Assessment of Local Food System and Impact posed by flood and drought in Barbardiya Municipality of Bardiya District

Study Report

Submitted by

Local Initiative for Biodiversity, Research and Development (LI-BIRD)

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DanChurchAid (DCA) Nepal

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Acronyms

BASE	Backward Society Education
CAET	Characterization of the Agroecological Transition
DCA Nepal	Dan Church Aid
FGDs	Focus Group Discussion
HH	Household
IALDO	Integrated Agriculture and Livestock Development Office
IIED	International Institute for Environment and Development
KIIs	Key Informant Interviews
LEOC	Local Emergency Operation Center
PMAMP	Prime Minister Agriculture Modernization Project
RJKS	Radha Krishna Tharu Sewa Kendra
TAPE	Tool for Agroecology Performance Evaluation
TCDF	Tharu Community Development Forum
TMUK	Tharu Mahila Uthan Kendra
USAID	U.S. Agency for International Development
VRA	Vulnerability and Risk Assessment

Executive Summary

The "Easing and de-risking transition to climate-resilient food production for enhanced self-reliance in humanitarian contexts (NOVO de-risking agroecology)" project was initiated in Barbardiya Municipality, Nepal, to address vulnerabilities in local food systems caused by climate shocks, particularly floods and droughts. As a part of the project, this assessment seeks to assess agroecology-based food systems, evaluate risks, identify relevant stakeholders and policies, and document adaptive and mitigation practices to enhance resilience. A participatory and multidimensional approach was employed, combining qualitative tools such as focus group discussions and key informant interviews with quantitative household surveys covering 154 households across six wards. Analytical frameworks, including FAO's agroecological principles and vulnerability risk assessments, were utilized to evaluate the local food system's status and challenges.

The assessment identified significant vulnerabilities in Barbardiya's food systems, with flood and drought reported as major climate hazards by the 67.5% and 31.8% surveyed households respectively. Communities exhibited high exposure and sensitivity to these hazards but demonstrated only moderate adaptive capacity. The agroecological transition remains limited, with an overall score of 42.4%*, indicating poor implementation of practices like biodiversity enhancement, recycling, and resource integration. Cultural and traditional practices, however, remain strong, providing a foundation for resilience. Community adaptation strategies are primarily focused on adopting flood and drought-resistant cropsand modifying agricultural practices as reported by 76% and 50% surveyed households respectively. However, infrastructure development, early warning systems, and social safety networks remain weak.

The findings underscore the urgent need for targeted interventions to strengthen climate resilience in Barbardiya's food systems. Both short-term and long-term measures are proposed. Key recommendations include promoting agroecological practices such as mixed farming, agrobiodiversity conservation, and organic inputs; investing in infrastructure like irrigation systems, market facilities, and early warning mechanisms; and enhancing capacity-building programs for farmers. Moreover, the implementation of existing policies must be prioritized, with equitable allocation of resources and improved stakeholder collaboration to ensure sustainable outcomes. These measures are essential for building a climate-resilient, self-reliant, and sustainable food system in Barbardiya Municipality.

* As proposed by Lucantoni et al. (2023), the systems with a CAET score lower than 50% are considered "non agroecological", whereas systems with a CAET score comprised between 50% and 60% are considered in "incipient transition", systems with a CAET score comprised between 60% and 70% are considered "in transition to agroecology" and lastly systems having a CAET score higher than 70% are considered "agroecological".

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1. Introduction

1.1 Background

The increasing frequency and intensity of climate-induced disasters, such as floods and droughts, present significant threats to local food systems globally. These events disrupt the interconnected processes of food production, processing, distribution, and consumption, resulting in widespread food insecurity (FAO, 2021). In countries like Nepal, where agriculture underpins rural livelihoods, enhancing the resilience of local food systems is crucial.

Agroecology has emerged as a transformative solution to these challenges. Grounded in ecological principles and traditional knowledge, it promotes biodiversity, improves soil and water management, and strengthens community resilience (Altieri et al., 2017). Research shows that agroecological practices enhance ecosystem services, such as nutrient cycling and water retention, which are vital for mitigating the impacts of extreme weather events (Pretty et al., 2018). Examples include community seed banks and agroforestry systems, which have proven effective in boosting adaptive capacities in disaster-prone areas (Shrestha et al., 2019). In the context of Nepal, agroecology offers practical pathways for climate change adaptation by diversifying farming systems, reducing vulnerability to erratic rainfall and drought, and sustaining rural livelihoods under shifting climatic conditions (FAO, 2019; Shrestha et al., 2019).

Participatory approaches further amplify resilience by involving local stakeholders in decision-making. Farmer-led vulnerability assessments and the integration of local knowledge result in more context-specific and effective adaptation strategies (Thapa & Rimal, 2020). This is especially relevant in Nepal, where diverse agroecological zones require tailored interventions (Adhikari & Ojha, 2021).

In this context, LI-BIRD has initiated the "Easing and de-risking transition to climate-resilient food production for enhanced self-reliance in humanitarian contexts (NOVO de-risking agroecology) project." Funded by the Novo Nordisk Foundation and managed by DanChurchAid (DCA), the project operates in Barbardiya Municipality, Bardiya district, a region highly vulnerable to flood and droughts. The project aims to:

- Assess the vulnerabilities of local food systems to climate shocks.
- Develop and test adaptive strategies, based on agroecological principles, including anticipatory action and risk mitigation.
- Embed findings into policy and humanitarian frameworks to scale resilience-building efforts.

Research underscores the importance of institutional support and governance mechanisms in sustaining agroecological transitions (Wezel et al., 2020; and Anderson et al., 2021). Global initiatives, such as the FAO's Scaling up Agroecology Programme and the UNFCCC's Koronivia Joint Work on Agriculture, highlight the value of strengthening local institutions and leveraging indigenous practices to create climate-resilient food systems (FAO, 2021; UNFCCC, 2019). These frameworks provide valuable insights for enhancing local adaptation and disaster preparedness, enabling projects like 'NOVO de-risking agroecology' to address both immediate and long-term challenges effectively.

By synthesizing global knowledge with local experiences, the NOVO de-risking agroecology project seeks to develop an actionable framework for de-risking agroecological food systems. Its overarching goal is to ensure sustainable food security and community resilience in the face of escalating climate challenges. Specifically, the project aims to evaluate existing evidence, identify best practices, and apply lessons learned to ease the transition to sustainable, climate-resilient agroecological systems. This includes developing models for forecasting and anticipatory action

to safeguard local food and market systems from climate shocks, while integrating findings into humanitarian efforts with local and international partners.

1.2 Objectives of the Assessment

The specific objectives of the assessment are:

- Assess the existing local food system that is based on agroecological practices in the Barbardiya Municipality.
- Assess the specific risks, vulnerabilities, and impacts posed by flood and drought on the local food system.
- Identify key stakeholders and existing policies, programs and practices of local government related to climate-resilient food system.
- Assess and document the adaptation and mitigation practices adopted by communities for the resilient local food system against flood and drought risks.

1.3 Scope and Limitations of the Assessment

The assessment focused on evaluating the local food system and the impact of floods and droughts, particularly in the wards adjacent to the Babai River basin in Barbardiya Municipality (Wards 1, 2, 3, 4, and 11). The findings are intended to assist the municipality in developing Standard Operating Procedures (SOPs) and early action protocols essential for creating a resilient local food system. These efforts will support the municipality in preparing mitigation and adaptation strategies aimed at de-risking agroecology-based food systems against the impacts of floods and droughts.

2. Methodology

2.1 Approach and Methodology

This assessment gathered the necessary information through various data collection methods, incorporating both secondary and primary sources. It was inclusive and participatory, utilizing qualitative tools. The methodological framework employed in this assessment is presented in Figure 1.

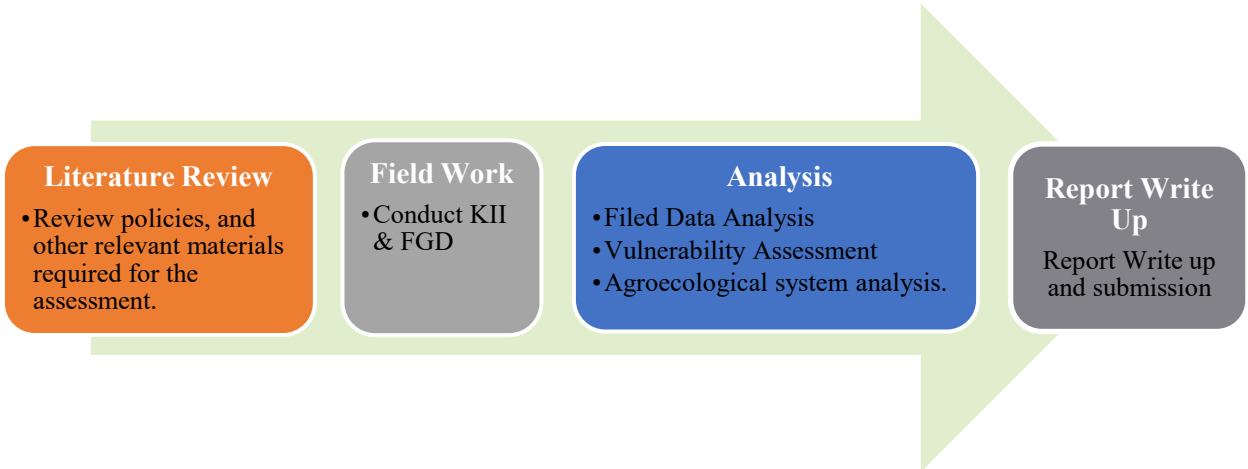


Figure 1. Methodological framework of the assessment

The assessment was grounded in the 10 elements of Agroecology (FAO, 2019), as outlined in Figure 2. It also considered six components of LI-BIRD's agroecological framework which has been developed following FAO's 10 elements of agroecology with customization in Nepalese context: i) Strong community institutions; ii) Agricultural biodiversity and local seed systems; iii) Soil fertility and water resource management; iv) Disease and pest management; v) Indigenous knowledge, social values, and food culture; and vi) Value addition, branding, and marketing.

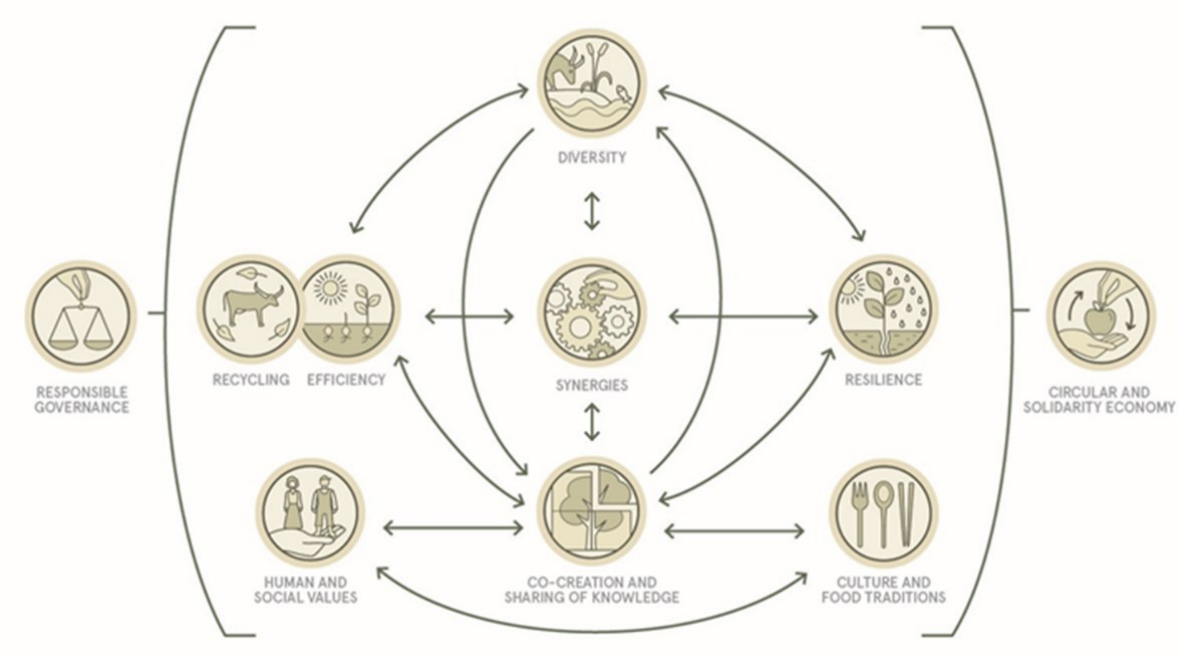


Figure 2. Elements of agroecology

This assessment also adopted the Community-Based Climate Change Vulnerability Risk Assessment method developed by MoEST (2021), which is grounded in the conceptual framework outlined in the IPCC's fifth assessment report.

2.2 Study Area and Sampling

Barbardiya Municipality is located in Bardiya District, Lumbini Province, Nepal. It was established through the merger of the former Village Development Committees (VDCs) of Baniyabhar, Padanaha, Magaragadi, and Dhadhawar. Geographically, the municipality is positioned in the central part of the district. It shares borders with Bansgadhi Municipality to the east, Madhuban Municipality to the west, Thakurbaba Municipality and Bardiya National Park to the north, and Gulariya Municipality to the south.

The municipality is situated at an elevation of approximately 175 meters above sea level, with the Chure hills to the north and the Terai plains to the south. It spans an area of 226.09 square kilometers (87.29 square miles) and is divided into 11 administrative wards. According to the 2021 National Census, Barbardiya Municipality comprises 16,897 households and a population of 72,533, including 34,126 males and 38,407 females (National Census, 2021).

Initially, this assessment was designed to cover five wards (1, 2, 3, 4, and 11) of Barbardiya Municipality (Figure 3). However, Ward 5 was later added to the study, specifically for the household survey component. The sampling plan, finalized in collaboration with the LI-BIRD team, is outlined in Table 1. It involved 10 FGDs, 25 KIIs, and 154 household surveys.

Table 1. Sampling plan for the assessment

Barbardiya Municipality Wards	No. of FGD	No. of KII	HH Survey
Ward No 1	2	5	31
Ward No 2	2	5	25
Ward No 3	2	5	26
Ward No 4	2	5	26
Ward No 5	-	-	16
Ward No 11	2	5	30
Total	**10**	**25**	**154**

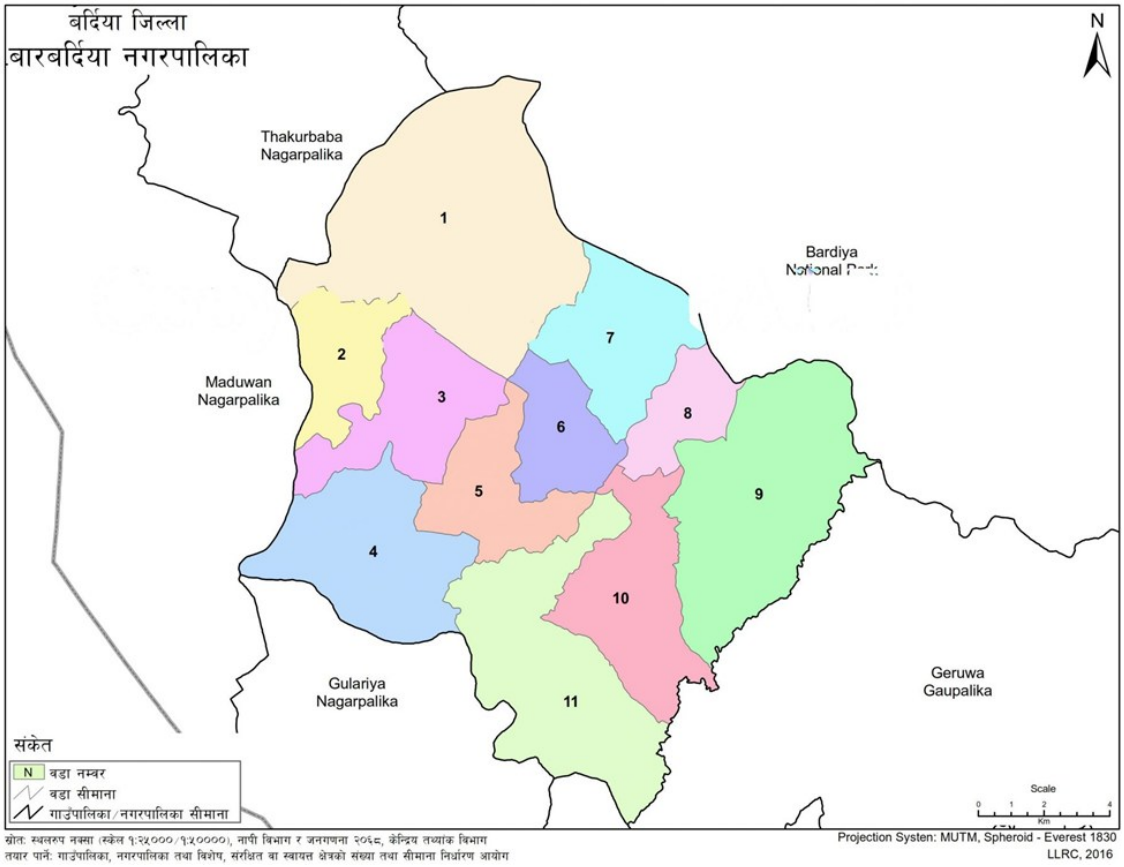


Figure 3. Study area

2.3 Data Collection Tools and Techniques

This assessment employed a variety of vulnerability and capacity assessment tools (refer Annex), including the review of secondary sources, key informant interviews (KIIs), focus group discussions (FGDs), direct observations, mapping of community resources, hazards, and livelihood assets, crop calendars, institutional and social network analysis, and household surveys.

Household survey was conducted in 154 randomly selected households across selected six wards. A structured questionnaire was used for the survey, which was digitized using the KoboCollect app. Three enumerators were trained to collect data using the mobile app.

Key informant interviews were conducted to gather in-depth information. The interviews used checklists to explore various aspects, including existing evidence, good practices, and lessons learned related to the transition to sustainable, climate-resilient agroecology-based food production. The focus was on enhancing food security and self-reliance in the face of climate

shocks, particularly floods and droughts. For the KIIs, up to five individuals from the target group (lead farmers and *Badghar* from risk prone communities) and other stakeholders (governmental stakeholders, traders, processors etc) were selected from each ward. Stakeholders, including government officials, lead farmers, and other key participants, were chosen in consultation with the project team.

A total of 10 *focus group discussions* were organized across selected wards (2 per ward), ensuring the active participation of women and youth. These FGDs took place in 30 at-risk communities/settlements in Barbardiya Municipality, covering wards 1, 2, 3, 4, and 11. A checklist was used to explore various aspects, including existing evidence, best practices, and lessons learned on transitioning to sustainable, climate-resilient agroecology-based food production. The focus was on improving food security and self-reliance in the face of climate shocks, particularly floods and droughts. Participants included target groups, representatives from collaborating institutions, local government bodies, sectoral line agencies, and community leaders. The selected communities for the FGDs in the study wards were: Laungahawa and Jodhipur (Ward 1), Dhungrahi and Bepattapur (Ward 2), Bhaisakhani and Jhakkipur (Ward 3), Guruwagaun and Ranipur (Ward 4), and Bijaynagar and Lamkiphanta (Ward 11).

2.4 Data Analysis

Qualitative data and information were transcribed to conduct thematic and narrative analysis and vulnerability risk assessment analysis. The analysis included two major approaches.

2.4.1 Vulnerability Assessment

The Vulnerability Assessment aimed to explore the impacts and risks posed by floods and droughts on local food systems. Figure 4 illustrates the vulnerability assessment framework used in the study. This assessment employed an indicator-based method, identifying specific indicators for hazards, exposure, sensitivity, and adaptive capacity.

To calculate the index values for exposure, sensitivity, and adaptive capacity, the perceived change scores for each associated criterion were averaged. An overall average index value (AVG) was then computed, considering the index values for all indicators across these three dimensions. The final rankings for exposure, sensitivity, and adaptive capacity were determined based on the AVG index values, which were categorized into four levels: "LOW," "MEDIUM," "HIGH," and "VERY HIGH." A community with an AVG index value below 1 is classified as "LOW," those with values between 1 and 2 fall under "MEDIUM," communities with values between 2 and 4 are considered "HIGH," and those with values above 4 are categorized as "VERY HIGH." The analysis used these final rankings to assess vulnerability.

Range	Rank
≤ 1	LOW
1-2	MEDIUM
2-4	HIGH
>4	VERY HIGH

Vulnerability was calculated based on the following theoretical bases.

Vulnerability is defined as a function of exposure, sensitivity, and adaptive capacity and formula for calculating vulnerability is purposed as :

V=(E*S)-AC

V= (E*S)/A

Where,

E= Exposure (AVG index value)

S= Sensitivity (AVG index value)

A= Adaptive Capacity (AVG index value)

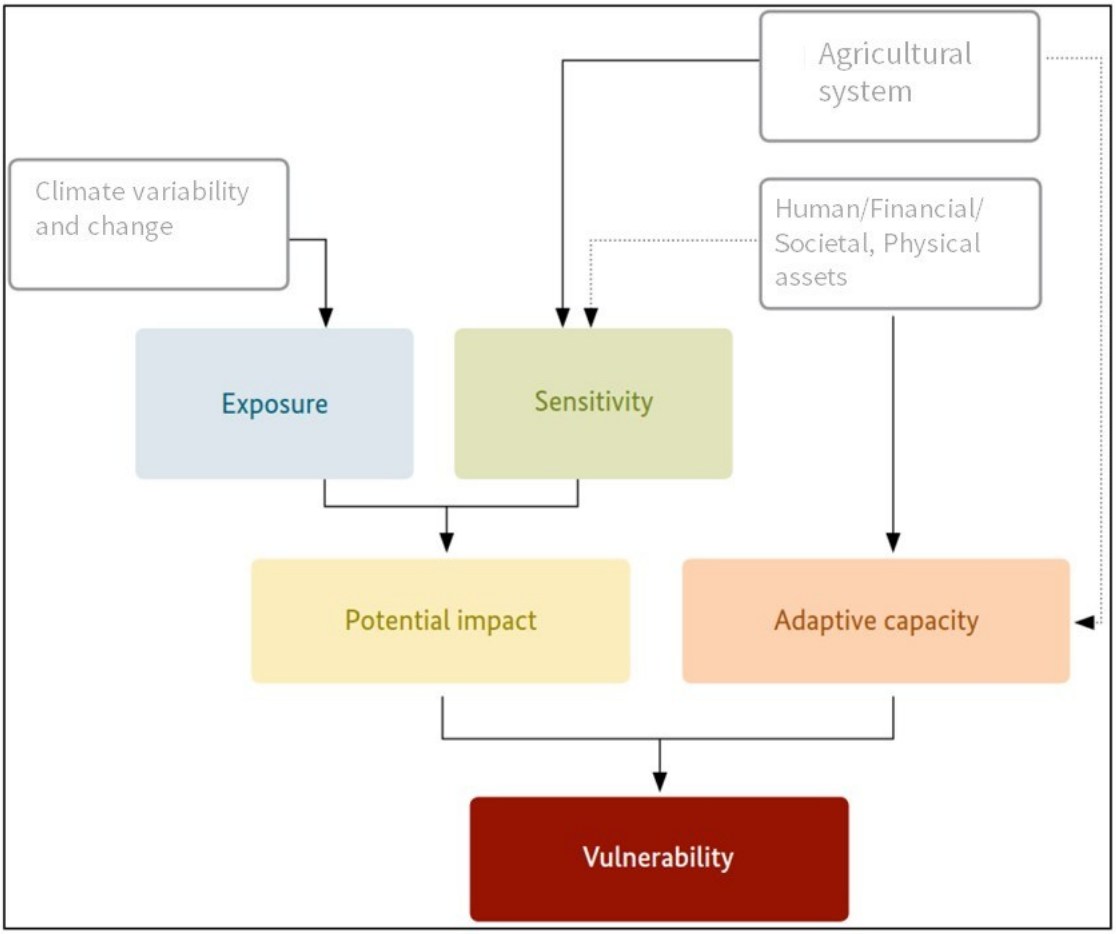


Figure 4. Vulnerability assessment framework used in the assessment

2.4.2 Agroecological System Analysis

Agroecological System Analysis is based on FAO's 10 elements of agroecology as presented in Figure 2. Based on FAO's Tool for Agroecology Performance Evaluation (TAPE) which includes Scores for Characterization of the Agroecological Transition (CAET), the analysis used Modified Light TAPE tool of DCA for Household Survey using KOBO Tool. The 10 Elements were disaggregated into 33 indices with descriptive scales explaining five level of transition (Scores from 0 to 4). The final scores were converted into a percentage of transition for each element. The CAET total score is the average score across all 10 elements.

As proposed by Lucantoni et al. (2022), the systems with a CAET score lower than 50% are considered "non agroecological", whereas systems with a CAET score comprised between 50% and 60% are considered in "incipient transition", systems with a CAET score comprised between 60% and 70% are considered "in transition to agroecology" and lastly systems having a CAET score higher than 70% are considered "agroecological".

The analysis interpreted results from both VRA and TAPE to understand the vulnerability and current status of agroecology and local food system against drought and flood risks (Figure 5). Eventually, this assessment provided recommendations for adaptation and mitigation measures.

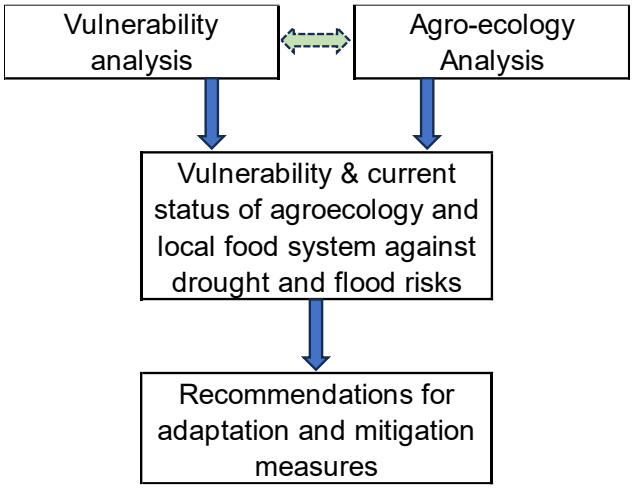
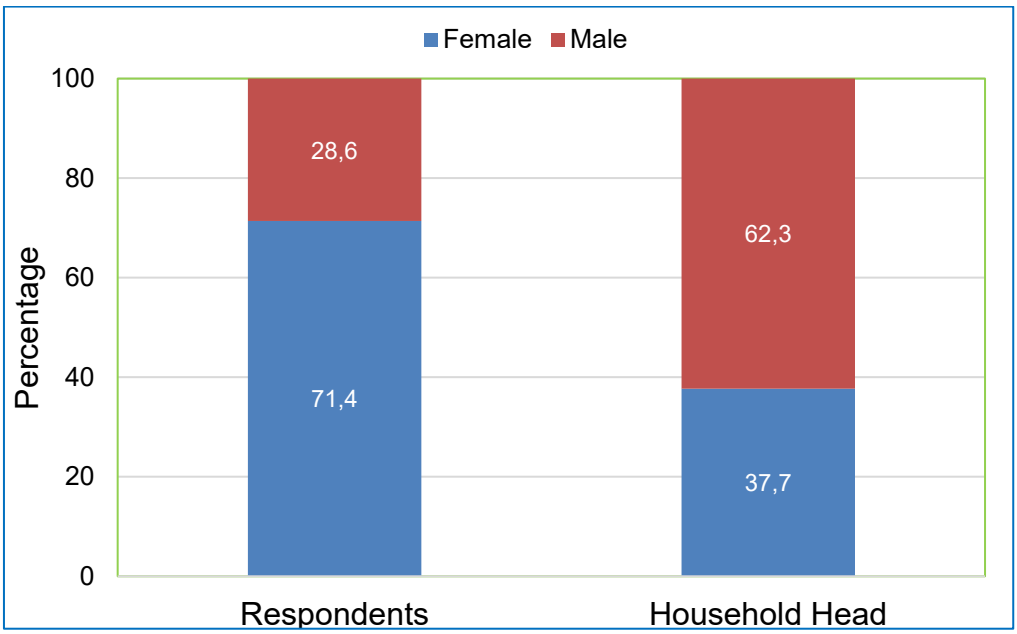


Figure 5. Overall analysis framework

2.5 Sample and Household Characteristics

Among the respondents nearly three-fourth were female, but the situation was different in case of household head. Only slightly more than one-third of surveyed household reported female as household head (Figure 6). Overall, 71.4% of respondents were female, while 62.3% of household heads were male, with the average age of respondents and household heads being 41.2 (SD 14.8) and 46.9 (SD 12.5) years, respectively. Household survey result reflects significant variations in gender composition and age distributions across the study communities.

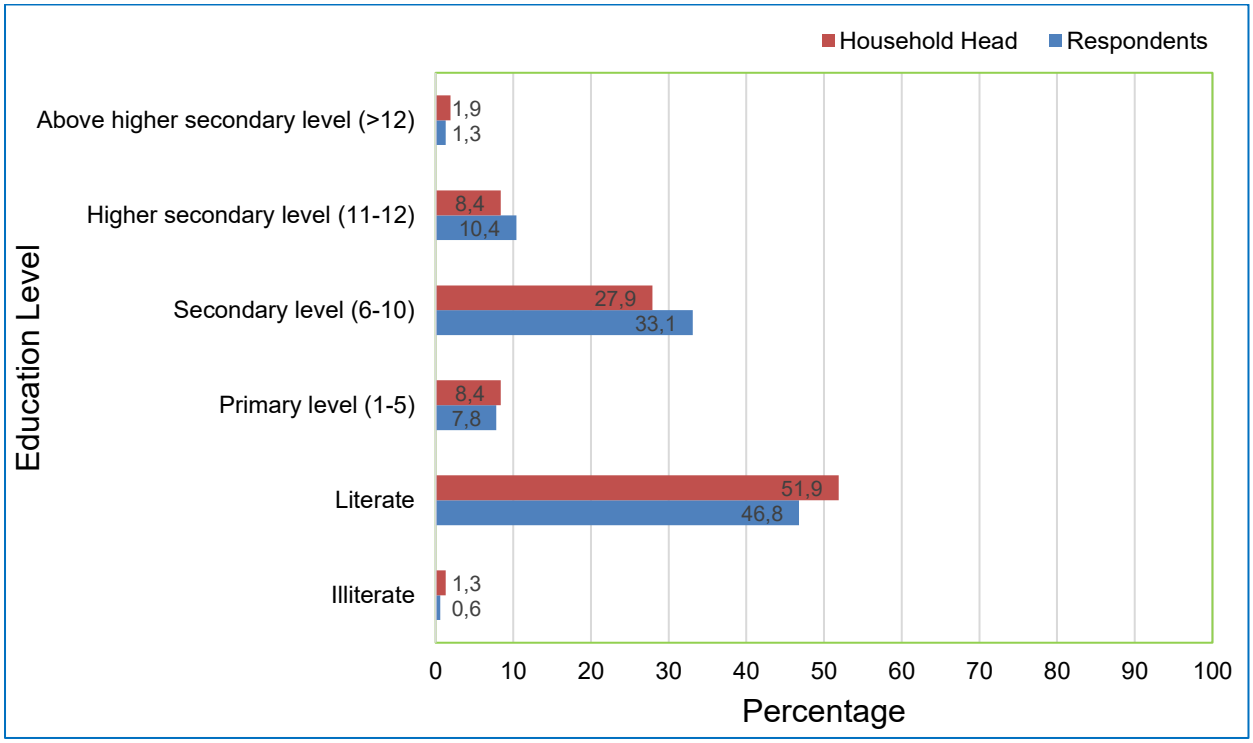


Source: Household Survey, 2024

Figure 6. Distribution of respondents and household head by gender

The educational attainment levels of respondents and household heads is presented in Figure 7. A majority of household heads (51.9%) and respondents (46.8%) were literate but have not completed formal education. Secondary education (6-10 grade) is the highest completed level for 33.1% of

respondents and 27.9% of household heads. Very few individuals have education above higher secondary level (>12 grade), with only 1.9% of household heads and 1.3% of respondents achieving this. The illiteracy rate is low, at 1.3% for household heads and 0.6% for respondents.



Source: Household Survey, 2024

Figure 7. Distribution of education level of respondents and household head

The household survey revealed that most respondents (94.2%) belong to the Adibasi Tharu group, indicating a strong predominance of this ethnicity in the studied communities. Smaller proportions include the Brahmin/Chhetri/Thakuri group (3.9%) and the Dalit group (1.9%). The average household size is 5.7 (SD 2.3), with slight variations across communities. Children under 20 years form the largest group, averaging 1.4–1.8 per household across wards, with overall average of 1.6 (SD 1.1). Adults aged 20–40 years are fairly balanced by gender, averaging 1.1–1.4 per household, while those aged 40 and above are fewer, averaging 0.8–1.0 per household.

Being a predominantly rural area, most households rely on farming as their main source of livelihood. However, other income sources are also significant (Household Survey, 2024). Wage labor is the dominant income source (53.9%), followed by remittances from outmigration (14.3%). Business and services contribute 5.2% and 11.0%, respectively, while "other sources" account for 28.6%, reflecting diverse activities. Outmigration significantly influences household dynamics, with 53.2% of households having migrant family members. Short-term migration is slightly more common than long-term, averaging 1.6 (SD 0.8) and 1.2 (0.4) family members per household, respectively (Household Survey, 2024).

Household survey further revealed that nearly all households (98.7%) own land, with an average holding of 0.57 hectares.

Table 2 Distribution of Households by size of landholdings

Land Holdings in Hac	Number of HHs	Percentage of HHs
Less than 0.2 hac	41	26.62

0.2-0.67 hac	79	51.30
More than 0.67 hac	34	22.08
Total	154	100

Land ownership is primarily female (77.3%), followed by joint (15.6%) and male ownership (14.3%). Renting-in land is relatively common in some communities, averaging 0.66 hectares (SD 0.52) for those who rent, while renting-out is less frequent, averaging 0.4 hectares (SD 0.39). The findings highlight the predominance of female and joint land ownership and varying land renting patterns across communities.

3. Local Food System and Agroecological Transition

This section first discusses existing production system in the study area and the local food system. Then another section explains the agroecological transition in those communities.

3.1 Production and Local Food System

Farmers cultivate crops across seasons, with Table 2 highlighting seasonal patterns of household engagement and average cultivated area. During the monsoon, 97.4% of households cultivate an average of 0.66 hectares. Winter cultivation is equally prevalent, with 97.4% of households cultivating an average of 0.57 hectares. Spring *(Chaite)* season sees moderate activity, with 43.5% of households cultivating 0.28 hectares on average, while summer has the lowest participation, with 37.7% of households cultivating 0.29 hectares. Cultivation patterns and areas vary across communities, with monsoon and winter being the primary seasons, while spring and summer show reduced activity and smaller areas.

A significant portion of land remains fallow during spring and summer, primarily due to a lack of irrigation (78.7% of households) and wildlife interference (73%). Other factors, such as insufficient labor and high production costs, impact only 1.9% of households. Overall, irrigation challenges and wildlife are the main barriers to utilizing fallow land.

Table 3. Seasonal cultivation patterns in the study area

Cultivation season	HH cultivating (%)	Average area (ha)
Monsoon	97.4	0.66 (SD 0.60)
Winter	97.4	0.57 (SD 0.55)
Spring/Chaite	43.5	0.28 (SD 0.21)
Summer	43.5	0.28 (SD 0.25)

Source: Household Survey, 2024

Table 4 Seasonal cultivation patterns across the study wards

Wards	Monsoon		Winter		Spring/Chaite		Summer	
	HH cultivating (%)	Average area (ha)	HH cultivating (%)	Average area (ha)	HH cultivating (%)	Average area (ha)	HH cultivating (%)	Average area (ha)
Ward 1	100.0	0.48	100.0	0.45	51.6	0.20	32.3	0.16
Ward 2	96.0	0.88	96.0	0.87	36.0	0.43	32.0	0.42
Ward 3	92.3	0.40	100.0	0.40	46.2	0.23	42.3	0.25
Ward 4	96.2	0.69	88.5	0.61	38.5	0.29	61.5	0.53
Ward 5	100.0	1.07	100.0	0.74	43.8	0.38	25.0	0.19
Ward 11	100.0	0.63	100.0	0.50	43.3	0.19	30.0	0.18
Total	97.4	0.66	97.4	0.57	43.5	0.28	37.7	0.29

Source: Household Survey, 2024

Table 5 Seasonal cultivation patterns according to size of land holdings

Land holdings size	Monsoon	Winter	Spring/Chaite	Summer

	HH cultivating (%)	Average area (ha)	HH cultivating (%)	Average area (ha)	HH cultivating (%)	Average area (ha)	HH cultivating (%)	Average area (ha)
Less than 0.2 hac	97.6	0.33	97.6	0.31	34.1	0.33	34.1	0.19
0.2-0.67 hac	96.2	0.54	97.5	0.50	41.8	0.49	39.2	0.71
More than 0.67 hac	100.0	1.37	97.1	1.13	58.8	1.09	38.2	1.50
Total	97.4	0.66	97.4	0.57	43.5	0.28	37.7	0.29

Source: Household Survey, 2024

The local food system is primarily subsistence-based, with nearly all community members cultivating paddy, the main food crop (Table 3). Paddy is grown by 98.1% of households, mainly for self-consumption (56.3%), with some engaging in mixed use (43.7%). Wheat, maize, and lentils are moderately cultivated by 45.9-77.6% of households, mostly for self-consumption. High cultivation rates are also observed for mustard, legumes, potatoes, vegetables, and spices (42.9-91.6%), with potatoes (89.9%), vegetables (86.5%), and spices (84.6%) predominantly grown for self-consumption. Crops grown primarily for sale are rare (0-3.4%), while 2.2-26.5% of households grow crops for mixed purposes. Overall, the findings indicate a strong focus on subsistence farming, with limited commercial activity, particularly for crops like mustard, legumes, and cereals.

Table 6. Cultivation of different crops and purpose of production

Crops	Households cultivating (%)	Purpose of production (% of cultivating households)			
		Sale	Mostly sale and a small part of self-consumption	Mostly self-consumption and a small part of sale	Self-consumption
Paddy	98.1	-	18.5	25.2	56.3
Wheat	63.6	3.1	26.5	24.5	45.9
Maize	56.5	3.4	23.0	18.4	55.2
Mustard	89.0	-	4.4	15.3	80.3
Lentil	55.6	-	8.2	14.1	77.6
Other legumes	42.9	-	6.1	15.2	78.8
Potato	89.6	-	2.2	8.0	89.9
Vegetables	91.6	-	6.4	7.1	86.5
Spices crops	88.3	-	2.9	12.5	84.6

Source: Household Survey, 2024

FGDs and crop calendars from selected communities highlight the year-round, subsistence-focused agricultural practices in the study villages. Major crops include paddy, maize, wheat, mustard, lentils, potatoes, vegetables, spices, and fruits. Paddy, the main crop, is primarily grown for household consumption, with improved varieties like Radha-4, Sawa Mansuli used and occasional surplus sold. Maize is grown in two seasons, with local varieties for consumption and hybrids for sale. Other crops such as wheat, mustard, legumes (lentils, soybeans, gram, black gram), and vegetables (like bitter gourd and cabbage) are cultivated mainly for subsistence, with some commercial farming. Potatoes like Lal Gulab, Cardinal and Tharu Aalu are grown for consumption and cultural purposes, while spices such as onion, garlic, and turmeric are primarily for personal

use, with limited sales in some communities. Fruits like mango, litchi, banana, and papaya are grown for household consumption, with small surpluses sold.

However, agricultural productivity varies across villages. While communities like Laungahawa, Jodhipur, and Dhungrahi shows agricultural diversity, challenges in areas like Lamkiphata are evident. Severe drought, inadequate irrigation, and reliance on rainwater or municipal water hinder productivity, further exacerbated by pest and disease outbreaks. The community-level Five Cell analysis revealed that paddy, wheat and mustard are cultivated by more households across larger areas, while commercial vegetables and maize are grown by fewer households but on more extensive land. Conversely, some crops are cultivated by more households in smaller areas, while others are grown by fewer households on limited land. Additionally, some crops are rare and seem to be either extinct or on the verge of extinction. Table 4 summarizes the situation across the study communities.

Table 7. Five Cell analysis of the crops grown

Features	**Crops**
Crop cultivated in larger portion of area by a large number of HH	Paddy, wheat, and mustard
Crop cultivated in larger portion of area by less number of HH	Commercial vegetable (mainly, tomatoes, chilly), and Maize
Crop cultivated in small area by large number of HH	Vegetables, potatoes, turmeric, onion, garlic, fruits, Anadi rice, leafy vegetable (*pohi*), spices, gram, peas, beans, yam, lentil, soyabean, black gram, and sweet potato.
Crop cultivated in small area by less number of HH	Ginger, soyabean, black gram, pigeon pea, peanut, siltung (rice bean), sesame
Crops at the risk of extinction (rarely grown) or are not grown in last few years.	Siltung (rice bean), flaxseed, pigeon pea, *latera* rice, peanut, sesame, barley

Source: FGDs with communities

Several crops, including flaxseed, pigeon pea, Siltung (Rice Bean), latera rice, sesame, and barley, are becoming increasingly rare due to various factors that threaten their extinction. Flaxseed, in particular, has seen a significant decline in productivity, leading to reduced interest in its cultivation farmers preferring mustard. The cultivation of pigeon pea has decreased because of severe pest infestations and lower yields. Similarly, Siltung is less commonly grown particularly because it takes more than 4 months to mature, which has led to diminished interest among farmers. While Anadi rice is still cultivated by nearly all households on a smaller scale, primarily for its cultural significance during the Maaghi festival. Yam also holds cultural importance during the Maaghi festival. Crops like gram and pigeon pea are cultivated by fewer households due to reduced land availability. Lentil production remains minimal, mainly due to a lack of irrigation and damage from rainfall. Local maize is also less frequently grown, primarily because of irrigation scarcity, and this could ultimately lead to its extinction.

Likewise, community members keep a diverse range of livestock, which is the source of food as well as income. Local chicken and duck are key parts of the local cuisine. Table 5 provides insights into livestock rearing among households, highlighting the proportion of households involved and their purpose for rearing. Goats are the most commonly reared livestock (73.1%), primarily for sale (52.8%) or for mixed purposes (30.2%) Fowl (Chicken) is the second most common (66.2%), but with a different emphasis, as 50.0% of households rear them mainly for mixed use, combining sale and consumption. Buffaloes (34.5%) and pigs (36.6%) are also popular, with pigs being reared mainly for sale or mostly sale (41.5% and 58.5%, respectively). Less common livestock includes cattle (10.3%), ducks (5.5%), sheep (4.8%), and fisheries (0.7%). Cattle are mostly reared for sale

of milk and milk products (80.0%), while ducks are largely for self-consumption (50.0%). Sheep rearing combines sale and mostly sale (28.6% and 57.1%), and fisheries are exclusively reared for "mostly sale" (100%).

Table 8. Rearing of different animals and purpose of production

Livestock	Households rearing (%)	Purpose of rearing livestock (% of rearing households)			
		Sale	Mostly sale and a small part of self-consumption	Mostly self-consumption and a small part of sale	Self-consumption
Cattle	10.3	80.0	6.7	6.7	6.7
Buffalo	34.5	74.0	14.0	2.0	10.0
Goat	73.1	52.8	30.2	12.3	4.7
Sheep	4.8	28.6	57.1	-	14.3
Pig	36.6	41.5	58.5	-	-
Fowl	66.2	2.1	14.6	50.0	33.3
Duck	5.5	12.5	12.5	25.0	50.0
Fisheries	0.7	-	100.0	-	-
Others	2.8	50.0	50.0	-	-

Source: Household Survey, 2024

FGDs at the community level revealed common livestock combinations across villages. In Laungahawa, Jodhipur, Dhungrahi, Bepattapur, Bhaisakhani, Jhakkipur, Guruwagaun, Ranipur, Bijaynagar, and Lamkiphata villages, the primary livestock include goats, pigs, and fowls, with some also raising buffaloes and cattle. Livestock rearing serves both commercial and subsistence purposes, with goats, buffaloes, and poultry being raised widely, while smaller livestock are kept for specialized uses.

3.2 Agroecological Transition

Result showed that the overall Score for agroecological transition, the CAET Score, is below 50% across all wards. It revealed that the level of transition to agroecology is poor, and the farms cannot be considered as agroecological. Among the 10 elements, the score was below 40% for 5 elements. The overall average score was only 42.4. Only the score of Human and Social Values was above 50%. The poor result showed that the implementation of agroecological practice is very low in the study area. The overall score of these elements is shown in Figure 8 and Table 6.

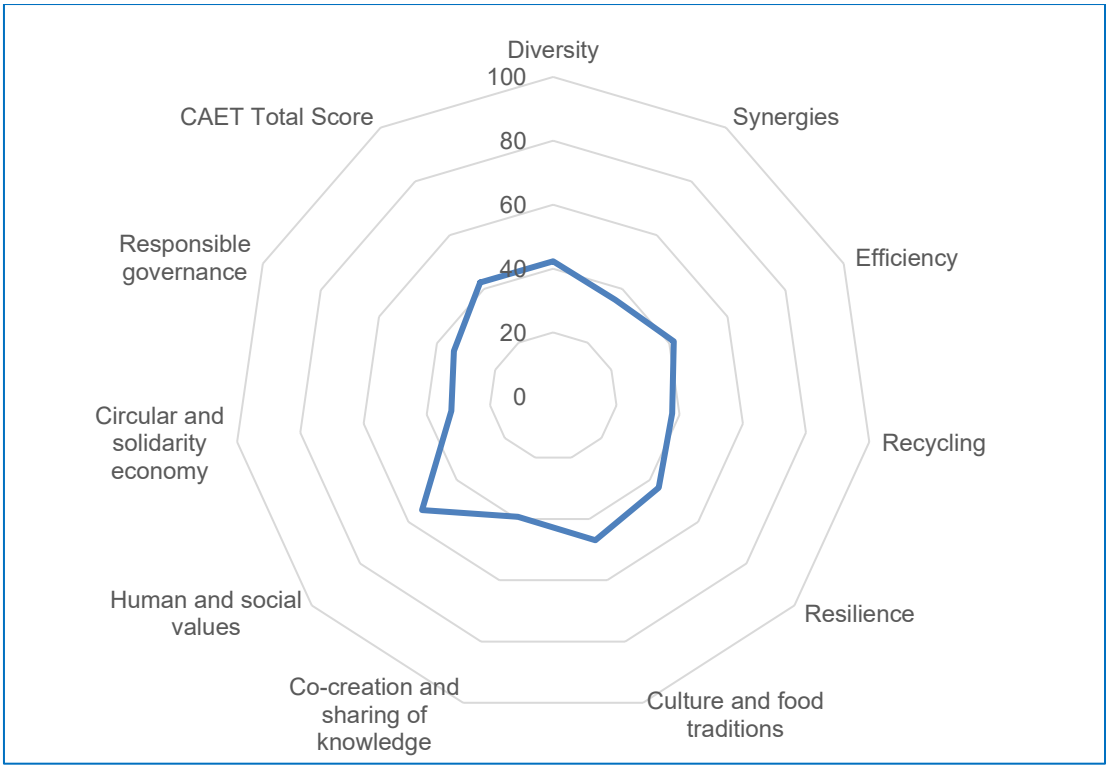
The average score for ***Diversity*** was 42.3 which is lower than anticipated, though it is higher than some other elements shown in Table 6. Result showed that 2-3 crops with significant cultivated area, 2-3 species with few animals, more than one species of trees, and 2-3 income generating activities was dominant in the study area. The result indicates that the villagers have made no attempts to enhance biodiversity; rather, agrobiodiversity has significantly declined, negatively impacting food security amid climate change. The variety of food products and production is diminishing, leading to a greater reliance on a limited range of food options. The findings clearly indicate that it is essential to prioritize the cultivation of a variety of nutrient-rich crops in the region, given the constraints of limited land availability and the high demand for nutrients. Additionally, efforts must be made to preserve species that are at risk of extinction, as well as local, traditional, and indigenous varieties that are well-suited to the area. The conservation of forests and the protection of local and natural pollinators are also critical components to initiate.

The average score for ***Synergy*** was low at 36.0. Farmers had medium level of integration of crops and animals where animals are mostly fed with feed produced on the farm and or grazing and their manure is used as fertilizer. Some crops are rotated or intercropped. Result showed low level of integration with trees i.e. small number of trees or perennial species provide only one product or

service. Most of the farms has low connectivity as only few isolated elements are present. The previous synergy and integration among animals, crops, trees, soil, and water have been disrupted due to resource constraints, changing family dynamics particularly joint to nuclear families, and pressures on livelihoods. Limited land availability seems another constraining factor. Results shows the need to prioritize mixed farming systems, intercropping, livestock integration, agroforestry practices, extensive use of manure-based composts than using chemical fertilizer, integrated pest management, and comprehensive landscape planning contributing to production and multiple ecosystem services.

The ***Efficiency*** score is 41.5 which was greater than that of synergy. Result showed that more than half of the farmers were using inputs purchased from the market. About one-third of the farms use synthetic fertilizers regularly and about one-third of them use synthetic fertilizers for a few specific crops only. The farmers are using chemical pesticides for specific crops, synthetic medicines for animals and only few of them are using organic pesticides for crop disease and pest control. Production primarily covers household consumption needs only and only few farmers have marketable surplus. Farmers appear to lack awareness regarding the adoption of innovative agroecological practices. They continue to rely on external inputs and have not prioritized opportunities for value addition or market demand-driven farming. Instead of creating opportunities within the agricultural sector, all households are involved in labor activities to sustain their livelihoods. There is minimal interest in diversifying their production, and many indigenous and local crops have been abandoned in their cultivation. Farmers often procure seeds, synthetic fertilizers, pesticides, veterinary medications, and feed from India. This includes the use of pesticides that are banned in Nepal, as well as seeds that are ill-suited for Nepal's agroecological conditions. The result clearly indicate that it is essential to develop innovative agroecological practices to make it possible to produce more with fewer external inputs, eventually utilizing local resources maximum possible.

Result showed that the score for ***Recycling*** was poor as average score was less than 40 (i.e. 37.6). More than half of the farmers are recycling small portion of wastes and byproducts, e.g. crop residues as animal feed, use of manure as fertilizer, production of compost from manure. Nearly 50% of the farms surveyed have one method or type of equipment for water harvesting or saving. Likewise, nearly 50% of the farmers use non-renewable energy in farming. A limited number of households appear to utilize local renewable resources, though not in a preferential manner, and strive to align closely with the natural cycles of nutrients and biomass. For instance, crop residues from plants like mustard are repurposed as biomass, while residues from paddy and maize are used as livestock feed. The idea of wastewater reuse and water harvesting has not been given serious consideration by the villagers, even in regions susceptible to drought. Result indicates the need of advancement of small and medium-sized enterprises or cooperatives in the sector focused on the production of organic fertilizers, including farmyard manure, compost, and vermicompost.



Source: Household Survey, 2024

Figure 8. Agroecological transition in the study area

Result from the Household Survey showed slightly better score for ***Resilience***, 43.7, indicating relatively more resilient system. The community is supportive to each other but its capacity to help after the shocks is limited. Access to credit is available but hard to obtain in practice. Insurance is rare and does not allow for complete coverage from risks. Local environment suffers from climatic shocks and stress and the system has little to good capacity to adapt to climate change in about half of the farms. The farmers are unaware of the harmful effects of nitrates, phosphate and synthetic pesticides. There is insufficient attention given to the optimization and conservation of seed resources. Instead of fostering resilience within the agricultural sector, many households have shifted towards alternative livelihood opportunities, such as labor. Result shows the need to promote nitrogen-fixing plants, biological pest management, and natural remedies, while strengthening seed conservation through community seed banks for local crops like Tharu potato, lentils, and flaxseed. Supporting resilient, locally adapted livestock breeds, increasing organic feed use, and strengthening shelters with permanent structures and safety measures to reduce risks from floods and storms also emerge as priorities.

In case of ***Culture and Food Tradition***, the situation is slightly better as reflected by the score of 47. Result showed that majority of farmers consume the food either self-produced by the households or exchanged within the community. The household diet is increasingly composed of homegrown food with desired levels of diversity and nutrition. Farms were seen with overall good awareness of local or traditional identity and respect of traditions or rituals. Some aspects of local or traditional food heritage are acknowledged but not fully embraced. Majority of the food consumed comes from local varieties/breeds and traditional knowledge and practices for food preparation are implemented.

The Tharu community primarily relies on food systems that are deeply rooted in their culture and traditions. Certain foods, including *Anadi* rice, *pohi* (a kind of leafy vegetable), yam and sweet potato, hold particular significance during specific festivals such as *Maaghi*, *Naag Panchami*, and

Dashain. This cultural heritage and the associated social values have enabled the community to maintain a diet that is both local and diverse to some extent. However, traditional crops are facing the threat of extinction for various reasons, including climate change, drought, migration, and the emergence of micro-families. There is a noticeable decline in traditional diets, with a shift towards agro-industrial products evident in the local snack houses, where items such as *momo* and *chowmein* are increasingly popular. Previously, the Tharu community predominantly used to live in joint families spanning up to five or six generations; however, this trend is now shifting, leading to the erosion of social relationships and local cultures. Standardizing diets in accordance with the dietary requirements, including traditional diets, plays a crucial role in enhancing food security and reducing malnutrition. It is essential to ensure that women have access to education, resources for skill development, and opportunities to engage in decision-making processes. This empowerment enables them to significantly contribute to the preservation of culture and tradition, as well as to the promotion of food security and the inclusion of nutritious diets for their families.

Result showed less score (39.3) for ***Co-creation and Sharing of Knowledge*** than anticipated. Majority of the households reported that at least one platform or mechanism for the co-creation and transfer of knowledge exists but is not used to share knowledge on agroecology specifically. Principles of agroecology are mostly unknown to farmers however interest was seen mostly on younger generations. Producers despite being the part of their local community they rarely participate in meetings and grassroot organisation activities. The region is characterized by a deficiency in comprehensive and inclusive innovations aimed at addressing local issues through participatory approaches, primarily due to limited resources and capacity. The traditional knowledge possessed by farmers is diminishing, and indigenous practices are facing extinction. Result shows the need to establish farmer field schools and knowledge hubs, recover and document traditional practices, expand access to agroecological information, and foster knowledge sharing and co-creation between producers and consumers.

The score for ***Human and Social Values*** is more than 50%, that is 54.3. Result showed that women take full part in decision making processes but still don't have full access to resources. Women organisations such as *'Aama Samuh'* exist and are used. Agriculture is mostly based on family farming, but producers have limited access to capital and decision-making processes. Workers have the minimum decent labour conditions. But there is a decreased interest from young people to pursue a career in farming. Livestock are generally healthy, have sufficient access to food and water, and their slaughter practices aim to minimize stress and avoid unnecessary pain. They are treated with dignity in most aspects. In overall, the villages appear to uphold and safeguard social well-being. The social framework remains intact, supported by practices such as "*badhghar*". Nevertheless, there has been no noticeable advancement in rural livelihoods and equity.

The score of ***Circular and Solidarity Economy*** was 32.2, the lowest among the elements. Only one to two of the farm's products/services are marketed locally during the current season. Networks of producers exist but face challenges in their operations. Limited relationship with consumers exists, and intermediaries are heavily involved in managing the marketing process with no engagement of producers. Limited local sourcing: some agricultural inputs are sourced locally, but a significant portion is still obtained from outside the territory (community or local level). Products are partially processed locally, and there is minimal exchange or trade of products and services between local producers.

Most of the farmers are consuming their agricultural products by themselves as the food self-sufficiency from their own production is not sufficient for whole year. However, these communities are selling some of the commodities like Black Mustard, Lentil and some vegetables in the market. There are the opportunities for branding and marketing of Anadi rice (sticky rice), Local Lentil and mustard oil as local products from Tharu community.

The study area characterizes a significant lack of processing infrastructure as well as absence of food manufacturing facilities. A cooperative manages a mill that specializes in rice processing, but the volume of business is small compared to the potential demand in the area. This clearly indicates that the region is deficient in initiatives aiming to establishing connections between producers and consumers within a framework of a circular and solidarity economy.

While there are a limited number of local markets that contribute to local economic development, farmers do not possess the necessary strategies to align their production with local demands, resources, and capabilities. The region is deficient in marketing opportunities for farmers. There is a notable absence of direct marketing and other alternative marketing arrangements that would enable farmers to sell their products to end-consumers such as restaurants and households. Result shows the need to strengthen direct connections and trust between producers and consumers by supporting local farmers' markets and cooperatives while reducing reliance on intermediaries.The study area is also short of collection centers, cold storage facilities, and other necessary infrastructure that is crucial to circular economy. Despite being relatively close to highway, the farming communities experience a notable deficiency in transportation facilities, with the exception of a few traders who engage with farmers to collect the farm products, mainly paddy, directly from their fields.

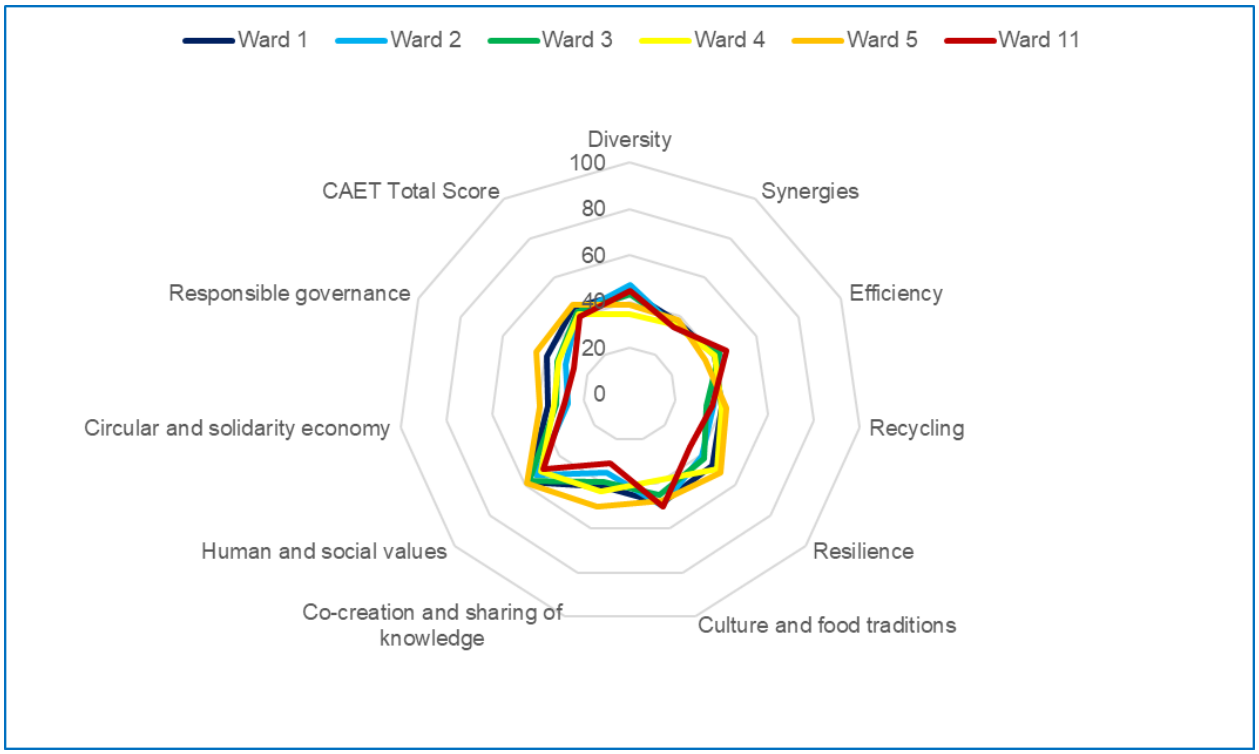
Finally, ***Responsible Governance*** has also lower score, 34.1, than the total score. Producers have limited empowerment, facing challenges in securing access to land or other natural resources. They possess minimal bargaining power and limited opportunities to improve their livelihoods and develop their skills. At least one organisation of producers exists but its role is marginal and support to producers limited to market access. Producers participate in decision-making processes, but their impact on land, natural resource management, and relevant system aspects remains extremely limited.

The villages, particularly the communities established following the government's liberation of bonded laborers, possess minimal land ownership, averaging around 5 katha (0.169 hectare) per household. These regions are deficient in natural resources, resulting in lower agricultural productivity that is inadequate for the villagers to support their families year-round. Disparities are evident in access to resources, as well as in health and safety conditions within these settlements. The region is susceptible to various types of disasters, yet the government initiatives is inadequate to address this vulnerability. Although the local government has initiated a few programs aimed at promoting sustainable food and agriculture, these efforts are insufficient in accordance to the area's needs. There is a pressing need for accountable and effective governance.

Table 9. Agroecological transition score in the study area

Particulars	Score
Diversity	42.3
Synergies	36.0
Efficiency	41.5
Recycling	37.6
Resilience	43.7
Culture and food traditions	47.0
Co-creation and sharing of knowledge	39.3
Human and social values	54.3
Circular and solidarity economy	32.2
Responsible governance	34.1
CAET Total Score	42.4

Source: Household Survey, 2024



Source: Household Survey, 2024

Figure 9 Agroecological transition scores across the study wards

Ward 1 has strengths in *human and social values* (58.1) and *culture and food traditions* (49.0), but its scores in *synergies* (37.5) and *circular and solidarity economy* (35.8) are relatively weaker. Ward 2 shows relatively balanced scores, with a standout in *culture and food traditions* (49.8), but it underperforms in *responsible governance* (30.3).

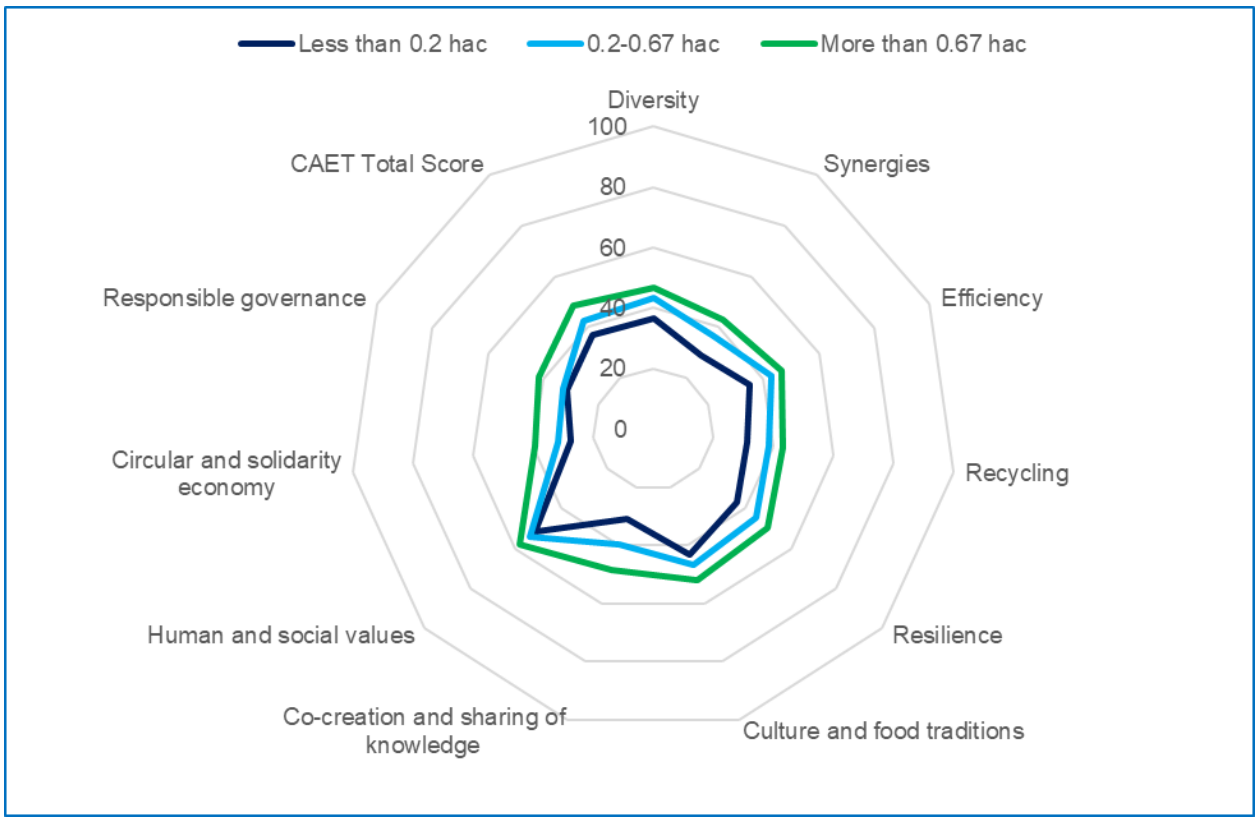
Ward 3 and Ward 4 exhibit moderate scores across most dimensions, though Ward 4 excels in *resilience* (49.5) while lagging in *diversity* (34.4). Overall, the results suggest that while each ward has unique strengths, efforts are needed to balance and enhance agroecological practices in lower-performing dimensions.

Table 10 Agroecological transition scores across the study wards

Particulars	Ward 1	Ward 2	Ward 3	Ward 4	Ward 5	Ward 11
Diversity	44.0	47.0	43.3	34.4	38.7	44.6
Synergies	37.5	35.3	35.3	35.8	38.3	34.6
Efficiency	40.3	42.3	42.3	40.1	35.9	45.6
Recycling	39.7	36.5	33.4	39.9	42.2	35.6
Resilience	46.8	41.0	42.3	49.5	51.6	34.6
Culture and food traditions	49.0	49.8	45.0	38.9	48.0	50.6
Co-creation and sharing of knowledge	41.4	35.0	39.4	43.6	50.5	30.8
Human and social values	58.1	53.3	57.2	51.0	58.6	49.6
Circular and solidarity economy	35.8	27.0	32.1	33.3	39.1	28.3
Responsible governance	39.2	30.3	34.3	34.0	44.3	26.7

CAET Total Score	44.7	41.6	42.0	41.0	45.9	40.1

Source: Household Survey, 2024



Source: Household Survey, 2024

Figure 10 Agroecological transition scores according to landholding.

The Agroecological transition scores for all the elements were found to be correlated with the size of landholdings. The results suggest that focused interventions for HHs with smaller landholdings should be prioritized to enhance agroecological practices for all elements.

Table 11 Agroecological transition score according to landholding

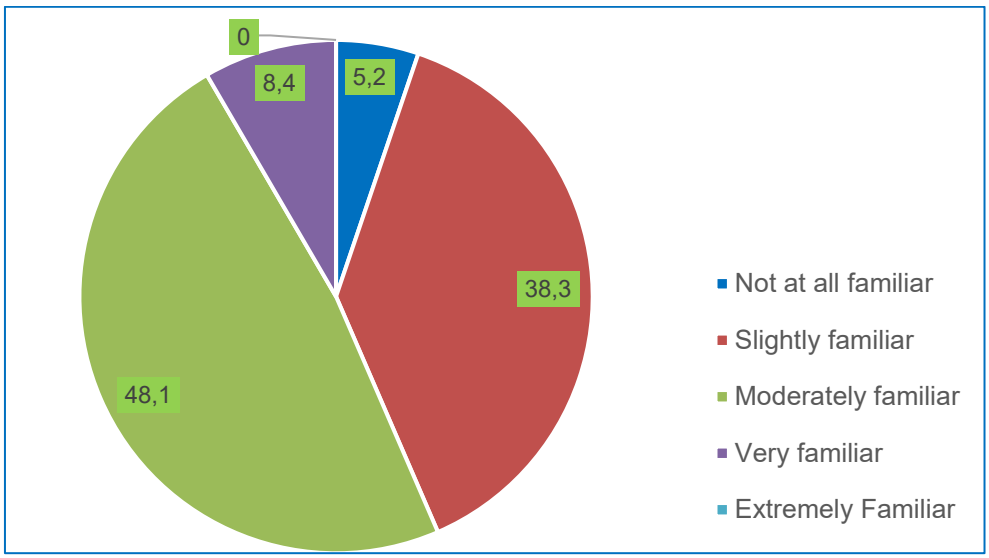
Particulars	0-5 kattha	6-20 kattha	Above 20 kattha	Total
Diversity	36.7	43.3	46.7	42.3
Synergies	29.1	36.6	42.8	36.0
Efficiency	35.2	42.7	46.3	41.5
Recycling	31.4	38.4	43.2	37.6
Resilience	36.6	44.8	49.6	43.7
Culture and food traditions	43.1	46.8	52.0	47.0
Co-creation and sharing of knowledge	30.9	39.7	48.5	39.3
Human and social values	51.8	54.0	58.3	54.3
Circular and solidarity economy	27.6	31.5	39.2	32.2
Responsible governance	31.1	32.5	41.7	34.1
CAET Total Score	36.9	42.6	48.4	42.4

Documentation and safeguarding of traditional knowledge are essential. It is necessary to develop additional plans and programs that specifically target smallholder farmers. There should be a focus on integrated seed governance that highlights farmer-managed seed systems. Furthermore, ensuring equitable ownership and access to natural resources in areas previously affected by bonded labor is crucial.

4. Vulnerabilities of Local Food System

4.1 Climate Hazards and Impacts on Local Food System

Regarding the familiarity with climate change, the majority of respondents from the household survey are "Moderately familiar" (48.1%), followed by the "Slightly familiar" category as the next most common (38.3%). A small proportion of the respondents are "Very familiar" (8.4% overall). No respondents identified as "Extremely familiar," and a minor proportion are "Not at all familiar" (5.2% overall).



Source: Household Survey, 2024

Figure 11. Familiarity of community people about climate change

Household survey results revealed prevalence of several climate hazards in the study area. "Increased diseases and pests" is the most commonly reported hazard (87.7%), which is though not climate hazard itself but is the condition induced by changes in climatic parameters. Floods are the second most common hazard (67.5%). Droughts are noted by 31.8% of respondents, whereas river bank erosion (Landslides) is relatively uncommon (6.5%), except in some study communities. Other hazards are infrequent (3.2%) and reported sporadically.

FGDs with communities also revealed a range of climate hazards that include floods, droughts, cold wave, hailstorms, wind/storm, increased incidence of diseases and pests, river bank erosion (landslides), and wild animals. While the floods and droughts were reported by all the studied communities, hazard ranking based on severity of occurrence and potential impact to agriculture and livelihoods varied across the study communities.

Flood and drought are the most significant challenges for the communities in Barbardiya Municipality, especially those near rivers like Babai, Budhi, and Jorpani. Flood, particularly during

major events in 2071 B.S. and 2074 B.S., has caused extensive damage to infrastructure, homes, crops, and livestock, leading to substantial economic losses. Although some villages, such as Bhaisakhani, have implemented adaptive measures like embankments and flood warning systems, many communities remain highly vulnerable. Drought is another critical issue, significantly reducing agricultural yields, turning fertile land barren, and causing economic hardship, particularly for winter crops like wheat and vegetables. Villages such as Laungahawa, Jodhipur, and Dhungrahi have faced devastating floods, while areas like Bijaynagar and Lamkiphata struggle with recurring droughts. Efforts such as groundwater extraction and seed storage help mitigate some drought impacts, but they are insufficient to address the scale of these recurring disasters. The region's vulnerability underscores the urgent need for more comprehensive and sustainable risk management strategies to protect lives, livelihoods, and infrastructure.

Among the respondents who reported flood and droughts as climate hazards, the frequency of occurrence varied (Table 7). Flood occurs annually in 28.6% of cases, while droughts occur annually in 26.6%. Flood is more frequent overall, with higher percentages in intermediate intervals (e.g., every 2 and 5 years). Droughts are predominantly rare, with 57.1% reported as infrequent, compared to 36.4% for flood. This highlights flood as more consistently recurring than droughts.

Table 12. Frequency of occurrence of flood and drought across the study wards

Frequency of occurrence	Flood (%)	Droughts (%)
Every Year	28.6	26.6
Every 2 years	5.2	1.3
Every 3 Years	8.4	7.1
Every 5 Years	21.4	7.8
Rarely	36.4	57.1

Source: Household Survey, 2024

Both flood and droughts have impacts on local food system and income stability (Table 8). Flood significantly impacts the local food system (35.1%) and income stability (34.4%), with smaller extreme impacts (5.2% and 7.8%, respectively). In contrast, droughts are perceived to affect these areas less drastically, with the majority of respondents rating the impact as slight (48.7% for the food system and 55.2% for income stability). Only a small fraction consider the effects of droughts to be significant or extreme. Conversely, a notable proportion of respondents (27.9% for flood and 25.3% for droughts) perceive no impact on the food system. Overall, flood is seen as having a more immediate and severe impact compared to droughts, which tend to affect income and food systems more subtly.

Table 13. Perceived impacts of flood and droughts on local food system and income stability

Response rating	Impact of flood on		Impact of droughts on	
	Local food system (%)	Income stability (%)	Local food system (%)	Income stability (%)
Not at all	27.9	22.7	25.3	12.3
Slightly	16.2	13.6	48.7	55.2
Moderately	15.6	21.4	14.9	20.1
Significantly	35.1	34.4	11.0	9.7
Extremely	5.2	7.8	-	1.3

Source: Household Survey, 2024

Hazard score calculated based on the selected indicators showed overall Hazard Index value of 2.9 that indicates that study area is at HIGH hazard level. All study communities showed almost similar

hazard index and thus were at similar hazard level. Such uniform high ranking underscores widespread risk exposure across study communities.

4.2 Exposure to Climate Change

This sub-section discusses exposure of local food systems to climate change considering key parameters. Table 9 summarizes perceptions of changes in temperature, rainfall intensity, and plant behavior over the past decade. A majority (52.6%) perceive temperature changes as high, with moderate changes noted by 43.5%. Rainfall intensity is predominantly rated as moderate (56.5%), followed by high (30.5%). In contrast, changes in plant behavior are largely perceived as moderate (37.0%) or low (22.1%), with a notable 24.7% perceiving very low change. Very high ratings for all three categories are minimal, under 2%. The result reflects greater concern over temperature and rainfall compared to plant behavior. Result further suggests a widespread perception of significant temperature rise in the community, but the majority perceive a moderate to high change in rainfall intensity.

Table 14. Perceived changes in temperature, intensity of rainfall and plant behavior in past decade

Response rating	Changes in Temperature (%)	Changes in intensity of rainfall (%)	Changes in plant behavior (%)
Very low	-	-	24.7
Low	2.6	12.3	22.1
Moderate	43.5	56.5	37.0
High	52.6	30.5	16.2
Very High	1.3	0.6	-

Source: Household Survey, 2024

The overall exposure level of the study area was assessed based on selected parameters, including temperature, rainfall, plant and animal behaviors, hazards, livelihood activities, physical information, and population density (Table 10). The results indicate that the study area falls under the “HIGH” exposure level, highlighting significant vulnerability to environmental, social, and economic challenges.

Table 15. Exposure level of the study area

Parameters	Index value/rating
Temperature	3.0
Rainfall	2.0
Plants and animal behaviours	3.0
Hazards	2.9
Livelihood activities	3.0
Physical information	3.0
Population density	3.0
Exposure Index	2.9
Exposure Level	HIGH

Source: Household Survey, 2024

Temperature emerged as a key factor contributing significantly to the area's exposure. Rainfall, on the other hand, has a moderate impact, playing a less prominent role compared to other parameters. The behaviors of flora and fauna are markedly influenced, reflecting stress responses or adaptations to the area's environmental conditions.

The region also faces a high prevalence of hazards, such as floods and droughts, which strongly contribute to its exposure. Livelihood activities are particularly vulnerable, likely due to dependence on natural resources or engagement in high-risk economic practices. Additionally, the area's geographical and physical features indicate a heightened susceptibility to external factors.

Finally, the dense population exacerbates the exposure level by increasing resource demand and overall vulnerability. These findings emphasize the critical need for targeted interventions to reduce exposure and enhance resilience in the study area.

4.3 Sensitivity to Climate Change

This sub-section highlights the sensitivity of local food system to climate change, particularly flood and droughts. The sensitivity is assessed mainly in terms of impact on agriculture and local food security, changes in yields, incidence of crop diseases and pests and animal health and other aspects that affect agriculture and food security. Table 11 highlights the sensitivity of agriculture and local food security to flood and drought over the past decade. Flood is perceived as highly or very highly impactful by 48% of respondents, while drought is seen as moderately impactful (35.7%) but with lower high or very high sensitivity ratings (21.4%). Conversely, drought shows higher low or very low sensitivity (42.8%) compared to flood (15.5%), indicating greater concern for flood's impact on agriculture and food security. The result suggests flood generally poses a substantial challenge to agriculture and food security. Overall, droughts are viewed as a notable challenge, though not as severe as flood.

Table 16. Sensitivity of agriculture and local food security to flood and drought in past decade

Response rating	Flood (%)	Drought (%)
Very low	4.5	9.7
Low	11.0	33.1
Moderate	36.4	35.7
High	37.0	19.5
Very High	11.0	1.9

Source: Household Survey, 2024

Table 12 illustrates the perceived sensitivity of various sectors to climate change over the past decade. Pest and disease incidence is deemed highly sensitive, with 76.6% rating its impact as high, while irrigation water is mostly rated as moderately sensitive (70.8%). Livestock health shows moderate sensitivity (46.1%) but has a higher proportion of low sensitivity ratings (29.9%). Forest and biodiversity, along with infrastructure and settlements, are predominantly perceived as moderately sensitive (58.4% and 67.5%, respectively). Very high sensitivity ratings are minimal across all sectors. The data highlights pest and disease incidence as most affected, followed by irrigation water and infrastructure, while livestock health and biodiversity are less likely to be impacted.

Table 17. Sensitivity of various sectors to climate change in past decade

Response rating	Pest & disease incidence (%)	Irrigation water (%)	Livestock health (%)	Forest and biodiversity (%)	Infrastructure and settlements (%)
Very low	-	1.3	6.5	-	-
Low	3.9	9.1	29.9	22.7	9.1
Moderate	17.5	70.8	46.1	58.4	67.5
High	76.6	18.8	17.5	18.2	22.7
Very High	1.9	-	-	0.6	0.6

Source: Household Survey, 2024

Overall Sensitivity level of the studied communities was calculated considering selected parameters. Table 13 evaluates the sensitivity of local food systems to climate change across various sectors, including agriculture and food security, forests and biodiversity, settlements and infrastructures, and water and energy. Study area is rated as having a high sensitivity level, with sensitivity score of 3.0. Agriculture and food security, along with water and energy, emerge as critical areas of high sensitivity in most wards, emphasizing the interconnected nature of these sectors. The result highlight the widespread vulnerability of local food systems to climate change, necessitating targeted interventions to enhance resilience and adaptive capacity.

Table 18. Sensitivity level of the study area

Parameters	Index value/rating
Agriculture and Food Security	3.0
Forest and Biodiversity	3.0
Settlement and Infrastructures	3.0
Water and Energy	3.0
Sensitivity Index	3.0
Sensitivity Level	HIGH

Source: Household Survey, 2024

4.4 Adaptive Capacity

Understanding adaptive capacity of the household and community is crucial in addressing and mitigating the impacts of climate change. It involves the ability of systems, institutions, and communities to adjust to potential damages, take advantage of opportunities, and respond to consequences associated with climate change. This capacity is evaluated across five key assets: human, natural, social, financial, and physical resources. Indicators for assessing adaptive capacity of household include mobilization of human resources, availability of natural and financial resources, the density of service providers, and the access to sector-supportive communication resources.

Despite facing key hazards, exposed to climate change and being sensitive to climate change, the community people show high levels of adaptive capacity. Table 14 presents the adaptive capacity of households in the study area, considering five asset categories: human, natural, social, financial, and physical. Study area exhibit a high adaptive capacity level, with adaptive capacity index score of 3.0. The results suggest households in study area have a relatively strong ability to adapt to climate change challenges. However, variations across the study communities highlight areas where targeted efforts, such as enhancing financial and physical assets, could further improve resilience.

Table 19. Adaptive capacity of households in the study area

Parameters	Index value/rating
Human assets	3.0
Natural assets	3.0
Social assets	3.0
Financial assets	3.0
Physical assets	3.0
Adaptive Capacity Index	3.0
Adaptive Capacity Level	HIGH

Source: Household Survey, 2024

The perceived situation of households' assets across different categories is summarized in Table 15. Human assets are predominantly rated as moderate (75.3%), with minimal high ratings (1.9%). Natural assets, social assets, and physical assets also show a strong majority of moderate ratings (70.8%, 63.0%, and 61.0%, respectively), though they include slightly higher proportions of low ratings compared to human assets. Financial assets are the weakest, with only 54.5% rated as moderate and the highest percentage of low ratings (34.4%) among all asset types. Very high ratings are entirely absent across all categories, indicating that most households perceive their assets as being in moderate to low condition, with financial assets appearing to be the most vulnerable.

Table 20. Perceived situation of households' different assets

Response rating	Human assets (%)	Natural assets (%)	Social assets (%)	Financial assets (%)	Physical assets (%)
Very low	-	0.6	0.6	4.5	-
Low	22.7	24.7	27.9	34.4	26.6
Moderate	75.3	70.8	63.0	54.5	61.0
High	1.9	3.9	8.4	6.5	12.3
Very High	-	-	-	-	-

Source: Household Survey, 2024

Community level adaptive capacity assessed through FGDs is presented in Table 16, which provides insights into the adaptive capacity of communities based on five asset categories. The adaptive capacity of the communities in the study area reflects strengths and challenges across various asset types. Social assets, with the highest index value of 4.0, are the community's strongest aspect, indicating robust networks and social cohesion that can facilitate collective adaptation efforts. However, physical assets (2.4) and financial assets (2.6) are the most significant constraints, highlighting inadequate infrastructure and limited financial resources for resilience. Human assets (2.5) and natural assets (2.5) show moderate levels.

Table 21. Adaptive capacity of the communities in the study area

Parameters	Index value
Human assets	2.5
Natural assets	2.5
Social assets	4.0
Financial assets	2.6
Physical assets	2.4

Source: FGDs with communities

The adaptive capacity of the communities shows varying strengths and weaknesses across different assets. Human assets range from limited technical skills and access to climate-resilient farming practices, with challenges prevalent in most areas. Natural assets show a broad range, with some communities benefiting from abundant resources like forests and rivers, while others face minimal access or underutilization. Social assets are consistently strong, supported by robust networks, traditional systems like the *badhghar*, and community collaboration, though issues like youth drug abuse persist in some areas. Financial assets vary, with communities facing challenges such as limited cooperative access, inconvenient credit facilities, and loan stress, while others benefit from better financial inclusion. Physical assets also show a wide range, with some communities

benefiting from well-maintained infrastructure, while others struggle with poor roads, irrigation systems, and a lack of essential facilities like schools and healthcare centers. To enhance adaptive capacity, efforts should focus on leveraging social strengths while investing in physical infrastructure, financial mechanisms, human capital development, and sustainable use of natural resources.

4.5 Vulnerability of Communities

Based on exposure, sensitivity and adaptive capacity of the community people, vulnerability was estimated. Table 17 provides an overview of community vulnerabilities to climate change, focusing on flood and droughts. Study area is categorized as having *high* vulnerability level, indicating significant exposure, sensitivity, and varying adaptive capacities. The overall Exposure Index is 2.9 which varies across study communities, reflecting a consistently high likelihood of experiencing climate change impacts. The Sensitivity Index, representing how susceptible these communities are to climate stressors, varies slightly among communities with an overall index of 3.0.

Table 22. Overall vulnerability index of the communities in the study area

Parameters	Index value
Exposure index	2.9
Sensitivity index	3.0
Adaptive capacity index	3.0
Vulnerability index	2.9
Vulnerability level	HIGH

Source: Household Survey, 2024

The Adaptive Capacity Index, which measures the community's ability to respond to climate impacts, is 3.0 and varies across study communities. Finally, the Vulnerability Index, integrating all factors, is 2.9, indicating significant vulnerability. These results highlight the urgent need for targeted interventions across the communities, focusing on reducing exposure and sensitivity while enhancing adaptive capacity, particularly in highly sensitive areas.

5. Stakeholders, Policies and Practices

This section discusses key stakeholders and existing policies, programs and practices of local government related to climate-resilient food system.

5.1 Key Stakeholders

Various stakeholders are actively engaged in the communities studied within Barbardiya Municipality, broadly classified into three categories with the community at the center (Figure 10). The first category includes government agencies, such as the Municipality (including Ward Offices), the Integrated Agriculture and Livestock Development Office (IALDO Bardiya), and the Prime Minister Agriculture Modernization Project (PMAMP). The second category comprises development partners, including the U.S. Agency for International Development (USAID), Heifer International Nepal, the Red Cross, LI-BIRD, and Practical Action. Lastly, the third category encompasses local NGOs, such as the Tharu Community Development Forum (TCDF), Radha Krishna Tharu Sewa Kendra (RJKS), Tharu Mahila Uthan Kendra (TMUK), Backward Society Education (BASE), Bardiya Unique Nepal, and the BEE Group.

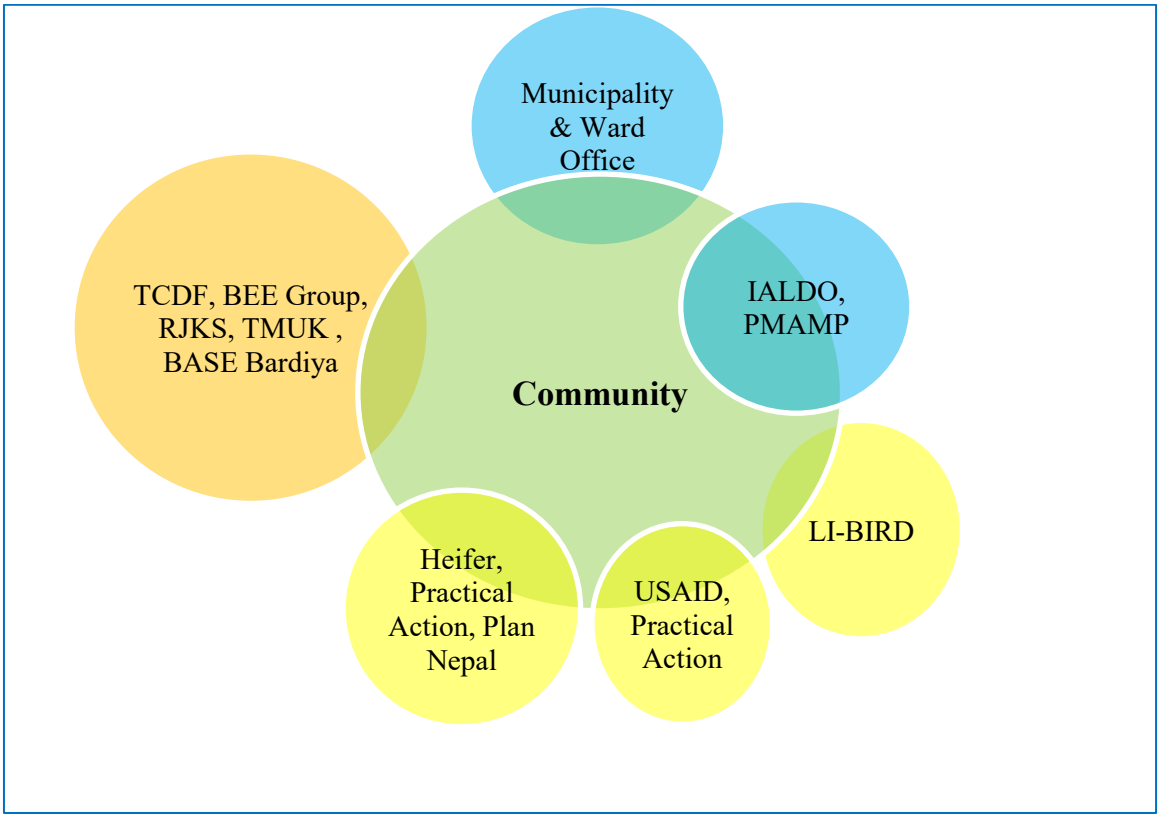


Figure 12. Stakeholders related to climate-resilient food system

Among these stakeholders, the Municipality and Ward Offices have contributed consistently across all the study communities, while the involvement of other stakeholders has varied by community. PMAMP has played a significant role, establishing a Rice Super Zone in Wards 3 and 4, a Fish Zone in Wards 3, 9, and 10, and a Cow/Buffalo Zone covering the entire municipality. A detailed breakdown of community-wise stakeholder involvement is provided below.

In Laungahawa, Ward 1, the Municipality plays a significant role in engaging the community. Organizations such as the TCDF have also contributed to agricultural activities. The Ward Office is actively involved in various initiatives. IALDO Bardiya, TCDF, and LI-BIRD, emerge as the

most prominent contributors to community activities. Similarly, in Jodhipur, Ward 1, the Municipality maintains its presence alongside TCDF's efforts in the agricultural sector. Heifer International has made impactful contributions by supplying goats, while LI-BIRD has focused on initiatives related to agriculture, livestock and nutrition.

In Dhungrahi, Ward 2, multiple organizations demonstrate a significant presence. LI-BIRD, TCDF, USAID's KISAAN 2 program, and the BEE Group are actively engaged in diverse projects, some of which have recently concluded. The Municipality has also implemented several programs in the community.

Conversely, in Bhaisakhani, Ward 3, LI-BIRD stands out with its interventions on home garden, mushroom cultivation, commercial vegetable cultivation, and climate resilient agriculture, alongside distributing fruit saplings to increase diversity. TCDF has supported the community by providing goats and boars. However, apart from these initiatives, no other organizations or projects are active in this area, and the Municipality has had no notable presence.

In Guruwagaun, Ward 4, the Red Cross has taken the lead in conducting disaster risk reduction (DRR) training sessions. The Municipality has contributed by supplying seeds and saplings while participating in village cleaning initiatives. Additionally, organizations like RKJS have offered DRR training programs, and Unique Nepal has provided investment and savings opportunities. The Municipality has further supported the community through several programs. In Ranipur, Ward 4, Practical Action has established a shelter house, while TMUK has developed a community building. The Municipality remains active in implementing various community initiatives.

In Lamkiphata, Ward 11, there have been no active programs, projects, or support from government or organizations over the past two to three years. Earlier efforts by Plan Nepal included distributing uniforms and stationery to students in the education sector, while the Social Welfare Council supplied goats and provided training on goat rearing. The Municipality's only contribution has been the construction of a community building. Currently, no initiatives or programs are underway, and the Municipality has no significant presence in this ward.

Result clearly show that the level of engagement by stakeholders across the study communities of Barbardiya Municipality varies significantly. In areas like Laungahawa and Jodhipur, Ward 1, a range of organizations, including TCDF, LI-BIRD, and Heifer International, collaborate with the Municipality to drive agricultural and community development. Communities such as Dhungrahi and Bhaisakhani, Ward 2, showcase active contributions from organizations like LI-BIRD and TCDF, though some areas experience gaps in municipal involvement. In Guruwagaun and Ranipur, Ward 4, the Municipality partners with organizations like the Red Cross, RKJS, and Practical Action to implement disaster preparedness and infrastructure projects. However, Lamkiphata, Ward 11, presents a stark contrast, with little to no recent activity or municipal engagement. These disparities highlight the need for more equitable distribution of resources and consistent collaboration between stakeholders to ensure balanced development across all wards.

5.2 Existing Policies and Programs

Barbardiya municipality has prepared only few policy documents linked to agriculture and disasters, the relevant ones include Municipal Profile (BS 2074), Annual Policy and Program, whereas the District Disaster Preparedness and Response Plan of Bardiya (BS 2078) is also linked. Municipal Profile has done assessment of situation of agriculture in different parts of municipality highlighting the potential areas of interventions. Whereas Bardiya's District Disaster Preparedness and Response Plan outlines the measures to be taken while facing major disasters including floods and droughts in different parts of the district. The plan includes vulnerability ranking of communities across the municipalities within the district specifying the households at low, medium, high and very high vulnerability level. It provides guidelines for the operation of Local

Emergency Operation Center (LEOC) at the Municipality and preparation of municipal level Disaster Preparedness and Response Plan.

Barbardiya Municipality's annual policy and program prioritize agricultural development and modernization as essential drivers of growth and self-reliance. The municipality continues the implementation of its agricultural mechanization initiative, ensuring farmers benefit from modern equipment and techniques to boost productivity. Grants and funding enhance the cultivation of maize and fine-grain rice during the spring and summer seasons, establishing Barbardiya as a leading hub for maize production. This focus extends to the commercialization, diversification, marketing, and modernization of agriculture, creating sustainable livelihoods while ensuring food security. The municipality actively encourages the cultivation of local and indigenous crops, preserving traditional agricultural practices and promoting biodiversity. In parallel, potato and vegetable farming receive strong support, with grants provided to cooperatives to strengthen collective marketing efforts. Soil testing camps assess the nutritional status of farmland, enabling informed agricultural practices, while the Integrated Pest Management (IPM) farm school introduces environmentally sustainable pest control methods, equipping farmers with critical skills.

The municipality's commitment to infrastructure development underpins its agricultural and economic goals. Investments focus on constructing irrigation systems, road networks, village electricity grids, and market infrastructure, including local markets, wholesale markets, collection centers, and processing facilities. These activities enhance connectivity, reduce post-harvest losses, and ensure better market access for farmers, boosting their incomes. Collaboration with the provincial government plans to support the establishment of a compost factory, promoting sustainable and organic farming practices. Livestock production also receives significant attention, with initiatives to improve breeding through natural and artificial insemination techniques. Partnerships with community forests facilitate the management of fodder and grazing, ensuring livestock have adequate resources. The municipality aims to provide extensive support for processing, packaging, storage, and marketing of animal products, fostering value addition and market competitiveness. To mitigate wildlife-induced losses, aims to install protective iron barriers safeguard vegetation, securing livelihoods and reducing conflicts between wildlife and agricultural activities.

Environmental sustainability forms a cornerstone of Barbardiya's development strategy. The municipality takes a proactive approach by promoting renewable energy sources, including the adoption of advanced traditional stoves and efficient electric stoves, to reduce dependency on fossil fuels and alleviate environmental pressure. Under the "green city, clean city" initiative, nurseries are established, and greening projects are implemented to enhance the municipality's ecological footprint. Scientific management of community and private forests ensures their preservation, balancing resource use with conservation. Waste management programs address pressing environmental challenges through the development of a landfill site and a fecal slurry management facility, established via collaborative partnerships. These facilities contribute to cleaner surroundings and promote hygienic living conditions for residents. Collectively, these measures reflect the municipality's determination to create a sustainable environment, ensuring long-term ecological health and a high quality of life for its citizens.

Disaster preparedness and management remain vital priorities in Barbardiya. Municipality aims to ensure that Local Emergency Operation Center operates 24/7, ensuring rapid responses to emergencies and coordination among stakeholders. A comprehensive Disaster Preparedness and Response Plan provides a structured framework for action during crises based on the identified vulnerability level of the households. As per the plan majority of the households in the municipality are at very high vulnerability level. The municipality organizes workshops and orientation programs to equip communities with knowledge on monsoon preparedness, disaster mitigation, and search and rescue operations. Simulated drills for various disaster scenarios strengthen

readiness, ensuring both authorities and residents are prepared to handle emergencies effectively. The disaster management fund plays a crucial role in providing immediate assistance, supporting relocation efforts, and addressing the needs of affected communities. These proactive measures enhance the municipality's resilience, minimizing the impact of natural and man-made disasters on residents and infrastructure.

Community welfare initiatives form another key aspect of Barbardiya Municipality's policies. Issuing land ownership certificates helps resolve the challenges of poorly managed settlements while assisting individuals without land, promoting social equity and better living conditions. This approach integrates with the broader vision of inclusive growth and sustainable development. By addressing agricultural advancement, infrastructure development, environmental sustainability, disaster resilience, and social welfare, Barbardiya emerges as a model municipality committed to holistic progress. These efforts collectively contribute to transforming Barbardiya into a self-reliant, thriving, and environmentally conscious community that supports the aspirations of its residents.

Result indicated that some policies and programs exist as described above, but the implementation of those programs/activities is limited.

6. Adaptation and Mitigation Practices at Community Level

This section assesses and documents existing adaptation and mitigation practices adopted by communities for the resilient local food system against flood and drought risks.

6.1 Existing Adaptation and Mitigation Practices

Various adaptive strategies adopted by different communities to cope with the effects of flood and droughts is presented in Table 18. Some strategies were adopted at community level such as climate-resilient infrastructure, early warning system and community networks, whereas others such as livelihoods diversification, change in agricultural practices and using resistant varieties were adopted at household level. In responding to the flood, overall, the use of flood-resistant crop varieties (76.0%) and changing agricultural practices (50.6%) are the most widely adopted strategies, reflecting a strong focus on securing food production. The adoption of flood-resistant varieties was very high in some communities. Diversification of livelihoods is adopted by 14.9% overall, whereas building flood-resilient infrastructure is less common (13.6%). Participation in early warning systems is limited (10.4%), and strengthening community networks is adopted by 22.1%. Result suggests a reliance on agricultural adaptations and social support systems, with lower emphasis on infrastructure and early warning systems in the study communities. Low emphasis on climate-resilient infrastructure could be because of high investment requirement and need of collective action, while adopting other practices are more household level decisions.

Likewise, regarding the adaptive strategies adopted to cope with droughts, the most common strategy across the study communities is using drought-resistant crop varieties (72.7%). Changing agricultural practices, such as using improved technologies (intercropping, time of sowing, mulching and alike) and inputs, is the second most prevalent adaptation (50.0%), whereas diversification of livelihoods is adopted by 13.0% overall. Building drought-resilient infrastructure, though less directly relevant to droughts, is practiced by 16.9%, on the other hand, participation in early warning systems is limited (8.4%). Strengthening community networks is practiced by 16.9. In this case also, the result suggests a strong reliance on agricultural adaptations, with limited focus on diversification, early warning systems, and social support. In overall, the result showed that the access to Agromet advisory services is limited.

Table 23. Existing adaptation measures to cope with effects of flood and droughts

Adaptation measures	Responding to flood (%)	Responding to drought (%)
Diversification of livelihoods	14.9	13.0
Changing agricultural practices	50.6	50.0
Use of resistant varieties	76.0	72.7
Build climate-resilient infrastructure	13.6	16.9
Participating in early warning system	10.4	8.4
Strengthening community networks and social support systems	22.1	16.9

Source: Household Survey, 2024

The perceived effectiveness of adopted adaptive strategies in reducing impacts of floods and droughts is presented in Table 19. In the case of strategies adopted in responding to effects of floods, most respondents (65.6%) rate the strategies as "moderately effective," indicating a general acknowledgment of their utility. "Very effective" ratings are less frequent (18.8%), however, none of the study ward reported the strategies as "extremely effective" or "not effective at all," suggesting that while the strategies help mitigate impacts, they may not fully address the challenges.

Likewise, in the case of adopted adaptive strategies in reducing the impacts of drought, a majority of respondents (67.5%) believe the strategies have been "moderately effective". Only 11.0% consider the strategies "very effective". No respondents in any study communities consider the strategies "extremely effective". Overall, while the strategies show moderate success, there is still considerable room for improvement, as only a few reported them as highly effective.

Table 24. Effectiveness of measures adopted to cope with effects of flood and droughts

Response rating	Effects of flood (%)	Effects of droughts (%)
Not effective at all	-	-
Slightly effective	15.6	21.4
Moderately effective	65.6	67.5
Very effective	18.8	11.0
Extremely effective	-	-

Source: Household Survey, 2024

6.2 External Support Systems

The adaptation to climate change is facilitated through a range of external facilitations that includes support system, access to inputs, such as seeds, access to improved technologies, weather information, infrastructure such as irrigation facilities, financial resources, access to capacity development programs and community support and networks. Table 20 provides an overview of facilitating conditions for climate change adaptation, revealing notable variations across key factors. Most households rate their access to resources and infrastructure as "moderate," with high percentages for weather information (69.5%), irrigation infrastructure (70.1%), and community support networks (57.8%). These factors suggest a foundational level of support that households can build upon. However, significant challenges remain. Access to financial resources and training programs has higher "low" ratings (38.3% and 31.8%, respectively), indicating critical gaps in these areas. Similarly, while the use of modern farming techniques sees a relatively high percentage of "high" ratings (25.3%), other factors, such as financial resources (6.5%) and training programs (11.0%), lag behind in achieving high accessibility or adequacy. "Very low" ratings are minimal across all factors, showing that basic support exists but is insufficient for many households. No factors achieve a "very high" rating, highlighting the need for systemic improvements to create

equitable and efficient conditions for climate adaptation. Overall, while moderate support prevails, targeted interventions are necessary to address low accessibility and improve outcomes in financial, technical, and training domains.

Table 25. Facilitating condition for adaptation to climate change

Response rating	Access to climate resilient seeds (%)	Use of modern farming techniques (%)	Access to weather information (%)	Adequacy & efficiency of irrigation infrastructure (%)	Access to financial resources (%)	Community support and networks (%)	Access to training programs (%)
Very low	7.1	0.6	-	0.6	1.3	1.3	3.9
Low	37.0	18.8	6.5	17.5	38.3	29.9	31.8
Moderate	48.1	55.2	69.5	70.1	53.9	57.8	53.2
High	7.8	25.3	24.0	11.7	6.5	11.0	11.0
Very High	-	-	-	-	-	-	-

Source: Household Survey, 2024

FGDs with communities across the study area revealed that their efforts of adapting to climate change related risks, particularly of flood and droughts, are facilitated by the supports from government and non-government actors, which is discussed earlier in section 5 as well. Examples include construction of infrastructure either to reduce the impact of floods, such as embankments, or to react when they face the impacts, sch as shelter houses. In some areas, community people reported having an early warning system such as Siren or text messages, but the coverage is limited. The early warning system not only helps producers plan their farming related practices, it also helps traders particularly to plan transportation of agricultural products.

The district level agencies such as the District Administration Office and municipality have included plans to provide emergency relief when there is a disaster, particularly flooding. Such emergency relief helps both food producers and other food system actors. External facilitation also includes capacity development of communities on disaster risk reduction and emergency responses.

Result further showed how communities have strengthened their social support systems to help households adapt to climate change (Table 21). The formation of mutual aid groups is the most favored, with 85.7% of respondents valuing their collaborative and resource-sharing approach. Over half (53.9%) emphasize the importance of traditional knowledge and practices, reflecting a reliance on culturally rooted, sustainable strategies. In contrast, only 3.2% prioritize the establishment of community-based organizations, suggesting limited perceived effectiveness or feasibility of formal structures. These results underscore a strong preference for informal, grassroots mechanisms over formalized approaches, emphasizing the need to support and integrate these trusted systems into broader climate adaptation strategies.

Table 26. Social support systems to adapt to climate change

Social support systems	Response (%)
Establishment of community-based organizations	3.2
Formation of mutual aid groups	85.7
Sharing of traditional knowledge and practices	53.9

Source: Household Survey, 2024

6.3 Stakeholders Vision on Future of the Food System

FGDs with communities and KIIs with other stakeholders revealed what the ideal situation for the sustainable food system could be.

1. Environmental Sustainability: They prioritize environmental health by promoting sustainable approaches that minimize ecological harm. This includes practices like reuse, recycling, and reducing greenhouse gas emissions to create a food system that nurtures the planet and mitigates climate change.

2. Equity and Access: They strive to ensure healthy local food is accessible to all, fostering food security and equity. Key focus areas include providing access to agricultural inputs, natural resources, and finance to support equitable participation in the food system.

3. Economic Development: The development of locally owned food businesses is essential to a thriving economy. They aim to improve pay and working conditions, especially for field workers, and expand processing units to create jobs and add value within the local food system.

4. Infrastructure and Systems: A resilient and efficient food system requires robust infrastructure and strategic planning. Strengthening the system through investment in food-related infrastructure and community planning ensures food availability and long-term resilience.

5. Knowledge and Cultural Alignment: Knowledge on nutrition and consumption is vital for a healthy community. We also emphasize creating a food system that respects socio-cultural norms, ensuring it is inclusive and reflective of local traditions and values.

The specific examples presented below, whereas an elaborative vision, opportunities and potential barriers to achieve the vision is presented in Table 22.

- They envision all households achieving food security, provided there is access to adequate irrigation facilities, technical support, and necessary inputs.
- They seek new market opportunities for traditional niche crops and short-duration crops such as vegetables, mushrooms, lentils, and black mustard.
- Revitalizing traditional crops is a priority, as the genetic resources of many local varieties are being lost. This requires product diversification and strong market linkages to preserve and promote these crops.
- Promoting cultural and traditional festivals as national events is vital for showcasing crops like black gram, lentils, and Anadi (sticky rice). For example, festivals like Guriya Parva (where black gram *pakoda* is mandatory), *Atwari* (featuring Anadi sticky rice roti), and Maghi (with dishes like *Dhikri* and *Chichhad*) highlight the cultural significance of these crops.

Table 27. Future of the local food system: vision, opportunities and barriers

Vision	Opportunity	Barrier
Input		
Support farmers to implement climate resilient agricultural practices.	Farmers are enthusiastic to learn new technologies	Access to financial resource for agricultural inputs Technical know-how
Provide agri-inputs on time	Accessibility of the region	Financial constraints
Food Production		
Promote indigenous crops	Farmers have knowledge	Awareness
Support experimental plantings that could lead to established commercial production.	Farmers are enthusiastic and ready for change	Limited land holding Poor local leadership
Manufacturing and Processing		
Develop food manufacturing and processing infrastructure	Accessibility of the region	Financial constraints Poor local leadership
Outreach and Expansion		

Vision	Opportunity	Barrier
Raise public awareness on the value of local food, in order for communities to place a higher value in local food	Accessibility of the region	Limited available infrastructures Insufficient initiation
Consumer Demand		
Explore avenues for creating products and markets that address the distinct preferences for flavors and goods of the region's various ethnic communities, reflecting their unique cultural backgrounds.	Residents are from unique cultural backgrounds.	Poor local leadership Minimal stakeholders involvement for promotion
Nutrition and Food Security		
Develop programs that help secure access to nutritious food for underserved populations.	Availability of local foods	Limited land holding Poor local leadership Access to financial resources
Address underlaying poverty conditions that lead to food insecurity	Opportunity of livelihood diversification	Limited land holding Poor local leadership Access to financial resources
Education and Works force Development		
Make education and training opportunities related to the food system accessible to disadvantaged populations.	Farmers are eager to learn	Insufficient stakeholders' involvement Access to financial resources
Storage and Distribution		
Enhance prospects for direct marketing and various alternative marketing strategies that emphasize increased direct sales.	Accessibility of the region	Limited available infrastructures and practices Poor transportation facilities Poor local leadership and insufficient initiation
Encourage small farmers to collaborate in aggregating their produce for distribution, thereby minimizing expenses and fostering collective economies of scale, establishing a local collection center.	Good social network among the villagers	Access to financial resources Poor planning/ initiation
Wasted Food		
Increase education and training around on-site residential composting from wasted food.	Demand for by-products	Insufficient knowledge
Explore strategies to utilize wasted food for biofuel and bio-products.	Potential demand for products	Access to financial resources Lack of planning/ initiation

Source: FGDs with communities and KIIs

6.4 Key Challenges in adopting Agroecological Approaches

Agroecological practices hold significant potential for achieving sustainable agriculture, yet their widespread adoption faces numerous challenges that demand careful consideration. A primary obstacle is the gap in knowledge and awareness, as farmers, extension services, and policymakers often lack a thorough understanding of agroecological principles. This underscores the need for comprehensive educational initiatives to promote effective implementation (Leippert et al., 2020). Technological and infrastructural barriers further hinder adoption, with limited access to innovations impeding the transition from conventional methods (Boulestreau et al., 2021). Additionally, risk aversion due to uncertainties surrounding agroecology can discourage farmers, necessitating the demonstration of tangible benefits and strategies for mitigating risks (Chèze et al., 2020). IConcerns over short-term yields exacerbate this reluctance, emphasizing the

importance of highlighting long-term advantages such as improved soil health and resilience (Kipling et al., 2019).

Policy and market challenges add to the complexity, with insufficient support and incentives deterring adoption. Addressing these issues requires targeted interventions, including subsidies and market promotion (Mockshell et al., 2023). The fragmentation of agroecological knowledge furthercomplicates matters, making it essential to integrate and disseminate localized insights (Takahashi et al., 2020). Labor and time-intensive practices, coupled with labor shortages in certain regions, pose additional barriers. Socioeconomic factors, such as poverty, limited access to credit, and gender disparities, hinder progress, highlighting the need for inclusive solutions (Rao and Moharaj, 2023). Resistance to change, rooted in farmers' attachment to conventional practices, can be mitigated by showcasing successful case studies and involving farmers in hands-on experimentation (Antwi-Agyei and Stringer, 2021). Finally, scaling up agroecological practices necessitates strengthening extension services and technical support to facilitate broader adoption (Autio et al., 2021).

This study also assessed key challenges related to local food systems considering the impact of climate change, particularly floods and droughts. The major challenges are grouped into 6 thematic areas and discussed hereunder.

1. Knowledge and Technical Expertise

Communities face significant gaps in technical knowledge and skills, particularly in contemporary climate resilient, agroecological based farming techniques, integrated pest management (IPM), and new agricultural practices. These limitations hinder productivity and the adoption of innovative farming methods. Key challenges include:

- Lack of technical knowledge and skill/expertise (Bhaisakhani, Laungahawa, Ranipur, Lamkhiphata)
- Lack of technical knowledge on IPM, Agroecology, off-seasonal vegetable farming (Guruwagaun)
- Lack of knowledge on new varieties introduced (Bijaynagar)
- Timely access to information regarding technology, weather, or any other significant matters is not guaranteed (Bhaisakhani, Dhungrahi)

2. Input and Resource Availability

Farmers encounter challenges related to the availability and timely access to essential agricultural inputs such as seeds, fertilizers, and organic materials, as well as infrastructure deficits like protective barriers and embankments. Key challenges include:

- Lack of access to improved seed varieties (Bhaisakhani, Dhungrahi, Guruwagaun, Lamkhiphata)
- Problems with timely availability of seeds (Laungahawa)
- Unavailability of synthetic fertilizers (Guruwagaun, Lamkhiphata)
- Inadequate management of organic fertilizers (Bhaisakhani)
- Problem related to the production of foundation seed (Bhaisakhani)
- Lack of woods, even for basic needs like funerals (Lamkhiphata)
- Absence of protective barriers/embankments (Bhaisakhani)

3. Market Access and Infrastructure

The lack of market access, collection centers, transportation facilities, and irrigation infrastructure limits the economic potential of agricultural products. These issues also discourage farmers from diversifying into non-seasonal and high-value crops. Key challenges include:

- Lack of market (Bhaisakhani, Ranipur, Dhungrahi, Guruwagaun)
- Lack of collection centers (Bhaisakhani, Dhungrahi, Guruwagaun)
- Insufficient transportation services for agricultural products (agricultural ambulance) (Bhaisakhani, Jodhipur)
- Lack of irrigation facilities (Bhaisakhani, Bijaynagar, Ranipur (mainly in winter), Jodhipur, Lamkhiphata)
- Lack of irrigation facilities for off-seasonal vegetables (Guruwagaun)

4. Economic and Financial Constraints

Limited access to financial resources, credit facilities, and land ownership hampers the ability of farmers to invest in their farms, adopt new technologies, and secure their livelihoods. Key challenges include:

- Lack of financial resources (Laungahawa)
- Lack of credit facilities (Jodhipur)
- Lack of permanent ownership of land (Laungahawa, Bijaynagar)

5. Environmental and Climate Challenges

Farmers face environmental and climate-related issues such as floods, droughts, elevated water temperatures, and wildlife encroachments, which adversely affect crop yields and overall farming practices. Key challenges include:

- Impacts of flood (mostly across all communities)
- Impact of hazards (drought most prominently) (Ranipur)
- Elevated temperatures of boring water impacting vegetation (Bhaisakhani)
- Fear stemming from wild animals and their encroachment (Bhaisakhani)

6. Governance challenges

The concept of sustainable consumption is a least priority at the federal level, that is also the case at the local level.

- Lack of policies and programmes supporting sustainable, climate resilient food production and marketing at the municipality level
- Lack of policies and programmes supporting sustainable, climate resilient food production and marketing at the provincial level

By addressing these thematic challenges, stakeholders can target specific areas such as knowledge enhancement, resource provision, market development, financial accessibility, and environmental mitigation to drive sustainable development in these communities.

Resilience in agricultural systems depends on the ability to adapt effectively to changing conditions. However, the adoption of inputs such as drought-resistant seed varieties and flood-tolerant crops hinges on farmers' access to and availability of these resources. Limited financial resources further constrain smallholder farmers, often forcing them to abandon resilient strategies such as agricultural diversification and agroforestry.

Locally relevant solutions developed through participatory processes and the co-creation of knowledge with farmers can significantly enhance climate change adaptation and mitigation in a sustainable manner. To fully realize this potential, supportive policies, education, and access to necessary resources are essential for empowering farmers to implement these practices effectively.

7. Conclusion and Recommendations

7.1 Conclusion

The Barbardiya Municipality in Bardiya district faces significant challenges posed by climate hazards such as floods, droughts, and associated impacts, which severely affect local agroecology-based food systems. As indicated by various research findings, transitioning to agroecology may offer a promising pathway for resilience and sustainability in food production, yet the region's vulnerability necessitates a tailored approach to adaptation measures.

Agroecology integrates principles such as biodiversity, synergies, recycling, and resilience to create sustainable farming systems. However, the study reveals that the agroecological transition in Barbardiya Municipality is at a nascent stage, with an overall low CAET score of 42.4 across key indicators. This highlights the limited implementation of practices such as crop diversification, integration of animals, efficient resource use, and community-based governance. Culture and food traditions remain relatively strong, reflecting the community's attachment to indigenous crops and practices. However, economic pressures and climate shocks threaten these traditions, emphasizing the need for conservation and reinforcement of local knowledge and biodiversity.

Floods and droughts are the predominant climate hazards in the region, with significant variability in their frequency and severity. These hazards lead to losses in crops, livestock, and infrastructure, disproportionately affecting vulnerable communities. The repeated occurrence of these hazards underscores the urgency of building robust adaptive capacity within the agroecological framework. Increased pest and disease incidence further compounds the challenges, exacerbating food insecurity and economic instability.

Effective adaptation measures are essential for enhancing the resilience of agroecology-based food systems. Strategies such as promoting drought-resistant crops, sustainable water management, and strengthening local seed systems are critical. Community-based initiatives like community seed banks, agroforestry, and integrated pest management can mitigate risks while preserving biodiversity. Empowering women and marginalized groups through access to education, resources, and decision-making platforms can further bolster resilience. Enhanced governance, including participatory planning and equitable resource distribution, is vital for addressing systemic vulnerabilities and fostering long-term sustainability.

In conclusion, while agroecology offers a holistic approach to addressing climate hazards, its success depends on the integration of scientific innovation with traditional knowledge, community engagement, and robust governance. Limited access to agromet advisory services significantly constrains the ability of farmers to anticipate and respond to climate risks, highlighting the need for expanding these services to ensure timely and actionable information reaches local communities. By fostering a culture of resilience and sustainability, Barbardiya Municipality can serve as a model for climate-adaptive agroecological systems in similar contexts. The findings underscore the urgency of scaling up agroecological practices and addressing systemic barriers to tackle the dual challenges of climate adaptation and food security.

7.2 Recommendations

Based on the finding; to build a resilient agroecology-based food system in Barbardiya Municipality and mitigate the impacts of climate hazards, following short-term and long-term measures are proposed.

1. Short-Term Measures considering Immediate Response and Relief
Climate Hazard Preparedness and Risk Reduction

- **Rescue and relief materials:** Distribute rescue and relief materials such boats, foods and clothes and tents.

- **Early warning systems**: Implement community-based flood and drought early warning systems.
- **Flood mitigation**: Strengthen embankments, create raised platforms for storage, and promote floating gardens in flood-prone areas.
- **Disaster management**: Form local committees and train communities in first-response strategies.

Enhancing Agroecological Practices and Biodiversity

- **Crop and livestock diversification**: Promote drought-resistant and flood-tolerant crops alongside indigenous varieties like Anadi rice and Siltung, and diverse livestock breeds.
- **Seed conservation**: Establish community-managed seed banks to ensure access to climate-resilient seeds.
- **Eco-friendly pest management**: Encourage biological pest control methods to reduce chemical reliance.
- **Participatory Action Research and Local Seed System:** Selection of suitable varieties through Participatory Varietal Selection, Promote seeds and breeds production system managed by community/cooperatives.

Sustainable Soil and Water Management

- **Irrigation infrastructure**: Develop small-scale irrigation systems, check dams, and rainwater harvesting structures.
- **Soil moisture retention**: Use mulching, biochar and organic compost to improve water retention.
- **Water efficient use:** Promote technologies like drip irrigation, multi-use water system, irrigation time etc. for efficient use of water.
- **Soil Fertility Management:** Conduct soil tests and promote soil fertility management practices (Green Manure, Inclusion of legumes, Farmyard Manure Improvement, Collection and use of animal Urine, Tricho-Vermicomposting, etc).

Empowering Communities

- **Farmer training**: Conduct workshops on agroecology, integrated soil and pest management, water management, and climate adaptation.
- **Women's empowerment**: Enhance women's access to resources and participation in decision-making.
- **Youth engagement**: Attract youth to agriculture through entrepreneurial opportunities and skill development.
- **Traditional knowledge preservation**: Document and integrate indigenous knowledge into adaptation strategies.

Market Access and Economic Support

- **Local market development**: Strengthen farmer cooperatives and reduce intermediary reliance.
- **Microfinance access**: Provide low-interest credit to support adaptive farming practices.

2. Long-Term Measures for Systemic and Sustainable Adaptation

Enhancing Agroecological Practices and Biodiversity

- **Integrated farming systems**: Promote intercropping, crop rotation, and agroforestry to optimize resources.

Climate Hazard Preparedness and Risk Reduction

- **Agromet advisory services with early warning systems**: Integrate meteorological data with advisory services to provide timely, actionable climate risk information.

- **Flood-resistant infrastructure**: Build long-term flood-proof shelters and mitigation structures.

Sustainable Water Management

- **Wastewater reuse**: Develop systems for treated wastewater irrigation in drought-prone areas.

Empowering Communities

- **Youth engagement**: Attract youth to agriculture through entrepreneurial opportunities and skill development.
- **Traditional knowledge preservation**: Document and integrate indigenous knowledge into adaptation strategies.

Market Access and Economic Development

- **Value addition and processing**: Invest in crop processing units for increased income opportunities.
- **Agri-tourism**: Leverage cultural heritage for eco-tourism linked to traditional farming practices.

Policy and Governance

- **Supportive policies**: Advocate for climate resilient agroecological practices, equitable resource distribution, and land tenure security.
- **Participatory Monitoring and evaluation**: Create systems to assess and improve adaptation measures over time.

Promoting Sustainable Livelihoods

- **Livelihood diversification**: Encourage non-agricultural income sources like beekeeping, fisheries, and eco-tourism.
- **Skill development**: Provide vocational training for alternative income opportunities.

By adopting these recommendations, Barbardiya Municipality can enhance its agroecological transition, build resilience against climate hazards, and foster sustainable and equitable food systems for its communities.

References

Adhikari, B., & Ojha, H. 2021. Agroecological Zones and Adaptation Strategies in Nepal's Changing Climate Context. Climate Policy, 21(4), 491-505.

Altieri, M. A., Nicholls, C. I., & Funes, F. 2017. Agroecology and the Search for a Truly Sustainable Agriculture. United Nations Food and Agriculture Organization (FAO).

Anderson, C. R., Maughan, C., & Pimbert, M. P. 2021. Transformative Agroecology Learning in Europe: Emancipatory Politics and Food Sovereignty. Agriculture and Human Values, 38, 379-396.

Antwi-Agyei, P., and Stringer, L. C. 2021. Improving the effectiveness of agricultural extension services in supporting farmers to adapt to climate change: insights from northeastern Ghana. Clim. Risk Manag. 32:100304. doi: 10.1016/j.crm.2021.100304

Autio, A., Johansson, T., Motaroki, L., Minoia, P., and Pellikka, P. 2021. Constraints for adopting climate-smart agricultural practices among smallholder farmers in Southeast Kenya. Agric. Syst. 194:103284. doi: 10.1016/j.agsy.2021.103284

Boulestreau, Y., Casagrande, M., and Navarrete, M. 2021. Analyzing barriers and levers for practice change: a new framework applied to vegetables' soil pest management. Agron. Sustain. Dev. 41:44. doi: 10.1007/s13593-021-00700-4

Chèze, B., David, M., and Martinet, V. 2020. Understanding farmers' reluctance to reduce pesticide use: a choice experiment. Ecol. Econ. 167:106349. doi: 10.1016/j.ecolecon.2019.06.004

FAO. 2020. Scaling up Agroecology: A Transformative Agenda for Food Security and Climate Resilience. Food and Agriculture Organization of the United Nations.

FAO. 2021. The State of Food Security and Nutrition in the World 2021: Transforming Food Systems for Food Security, Improved Nutrition, and Affordable Healthy Diets for All. Rome: FAO.

Kipling, R. P., Topp, C. F., Bannink, A., Bartley, D. J., Blanco-Penedo, I., Cortignani, R., et al. 2019. To what extent is climate change adaptation a novel challenge for agricultural modellers? Environ. Model Softw. 120:104492. doi: 10.1016/j.envsoft.2019.104492

Lucantoni, D., Thulo, M., Makhoebe, L.M., Mottet, A., Bicksler, A., Sy., M.R. 2022. Report on the use of the Tool for Agroecology Performance Evaluation (TAPE) in Lesotho in the context of the Restoration of Landscape and Livelihoods Project (ROLL). Results and analysis. Food and Agriculture Organization of the United Nations (FAO), Rome

Mockshell, J., Ogutu, S., Alvarez, D., Nielsen, T., Steinke, J., Remans, R., et al. 2023. Transitioning to agroecological food systems: a review of incentives for adoption of agroecological practices and outcomes. Montpellier: CGIAR.

Pretty, J., Toulmin, C., & Williams, S. 2018. Sustainable Intensification in African Agriculture. International Journal of Agricultural Sustainability, 16(1), 3-24.

Rao, R., and Moharaj, P. 2023. Empowering women in climate-resilient farming through sustainable agriculture technologies. Int. J. Multidiscip. Res. Growth Eval. 4, 157–265.

Shrestha, P., Sthapit, B., & Subedi, A. 2019. Community Seed Banks: Promoting Agro-Biodiversity and Food Security in Nepal. Agriculture & Food Security, 8(1), 1-12.

Takahashi, K., Muraoka, R., and Otsuka, K. 2020. Technology adoption, impact, and extension in developing countries' agriculture: a review of the recent literature. Agric. Econ. 51, 31–45. doi: 10.1111/agec.12539

Thapa, B., & Rimal, B. 2020. Community-Based Climate Adaptation in Nepal: Lessons Learned and Future Pathways. Journal of Mountain Science, 17(6), 1398-1410.

UNFCCC. 2019. Koronivia Joint Work on Agriculture: Key Outcomes and Implications for Climate-Resilient Agriculture. UN Framework Convention on Climate Change.

Wezel, A., Soboksa, G., McClelland, S., Delespesse, F., & Boissau, A. 2020. The Ambivalence of Agroecology in the Era of Sustainable Development Goals. Sustainability, 12(7), 2751.

FAO. (2019). The 10 Elements of Agroecology: Guiding the Transition to Sustainable Food and Agricultural Systems. Food and Agriculture Organization of the United Nations. Rome. http://www.fao.org/agroecology/knowledge/10-elements

Shrestha, S., Gautam, M., & Joshi, N. (2019). Community-based agroecological practices for climate change adaptation in Nepal. Journal of Agriculture and Environment, 20, 45–56.

Ministry of Forests and Environment (MoFE). (2021). Vulnerability and Risk Assessment and Identifying Adaptation Options: Summary for Policy Makers. Government of Nepal, Kathmandu .