

Traditional Knowledge and Practices for Resilience to Climate Change in Nepal's Mid-Hills: Perspectives from Darma and Madi Rural Municipalities

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Lund 2023

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Number of pages: 60

Keywords

Climate change, traditional knowledge, Indigenous knowledge, Nepal, resilience, agriculture, Magar

Abstract

With climate change impacting countries around the world, rural communities in Nepal are among those most affected. As acknowledged by global climate discourses, traditional knowledge plays a vital role in understanding and adapting to climate change. Therefore, the purpose of this research is to explore how community members from Darma and Madi Rural Municipalities in western Nepal experience the impacts of climate change, how their traditional knowledge and practices contribute to resilience to these impacts, and how they may integrate non-traditional knowledge to further enhance resilience. This was achieved by conducting 34 interviews and four focus group discussions in the two municipalities, which were analysed through grounded research methods and linked to the resilience functions of anticipating, recognizing, adapting, and learning. The results reflect that participants have observed significant changes in their environment, which have affected local agriculture, livestock, health, and financial stability. The researchers found that community members employ a variety of traditional practices and knowledge contributing to environmental, economic, social, and infrastructural resilience. These practices relate to agriculture and livestock rearing, water, hazard and forest management, health, social organizing, and infrastructure. However, challenges in managing unprecedented environmental changes and unpredictable impacts have also led some community members to further enhance their resilience by adopting non-traditional practices. While such practices show initial benefits for local farmers' resilience, long-term effects need to be further researched, as well as approaches for the holistic integration of traditional and non-traditional knowledge within the communities.

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Avdeleningen för Riskhantering och samhällssäkerhet, Lunds tekniska högskola, Lunds universitet,
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Acknowledgements

This research was conducted with the invaluable input, support, and time of the International Federation of the Red Cross (IFRC), Finnish Red Cross Society (FRC), and Nepal Red Cross Society (NRCS). Thank you to all the staff and volunteers of these organizations that provided support and ensured the ability of the authors to complete this project. The authors would like to give a special thank you to **Sushma Shrestha**, Country Manager, and **Kalpana Rijal**, Finance and Programme Support Officer, from the Finnish Red Cross Society. This research could not have moved forward without your strong and continued support.

The authors are also so incredibly grateful to the staff of the NRCS that supported this project, including **Buddhi Sagar Shrestha**, Director Community Development Department, and **Nanda Raj Thapaliya**, Program Manager. A massive thank you to **Kiran Acharya**, WASH Engineer, for providing translation and logistics support in Salyan District, and to **Arjun Khanal** for translation in Rolpa District. A further thank you to **Urgesh Parsaila**, **Bikesh Mahara**, **NRCS Social Mobilizers**, and all the **interview participants** willing to share their valuable experience and knowledge.

Thank you to our supervisor **Per Becker**, Professor of Risk and Sustainability at the Division of Risk Management and Societal Safety, for his support and guidance throughout this research process. We especially appreciate his compassion and understanding as we navigated some unforeseen health challenges that impacted our research timeline and planning.

Last, but certainly not least, we want to express our deep gratitude to our friends and family who supported us throughout the research and writing process of this thesis. A special thank you goes to our family members **Henri, Leslie, Andreas, Ute, Rita, and Bart** for supporting us in so many ways.

Summary

Across Nepal, communities are confronting the compounding effects of climate change. Rural and Indigenous populations are often disproportionately vulnerable to climate change impacts due to reliance on natural resources and experiences of socio-political marginalization. However, these communities also hold important traditional knowledge and practices that contribute to resilience in the face of changes. Global discourses on climate change have progressively called for the recognition of traditional knowledge in supporting community resilience and adaptation. To support these efforts, this thesis explores how two rural communities in western Nepal experience the impacts of climate change, how their traditional knowledge and practices contribute to resilience to these impacts, and how they may integrate non-traditional knowledge to further enhance resilience. In this research, the concept of resilience is understood in alignment with Becker (2014), building on the functions of anticipation, recognition, adaptation, and learning. A grounded research approach was adopted to capture local community perspectives through 34 interviews and four focus group discussions with residents of Darma and Madi Rural Municipalities in Salyan and Rolpa Districts in Nepal. The limitations of this research include potential misinterpretations due to language barriers and cultural biases of the researchers, as well as constraints on exploring all existing changes, impacts and traditional and non-traditional practices. Therefore, this research does not claim an exhaustive representation of all community perspectives. Additionally, while particular parallels regarding climate change impacts and traditional practices in other areas of Nepal were found, the generalizability of the insights from this research may be limited.

Discussions with community members revealed that both districts have experienced increasingly erratic rainfall patterns, shifting seasons, high and low-temperature extremes, and variations in snowfall, fog, and wind. These changes have had pervasive impacts on water availability, occurrence and severity of hazards, emergence of pests and invasive species, livestock rearing, mental and physical health, and livelihoods and financial stability. They also interact with wider societal changes, such as shifting dietary trends and access to increasingly globalized markets. While these changes have created new challenges or exacerbated existing ones, community members in Darma and Madi have maintained a variety of traditional practices and knowledge that contribute to their environmental, economic, social, and infrastructural resilience. Some of these practices include agricultural techniques that determine which crops are used, how they are grown, how soil is managed, and specific techniques for crop irrigation and water collection. Others include health practices, such as the use of medicinal herbs, and the formation of community support groups including farmers' groups, mothers' groups and the *Parma*

system. The management of water, forests, and hazards is also informed by traditional knowledge rooted in a time-tested understanding of local environmental dynamics.

Many participants highlighted challenges in dealing with rapid, unprecedented environmental changes. Significant concerns raised by interviewees include the inability to predict rain patterns, a lack of knowledge for managing water scarcity, and concerns about potential crop losses leading to insufficient household income. Therefore, this research also investigates how community members integrate non-traditional practices to further enhance their resilience. Predominant practices include changes in agriculture through the integration of new types of crops, use of machinery, and chemical pesticides and fertilizers. Some community members are also diversifying their livelihoods through labour migration, commercial livestock farming, and shop keeping. Health and medicinal practices have also changed with increasing access to hospitals and clinics, while new infrastructure sometimes integrates imported materials with traditional approaches. While in certain scenarios, non-traditional practices can offer vital solutions to emerging challenges, in other cases, traditional methods might be better suited due to their contextualized nature. Based on the perspectives and experiences shared by community members, this research finds that in Darma and Madi, both traditional and non-traditional knowledge can improve resilience, particularly when integrated by community members in alignment with local needs and interests. This requires directing further attention to the benefits of traditional knowledge and the development of effective integration strategies to bridge gaps identified by local communities. Furthermore, the sustainability and long-term effects of many new techniques are yet to be investigated in these contexts and therefore offer opportunities for further research.

List of Abbreviations

BS	Bikram Samvat (official calendar of Nepal)
CCA	Climate Change Adaptation
CGT	Constructivist Grounded Theory
CRI	Climate Risk Index
FGD	Focus group discussion
FRC	Finnish Red Cross
GMO	Genetically modified organism
IFRC	International Federation of the Red Cross
IPM	Integrated Pest Management
IPNM	Integrated Plant Nutrient Management
NEFIN	Nepal Federation of Indigenous Nationalities
NRCS	Nepal Red Cross Society
SOM	Soil organic matter
UN	United Nations
WIPO	World Intellectual Property Organization

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1. Introduction

Although Nepal is among the lowest greenhouse gas emitters in the world, it is considered a global warming hotspot because of the direct impact of climate change on its people and local resources (Kapoor et al., 2021). Changes in temperature and precipitation are already affecting local water access, sanitation and health, agriculture, and livelihoods. Communities are also experiencing increasing frequency and severity of natural hazards including drought, heatwaves, and flooding, with over 80 percent of the population exposed to climate-related hazards (Kapoor et al., 2021; Ministry of Forests and Environment, 2019). These impacts are especially pronounced among vulnerable populations, such as rural communities and Indigenous groups, who tend to be more dependent on natural resources for livelihoods and may face economic, political or social marginalization (Khanal et al., 2019). However, across Nepal, a diverse range of traditional and Indigenous knowledge systems exists which have helped communities adapt to changes over time (Karki & Adhikari, 2015; Karki et al., 2017). In recent years, there has been an increase in research focused on different traditional knowledge systems in the context of climate change across the country (Acharya et al., 2016; Chaudhary et al., 2021; Khanal et al., 2019). Nonetheless, this field is still under-researched, with academics calling for improved documentation of traditional and Indigenous knowledge for climate change adaptation and resilience in Nepal (Gyawali et al., 2021; Biggs et al., 2013).

The purpose of this research is to explore how traditional knowledge is supporting community resilience to climate change in Darma Rural Municipality, Salyan District and Madi Rural Municipality, Rolpa District in the western hills of Nepal. Existing research on this topic has so far focused on other areas in the country (Acharya et al., 2016; Chaudhary et al., 2021; Khanal et al., 2019). Therefore, this research contributes to closing existing gaps in the field and offers a place-specific perspective. Furthermore, it was supported by the Finnish Red Cross (FRC), the International Federation of the Red Cross (IFRC), and the Nepal Red Cross Society (NRCS), who have demonstrated a strong interest in the research results to inform program development to support community resilience and CCA in Nepal.

This research addresses three main questions:

1. What changes and associated impacts have community members experienced in their surroundings in recent years?
2. How do traditional practices and knowledge systems support resilience to climate change-related impacts in the communities?
3. In what ways have community members integrated non-traditional practices and knowledge systems with traditional approaches to support their resilience?

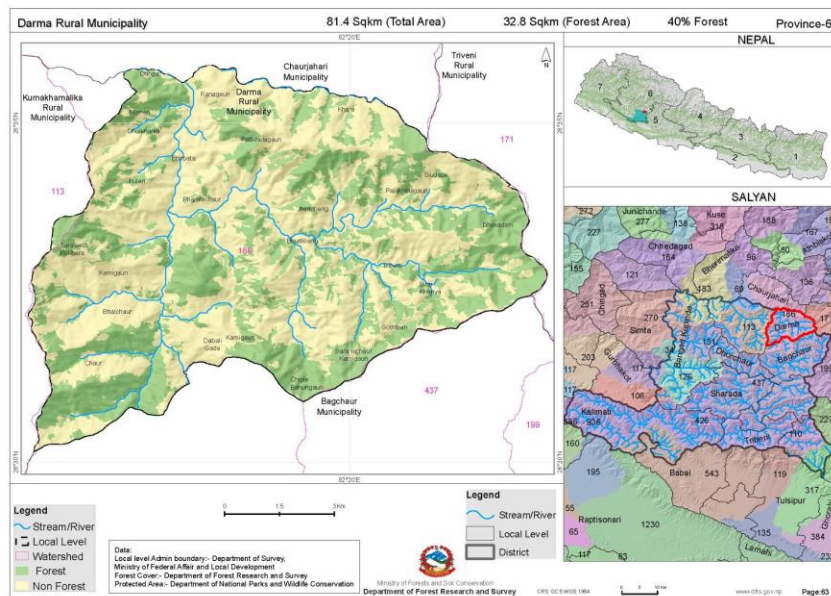
In order to understand the complex relationship between climate change and traditional practices and knowledge, this research explores the recent changes that participants have observed in their surroundings and subsequent impacts across many aspects of community life. It then examines how traditional and non-traditional practices contribute to local environmental, economic, social, and infrastructural resilience in relation to Becker's (2014) concept of form and functions of anticipating, recognizing, adapting, and learning.

2. Background and Research Area

2.1 Geographies and Climate

Nepal is a landlocked country, bordered to the north by the Autonomous Region of Tibet, and to the south, east, and west by the Republic of India. As of 2011, Nepal's population totals at 26.5 million. The country's landscape is known for its high mountains, glaciers, numerous rivers, tectonic valleys, and rugged terrains. Geographically, Nepal is divided into three regions: the Himalayas, Hills, and Terai (flat region). Its highest point is Mount Everest, with an elevation of 8848 meters, and the lowest point measures 62 meters above sea level, located in the southern Terai. Within the country, there is a wide-ranging network of parks and protected areas, which attract many tourists (Bhattarai & Conway, 2021).

Figure 1
Map of Darma Rural Municipality

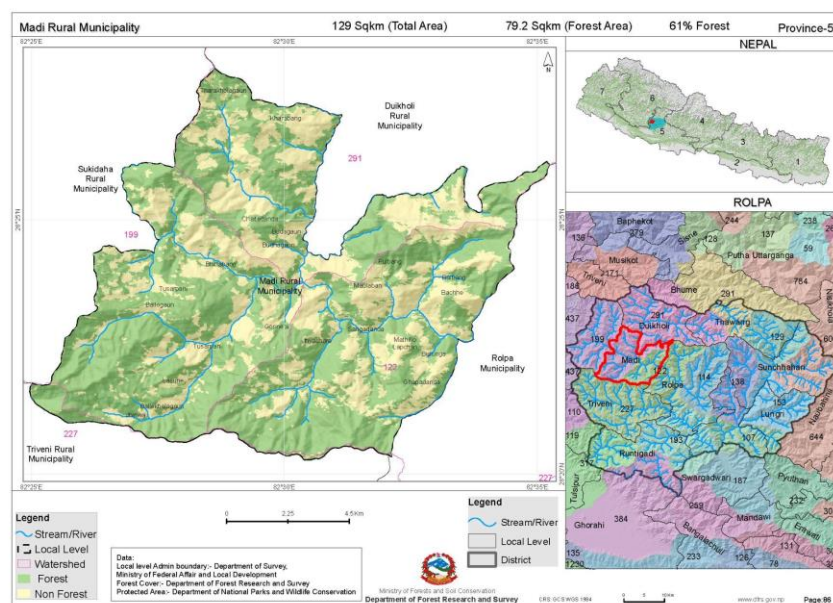


Note. From “Local Resource Map - Salyan - Darma Rural Municipality”, by Nepal in Data, 2018a, (<https://nepalindata.com/resource/Local-Resource-Map---Darma-Rural-Municipality/>). Copyright 2017 by the Department of Forest Research and Survey.

The central municipalities for this research are Darma and Madi Rural Municipalities, located in the western mid-hills of Nepal. Darma Rural Municipality lies in Salyan district in Karnali province and spans over an area of 81.46 km². It is located at an altitude ranging

from 1097 to 2487 meters and includes six different wards (Darma Rural Municipality, n.d.). Madi Rural Municipality is situated in the north-western part of Rolpa District, Lumbini Province. The village comprises six wards and spans over an area of 129.05 km². The village center, Gharti Gaun, is named after the Madi river, which runs through the region. The altitude of Madi Rural Municipality ranges from 900 meters to 2700 meters above sea level (Madi Rural Municipality, n.d.). Due to the high variances in altitude, the topographies feature both gentle slopes and steeper hillsides. As seen in Figures 1 and 2, forest cover occupies 40% of Darma and 61% of Madi. These factors have significantly shaped land use practices in the region, despite only approximately 14% of Salyan's and 11% of Rolpa's surface area being arable land (Government of Nepal, 2013a, 2013b). Salyan and Rolpa districts are part of a greater region crossed by the major rivers flowing southward from the higher mountain ranges in the north, thus representing a major water source for the local population (Gurung et al., 2019).

Figure 2
Map of Madi Rural Municipality



Note. From “Local Resource Map - Rolpa - Madi Rural Municipality”, by Nepal in Data, 2018b, (<https://nepalindata.com/resource/Local-Resource-Map---Darma-Rural-Municipality/>). Copyright 2017 by the Department of Forest Research and Survey.

The climate in the research area is influenced by two major weather circulation systems: the summer monsoon, which lasts from June to September, and the westerly circulation, taking place from November to May. During the summer monsoon, the country receives around 80% of its annual precipitation (Karki et al., 2016, p. 800). The research districts have a subtropical to temperate climate with dry winters and warm to hot summers, and

the region is known for its highly diverse ecosystems and varied vegetation (Karki et al., 2016; Dhital et al., 2023). The interplay of geography and climate in the mid-hills have profoundly influenced agricultural systems and cultural practices in the region. Many farmers utilize the steep hills for traditional terrace farming and integrate forest resources and livestock rearing activities into local agroforestry practices (Amatya et al., 2018).

The changing climate has increasingly impacted Nepal's diverse geographies, with rising temperature extremes and erratic rainfall patterns expected to trigger more droughts, landslides, mudflows, flooding, and avalanches in the future. On the Climate Risk Index (CRI), Nepal is ranked as the 10th country most affected by climate change in the last decade (Eckstein et al., 2021). It also occupies the 125th position on the ND-Gain Country Index, which determines a country's vulnerability to and readiness for climate change and related challenges (ND-Gain, 2023). The ecological impacts of extreme weather are particularly pronounced in the mid-hills and mountainous regions, where they threaten local agricultural activities. As highlighted by Biggs et al. (2013, p. 166), "acceleration in the rate of climate change is making adaptation increasingly difficult for rural populations, particularly for those entirely dependent on the environment for subsistence."

2.2 Demographics

According to the national census, in 2068 BS (2011/12 AD), Darma Rural Municipality had a population of 19,966 people. A total of 3460 households reside in this area, and the population is diverse in terms of ethnicity and religion. Darma Rural Municipality features multiple educational institutions, from basic to higher level. In terms of religion, the village is populated by Hindus and Christians. Agriculture is the primary source of income for locals, although there are other occupations such as trade, labour, industry, and foreign employment (Darma Rural Municipality, n.d.). Generally, Nepal's economy relies heavily on agriculture and around 60% of the population is engaged in this sector, which is especially crucial for ensuring food security in rural districts (Government of Nepal, 2020; Dhital et al., 2023; Biggs et al., 2013). However, due to the abandonment of farming areas, agricultural contributions to national GDP have dropped from 80% in the 1980s to 26% in the recent decade (Bhattarai et al., 2020).

Madi has a population of 23,464 people, the majority of whom belong to the Indigenous Magar community (Madi Rural Municipality, n.d.). The village municipality is composed of five former village development committees that were merged to form Madi (Madi Rural Municipality, n.d.). Generally, Rolpa District is predominantly rural, with agriculture also being the main source of livelihood for the local population. The district is also known for its historical significance, as it was the birthplace of the Maoist insurgency in Nepal in 1996 (Ojha, 2021). While it is accessible by road, the transportation infrastructure is limited, and a lack of employment opportunities has led the young population to

increasingly migrate. As of 2013, Rolpa was labelled as “highly vulnerable” to the impacts of landslides and epidemics, especially during the monsoon period (UNRCHCO, 2013).

Despite its small land area and population, Nepal comprises over 125 ethnic communities who speak 92 different languages (Central Bureau of Statistics, 2012). The country is populated by a diverse set of Indigenous groups, nowadays called *Adivasi Janajati* (Bennett et al., 2008). The Magar are the largest Indigenous group in Nepal’s hill region and comprise 7% of the country’s total population. Their origins are contested, but they are commonly believed to have Mongolian or Tibetan roots and have been settled in Nepal for more than 2500 years (Magar, n.d.). Many of them became known for serving as Gurkha soldiers for the Indian and British military. The Magar follow a different set of religious traditions: the majority are Hindu, some are Buddhist, and certain rituals and beliefs of tribal and shamanic origins are also practised (Sapkota, 2011; Torri, 2019). In Rolpa, 43% of all inhabitants are Magar, and most families are involved in agricultural activities (Government of Nepal, 2011; Subba et al., 2014).

Like other Indigenous communities in the country, the Magar have not always experienced equal access to rights and decision-making power. Only recently, the non-discrimination of all citizens and right of every person to food, health care, and a clean environment was legally enshrined in Nepal, and the government ratified international declarations on the rights of Indigenous peoples (Tamang, 2017). While the 2007 Nepal constitution has been “comparatively promising in terms of reflection of indigenous peoples’ issues and rights” (Maharjan & Maharjan, 2017, p. 276), advocates of indigenous rights continue facing ongoing challenges in actualizing these rights in their day-to-day lives due to limited access to power and protection (Maharjan & Maharjan, 2017). In a recent report, the Nepal Federation of Indigenous Nationalities (NEFIN, 2021) criticized the lack of involvement of indigenous populations in decision-making and needs assessments for the promotion of climate resilience in Nepal. This highlights that, despite certain legal protections and recognition, indigenous communities in Nepal still face challenges regarding proper representation and inclusion on all levels.

Another group living in Salyan and Rolpa that has faced historic marginalization is the Dalit caste. The Dalit caste predominantly lives in the rural hills and makes up around 13% of the Nepalese population, including 26 further sub-caste communities (Central Bureau of Statistics, 2012). The caste system is deeply rooted in Nepal’s political, social, and cultural development and has strongly influenced Nepalese society and customs. Through the Hindu Varna system, the lowest castes such as the Dalit were considered “untouchable”, and therefore effectively excluded from meaningful participation in society. In the 20th century, affected communities started advocating for their rights and fought for the abolishment of discriminatory practices, gaining momentum in Nepal during the

1990s (Bishwakarma, 2017). Political reforms in 2007 legally eliminated caste-based discrimination and improved the inclusion of Dalit groups in the political sphere (Tamang, 2017). While nowadays, the word 'Dalit' itself is no longer commonly spoken, as it is perceived as derogatory, many still face unequal access to power, economic exploitation, educational disadvantages, and political marginalization (Bishwakarma, 2017; Tamang, 2017). While this research does not explicitly focus on this aspect of Nepali society, it is worth noting that these political, social, and economic dynamics may influence the different experiences expressed by participants in interviews and their capacity to adapt to the impacts of climate change.

3. Conceptual Clarifications

3.1 Traditional and Indigenous Knowledge

Definitions of traditional knowledge are varied and have undergone considerable changes throughout time. The World Intellectual Property Organization (WIPO) (2012, p. 43) defines traditional knowledge as

knowledge that is dynamic and evolving, resulting from intellectual activities which is passed on from generation to generation and includes but is not limited to know-how, skills, innovations, practices, processes and learning and teaching, that subsist in codified, oral or other forms of knowledge systems. Traditional knowledge also includes knowledge that is associated with biodiversity, traditional lifestyles and natural resources.

This definition was selected as it includes various types of knowledge and emphasizes the role of dynamic change and innovation in traditional knowledge systems - a characteristic that has historically been ignored (Matsui, 2015). In the research communities, traditional knowledge has emerged in the form of practices, beliefs, attitudes and values that were passed down by either the participants' parents, grandparents, or ancestors that lived multiple generations back. However, due to temporal proximity, most persons could only recall learnings from their parents or grandparents, which are here understood as traditional.

The concept of Indigenous knowing is also important for the research conducted in Madi Rural Municipality, which is predominantly populated by the Magar Indigenous community. Although often used interchangeably, the terms 'traditional' and 'Indigenous' can be distinguished through the definition by WIPO (n.d.), according to which Indigenous knowledge is traditional, but traditional knowledge is not necessarily Indigenous. According to the 2002 Indigenous Nationalities Act of Nepal, Indigenous peoples are defined as "having their own mother tongue, distinct traditional values, and cultural identities, including social structure and written/non-written history" (Acharya et al., 2016, p. 53). Indigenous knowledge is characterized by being collective, location-specific, intergenerational, experiential, tacit, holistic, and dynamic. While traditional knowledge can also embody these characteristics, unlike Indigenous knowledge, it is not always unique to a specific cultural group (Orlovic Lovren, 2019, p. 1034; Warren & Rajasekaran et al., 1993). While some community members participating in this research have identified as Indigenous, others hold traditional knowledge that is not associated with an Indigenous identity. Therefore, the authors decided to utilize the term traditional

knowledge, which also encompasses the views expressed by members of the Indigenous Magar population in Madi, unless otherwise stated.

3.2 Climate Change and Resilience

As defined by the UN (1994), climate change refers to a shift in climate that is caused directly or indirectly by human activity and deviates from natural climate variability. Many climate change indicators are not directly observable by individuals in their daily lives, as they are measured by scientific means and supported by mathematical modelling over an extended period. As highlighted by Spence et al. (2011, p. 46), direct observations and experiences of climate change are predominantly limited to the weather and specific seasonal events. Nonetheless, the process of involving people's experiences in the recording of environmental changes shows high relevance in the climate change discourse, particularly due to the consideration of complex social factors and emotions (Lawrence, 2009). The government of Nepal has identified a range of observable indicators that determine the country's exposure to climate change, including extreme events, changes in temperature and precipitation trends, drought and flooding, and changes related to agricultural and livestock productivity, invasive species, and pest occurrence (Government of Nepal, 2022). In this study, observations relating to such changes in the environment and their impacts are treated as indicators for local experiences of climate change. This is not to replace, but rather to complement statistical analyses of environmental changes in Nepal through personal accounts and experiences.

As defined by Becker (2014, p. 143), resilience is "the capacity of a human-environment system to continuously develop, while remaining within human and environmental boundaries". This concept has been chosen as it allows for dynamic interpretations without being prescriptive of resilience indicators, taking into account how human and environmental boundaries are socially constructed and differ based on what is valued in each context (Becker, 2014, p. 144). Resilience emerges through four functions: anticipation, recognition, adaptation, and learning. Anticipation is a proactive function that refers to the ability to predict potential events that may occur in the future. Recognition refers to the proactive monitoring of important variables that may lead to undesirable events, as well as the reactive assessment of consequences caused by actualized events (Becker, 2014, p. 157). Adaptation involves a system's capacity to change or transform in the face of impacts and includes the actions that people take which contribute to the prevention and mitigation of, preparation for, response to, and recovery from the impacts of climate change in their environment (Becker, 2014, p. 159). While preventive action reduces the likelihood of an event, mitigation limits the consequences of such an event ahead of time, and preparation eases the later response and recovery from the event if it occurs. Responding focuses on the direct impacts of real deviations, while recovery aims to restore such impacts to return to the initially envisioned scenario (Becker, 2014, p.

159). Finally, learning encompasses the experiential understanding and reflecting of the impacts of past events, as a “constant cycle of action and reflection” that informs the other functions of anticipation, recognition, and adaptation (Becker, 2014, p. 154-162). In addition to these four functions, form also constitutes an important element of resilience. It relates to the complexity within the system, ranging from different kinds of knowledge and skills to rules, regulations, formal institutions and norms, values and informal institutions (Becker, 2014, p. 165). This research explores the form and functions of resilience across four general themes of environmental, economic, social, and infrastructural resilience.

4. Methodology and Methods

This research builds on an abductive approach to produce an understanding of how community members experience climate change, which traditional knowledge and practices are present within the communities, and how these may or may not contribute to resilience. This bottom-up approach attempts “to present descriptions and understanding that reflect the social actor’s points of view rather than adopting entirely the researcher’s point of view” (Blaikie, 2010, p. 91). It aligns with Constructivist Grounded Theory (CGT), which is rooted in the interpretive tradition and prioritizes understanding the reality of study participants. This is particularly important when discussing local and traditional knowledge. CGT also builds on the idea that the researcher actively co-creates the research process, as data and analysis emerge “from shared experiences and relationships with participants and other sources of data” (Charmaz, 2006, p. 130). Using CGT, the research team examined how meanings and actions regarding climate change, resilience, and traditional knowledge are constructed in the two rural communities. As described by Charmaz (2006, p. 130), the researchers “realised that [they] cannot replicate the experiences of (...) research participants,” and that the final research outcomes are themselves interpretations. It was therefore important for the researchers to reflect on their values, perspectives, and biases, and reconfirm information during interviews to ensure the understood narratives aligned with those of the community members (Blaikie, 2010, p. 90).

4.1 Data Collection

This research consists of 34 semi-structured interviews and four focus group discussions (FGDs) with community members in Darma and Madi Rural Municipalities. These municipalities were selected based on the Red Cross’ identification of these areas as being highly vulnerable to climate change and their ability to provide logistical support. The interviews and FGDs were conducted in-person by one member of the research team between February and March 2023 and ranged between 37 and 74 minutes in length, with an average of 57 minutes. Translation between English and Nepali was provided by translators affiliated with the NRCS. The semi-structured nature of the interviews allowed space for participants to express their perspectives in rich detail through guided conversation (Curry, 2015). Open-ended interview questions and potential probes were developed in line with Charmaz’s (2006, p. 30-31) recommendations regarding intensive interviewing. Two focus groups were conducted in each district: one composed of a mixed-gender cohort and the other composed of only female participants. Research has shown that providing spaces for women to express themselves can shed light on the often-overlooked contributions they make, allow them to connect their personal

experiences, encourage the questioning of dominant beliefs, and discuss gender issues or differences (Pini, 2002, p. 343).

The Interview Guide shown in Appendix A consisted of 14 open-ended questions exploring the following five themes:

- (1) Daily practices and guiding views
- (2) Experienced changes in everyday life
- (3) Responses to changes (past and present)
- (4) Challenges and benefits of changes
- (5) Managing challenges

4.2 Data Sources

This research uses purposeful, non-probabilistic sampling, by which “the inquirer selects individuals and sites for study because they can purposefully inform an understanding of the research problem and central phenomenon in the study” (Creswell, 2013, p. 156). Rather than selecting a sample to be representative of the entire population of the two municipalities, this approach was employed to prioritize participants who hold traditional knowledge and have a relationship to the natural environment, often through being active in local agriculture. In Madi, there was a particular emphasis on selecting individuals from the Magar Indigenous community, as Indigenous knowledge, practices, values and beliefs have been historically marginalized in Nepal (Naharki & Jaishi, 2020).

As the NRCS has been actively engaging with communities in the municipalities of Salyan and Rolpa districts, the organization provided support in identifying community members for participation in this study. After the initial recruitment, other suitable participants were selected through the snowball method (Blaikie, 2010). During the interview process, sample characteristics such as gender and age were continuously evaluated in dialogue with the NRCS to establish a more representative sample. For example, after observing a significant over-representation of men in the initial interviews, the interviewer established a women-only focus group to ensure the voices and perspectives of women were equally represented. To capture a more comprehensive and holistic understanding of the community and its various unique perspectives, efforts were made to increase the diversity of the focus groups by including participants from a wide range of ages and from multiple wards across the two municipalities. Furthermore, while the majority of the participants were engaged in agricultural activities, the research team recognized the importance of including individuals with different occupations and levels of community engagement.

Participant characteristics

In Darma, 16 participants were interviewed one on one, of which 11 were men and five were women. Two FGDs were held with a total of 13 people, one group consisting of five women, and the other including three men and five women. The age distribution of interviewees and FGD participants is illustrated in Table 1 below. As depicted in Figure 4, most people's families have been settled in the area for two to three generations. However, many women reported that they had only moved to the community after marriage to join their husband's families, reflecting a common cultural practice in Nepal.

Table 1

Age distribution of participants in Darma

	<35	35-55	Elder (55+)	Total
Men in FGD	0	3	0	3
Women in FGD	7	1	2	10
Men in Interviews	1	6	4	11
Women in Interviews	2	3	0	5
Total	10	13	6	29

The majority of interviewees in Darma conducted subsistence agriculture, and around half reared subsistence livestock. The predominant income source for participants was commercial agriculture, followed by raising commercial livestock. Those only engaged in subsistence farming relied on alternative sources of income, primarily selling livestock. Notably, many people combined multiple income streams, such as commercial agriculture and livestock, shopkeeping, or work abroad. Four participants owned a shop or business, and most of the men generated income through seasonal or long-term migration abroad. In the all-female FGD, all women were part of the Dalit caste and had husbands who migrated abroad for extended periods. Thus, their main source of income came from their husbands working abroad. Aside from generating income, two males and two females were active as community volunteers in Darma, working in the areas of water and forest management, political participation, and women's rights.

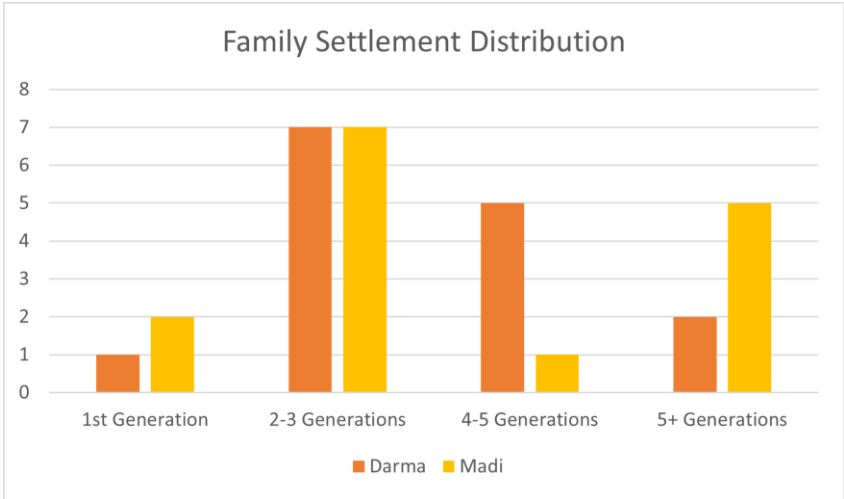
In Madi, interviews were conducted with 16 participants, of which eight were male and eight were female. Two FGDs were held with a total of 12 people, including four men and two women in the first, and six women in the second. The age distribution of participants is shown in Table 2. Out of all the participants, 22 belonged to the Indigenous Magar

community, which is one of the main ethnic groups present in the region. Similar to Darma, the majority of people reported that their families had been residing in Madi for two to three generations. An elder participant of the mixed-gender FGD, who was 70 years old, proudly stated that his family had lived in the community for ten to twelve generations. However, many people were uncertain about how many generations back their ancestors had lived in the village and therefore had to guess.

Table 2
Age distribution of participants in Madi

	<35	35-55	Elder (55+)	Total
Men in FGD	2	1	1	4
Women in FGD	5	2	1	8
Men in Interviews	1	5	2	8
Women in Interviews	2	4	2	8
Total	10	12	6	28

Figure 4
Family settlement distribution of participants in Darma and Madi



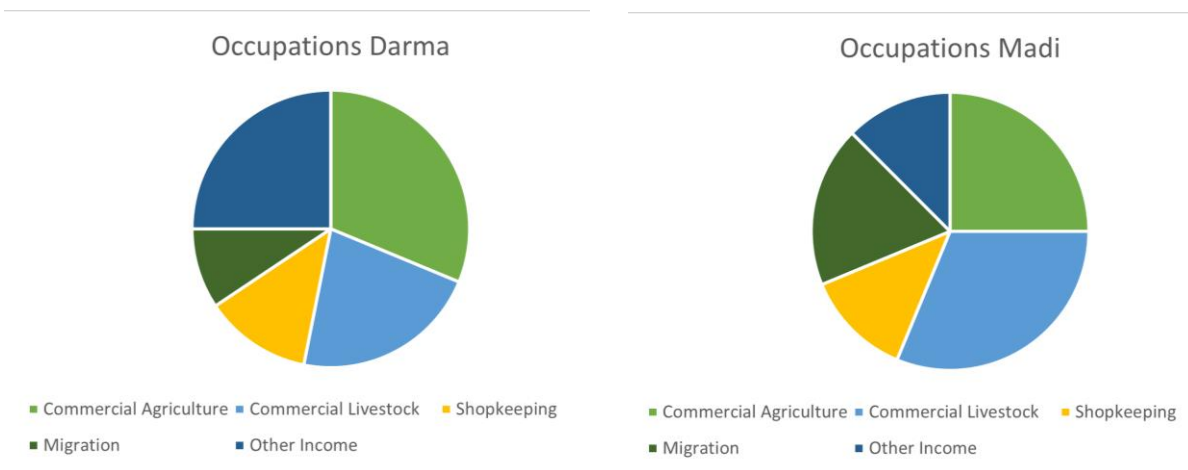
Note. The graphs only include information from interview participants.

Regarding sources of income, more people were involved with commercial livestock in Madi than in Darma. As shown in Figure 5, most participants generated income through

livestock rearing, followed by commercial agriculture. Migration also seemed more common in Madi, as men predominantly migrated long-term, and some were also involved in seasonal work abroad. A few people owned a shop or business or claimed to have other sources of income. Similar to participants in Darma, earnings from commercial agriculture were supplemented with livestock and business endeavours. Subsistence agriculture was practised by the majority of participants, and many people also reared subsistence livestock.

In most households in the two municipalities, community members raised several types of animals, including goats, chickens, cows/oxen, buffaloes, pigs, and sheep. These animals produce milk, eggs, and/or meat, which is consumed by households, made into byproducts such as yoghurt or ghee, or sold for extra income. Assessing the initial differences between the districts, Madi stood out due to elevated rates of animal farming and migratory labour. Additionally, more participants in Madi reported having lived in the village for more than five generations, which might be attributable to the local presence of the Magar Indigenous population. In Darma, the gender balance among interviewees was more evenly distributed. However, the communities also had much in common; agriculture played a major role in income, and results showed that many participants across the districts utilize a combination of commercial, subsistence, and migratory activities to provide for their families.

Figure 5
Occupations of interview participants in Darma and Madi



Note. The occupation distribution in this Figure is not mutually exclusive; several participants enhanced their income with multiple occupations. The graphs only reflect income generation among individual interviewees, not FGD participants.

4.3 Data Analysis

CGT “provides a procedure for developing categories of information (...), interconnecting the categories (...), building a “story” that connects the categories (...), and ending with a discursive set of theoretical propositions” (Strauss & Corbin as cited by Creswell, 2013, p. 195). To avoid imposing theory or concepts on the data as much as possible, the researchers took a “low stance” to derive concepts and meanings from language and words used by community members (Blaikie, 2010, p. 212).

Coding was developed alongside data collection and was based on verbatim transcripts of the interviews and FGDs. To code and organize the data, the research team employed the qualitative analysis software Atlas.ti 23. The data analysis entailed (1) line-to-line coding, (2) focused coding involving the most significant or frequent initial codes to organize large datasets (Charmaz, 2006, p. 46), and (3) axial coding to reunite data into a coherent whole. Line-by-line coding was used to capture interview data as accurately as possible. Subsequently, the codes were grouped based on their frequency to develop category codes and subcodes. The researchers then compared and evaluated the categories and their relationships to identify prevalent themes. Special attention was given to in-vivo codes for specific terms used by participants, to better understand guiding principles, behaviours, and expectations of participating communities. This systematic and comprehensive approach supported a thorough first round of data scrutinization and for the analytical unification of ideas (Charmaz, 2006, p. 71). The second round of analysis consisted of memo writing, which entailed the capturing of thoughts, comparisons, and connections in the data in relation to the initially posed research questions. The researchers gained new perspectives by actively engaging with the data through constant comparison and the establishment of categories (Charmaz, 2006, pp. 72-73).

The key themes that emerged in this analysis were then examined through Becker’s (2014) framework of resilience to highlight the different instances of form and functions of anticipation, recognition, adaptation, and learning. This analysis was done by organizing emergent themes in categories of environmental, economic, social, and infrastructural resilience. While the interview discussions did not include explicit references to resilience, this framework was applied based on the researcher’s understanding of what the participants expressed as meaningful or helpful while facing the impact of climate change in their lives. Relying on the experiences shared by community members was an important step to ground the idea of resilience in local understanding. Lastly, participant knowledge and resilience theory were integrated with wider academic literature to holistically examine how traditional knowledge can contribute to community resilience to climate change in areas of environmental, economic, social, and infrastructural resilience.

Priority was given to literature produced in the past decade and focused on similar regions of Nepal, particularly the mid-hills.

4.4 Limitations and Ethical Considerations

While this research investigated a broad variety of changes, impacts, and practices related to climate change resilience in Darma and Madi, it is not without limitations. It is important to note that the researchers conducting this study are not from Nepal and do not speak Nepali or any other local languages. Therefore, they relied on live translation, which may have contributed to misinterpretation, a loss of meaning, or other limitations regarding what information was shared. In order to mitigate potential misunderstandings and ensure the aligned interpretation of major concepts, the interviewer checked back specific terms and information with the participants throughout the interviews. Furthermore, the researchers' understanding of local experiences and knowledge may have been influenced by their different cultural backgrounds, perspectives, and biases. To address this, interviews consisted of open-ended questions to reduce the imposition of external assumptions and motivations. However, some of the researchers' biases may still have influenced the formulation of questions and analysis of the data. It is also possible that different understandings of what might constitute traditional knowledge influenced what information participants shared. Since the interviews were restricted to a specific period of time, there was also limited opportunity to gain a deeper familiarity with the local community and relevant long-term developments. To foster trust with community members, the local Red Cross community volunteers played a pivotal role in facilitating the interview process.

Before commencing the interviews, the consent forms in Appendices B and C were read aloud by the translator and signed by the participants. This ensured that participants understood the purpose of the study, how the data collected would be used in thesis research, and that their participation was voluntary. While the presence of the Red Cross staff could have influenced participant responses, the role of the interviewers as independent student researchers was made clear. This included emphasizing that this research was not connected to any future Red Cross projects or funding.

Due to the explorative nature of the interviews, language barriers, and the research team's position as external to the communities, there may be traditional and non-traditional practices that are relevant for climate change resilience but did not emerge during interviews and FGDs. Due to the range and depth of information collected by the research team, the themes selected for analysis were chosen based on how often participants raised these topics and the importance they placed on them during interviews. Thus, this research is not an exhaustive representation of the communities and perspectives in Darma and Madi, but rather offers a starting point for understanding

rural experiences and the relevance of traditional and non-traditional knowledge in the face of ongoing climate change. Additionally, traditional knowledge is inherently context-specific. Therefore, while particular parallels regarding climate change impacts in other areas of Nepal were found, the generalizability of the insights from this research may be limited.

Lastly, as part of the interviews with members of the Magar community, the researcher asked participants if they could identify any traditional knowledge, beliefs, or practices that they perceived as being distinct from other cultural groups in the area or country. When asked specifically, participants primarily identified cultural differences including language, traditional clothing, art, and some particular food practices. However, the interviews and later data analysis did not reveal substantial differences in traditional practices in the areas of agriculture, water, forest, and hazard management, health practices, and community organizing. This is not to claim the absence of differences, but rather to note that they were not captured in the interviews.

5. Results

The following section illustrates the results of interviews with community members in Madi and Darma. Answering the first research question, it highlights the recent changes experienced by participants in their surroundings and how these changes impact various aspects of their lives. It also documents the traditional knowledge and non-traditional practices identified by interviewees in connection to their livelihoods and income, health, resource management, community dynamics, and the changes they have been experiencing.

5.1 Climate-Related Changes

Overall, participants emphasized various ways in which weather and the environment have changed recently, including more incidences of drought, changing rainfall patterns, heavier rains leading to landslides and floods, temperature extremes, drying up of water sources, shifting monsoon seasons, sustained morning fog, lack of snowfall, and more dust and wind. Temperature changes were noticed by most participants, with the majority reporting increases and a minority reporting decreases in the overall temperature. Most noted both hotter and colder extremes, including gradual temperatures on a year-to-year, week-to-week, and seasonal basis. Overall, these weather changes were perceived as unpredictable. Interviewees attributed the causes of these changes to a lack of precipitation, climate change, Coronavirus, the presence of dust, smoke, or the old age of the earth. When asked how community members are discussing changes in their environment, one participant shared that “as per the change in atmosphere, there are a lot of construction going on, a lot of dust is everywhere, and the rivers it's been drying up. So, they are thinking, now the earth is getting old.”

Almost all participants discussed changes in rainfall patterns in recent years. Overall, the year-to-year changes in rainfall include delayed rain or drought. Many noted changes in seasonal weather patterns, especially concerning the annual monsoon, which participants remarked was either delayed or early. In the past four to five years, the number of rainy days has decreased, yet the intensity of rainfall has increased. This is a drastic change from the past, where precipitation was more frequent and less heavy, and communities did not experience such a significant shortage of rainfall. One participant in Darma cited a local proverb, that in the past, “even [on] the Buffalo horns, mushrooms used to grow there due to overexposure of rains”. During the time of the interviews, participants were worried about imminent drought.

In addition to temperature and rainfall fluctuations, some interviewees have observed increasing patterns of persistent morning fog that dissipates only after the sun rises. Many related this to the changing climate and decreasing rainfall. Several participants also noted a decrease or loss of snowfall, which they had previously experienced five to 10 years ago. Some also observed more frequent wind and hailstorms. Lastly, interviewees pointed out a scarcity of water in traditional sources, such as springs and rivers, which manifested through diminishing water levels of some and the complete drying up of others. Participants also noted that the location of the spring water source has shifted downhill, indicating fluctuations in the water table.

Most interviewees emphasised their unfamiliarity with recent and ongoing changes in weather patterns and how to manage them. Many were not able to identify the causes of these changes, including links to climate change. They reported never having faced such extremes, and especially the seasonal shifts were perceived as being out of human control. One participant noted that:

They all are dependent upon nature. Nature will give us the rain. And they don't know how to (...) get the rain. Because the rain is not in their hands, that is done by the heavens or the clouds, so they are all totally dependent on the rain.

5.2 Climate-Related Impacts

5.2.1 Water Availability

Participants repeatedly emphasised that the primary challenge they face in their lives is scarcity of water, which has detrimental impacts on agriculture. The combined effects of inadequate rainfall and high temperatures induce drought, which dries out crops and reduces yields. Soil fertility is also impacted by these changes, as the ground has become drier and harder, which increases the risk of soil runoff during heavy rainfall. Although the effects of water shortages have not yet been extreme enough to destroy all crops, the lack of water has significantly affected agricultural productivity. A participant regretted relocating to the community as reduced rainfall has negatively affected his agriculture. Most notably, interviewees stressed that challenges have increased in recent years:

From five to six years back, he's doing agriculture happily. But now, from that year, it's taken five to six years, that he somehow quit the agriculture because the productivity is not increasing. And it's all because of the lack of water is the main problem in this area (Participant in Madi).

In the seven years back, he said that they can do agriculture and that agriculture is enough to get food. But from that years to this years, the climate change is wholly change (Participant in Madi).

Multiple participants mentioned that the negative impacts of the burgeoning water shortage is particularly detrimental for crops such as maize, garlic, wheat, oranges, and potatoes. These crops have a high water demand, and the lack of water has delayed planting cycles and reduced productivity. Many participants discussed how these recent changes in rainfall patterns make it very difficult to predict the occurrence of rainfall. In the past, it was easier to anticipate when rain was coming, as it would usually occur around the same time each year. As many practise rain-fed agriculture, the unreliability of rain and changes in seasons makes it difficult to plan for planting. In some cases, the cultivation is stalled to the extent that whole cropping periods are missed. By the time the rains come, participants have already planted a different type of crop. As a result, farmers either miss out on growing the specific crop that year, which can lead to a major loss in income, or they have to plant and harvest all their fields at the same time, which constitutes a significant increase in labour.

5.2.2 Occurrence and Severity of Hazards

Participants across the two districts also discussed the impacts of hazards in their communities. Many have observed an increase in the occurrence of landslides in the last few years, which they attribute to the impacts of road construction exacerbated by heavy rainfall and deforestation. Some participants noted that the risk of landslide occurrence is higher during the rainy season. When local roads are constructed without proper drainage, it can contribute to flooding and landslides during heavy rainfall. Participants also noticed that landslides can cause flash floods when large amounts of mud and rocks fall into rivers, blocking their flow and leading to flooding of agricultural fields. Except for flash floods, overall, flooding was not rated as a primary concern for participants due to lower river water levels and because houses are built at a safe distance from rivers.

In addition to triggering landslides and flooding, heavy rains also have directly impacted crop productivity. Garlic, tomatoes, oranges, potatoes, maize, and wheat were identified as being especially vulnerable. Multiple participants noted morphological changes in garlic after heavy rainfall, which influenced their livelihoods by hindering sales to vendors. Additionally, heavy rain and associated rainwater runoff have caused the leaching of nutrients from the soil. However, one interviewee from Darma also mentioned the benefit of heavy rainfall doubling lemon production. One participant stated that hail storms affected the vegetables growing in his open field, while others lost vegetables and fruits

due to increasing and persistent morning fog. Wind also impacted crop productivity, predominantly maize plants, as traditional crop varieties grow high and are blown over.

Some interviewees in Madi also mentioned the occurrence of wildfires, which have predominantly resulted in forest damage, affecting medicinal herbs like *timur* and forest animals. While these fires usually occur in the forest area, one participant also suffered crop damage. Interviewees described that the primary cause of such fires is linked to human behaviour, including the spread of campfires during the winter and the discarding of cigarettes. One participant in Madi also linked the source of forest fires to rock collisions that occur during landslides. While some experienced increasing fires, others observed no changes or even noted a decrease.

5.2.3 Pests and Invasive Species

Participants have experienced an increase in pests in both districts, including the emergence of new pests that were previously unknown. They attributed this phenomenon to changes in temperature and improved road access, which has resulted in people from different regions introducing new species. Participants noticed how these pests destroy plants and reduce yields, attacking seedlings as well as stored seeds. Maize and vegetables are particularly impacted, whereas millet and wheat are seemingly more immune. When crops are damaged, farmers are often unable to sell them due to compromised quality.

A few participants also discussed the emergence of novel invasive species. One farmer noticed the emergence of a plant that attacks lemon trees and needs to be cut away manually. Other participants have experienced the spread and multiplication of the invasive *banmara* plant, which translates to the “forest killer”. Participants have only recently encountered this plant and can neither identify its origins nor how to reduce its spread. This plant is thick and blocks access to water sources and forest resources, making it more difficult to collect wood, grass, leaves, and water.

5.2.4 Livestock

Participants also discussed the impact of weather changes on their ability to raise livestock. For households that do not have access to tap water, or experience unreliable water flow from their taps, the decrease in rain impacts the availability of water for livestock. One participant in Salyan noted that:

When the river dries up, they are more impacted because both the irrigation and for the drinking water they use the water from the same river. So, when it dries up,

now they have to explore more options so that they have less time for their agriculture... They have to travel a lot for the distance to carry the same water.

Changes in water availability and temperature also threaten the health of livestock by contributing to colds, coughs, and other illnesses. Dust from road construction, combined with a lack of rain, also links to health issues of local livestock when dusty grass is consumed. When animals fall sick or die, this directly impacts livelihoods, as participants may experience a decrease in production of dairy and other animal products. They are also not able to sell or breed the animals. Another impact of climate change on livestock is related to the collection of grass, leaves, and water for feeding. While some participants grow animal feed on their own fields, many walk long distances to collect it from forests. Lately, decreasing rainfall has impacted forest resources, leading to the drying out of grass. Since local sources are insufficient, participants must walk further to collect enough feed for their livestock, which is physically taxing and time-consuming. This creates an additional burden by decreasing time for activities such as education, leisure, cooking, and taking care of children.

Participants have also experienced more challenges in beekeeping, as their bee populations have been impacted by weather changes, pesticide use, and the increasing presence of hornets that attack bees. Participants shared that the decline in bee populations impacts their livelihoods as honey production decreases and therefore less can be sold.

5.2.5 Health

Physical Health

Many interviewees raised concerns about the increasing frequency of health issues, as well as the emergence of new diseases. Some illnesses, such as skin rashes, joint pain, respiratory problems, coughing, diarrhoea, and common colds were linked to the recent increases in extreme temperature, particularly more frequent and extreme heat or cold. Similar to its effects on animal health, participants also connected the emergence of respiratory issues to the increase in dust generated by road construction, combined with the lack of rainfall to settle the dust. Other health impacts included the increasing prevalence of mosquito-borne illnesses like malaria and dengue, which participants attributed to changes in weather patterns. While interviewees noted the benefits of improved roads in allowing greater mobility of people and goods, as well as access to health facilities, they also believed it increases the risk of spreading diseases. People also attributed some diseases to increased exposure to chemical pesticides, as more farmers use them to combat the emergence of new pests.

Some female participants also discussed growing issues of uterine prolapse in the community, which some indicated as being exacerbated by climate change, as women have to go further to collect water and grass for livestock. Uterine prolapse was connected to increased strain on the body by carrying or lifting heavy loads, such as carrying grass and wood, or climbing trees to collect leaves for livestock. Women in particular raised this as a post-pregnancy challenge, when they face a too high workload and therefore cannot take enough time to rest. Some women also mentioned they do more heavy lifting while their husbands migrate for work abroad. While some participants connected these problems to heavy lifting and climate change, others associated it with insufficient intake of nutrients, irregular eating habits, and the early marriage of girls.

Mental Health

Participants also indicated how changes impact their mental well-being, referencing emotions such as fear, uncertainty, and helplessness. Weather changes were especially feared due to their impact on financial security. Many participants were worried about affording to send their children to university for higher education due to lack of a stable income source. They expressed concern that their children would have to continue practising agriculture, which was perceived as undesirable. One participant from Darma also reported apprehension regarding a lack of social cohesion in the community, as the increased temperatures have led to depleted water sources in the area, which could provoke conflict.

Many participants highlighted the overwhelming difficulties of farming and reported feeling helpless and powerless in the face of unprecedented weather changes and natural hazards. Interviewees expressed having insufficient knowledge to address these changes, especially in managing water scarcity when trying to cultivate crops. As the heavy rainfalls destroy produce, more farmers are turning to suicide to escape their depression. One participant explained how drastic weather changes resulting in crop loss means that farmers lose their only source of income. If they do not possess the necessary skills or education for changing livelihoods to support their families, they may turn to suicide.

5.2.6 Financial Security

The impacts of climate change on local water availability, agriculture, livestock rearing, and health cumulatively contributed to financial challenges among participants. Financial instability was a key discussion topic in many interviews, especially for farmers reliant on agriculture for subsistence and income generation. Due to reduced agricultural productivity, participants expressed their increasing reliance on additional income streams. Nowadays, income generation is particularly important as farmers increasingly

struggle to grow enough food to feed their families. Therefore, they need further earnings to purchase food and, as a result, some resort to shifting livelihoods or migrating for work. One participant in Darma explained this, stating that:

[d]ue to change in temperature, if they don't have enough rainfall, they will have depreciated water source, even the canal system will be decreased. So, they will have less water eventually. And it will eventually lead them to less harvesting, then they will have less food to eat, then they need to buy more. To buy more, they need more money. And to get more money, they have to earn a lot. They have to do more labour-based works, other works, which will eventually hamper the earning that they have.

Weather-related crop failures have led to escalating reliance on market produce. Additionally, people described that food prices have been rising recently, making it more difficult to pay daily expenses. The same participant in Darma emphasised that:

there will be some inflation in the market, since there will be less production of crops and vegetables. They will have inflation and eventually, they will have to buy more food, right? The market will be inflated, and they will have to buy more food.”

5.3 Non-Climate-Related Changes and Impacts

5.3.1 Market Access

In interviews, participants also discussed non-climate-related changes that impact their wellbeing and livelihoods, a central factor being access to markets to sell agricultural products. Some interviewees indicated that the improving road networks have enhanced market access, allowing more farmers to sell their products and new types of goods, plus opening up opportunities to start businesses. However, participants described the challenge that vendors only visit smaller villages and towns when large quantities of produce are available, leaving farmers with the added expense of transporting their crops to other communities to make sales. In addition, participants reported cases where vendors did not turn up, resulting in spoilage and loss of income due to an absence of local collection and cooling centres. Farmers also struggle to compete with the prices of imported produce from countries such as India. All these factors have a strong impact on the types of crops grown, as farmers have to adapt to external market demands.

5.3.2 Nutrition

While some health issues were explicitly related to climate change, participants also linked illnesses such as gastrointestinal problems, diabetes, and blood pressure issues to malnutrition and changes in eating habits. They described a transition from a locally-grown, diverse, organic, whole-grain, and fermented diet, to more purchased, imported, and ultra-processed foods. A participant from Darma stated that whereas it used to be common to eat whole-grain *roti* with local dairy products, people now consume more rice and fast food. Many people buy food from the market, including staples such as rice, salt, oil, various vegetables, and hygiene items. Some participants have stopped eating their own dairy products, so that they have more to sell to earn money to buy rice, spices, and other commodities. Multiple interviewees raised concerns about eating more commercial foods due to the higher use of pesticides in imported foods in contrast to locally grown foods, where farmers can control the amount of pesticides used. There is also decreasing access to nutritious foods such as green vegetables and seasonal fruits, which one participant attributed to financial instability and lack of water for cultivation. Some interviewees contrasted the health of older community members, who used to eat local produce, to younger ones, who are experiencing new types of illnesses. Many participants mainly attributed these issues to changing eating preferences.

5.4 Traditional Knowledge

During interviews, participants discussed many types of traditional knowledge and practices that they had learned from their parents or grandparents. While not all interviewees knew the reasons why these practices were developed, some were able to determine their specific benefits. In general, community members spoke positively about traditional knowledge and practices, and acknowledged their importance for agriculture, management of water, forests and hazards, health, and community wellbeing.

5.4.1 Agriculture

Soil Management

All interviewees learned methods of traditional agriculture from their parents and grandparents. This includes the traditional farming systems of raising livestock alongside agriculture, which supports the use of organic fertilizers consisting of animal manure, ash, and compost for crop growth. While some participants have experienced lower yields using these methods in comparison with chemical fertilizers, most identified improved soil quality when using organic fertilizer. Another prominent practice in both districts is terrace farming, which allows farmers to cultivate on the hilly terrain. Participants noted that their terraces have been impacted by recent heavy rainfall and ensuing landslides. They also

highlighted difficulties in maintaining numbers of terraces due to the high level of labour required. Lastly, interviewees also discussed using a traditional soil management practice of planting trees on the outer lines of fields to stabilize the soil and prevent erosion as well as landslides.

Crop Types and Intercropping

Many participants continue to seasonally cultivate the same crops as their ancestors, such as wheat, millet, maize, and mustard. Wheat and millet were recognized as more resistant to drought, heavy rain, cold extremes, and pests. Farmers in Madi and Darma also practise intercropping, such as with maize serving as a stand for crawling beans. Some interviewees also described following a traditional practice that entails growing the crops in the middle of the field, surrounded by vegetables on the ploughed soil around the edges. However, for rice, rather than using terrace farming or intercropping, many participants also indicated that they grow separate fields at the bottom of the hills near rivers, so it is easier to irrigate the high water consuming crop.

Pest management

Lastly, interviewees discussed how pest outbreaks are particularly threatening to organic crops. Traditional pest management involves the use of ash, smoke, and cow urine to deter or inhibit pests. Farmers also protect their crops by not cultivating in pest-infested fields, planting more tolerant varieties, or drying seeds longer to prevent pests from manifesting. However, participants viewed traditional strategies as having limited success in the face of some emerging pest species.

5.4.2 Water Management

Water collection

In Darma and Madi, a few participants referred to ponds as a historical water source. While some of these ponds were constructed as means to collect rainwater for livestock and irrigation, some were believed to be naturally occurring. Most of these ponds have been lost over time due to changes in forest use, lack of maintenance, and decreases in rainfall. Lately, some projects aimed at their revival were implemented in the communities. One participant shared how his knowledge of a historic pond inspired a pond reconstruction project in Darma, intended to enhance groundwater recharging by allowing water to be collected and slowly percolated into the soil. However, since the construction of this pond is recent and rain has been scarce, participants were unable to comment on its potential benefits. Some other community members also reported being involved in projects to construct cement-based reservoirs collecting rainwater, however, the majority of participants did not implement any practice of rainwater saving to feed livestock or

irrigate farmland. When asked for the reasons, people often viewed a lack of knowledge or insufficient financial resources as obstacles.

Canal systems

In interviews, participants described the main sources of water for irrigation as nearby rivers, spring water sources, and rainfall. In some cases, interviewees utilized traditional canal systems to irrigate their fields with water from the sources. Some of these traditional canals have recently been reinforced with concrete or other modern materials through projects supported by local government or non-governmental organizations. Participants noted that these reinforced traditional canals prevent issues of water seepage and mitigated erosion, therefore resulting in higher water levels and more efficient irrigation of agricultural lands.

5.4.3 Forest Management

Community forest management

In discussing their daily activities, many participants spoke about regularly walking to the nearby community forest to collect firewood, grasses and leaves for livestock, and in some cases medicinal herbs. While community members have traditionally used forest resources for many purposes, they described how access to these resources has changed over time, as management of the forest shifted between communities and the government. They explained how Community Forest Committees regulate resource use within the forest nowadays, including determining when and where people have access. In some communities, specific zones are designated for use, and in others, the forest is only open certain times or days. Restrictions on which resources can be accessed, including medicinal plants, wood, or grass, are also often in place.

Participants mentioned that alongside the restriction of resource use, there have also been community efforts to regrow the forest by planting trees. For this, only local plants are used, as they are well-suited to the local terrain and climate. This includes local trees with broad leaves that store water in the ground, such as *Banyan* and *Pipal* trees, and other trees like the *Salla* and *Devdar* species. They also indicated that afforestation should be managed at the local level, paired with education so that individuals can learn about its benefits and proper implementation. Since the preservation of the community forests and improved afforestation efforts, participants have noticed significant changes in greenery, making it easier to collect grass for livestock in some areas and providing benefits to the soil quality.

Interviewees also explained that historically, their parents and ancestors took their goats to the jungle to graze, staying overnight and letting them roam free. However, over time,

the grazing of animals in the jungle contributed to a decrease in forest resources. Because of this, many Community Forest Committees have responded by banning the grazing of animals, or limiting the areas or times that this can occur. In response to these protection measures, community members now gather grass from the forest to feed their goats instead of grazing them. While this provides a good feeding source for livestock, there are some challenges, as it can be dangerous to climb trees to collect leaves and physically demanding to carry heavy loads for long distances.

5.4.4 Hazard Management and Awareness

In interviews and FGDs, many people discussed the frequent occurrence of landslides, describing previous occurrences and pointing to factors likely contributing to their emergence. Knowing when and where hazards may occur allows community members to prepare in advance. A participant from Darma described how landslides were anticipated by observing growing cracks in the fields, subsequently evacuating community members from the high-risk area. Another participant noted the connection between heavy rain and landslides, and stated that no houses are built in areas that have been identified as being prone to floods and landslides. Some highlighted the traditional practice of building dry walls as a way to mitigate the impacts of landslides on people, infrastructure, and agriculture, while others discussed the role of afforestation in reducing landslide risk. In the context of forest fires, which mainly occurred in Madi, participants described the traditional use of water and local plants to prevent fires from spreading.

5.4.5 Health Practices

Health procedures and local diets emerged as important cornerstones of traditional knowledge in the communities. Participants reported that their traditional diet consists of organic, local produce. This includes consuming *roti*, traditionally made from whole wheat flour, millet, locally produced dairy including ghee, organic vegetables and fruit, *gundruk* (fermented and dried vegetable leaves), and *sisno* (nettle). Many of the elders also emphasized that they cook with mustard oil instead of modern vegetable oils and consume little to no rice. In the Indigenous Magar community in Madi, meat is traditionally dried and mainly consumed on special occasions. The traditional cuisine and local healing traditions also utilize medicinal herbs and spices, of which many are grown in the local forests. Turmeric, *timur* pepper, cumin, and ginger are popular for preventing and responding to health issues; *timur* pepper when feeling cold, ginger when the throat is sore, and turmeric to avoid sickness or when suffering from a cold or fever. When experiencing a cold, interviewees reported drinking hot water or eating millet to warm the body.

5.4.6 Community Organizing

Farmers' Groups

Participants in Darma discussed the role of farmers' groups in their community, which started informally and were formalized about four to five years ago. These groups collect fees from community households and provide loans, which are given out based on the greatest need of vulnerable community members. Nowadays, they also meet with the Nepali Government's agricultural office to discuss local agricultural issues, pesticide and seed demands, and different farming techniques. Aside from these more organized structures, participants also mentioned the practice of informal seed exchanges among farmers.

Aama Samuha (Mothers' Group)

Many of the female participants are part of an *Aama Samuha* (mothers' group), through which they meet regularly to discuss and address the needs and challenges of their community. Participants in Darma and Madi have observed the formal establishment of such groups in the past 10–15 years to help respond to female health challenges, providing awareness about nutrition for new mothers and the negative effects of child marriages. Members of the mothers' group also attend weddings and other community celebrations to dance and raise funds. These funds are then used to build temples, offer loans with small interest rates to community members, or buy rental equipment. Some participants are also part of women's groups that advocate for women's rights, including the right to education, employment, and participation in politics. These groups also provide education to both men and women to address domestic violence.

Parma

Lastly, participants in Darma mentioned that the *Parma* system is utilized in times of need, for example during harvest or big celebrations when labour is needed. It is particularly important in the context of migration, where many people leave their rural homes in search of work opportunities in urban areas. In such cases, the system plays a crucial role in providing social and economic support to those left behind. In addition to labour support, interviewees reported that *Parma* also involves lending each other money, which can be used to start small businesses or recover from unexpected expenses or losses. Some participants expressed that people nowadays are taking out more loans than in the past, which demonstrates the importance of such small loan systems.

5.5 Integrating Non-Traditional Knowledge

Many interviewees stressed that the traditional knowledge they learned from their ancestors no longer applies to current weather-related challenges, which do not resemble historical weather patterns in the region. Therefore, many indicated that they feel unable to deal with the rapidly changing, unfamiliar, and unprecedented environmental impacts. Some people noted that they are not yet changing their practices in response to these changes, because impacts have not yet been drastic enough. However, many others discussed how there is a growing interest in adopting non-traditional practices in the communities to manage changes in the environment. Often, participants stated that their reasons for adopting new methods were due to “trends” they observed in use by others. While some preferred solely relying on traditional approaches, many saw newer techniques as the better or more desirable option for the future. Barriers to adopting such new solutions included limited technical know-how and financial resources.

5.5.1 Agricultural Practices

Crop types

The changes in water availability, combined with considerations for market demand, are also influencing which crops farmers grow. To cope with challenges related to climate change in Darma and Madi, people are exploring new agricultural methods, such as using different types of seeds, growing vegetables out of season, and switching to cash crops to enhance income. Certain traditional varieties of crops, such as maize, have shown sensitivity to weather extremes and therefore produce less yield. As a result, some farmers are switching from traditional to cash crops. These include lemons and oranges, as they offer a high financial benefit, are less water- and resource-intensive, and are well-suited to changing conditions. Oranges in particular thrive due to increasing temperatures. To supplement traditional crop income, a recent trend of cultivating more vegetables and medicinal herbs like ginger, *timur*, and turmeric has also emerged. Ginger was a particularly popular cash crop due to high demand and ease of growth in existing soil conditions.

Many have also started using hybrid genetically-modified organism (GMO) seeds, as fewer seeds are needed to increase production when utilizing the same field space and less labour than traditional varieties. Some of these seeds also allow farmers to grow vegetables out of season, allowing for year round food production and income opportunities. Furthermore, GMO seeds for maize are designed to grow shorter and therefore are less impacted by the wind, which has resulted in better yields. However, while some are implementing solutions such as crop switching and GMO seed use, many participants highlighted a lack of expertise in Nepal regarding the real impacts of climate

change on farming patterns and what seeds, approaches, and techniques can be used to adapt to these changes. A participant from Darma said, “I think it's important to inform the people about what's going on [in] the surroundings as well as how to deal with it. I think both should be endorsed in the community”.

Machinery and Equipment

One of the recent changes indicated by participants is the growing use of newer machinery, equipment, and cultivation techniques. Modern harvesting and de-seeding machines and tractors were identified as being less time- and labour-intensive than traditional techniques. Interviewees noted that the time saved using these machines allowed them to engage in other income-generating activities. However, some farmers noted that the traditional practice of ploughing fields with oxen is more effective in tilling the soil, leading to better crop growth. To reap the benefits of both techniques, many farmers preferred an approach that integrates the use of oxen and tractors. Community members also reported using new techniques to prevent extreme weather impacts on crops, including tunnel farming and use of greenhouses. These have improved yields in the face of adverse weather, thereby improving earnings. Some participants described learning these techniques by migrating to other regions or countries and witnessing alternative approaches to agriculture. For instance, a participant observed successful vegetable farming in Qatar's arid climate and wanted to replicate this approach, reasoning that if it worked in such harsh conditions, it could succeed in Nepal too. Once returning home, he watched YouTube videos to learn how to grow vegetables, and planned to share his knowledge with other farmers. Other participants mentioned they learned these techniques from their neighbours, family members, through formal training, or from simply researching and watching videos online.

Many participants noted how they are unable to produce enough crop yield to attract vendors to come to the village. Therefore, they discussed the need for a local collection centre to bridge the connection between farmers and vendors. This type of centre would provide a central place to store produce collected from multiple farmers in the community, to then sell larger quantities to vendors. This would allow people to grow smaller amounts, with less concern regarding food spoilage.

Water Management

Participants also discussed the positive impacts of new water and irrigation systems, such as water lifting and gravity supply water systems, which bring water from nearby sources into taps in the home. When water is lifted directly into home taps, participants save time collecting and bringing back water from distant sources. Better water access through this system also improves health, hygiene, and sanitation, and provides an opportunity to grow more vegetables and crops near the home. Some participants explained that their reliance on purchased market food decreases when they can grow more vegetables

themselves. However, the tap water system also has limits, and many participants rely solely on this water for drinking, cleaning, washing clothes, feeding animals, and watering vegetables grown close to the house. In most cases, the amount of water is therefore not adequate for irrigating larger fields of crops or those grown further away from the house. For these larger fields, many participants still rely on traditional irrigation canals, including those reinforced by concrete to reduce seepage.

Pest Management and Fertilizer

With the emergence of new types of pests, farmers reported that their traditional pest management techniques were not effective in preventing crop impacts. Therefore, many have responded by shifting to chemical pesticides. While chemical pesticides were described as more effective, participants also recognized health concerns related to such pesticides, thus highlighting potentially negative long-term impacts on resilience. Interviewees have started using more chemical fertilizers to enhance the yield of their crops. However, the combination of chemical pesticides and fertilizers contribute to the hardening and damaging of the soil. To prevent such negative impacts, multiple farmers reported that they completely avoid the use of chemical pesticides or fertilizers. Others use mixed methods, applying chemical pesticides only when traditional methods have failed to prevent pests, or mixing chemical fertilizer and traditional manure to regenerate the soil and improve its quality.

5.5.2 Diversification of Livelihoods

Migration

Many participants reported that agriculture, the traditional livelihood in rural mid-hill Nepal, is increasingly being abandoned in search of alternative income opportunities. As a result, there is a growing trend to migrate for work, predominantly for men, but also women in some cases. Participants noted that there are different types of migration, based on length of stay, destination, and occupation. In some cases, youth are migrating in search of better education and higher-paying opportunities. In other cases, migrants are seeking labour-based employment. Migration can be seasonal or long-term, and to nearby areas or further abroad. Popular destinations for Nepali migrants are India, Malaysia, the Gulf region, and larger urban areas in Nepal like Kathmandu and Dolpa. Reasons for migration were predominantly linked to the increasing cost of living and limited local income opportunities apart from agriculture.

Participants mostly perceived migration as beneficial, due to enhanced financial security and improved education for children. However, it also poses challenges for migrants and their families. Male participants talked about some of the challenges of working abroad, including hard physical demands, poor working conditions, and low pay. They discussed

ways in which Nepali migrants abroad support each other by pooling their earned money and sending it back to their families. The migration of men abroad also impacts women who stay behind. In interviews and FDGs, both women and men indicated that the majority of housework is usually shared between men and women, without strong divisions of labour between genders. The exception being the tasks of ploughing and preparing the fields, which is performed by men. When men migrate, women end up conducting all the agricultural tasks and household chores, which is physically demanding and limits their time to engage in other activities.

Shops

Another way that participants diversify their livelihoods is by opening and managing shops. Some participants engage in shop keeping to sell their agricultural products, as well as imported products, to supplement their income. Others noted that due to decreasing productivity of agriculture in connection to limited land and water availability, they have stopped agriculture altogether and now rely solely on income from their shops. These shops range from food stores to furniture manufacturers to construction supply stores. One woman in Madi shared how she is involved in a women's collective that runs a furniture manufacturing store and spice production business. Magar women in Madi also make traditional clothing and bags to sell, to supplement their income.

Commercial Livestock Rearing

To supplement agricultural income, non-traditional commercial livestock rearing has become a popular occupation, especially when selling animals in the higher-demand cities around Nepal. This includes focusing on rearing a larger number of one type of animal species, rather than the traditional practice of sustaining a smaller but more varied range of livestock for subsistence. Goat, pig, and buffalo farming is especially popular, but chickens, cows, and sheep are also raised for income. In order to expand their commercial livestock activities, people often take loans from organizations or groups. A central challenge to commercial animal farming is the availability of farmland in the communities and restricted forest access for feeding purposes. Furthermore, funds are needed to purchase new livestock, and therefore many small-scale farmers depend on loans.

5.5.3 Livestock Rearing

The integration of non-traditional practices has also impacted how livestock are reared. Traditionally, practices for keeping livestock healthy included feeding them grass, tree leaves, and staple grains like wheat, maize, and millet, which are ground into powder and mixed with hot water to prevent livestock illness. New schemes of livestock insurance promoted by the government have granted people from Darma and Madi greater financial

security in raising animals, especially when they fall ill due to extreme weather conditions. Some participants mentioned that they have purchased animal insurance to protect them against losses when animals become sick or die. For some participants that still graze their livestock in the fields, they also noted that when the weather is bad they feed livestock stored grass and hay, rather than taking them to the fields where they may fall ill. Many participants noted that they buy grass or hay to feed animals, or try to grow more grass using GMO grass varieties.

Participants also expressed a shift towards rearing more hybrid or imported animal breeds, such as Boer goats. These breeds often feature favourable traits for income generation, such as heavier weight. While some participants stated that these imported breeds are stronger, others stated that they are less resilient to weather changes and more easily fall sick than traditional breeds.

Sheltering of animals has also changed: while traditional methods such as tethering animals outside during the day and inside at night are still practised, others are building improved sheds to prevent livestock injury and sickness due to extreme weather. Participants have seen increased livestock productivity since switching to improved sheds. Similarly, participants who are switching to contemporary bee houses rather than the traditional log beehives, believe these houses better protect bees from extreme weather.

5.5.4 Health and Medicine

Many participants indicated that when they experience serious health issues, they respond by visiting a doctor or nearby clinic. While medicinal plants and traditional nutritional practices are still used as prevention measures, when issues become more severe, participants now seek out medical advice from doctors. Participants discussed how their ancestors used to summon healers to their homes when a family member was sick. These healers would use traditional medicines such as the spreading of ash on the chest when sick with a cough and chant particular mantras for healing. Part of this ritual included sacrificing a chicken or other animal. While some participants summon these healers when experiencing illness, many people now visit the hospital instead. In Darma and Madi, turning to non-traditional medicine was mainly attributed to convenience, as health facilities are more accessible nowadays than they were in the past. In the face of extreme heat, a participant stressed that they go “to the hospital and take medicine. That is only the solution they have.” While medicinal herbs and other traditional medicinal practices are still widely used, with the emergence of new health concerns and increasing access to doctors and clinics, more community members are seeking medical advice outside traditional forms of medicine.

5.5.5 Infrastructure

Participants shared that the traditional way of building houses in both districts is through use of local materials including mud or clay for the walls, hay for the roof, and structural supports made from stone or wood. Interviewees also described how increased availability of imported building materials due to the development of roads, as well as the growing severity of hazards such as heavy rains, have influenced local construction techniques. In recent years, community members have started using new building materials and construction techniques, including slate for roofs, rods for enhanced stability, cement walls, and colour paints. These materials are often imported and can be more expensive than the local materials used in traditional homes, so many community members face significant financial barriers. Some participants described how they learned about these new building techniques while migrating to other parts of Nepal or while working abroad.

Most participants perceived traditional houses as less sturdy in the face of natural hazards such as earthquakes, landslides, and heavy rains, as mud walls and hay roofs may not provide adequate stability and protection against such events. In contrast, participants described how the newer types of homes are built with stronger materials and are therefore sturdier, which participants described as making them feel more safe. However, participants also noted that they experience challenges with their concrete homes due to the decreased internal temperatures and therefore need to use internal space heaters to manage the colder winter temperatures. Some participants noted that they prefer the traditional methods of construction, as they are more adapted to the local climate needs. In contrast to this location-specific knowledge, modern building designs often neglect the local climate and geographical conditions.

6. Discussion: Traditional and Non-Traditional Knowledge for Resilience

In recent years, global climate discourses have highlighted the need for integrating traditional and Indigenous knowledge into climate change adaptation and resilience building. Both the Paris Agreement and UN Sustainable Development Goals acknowledge the vital role of such knowledge in understanding climate change and developing actions for adaptation as well as poverty reduction. This includes a growing global consensus that climate change adaptation should not rely solely on western, scientific knowledge, but rather requires integration and engagement with diverse systems of knowledge to support context-specific planning (Filho et al., 2023).

The traditional knowledge in Darma and Madi consists of tested, place-specific practices that were adjusted to varying environmental conditions over time. Developed through intergenerational “learning-by-doing”, such practices are “constantly changing as they are being regularly improved upon through their interaction and exchange with other systems of knowledge” (Karki & Adhikari, 2015, p. 3). Traditional knowledge contributes to climate change resilience, not only in the form of practices, institutions, and factual knowledge, but also through tacit knowing and social systems (Karki & Adhikari, 2015; Nakashima et al., 2012). Therefore, the holders of such knowledge possess important awareness of more subtle changes that have been occurring in the climate and environment (Acharya et al., 2016; Karki & Adhikari, 2015). In Darma and Madi, recognition and learning emerged as prominent components of traditional knowledge. Practices supporting the mitigation and prevention of impacts were also represented in various areas, from agriculture to forest and hazard management to community organizing. However, many interviewees could not specify their reasons for employing traditional methods beyond ancestral usage or noted that some practices have been lost over time.

While traditional practices are crucial in supporting resilience to the impacts of climate change in the communities of Darma and Madi, many interviewees discussed their lack of understanding and experience regarding the reasons behind the unprecedented changes and how to mitigate their impacts. As a result, participants have sought out non-traditional practices to improve their adaptability. Some acquired new knowledge abroad while migrating for work, and others did research online or attended training. Answering the second and third research questions, the following section discusses how both traditional practices and the integration of non-traditional knowledge can contribute to the concept of resilience outlined by Becker (2014). This includes anticipating, recognizing, adapting, and learning to cope with changing climate conditions and associated

challenges. Analysis of the collected data shows that while the functions of recognizing, adapting, and learning are prominent in these communities, participants are limited in their ability to anticipate due to the unprecedented nature of the changes they are experiencing. To explore how these resilience processes interact across various aspects of the lives of community members, this section is organized by themes of environmental, economic, social, and infrastructural resilience. Since many practices contribute to various aspects of resilience, they are not always confined to a single theme, but may also intersect and overlap.

6.1 Environmental Resilience

6.1.1 Water Management

A traditional practice of water management that arose during interviews was the historic use of ponds to collect rainwater for livestock and irrigation. Interviewees noted that many of these ponds have not been maintained and therefore disappeared. Traditional approaches to rainwater harvesting and recharge ponds have also been documented in other parts of the country (Merz et al., 2003; Shrestha & Maharjan, 2016). In recent years, community members in Darma have engaged in projects to reconstruct ponds with the purpose of recharging groundwater sources through slow percolation of water into the soil. Generally, reviving traditional recharge ponds that harvest rainwater and overflowing spring water represents an important climate-resilient intervention, as they improve local water availability in the face of irregular rain patterns (Matheswaran et al., 2019). Ponds constructed with other materials can also provide benefits for local water management. A study conducted by Kattel (2022) views re-designing and re-introducing the traditional technology of rainwater harvesting in Nepal's hill farming as a key climate change adaptation strategy. It was found that farmers who implemented plastic or cemented rainwater harvest ponds "earned around 270% more annual household income from agriculture and livestock sectors due to availability of irrigation water than the non-adopters farmers in the study area" (Kattel, 2022, p. 167). Due to the alternative supply of water for irrigation during the dry season, farmers diversified their crops and transitioned from subsistence production of cereals towards higher-value vegetables (Kattel, 2022). Generally, different types of water conservation and harvesting can improve crop production and enhance groundwater and soil moisture (Adhikari, 2018). Water collection can help farmers prepare for drought and mitigate the impacts of lack of rainfall on crop production, and therefore, their livelihoods.

Interviewed farmers also discussed the traditional use of canals to funnel water from natural sources to irrigate their crops. Research by Adhikari et al. (2009, p. 2822) has shown that these channels are not only useful for irrigation purposes but are also used

for drainage and to support flood management during the monsoon season. While the canal structures were viewed as traditional, interviewees talked about recent projects in their communities that reinforced them with concrete and other materials for protection against soil erosion resulting from flooding and landslides. The reinforcement of these traditional canal systems can contribute to water availability and management in the communities, rendering them more resilient to climate-induced water scarcity while also preserving traditional water networks. These measures support managing increasing water scarcity and mitigating the impacts of drought on agriculture, contributing to improved community resilience (Adhikari et al., 2009).

When discussing water accessibility, interviewees also raised many benefits of the recent installation of water supply systems in their communities, particularly the water-lifting systems that utilize solar energy. They shared how these new systems enhance their ability to diversify livelihoods by raising livestock, growing vegetables, and reducing time spent on water collection. Other benefits of this direct access to water also included improved health and sanitation. Increasing water access in response to reduced frequency of rain and decreasing water levels can help farmers mitigate the impacts of drought on agriculture (Rijal et al., 2022). Therefore, novel supply systems can contribute to community resilience by complementing existing traditional water networks and sources.

6.1.2 Hazard Management

Discussing the occurrence of hazards in the community, many participants identified the risks of landslides and flooding, which they noticed are exacerbated by heavy rains and road construction. Research conducted in hilly regions across Nepal also shows that flooding and landslides occur more frequently during the monsoon season, due to a combination of increased heavy rainfall, soil erosion, deforestation, water leakage, road construction, and other infrastructure failure (Gaire et al., 2015). While it can be hard to predict when a landslide may occur, some participants mentioned how they look for cracks in the mud to indicate landslide risk and can therefore take action to evacuate the area. By recognizing the connection between heavy rain and landslides, one interviewee stated that as a mitigation measure, no houses are built in areas that have been identified as flood- or landslide-prone. This also clearly demonstrates the interconnectedness of different resilience functions such as recognizing, mitigating, and learning, which operate interdependently (Becker, 2014). To manage the impacts of landslides, participants also described how they traditionally build drywalls to help prevent or mitigate landslide risk. This approach has been well-documented, and drywall fencing is a common approach across Nepal for mitigating the effects of floods, landslides, and general soil erosion. The construction consists of larger boulders at the bottom of the wall that are stacked with

smaller rocks on top (Thapa et al., 2008). In addition to drywalls, participants noted that planting trees in certain locations can help prevent landslides. It is demonstrated more broadly that tree roots and soil conservation can help stabilize hill slopes to prevent landslides and mitigate soil erosion during heavy rain (Paudel & Yadav, 2021; Forbes & Broadhead, 2011).

Some participants in Rolpa mentioned risks of fires in the drier months, predominantly caused by human activities. Research across the country has also shown that wildfires in Nepal occur more frequently during the warmer months, are human-induced, and represent a significant cause of deforestation (Matin et al., 2017). Interviewees in Madi reported that traditional fire management techniques they learned from their parents, such as using plants for smothering flames, aim mainly at responding to rather than preventing the hazard. Using plants, soil, or sand to extinguish local fires is also common across the country (Koirala, 2016; Sapkota, 2017). To prevent human-induced fires, participants highlighted the importance of spreading awareness about fire risk. Research by Sapkota (2017) has demonstrated the need for improved implementation of fire risk awareness campaigns in Nepal.

Generally, knowledge about the occurrence of hazards is often passed on over generations in the form of intergenerational learning, a process in which the community elders play a central role (Dasanayaka & Matsuda, 2022). Overall, hazard awareness and multi-generational learning of practices to prevent, mitigate, or respond to related impacts demonstrate how traditional knowledge contributes to resilience in the face of climate change. Moreover, government-backed non-traditional methods can address knowledge gaps beyond traditional approaches.

6.1.3 Forest Management

Community Forest

Interviewees explained how access to community forest resources has changed over time. Historically, forests were managed by local communities, using adaptive systems of traditional resource management. Such practices were developed over decades by those living close to the natural environment who adjusted their practices according to observed changes (Karki & Adhikari, 2015, p. 3). Forest use was cooperatively managed between villages, with access for harvesting restricted during certain times of year to allow for regeneration and reduce overharvesting of resources (Wakiyama, 2004). The government's nationalization of forests in the 1950s shifted management to a centralized approach (Karki & Adhikari, 2015). While traditional forest management ensured sustainable use of resources, the development of agricultural land, roads, and clearcutting of forests for timber export led to massive deforestation across the country

(Wakiyama, 2004). To combat deforestation, in 1993, the management of these forests was returned to local inhabitants, to be led by Community Forest User Groups made up of local community members and government representatives (Chhetri et al., 2023; Wakiyama, 2004). Further research has indicated that the government regulation of community forests builds upon traditional systems of forest management (Wakiyama, 2004).

Returning to community-led forest management also includes efforts for afforestation to address the misuse of forest resources. In this way, replanting of native plant species contributes to forest recovery and ensures development that considers local environmental boundaries. The integration of traditional knowledge for sustainable forest management in the hilly areas can also increase resilience by preventing or mitigating flood and landslide risk, as well as providing resources and ecosystem services including water, clean air, medicinal herbs, and wood for fuel (Karki & Adhikari, 2015).

Invasive species

Multiple participants have also recognized challenges with the spread of invasive species after informally monitoring the emergence of new varieties and assessing the impacts on forest resource access and agriculture. While some of these species were identifiable and familiar to community members, participants expressed a lack of familiarity with new varieties and were therefore unable to identify strategies to prevent their spread. One plant in particular that has been spreading is the *Ageratina adenophora* plant, known locally as *banmara*. Multiple studies in Nepal have noted the negative effects of invasive species on agriculture, livestock, and forest resources (Shrestha, 2019; Shrestha et al., 2017). Research has also examined how changing climate conditions can be expected to alter the distribution and growth of invasive species in the country, including *Ageratina adenophora* (Shrestha et al., 2018). However, local knowledge of the occurrence, location, identifiers and impacts of invasive species can contribute to responding to their spread across the country (Karki & Adhikari, 2015). Such knowledge can contribute to resilience by supporting the monitoring and assessment of potentially harmful species to the local ecosystem.

6.2 Economic Resilience

6.2.1 Agriculture

The major changes noted by participants in Darma and Madi related to climate were drought, temperature extremes, and erratic weather patterns, which have especially impacted crop productivity due to water scarcity. A similar picture has emerged among other populations in the mid-hills, where water scarcity affects agricultural production

(Khanal et al., 2019; Parajuli et al., 2019). It is estimated that in the whole of Nepal, 90% of crop losses are connected to weather and climatic events, of which 40% are caused by drought and 23% by flooding (Ramasamy & Regmi, 2014). Further research by Joshi & Joshi (2019) has demonstrated how crops planted in the spring are impacted by delayed monsoon rain, stretched out dry spells, and short periods of heavy rainfall. During the winter, there is less water during critical growth periods. And such developments are predicted to intensify: Kapoor et al. (2021, p. 18) have stated that erratic weather patterns will disproportionately affect agricultural operations in Nepal's hills and Terai regions in contrast to other parts of the country.

Soil Management

Through interviews and FGDs, practices relating to soil management emerged as central pillars of local agricultural activities. Participants viewed healthy soil as crucial to effective crop cultivation, and many had noticed their grounds becoming increasingly dry over the past years. According to Aryal et al. (2020, p. 5053), soil management practices are among “the most crucial measures for climate change adaptation”, maintaining the mineral balance needed for sufficient crop cultivation. The better the soil quality, the greater its resilience in the face of stressors due to the mitigation of impacts, therefore supporting local adaptation to changing weather conditions (Aryal et al., 2020, p. 5053). In order to maintain healthy soil, some participants reported using traditional organic methods, while others utilized non-traditional means of industrial agriculture.

In a recent systematic review of Nepalese farmers' climate change adaptation strategies, Rijal et al. (2022) recognized organic farming as an important traditional strategy for adaptation. It promotes diversification of the local ecosystem and increases soil organic matter (SOM), both of which contribute to resilience by mitigating the impacts of extreme weather on crop production. Compared to industrial agriculture, organic farming is also known to improve local water quality and provide better nutritional value for produce, therefore also contributing to health as a part of social resilience. It has been shown to lead to higher yields under drought conditions, which is mainly attributed to improved soil quality and therefore water retention (Seufert & Ramankutty, 2017). However, the performance of organic agriculture is highly context-dependent, and factors such as chemical pesticides and fertilizer use in the surrounding area can quickly nullify potential positive effects (Seufert & Ramankutty, 2017, p. 4). Also in the municipalities, participants observed negative long-term impacts of chemical fertilizers on soil health. Such impacts have been well-documented, leading to the hardening of soil, decreased water absorption capacity, and pollution (Pahalvi et al., 2021). Integrated Plant Nutrient Management (IPNM) has emerged as a viable option for fertilizer use, combining traditional manure application with low doses of chemical nutrients and modern crop protection techniques. This approach has shown strong potential for increasing yields of crops like maize and

millet, while at the same time contributing to sustainable soil health in Nepal's hills (Chapagain & Gurung, 2010).

Traditional soil management in the municipalities also included the planting of trees alongside the outside of agricultural fields. Such agroforestry practices are common across Nepal and demonstrate various benefits such as supporting conservation, improving nutrient cycling, providing fodder and firewood, and ensuring yield stability of crops (Rivera-Ferre et al., 2021, p. 655). Another central part of traditional soil management is the technique of terrace farming, practised by many participants in Darma and Madi living in the hilly terrain. Terrace farming can contribute to resilience by preventing erosion and enhancing soil stability. However, terraces across Nepal have increasingly been neglected due to local labour shortages, often induced by out-migration, which can result in "massive soil losses" (Chapagain & Raizada, 2017, p. 5). This demonstrates the potential adverse effects of shifting livelihoods on the resilience of local agricultural systems. Such developments also feature a gendered component, as the predominantly male migration leaves women with added responsibility, often leading to decreased attention diverted from terrace fields to other household duties (Chapagain & Raizada, 2017).

Crop Types and Intercropping

Many participants reported continuing their parents' cultivation of traditional crops, such as wheat and millet, which were also viewed as less affected by weather extremes or pests. Recent studies point to millet as an important climate-resilient crop that features high drought and heat tolerance (Mustafa et al., 2021). Additional characteristics of millet include strong pest resistance and low-input needs for cultivation, which shows the potential of this crop to enhance food security (Abdullah et al., 2022). While traditional crops are often highly valued by locals and therefore face fewer social barriers to cultivation (Adhikari, 2018), the decreasing consumption of these plants in the communities, in part due to changing access to markets, has led to lower production in recent years. Planting locally neglected and underutilized species (NUS) like millet can contribute to climate change adaptation and thus improve resilience (Aryal et al., 2020). It can be a means of mitigating crop loss caused by climate extremes while also improving "food security and at the same time (...) protect and conserve traditional knowledge" (Aryal et al., 2020, p. 5064). Despite this, the abandonment of traditional crop varieties and integration of new types of seeds and crops is a common response to drought in Nepal's mid-hill farming communities (Adhikari, 2018). GMO planting can improve small-scale farm resilience by mitigating impacts of pests, financial losses due to crop loss, and weather extremes (Coomes et al., 2019). However, these plants are also associated with biodiversity decline, effects on soil health, and subject farmers to global market dynamics

of large biotechnology companies (Adhikari, 2014). Hence, additional research into the lasting impacts of using GMO seeds on community resilience is needed.

Another practice, intercropping, is also widely practised in the focus communities. This practice can mitigate the impacts of climate change as it promotes more efficient use of space, nutrients, and water, as well as providing greater immunity when facing pests (Huss et al., 2022, p. 1351; Rivera-Ferre et al., 2021). Overall, diverse crop systems are less affected by extreme weather than single-crop systems, and thus contribute to resilience by mitigating extreme weather impacts (Huss et al., 2022, p. 1354).

Machinery and Equipment

When discussing their different agricultural practices, many interviewees also described the use of both traditional and non-traditional machinery and equipment for agriculture. People often viewed the benefit of these techniques as being time-saving and less labour-intensive. This includes using both oxen and tractors for ploughing fields to enhance efficiency and save time, as well as using techniques such as tunnel farming and greenhouse cultivation to protect crops from harsh weather conditions. Interviewees also explained how they learned these practices while migrating abroad, through watching YouTube videos, from neighbours, or from participating in formal training. Seeking out and utilizing novel techniques to protect crops and non-traditional machinery are central examples of enhancing resilience by learning from and adapting to changing weather conditions (Rijal et al., 2022). Farm mechanization “can contribute to increasing production, productivity, and profitability of agriculture by increasing land and labour productivity” in Nepal (Gauchan & Shrestha, 2017, p. 99). However, mechanization often demands substantial financial investments. Limited access to institutional credit hinders small-scale farmers from buying or hiring machinery (Gauchan & Shrestha, 2017). Furthermore, while portrayed as a solution to women’s drudgery in Nepal’s agriculture, realities show that currently endorsed tools and machines do not cater to the distinct requirements of female farmers (Gauchan & Shrestha, 2017).

Pest Management

Many interviewed farmers touched on increasing concerns regarding the emergence and spread of new types of pests in recent years. The emergence of new pests and crop diseases have been connected to weather changes across Nepal, particularly patterns of increasing temperatures, longer periods of drought, and increased numbers of wet days (Ramasamy & Regmi, 2014; Dhital et al., 2023). To manage pests, participants discussed how they traditionally use ash, smoke, and cow urine, or prevent impacts by not growing crops in pest-infested fields. Research across Nepal also shows how traditional pest management can include the ethnobotanical use of local plants, burning of fields, and the planting of attracting or repelling crops along field lines (Naharki & Jaishi, 2020, p. 255).

However, while these methods have positive impacts by enhancing soil quality and mitigating impacts of common pests, they do not always ensure local agricultural systems' resilience in the face of novel species (Milestad & Darnhofer, 2003). Participants noted that their practices are not always effective in getting rid of new types of unfamiliar pests.

Therefore, as a way of adapting to the emergence of new pests, many interviewees discussed how they are increasingly using chemical pesticides. However, some community members also expressed concerns with the negative impacts of these chemicals on the soil quality. Ifejika Speranza (2013, p. 532) has acknowledged the short-term "buffer capacity" of chemical pesticides for resilience, while also stressing their potentially negative long-term effects on system resilience as a whole. Interviewees also raised concerns about the effects of chemical pesticides on human health, including the exposure to pesticides through inhalation and eating foods grown with pesticides. Such exposure can affect health, particularly for children, and studies have shown that even short-term exposure can lead to serious health impacts (GC & Neupane, 2019).

To mitigate the negative impacts of chemical pesticides, while also addressing the increasing problems of pest infestations, some participants have started participating in training led by governmental and non-governmental organisations to learn about Integrated Pest Management (IPM). IPM approaches have become more popular in Nepal and provide an important tool for farmers to minimize chemical pesticide use and utilize ecological principles for pest management, while reducing negative impacts on environmental and human health (Paudel et al., 2020).

Collection Centres

When discussing changes in their communities, participants highlighted issues related to market access, and the ability to sell their agricultural products. The potential sale of produce relies on various factors, including the availability of yields and distance to selling points. These market challenges extend beyond Darma and Madi; rural farmers nationwide face difficulties selling vegetables, fruits, and other goods due to insufficient quantities and limited access to local markets (R. B. Shrestha et al., 2016). As this leads to subsequent negative impacts on local livelihoods and food security, Adhikari et al. (2021) have predicted that such developments will have more far-reaching consequences in the future. To address this, interviewees suggested establishing non-traditional collection centres to encourage vendors who prefer purchasing larger quantities of produce. A recent study by Thapa Magar et al. (2021) has emphasized the important role of such collection centres for building resilience in the post-COVID agricultural sector in Nepal. Furthermore, Romeo et al. (2021, p. 24) identified vegetable collection centres initiated by farmers' groups in Nepal as a crucial best practice for improving local livelihoods. It allows farmers to expand the reach of their sales and ensure better quality

control. Thus, collection centres can contribute to local economic resilience by preventing and/or mitigating financial losses associated with insufficient quantities of fruits, vegetables, or other goods.

6.2.2 Livestock Rearing

Participants discussed how changes in weather patterns, including temperature and rainfall, have also had negative impacts on the health of their livestock, which in turn impacts financial security. Previous studies have demonstrated the connection between climate change and livestock in Nepal, including the impacts of increased temperature and decreased rain on the health of livestock (Dhakal et al., 2013). This includes issues of animal diseases, heat stress, unavailability of animal feed, and loss of grazing land, which negatively affected milk production, lactation length, and fertility (Dhakal et al., 2013). A traditional way of reducing livestock sickness is feeding animals hot mash made from millet. Participants also raised several non-traditional techniques they are implementing to combat these negative impacts, including the building of enhanced shelters for their livestock to protect them against harsh weather conditions. This is common across the country, as people utilize novel mitigation strategies of improving animals sheds through use of stronger materials, providing bedding for warmth, combined with traditional feeding of hot food to reduce the risk of livestock falling ill due to adverse climatic conditions such as snow, heavy rain, cold, and wind (Koirala, 2018a).

The impacts of climate-related extreme events like drought, landslides, heavy rain, and floods can lead to the injury or death of livestock. Loss of livestock can have devastating economic consequences for farmers, particularly small-scale farmers that are more vulnerable to hazards. In order to mitigate these risks, participants discussed how they are increasingly investing in livestock insurance to reduce economic losses. Studies across Nepal reveal that people often depend on immediate aid from community members or informal institutions for short-term financial support, while livestock insurance is considered for long-term loss reimbursement (Rijal et al., 2022). Participants also mentioned how they have started raising different breeds of livestock, which may be stronger in the face of harsh weather conditions. The selection of new breeds of livestock is also a strategy used by farmers across Nepal to enhance livestock health and diversify livelihoods, therefore mitigating the impacts of weather changes (Upadhyay, 2019).

Participants that raise bees described the negative impacts of weather changes and pesticides on their bee populations. Impacts of weather phenomena such as dry spells, heavy rains, and freezing temperatures have also been documented in other regions of the country, leading to entire colonies collapsing (Ensor et al., 2019; Acharya, 2022). The

negative impacts of pesticides on bee populations are also recognized across Nepal (Pudasaini et al., 2016; Acharya, 2022). In response to these challenges, many participants are shifting away from the use of traditional beehives, and towards the use of contemporary beehives to better protect their bees. While traditional bee houses are easier to construct, less expensive due to use of local materials, and require less management, contemporary structures better protect bees from extreme weather, reduce attacks from predators such as red ants and hornets, and can lead to higher honey yields (Manandhar & Khanal, 2021).

Overall, interviewees noted many non-traditional techniques that are integrated with traditional approaches to reduce economic loss by mitigating the impacts of climate change on livestock health. The acquisition of livestock insurance, construction of more sturdy sheds for livestock, and use of modern bee houses are shown to be positive changes to mitigate the impacts of climate-related hazards and weather extremes on livestock across the country (Rijal et al., 2022; Koirala & Bhandari, 2018b; Manandhar & Khanal, 2021).

6.2.3 Diversification of Livelihoods

Throughout the interview process, participants stressed the various impacts of a changing climate and broader developments on their livelihoods. Due to decreasing earnings from agriculture, other occupations such as migratory labour, retail and business, and commercial livestock farming have become increasingly popular in Darma and Madi. This trend is not only limited to the two municipalities, but has been observed across Nepal (Rijal et al., 2022; Bhatta et al., 2015). The diversification of livelihoods through migrating abroad for labour-based income is recognized as a strategy for adapting to a changing climate and increasing economic resilience by reducing reliance on single, traditional sources of income such as agriculture (Arslan et al., 2021). With multiple income streams, community members improve their ability to cope with losses, particularly when their primary source of income is highly vulnerable to climate change (Rijal et al., 2022).

However, there are also challenges associated with migration. Male out-migration can cause distress and extra burden for women when their husbands are abroad, who have to assume greater responsibilities for agricultural activities. In a study conducted in Rolpa, it was found that “women's drudgery in the migrated households was found higher as compared to that in non-migrated households” (Subash et al., 2020, p. 36). However, the more reliable income source also appeared to have a beneficial effect on female participants' mental health, enabling them to better support the future of their children, and improving their capacity to deal with being separated from their partners. The increasing feminization of Nepalese agriculture can also contribute to the renegotiation of

roles and responsibilities at the individual, household, and community levels. It has enabled women to enter new decision-making arenas, allowing them to contribute their perspectives to resilience-building activities (Spangler & Christie, 2019). Aside from shifting gender dynamics, some participants noted that as people migrate away, more agricultural land has been left unused. This “increasing trend of land abandonment and exit from agriculture” (Subash et al., 2020) is also prominent in other areas of the country. Whether or not migration sustainably contributes to overall resilience is therefore highly context-dependent. While some research has stressed the importance of its economic benefits (Upreti & Shrestha, 2017), other studies have emphasised that seasonal migration might hamper adaptation by interrupting development activities in the local communities (Sapkota et al., 2016, p. 58).

Beyond migrating as a new source of livelihood, participants also reported being more involved in running businesses and commercial livestock farming. In Madi, some interviewees have been producing and selling furniture and clothing with Magar traditional designs. As shown across Nepal, manufacturing to diversify livelihoods often includes producing furniture, textiles, clothing, and footwear (Kapoor et al., 2021). It can enhance resilience by mitigating financial impacts of extreme weather and water scarcity on agriculture. The same applies to animal farming, which has become a popular adaptation option across the country (Rijal et al., 2022). However, increasing livestock presence can place an additional strain on local forest resources. In order to ensure sustainable and accessible commercial livestock rearing practices that contribute to resilience and adhere to local environmental boundaries, Pradhanang et al. (2015) have highlighted important policy gaps that need to be addressed by the Nepali government.

6.3 Social Resilience

6.3.1 Health Practices

Physical Health

Participants across both districts emphasised the impacts of weather changes on their physical health, including skin rashes, joint pain, respiratory problems, and mosquito-borne and diarrhoeal illnesses. This observation reflects experiences across Nepal’s hilly region. According to S. L. Shrestha et al. (2016, p. 151), temperature rises and heavy rainfall show a significantly stronger effect on the occurrence of water-borne diseases in the country’s mid-hills. Studies across Nepal indicate that the spatial spread and increased severity of these vector-borne diseases are tied to increases in temperature and precipitation (Bhandari, 2015; Dhimal et al., 2015). For example, it is estimated that a 1-degree Celsius increase in temperature in Nepal will raise the incidence of malaria by 26 percent (Dhimal et al., 2015). Furthermore, both vector-borne diseases and urinary

system infections were “found consistently associated with high temperature, low rainfall, and humid and windy days” in the region (S. L. Shrestha et al., 2016, p. 151). Notably, the effects were more pronounced among children and elderly in the communities. Diarrhoeal diseases are also increasing across the country due to rising temperatures and heavier rainfall, especially during the monsoon season (Bhandari, 2015). Reflecting participant’s realities, reports from other parts of Nepal indicate that the changing climate also influences the occurrence of uterine prolapse as the growing scarcity of water sources leads to women having to travel longer distances (Kapoor et al., 2021).

In interviews, community members reported how changing nutritional habits due to global market dynamics have also impacted community health, as more people eat purchased, processed foods. Studies of Nepal’s rural population have shown a prevalence of malnutrition across various age groups; however, children are especially affected due to their exposure to processed food and drinks from a young age (Tsang et al., 2019, p. 2). The trend towards more processed, oily, and sugary foods has been identified across Nepal, and is linked to increases in obesity and various non-communicable diseases (Subedi et al., 2017). Insufficient intake of nutrients and irregular eating habits in combination with increased heavy lifting may further contribute to uterine prolapse (Kapoor et al., 2021). While participants did not link nutritional deficiencies to climate change, studies across Nepal have pointed to the connection between decreasing access to nutritional foods and crop loss due to increasing drought and flooding (Bhusal & Dhimal, 2009; Kapoor et al., 2021).

To manage these effects on community health, participants employed both traditional strategies such as dietary adjustments and medicinal herbs, as well as non-traditional approaches like seeking care from modern healthcare facilities. In the context of traditional diets, elder community members in particular reported consuming mainly organic, locally grown, whole-grain, and fermented foods. While research about the concrete health benefits of organic produce for humans is ongoing, recent studies indicate a higher nutritional value and reduced contaminants like pesticides or antibiotics compared to conventional food (Groot, 2022, pp. 26-27). Organic dairy has been shown to reduce the likelihood of children developing skin rashes (Kummeling et al., 2008). The health benefits of whole wheat foods for humans have been well-documented (Liu et al., 2020), as well as the health-promoting properties of fermentation (Şanlıer et al., 2019). Most importantly, the traditional diets of Darma and Madi are highly diverse and localized, consisting of varying seasonal grains, fruits, and vegetables, local dairy and meat, as well as various naturally occurring plants, herbs, and spices. Diverse and locally-based diets are judged as more resilient and, in the face of climate change, have two central benefits:

firstly, they can prevent health issues in the face of weather extremes, and secondly, they mitigate the potential cascading effects of climate change-induced shortages of imported food (Berry et al., 2011; Tyler et al., 2013). Nutritional health is also an important preventative measure for many diseases that render people more vulnerable to climate change, such as cardiovascular diseases or diabetes (Manangan et al., 2015). Moreover, some traditional crops from the region, such as millet, are naturally climate-resilient, therefore mitigate impacts and improve food security under climate change (Mustafa et al., 2021).

While medicinal herbs and other traditional medicinal practices are still widely used, the emergence of new health concerns and increasing access to doctors and clinics have prompted more community members to seek medical advice outside traditional forms of healing. Studies across Nepal have yielded mixed results regarding the utilization of traditional and modern medicine in rural districts – while some communities still predominantly rely on traditional means, others prefer consulting governmental or private hospitals (Atreya et al., 2018; Bhattarai et al., 2015; Thorsen & Pouliot, 2016). According to these studies, demographic factors such as age and income, as well as the distance from health facilities, proximity to forests with medicinal plants, type of illness, and trends in the community were found to be factors influencing the uptake of different approaches. This was also apparent among participants in Darma and Madi, as many highlighted the severity of illness and convenience as central reasons for visiting local health facilities. A recent analysis demonstrates that by tracking outbreaks of climate-related diseases (S. L. Shrestha et al., 2016), facilities can inform local prevention and preparedness measures. Furthermore, active community health volunteers in Darma and Madi support resilience-enhancing activities by raising awareness and sharing information about relevant traditional and non-traditional health and dietary measures. In many ways, the spreading of health information and use of modern medical facilities can complement existing traditional structures and contribute to resilience in the face of climate-related impacts.

Mental Health

The mental health of participants has also suffered under the rapidly changing and unpredictable conditions. Feelings of fear and helplessness were especially prevalent in the two municipalities, and one participant mentioned suicides as a last resort for depressed farmers. While there has been limited research on the psychological dimension of farmer's suicides in Nepal, a study in India demonstrates how economic losses connected to seasonal crop failures can lead to depression and suicidal tendencies (Arafat et al., 2022). Kapoor et al. (2021, p. 24) highlight how threatened livelihoods and damaged local resources are “primary drivers” of mental health impacts related to climate change across the country. Overall, mental health issues have been

strongly underrepresented in academic research investigating the impacts of climate change. According to Petzold et al. (2020, p. 13), “[e]co-anxiety and mental wellbeing more generally (...) is still an area that is under-researched in climate science.” Studies have shown that local groups for self-help and mental health advocacy can be instrumental to prevent and mitigate related impacts (Arafat et al., 2022). This links to the positive potential of community groups for resilience, which is examined in the following section.

6.3.2 Support Systems

Aside from health and dietary practices, traditional social systems are crucial contributors to social resilience in Darma and Madi. Such systems, including formal and informal institutions, constitute form as defined by Becker (2014, p. 162). They facilitate the sharing of knowledge and skills, community organizing at all levels, and maintenance of regulations, norms, and values. Three different kinds of social support structures are examined in the following paragraphs: farmers’ groups, *Aama Samuha* (mothers’ groups), and the *Parma* system. The contributions of these community groups are not limited to social wellbeing, but also enhance economic and environmental resilience.

Many interviewees reported being part of local farmers’ groups, which support the exchange of knowledge and raise funds for community members. Collaborative spaces for farmers have been shown to contribute to adaptation and therefore resilience, as they allow people to “interact, communicate, experiment, and learn from each other” (Kangogo et al., 2020, p. 3). This pooling of resources and knowledge helps farmers to learn about the changes they face in their agricultural activities. Recently, formalizing this traditional structure has allowed the groups to access better resources to prepare for and respond to local impacts of climate change. Additionally, lifting the financial burden of making large investments enables farmers to invest in climate-smart practices for enhanced agricultural resilience and faster recovery from crop losses (Kangogo et al., 2020, p. 3). Local seed exchanges among farmers also mitigate potential effects of financial shortcomings to purchase seeds, while also encouraging traditional styles of farming. Therefore, they also significantly contribute to local economic resilience.

Local mothers’ groups, or *Aama Samuha*, also played an important role in knowledge exchange and microfinance schemes in the two municipalities. These groups are said to have developed informally in the Gurung and Magar communities in western Nepal, during a time when many male family members joined the army and women were left with more responsibilities in the public sphere. Since the 1980s, these organizations have been established formally (Poudel, 2021, p. 185). Overall, mothers’ groups contribute to a wide range of activities that build resilience to the impacts of climate change. These

groups spread information to mitigate health risks in the face of extreme weather and prevent malnutrition, provide microfinance to support farmers in adapting their agricultural activities and recovering from losses, and promote social cohesion. Most importantly, diverse sets of knowledge come together to facilitate peer-learning and response to local issues, which are crucial contributors to resilience (Webb et al., 2017; Khatri et al., 2023).

Lastly, participants in Darma mentioned the *Parma* system as an important pillar of local support. This social and economic support system has been observed in various parts of Nepal, and it builds on the principles of self-help and cooperation among community members (Holmelin, 2021). However, recent literature has also hinted at the gradual fading of this system (Chaudhary et al., 2020). Nonetheless, it represents a valuable form of community support and reciprocal exchange of labour, which has been an integral part of rural Nepali culture for generations. This system can be especially helpful for resilience in the context of preparing for and responding to hazards, such as the 2015 earthquake in Nepal (Spoon et al., 2023).

These three forms of social organizing in Darma and Madi are crucial for social, economic, and environmental resilience as they enable joint anticipation, recognition, adaptation, and learning of community members. As traditional systems, they are passed down by means of intergenerational learning, while also providing space for continued learning through social interactions and sharing of experiences. They contribute to local economic well-being by providing financial support to people in the community, including micro-financing to support the initiation or expansion of farming practices or businesses. Local groups can also support the exchange of knowledge, facilitate solution-oriented discussions, and raise awareness about climate change-related impacts. Lastly, local organizing can fuel joint action, as networks allow people to promote collective processes to address challenges in the community, such as water scarcity.

6.4 Infrastructural Resilience

Participants described the traditional method of building houses as using local materials including mud, clay, hay, stone and wood. These traditional construction practices have been developed and tested over time based on locally available materials, geography, and environmental conditions (Forbes, 2018). While some participants stated how they prefer such methods, others have started integrating the use of non-traditional approaches, which includes the use of imported materials such as concrete and slate. However, participants noted that these materials are often much more expensive and therefore not as accessible to most community members.

There was a general perception that these newer methods and materials provide more resilience to natural hazards such as earthquakes, heavy rainfall, and landslides. Interestingly, research conducted in the neighbouring hilly regions of Nepal has demonstrated that aspects of traditional housing construction are more shock resistant to earthquakes (Gautam et al., 2016). Unlike the newer techniques, which have not been monitored or assessed for long-term sustainability in these environments, traditional approaches have been tested and adapted over time (Forbes, 2018). However, there is limited research on the ability of traditional houses to withstand other types of hazards, such as heavy rainfall. Some participants also noted that while they feel safer in concrete houses, they often feel colder in these houses and therefore need to use space heaters. This is less of an issue in traditional houses, because the location, orientation, design, and materials used in construction ensure natural warming and cooling effects. Research into traditional construction of houses in hilly regions of Nepal demonstrate how some traditional buildings feature “solar passive measures to achieve thermal comfort conditions” based on the local climate (Bodach et al., 2014).

Perspectives shared by participants and studies across Nepal demonstrate a range of benefits and challenges for both traditional and modern construction techniques (Gautam et al., 2016; Bodach et al., 2014; Forbes, 2018). While some modern materials may be helpful for adapting to weather extremes, traditional knowledge and practices also play an important role in resilience as they have been adapted to the location environment over time. Failing to adapt new techniques to the location’s environment may contribute to the creation of new risks and insufficient resilience to hazards or weather extremes (Forbes, 2018). Therefore, learning how to integrate both traditional and modern construction techniques can enhance preparedness and mitigation of the impacts of changing climate conditions on infrastructure and households (Forbes, 2018).

8. Conclusion

This research explores how traditional knowledge is supporting climate change adaptation and overall community resilience to climate change in Darma Rural Municipality, Salyan District and Madi Rural Municipality, Rolpa District in Nepal. Answering the first research question, participants shared the changes and impacts they have experienced in their surroundings in recent years. This includes how shifting seasonal weather patterns, extreme heat and cold, drought, and unpredictable heavy rains have impacted local agriculture, livestock rearing, health, and financial security.

In response to research question two, this research demonstrates how traditional practices and knowledge systems support environmental, economic, social, and infrastructural resilience to climate change in Darma and Madi. Traditional knowledge encompasses not only practices, but also a time-tested understanding of the local environment that enables the identification of changes and their impacts. Practices related to agriculture, water, forest, and hazard management, health practices, and community organizing effectuate the crucial resilience functions of anticipation, recognition, adaptation, and learning. Examples include organic soil management, agroforestry, hazard risk reduction, rainwater collection, and the maintenance of community groups. In the municipalities, traditional practices are still pervasive and generally held in positive regard. However, many interviewees expressed feeling challenged by the unprecedented environmental changes and viewed traditional practices as insufficient to deal with emerging issues such as water scarcity or appearance of new types of pests.

Therefore, responding to research question three, this research also explores how community members integrate non-traditional practices to further support resilience. Contemporary methods can benefit community resilience to climate change by enhancing the efficiency of resource use, increasing income, reducing risk, diversifying livelihoods, and contributing to time-saving. These practices are acquired through migration, digital resources, formal training, and peer learning. However, many farmers also expressed concern about their lack of knowledge, technical skills, or financial resources to access solutions to intensifying challenges. Furthermore, the implementation of modern techniques is often trend-driven and may not always benefit long-term health and sustainability.

In order to balance short-term community needs and effects on human and environmental boundaries, further research is needed on how to best integrate traditional and non-traditional approaches for better anticipation, recognition, adaptation, and learning. This includes more attention to the benefits of traditional knowledge and collaborative development of integration strategies with community members to bridge identified gaps

and areas for improvement. While this research is inherently place-specific, findings may be applicable to other regions that feature similar geographic conditions and livelihood practices. However, application of these results should always align with the experiences and perspectives of local community members. As underscored by global climate change discussions, gaining a deeper insight into how traditional knowledge contributes to resilience through similar research conducted in various regions can contribute to more effective approaches to supporting local resilience worldwide.

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Appendix A: Interview Guide

This draft guide was developed as a semi-structured inspiration guided by themes rather than as a strict set of questions to be asked in each interview. They will be adapted during interviews and throughout the research process to align with themes and concepts that arise.

Themes to Guide Potential Interview Questions:

Daily practices and guiding views

1. Can you please tell me about yourself?
2. What is your role in the community?
3. What does a typical day look like for you?

Probes

- How do you do that?
- Why do you do it that way?
- Have you always done it like that?
- How did you learn this?
- Is this something your family has always done?

Experience of Changes in everyday life

1. Over the past few years, have you experienced any changes in your day-to-day life?
2. How have these changes impacted you and/or your family/community?

Probes

- Are these changes related to a) the weather, b) the water system, c) the surrounding nature?
- Would you give me an example?
- Can you tell me more about this?
- Can you explain this to me?
- What else? Is there anything else?

Responses to changes (past and present)

1. Have you done anything differently because of these changes?
2. Has anything changed in how you responded in the past? Or how your parents/grandparents responded?

Probes

- How do you do that?
- Why do you do it that way?
- Can you tell me more about this?
- Can you give me an example?
- What else? Is there anything else?

Challenges and benefits of changes

1. Have you experienced any challenges because of these changes?
2. Have you experienced any benefits because of these changes?
3. Which things are going well? Are there emerging issues/gaps?

Probes

- Why is this a challenge/benefit to you?
- Why is this going well?
- Why is this not going well?
- Would you give me an example?
- Can you tell me more about this?
- What else? Is there anything else?

Managing challenges

1. Does anything/anyone help you to manage these changes and challenges (now and in the future)?

Probes

- What could this look like?
- Would you give me an example?
- Where do you think this support could come from?
- Who is/could be involved? Who does this include?
- Is there anything being done in your community that has been helpful? Or unhelpful?

Ending Questions

1. Is there anything that you might not have thought about before that occurred to you during this interview?
2. Is there anything else you think we should know to understand ... better?
3. Is there anything you would like to ask us?

Appendix B: Consent Form (English)

Information about Participation in Thesis Research from Lund University

1. Information about the research

We are master's students at the Faculty of Engineering at Lund University who are interested in learning about the traditional or indigenous practices of your community. We invite you to participate in an interview to share your knowledge and experience. We are interested in learning about your everyday life, what changes you are noticing in your environment, which challenges you are experiencing, and how you are managing these challenges. The study will take place in Darma Rural Municipality, Salyan District, and Madi Rural Municipality, Rolpa District. You were selected to participate because of your knowledge and involvement in important daily activities in your community.

The research is independent. However, the Nepal and Finnish Red Cross Societies are providing support with logistics, transportation, and translation. The results will be shared with the Red Cross, but are not directly related to any future projects or funding.

2. Participation is voluntary

Your participation is voluntary and you do not have to answer any questions if you do not want to. If at any time you no longer want to participate in the interview, you are free to withdraw without any consequences. The interview will take around 1 hour. During the interview, we will take notes and record. The recording will later be transcribed. We may also take pictures, with your verbal consent and as agreed to below.

3. How your personal information will be used

The information you share will be analyzed for research purposes and will be included in a published master's thesis at Lund University. It will be presented without using your personal information, such as name or other identifying information. After the end of the project, all audio recordings of the interviews will be deleted. At any time, you can request for the information you provide to be deleted or excluded from the study. To do this, contact us using the contact details below.

You will be able to see the results of the study by downloading the finished thesis from <http://bit.ly/3K13LCU> later in 2023.

Consent to Participating in the Thesis Research

I have read and understood the information about the study in the above text. I have been given the opportunity to ask questions and I have had them answered. I may keep the written information.

- I consent to participating in the research described in this document, including being recorded.
- I agree to the use of my photos being taken and published.
- I consent to the use of my personal data as described in this document.

Place and date

Signature and name

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If you have any questions, please don't hesitate to contact us:

Tabitha Black-Lock, 9765406687, ta6311bl-s@student.lu.se
Dina Rodehorst, di2121ro-s@student.lu.se

If you need to contact our supervisor: Per Becker, per.becker@risk.lth.se

Appendix C: Consent Form (Nepali)

लुन्ड विश्वविद्यालयबाट शोध प्रबन्ध अनुसन्धानमा सहभागिताको बारेमा जानकारी

१. अनुसन्धान बारे जानकारी

हामीहरू लुन्ड विश्वविद्यालयको ईन्जिनियरिङ् संकायमा स्नातकोत्तर अध्ययनरत विद्यार्थीहरू हौं, र हामी तपाइँको समुदायका परम्परागत वा स्थानिय आदिवासीका ब्यबहारिक अभ्यासहरू बारे जान्न इच्छुक छौं। हामी तपाइँलाई तपाइँको ज्ञान र अनुभव साझेदारी गर्नको लागि एउटा अन्तर्वार्तामा भाग लिन आमन्त्रित गर्दछौं। हामी तपाइँको दैनिक जीवनको बारेमा जान्न इच्छुक छौं। तपाइँ आफ्नो परिवेशमा के कस्ता परिवर्तनहरू ध्यान दिँदैरहुनु भएको छ, तपाइँ कुन चुनौतीहरूलाई अनुभव गर्दैहुनुहुन्छ, र तपाइँ ती चुनौतीहरूलाई कसरी व्यवस्थापन गर्दै हुनुहुन्छ भन्ने बारेमा जान्न हामी उत्सुक छौं। यो अध्ययन सल्यान जिल्लाको दर्मा गाउँपालिका र रोल्पा जिल्लाको माडी गाउँपालिकामा हुनेछ। तपाइँलाई सहभागी हुन चयन गरिएको कारण तपाइँको समुदायको बारेमा तपाइँको ज्ञान र महत्वपूर्ण दैनिक गतिविधिहरूमा संलग्नता हो।

अनुसन्धानमा स्वतन्त्रता छ। यद्यपि, नेपाल र फिनिस रेडक्रस सोसाइटीहरूले कार्य योजना, रणनीतिहरूका रसद, यातायात र अनुवादको साथ सहयोग प्रदान गर्दै आएका छन्। परिणामहरू रेडक्रससँग साझेदारी गरिनेछ, तर कुनै पनि भविष्यका परियोजनाहरू वा कोषसँग प्रत्यक्ष रूपमा सम्बन्धित छैनन्।

२. तपाइँको लागि यो अन्तर्वार्तामा सहभागिताको अर्थ के होला

यस अध्ययनमा सहमत हुनुको अर्थ तपाइँले अनुसन्धानसँग सम्बन्धित आफ्नो अनुभवबारे छलफल गर्न अन्तर्वार्तामा भाग लिनु हो। अन्तर्वार्ता करिब १ घण्टा को हुनेछ। अन्तर्वार्ताको क्रममा, हामी नोटहरू लेख्नेछौं र रेकर्ड गर्नेछौं। रेकर्डिङ् त्यसपछि ट्रान्सक्राइब हुनेछ।

३. यस अनुसन्धानबाट प्राप्त नतिजाको बारे कसरी जान्न सकिन्छ

तपाइँले निम्न वेभसाइटहरूबाट समाप्त भइसकेका शोध प्रबन्धहरू डाउनलोड गरेर <https://lup.lub.lu.se/studentpapers/search/publication?sort=year.desc&q=studentpapertype%20exact%20H2&q=department%20exact%20v1000170&q=department%20exact%20v1000224&q=course%20exact%20VBRM15>

अध्ययनको नतिजा हेर्न सक्नुहुनेछ। यदि तपाइँ पछि २०२३ मा, सूचित हुन चाहनुहुन्छ भने कृपया हामीलाई खबर गर्नुहोस्।

४. सहभागिता स्वयंसेवी छ

तपाइँको सहभागिता स्वैच्छिक मात्र हो र यदि तपाइँ चाहनुहुन्न भने तपाइँले कुनै पनि प्रश्नको जवाफ दिनु पर्दैन। यदि कुनै पनि समयमा तपाइँ अन्तर्वार्तामा भाग लिन चाहनुहुन्न भने, बिना कुनै परिणाम तपाइँलाई फिर्ता हुने स्वतन्त्रता छ। यदि तपाइँले साझेदारी गर्नुभएको कुनै पनि जानकारी प्रयोग गर्न चाहनुहुन्न भने, यो मेटाइन्छ। यदि तपाइँ कुनै पनि बेला अन्तर्वार्तामा भाग लिन रोक्न चाहनुहुन्छ भने, कृपया हामीलाई जानकारी दिनुहोस्।

५. तपाइँको व्यक्तिगत जानकारी कसरी प्रयोग गरिनेछ

तपाइँले साझेदारी गर्नुभएको जानकारी अनुसन्धान उद्देश्यका लागि विश्लेषण गरिनेछ र लुन्ड विश्वविद्यालयमा प्रकाशित मास्टरको शोध प्रबन्धमा समावेश गरिनेछ। यो तपाइँको व्यक्तिगत जानकारी, जस्तै नाम वा अन्य पहिचान प्रयोग नगरी प्रस्तुत गरिनेछ। परियोजना समाप्त भएपछि, अन्तर्वार्ताका सबै अडियो रेकर्डिङहरू मेटिने छन्। कुनै पनि समयमा तपाइँले उपलब्ध गराउनुभएको जानकारी मेटाउन वा अध्ययनबाट अलग गर्नका लागि अनुरोध गर्न सक्नुहुन्छ। यो गर्नका लागि, तलको सम्पर्क विवरणहरू प्रयोग गरेर हामीलाई सम्पर्क गर्नुहोस्।

थेसिस अनुसन्धानमा भाग लिनको लागि मन्जूरी

मैले माथिको पाठमा अध्ययन सम्बन्धी विषयमा जानकारी पढेको र बुझेको छु। मलाई प्रश्नहरू सोध्ने मौका दिइएको छ र मैले तिनीहरूको जवाफ दिएको छु। मैले लिखित जानकारी राख्न सक्छु।

- म यस कागजातमा वर्णन गरिए झैं अनुसन्धानमा भाग लिन सहमत छु, रेकर्ड गरिँदै लगायत।
- म यस कागजातमा वर्णन गरिए अनुसार मेरो व्यक्तिगत डाटाको प्रयोग गर्न सहमत छु।

स्थान र मिति

हस्ताक्षर र नाम

.....

यदि तपाइँसँग कुनै प्रश्नहरू छन् भने, कृपया हामीलाई सम्पर्क गर्न नहिचकिचाउनुहोस्:

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