fund was established during COP27 in 2022, and its operationalisation occurred at COP28 in Dubai. However, the decision at COP29 in Baku, Azerbaijan, which focused on a new quantified climate finance goal, represented a setback, particularly regarding L&D finance. Despite this, the Fund for Responding to L&D has been institutionalised, and efforts continue to strengthen the global L&D ecosystem.

Now that the fund is operational, there has been growing pressure for developed countries to commit substantial financial resources to address L&D. While institutional mechanisms such as the Warsaw International Mechanism (WIM) and the Santiago Network have been established, financing remains one of the key unresolved challenges in the UNFCCC process. Figure 1 illustrates the summarised international framework and timeline for incorporating L&D into COP discussions.

Figure 1: Key Milestones in Loss and Damage at UNFCCC COP Events

1.4 National Framework for Loss and Damage

Nepal developed the National Framework for L&D in 2021 under the Ministry of Forests and Environment (MoFE, 2021a) to assess and address the impacts of climate change. The framework outlines various vulnerability and risk assessment methodologies to enhance the understanding of community resilience to natural hazards. Another key objective of the framework is to establish a method for assessing L&D specific to Nepal's context and to strengthen the country's actions on L&D, including policy integration. This, in turn, supports the least developed countries in international collaboration, securing funding, and building a robust evidence base on L&D.

The framework includes both slow-onset and rapid-onset weather extremes, as well as the exposure and vulnerability to climate change risks. It assesses L&D from the perspectives of avoided, unavoided and unavoidable impacts. Additionally, the framework analyses the limits of adaptation, and the constraints associated with adaptation (Figure 2).

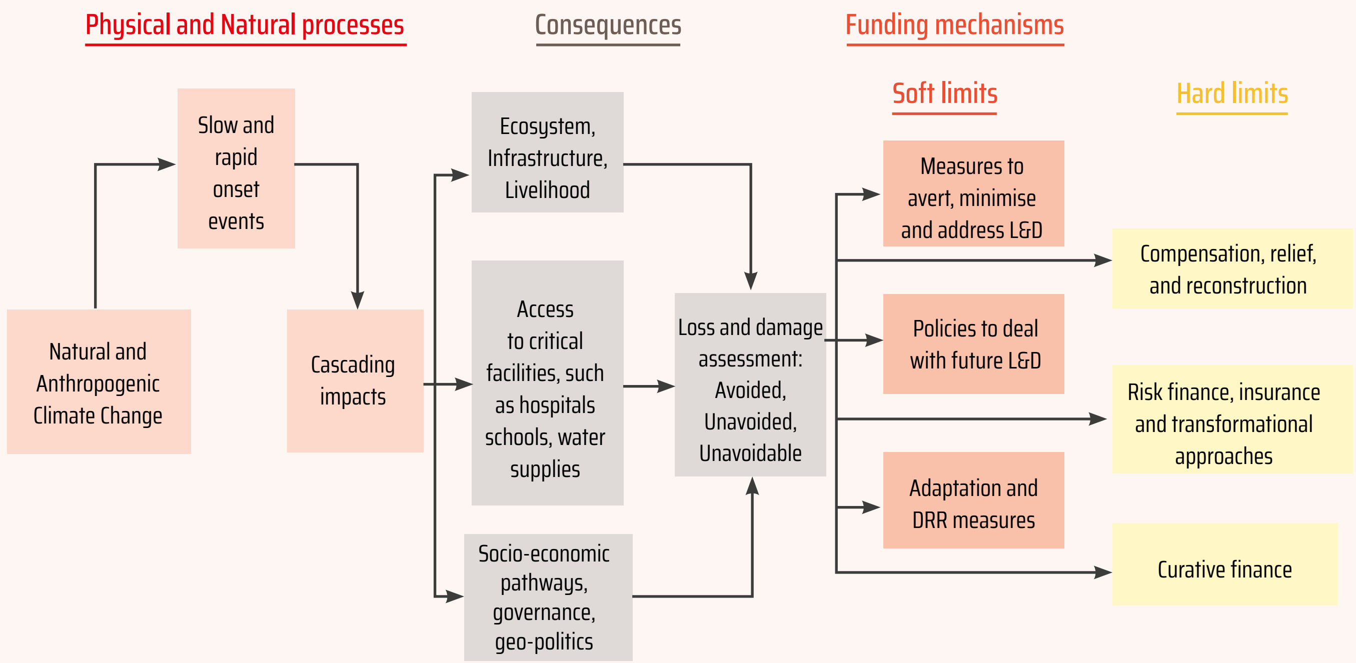


Figure 2: Framework established for assessing L&D caused by climate-induced hazards (Source: MoFE (2021a, Adopted by Parajuli et al. (2023))

To develop a mechanism for assessing L&D, six key steps are followed by the national framework, as listed below:

a. Identifying key indicators for extreme climate events
b. Identifying key indicators for exposure and vulnerability
c. Identifying indicators for Loss and Damage assessment
d. Data collection and analysis
e. Analysis of climate-induced hazards
f. Analysis of climate-informed multi-hazard risks

Despite being a pioneering document for contextualising the methodology to analyse L&D, Nepal's L&D framework lacks a clear and concise procedure, which hinders the country's ability to secure necessary financial support for climate recovery efforts. Additionally, there is a significant lack of clarity regarding future climate patterns and their localised impacts, further complicating the operationalisation of L&D strategies.

1.5 Flood and drought hazards in Gulariya and Dullu municipalities

Gurung et al. (2019) studied the water crisis in Nepal and found that many rural communities in the mid-hills face an unreliable water supply. The depletion of water resources disproportionately impacts women and girls, as they are primarily responsible for tasks such as fetching drinking water. The study also highlighted that low-income households bear a greater burden, coping with labour-intensive strategies like collecting water from distant sources, which is time-consuming and yields smaller amounts. In Dailekh District, where Dullu Municipality is located, Thapa, (2012) identified drought alongside food insecurity caused by prolonged dry spells, hailstorms, erratic rainfall, and an increase in crop-damaging insect pests. As a result, 90.5% of households experienced food shortages. Additionally, the absence of frost during winter has negatively affected orange trees, reducing their ability to produce high-quality fruit and leading to a decline in production.

Ghimire et al. (2020) assessed drought intensity in Dailekh District using the Standardised Precipitation Index (SPI). The study found that Dailekh experiences both winter and summer droughts, with winter droughts being more severe. In 2007, a significant reduction in barley yield was recorded, despite the year not being officially classified as a drought year. Winter droughts particularly impacted barley production, while summer droughts affected millet production. Regarding citrus crops, drought and elevated temperatures during the fruit-drop season cause significant fruit drops and reduced yields. High temperatures during the maturation phase also delayed the onset of colour change in the fruit, while excessive heat and drought led to increased fruit splitting and creasing, further lowering the yield (Sato, 2015).

Gulariya, located in Nepal's Western Terai region, is highly vulnerable to recurring floods, particularly during the monsoon season. These floods are primarily caused by heavy rainfall, which is further intensified by deforestation, unregulated urban development, and the region's naturally low-lying geography. Climate change has worsened the situation, contributing to increased rainfall intensity and rising river levels linked to Himalayan glacier melt. The recurrent flooding in Gulariya, situated in the Bardiya District, is primarily driven by the Karnali River. Additionally, smaller tributaries in the region, including the Babai River, also contribute to flooding in certain areas of Gulariya.

1.6 Objectives

The aim of this study is to assess the L&D caused by floods and droughts in Gulariya and Dullu municipalities, respectively, and to determine the needs and funding requirements for locally led actions to address these losses. The specific objectives are:

- Identify the economic L&D incurred by communities impacted by floods and droughts.
- Identify the non-economic L&D incurred by communities impacted by floods and droughts.
- Quantify the economic L&D.
- Build evidence to advocate for funding needs for L&D, with a focus on integrating these needs into national and international financing mechanisms.

2 Methodology

2.1 Study area

The Consolidated Vulnerability and Risk Index (CVRI) for Dullu Municipality, as outlined in the Vulnerability and Risk Assessment and Identifying Adaptation Options: Summary for Policy Makers report, assesses the municipality's exposure, sensitivity, and adaptive capacity in relation to climate change and associated risks. Dullu is highly exposed to climate-induced hazards, including floods, landslides, and droughts (the primary focus of this study). Key economic sectors, such as agriculture, are highly climate-dependent, heightening vulnerability to variability and extreme events. The municipality's high sensitivity value of 0.836 indicates significant susceptibility, largely due to socio-economic factors such as heavy reliance on agriculture and limited resources. The vulnerability score of 0.884 suggests that Dullu faces substantial challenges due to its high sensitivity and low adaptive capacity.

In comparison to Dullu, the CVRI of Gulariya Municipality, where this study piloted the L&D assessment framework for flood hazards, shows moderate exposure, sensitivity, and vulnerability. This indicates that Gulariya has a relatively higher adaptive capacity and resilience compared to Dullu. Although flood events have been recurring in the area over recent years, this study focused on the 2014 flood to assess NELD over a 10-year period. However, it is worth noting that Gulariya has experienced two major flood events since then. Both municipalities are at increased risk under the RCP 4.5 and RCP 8.5 scenarios.

Gulariya Municipality in Bardiya District and Dullu Municipality in Dailekh District were selected as study areas for assessing L&D due to their vulnerability scenarios. Figure 3 presents the location map of the selected municipalities.

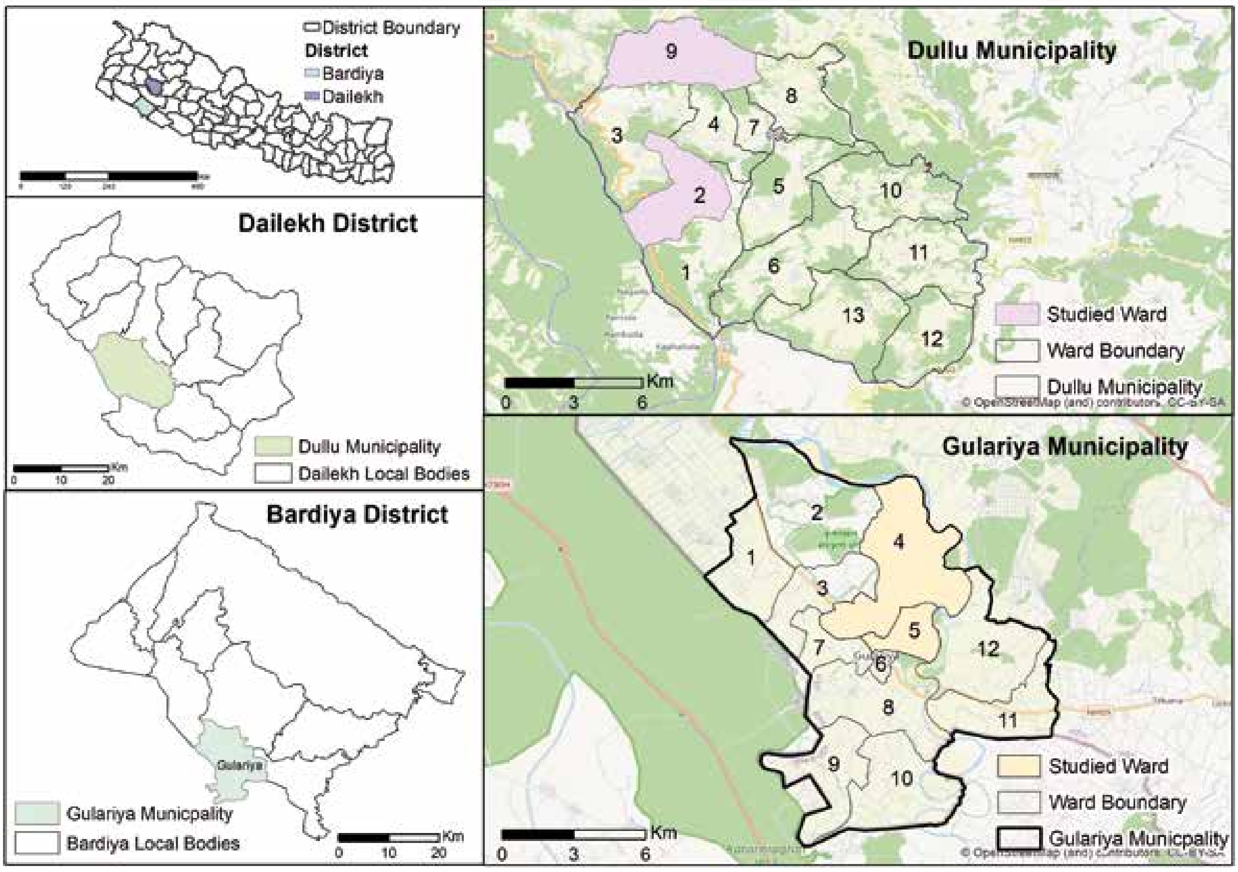


Figure 3: Map showing Piloting municipalities for Loss and Damage Assessment

Bardiya District is located in the western part of Nepal, covering an area of 2,025 sq. km. It is bordered by Banke District to the east, Surkhet to the north, and Kailali to the west. The altitude ranges from 138 m to 1,279 m. The district experiences an annual maximum temperature of 30.1ºC and a minimum temperature of 17.9ºC, with an average annual rainfall of 1,466.3 mm (DHM, 2021). Gulariya Municipality, the headquarter of Bardiya District, is situated in the, plains of the Terai region, near the southern border with Bahraich District, Uttar Pradesh, India. It is 35 kilometers west of Nepalgunj, about 10 km south of Murtiha Transit or railway station, India, and spans an area of 118.21 sq. km. Gulariya lies at an elevation of 187 m above sea level. The demographic details of Gulariya Municipality are provided in Table 1. Gulariya Municipality faces significant challenges due to annual flooding, which causes devastating impacts on both the community and the local economy.

Dailekh District is located in the western mid-hill region of Nepal, covering an area of 1,502 sq. km. It is bordered by Surkhet to the south, Achham to the west, Jajarkot to the east, and Kalikot to the north. The altitude ranges from 544 m to 4,168 m. Dailekh experiences a humid subtropical climate with dry winters. The district's average annual temperature is 16.4ºC, and it receives an average annual rainfall of 1,219.3 mm (DHM, 2021). Dullu Municipality, situated in the southern part of Dailekh District, covers an area of 156.77 sq. km and borders the Surkhet and Achham districts. The Municipality's elevation ranges from 544 m to 1,236 m. The demographic details of Dullu Municipality are provided in Table 1. Drought, extreme weather events, and shifting pest and disease patterns are some of the climate impacts affecting the community and local economy. Similarly, the Vulnerability and Risk Assessment report from MoFE (2021b) presents the climate risk index for both municipalities (Table 2).

Table 1: Population and Household status of selected municipalities (NSO, 2021)

SN	Municipality	Total Population	Male	Female	Number of Household
1	Dullu	39,143	18,105	21,038	9,053
2	Gulariya	74,505	36,727	37,778	16,002

Table 2: Vulnerability and Risk Assessment Score for Dullu and Gulariya Municipality (MoFE, (2021b))

SN	Municipality	Exposure	Sensitivity	Adaptive Capacity	Vulnerability	Risk
1	Dullu	0.221	0.836	0.335	0.884	0.2
2	Gulariya	0.262	0.521	0.335	0.884	0.161

2.2 Methodological approach

A mixed method approach was adopted, including qualitative and quantitative data collection and analysis through primary and secondary sources, to identify and address the local context of climate change and L&D issues. This approach provides an in-depth understanding of challenges and opportunities in undertaking L&D assessment at the local level, incorporating facts and data from the perspectives of communities and households. The methodological flowchart below illustrates the detailed process (Figure 4).

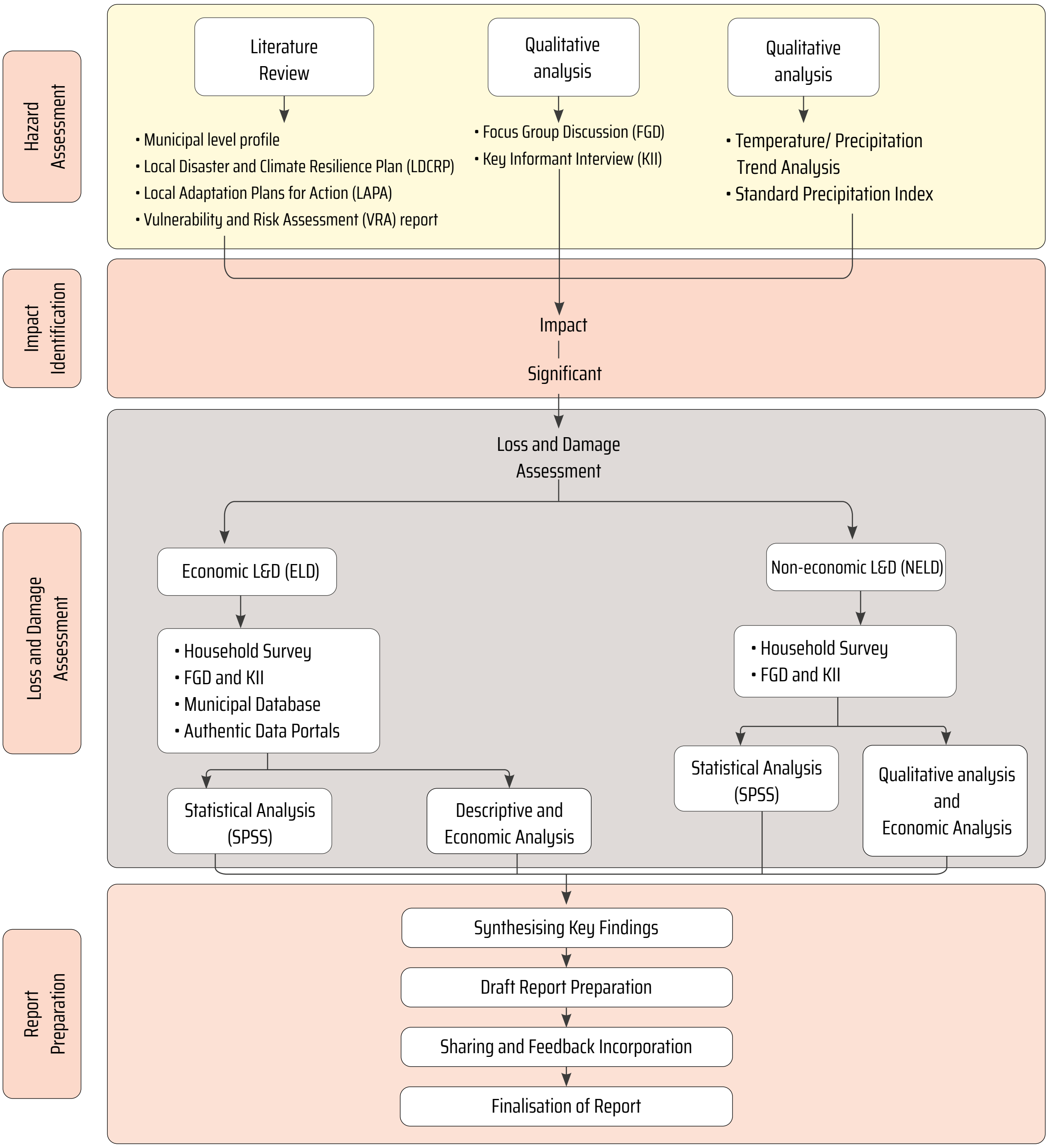


Figure 4: Methodological flow

The methodological flowchart outlines the process of collecting relevant information from various sources, including published literature, municipality profiles, policies, community discussions, and climate trend analyses. The data gathered were used to assess hazards and their impacts. Hazards with significant impacts were further analysed to determine both economic and non-economic losses. This study employed qualitative methods such as interviews and FGDs, as well as quantitative methods to calculate and analyse economic losses. Additionally, local and international organisations working on flood and drought-related hazards in both municipalities were identified to gather further information on the impacts. The detailed process is outlined below.

1. Hazard Assessment

The first step involved assessing the flood hazard in Gulariya Municipality and the drought hazard in Dullu Municipality. A literature review was conducted to understand the hazard landscapes of the municipalities, including key documents such as the Disaster Risk Reduction Plan (DPRP), Local Adaptation Plans of Action (LAPA), Vulnerability and Risk Assessment (VRA), and municipality profiles.

In addition, FGDs and KIIs were held to collect qualitative data on the incidents and impacts of floods and droughts. These discussions provided insights into local perceptions, experiences, and vulnerabilities related to these climate hazards.

To identify trends and patterns, rainfall and temperature data from two stations (one in Gulariya and one in Dullu) were analysed. The seasonal rainfall data, along with minimum and maximum temperatures, were examined using data from the Department of Hydrology and Meteorology (DHM). Furthermore, the Standardised Precipitation Index (SPI) was calculated using the SPI generator tool, applying a 3-month average. The main goal of this SPI analysis was to identify any extended periods of drought.

2. Impact Identification

The data and information from the hazard assessment were further used to analyse the impacts. The hazard incidents with significant impacts were selected as case studies for conducting L&D assessments in the respective areas. The drought event in Dullu Municipality was chosen based on recorded incidents and compared with desk-based calculations, recognising drought as a slow-onset hazard.

For the flood assessment in Gulariya Municipality, the 2014 flood disaster was selected, as it was the most devastating event in the past decade. This event was chosen to provide a 10-year timeframe for evaluating long-term NELD impacts. However, it is important to note that NELD may be cumulative, as other flood events have occurred in the area since the 2014 disaster.

While a small amount of relief was provided after the floods, a comprehensive L&D assessment has not been conducted. The municipality did undertake an assessment, but various challenges hindered the compensation process, and it remains incomplete.

3. Loss and Damage Assessment

L&D assessment involves quantifying the economic loss and identifying the economic and non-economic impacts of flood and drought in respective municipalities.

a. Economic Loss and Damage Assessment: ELD involves assessing the L&D of assets, income, agricultural lands and crops, tourism income, and other economic factors. Quantitative data on losses were collected through household surveys, as well as secondary sources such as municipal databases and reliable data portals (e.g., Bipad Portal/DRR Portal). The data collected was then analysed using statistical tools to quantify the ELDs. Additionally, the data was cross verified through KIIs and FGDs to establish connections with NELDs.

b. Non-economic L&D Assessment: NELD was assessed using qualitative data on impacts in key non-economic sectors such as health, mobility, education, culture, ecosystem, and community well-being. The qualitative data were analysed to identify key themes and issues related to non-economic losses. Narratives and stories collected from the community will provide in-depth insights into the impacts of climate change and associated L&D, as well as the coping strategies employed. The analysis followed the methodology outlined by Bharadwaj et al. (2024). Annexes I and II include the checklists for FGDs and household surveys used for the L&D assessment.

2.3 Data Collection and Analysis

Data collection was conducted after a comprehensive literature review, municipal consultations, KIIs, and FGDs.

- **Analysis of Climate Data**

  Climate trend analysis was conducted using precipitation and temperature data to assess their role in exacerbating or triggering specific flood and drought events. This analysis helps identify current and historical hazard patterns, while also providing insights into potential future risks.

- **Focus Group Discussions (FGD)**

  Five FGDs were held, including three in Dullu and two in Gulariya Municipality, with an average of 10 participants per session. These groups consisted of community leaders and members affected by floods and droughts. Each discussion lasted approximately 80 to 90 minutes, focusing on gathering collaborative insights into the socio-economic impacts of these events.

- **Key Informant Interview (KII)**

  In addition, KIIs were conducted with selected individuals possessing expert knowledge and experience regarding floods and droughts. Four KIIs were carried out in each municipality, with informants including officers from the municipal consultation and agriculture divisions.

- **Household Survey**

  The household surveys were conducted with a 95% confidence level and a 5% margin of error. A purposive random sampling method was employed (Patton, 2002), where households were selected based on their perceived relevance and representativeness for the study. Ten enumerators received training to conduct the surveys. Efforts were made to ensure diversity and inclusivity by including vulnerable groups such as women, indigenous communities, and various ethnic groups.

The selection of wards for the household surveys and FGDs was based on KIIs with local stakeholders and municipality authorities. These stakeholders were asked to identify the two major wards most affected by the particular hazards. Based on their responses, the wards for the survey were selected.

The survey was administered using the *Tathyanka* Toolbox on Android devices, with data analysis conducted through Microsoft Excel and SPSS. The survey gathered insights into both ELD and NELD experienced by households, as well as government interventions addressing these impacts. It also identified the immediate and long-term priorities and needs of the affected families.

The following formula by Arkin and Colton (1963), was applied to determine the appropriate sample size:

$$n = \frac{NZ^2 * p * (1-p)}{Nd^2 + Z^2 * p(1-p)}$$

Where:
(n) is the sample size
(N) is the population size
(Z) is the Z-score (which corresponds to the desired confidence level)
(p) is the estimated proportion of an attribute present in the population
(d) is the margin of error
The sample size for the study was calculated as follows (Table 3):

Table 3: Number of Sampling Size

Municipality	Wards	Total Households	Sampling Size
Dullu	2	1,303	297
	9		
Gulariya	4	3,310	345
	5		

Tables 4, 5, and 6 provide the data collection tools and their methods of analysis. They include the indicators for hazard assessment and L&D assessment, followed by the data sources, analysis methods, and tools used.

Table 4: Tools and methods for hazard analysis

SN	Hazard	Indicators	Source	Method
1	Drought	• Precipitation • Temperature	DHM	Standard Precipitation Index (SPI) Trend Analysis
2	Flood	• Precipitation • Temperature	DHM	Trend Analysis

Table 5: Tools and methods for data collection and analysis for economic loss and damage

Indicators	Data source	Analysis method	Remarks
Drought			
Agriculture Productivity	Household survey	Descriptive Statistics in SPSS and Economic Analysis	Acquired market value for agricultural products from the municipality's respective agriculture department or agriculture information centre.
	Municipal Database	Economic Analysis	Reference from municipal records (pinpoint the particular year of lowest production for any specific crops, if any)
	FGD	Triangulation and validation	
Livestock	Household Survey	Descriptive Statistics in SPSS and Economic Analysis	Data and costs were acquired from the livestock department of the respective municipality.
	Municipal Database	Economic Analysis	
	FGD	Triangulation and validation	
Tourism	Household Survey	Descriptive Statistics in SPSS and economic analysis	Changes in the revenue identified.
	FGD	Triangulation and validation	
Employment activities	Household Survey	Descriptive Statistics in SPSS	Job losses, changes in working hours
	FGD	Content and thematic analysis	
Flood			
Household and Infrastructure	Household Survey	Descriptive Statistics in SPSS Economic Valuation	The market value for land and house construction cost per square foot is analysed for house valuation. The number and extent of infrastructures damaged and their valuation acquired from the municipality.
	Municipal Database	Economic Valuation	
	KII	Triangulation and validation	
	FGD	Triangulation and validation	

Agriculture	Household Survey	Descriptive Statistics in SPSS Economic Valuation	Acquired market value for agricultural products from the municipality's respective agriculture department or agriculture information centre
	Municipal Database	Economic Valuation	Reference from municipal records
	FGD	Triangulation and validation,	
Livestock	Household Survey	Descriptive Statistics in SPSS Economic Valuation	Data and costs are acquired from the livestock department of the respective municipality.
	Municipal Database	Economic Valuation	
	FGD	Triangulation and validation,	
Employment activities	Household Survey	Descriptive Statistics in SPSS Economic Analysis	Job losses, changes in working hours
	FGD	Triangulation and validation,	
Tourism	Household Survey	Descriptive Statistics in SPSS and economic analysis	Changes in the revenue
	KII	Content and thematic analysis	
	FGD	Triangulation and validation,	

Table 6: Tools and methods for data collection and analysis for non-economic loss and damage for both flood and drought

Loss and damage indicators	Data source	Analysis Methods	Remarks
Human well-being and lifestyle	Household Survey	Qualitative analysis and Economic valuation (averting behaviour method)	Cost valuation for health recovery for human as well as livestock
	FGD		
Access to basic needs and services	Household Survey	Qualitative analysis and Economic valuation (averting behaviour method)	Cost valuation for access, Monetising time value into income lost
	FGD		
	KII		

<table>
<tr><td rowspan="3">Cultural practices</td><td>Household Survey</td><td rowspan="3">Qualitative analysis</td><td rowspan="3"></td></tr>
<tr><td>FGD</td></tr>
<tr><td>KII</td></tr>
<tr><td rowspan="2">Social cohesion</td><td>Household Survey</td><td rowspan="2">Qualitative analysis</td><td rowspan="2"></td></tr>
<tr><td>FGD</td></tr>
<tr><td rowspan="2">Environment</td><td>Household Survey</td><td>Qualitative analysis, Economic valuation (Contingent Valuation Method)</td><td rowspan="2">Valuation of plant species having significant value</td></tr>
<tr><td>FGD</td><td>Triangulation and validation,</td></tr>
<tr><td rowspan="3">Migration</td><td>Household Survey</td><td>Qualitative analysis and Economic valuation (Contingent Valuation, Averting Behaviour Method)</td><td rowspan="3">Relocation valuation</td></tr>
<tr><td>FGD</td><td rowspan="2">Triangulation and validation,</td></tr>
<tr><td>Municipal Database</td></tr>
</table>

2.4 Limitations

The assessment of flood-related L&D, in this research focused on the 2014 flooding incident in Gulariya Municipality. This reliance on retrospective incidents may introduce potential inconsistencies, as community memories may have faded, making it challenging to document the full extent of the impacts.

Additionally, the SPI calculation for drought utilised 24 years of precipitation data, though standard practice recommends at least 50 years for improved reliability. This limitation introduces uncertainties in the analysis of drought conditions in Dullu Municipality. The drought analysis also did not incorporate data on ground-sensed soil quality, type, and moisture content, limiting a comprehensive understanding of its impacts on agriculture and the environment.

The study's limited timeframe restricted the depth and extent of data collection and analysis. Moreover, the municipalities do not consistently maintain comprehensive records of L&D, necessitating reliance on community-level data and secondary sources, which may introduce disparities and limit cross-verification.

While cumulative impacts of drought and flood hazards were considered, the study may have underrepresented long-term and interlinked socio-economic effects due to limited long-term data. Furthermore, although non-economic impacts like psychological stress and disruptions to cultural practices were documented, the full spectrum of these indirect impacts may not have been comprehensively captured due to methodological constraints.

3 Findings and discussion

3.1 Dullu Municipality- Drought Hazard

3.1.1 Climate Trend Analysis

Table 7 presents the projected changes in temperature (°C) and precipitation (mm) for Dailekh district relative to a reference period (1981–2010). The data covers two Representative Concentration Pathways (RCPs), RCP 4.5 and RCP 8.5, over two future time periods: 2016–2045 and 2036–2065. The projections indicate a gradual increase in both temperature and precipitation across all scenarios. Notably, RCP 8.5 shows a more substantial increase in temperature and precipitation compared to RCP 4.5. While precipitation under RCP 4.5 is projected to slightly decrease during the 2016–2045 period, it is expected to rise significantly by 2036–2065.

Table 7: Change in Temperature (°C) and Precipitation (mm) for Dailekh district of Nepal from the reference period (1981-2010) (MoFE, 2019)

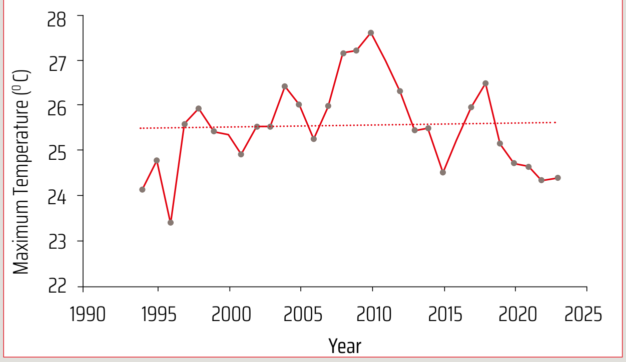
SN	Reference Period	RCP 4.5		RCP 8.5	
		2016-2045	2036-2065	2016-2045	2036-2065
Temperature	15	0.96	1.38	1.1	1.85
Precipitation	1532	-0.11	7.33	6.37	13.31

A trend analysis was conducted for temperature and precipitation patterns in Dailekh. Temperature data from the Dailekh station were analysed for maximum and minimum temperature trends, while rainfall data from the Dadimadi station were used to assess precipitation trends. The SPI was calculated using rainfall data from Dadimadi station to evaluate drought conditions. Seasonal temperature data from 1994 to 2023 were analysed to explore potential correlations with drought events, while monthly rainfall data from 2000 to 2023 were used to calculate the SPI.

A. Annual Temperature Trend

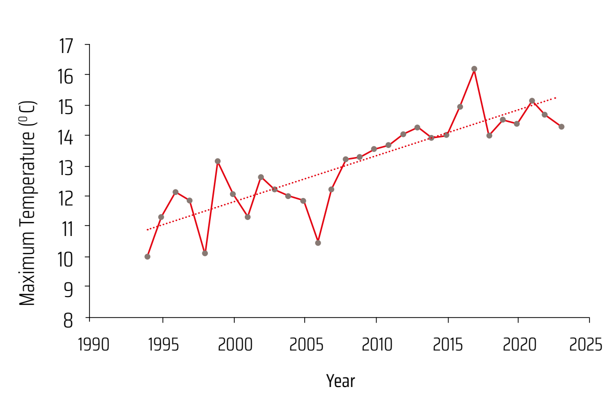
Figure 5 shows the annual maximum temperature at Dailekh station from 1994 to 2023. Significant fluctuations are evident, with the highest peak in 2010 and the lowest in 1994, along with variations in other years. The trend line indicates a slight increase in temperature over time, although no significant overall trend is observed. Therefore, the maximum temperature trend does not suggest a direct implication for drought.

Figure 5: Annual Maximum Temperature of Dailekh Station



However, the annual average minimum temperature at Dailekh station from 1994 to 2023 shows a significant increasing trend (Figure 6). A noticeable rise in minimum temperature has been observed since 2007, with the highest peak in 2017. This significant increase could have important implications for drought hazards, including reduced night-time cooling, which may worsen water stress, increase evaporation, and potentially intensify drought conditions, leading to more frequent droughts.

Figure 6: Annual Minimum Temperature of Dailekh Station

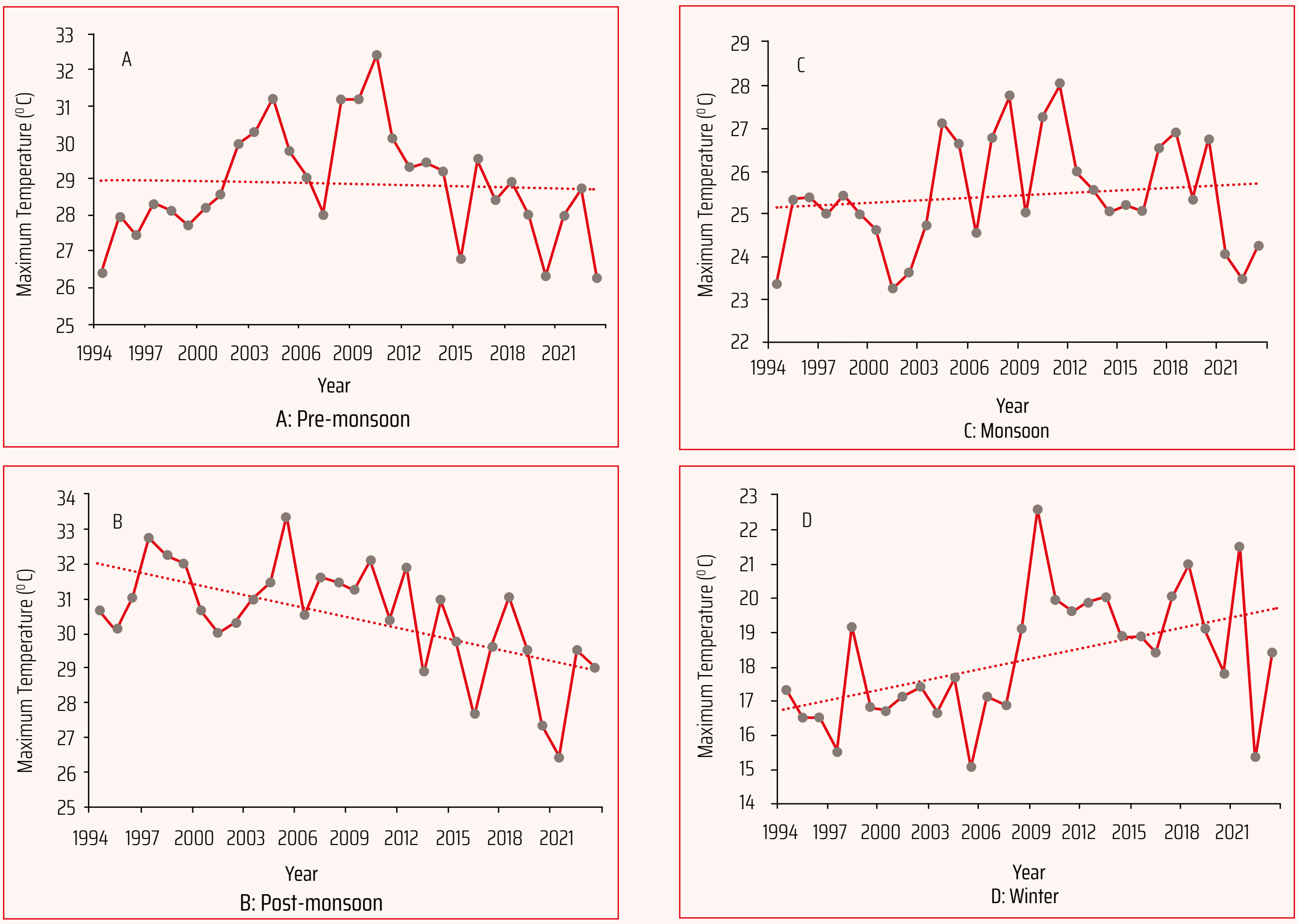


B. Seasonal Temperature Trend

The seasonal trend for both maximum and minimum temperatures was analysed from 1994 to 2023. The analysis was divided into the following seasons: Winter (December, January, and February), Pre-monsoon (March, April, and May), Monsoon (June, July, and August), and Post-monsoon (September, October, and November).

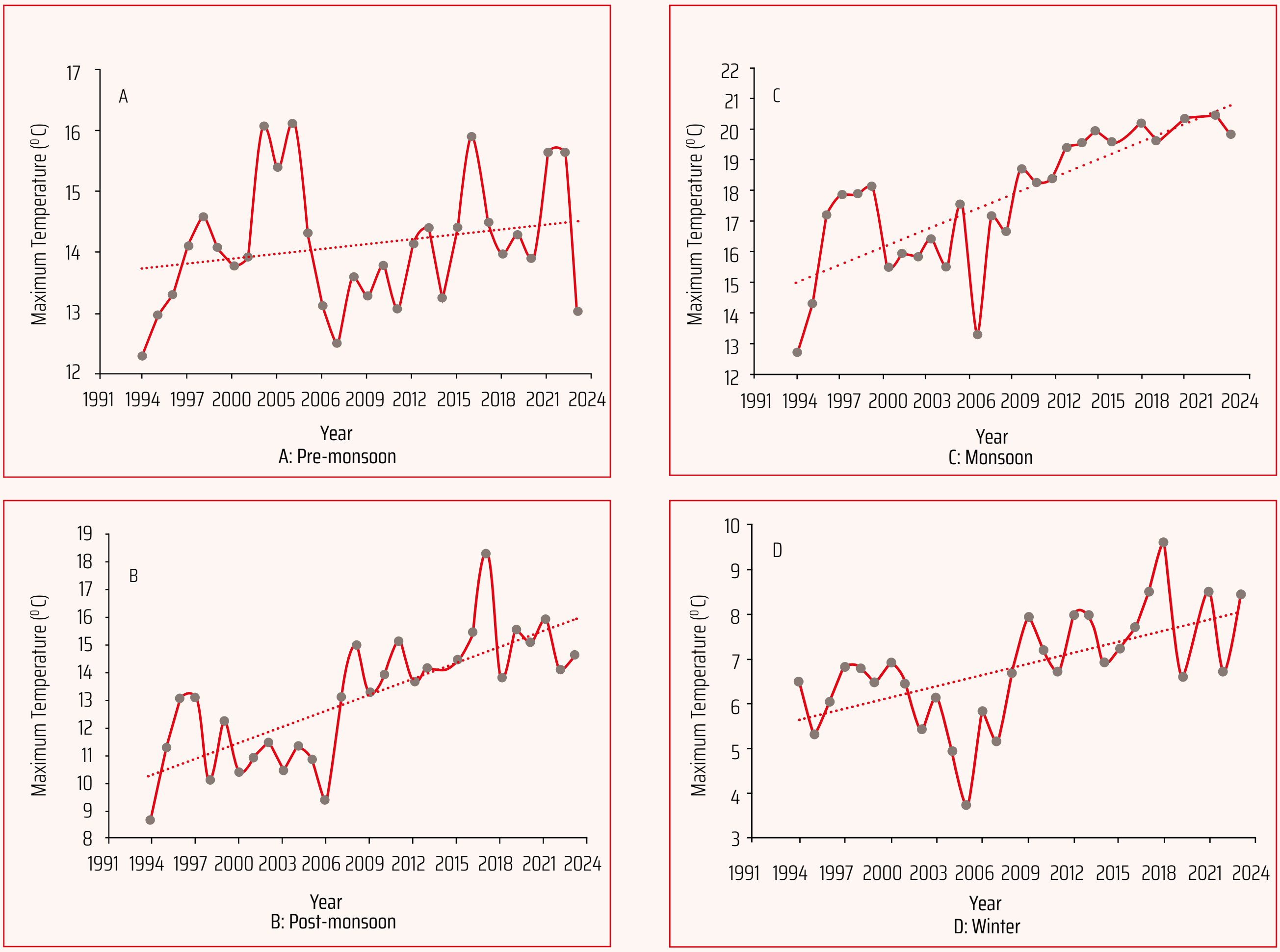
The seasonal average maximum temperature trends at Dailekh station from 1994 to 2023 showed significant fluctuations across all seasons. In winter, temperatures peaked in 2010 and showed a significant upward trend. The pre-monsoon season also peaked in 2010, but with a minimal decrease over time, though this trend was not statistically significant. The monsoon season experienced a slight upward trend. The post-monsoon temperatures peaked in 2011, showing a minimal increase over time. Overall, while temperature variations across seasons exhibit fluctuations, clear long-term trends are not strongly evident (Figure 7).

Figure 7: Seasonal maximum temperature trend from 1994-2023 for Dailekh Station



The seasonal minimum temperature trends at Dailekh station show significant fluctuations across all seasons. Winter temperatures exhibited a moderate increasing trend, with the highest temperature recorded in 2019 and the lowest in 2005, although this trend was only moderately substantial. Pre-monsoon temperatures peaked in 2004, with minimal long-term increase, with variations likely due to other influencing factors. Both the monsoon and post-monsoon seasons showed statistically significant growth, with peaks in 2022 for the monsoon season and in 2017 for the post-monsoon. This rising trend, particularly in the monsoon and post-monsoon periods, could exacerbate drought conditions by reducing night-time cooling, increasing evaporation, and worsening water stress (Figure 8).

Figure 8: Seasonal minimum temperature trend from 1994-2023 for Dailekh Station



C. Rainfall Trend

Figure 9 shows the annual rainfall at Dadimadi Station, Dailekh, from 2000 to 2023. The trend suggests a minimal increase in rainfall over time, with significant rainfall fluctuations observed. The highest rainfall peak was recorded in 2022 and the lowest in 2012, with smaller variations in other years.

Figure 9: Annual Rainfall of Dadimadi Station Dailekh

D. Drought Index

The SPI was calculated using precipitation data from 2000 to 2023 for the Dadimadi station in Dailekh. The SPI values for each month (January to December) over these years were plotted, with positive values indicating wet conditions (higher-than-average rainfall), and negative values indicating dry conditions or drought (lower-than-average rainfall). Higher positive values correlate with a decreased likelihood of drought, while lower negative values indicate the severity of drought conditions.

Figure 10 illustrates the monthly SPI for Dadimadi Station from 2000 to 2023. The figure reveals frequent positive SPI values in 2020 and 2022, indicating wetter conditions during these years. On the other hand, years like 2002, 2005, 2012, 2013, and 2014 show negative SPI values, suggesting drier conditions and potential drought episodes. Bars below -2 represent severe drought conditions, while values below -3 indicate extreme drought. The period from 2020 to 2023 shows a recovery from drier years, with more frequent positive SPI values suggesting wetter years.

Figure 10: Monthly SPI of Dadimadi Station from 2000 to 2023

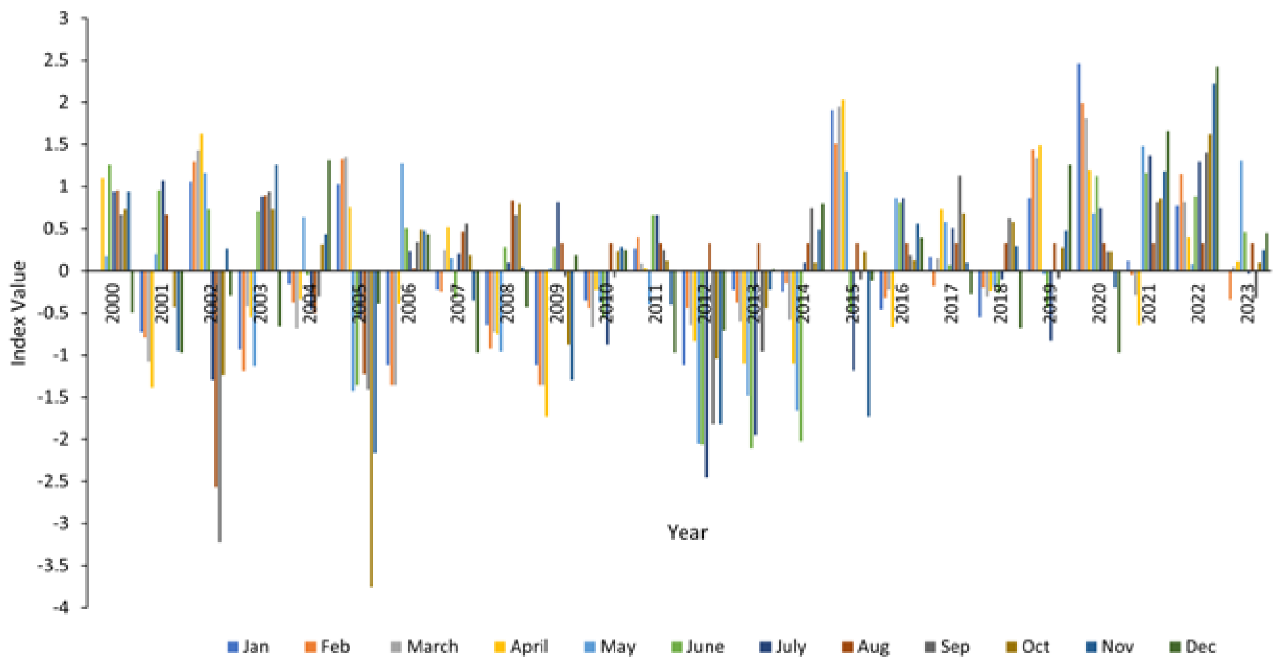


Figure 11 shows a bar chart of the SPI for the winter months—January, February, and December, spanning from 2000 to 2023. The chart indicates that the early 2000s (2000-2006) generally experienced wet conditions in all three winter months, with positive SPI values suggesting higher-than-average rainfall. However, from 2007 to 2014, a drying trend emerged, with more frequent negative SPI values, signaling periods of drought during winter. In recent years, the SPI values have become more positive, suggesting a shift toward wetter conditions during the winter months.

Figure 11: Winter Season SPI of Dadimadi Station from 2000 to 2023

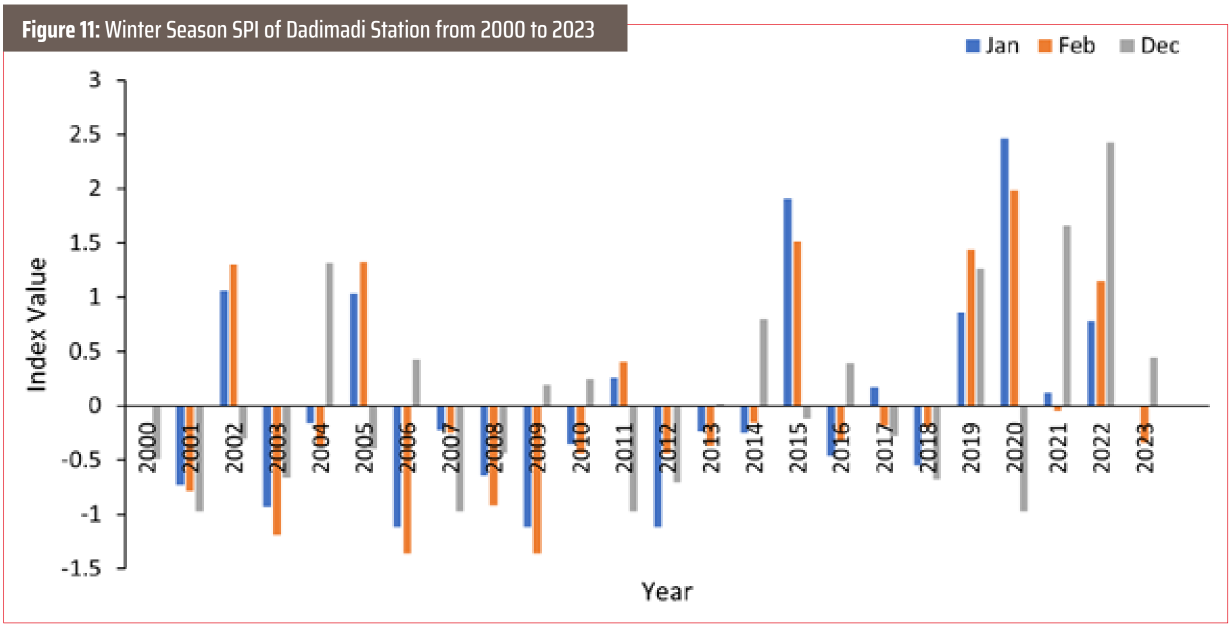


Figure 12 presents a bar chart of the SPI for the pre-monsoon months—March, April, and May—from 2000 to 2023. The chart illustrates that the early 2000s (2000-2006) were characterised by wet conditions, with predominantly positive SPI values across these months, indicating above-average rainfall during the pre-monsoon period. From 2007 to 2015, a drying trend emerged, marked by more frequent negative SPI values, suggesting drought conditions or below-average rainfall during the pre-monsoon period, particularly in March and May. In recent years, there has been a recovery, with more positive SPI values, signalling a shift toward wetter conditions in the pre-monsoon months. This recovery is especially noticeable in April and May in 2021 and 2022. March shows some wetter years but remains more variable compared to the other two months.

Figure 12: Pre-monsoon Season SPI of Dadimadi Station from 2000 to 2023

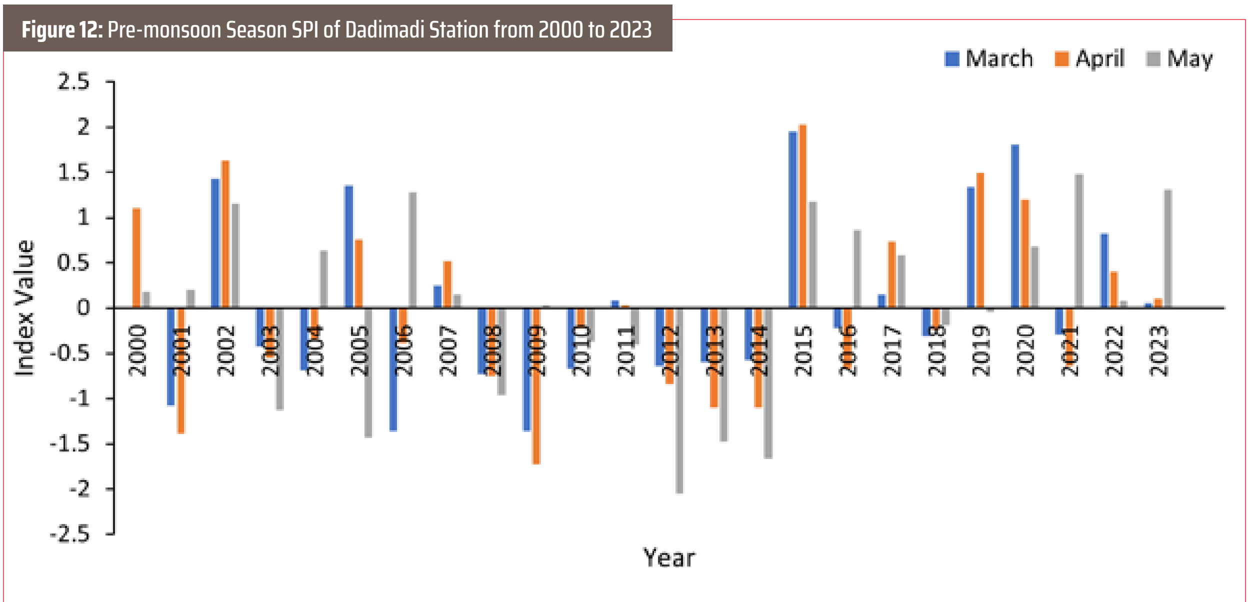


Figure 13 shows a chart of the SPI for the monsoon months—June, July, and August—from 2000 to 2023. The chart shows that the early 2000s (2000-2003) and late 2000s (2006-2011) were characterised by wet conditions, with predominantly positive SPI values, indicating above-average rainfall during these months. However, the years 2004, 2005, and 2012-2015 exhibited moderate drying trends, with more frequent negative SPI values, suggesting drought conditions or below-average rainfall, particularly in June and July during 2012 and 2013. In recent years, from 2020 to 2023, there has been a noticeable recovery, marked by more positive SPI values, signalling a shift toward wetter conditions during the monsoon months.

Figure 13: Monsoon Season SPI of Dadimadi Station from 2000 to 2023

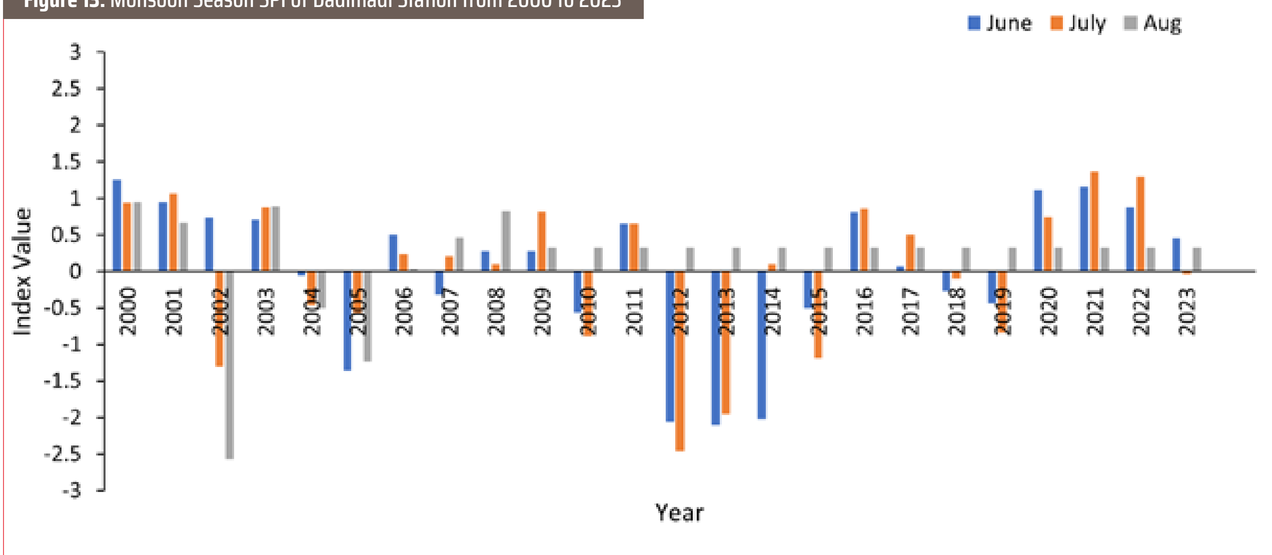
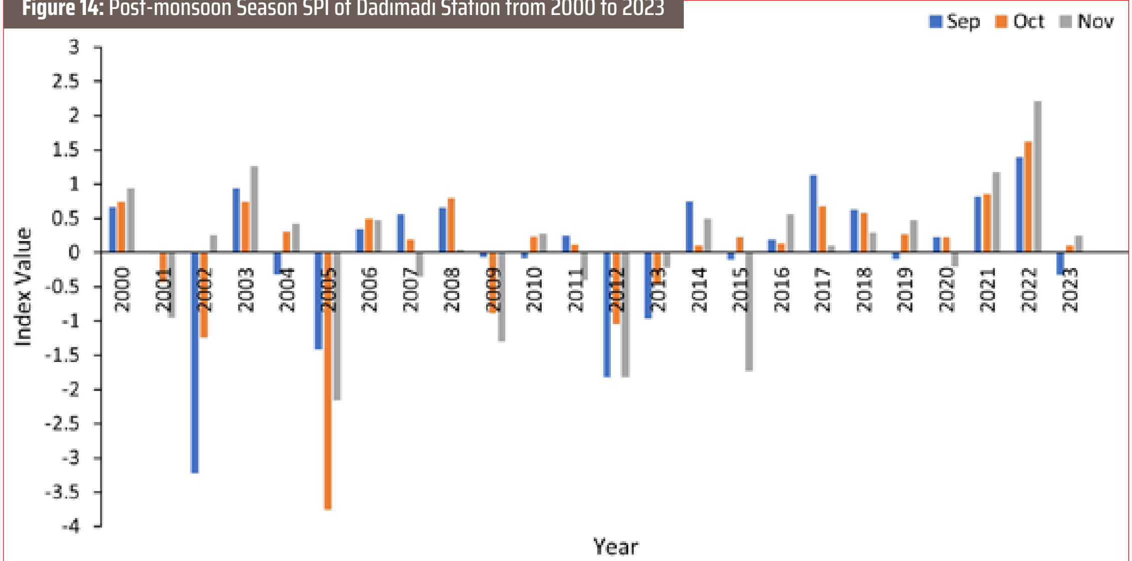


Figure 14 shows a bar chart of the SPI for the post-monsoon months—September, October, and November—from 2000 to 2023. The early 2000s (2000-2006) generally show fluctuating conditions, with mostly positive SPI values across these months, except for 2002 and 2005. This indicates that the post-monsoon period experienced above-average rainfall during this time. A similar trend has been observed from 2007 to 2015, where a drying trend emerges with more frequent negative SPI values and fewer positive SPI values, suggesting drought conditions or below-average rainfall during the post-monsoon period. In recent years, particularly from 2021 and 2022, there has been a recovery, marked by more positive SPI values, indicating a shift toward wetter conditions during the post-monsoon months.

Figure 14: Post-monsoon Season SPI of Dadimadi Station from 2000 to 2023



3.1.2 Loss and Damage context in Dullu Municipality

Dullu is well known for its religious landmarks, such as the "Fire in Water," and its prominent citrus fruit production, especially oranges. However, the region is increasingly grappling with extreme drought and shifting rainfall patterns. Prolonged drought conditions have become a critical issue in Dullu Municipality, resulting in significant economic and non-economic losses. Insufficient and irregular rainfall has severely impacted agriculture-dependent livelihoods, leading to a marked reduction in the production of cereals, vegetables, and traditional crops like millet and wheat. Farmers have reported worsening soil quality and a lack of surplus water for irrigation, further complicating crop cultivation.

The changing climatic conditions, characterised by unpredictable weather, have also disrupted traditional adaptation practices. Farmers have attempted to cope by shifting agricultural practices and planting hybrid crops like bananas, but the lack of adequate irrigation has undermined these efforts. Many agricultural lands now lie fallow and barren, further exacerbating the challenges faced by the farming community.

Water scarcity caused by repeated drought events has become a pressing issue in Dullu Municipality. The prolonged drought, particularly during the winter months, has led to the drying up of major spring sources and rivers, compounding the region's water crisis. These challenges have disproportionately impacted women and children, who are often required to travel long distances, sometimes for hours, to collect water.

The depletion of water sources has also severely affected irrigation facilities, further straining the agricultural sector. As a result, crop yields have been declining rapidly, undermining the livelihoods of farming households and exacerbating the municipality's food security challenges.

In addition to its direct impact on agriculture, drought in Dullu Municipality has caused significant non-economic losses affecting livelihoods, health, culture, and the natural environment. Children often face disruptions in their education as they spend more time fetching water instead of attending school. The physical stress of carrying heavy water loads, coupled with the limited availability of clean water, has led to an increase in health problems, including waterborne diseases.

Moreover, cultural practices and ceremonies that rely on water sources have been adversely impacted by the drying up of these resources. This disruption has caused imbalances within the community, further highlighting the broader socio-cultural implications of prolonged drought in the region.

3.1.3 Economic loss and damage (Drought)

Agriculture, a cornerstone of Dullu's local economy, has suffered immensely due to the ongoing drought. Crop yields have drastically declined, with staple crops such as maize, wheat, millet, and vegetables like tomatoes and cabbages experiencing significant reductions. The scarcity of water and decreasing soil fertility have also adversely affected traditional local crop varieties.

In response, many farmers have attempted to adapt by shifting to alternative or hybrid crops, but these efforts have seen limited success due to persistent drought conditions and inadequate irrigation infrastructure. Banana farming, which has shown some resilience, has also been adversely affected by erratic weather patterns. Additionally, forest fires have destroyed portions of the banana harvest, compounding financial losses for farmers and further straining the local agricultural economy.

The effects of climate change have taken a toll on citrus production in Dullu, with reduced germination rates and an increase in barren lands. The municipality, which has 893 hectares under citrus cultivation producing approximately 6,500 metric tons of oranges annually, has witnessed a decline in output due to prolonged drought conditions. Livestock has also been significantly affected, with the goat population dropping sharply from 18,000 to 10,000 in the fiscal year 2080/81, as per data from Dullu Municipality.

Water scarcity remains a critical issue, with key sources such as the Karnali River, Chanhchang Khola, and nearby springs drying up. This situation has been exacerbated by infrastructure developments like road construction, which have disrupted spring recharge systems and further strained water availability. These challenges have heightened the need for water-lifting systems to meet demands for both drinking and irrigation purposes.

Droughts have significantly reduced agricultural production, leading to substantial economic losses. Farmers who previously sold surplus crops are now limited to subsistence farming, consuming the little they produce. The decline in vegetable farming has particularly caused financial distress, reduced household incomes and increasing debt levels. This loss of earning capacity has weakened local purchasing power and created economic burdens. Staple crops such as wheat, beans and chickpeas have experienced a notable decline in yield, forcing many farmers to abandon traditional practices and explore alternative livelihoods or business ventures.

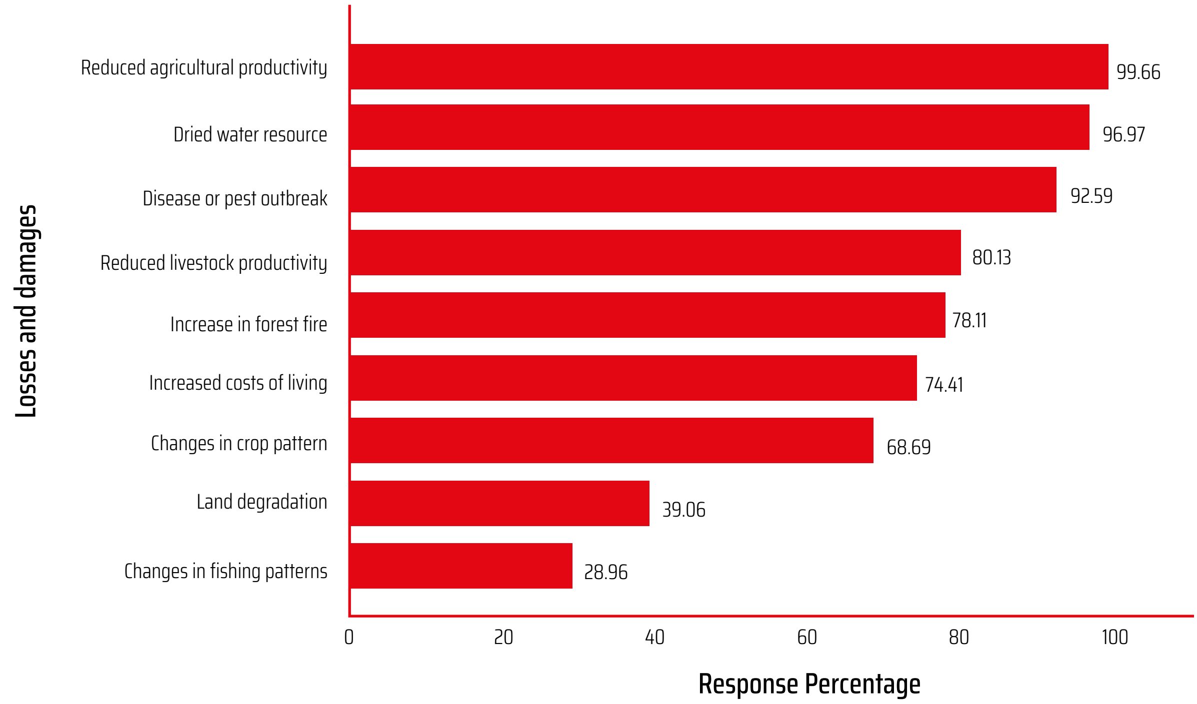
Dullu Municipality's annual budget stands at NPR 920 million, with 40–45% allocated to agriculture, livestock, and irrigation—a significant increase from the previous year's 15%. However, persistent drought conditions have led to rising food prices, placing additional financial strain on households. Climate change has also exacerbated agricultural challenges, with increased pest infestations and livestock diseases further threatening farmers' livelihoods and the community's economic stability.

"Earlier, we could grow enough food for our family. But now, we have to buy most of what we eat." - Female Respondent from Ward 2 Dullu Municipality.

Despite ongoing challenges, local authorities have provided limited compensation for drought impacts. However, international organisations, such as UNDP, have supported women affected by the drought. Local communities have adapted by focusing on large-scale production of traditional crops like millet and chickpeas and implementing afforestation programmes near springs and water sources to mitigate water scarcity. In previous years, farmers received compensation of NPR 15,000–21,000 (USD 133.42 -186.79) for crop damage caused by heavy rainfall, but similar support for drought-related losses remains inadequate. The drought has also disrupted daily life, forcing people to travel long distances during winter to fetch water. While the direct impacts of drought may not always be visible, its indirect effects, such as economic strain and disruptions to daily routines, are increasingly evident.

Nearly all survey respondents (n=297) acknowledged the prevalence of drought and the resulting L&D they have experienced. The most significant impact was on agricultural productivity, followed by dried water sources, increased disease and pest outbreaks, reduced livestock productivity, and more. Figure 15 illustrates the percentage of responses related to drought-induced losses. The majority of respondents reported a reduction in agricultural productivity (99.66%), followed by dried water sources (96.97%) and outbreaks of diseases or pests (92.59%). Other notable impacts included reduced livestock productivity (80.13%), increased forest fires (78.11%), higher living costs (74.41%), changes in crop patterns (68.69%), land degradation (39.06%), and changes in fishing patterns (28.96%). These findings underscore the severe consequences of drought on both livelihoods and ecosystems. Specifically, in terms of agricultural production, respondents reported smaller fruit sizes, slower germination, and an uptick in pest attacks.

Figure 15: Losses and damages faced due to drought (Multiple response)

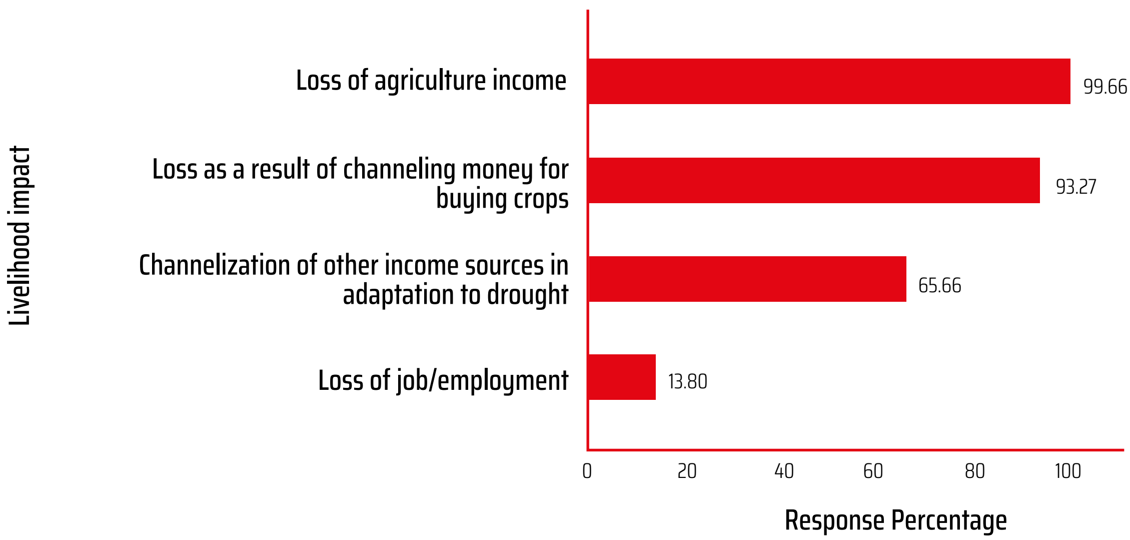


Loss of local crops is a major concern for farmers in the surveyed area. Both field consultations and household surveys provided evidence of a decline in local crop production due to drought. According to 64.31% of respondents, the production of maize, paddy, millet, wheat, and local vegetables has significantly decreased.

The decline in agricultural and livestock production has severely impacted the livelihoods of people in Dullu. The effects of drought on livelihoods are particularly evident among those reliant on agricultural income (99.66%), followed by the need to spend money on purchasing food grains and vegetables (93.27%), which were previously sufficient through self-production (Figure 16). A significant number of respondents also reported diverting other income sources to adapt to drought conditions (65.66%), while a smaller percentage experienced job or employment loss (13.80%).

"Many people have had to leave their villages because they couldn't find work or enough food."- Male Respondent of Ward 9, Dullu

Figure 16: Livelihood Impact due to drought



Additionally, 31.31% of respondents reported changing their occupation due to drought, indicating that some individuals have been forced to shift their livelihoods, potentially due to unemployment or the necessity to adjust to shifting economic conditions. The impacts on livelihoods have persisted for the past two years, according to 57.58% of respondents. However, a significant portion (35.02%) noted that these impacts began a decade ago, while a smaller percentage (7.41%) experienced them for less than a year. The KIIs and FGDs revealed that the decline in agricultural production, driven by drought, has made agriculture-based livelihoods less viable. Due to the unsustainable nature of traditional agricultural practices, many residents have sought alternative livelihoods in trade, services, and migration. The scarcity of food production and water has also prompted migration to India in search of better opportunities.

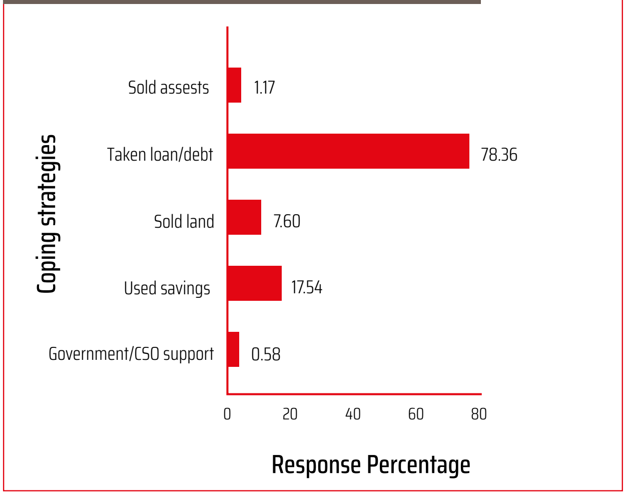
Majority of respondents reported losing between NPR 50,000 (USD 446.4) and NPR 100,000 (USD 892.85) annually, followed by losses in the ranges of NPR 20,000 (USD 178.57) to NPR 50,000 (USD 446.43). Fewer respondents reported losses between NPR 10,000 (USD 89.28) and NPR 20,000 (USD 178.57), or less than NPR 10,000 (USD 89.28). Similarly, the annual income lost due to reduced livestock productivity and treatment was also calculated. Most of the respondents reported losses between NPR 10,000 (USD 89.28) and NPR 20,000 (USD 178.57) annually, followed by losses in the range of NPR 20,000 (USD 178.57) to NPR 50,000 (USD 446.43) and NPR 50,000 to NPR 100,000 (USD 892.85). A smaller number of respondents reported losses between NPR 5,000 (USD 446.43) and NPR 10,000 (USD 89.28), or less. These findings highlight the significant economic impact of reduced agricultural and livestock productivity on livelihoods in the region. The average annual family income over ten years is NPR 2.54 million (USD 18,974), representing a 43.54% reduction (USD 10,706) due to drought-related losses in agricultural productivity and other factors (Table 8). The maximum and minimum reported annual incomes for one year were USD 372 and USD 11,174 , respectively. The cumulative loss of agricultural and livestock income per household over the past ten years, based on responses from 297 survey participants, is detailed in Table 8.

Table 8: Household loss in monetary terms due to drought

Household-level loss	Loss (USD)
Average	10,706
Maximum	78,224
Minimum	447

Farmers and local respondents have adopted various coping strategies to manage the impacts of drought (Figure 19). The most common strategy was taking loans or incurring debt (78.36%), followed by using savings (17.54%) and selling land (7.60%). A small percentage of respondents (1.17%) reported selling other assets, while only 0.58% of respondents received support from government or civil society organisations (CSOs). These findings highlight the financial difficulties faced by drought-affected communities and their reliance on coping mechanisms. To manage their debts, community members are repaying loans by allocating a portion of their monthly income to cover interest payments.

Figure 17: Coping strategies for the drought challenges



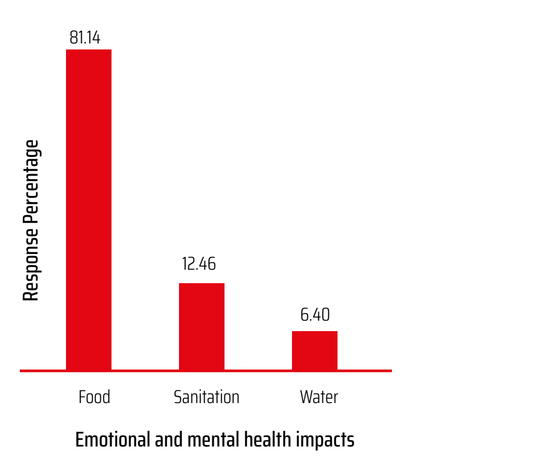
3.1.4 Non-economic loss and damage (Drought)

Beyond the economic impacts on agriculture and livelihoods, the drought has had significant consequences on the community's health, social systems, cultural practices, and the environment, which are difficult to quantify in monetary terms.

A. Health impacts

Several health impacts have been reported due to the drought. Figure 18 shows the percentage of respondents who experienced emotional and mental health effects due to drought. A significant majority (81%) of respondents reported facing such impacts. These findings underscore the considerable psychological toll that drought can impose on individuals and communities.

Figure 18: Emotional and mental health impacts face



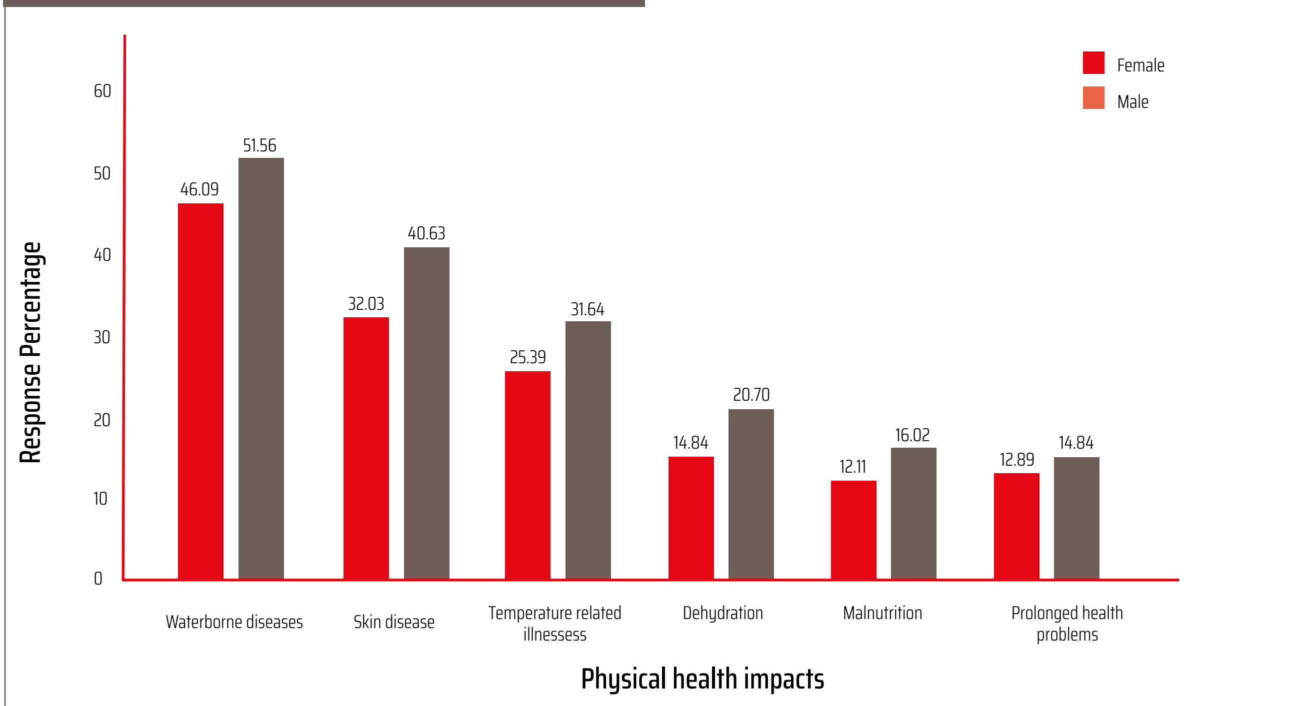
Regarding the prevalence of emotional and mental health issues among females and males, both groups reported experiencing stress/anxiety and sleep disturbances, with females reporting slightly higher rates. Depression, however, was less common, especially among males,with only 0.41% of males and 1.60% of females reporting it.

"I am worried about the future. I don't know how we will be able to continue our livelihood in the absence of enough water."- Male Respondent of Ward 2, Dullu

Approximately 83.50% of respondents also mentioned facing physical health impacts due to drought. This data clearly indicates that physical health impacts are prevalent concern among the surveyed population. During the FGD with residents of Dullu Municipality, Ward-2 and Ward-9, participants reported an increase in the incidence of diseases such as diarrhoea, fever, and kidney stones, primarily due to the lack of access to clean water and sanitation facilities. People are forced to travel long distances to fetch water, contributing to fatigue, weakness, and other health problems.

As per the survey, the majority reported waterborne diseases as the most prevalent, followed by skin ailments, which were also common. Overall, the data suggests that both males and females are affected by a range of physical health challenges, with some variations in the prevalence of specific issues between the two genders. The respondents mentioned frequent illness due to drought and water problems.

Figure 19: Physical health impacts



Moreover, the decline in agricultural production and subsequent food shortages can have long-term consequences for health and individual development, especially for children and the elderly. These physical health impacts underscore the urgent need for interventions to address the drought-related challenges in Dullu Municipality.

Majority of respondents (60.94%) reported recovering within a month, while 20.54% required up to six months. A smaller proportion (7.41%) required up to a year to recover, and only 11.11% needed more than a year for full recovery (Figure 24).

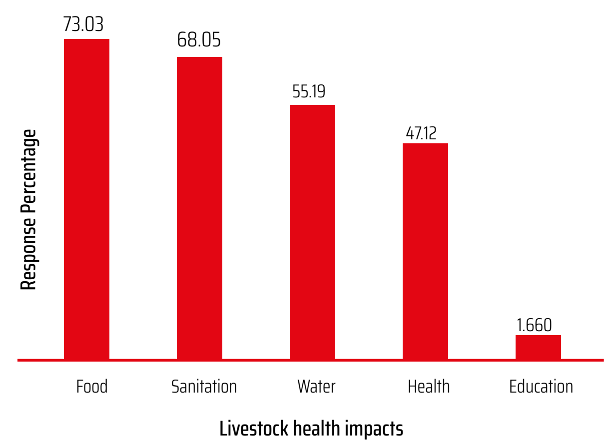
B. Impact on Livestock

The prolonged drought has also had a significant impact on livestock health. Majority of the respondents (83.50%) reported experiencing livestock health issues. Diseases have led to goat deaths, and the lack of fodder and water has negatively affected the overall health of livestock.

"Many of our goats have died due to diseases caused by the lack of water; we know the cause, but we don't have solutions yet"- A female respondent during FGD in ward 2, Dullu

Among the listed categories, waterborne diseases in livestock were the most prevalent, with 73.03% of respondents reporting their impact on livestock. Skin diseases were also common, affecting 68.05% of the livestock. Reduced milk production was reported by 55.19% of respondents, while 47.72% experienced livestock mortality. Other physical health issues, such as infertility and weakness in cattle and buffalo (locally known as *Chamre rog)*, were reported by a smaller proportion of respondents (Figure 20).

Figure 20: Impact to Livestock health



Regarding coping mechanisms for livestock- farmers perceive immunisation and vaccination to be the most effective. Constructing livestock sheds, and buying improved breeds and fodder were considered effective. Vaccines are provided by the district's livestock department for common health issues, such as worms. However, other health problems are generally addressed by farmers themselves, with some support from local government incentives. The average annual cost incurred by households for livestock treatment was USD 152, with a maximum cost of USD 559 and a minimum of USD 45 (Table 9).

Table 9: Average household level cost incurred in treating livestock

Livestock treatment cost (USD)	
Average	152
Maximum	559
Minimum	45

C. Impact on Access to Basic Necessities

A significant majority of respondents reported that climate change has had a substantial impact on food (99.66%), sanitation (99.66%), water (99.33%), and health (98.99%). However, the impact on education was reported to be slightly lower, with 83.84% of respondents perceiving a significant effect. The decline in agricultural production and subsequent food shortages have made it difficult for some residents to meet their basic needs. Additionally, limited access to water has hindered residents' ability to prepare food and maintain hygiene. Table 10 shows the extra costs incurred by respondents to access necessities, with an average expenditure of USD 755.

Table 10: Extra cost incurred in accessing basic necessities

Extra cost incurred in Accessing basic necessities (In USD)	
Average	755
Maximum	1788
Minimum	93

The research tried to understand the differential impacts of drought on access to basic needs among female and male respondents in Dullu Municipality. Among the listed categories, reduced availability of basic needs was reported as the most significant impact, affecting 53.71% of females and 43.11% of males. Overall, the data indicates that females and males are experiencing significant impacts on their basic needs due to the drought, with reduced availability and quality of services and products being the most prevalent concerns.

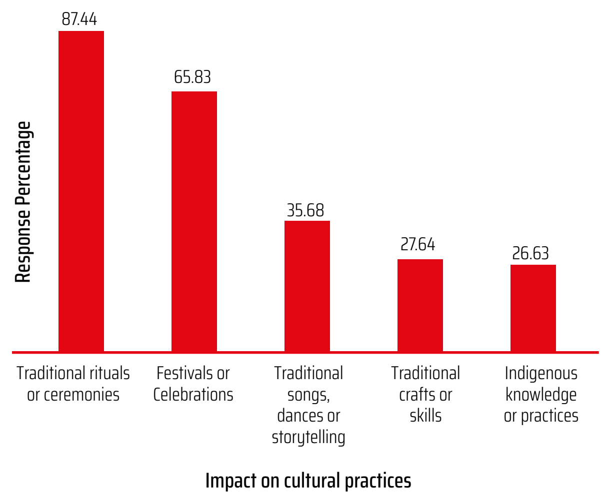
Water scarcity has become a critical issue in Dullu, with residents reporting longer distances to fetch water, particularly during the winter months. This situation has disproportionately burdened women and children. Traditional water sources have dried up, forcing the community to rely on alternative methods, such as water lifting. This has also negatively affected irrigation, resulting in reduced agricultural productivity.

A large majority (82.83%) of respondents reported travelling long distances to access water. The FGDs revealed that the water source is located about 1 km away, where individuals often must wait for their turn. Women and children predominantly bear the responsibility of fetching water. Children are forced to leave school to assist with household chores, such as fetching water, which disrupts their education. Due to the time spent fetching water and managing household and agricultural tasks, 39.06% of respondents reported a decline in their children's interest and ability to attend school, indicating that education is being affected.

D. Impact on Cultural Practices and Traditions

In recent years the increasing severity of drought has had both direct and indirect effects on cultural practices in Dullu. About 61% of respondents reported observing the drought's impact on cultural traditions. Among them, the majority noted the drought's effect on traditional rituals and ceremonies (87.44%), followed by its impact on festivals and celebrations (65.83%) (Figure 21).

Figure 21: Impact on cultural practices due to drought



Religious ceremonies, such as the *muhan puja*, have had to adapt to the drying up of water sources. Traditional social gatherings, especially those involving water-related activities, have been limited due to the drought. This loss of traditional practices and the need for adaptation can negatively impact cultural identity and community cohesion. For example, villagers have been forced to conduct the *muhan puja* at the river's source instead of its traditional location, and the community's ability to organise festivals and gatherings has been significantly altered.

About 7% of the total respondents also reported the impact on death rituals, noting changes in the usual locations for rituals and practices, such as *bhurkey chharne*, a tradition where parched barley is spread along the path to the cremation site. Vow-based rituals, where promises are made to God in exchange for rain, have increased in recent years.

"Our traditional festivals are being affected because we don't have enough water for the rituals", said a respondent during consultation at ward 9 Dullu

E. Social cohesion and interactions

Around 86% of respondents reported experiencing social disputes and conflicts within the community (Figure 22) and with neighbouring communities (Figure 23) due to drought and water unavailability. Among these respondents, 99.61% noted that drought has created competition for limited resources, leading to disputes. These conflicts have been prevalent both within the community and between neighbouring communities. As water resources gradually deplete, the water demand has steadily increased, leading to tensions over the limited supply. During the community consultation, respondents highlighted disputes, especially involving children and youth, with cases of violence, particularly between males.

Figure 22: Social impact within community

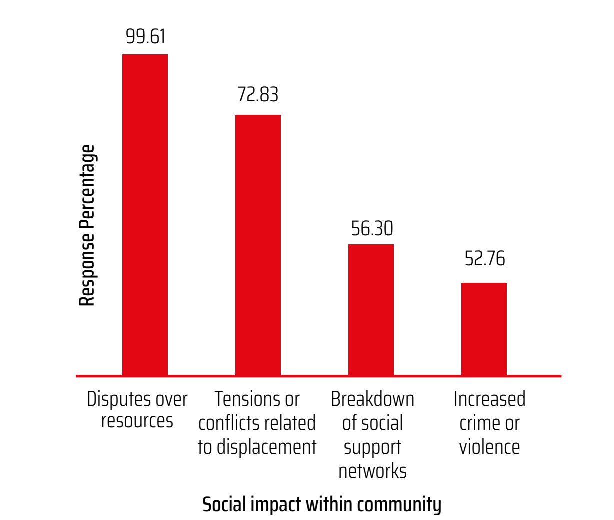
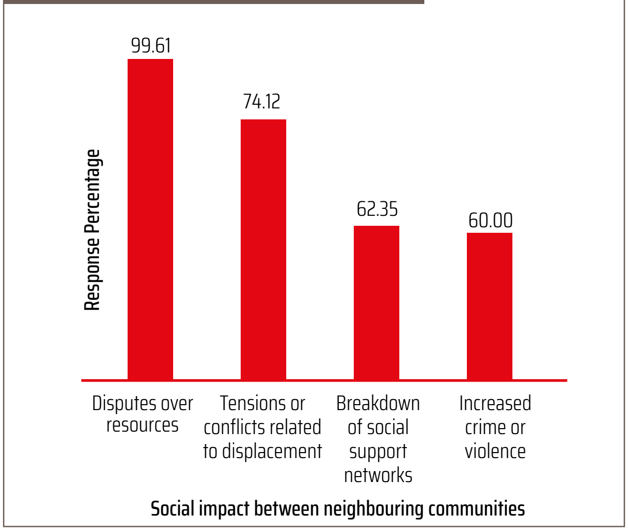


Figure 23: Social impact within community

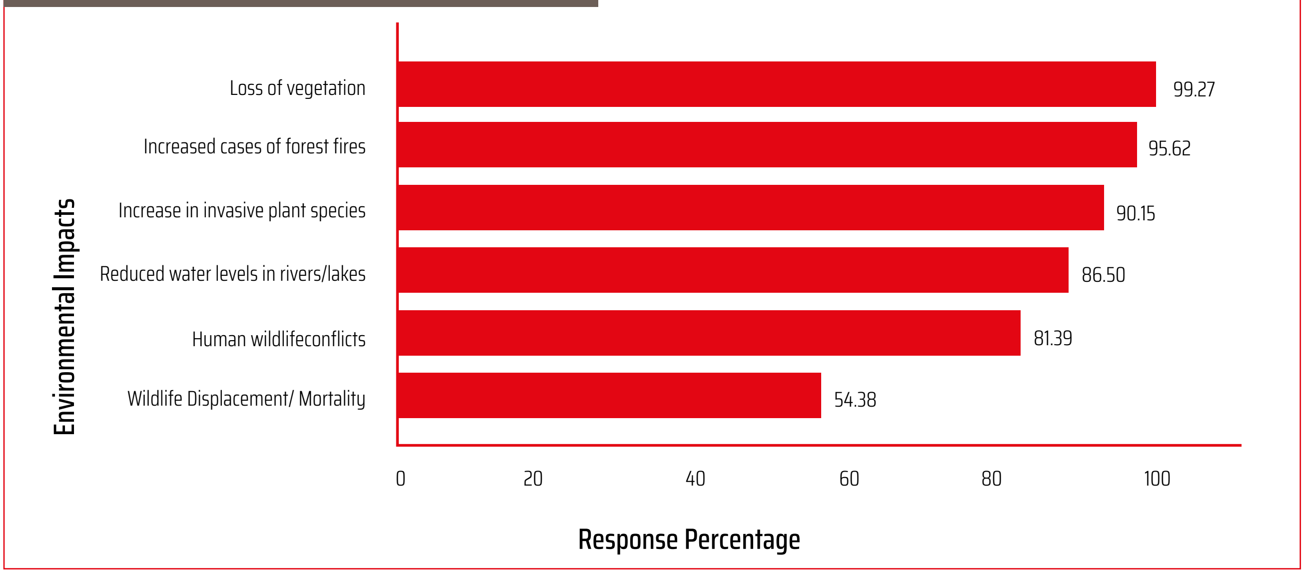


During the consultation, 37% of respondents reported instances of gender-based violence (GBV) that may be indirectly attributed to the drought. The drought has led to economic hardship, displacement, and increased competition for resources, creating an environment conducive to GBV. Domestic violence against women has become prevalent due to frustration over the lack of sufficient water, often triggering irritation and conflict. Additionally, young girls are disproportionately tasked with fetching water and performing household chores compared to boys.

F. Environmental Impact

Aprroximately 99.27% of respondents reported impacts on the natural environment, with the most common being loss of vegetation, followed by an increase in forest fires (95.62%), growth of invasive plant species (90.15%), reduced water levels in rivers and lakes (86.50%), and human-wildlife conflicts (61.39%). Fewer respondents mentioned wildlife displacement and mortality (54.30%) (Figure 40). Respondents also noted a rise in invasive plant species. While *Tite Pati* (Mugwort) was once commonly used as a fertiliser, new invasive species, particularly *Kalo Banmara* (Ageratina adenophora), have become dominant, restricting the growth of other plants. Additionally, forest fires, particularly in the nearby *Sal* (Shorea robusta)-dominated forest, have posed a significant issue, severely affecting grass and animal fodder.

Figure 24: Responses on environmental impact due to drought



Nearly 98.65% of respondents reported a decrease in water levels due to the impacts of drought. This decline in water levels, leading to water scarcity, was particularly felt during the winter seasons by both survey and FGD respondents. The observed trend aligns with the SPI values, which indicated a drying period between 2007 and 2014.

G. Migration and Relocation

Migration is becoming a common coping strategy as residents seek alternative income sources outside the municipality, particularly in India, due to food insecurity. According to the FGD and household discussions, at least one person from each household has migrated to India in search of livelihood opportunities. The large-scale movement of labour, particularly from the agricultural sector, has resulted in labour shortages, making farming even more challenging. These shortages have reduced agricultural input, creating a vicious cycle of reduced interest in agriculture, followed by decreased input and production, further impacting the local economy. However, drought was not identified as the primary driver of migration. Survey respondents were also asked about their willingness to migrate in response to drought impacts. About 31% of respondents expressed a willingness to migrate to nearby areas with better access to water facilities, while the majority (69%) preferred to remain in the same location and diversify their livelihood sources.

Among the 31% of respondents willing to relocate, the average amount they were willing to pay was USD 755, with a maximum of USD 1,788 and a minimum of USD 93. When asked about restoring the land they currently use, all respondents indicated a willingness to pay varying amounts. The maximum amount reported was USD 7,540, while the minimum was USD 112, with an average of USD 1,566 (Table 11). This suggests a strong interest among respondents in preserving or improving the local environment.

Table 11: Willingness to pay for relocation and restoration

Willingness to pay (USD)	For Relocation (Out of 31%)	For Restoration (Out of 100%)
Average	755	1,566
Maximum	1,788	7,450
Minimum	93	112

3.1.5. Financial Compensation and Adaptation Support

The ward and municipality lack clear plans and compensation mechanisms to address the challenges posed by drought. During the FGD, residents of Dullu reported that they have not received compensation for loss and damage caused by drought, with only 11% receiving support. However, they acknowledged receiving training and financial assistance from local government and NGOs for initiatives such as rainwater harvesting systems, drought-tolerant vegetable varieties, and beekeeping. The respondents noted that while the training was effective, some of the vegetable seed varieties provided did not grow well, and their efforts to cultivate them yielded limited results.

The ones who had received training- mentioned initiatives included training on locally made bio-fertilisers *(Jholmal)* and the construction of artificial recharge ponds. These efforts aim to equip communities with practical skills to better cope with drought conditions.

“We need help from the government and NGOs to adapt to these changing conditions."- Ward Chairperson, Ward 2, Dullu

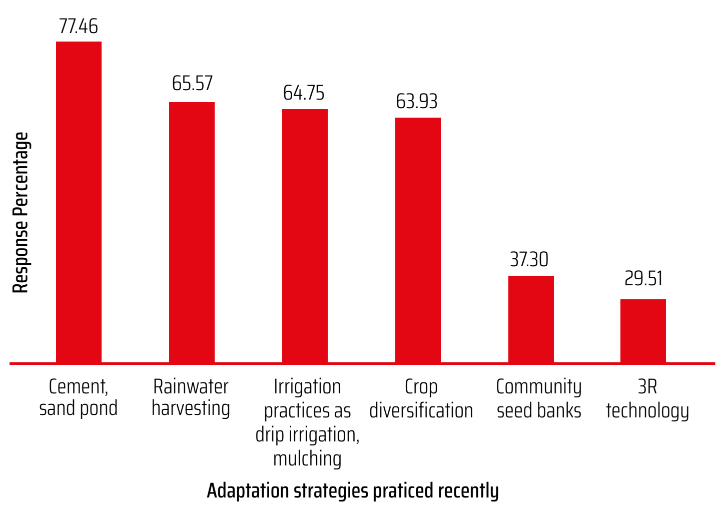
Other coping mechanisms include shifting cropping practices, such as moving from less profitable crops like millet to vegetable farming. However, the increased prevalence of pests has negatively impacted these efforts. Currently, some adaptation strategies, such as lifting water from tanks and using solar-powered pumps, are being implemented and planned to supplement water needs for both agriculture and domestic use. Community-based initiatives have also been developed to address the drought, including the construction of water tanks, tree planting, and participation in afforestation programmes.

"We have started growing millet instead of rice because it is more drought-tolerant," said a respondent during a consultation in ward number 09 of Dullu.

About 56.23% of respondents have implemented adaptation strategies in the past to cope with drought in their community. Among them, the majority practised mulching, followed by the construction of mud-made irrigation canals, rainwater harvesting, and multi-cropping. Similarly, 18% of respondents have not implemented any adaptation strategies. Out of those who have implemented adaptation practices, a higher percentage (77.46%) of repondents have constructed cement-sand ponds, 64.75% have adopted irrigation practices such as drip irrigation and mulching, 63.93% have practised crop diversification, and 65.57% have engaged in rainwater harvesting. These adaptation practices are supported by local institutions, including CSOs working in the area (Figure 48).

"We have been planting trees near the springs to help conserve water"- said a respondent during consultation at ward 2 of Dullu

Figure 25: Adaptation strategies practiced



3.2 Gulariya Municipality- Flood hazard

3.2.1 Climate Trend Analysis

Table 12 presents the projected changes in temperature (°C) and precipitation (mm) for Bardiya district relative to a reference period (1981–2010). The data compares two RCPs, RCP 4.5 and RCP 8.5, across two future time periods: 2016–2045 and 2036–2065. Both scenarios indicate a gradual increase in temperature and precipitation, with RCP 8.5 projecting a larger rise in both compared to RCP 4.5.

Table 12: Change in Temperature (°C) and Precipitation (mm) for Bardiya district of Nepal from the reference period (1981-2010). (MoFE, 2019).

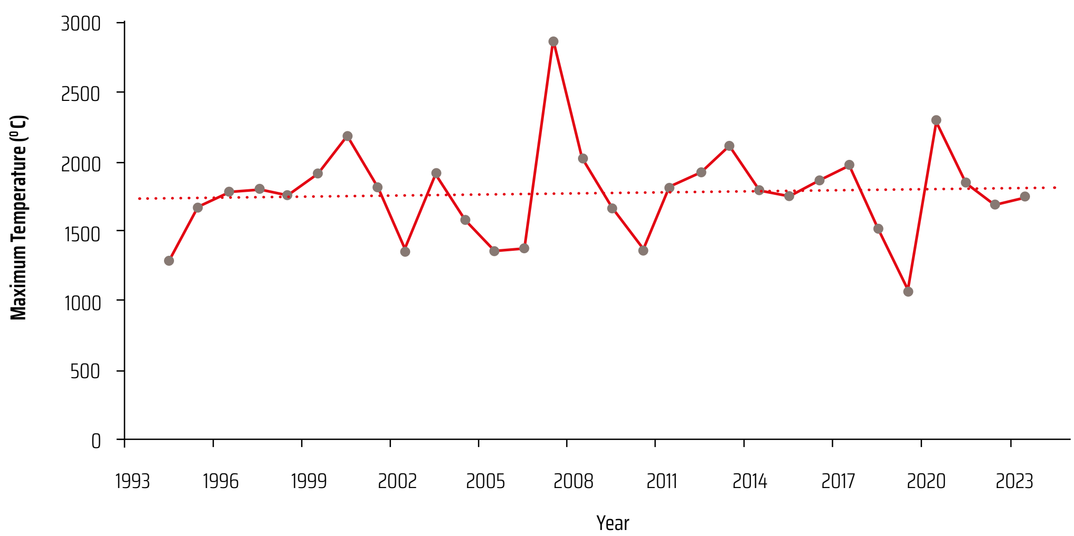
SN	Reference Period	RCP 4.5		RCP 8.5	
		2016-2045	2036-2065	2016-2045	2036-2065
Temperature	24.5	1.07	1.51	1.01	1.7
Precipitation	1551	1.15	9.33	7.33	14.53

Similarly, a trend analysis was conducted for temperature and precipitation patterns in Bardiya. The average yearly rainfall trends were analysed using data from the Bargadaha station, while temperature trends were examined using data from the Ranijharuwa station. The analysis of monthly rainfall data from 1994 to 2023 focused on identifying rainfall trends, including seasonal variations. Additionally, minimum and maximum temperature data from 1994 to 2023 were analysed to assess temperature trends.

A. Annual Rainfall Trend

Figure 26 shows the annual rainfall data from the Bargadaha Station, Bardiya, covering the period from 1994 to 2023. The trend indicates a minimal increase in rainfall over time, with notable fluctuations from year to year. The highest rainfall peak occurred in 2007, while the lowest was recorded in 2019, with smaller variations observed in other years.

Figure 26: Annual Rainfall of Bargadaha Station

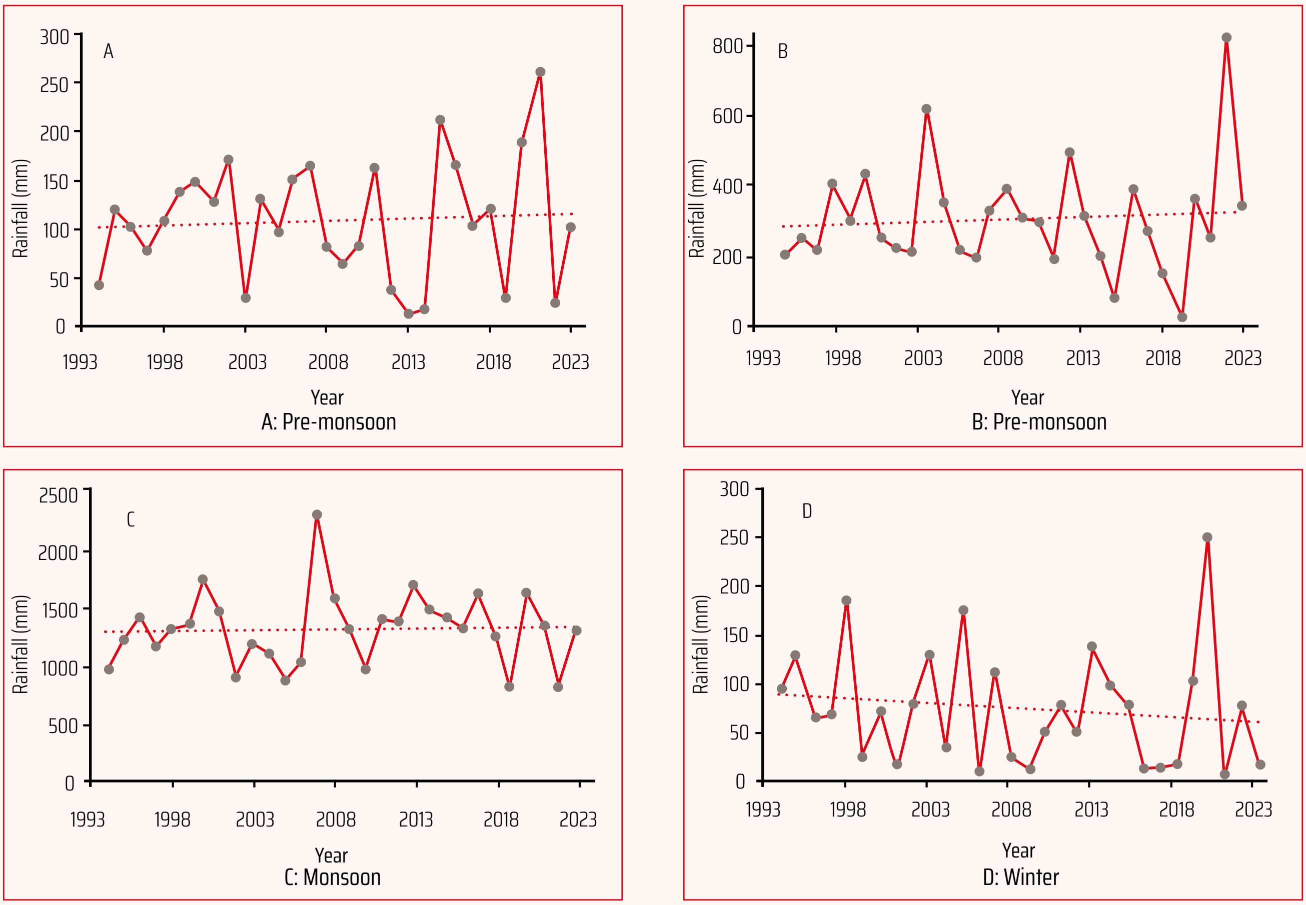


B. Seasonal Rainfall Trend

The seasonal rainfall trend from 1994 to 2023 was also analysed. The seasons are categorised as follows: Winter (December, January, and February), Pre-monsoon (March, April, and May), Monsoon (June, July, and August), and Post-monsoon (September, October, and November).

The seasonal rainfall trends at Bargadaha Station from 1994 to 2023 show significant fluctuations across all seasons. The highest rainfall peaks occurred in the following years: post-monsoon in 2022, winter in 2019, pre-monsoon in 2021, and monsoon in 2007. Winter shows a less significant downward trend, while the other seasons exhibit a minimal increasing trend, though this is not statistically significant. Overall, rainfall variations across seasons are influenced by multiple factors, and clear long-term trends are not strongly evident (Figure 27).

Figure 27: Seasonal Rainfall trend of Bargadaha Station from 1994 to 2023



C. Annual Temperature Trend

Figure 28 shows the annual average minimum temperature at Ranijharuwa Station, Bardiya, from 1994 to 2023. The trend indicates a minimal increase in minimum temperature over time, with significant fluctuations observed. The highest temperature peak was recorded in 2014, while the lowest occurred in 2015, with smaller variations in other years.

Figure 28: Annual Maximum Temperature of Rani Jharuwa Station

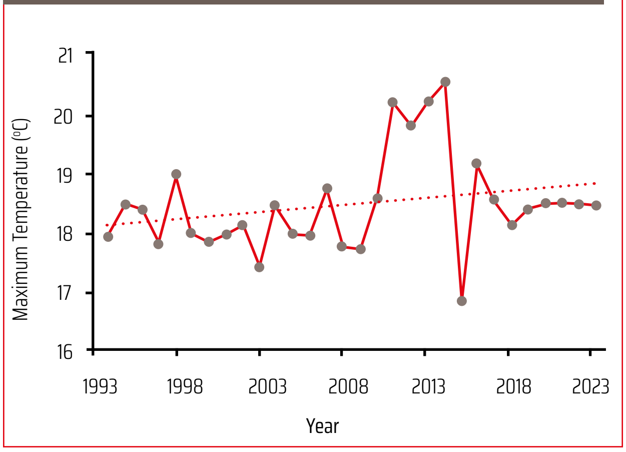
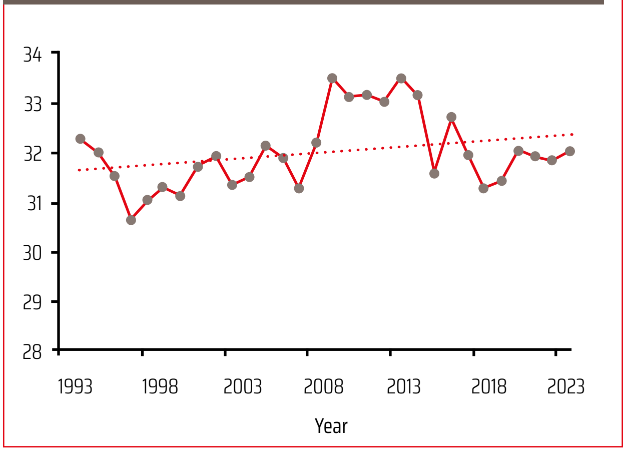


Figure 29: Annual Maximum Temperature of Rani Jharuwa Station



3.2.2 Loss and Damage context in Gulariya Municipality

Gulariya is frequently affected by recurrent floods that impact settlements and the local population. The most recent major flood occurred from October 15-19, 2021, causing losses of approximately USD 1.33 million in paddy crops alone. This flood was triggered by off-seasonal rainfall, which coincided with the paddy harvesting season. Wards 4, 5, 8, 9, 10, 11, and 12, located near the river, are identified as flood-prone areas, with paddy rice being the most affected crop. The flood impacted 10,553 farming households across 973 hectares of land. In response, the municipality has established organisational structures and policies to manage disasters, with a particular focus on addressing floods as the primary concern.

Floods have also affected livestock, homes, and other property. In addition to these damages, the floods pose significant risks to human health and safety, particularly through water contamination and the spread of diseases. While recent improvements have facilitated more timely evacuations, helping to minimise human casualties, other losses and damage continue to rise. According to the KIIs with the agriculture department and ward offices, the early warning system has been effectively managed, including community-based practices for risk communication.

3.2.3 Economic losse and damage (Flood)

Economic loss and damage due to flood hazards remain a significant concern. The 2014 flood occurred with minimal early warning, resulting in sudden inundations that destroyed homes and crops, leading to substantial economic losses. Survey respondents from wards 4 and 5 of Gulariya Municipality reported experiencing significant economic losses as a result of the event. Crop loss was the most frequently mentioned, reported by 97% of respondents, followed by house loss (92.75%), land loss (73.91%), and livestock loss (67.25%) (Figure 30).

Figure 30: Economic losses and damages in different sectors

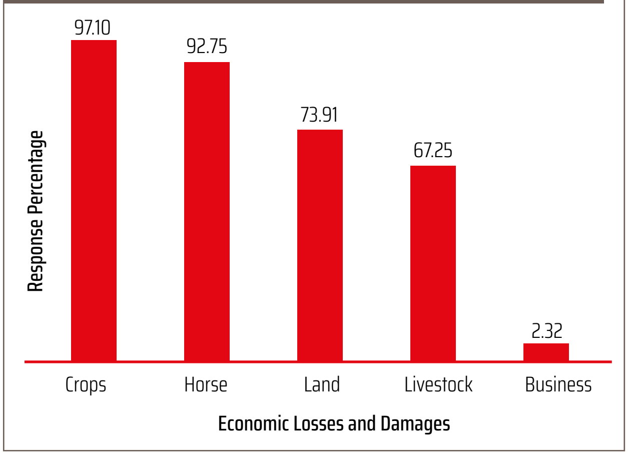
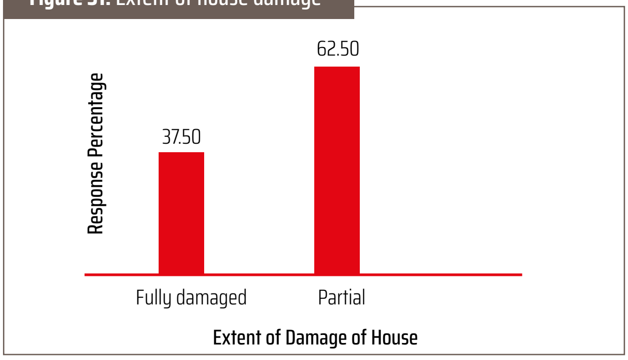


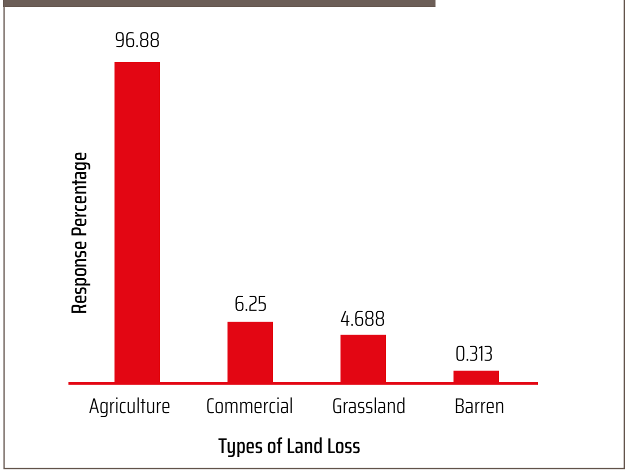
Figure 30 illustrates the extent of damage to the houses of 92.75% of respondents. Of these, 37.50% reported their houses being fully damaged, while 62.50% experienced partial damage. The houses were primarily constructed with materials such as stone, wood, straw, brick, and asbestos.

Figure 31: Extent of house damage



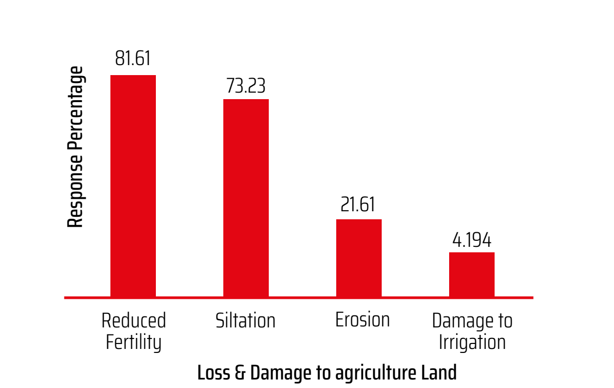
Around 73.91% of the respondents reported losing land due to flooding. Among them, the majority experienced agricultural land loss (96.88%), followed by commercial land (6.25%), grassland (4.68%), and barren land (0.31%) (Figure 31).

Figure 32: Type of Land Loss due to flood



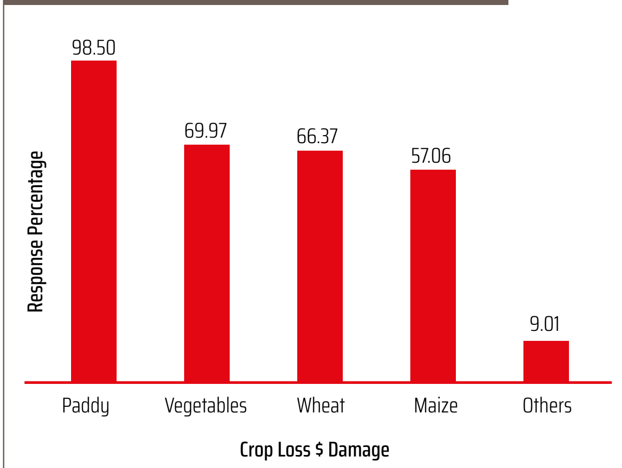
Out of the 97.1% of respondents who reported crop damage due to the flood, reduced fertility (81.61%) was identified as the most significant impact, followed by siltation (73.23%). Erosion was reported by 21.61%, while damage to irrigation systems (4.19%) was relatively low. However, farmers also highlighted some benefits after the flood, mentioning that the deposited silt is used for watermelon cultivation and provides fertile soil for other crops (Figure 32).

Figure 33: Loss and Damage to agricultural Land



Crop loss was especially significant for paddy, vegetables, wheat, and maize, with other crops such as mustard, lentils, and chickpeas also being affected. The inundated crops were damaged beyond recovery, while the harvested crops were swept away. According to 98.50% of the respondents, paddy was the most affected crop by the flooding, followed by vegetables (69.97%), wheat (66.37%), and maize (57.06%) (Figure 33). These figures align with the national agricultural losses reported at that time, which were substantial. Other crops were affected to a much smaller extent (9.01%). The average crop loss valuation was estimated at USD 478.

Figure 34: Crop Loss and damages (multiple response)



The average household-level loss was estimated at USD 10,132, which is 6.43 times higher than the average household income of USD 1,573 (Table 13). The maximum and minimum losses were recorded at USD 67,943 and USD 74, respectively, with these losses stemming from damage to houses, land, and crops. The maximum annual income was found to be USD 11,174, while the minimum annual income was USD 37.

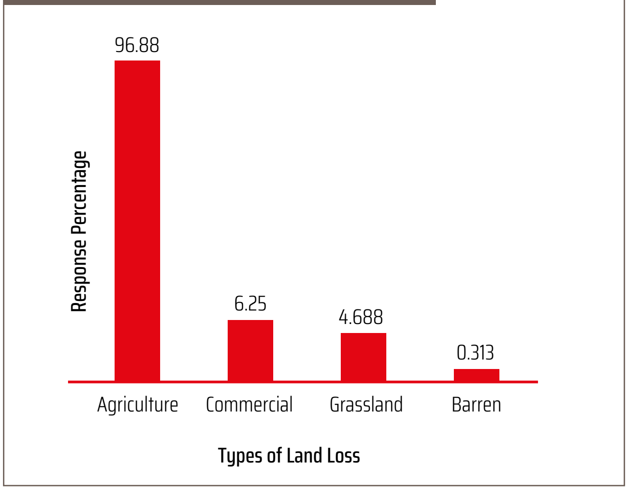
Table 13: Household-level loss for house, land, crops and livestock in monetary terms due to flood

Household-level loss	Loss (USD)
Average	10,132
Maximum	67,943
Minimum	74

Impact on livelihood sources

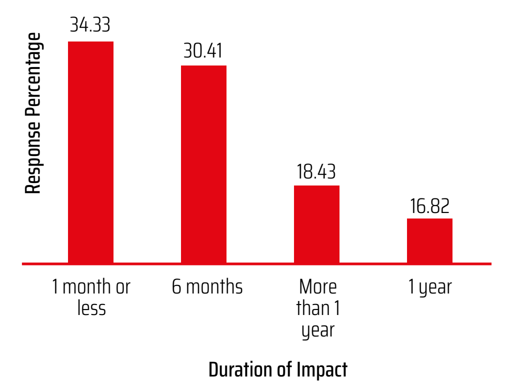
About 88% of respondents reported that their source of income was impacted by the flood. The most significant impact was a decrease in agricultural production, as reported by 96.05% of respondents, followed by loss of employment (9.54%), loss of business (8.22%), and other impacts at much smaller proportions (0.33%) (Figure 34). Heavy rainfall and flooding disrupted the harvest of paddy and other crops, leading to crop damage and a significant reduction in income. The average loss in agricultural income was reported to be USD 427, with a maximum of USD 7,450, while the overall income loss from all sources was found to be USD 531 on an average, with a maximum of USD 9,685.

Figure 35: Type of Land Loss due to flood



The graph shows the duration of flood impacts on livelihoods within the community. Among the respondents, 34.33% reported that the impact has been felt for less than a month, 30.41% indicated that the impact lasted for six months, while 18.43% and 16.82% have been affected for more than a year and for one year, respectively. The effects include deposition of silt on houses, damaged assets, and other issues. The recovery period is also longer in the case of flood effects, with many households reporting that their farmlands have been turned into barren land due to siltation (Figure 35).

Figure 36: Duration of Impact



Debt and Asset Sales to Cope with Losses

Nearly 69.28% of respondents reported taking on debt due to the damage caused by the flood. The highest percentage of respondents (40.34%) took between NPR 20,000 (USD 178) and NPR 50,000 (USD 446.42) in debt. A similar proportion (23.11%) took between NPR 20,000 and NPR 50,000, while 22.27% took between NPR 50,000 and NPR 100,000 (USD 892.85). A smaller group (13.45%) incurred debts ranging from NPR 100,000 to NPR 500,000 (USD 4,464.28), and only 0.84% took on debts exceeding NPR 500,000. The average debt amount was NPR 80,924 (USD 4464.28) , with a maximum debt of up to NPR 750,000 (USD 6,696.42) and a minimum of NPR 15,000 (USD 133.92) . Many households are still repaying their debts, while others have resorted to selling assets and employing other coping mechanisms to manage repayment.

Apart from debt, respondents reported selling assets to cope with the challenges posed by floods. About 70% of them had to sell livestock, 16.67% sold land, and 12.5% sold ornaments. Additionally, 16% of respondents shifted their occupation from farming to daily wage labour, primarily due to the loss of agricultural land.

3.2.4 Non-economic losses and damages (flood)

Non-economic loss and damage are becoming an increasing concern in the context of flood impacts. The effects of floods, both before and after the event, often persist for extended periods. In many cases, the damage is so severe that it cannot be fully addressed through financial compensation alone.

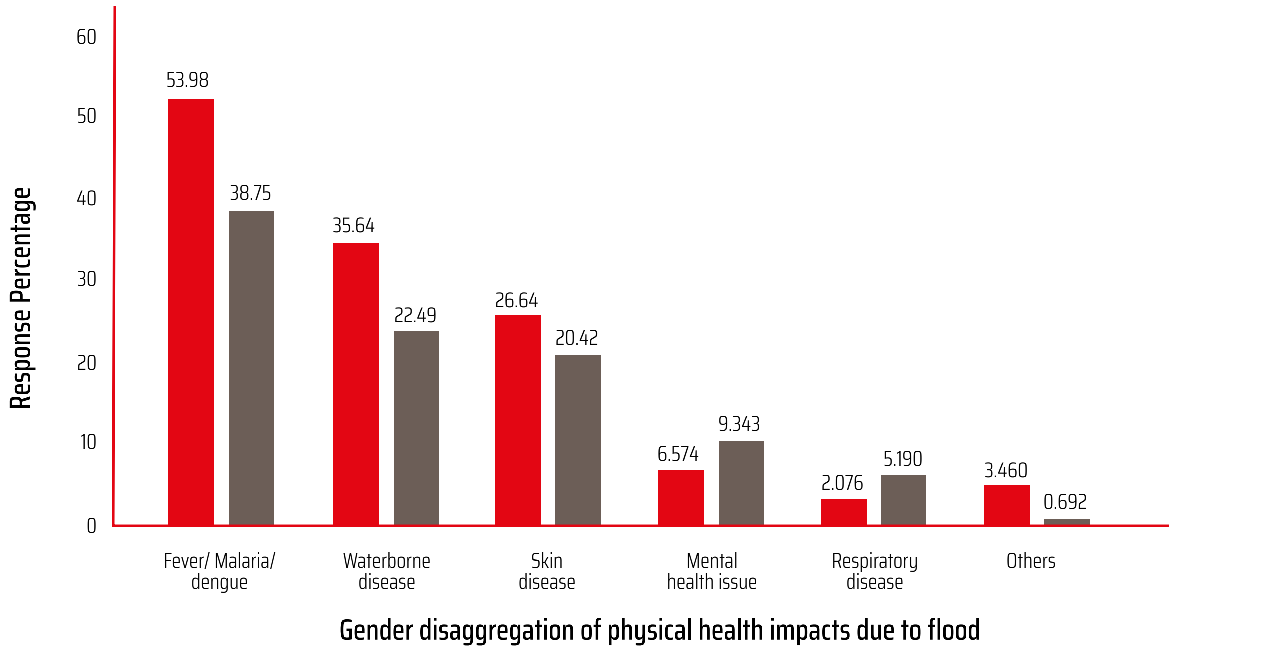
The most significant impact on lifestyle was reported as changes in daily routines (85.27%), followed by injuries and trauma (64.34%), difficulty in accessing basic needs (60.08%), and alterations in sources of livelihood (11.63%), respectively.

A. Health impact

Different physical health impacts were reported among females and males following the flood. Among the respondents, 85% reported experiencing physical health impacts due to the flood. The most common impact was fever, malaria, or dengue, affecting 53.96% of females and 36.75% of males. Waterborne diseases were also a major concern, with 36.64% of females and 22.49% of males reporting them. Skin diseases followed, affecting 26.64% of females and 20.42% of males. Mental health issues were less common, reported by 9.57% of females and 9.34% of males, while respiratory diseases affected 5.19% of females and 5.18% of males. A small proportion of the population reported other physical health issues (3.46% of females and 0.69% of males). The average health recovery cost was USD 72, with a maximum cost of USD 1,117.

Respondents in the FGD and KII mentioned that the flood further worsened the health of individuals with chronic conditions, such as asthma, due to the consumption of polluted tubewell water during flood events (Figure 36).

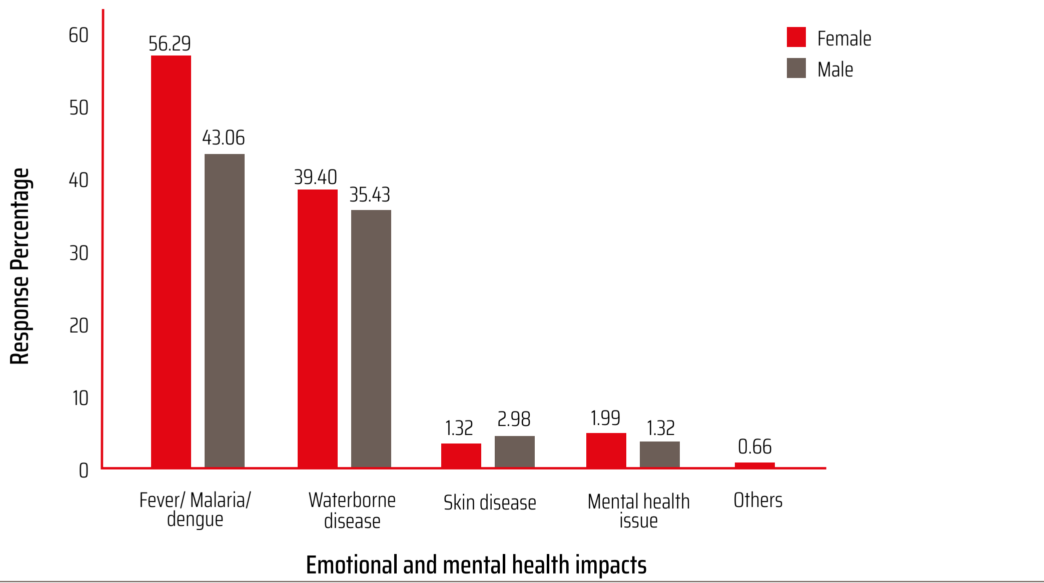
Figure 37: Gender disaggregation of physical health impacts due to flood



B. Emotional and mental health impact

Nearly 88% of respondents reported experiencing emotional and mental health impacts due to the flood, including stress, anxiety, and sleep disturbances. Figure 37 illustrates the emotional and mental health impacts among female and male respondents. Stress and anxiety were the most common, affecting 56.29% of females and 43.05% of males, while sleep disturbances were reported by 39.40% of females and 35.43% of males. A small percentage of respondents mentioned conflict within families. The findings suggest that both females and males face a range of emotional and mental health challenges, with stress/anxiety and sleep disturbances being the primary concerns. The ongoing fear of future floods continues to disrupt their sense of security and well-being, creating psychological challenges.

Figure 38: Gender disaggregation of Emotional and Mental Health Impacts due to flood



"We were unable to sleep at night as we had to keep a constant watch on the water levels."- A male respondent of ward 4 of Gulariya Municipality.

C. Impact on Access to Basic Necessities

The flood immediately disrupted access to clean drinking water, food, and sanitation. Access to education and healthcare was also interrupted for about a month due to mobility issues caused by damage to roads, bridges, and marketplaces. Additionally, communication was hindered by unstable network connections and damage to electric poles.

The household survey revealed that drinking water was the most significantly impacted, with 99.71% of respondents reporting difficulties accessing it. Access to food (97.10%), sanitation (96.81%), education (91.01%), and healthcare services (82.32%) were also affected. Electricity and communication faced challenges as well, with 76.52% and 71.30% of respondents reporting disruptions, respectively.

"We couldn't eat our food because our surroundings felt unpleasant and bad"- Male Respondent of Ward 5, Gulariya Municipality.

In addition, FGD participants reported that the lack of access to toilet facilities in temporary shelters led to reduced food intake for children and the elderly, as people would avoid eating to minimise the need for frequent trips to the toilet. This resulted in extreme hunger, irritability, and potential health impacts.

Approximately 95.2% of survey respondents reported relying on food and water distributed by the government and NGOs following the flood. Additionally, 52.11% of respondents resorted to temporary migration, while 35.63% utilised alternative routes to access basic needs. Support from neighbours and external sources was reported by 20.69% and 15.71% of respondents, respectively (Figure 66). Due to the challenges in accessing necessities, many people were displaced and temporarily sheltered in safe locations, such as schools and safe houses constructed by the municipality.

Local communities have implemented risk reduction measures, including monitoring river water levels during the monsoon by observing the river, safely storing grain, and securing essential documents and valuables on higher floors of their homes.

"We store important documents and money in the room ceiling to keep them safe from water or flooding." - Ward 4 Representative, Gulariya Municipality.

Additionally, they have begun cultivating flood-resilient paddy varieties, such as *Sawa Mansuli* and *Sab Ek*, which can regrow even if submerged in floodwater for up to three days.

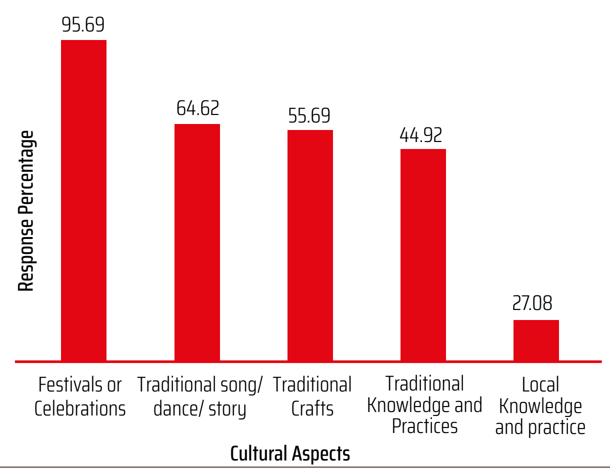
About 82% of respondents reported not receiving any training or support related to flood mitigation or adaptation. Among those who did receive training, they mentioned awareness programmes on evacuation procedures, preparing go-bags, and storing essentials in the upper compartments of houses for those living in frequently inundated areas.

D. Impact on Cultural Practices and Traditions

About 72% of respondents reported no impact on cultural sites and landmarks, while 13% mentioned that temples were affected, and the remaining 15% reported damage to a worship space for the collective village deity, *Maruwa*, in the Tharu culture.

Similarly, festivals and celebrations for that particular year were disrupted. Over time, the frequency of traditional songs, dances, and crafts decreased, and practices related to traditional rituals were altered. Festivals and celebrations were the most significantly impacted, with 95.89% of respondents reporting changes, affecting almost all respondents. The impact also extended to traditional songs, dances, and stories (64.62%), traditional crafts (55.69%), and traditional knowledge and practices (44.92%). Local knowledge and practices were the least affected, with 27.08% of respondents reporting changes. Additionally, death rituals and cremation sites were impacted by the erosion of the sites, deposition of mud or water, and damage to surrounding roads (Figure 38).

Figure 39:Impact on cultural practices due to flood incident



E. Impact on social cohesion and gender-based violence

During the survey, about 27% of respondents mentioned a decrease in social cohesion and interaction following the flood. Among this group, the most significant reason (96.70%) was the impact on community forests, as people relied on forest products for their daily needs, which was interrupted due to the loss of these resources. A smaller proportion reported the impact on community buildings (4.37%) and parks (2.19%). Participants in the FGD also noted that the disruption in social cohesion was partly due to the uneven distribution of relief materials.

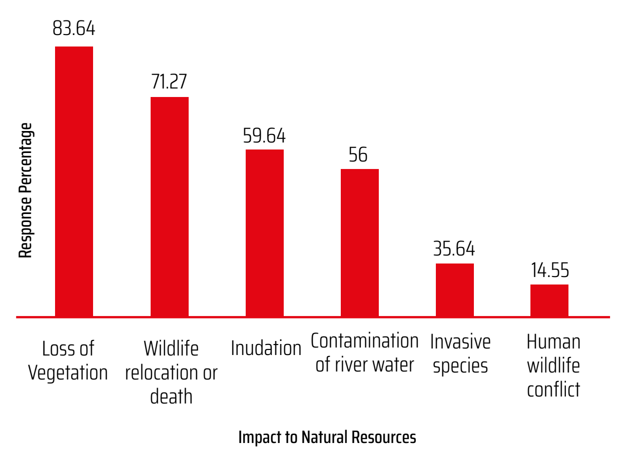
About 27% of the repondents indicated experiencing some form of dispute owing to an increase in disputes over resources, different types of social conflicts, and disputes arising from disparities in compensation distribution.

In the context of 2014 floods, small percentage of respondents (1.14%) indicated that the flood and its associated challenges led to an increase in GBV and conflicts, primarily manifesting as increased disputes among family members, which ultimately resulted in violence.

F. Environmental Impact:

Regarding the impact of floods on natural resources, the loss of vegetation was identified as the most significant consequence, followed by wildlife relocation or death, inundation and river water contamination. Invasive species and human-wildlife conflict were less commonly reported.

Figure 40: Environmental impacts



G. Relocation

Nearly 16% of respondents reported being relocated due to the impacts of flooding- major causes being frequent flooding, damage to assets, resulting water pollution and conflicts.

3.2.4 Financial Compensation and Support

According to the 'Bardiya Flood Disaster 2071 (Activity 2071/7/11)' report by the District Disaster Relief Committee, the flood in Gulariya Municipality caused significant devastation. A total of 1,681 houses were destroyed, affecting 8,434 individuals, while 5,633 households sustained partial damage, impacting 27,603 people. The disaster resulted in four confirmed deaths, with three individuals still missing as of the report date. In response, compensation measures have been implemented, providing NPR 28,000 (USD 250) for each verified death and NPR 50,000 (USD 446.42) for each affected family.

The household survey respondents also reported receiving support from the government and various organisations after the incident. Approximately 90% of respondents mentioned receiving assistance, with 74% receiving economic support and 50% benefiting from technical and logistical support provided by government bodies and organisations. This support mainly consisted of emergency relief, cash assistance, and logistical supplies such as tents and clothing for temporary shelter. Additionally, some support was provided at the individual level, including cash, technical, and logistical assistance.

According to a report from the Ministry of Urban Development's Department of Urban Development and Building Construction, 1,552 households in Gulariya received the first installment of NPR 50,000 (USD 446.42) each following the devastating floods of 2014. This financial aid was aimed at supporting the affected families in municipality as they began the recovery and rebuilding process. In response to the 2014 flood, several houses were constructed in Ward 4 of Gulariya, and respondents were relocated with financial assistance. The total financial contribution included NPR 3,00,000 (USD 2678.57) from Gulariya Municipality, NPR 158,820 (USD 1418.03) from civil societies, and NPR 2,32,731 (USD 2077.95) per household from the community.

Additionally, when asked about other financial risk management tools, respondents indicated that grants were considered the most useful, followed by insurance, reconstruction support and social protection schemes.

4 Recommendations and Way Forward

The following section provides general as well as specific recommendations based on the findings of the study.

Key recommendations of the study for the Loss and Damage Assessment Framework 2021

- In the case of drought hazard, the given indicators in the framework aren't enough. We need to consider the SPI as the key indicator.
- The drought hazard is slowly but steadily rising. It is important to monitor the phenomenon and attribute it to climate change. For this, there is a crucial need for an integrated drought information mechanism and multistakeholder collaboration.

Policy Recommendation

- Slow onset disasters like drought have profound impacts on the communities. L&D Assessment Framework needs to develop methods and tools to understand slow onset disaster and its impacts.
- NELD is prominent in both disasters. Therefore, there is a need to enhance our understanding on NELD and develop methods and framework to document and address them.

General Recommendations

- Capacitate local institutions to understand, document, and address loss and damage.
- Invest in community empowerment through locally-led adaptation initiatives, leveraging the capacities of local governments, communities, and CBOs.
- Integrate immediate L&D responses with strategies for long-term resilience-building, ensuring that adaptation options are aligned with local needs.
- Facilitate community dialogues to reduce resource-based conflicts and strengthen social cohesion, especially in areas with limited resources being depleted due to environmental and climate-related changes.
- Improve the reliability of local climate data and incorporate soil and environmental monitoring to inform evidence-based adaptation planning.
- Promote gender-responsive adaptation actions by addressing unique impacts on women and marginalised groups, ensuring their participation in planning and implementation.
- Promote sustainable water management strategies, such as rainwater harvesting, soil management techniques, and efficient irrigation facilities, such as drip irrigation.
- Design watershed management plans to protect and restore degraded watersheds and ensure water flow throughout the year.
- Introduce drought-tolerant crop varieties, promote agroforestry, and integrate pest management to improve resilience to droughts.
- While the methodologies and tools developed align with the national framework, its broad scope allows for flexibility in assessing L&D. Consistency can be achieved if future studies apply the same framework, even if different methodologies are used.

Municipality and hazard specific Recommendations

Dullu Municipality (Drought)

- Implement watershed management plans to ensure sustainable water availability and ecosystem health.
- Empower women through water management and resource conservation strategies to address their disproportionate burdens.

- Establish community-based water-sharing conservation initiatives to minimise conflicts over water resources.
- Invest in soil quality monitoring to support farmers toward resilient crops and improve agricultural productivity.
- Enable access to health services to address the increase in waterborne diseases and physical stress associated with water collection.
- Increase funding for sustainable irrigation infrastructure and community-led afforestation programmes to conserve water resources.
- Build capacity for community members to lead and manage context-specific adaptation actions, enhancing local ownership and sustainability.

Gulariya Municipality (Flood)

- Strengthen flood preparedness through early warning systems and community-based risk communication mechanisms.
- Promote sustainable agricultural practices, including flood-tolerant crop varieties, to mitigate losses from recurrent floods.
- Build and maintain flood barriers, improve drainage systems, and relocate vulnerable communities to safer areas.
- Coordinate with communities to design and implement equitable and conflict-sensitive flood relocation plans.
- Provide farmers access to crop insurance, financial support, and risk transfer mechanisms for adequate recovery.
- Develop gender-responsive flood action plans to address the specific challenges faced by women during flood events.
- Organise community dialogues to manage conflicts arising from flood relocation or resource redistribution.
- Leverage local government initiatives and build community capacity for participatory flood risk management.
- Improve future flood assessments by integrating comprehensive temporal and spatial data on flood impacts.
- Establish a database system that is periodically updated at the local level to keep track of L&D from flooding and associated climate-induced hazards.
- Incorporate local and traditional water conservation practices in development planning to ensure the sustainability of the interventions.

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3	Member	Rekha Kandel, Secretary, Ministry of Interim Affairs and Law Gangadhar Pandey, DRR Focal Point, Ministry of Interim Affairs and Law
4	Member	Nirmal Chaudhary, Ministry of Forest and Environment Mahendra Chaudhary, Ministry of Forest and Environment
5	Member	Subodh Guragain, Ministry of Energy, Water Resources, and Irrigation
6	Member	Ghanshyam Chaudhary, Ministry of Agriculture, land Reform and Cooperatives Anup Tiwari, Agriculture Economist- Ministry of Agriculture, land Reform and Cooperatives
7	Member	Disaster Focal Person from Gulariya Municipality

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1	Coordinator	Ramesh Kumar Giri, Ministry of Industry, Forest, Environment, and Tourism
2	Member Secretary	Puskar Pd. Sharma - SOSEC Nepal
3	Member	Shamsher Bahadur Shahi – Dullu Municipality, Dailekh
4	Member ('s)	Dhan Bahadur Kathayat, Ministry of Land Management, Agriculture & Co-operative Krishna Kokaya, Ministry of Internal Affairs and Law Kamala Khan , Ministry of Water Resources and Energy Development
5	Member	Representative from the Mid-West University Agriculture Campus

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3.	Member	Department of Hydrology and Meteorology
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