MISEREOR
IHR HILFSWERK

LUMANTI
SUPPORT GROUP FOR SHELTER

ASSESSMENT OF CLIMATE CHANGE IMPACT, ADAPTATION & DISASTER RISK REDUCTION AND MANAGEMENT (DRRM) IN KALAIYA, KHAIRAHANI AND SUNDAR HARAICHA

ACKNOWLEDGEMENT

This report is prepared based on the municipal consultations and community discussions in Kalaiya Sub-metropolitan City, Sundar Haraicha Municipality and Khairahani Municipality. Our deepest gratitude to the mayors of respective cities as well as to all the ward-chairpersons and municipal staff for their coordination, participation, and their valuable time. The community discussions were carried out in four wards of Kalaiya and Khairahani city and Sudar Hariach Municipality which involved the community members, including women and children. Their active participation and interaction have helped us tremendously in gaining information at the ground level.

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LIST OF ABBREVIATIONS

CC	Climate Change
CCA	Climate Change Adaptation
CL	Confidence Level
DHM	Department of Hydrology and Meteorology
DRR	Disaster Risk Reduction
DRRM	Disaster Risk Reduction and Management
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GLOF	Glacial Lake Outburst Flood
masl	meter above sea level

EXECUTIVE SUMMARY

Climate change is an emerging global issue having localized impacts. Climate-induced hazards and extreme events have been increasing globally and Nepal is placed on the frontline in terms of the impact of climate change. Nepal has experienced changing weather patterns, increasing climate variability, and extreme climate events. Nepal is exposed to varieties of natural hazards and takes the lives of thousands of people each year. Also, Nepal being a developing country with around 35% of the GDP associated with climate-sensitive activities, key economic sectors including agriculture, tourism and transportation are vulnerable to climate change impacts and climate-induced hazards. The impact is observed both in the cities and rural areas, and there is a need to understand the location and context-specific vulnerability to specific hazards.

In this context, the assessment of climate change impact and disaster risk reduction and management at the local level, especially in cities can be very useful for effective development planning by incorporating risk reduction measures. This report presents the findings from the assessment of climate change impacts, vulnerability, and coping strategies adopted in three cities; Kalaiya Sub-metropolitan city, Khairahani Municipality, and Sundarharaicha Municipality and explores existing plans and policies regarding climate change and disaster risk reduction within the local context. The study involves field observations, orientation, consultations, learning, and data collection workshops followed by discussions in communities. The information collected is verified with municipality offices with the involvement of the mayor, ward chairpersons, municipal focal persons on disaster and local people. The report also presents the potential leveraging points for local governments and stakeholders to jointly plan and execute programs and plans in disaster risk reduction and climate change adaptation.

1. INTRODUCTION

1.1 Background

Climate change has become a major global concern in recent times having a widespread impact on human and natural systems (IPCC, 2019). The warming of the climate systems over decades, with a melting of ice and snow and rising sea level, have resulted in various climate-induced disasters (Olsson et al., 2014). According to the Global Climate Risk Index for 2021, Nepal is ranked as the 10th most affected country in the 20 years period of 2000 to 2019, and ranked as 12th in the year 2019, which was attributed to the level of exposure and vulnerability to extreme weather events (Eckstein et al., 2021). The diverse topography, climatic conditions, steep landscape, and rugged mountains exacerbated by the heavy monsoon rainfall patterns, environmental degradation, and climate change have made Nepal highly prone to multiple hazards (MoHA, 2019).

A wide range of geological and hydro-meteorological hazards such as landslides, debris flows, floods and glacial lake outburst floods (GLOFs), epidemics, droughts, etc. hit the country frequently (MoHA, 2015). These hazards are worsened by extreme climate events and the associated physical, social, and economic vulnerability (MoE, 2010). Floods, landslides, and droughts are found to be the most destructive climate-induced hazards for Nepal, the frequency and intensity of which are increasing (Karki, 2009; MoHA, 2017). The impacts of climate change have been seen as changes in temperature and precipitation patterns, changes in seasonal timings, the incidence of drought and less water availability, etc. causing higher flood risks, enhanced soil erosion, a decline in production, incidence of crop pest attacks and food insecurity (Thapa & Hussain, 2021). Intensive precipitation events have led to increased events of floods in the plain and landslides in the hills and mountains of the country. Around 1,243 cases of disaster incidents from landslides, floods, and heavy rainfall have been recorded in Nepal in the year 2017 and 2018, with a loss of 374 people (MoHA, 2019).

Climate variability and extreme events lead to a major impact on the economy of Nepal as 35% of the GDP is associated with climate-sensitive activities (NPC, 2014; World Bank, 2021). These extreme events are dominated by floods, but also include rainfall variability on agriculture as soil erosion and droughts (MoFE, 2018a). Drought accounted for 38.9% of all losses caused by weather and climate-related events between 1971 and 2007 while floods accounted for 23.2 % (UNDP, 2009). The agriculture system in Nepal is mostly reliant on rainwater for irrigation, while the extended intensity of the dry period has impacted agricultural productivity resulting in food insecurity (MoAC, 2011). Rice, wheat, and maize are the main cereal crops mostly produced in the Terai region of Nepal that depend on the regular provision of surface water. Irregularities in the monsoon rainfall pattern, as well as time shift in the rainfall pattern, has increased the vulnerability of these crops (Paudel et al., 2020).

The vulnerability to climate-related extremes and natural hazards are often attributed due to the settlements in hazardous areas and marginal land. Those living in the hazard-prone areas, with the least resources and knowledge to cope, are the most vulnerable, who are also often poor and marginalized (Yoon, 2012). Disaggregating poor and marginalized, women and children are most vulnerable to climate change as they are mostly engaged in household activities like collect firewood, carry water travelling long distances, and left to cope with variable climate along with management of household and farm (Tuladhar et al., 2021). Similarly, with over 65% of the population in Nepal dependent on agriculture for the economy, farmers are the most vulnerable to the predicted impacts of climate change (MoFE, 2018b). Smallholder farmers rely on subsistence farming for their livelihood

while floods, drought, and landslides along with drying up of local water sources and changes in the vegetation cover has increased their vulnerability (Fellmann, 2012).

These changing weather patterns have also caused resource degradation and increased social inequalities with an additional burden to the poor, vulnerable, and excluded communities (Gentle and Maraseni, 2012). The recurring climate related natural hazards undermine agricultural productivity causing food insecurity and excessive use of other available resources, which seem to magnify the existing inequalities in the society, based on gender, ethnic groups, economic status, etc. (IDS-Nepal, PAC and GCAP, 2014; FAO, 2016). Usually, the low-income groups are concentrated around flood plains and steep slopes and have higher exposure to hazard as they are less able to avoid and cope with them. The inequalities, exclusion, and discrimination against certain social groups also push them to higher vulnerability through decreasing adaptive capacity and increased sensitivity compared to other people (Sridevi et al., 2014).

However, adaptation strategies and coping practices are implemented by people to overcome vulnerabilities to climate change. Changes in the farm management practices, rainwater harvesting, growing vegetables instead of grain crops, etc. are some of the strategies used by farmers (UNDRR, 2019). The lack of technical knowledge and technological advancement has been hindering people from adapting to various coping mechanisms. Adaptation practices and adoption of new higher-yielding crop varieties, enhanced irrigation systems, switching to hybrid seed have been sustaining yield increases, but at the high cost associated with it, even when climate changes create downward pressure. Moreover, improving and strengthening human capital through training, outreach plans, extension services at different levels will enhance capacity to climate change adaptation mainly in developing countries (MoHA, 2018).

Climate Change Trends and scenarios in Nepal

Nepal is highly vulnerable to climate change and has already experienced changes in temperature and precipitation at a faster rate than the global average. The latest study shows that significant positive trends are observed in annual and seasonal all Nepal maximum temperature, a significant positive trend only in monsoon season for all Nepal minimum temperature, whereas no significant trend in precipitation in any season (DHM, 2017). The maximum temperature of Nepal increased by 0.56ºC per decade (0.056ºC per year) between 1971 and 2014, while the minimum temperature trend by 0.002ºC per year (DHM, 2017). Precipitation has a high level of variation with a decreasing trend during the pre-monsoon season while an increasing trend in other seasons (DHM, 2017).

The district-wise trend analysis for the extreme climate indices shows that the number of rainy days is increasing significantly mainly in the northwestern districts, and very wet days and extremely wet days are decreasing significantly, mainly in the northern districts. Similarly, trends of warm days and warm nights and warm spell duration are significantly increasing in the majority of the districts, while cool days are decreasing in a majority of the districts, cool nights are increasing in few northwestern and northern districts and decreasing in few southeastern districts significantly. The cold spell duration is also increasing significantly only in the FWDR (DHM, 2017).

As per the climate projection scenario in Nepal, the temperature is likely to increase by 0.92 – 1.07^{0}C by 2045, 1.3-1.82^{O}C by 2065, and 1.72-3.53 ^{0}C by 2100 compared to 1981-2010 reference. Precipitation will negligibly increase by 2.1-6.4% by 2045, 7.9-12.1% by 2065, and 10.7-23% by 2100 compared to 1981-2010 reference (MoFE, 2019).

The projected climate change patterns in Nepal shows that the frequent unpredictable patterns of precipitation would lead to more extreme climate-related disasters along with uncertainties in weatherly events would affect different development aspects, such as drinking water, disaster management, energy, biodiversity, agriculture, health, urban planning and livelihoods among others (MoFE, 2019).

Policy interventions in Climate Change and DRR

Nepal's Climate Change Policy, 2011 was envisioned in the country to reduce GHG emissions by promoting the use of clean energy; enhancing the climate adaptation and resilience capacity of local communities for optimum utilization of natural resources and their efficient management; and adopting a low-carbon development path by pursuing climate-resilient socio-economic development (MoPE, 2016). With the endorsement of a new constitution in 2015, and changes in the governance, a need for programs pertaining to climate change adaptation and mitigation effectively by integrating the issues of climate change into the policies and programs of all three levels of government was envisioned. Hence, National Climate Change Policy, 2019 has been introduced in Nepal to provide policy guidance to various levels and thematic areas towards developing a resilient society by reducing the risk of climate change impacts.

Similarly, the Disaster Risk Reduction and Management (DRRM) Act was enacted in 2017, having the vision to integrate disaster management as one of the key priorities of all tiers of government (federal, provincial, and local). The act focused on a comprehensive DRRM approach incorporating Disaster Risk Management (DRM) planning, response, and recovery. The National Policy on Disaster Risk Reduction, 2018, and the Disaster Risk Reduction National Strategic Plan of Action (2018-2030) was also endorsed to strengthen the government's initiatives on DRM.

While, the absence of uniformity in understanding the multi-sectoral issues of climate change among the inter-sectoral agencies and the lack of coordination among them, lack of studies, research, and basic data about the impacts of climate change effect, adaptation practices, and potential loss or damage resulting from climate-induced disasters are the major gaps and challenges in the area of climate change management. Nepal is in the formulation phase of its National Adaptation Plan (NAP) process, which aims to reduce the country's vulnerability to climate change and to facilitate the integration of climate change adaptation in policies, programs, and activities across sectors and levels (MoPE, 2017).

1.2 Significance of the study

Climate change and its impact have been attributed in the local communities as local issues. Increasing awareness on the connection between local issues and global climate change by making climate change relevant at the local level is an important step in bridging the gap for communities at risk (Nash et al., 2019). The lack of knowledge and institutional frameworks are barriers to the adaptation to climate change. This can be addressed by reworking the ways of building skills and knowledge, and design effective development planning and modes of delivery (Regmi and Bhandari, 2013).

In this context, an assessment of climate change adaptation to explore the issues and their impact and sensitization on the existing plans and policies regarding CCA and DRRM to the actors within the

local government is very much vital. This assignment has therefore conducted a city-level assessment on CCA and sensitization on DRR in communities and municipalities of three cities Kalaiya, Khairahani, and Sundarharaicha,.

1.3 Study objectives and scope

The overall objective of this study was to identify the climate change impacts, vulnerability, and adaptation policies and measures adopted at the local and community level, as well as to sensitize the city level actors, staffs, and community members on the technical terminologies, existing policies, and plans on CCA and DRRM issues. In order to do so, the study involved field observations, consultations, and orientation followed by discussion in communities and municipality offices. The specific objectives are as follows.

- To orient staff members, government and community representatives in CCA and DRRM
- To sensitize local to city level actors on the existing plan and policies regards CCA on identified issues in regular plan of action and explore a possible partnership
- To conduct an assessment on climate change adaption (CCA) & its impact on the city level focused on two working cities
- To produce city-level reports on issues of CCA and its impact and prioritize the partnership action with local government

1.4 Limitations

Some of the limitations of this study are as follows.

- The study was carried out thoroughly in short period, due to which some of the issues from all parts of the city might not have been captured.
- Findings drawn from the field works are based on the consultation and FGDs from representative communities, as a result some of the findings might be subjected to spatial and temporal variations.

2. STUDY FRAMEWORK

The study was carried out in the three cities Sundarharaicha, Kalaiya, and Khairahani of Province 1, 2 and 3 (Bagmati Province) respectively. All three cities are situated in the lowlands of Terai. The assessment was conducted using the quantitative and qualitative approach of data collection from different primary and secondary sources. Various levels of consultations, focus group discussions, and interviews, were conducted at the local and community level with different groups, networks, and actors to collect, analyze and validate data for the selected study area. Review of different existing policies, plans, and information of city level regarding CCA and DRRM was done. Similarly, analysis of the collected information, data, and interview was carried out followed by final report preparation and sharing. The methodological approach is shown in Figure 1.

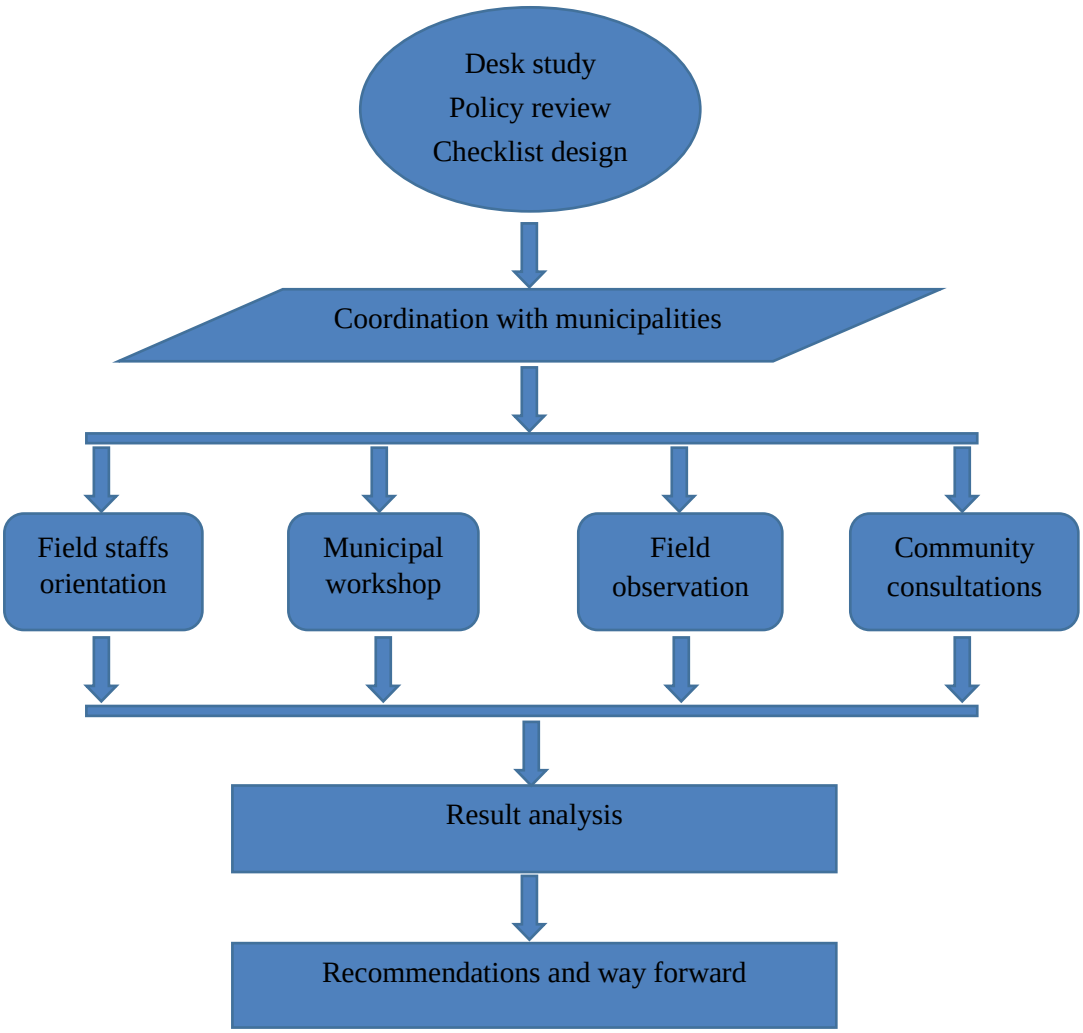

Figure 1: Methodological approach

1. Background study

A desk study and policy review were carried out on the climate change and DRR sectors in Nepal. Coordination with the municipalities of the respective cities was done, based on which, need of a study on the climate change and DRR sector was identified in the cities. In this regard, this study was initiated with the design of a checklist and methodological framework.

2. Field staff's orientation

Five staffs each from Lumanti's branch office in Sundarharaicha, Khairahani and Kalaiya were oriented on the terminologies of climate change, DRR, and basic understanding of research methodologies and data collection strategies. The staffs were given basic concepts on hazard, vulnerability, risk, disaster, climate change, etc. along with a concept on capacity building, adaptation and the international bodies working on these. Similarly, they were oriented on the national and international framework for disaster risk reductions. Along with it, the field staffs were briefed on the data collection techniques and the types of data to be collected from community consultations and municipal workshops.

3. Municipal workshop

Consultation and workshop was conducted in the Khairahani Municipality, Kalaiya Sub-metropolitan City and Sundarharaicha Municipality on 16th April, 20th April, and 29th August respectively. Mayor, ward chairpersons, municipal focal persons on CC and DRR, media persons and other officials were present in the workshop. The program was carried out with an orientation on the basic terminologies such as hazard, disaster, preparedness, response, adaptation, and plans and policies on DRRM, followed by a discussion and a data collection workshop. The workshop involved group work and presentation through which municipality and ward level data on climate change, its impact, response, policy, plan, budget, etc. were collected.

4. Policy and gap analysis

Through the review of different existing policies, plans and information on CCA and DRRM along with the information collected on the field from respective stakeholders, a review was done to analyze the current gaps and challenges faced by the cities regarding climate change adaptation.

5. Community consultations

Total eight Focus Group Discussions (FGDs) were carried out in the three cities, out of which two FGDs were done in two communities each of Khairahani Municipality and Kalaiya Sub-metropolitan City, while four FGDs were done in four communities of Sundarharaicha Municipality. The communities were selected based on the major impact of climate change and disaster faced, identified through municipal consultation and consensus-building among local government representatives. The community people were given a group work to note down the available resources in the community, climate-induced hazards faced in the community and its impact on those resources, local perception

on climate change, problems faced, and potential solutions to solve the problem as well as adaptation strategies were further discussed. The list of participants from each community is presented in table 1.

Table 1: Participants lists from each community

Municipality	Ward number	Place	Participants
Khairahani	4		
Khairahani	13	Simreni	
Kalaiya	18	Bharwaliya	
Kalaiya	8, 11	Khapartatta	
Sundarharaicha	4	Badahara	
Sundarharaicha	10	Barpipal	
Sundarharaicha	5	Gaushala	
Sundarharaicha	2	Karebana	

6. Data analysis

The data from FGDs and consultations were verified with each other and further analyzed through existing literature and news. The data on the climate trend for Bara and Chitwan district has been taken from the latest climate trend analysis report of 2017 by the Department of Hydrology and Meteorology (DHM, 2017). The report provides district-wise data and thus, climate trends have been discussed for the whole district, due to the unavailability of municipal level data. Similarly, the land cover map has been prepared in ArcGIS using the satellite image from 2019 downloaded from the USGS Earth Explorer.

3. FINDINGS

Below are the findings from both the primary sources such as municipal consultations, workshops, FGDs at communities as well as from secondary sources such as literature review, online data portals, municipal websites, and official reports. The findings are presented separately for all three cities including the key opportunities and way forward and recommendations for each area.

3.1 Kalaiya Sub-metropolitan City

Kalaiya is a Sub-metropolitan City of Bara district, situated in the lowland of the Terai region at an elevation of 152 masl. The climatic normal for the maximum temperature is 30.5ºC and the minimum temperature is 18.4ºC with an average precipitation of 1692.3 mm annually in Bara district. According to the latest statistics of the National Census 2011, the city consists of total 28,645 households with the total population of 123,659, which is 17.98 percent of the total population of the district. The city is surrounded by other rural and urban municipalities of Bara district, whereas in the southern part lies India. The municipality is divided into 27 wards as shown in figure 2.

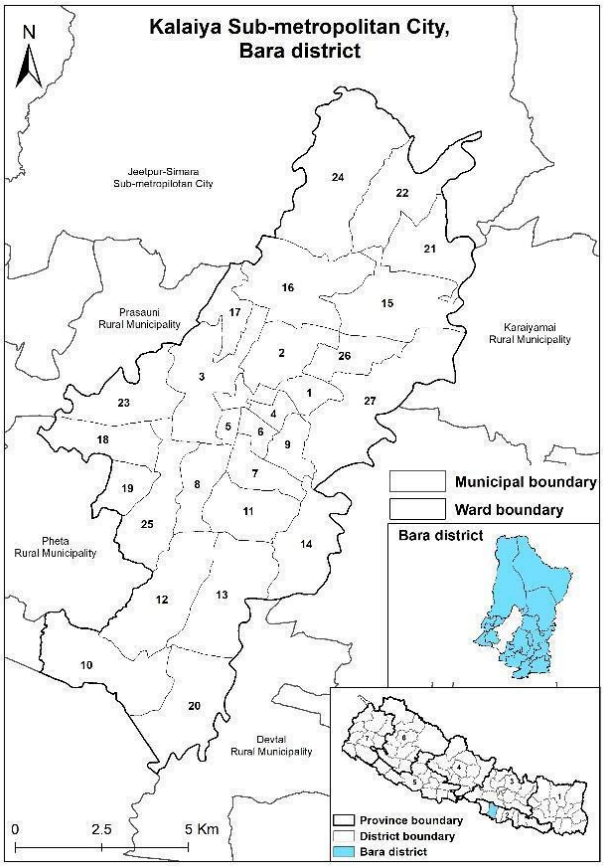

Figure 2: Location map of Kalaiya Sub-metropolitan City

The city is inhabited by different ethnic groups from all categories of Madhesi high, middle and low caste, Muslims, Hill Brahmin, Tharu, etc. Yadav, Kurmi, Kanu, Kushwaha, Chamar, Dhanuk, etc. are the major castes living in the area. Bhojpuri is the main language spoken. Agriculture is the main occupation of the majority of people, while during the dry period, mainly the months of October to April, people in the city often work in brick kilns and are involved in other labor works. Rice, wheat, and maize are the major agricultural production followed by seasonal vegetable farming. Kalaiya Bazar is the nearest marketplace. Similarly, vegetables are sold to Kathmandu and other districts as well. Birgunj is the nearest city to Kalaiya facilitated by large hospitals and markets. Health posts are available in the ward level whereas, for major health problems, people often go to Birgunj city for treatment. The major source of drinking water is tube well/hand pump, while some use tap/piped water. Very few households have deep wells as well. For irrigation, as rainwater is insufficient during the dry months, boring water is used through a diesel water pump (*damkal* motor called locally). The water pump is taken on lease on an hourly basis. Firewood is the main source of cooking fuel in most of the households in the city, while some use cow dung and LPG as well.

Bakaiya, Pasaha, Dudhaura and Bangari are the main rivers of Kalaiya. There are very few forest resource in the municipality. The land cover map of Kalaiya sub-metropolitan city is presented in figure 3, which shows the land cover into three categories; settlement area, agricultural land and water sources.

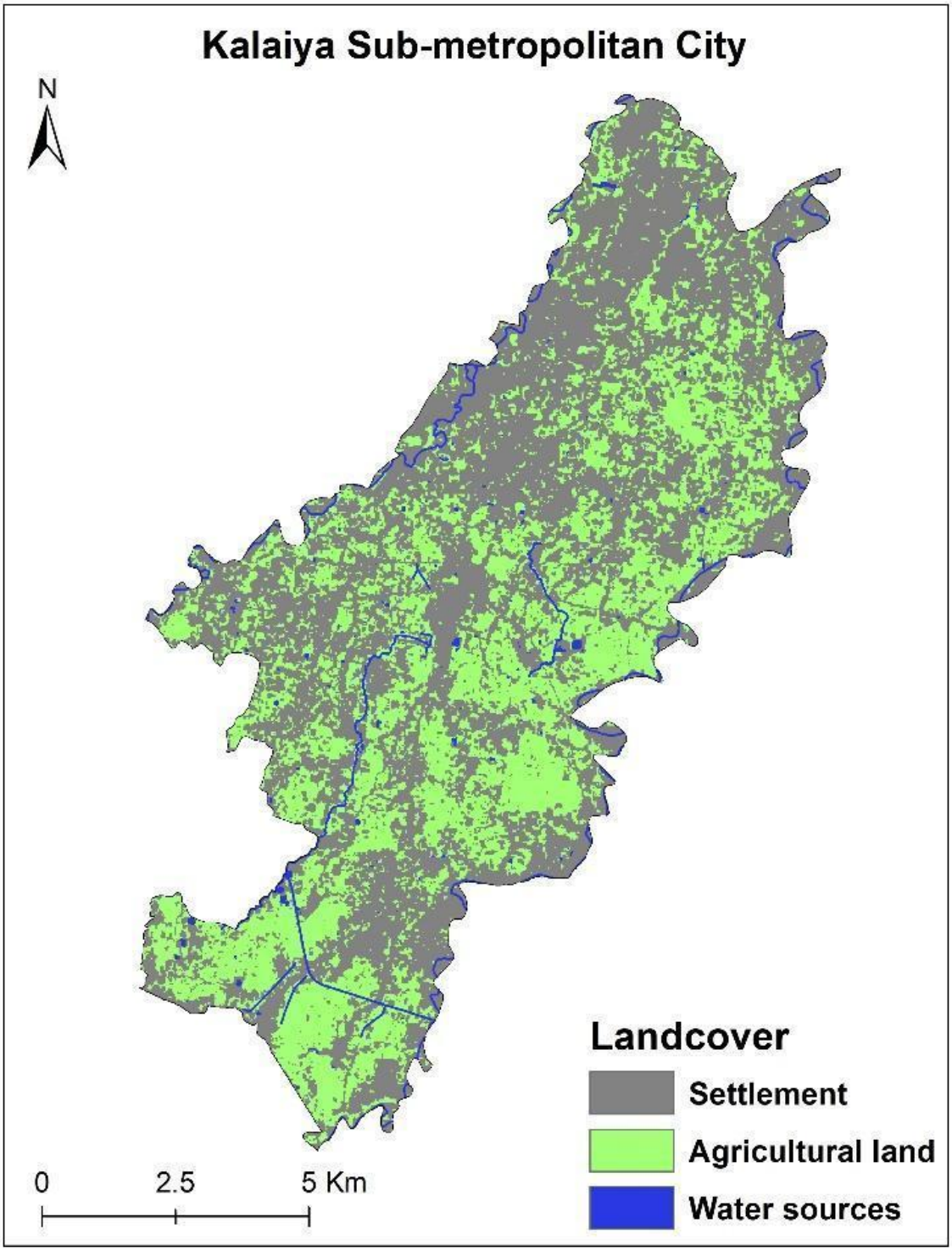

Figure 3: Land cover map of Kalaiya Sub-metropolitan City

3.1.1 Climate trends and impacts

The climate trend has been presented for the whole Bara district extracted from the latest trend analysis report by the Department of Hydrology and Meteorology (DHM) in 2017 which presents district-wise trend data. The trends for the major climate indices; precipitation, maximum temperature, and minimum temperature as well as the eleven extreme climate indices are discussed below. Table 2 lists the major climate indices trends for the Bara district analyzed from the year 1971-2014 along with its significance level (α). Both the seasonal and annual trend is presented in the table.

Table 2: Seasonal and annual climate trend of Bara district with corresponding significance level

Indices	Winter		Pre-monsoon		Monsoon		Post-monsoon		Annual	
	α	Trend	α	Trend	α	Trend	α	Trend	α	Trend
Precipitation (mm/year)	0	-0.15	0	0.0524	0	-2.72	0	-0.62	0	-4.644
Max. Temperature (ºC/year)	+	-0.021	0	0.007	***	0.030	0	0.016	0	0.010
Min. Temperature (ºC/year)	**	0.030	**	0.023	***	0.017	*	0.018	***	0.023

Note: Significant: * 95% CL, ** 99% CL and *** 99.9% CL; Insignificant at 95% CL: +, 0

Source: DHM, 2017

The seasonal and annual precipitation trend in the Bara district shows a decreasing trend except in the pre-monsoon season. The increasing trend of pre-monsoon precipitation is observed in the whole Terai region as well (DHM, 2017). However, the annual precipitation decreasing trend is very high in the district (-4.644 mm/year), which is one of the highest decreasing trend of all Terai region as most of the districts in Terai has an increasing trend of annual precipitation (DHM, 2017). The seasonal decreasing trend is highest (-2.72 mm/year) in the monsoon season. But all the seasonal and annual precipitation trend is insignificant.

The maximum temperature shows an increasing trend annually as well as seasonally except for the decreasing trend in winter. The monsoon season has the highest increasing trend (0.030ºC) and is highly significant at 99.9% confidence level while all other trends are insignificant.

The minimum temperature trend shows a significant increasing trend in all seasons as well as annually. The highest increasing trend (0.030ºC) is seen in the winter season, significant at 99% confidence level. Similarly, the annual minimum temperature trend is increasing at 0.023ºC which is highly significant at 99.9% confidence level.

Extreme climate indices

The extreme climate events are categorized into eleven indices and their trend analysis from the year 1971-2014 is presented in table 2.

Table 3: Trend for extreme climate indices with corresponding significance level for Bara district

Indices	α	Trend	Indices	α	Trend
Rainy days	0	0.2	Cool days	0	0.2
Consecutive dry days	0	0.1	Warm spell duration	0	0.0
Consecutive wet days	0	0.3	Warm nights	***	0.6
Very wet days	0	-0.1	Cool nights	**	-0.5
Extremely wet days	0	0.0	Cold spell duration	+	-0.2
Warm days	0	0.2			

Note: Significant: * 95% CL, ** 99% CL and *** 99.9% CL; Insignificant at 95% CL: +, 0

Source: DHM, 2017

The extreme climate indices in the district shows a slight increasing trend for indices like number of rainy days (rainfall greater than 1mm in a day), consecutive dry days (maximum number of consecutive days with daily rainfall <1mm), consecutive wet days (maximum number of consecutive days with daily rainfall >1mm), warm days (percentage of days when maximum temperature is greater than 90th percentile) and cool days (percentage of days when maximum temperature $<10^{th}$ percentile). But all the positive trends are insignificant. The very wet days (days with daily rainfall $>95^{th}$ percentile) are in decreasing trend and there are no changes in the extremely wet days (days with daily rainfall $>99^{th}$ percentile) and warm spell duration (annual count of days with at least 6 consecutive days when maximum temperature $>90^{th}$ percentile), while cold spell duration (annual count of days with at least 6 consecutive days when minimum temperature $<10^{th}$ percentile) is decreasing at 0.2, which are all insignificant trends. Warm nights (percentage of days when minimum temperature exceeds 90th percentile) are in increasing trend (0.6) which is highly significant at 99.9% confidence level whereas cool nights (percentage of days when minimum temperature <10th percentile) are in decreasing trend (-0.5), significant at 99% confidence level.

Local perception on climate trend

The community consultations and FGDs report that the temperature in the area has been increasing recently compared to previous years. This was raised both in the municipal consultation and community consultations. The winter season is also less cold than before whereas there has been no change in visibility issues due to climatic factors. Similarly, the majority of respondents observed long dry periods during the winter season with no or very minimum winter rain. However, during the monsoon season, people are facing heavy rainfall events as a result some parts of the sub-metropolitan city are inundated. Similarly, people believe that new pests are seen in the crops due to changing climatic conditions and the water availability in the village has greatly changed as compared to few decades before.

Impacts

The impacts of climate change have been seen in the Bara district and in the Kalaiya city for decades. Number of extreme events including fire, lightning, windstorm, and flood have been recorded in

Kalaiya city. Frequency of fire, lightning and flood incidents has increased in the past years. According to the government data portal “Bipad", 43 incidents of fire were reported from 2018 to April 2021 by Nepal police. One of the incidents was major, where one person was killed while others experienced minor injuries. This event has also damaged infrastructures and some livestock were killed. Similarly, two incidents of lightning and one flooding were recorded in the same timeline causing the death of three people.

Based on the municipal consultation, several disaster events were recorded in different periods. Flood event was recorded in 2018, lightning was recorded in 2014 and 2019, windstorm in 2019, and fire in 2020.

Both the municipal consultation with the ward chairpersons and community consultation revealed that fire and flood are the major hazards with the highest occurrence, drying of water sources being a major hazard since a few years recurring in each dry period, followed by thunderstorm occurred once but being the highly devastating hazard. While increased pests’ occurrence, lightning, drought, and hailstorm are also common with relatively lesser impacts. Figure 4 shows the list of hazards in Kalaiya city and the level of impact faced.

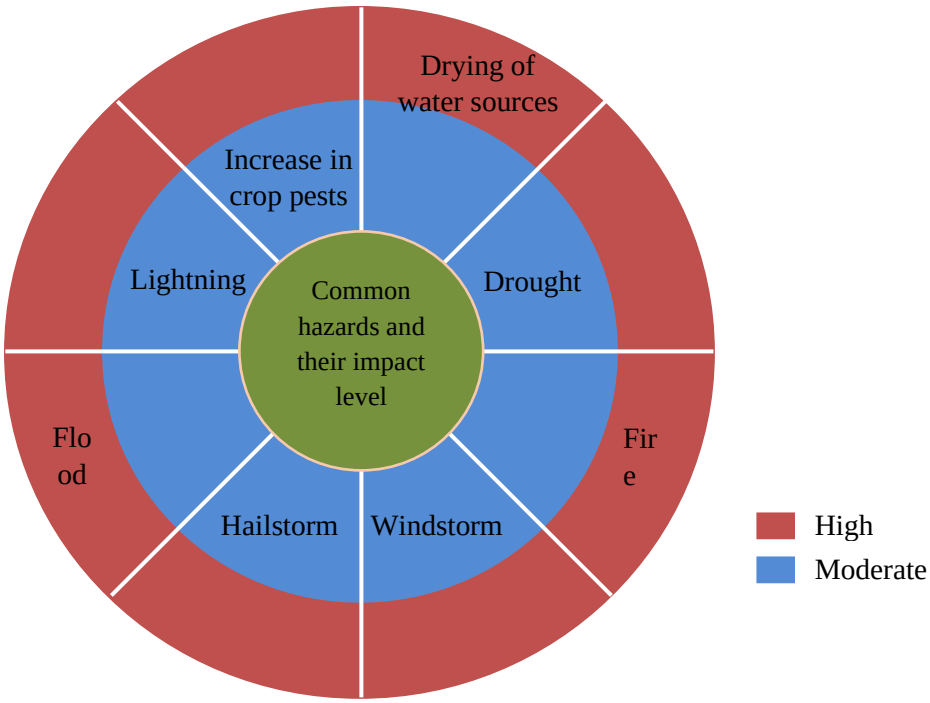

Figure 4: Common hazards and its impact level in Kalaiya city

A massive windstorm struck in Bara on March 2019, killing around 27 people with more than 500 injured. Ward no. 18 of Kalaiya city was affected by the incident, taking the life of five people and destroying around 54 households. According to the local villagers, this was the most devastating windstorm they had ever experienced in their life which damaged almost everything on its way. As a result, a huge loss of infrastructure, agricultural production, livestock, and other property occurred. People were deprived of shelter, food, and education for more than a month; this has disrupted their livelihood, children's education, and other basic needs. People were forced to live in the temporary shelter and several internal conflicts took place while communities were fed in a mesh and lived in a temporary shelter. The food grains were supplied by the metropolitan city. There was also an increased clash between the people regarding the distribution of foods, tents, and other relief materials as the frontline households used to get more whereas the latter households were disadvantaged.

People believed they were not equally treated as nearby villages, due to political affiliations and reach to political leaders. Some of the respondents shared that less affected families in the nearby village were provided with more relief materials regardless of the extent of the damage.

Drying up of water sources has been a big problem for the people of ward number 8 and 11. Increased temperature and decreased winter precipitation pattern have impacted the livelihood of people causing drying up of water sources. This has led to the scarcity of drinking water in the community, usually in the months of Falgun to Jestha. Similarly, the incidents of crop pests have been increasing in the area, decreasing agricultural productivity.

The impact of the flood is seen in 11 wards (ward no. 9, 13, 14, 15, 17, 18, 20, 21, 23, 24, and 27) of the city. The flood has mostly impacted crop production and infrastructures as the flood water enters the agricultural land and settlements causing inundation.

> *"Flood occurs frequently in the Bangari Khola which brings the mudded water in the agricultural land destroying the agricultural production. Also, during the flooding season, wild animals often enter the agricultural land and eat the vegetables and other crops. Moreover, there was an increase in crop pests, leading to the use of more chemicals to kill pests."*
>
> Anonymous, Ward 18, Kalaiya

> *"Last year, extreme rainfall caused inundation in agricultural land, weakening and destroying the roots of crops, which ultimately decreased the production. Heavy rainfall also caused inundation in the settlement area."*
>
> Anonymous, Ward 8, Kalaiya

3.1.2 Sector-wise vulnerability and adaptation

The climate change vulnerability mapping for Nepal, 2010 shows Bara district being under the high category of human sensitivity index i.e. from a human population perspective. Similarly, in terms of temperature and rainfall trends, Bara district lie under the high exposure zone. The overall vulnerability index ranked the district under the high category for flood vulnerability and rainfall temperature vulnerability (MoE, 2010).

However, the vulnerability and risk assessment report by the Ministry of Forests and Environment (MoFE, 2021) shows that the occurrence of climate extreme events are high in Bara district along with its high exposure, while the overall district-wise vulnerability is low. This may be attributed to the high adaptive capacity and comparatively lower sensitivity which is influenced by various factors like improved access to roads and infrastructure, diverse biodiversity, and access to energy (MoFE, 2021).

The rainfall and temperature variability along with other associated factors in the Kalaiya Sub-metropolitan city has led to various climate-induced disasters, increasing the vulnerability in agriculture, infrastructure, livelihood, education, and health sectors. Coping mechanisms have been applied in some sectors to reduce the vulnerability while some are not able to cope with it and face loss and damage. Table 4 lists the sector-wise vulnerability and coping mechanisms applied in the city.

Table 4: Sector-wise vulnerability and coping mechanisms in Kalaiya city

Sector	Factors	Vulnerability	Coping mechanisms
Agriculture	Changing weather patterns, insufficient and irregular rainfall, temperature rise	The production of grains and vegetables has been decreasing due to drought or heavy rainfall events, and the occurrence of crop pests and diseases, and insufficient irrigation water has further decreased crop productivity increasing the agricultural vulnerability.	People are using insecticides and pesticides to kill pests, while boring water is used for irrigation, taking a diesel motor pump on lease which takes around Rs. 300 per hour as per the locals.
Infrastructure	Increasing hazard events	Straw/thatch houses are available in various parts of the city which are vulnerable to fire, windstorm, and other various hazards. Similarly, tube wells, poles, bridges, and other infrastructures are also	Destroyed houses are being constructed of bricks and cement with the support from the sub-metropolitan city.

		damaged due to extreme events.	
	Insufficient and irregular rainfall	Tube wells and other water sources are dried up in different places.	No mechanisms have been taken in maintaining the water sources.
Education	Increasing hazard events	Schools are also interrupted for several days or months because of an impact of flood, windstorm, and other hazards.	No major action has been taken for the education sector.
Health	Flood	Children are usually vulnerable to water-borne diseases from flooding and inundation in the settlement.	No major action has been taken on health awareness or in inundation control.
Livelihood	Insufficient rainfall	Water in tube wells are dried up during the winter season, causing scarcity of drinking water and making daily household activities very difficult, especially for women.	People carry water from the deep wells in the neighboring communities. A water tank of around 50,000 liters is being constructed by the sub-metropolitan city near the community having water scarcity.
	Flood, Heavy rainfall	Increased flooding events and inundation has damaged property and affected people's livelihood	No any measures taken.
	Decrease in crop productivity	The amount of production is insufficient to feed themselves as well as sell excess which has decreased the annual income of the people	People have switched to labor works and other income generating activities
	Fog events	Reduced visibility with increased road accidents	No major actions has been taken

3.1.3 Climate related policies and activities at the local level

The National DRRM Act, 2017, addresses a comprehensive role and responsibilities for the local government on DRM. It includes the guidelines and roles for local governments regarding DRRM to prepare its own policy, law, implementation of local disaster risk reduction programs, response, recovery, etc. In this context, Kalaiya Sub-metropolitan city has prepared its own local DRRM Act as per the national guideline, but the officials are quite unclear about the act, their roles and responsibilities, and programs to be implemented. The city also has a Disaster Management Fund which is utilized for disaster response programs. However, the utilization of funds in risk reduction programs has not been practiced. This also depicts a relatively poor understanding of the utilization of funds in the municipality for risk reduction purposes.

The sub-metropolitan city has formed different committees and allocated focal persons and their work area as per the committees. A separate DRRM committee has not been formed whereas Environment and Disaster Management Committee has been formed which works on climate change, water-induced disasters, disaster management, waste management, environmental conservation, etc. The municipal staffs are to some extent aware of the hazards and their impact in the city, whereas, they have are not clear regarding all phases of disaster risk management. A comprehensive DRRM approach is yet to be implemented by the sub-metropolitan city. Similarly, the list of other committees formed are provided below:

- Social Development Committee
- Economic Development Committee
- Infrastructure Development Committee
- Public Service and Capacity Development Committee
- Financial Management and Good Governance Committee

These committees have been providing training and awareness to different communities at the ward level. The Public Service and Capacity Development Committee has been working in different wards to provide training on sewing, embroidery, and many other capacity-building activities.

3.1.4 Opportunities

The list of opportunities at different phases that can be adopted in Kalaiya Sub-metropolitan city is presented in table 5.

Table 5: Short term, Mid-term and Long-term opportunities in the Kalaiya Sub-Metropolitan City

Short term	
1. Advocacy	The orientation and municipal consultation revealed that this was the first program of its kind, organized in the Kalaiya Sub-Metropolitan City. This shows there is an ample of opportunities to organize advocacy campaigns and capacity building training at the municipal and local level.
2. Awareness	Some awareness-raising campaigns could be organized in the communities, especially on properly using pesticides, disaster risk reduction, and preparedness measures. Many community people work in the nearby brick-kilns which might have a negative impact on their health and environment. There is an opportunity to work on environmental and health-related issues. Awareness can be raised in communities regarding the current hazards, their impacts, and local ways to reduce the hazard. For example; fire risk is very high in the city, which requires proper awareness.
3. Policy support	The municipality has prepared a local disaster risk reduction and management act based on the template provided by the federal government. However, there is a significant gap about how best to implement the act for better disaster risk reduction. There is an environment and disaster management committee, but it is not chaired by the mayor. This shows the local government is trying its best to comply with the policy requirements in disaster risk reduction and climate change, but needs more support to implement.
4. Community mobilization	Youths and skilled people in the community can be mobilized in providing awareness campaigns and other training activities.
Mid term	
1. Capacity building	Locally elected representatives and government officials are keen to learn about climate change and disaster risk reduction, but have not been able to prioritize these issues due to other overwhelming priorities. During the municipal consultation, they shared that their municipality needs more programs and technical support from other agencies to build the capacity of government and local people.
2. Hazard mapping	Some of the hazard mapping attempts were made by the municipality in the past, but were not done in all the wards. Complete hazard/ risk

	mapping of all the wards of Kalaiya would be an excellent contribution to guide informed decision-making and development planning.
3. Post-disaster needs assessment	Post-disaster needs assessment is required to address the status, needs, and potential urgent interventions in disaster risk reduction to ensure the most vulnerable and affected communities gets essential support.
Long term	
1. Adaptation measures	Long-term adaptation strategies on each sector could be developed based on the need and mutual understanding between Kalaiya Sub-metropolitan city and partner organizations.
2. Develop information flow mechanism	There is existing information on climate change, disaster risk reduction and early warning issued by the government and non-governmental agencies. In the longer term, there is an opportunity to collaborate with municipalities and local communities to find the best potential information flow mechanism to enhance preparedness to the impacts of climate change and hazards.
3. Early warning system	Developing an early warning system in the flood risk zone could be another longer-term partnership to reduce the risk from potential hazards.

3.1.5 Way forward and recommendations

1. Kalaiya Sub-metropolitan City has an Environment and Disaster Risk Reduction Committee led by respective division, but they are yet to form a municipal Disaster Management Committee under the chairmanship of the Mayor as mandated by the National Disaster Risk Reduction/Management Act, 2017.
2. There is an opportunity to work closely with the sub-metropolitan city and provide technical assistance to form the mandated committee.
3. The municipal and ward staffs need to have a proper understanding of hazards and disasters at their community level which helps them better to overcome the impact and work further in mitigation measures.
4. There is no provision of keeping a record of hazard events within the sub-metropolitan city; as a result, it is very difficult to track past hazards and levels of devastation caused by each event. The introduction of a simple system to keep a record of major disaster events can greatly help in effective and need-based development planning.
5. The sub-metropolitan city has maintained disaster management funds at the municipal level including some of the wards, but these have been mostly used for post-disaster relief and rehabilitation. With proper policies and guiding acts, there is ample opportunity to use this resource in disaster preparedness and risk reduction measures.
6. Kalaiya sub-metropolitan city has great agricultural productivity. Varieties of green vegetables like cauliflower, cucumber, tomato, potatoes, rice, and sugarcane are produced here. In this context, it is advised to integrate the disaster risk reduction and climate change adaptation programs and plans in line with agriculture rather than on a stand-alone basis.
7. Women's participation was in the municipal consultations and FGDs but their engagement in discussion and interaction was unseen. As gender inclusiveness is very important in every sector for representing equality, there is a need to encourage women engagement in all the activities carried out and include their opinion.

3.2 Khairahani Municipality

Khairahani Municipality lies in Chitwan district, which is about 18 km from Bharatpur, the district headquarter of Chitwan. The normal maximum temperature is 29.5ºC and the minimum temperature is 17.4ºC with 1783.7 mm/year of precipitation. The municipality lies at an elevation of around 192 masl and covers an area of 85.57 sq. km. According to the 2011 census data, 12,983 households are present with the total population of 66,629. The municipality is surrounded by the other three municipalities of Chitwan district, Rapti, Kalika and Ratnanagar, while Chitwan National Park lies in the southern part. The municipality is divided into 13 wards as shown in figure 5.

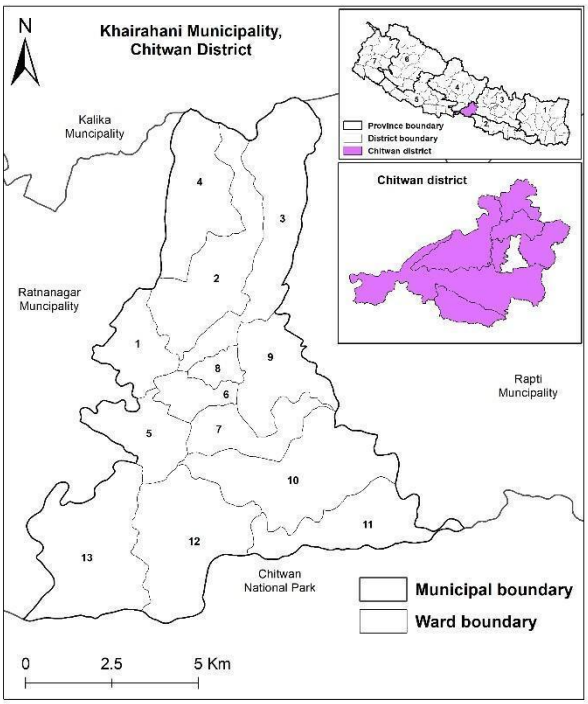

Figure 5: Location map of Khairahani Municipality

The city has a wide social, cultural, and historical diversity. People of different ethnic groups reside within this city with the majority being Brahmin, Chhetri, and Tharu, along with Darai, Tamang, Magar, Newar, Gurung, Kami, Damai, etc. Initially, Khairahani was a small rural market followed by rapid urbanization due to the advancement of the East-West Highway. Agriculture is the main occupation of the people. This area is very suitable for agriculture due to the fertile soil brought regularly by the Rapti River and its tributaries. While sometimes flood is found to be impacting the agricultural production and livelihood as well. Rice, wheat, and maize are the major agricultural production followed by mustard, beans, lentils, and vegetables. The production of mustard oil is very famous in the city and the whole Chitwan district with many mustard oil industries. Similarly, poultry and cattle farming is also rising in the area with the growing business of milk and other dairy products. Parsa Bazaar is considered as the main market of this city and a major trading center for other nearby settlements. The major source of drinking water is tube well/hand pump, while some have tap water and deep wells. The majority of people use firewood as a primary source of cooking followed by LPG, biogas, and other sources in the city.

East rapti, Budhi rapti, Ladari, Kayar, Kanta, Pampha and Dungre are the major rivers in the city. Figure 6 shows the land cover map of Khairahani municipality which categorizes the land into settlement area, agricultural land, water sources, and forest area.

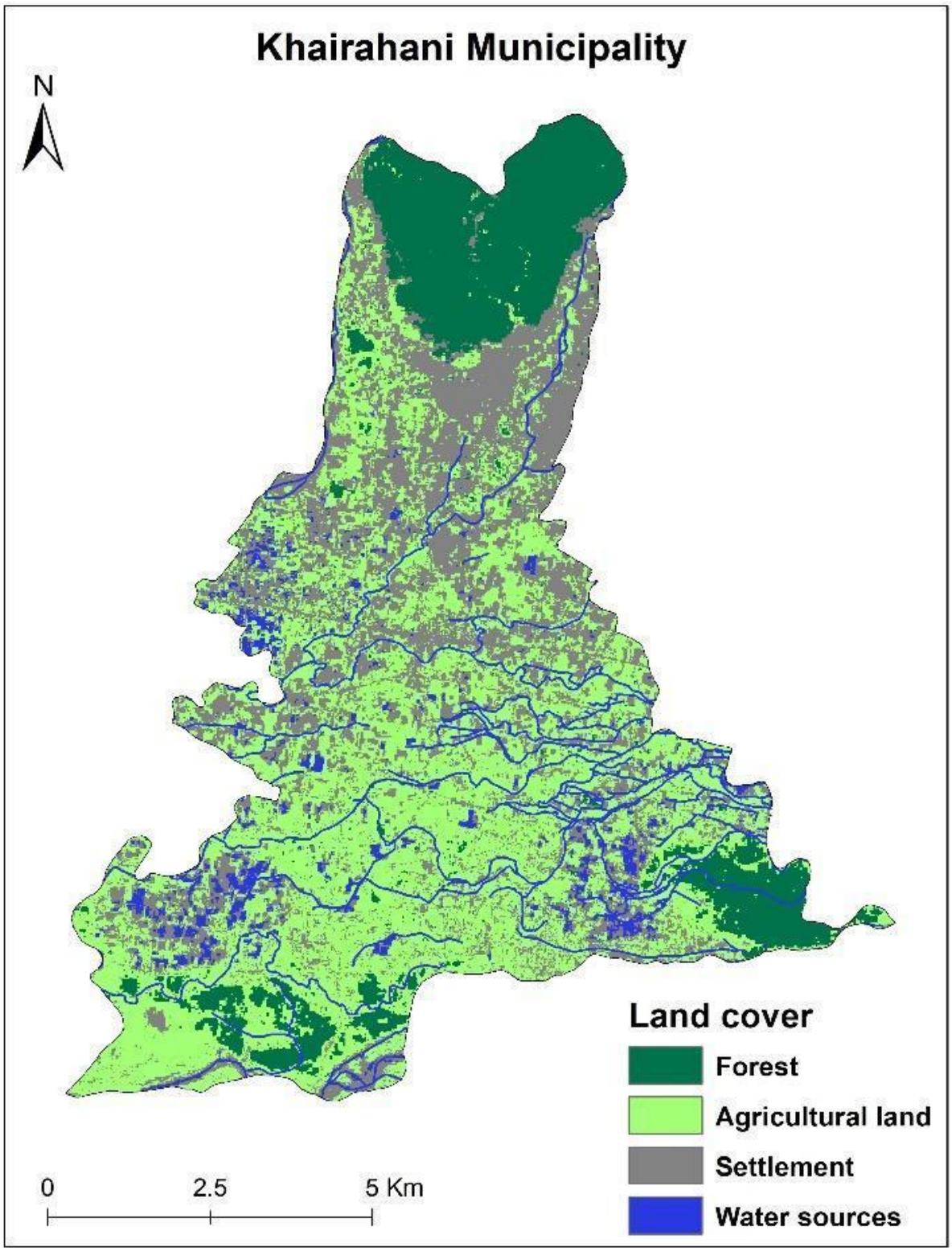

Figure 6: Land cover map of Khairahani Municipality

3.2.1 Climate trends and impacts

The climate trend for Chitwan district has also been presented from the latest trend analysis report by DHM (DHM, 2017). The major climate indices; precipitation, maximum temperature and minimum temperature as well as the eleven extreme climate indices are discussed below. Table 6 lists the seasonal and annual climate trends for Chitwan district analyzed from the year 1971-2014.

Table 6: Seasonal and annual climate trend of Chitwan district with a corresponding significance level

Indices	Winter		Pre-monsoon		Monsoon		Post-monsoon		Annual	
	α	Trend	α	Trend	α	Trend	α	Trend	α	Trend
Precipitation (mm/year)	0	-0.12	+	1.708489	0	0.17	0	-0.33	0	1.319968
Max. Temperature (ºC/year)	0	0.002	*	0.034	***	0.048	**	0.029	***	0.027
Min. Temperature (ºC/year)	**	0.022	**	0.018	***	0.022	*	0.028	***	0.025

Note: Significant: * 95% CL, ** 99% CL and *** 99.9% CL; Insignificant at 95% CL: +, 0

Source: DHM, 2017

The annual trend shows a positive increasing trend for all the climate indices, the maximum and minimum temperature increasing at a highly significant trend, while precipitation trend is high (1.319968 mm/year) but insignificant. Similarly, the seasonal maximum temperature and minimum temperature is also positive for all seasons while the seasonal precipitation has an increasing trend in monsoon and a highest increasing trend (1.708489 mm/year) in pre-monsoon while there is a decreasing trend during winter and post-monsoon. All the precipitation trends are insignificant.

The maximum temperature has the highest increasing trend (0.048ºC/year) during the monsoon season which is also highly significant at 99.9% confidence level. Whereas, the winter maximum temperature trend is insignificant and also has quite low trend value (0.002ºC/year). However, the minimum temperature has the highest trend (0.028 ºC/year) during post-monsoon at 95% CL. All the minimum temperature trends are significant.

Extreme climate indices

The extreme climate events are categorized into eleven indices and their trend analysis from the year 1971-2004 is presented in table 7.

Table 7: Trend for extreme climate indices with corresponding significance level for Chitwan district

Indices	α	Trend	Indices	α	Trend
Rainy days	0	0.0	Cool days	0	-0.2

Consecutive dry days	0	0.1	Warm spell duration	0	0.2
Consecutive wet days	0	0.1	Warm nights	***	1.0
Very wet days	0	0.0	Cool nights	*	-0.3
Extremely wet days	0	0.0	Cold spell duration	0	0.0
Warm days	**	0.6			

Note: Significant: * 95% CL, ** 99% CL and *** 99.9% CL; Insignificant at 95% CL: +, 0

Source: DHM, 2017

The extreme climate indices in the district show a neutral trend for indices like number of rainy days (rainfall greater than 1mm in a day), very wet days (days with daily rainfall >95th percentile) and extremely wet days (days with daily rainfall >99th percentile), while a slight increasing trend for consecutive dry days (maximum number of consecutive days with daily rainfall <1mm) and consecutive wet days (maximum number of consecutive days with daily rainfall >1mm), which is also insignificant.

Warm days (percentage of days when maximum temperature is greater than 90th percentile) and warm nights (percentage of days when minimum temperature exceeds 90th percentile) are in highly increasing trends with highly significant confidence level whereas cool days (percentage of days when maximum temperature <10th percentile) and cool nights (percentage of days when minimum temperature <10th percentile) are in decreasing trend. Similarly, warm spell duration (annual count of days with at least 6 consecutive days when maximum temperature >90th percentile) has an increasing trend, but insignificant, while cold spell duration (annual count of days with at least 6 consecutive days when minimum temperature <10th percentile) has no change.

Local perception on climate trend

During municipal consultation and community consultations, respondents perceived local temperature to have increased. The intensity of rainfall has also changed and a late monsoon was observed last year. Local people believe that the water availability has increased throughout the period, they think this is because of increased flooding events in the municipality. The forest coverage has increased due to nearby Chitwan National Park. During the municipal consultation, local representatives shared that some new species of fruit including strawberry which were never cultivated before are now growing successfully in the region.

Impacts

The impacts of various factors associated with climate change like change in rainfall and temperature, heavy rainfall, fog events, etc. have affected the livelihood of Khairahani city. Flooding in medium rivers and small streams of Khairahani during monsoon is common and result in huge economic and minor human loss every year. Some of the major hazards in Khairahani include flood (inundation and sedimentation), lightning, hailstorm, windstorm, erosion, crop pest attack, animal attack, and fire which is demonstrated in figure 7.

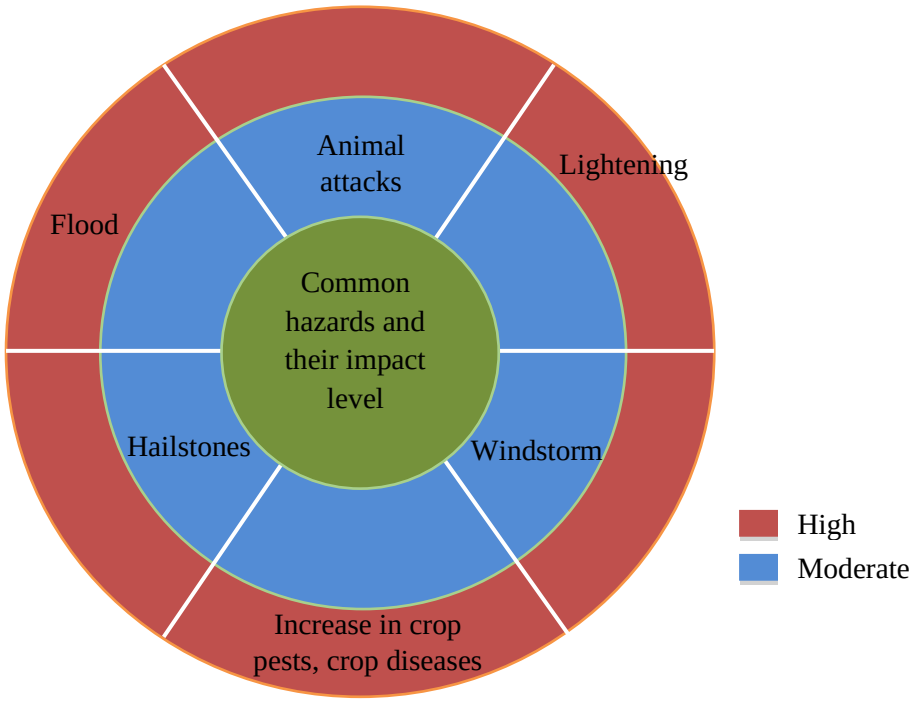

Figure 7: Common hazards and its impact level in Khairahani Municipality

According to the municipal consultation, major flood events occurred in the city in the year 2050 BS and 2059 BS in Rapti River and its tributaries. The 2050 BS flood-affected wards 10, 12, and 13 causing inundation in the agricultural land and settlement. Three check dams were swept away by the flooding. Similarly, the 2059 flood occurred in Dungre and Pampha rivers devastating the settlement and crop production of wards 6, 7, 8, and 9. Apart from these events, the incidents of flash floods have also been increasing in Kayar, Kanta, Pampha and other rivers annually, which impact the infrastructures, settlement, and livelihood. During the flooding season, the level of water in highways is found to be around five feet high. This shows that flood remains a major and recurrent hazard in the municipality.

Lightning has become another major problem in Khairahani recently, whose impact has also been increasing over the period. Frequent incidents have been recorded to impact the livestock and people. Seven goats died in one of the farms due to lightning in ward number 2. Khairahani municipality is interested to collaborate with potential partners to implement a possible lightning early warning system or protection system.

The winter fog has impacted the visibility in many places of the municipality which has led to road accidents. Incidents of fire have also been recorded in the city, destroying the settlement and property. Pest attacks have been increasing in crops. Diseases and pests are found in maize, and other crops which have decreased production. Similarly, pests have been impacting vegetable production as well.

> *"There has been an increased pest attacks in crops which has increased haphazard use of pesticides. The use of pesticides has been exposed in the grasses and hay, and feeding on those by the livestock has increased infertility rate in livestock."*
>
> Anonymous, Ward 4, Khairahani

Apart from the negative impacts of the changing climate, positive impacts have been found in the production of strawberries. As per the locals, there used to be no strawberry production in the area, whereas recently its growth has been seen.

Along with the climate-induced hazards and impacts, animal attacks have been an emerging problem in different areas of Khairahani. Ward number 11 and 12 are facing attacks of dogs while ward 13 being in a buffer zone of Chitwan National Park is facing tiger attacks, which has killed people.

3.2.2 Sector-wise vulnerability and adaptation

The climate change vulnerability mapping for Nepal, 2010 shows Chitwan district under the very high risk of temperature and rainfall indices. It means that Chitwan district has higher exposure to temperature and rainfall variability. Similarly, the flood risk is also shown to be high in the district. The overall vulnerability index ranked the district under the high category for flood vulnerability and very high rainfall temperature vulnerability.

However, the vulnerability and risk assessment report by the Ministry of Forests and Environment (MoFE, 2021) shows that the occurrence of climate extreme events are very high in Chitwan district along with its high exposure, while the overall district-wise vulnerability is low.

The climate change risk and vulnerability have been seen in various sectors of Khairahani municipality. The agricultural sector has been highly impacted by climate change along with infrastructure, livelihood, education and health. Frequent incidents of flash floods and heavy rainfall has made the agricultural land highly vulnerable with reduced crop productivity. The increased use of hybrid crop species has led to the extinction of local crops, increase in crop pests has increased the use of pesticides in crops. Similarly, there are various factors associated with the vulnerability of different sectors. The sector-wise climate change vulnerability and the coping mechanisms applied in Khairahani municipality are presented in table 8.

Table 8: Sector-wise vulnerability and coping mechanism in Khairahani city

Sector	Factors	Vulnerability	Coping mechanisms
Agriculture	Increased crop pests and diseases Decreased agricultural production Changing rainfall pattern	The agricultural crops including banana, rice, and vegetables are more vulnerable to new diseases and pest attacks. Smallholder farmers and people with subsistence agriculture practice are more vulnerable to changing rainfall patterns and changes in water availability with seasonal variation.	There is a crop insurance mechanism established at the municipality. After the establishment, approximately 25 farmers have insured their crops, especially bananas. However, one of the members during the municipal consultation shared that the overall process to get insured and claim the compensation is a bit technical. The farmer has to make a small video of their land and crop, meet the insurance agent, prepare technical estimation with help from a technical officer in the municipality and submit the application.
Infrastructure	Increased frequency	The increase in flooding events in	The municipality has received technical support from a Swiss agency to mitigate

	and intensity of extreme events	Rapti, Kayar and Kanta River has damaged bridges, buildings, road and schools.	flood impacts at Rapti river, where several check dams and gabion walls have been constructed. Municipality from their own fund is constructing bridges in different wards by considering the flood levels during the monsoon period.
Education	Hazards such as flooding and inundation	Inundation in settlements, roads along with bridge falling has interrupted students from going to schools.	Flood control mechanism has been applied while no major action has been taken for the education sector.
Livelihood	Increased fog events	Reduced visibility with increased road accidents.	No major actions has been taken.
	Flooding	Increased flooding events have negatively affected people's livelihood.	Some livelihood support and employment opportunities were created by the municipality but very few were attracted to this.
	Animal attacks	People living in buffer zones face tiger attacks, and dog attacks are also increasing in other places.	Fencing has been done by the CNP to prevent tiger attacks, but attacks are mainly faced during firewood collection and other activities inside the national park. No major action has been taken for dog attacks.
	Increased crop pests and diseases	Increased crop pests have decreased agricultural production which has decreased the income source.	People are involved in labor activities, whereas women are seeking other income-generating activities such as embroidery, sewing, etc.

3.2.3 Climate-related policies and activities at the local level

The Environment and Disaster Management Committee at the Municipal level has been formed whereas a separate DRRM Committee under the Chairmanship of the Mayor has not been formed yet. Disaster Management Fund has been allocated in the municipality and wards. A budget of five lakhs has been allocated at the ward level and one crore and fifty lakhs at the municipality level which is used especially for mitigation purposes. The fund is transferred to next year in case the fund is not used up. However, a separate fund for climate change has not been allocated.

The municipality has conducted several activities in different communities as per the need. Construction of gabion walls and dykes has been done along the Rapti River in order to mitigate flood which was funded by a Swiss project. Similarly, awareness training, relief, and rescue, ambulance service, etc. is being provided by the municipality in coordination with the Armed Police Force (APF), Asian Disaster Preparedness Center (ADPC), and other organizations. Awareness of lightning was conducted recently as its impact has been increasing in the communities.

Similarly, in the agriculture sector, the municipality has been providing hybrid crops, whose production has also been increasing. Soil test campaigns are also frequently conducted. A provision of crop insurance policy was brought by the municipality in coordination with Shikhar Insurance Company and Nepal Life Insurance Company, which mainly focused on banana insurance. The procedure was quite tedious as it involved taking a video of the farm by the owner, followed by meeting an agent, providing a technical estimation of the farm area, banana production, etc., and finally ensuring the policy. Thus, farmers found it quite difficult and ineffective. 25 banana farms in ward numbers 1, 2, 3, and 5 had done their insurance. The municipality had also brought up the 100 days employment program to the poor and marginalized people, which was also ineffective due to low wages.

The Lutheran World Federation (LWF) has been working in the city in the disaster management sector. It had established an early warning system with a tower and siren and a water monitoring system was made, but the system gave false warnings and has stopped working.

An institution named Mahila Muskan has been working in ward number 13 which works in issues related to women, their health, environmental awareness, agriculture, and disaster management. Similarly, Environmental Camps for Conservation Awareness (ECCA) has been working in schools to provide training related to environmental awareness. World Food Programme (WFP) through an organization Made Nepal had encouraged goat farming in communities and provided goats to many families.

Similarly, Lumanti Support Group for Shelter is active in these municipalities since long particularly in organizing, capacity enhancement of communities as integrated action addressing various sectoral issues. It has also facilitated between communities and local government to ensure partnership and developmental support in marginalized, informal and lower income communities of the cities. As a result of these interventions and action different level of structure, community based organizations and mechanisms are in place to address different sectoral issues in communities.

The mechanisms such as Women Saving groups/Cooperatives that access easy funding for community groups to start and initiate livelihood activities and priorities members. There is an establishment of urban community Support Fund (UCSF) that is a collaborative fund with an

objective of making financial access of community for the local level development initiatives along with the representation of local municipalities. Moreover, establishment of Youth organizations in cities are developing as second level of developmental partners that sustain and continue the process in communities even if there is no any other project intervention in the cities. They will be the one who would lead and continue further issues of the communities as well as cities.

Regards the climate change and disaster risk reduction sectorial issues the base is already there in cities to continue action and taking along recommendations of assessment in a partnership with city stakeholders especially local government, local community, established community-based organizations as much as possible. The tremendous support getting from local government as of now would definitely expect to resolve the identified issues of climate change impact and disaster risk reduction in coming years by proper planning and funding allocation.

3.2.4 Opportunities

The list of opportunities at different phases that can be adopted in Khairahani Municipality is presented in table 9.

Table 9: Short term, Mid-term and Long-term opportunities in the Khairahani Municipality

Short term	
Advocacy	The commitment shared by the mayor and government officials shows that there is a great opportunity to collaborate with Khairahani municipality to conduct advocacy works in climate change, environmental issues, and disaster risk reduction issues.
Training	The municipality has collaborated with Armed Police Force to organize training on disaster response where some of the community representatives have been trained. They find this training very useful as they are housed within the municipality and can be quickly mobilized during emergencies. This shows training local human resources on disaster preparedness, response, and climate change-related issues can greatly help communities to adapt potential future disasters.
Midterm	
Capacity building	During the community consultation, people emphasized need of income-generating opportunities to build resilience to future climate change impacts and disasters. People believe that more young and skilled people are leaving the community due to a lack of opportunities.
School based DRR and CCA activities	There is a great opportunity to organize school-based disaster risk reduction activities through the formation of eco clubs and engaging school students to disseminate knowledge at the schools and community level.
Long term	
Mitigation	The success of mitigation projects supported by the Swiss agency has encouraged the municipality to invest more on mitigation projects. In

	the longer term, there is an opportunity to collaborate with Khairahani municipality to implement climate change mitigation projects to prevent potential hazard turning into disasters.
Establishment of early warning system	There has already been an attempt to establish a flood early warning system in the Rapti river, according to locals, the scheme is not very reliable. In this context, there is an opportunity to upgrade the whole system around hazard monitoring, improving risk knowledge of the community, dissemination strategies, and response capacities at the community level. Furthermore, lightning in Khairahani is common and there is an opportunity to explore potential technologies to prevent/warn the potential danger from lightening.

3.2.5 Way forward and recommendation

1. Khairahani Municipality also has an Environment and Disaster Risk Reduction Committee led by respective divisions, but they are yet to form a municipal Disaster Management Committee under the chairmanship of the Mayor as mandated by the National Disaster Management/ Reduction Act, 2017. The Local Disaster Risk Reduction and Management act is yet to be prepared.

2. The municipality has implemented some of the initiatives like crop insurance which can be simplified and scaled up in all the wards.

3. The Municipality has maintained disaster management funds at the municipal level; there is a firefighter unit at the municipal office as well. The current focus seems more on post-disaster response and there is an opportunity to use the available funds in disaster preparedness and building the technical capacity of municipal officials.

4. Khairahani doesn't have a provision of keeping record of hazard events within the municipality; as a result, it is very difficult to track past hazards and the level of devastation caused by each event. The introduction of a simple system to keep a record of major disaster events can greatly help in effective and need-based development planning.

5. As some of the wards are close to the Chitwan National Park, there are a number of issues related to human-wildlife conflict, disputes on resource sharing. There is an opportunity to play an intermediate role to bridge the gap between National Park authorities, municipality, and local committees.

6. During the community consultations, water pollution and noise pollution due to the nearby Beer factory has been raised as a serious concern. There is a need to establish a proper monitoring mechanism to ensure that wastes are released in the environment after treatment at the lowest harmful condition possible. Also, there are a number of opportunities to initiate dialogues between factories, local governments and the affected community to find the best possible solution.

7. Some of the participants suggested having school-based programs on climate change and disaster risk reduction. This approach can be very effective in spreading awareness to the community through students.

8. Women's participation was in the municipal consultations and FGDs but their engagement in discussion and interaction was unseen. As gender inclusiveness is very important in every sector for representing equality, there is a need to encourage women engagement in all the activities carried out and include their opinion.

3.3 Sundarharaicha Municipality

Sundarharaicha Municipality lies in Morang district. It is around 19 km distant from the district headquarter, Biratnagar. The city lies at an average elevation of 140 masl with an average climatic normal maximum temperature of 29.4°C and minimum temperature 18.1°C. The city receives an annual precipitation of 1863.9 mm/year. Sunsari district lies in the western part of the municipality while on the east, north and south lies Kerabari Rural Municipality, Belbari Municipality, and Budhiganga and Gramthan Rural Muicipalities, respectively. The municipality is divided into 12 wards as shown in figure 8, which occupies a total area of 110 sq. km. According to the 2011 census, it consists of 80518 population with 18610 households.

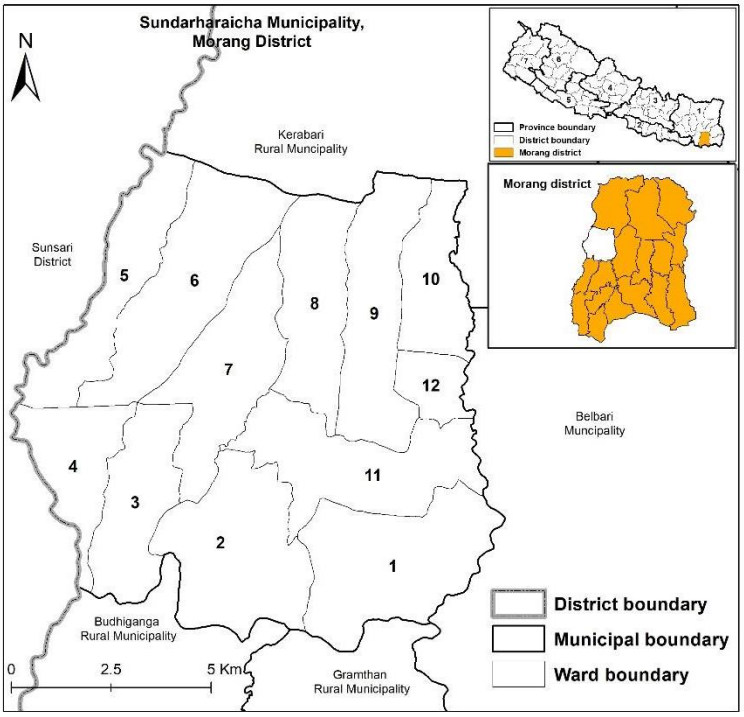

Figure 8: Location map of Sundarharaicha Municipality

People of different ethnic groups speaking different languages reside in the municipality. Around 53% of the total population consists of Brahmin, Chhetri, and Tharu, followed by Newar, Rai, Khawas, Limbu, and Tamang covering 24%. Kami, Damai, Muslim and many other ethnic groups are also present in the municipality. Nepali is spoken as a common language among all ethnic groups along with people of different ethnic groups speaking their mother tongue also. Agriculture is the major occupation of the people. Many people are involved in sand and gravel extraction from the rivers as well. The period of mid-March to mid-June and October, November are the busiest months for extraction, while people are engaged in agriculture throughout the year.

The municipality has enough agricultural lands for farming, tubewells for drinking water which is extracted through deep borings in many places, and forests resources in wards 5, 6, 7, 8, 9, and 10. Other wards feel the scarcity of forest resources. Budhi, Gachiya, Lohandra and Khadam are the main rivers in Sundarharaicha. The land cover of Sundarharaicha classified into agricultural land, forest, settlement area, and water sources is presented in figure 9.

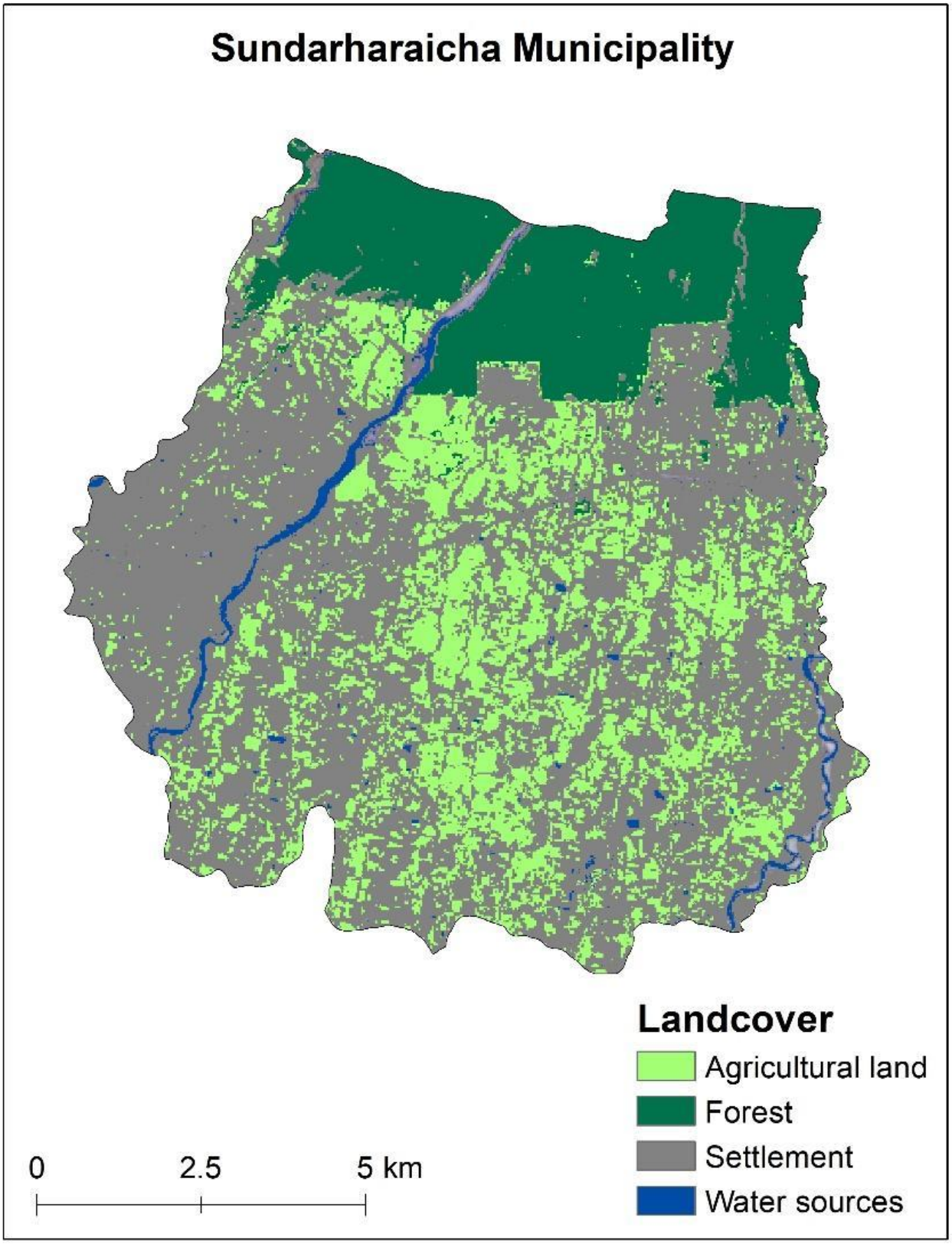

Figure 9: Land cover map of Sundarharaicha Municipality

3.3.1 Climate trends and impacts

The climate trend for Morang district as per the latest trend analysis report by DHM (DHM, 2017), for the major climate indices; precipitation, maximum temperature and minimum temperature as well as the eleven extreme climate indices are discussed below. Table 10 lists the seasonal and annual climate trends for Morang district analyzed from the year 1971-2014.

Table 10: Seasonal and annual climate trend of Morang district with a corresponding significance level

Indices	Winter		Pre-monsoon		Monsoon		Post-monsoon		Annual	
	α	Trend	α	Trend	α	Trend	α	Trend	α	Trend
Precipitation (mm/year)	0	-0.0375	*	2.00	0	-0.67	0	-0.57	0	0.04
Max. Temperature (ºC/year)	**	0.028	**	0.034	***	0.046	***	0.051	***	0.040
Min. Temperature (ºC/year)	**	0.024	+	0.013	*	0.010	0	0.007	**	0.014

Note: Significant: * 95% CL, ** 99% CL and *** 99.9% CL; Insignificant at 95% CL: +, 0

Source: DHM, 2017

The precipitation trend shows a decreasing trend seasonally during winter, monsoon and post-monsoon season while the pre-monsoon season has a significant highly increasing trend. The annual trend is slightly increasing but is insignificant.

The temperature indices show an increasing trend annually as well as seasonally. The seasonal as well as annual trend for maximum temperature is highly significantly increasing while for the minimum temperature, during pre-monsoon and post-monsoon, the increasing trend is insignificant.

Extreme climate indices

The extreme climate events are categorized into eleven indices and their trend analysis from the year 1971-2004 is presented in table 11.

Table 11: Trend for extreme climate indices with corresponding significance level for Morang district

Indices	α	Trend	Indices	α	Trend
Rainy days	*	-0.3	Cool days	***	-0.6
Consecutive dry days	0	0.2	Warm spell duration	0	0.1
Consecutive wet days	**	-0.5	Warm nights	0	0.3
Very wet days	0	0.1	Cool nights	*	-0.4
Extremely wet days	0	0.0	Cold spell duration	0	-0.1

Warm days	***	1.0			

Note: Significant: * 95% CL, ** 99% CL and *** 99.9% CL; Insignificant at 95% CL: +, 0

Source: DHM, 2017

Table 11 shows that the rainy days and the consecutive wet days are decreasing significantly, while the very wet days are slightly increasing but insignificant. The extremely wet days are constant. Warm days are increasing while the cool days are decreasing significantly. The warm spell duration is increasing and the cold spell duration is decreasing but are both insignificant. Similarly, warm nights are increasing while cool nights are decreasing.

Local perception on climate trend

During municipal consultation and community consultations, respondents perceived local temperature to have increased. The intensity of rainfall has also changed and more severe flooding events were observed. The number of flooding events in Budhi, Gachhiya and Lohandra River has been perceived to have increased with more losses and damage.

Impacts

The impacts of climate change in Sundarharaicha municipality has been mainly seen as flood, which has been affecting the settlements and livelihoods of wards 1, 4, 5, 6, 7, 10, 11, and 12. Budhi, Gachhiya, and Lohandra are the rivers frequently undergoing flooding during the monsoon season. According to the municipal consultation, ward numbers 4 and 5 are found to be more at the risk of flood with a high impact on the settlement, agricultural lands, livestock, culverts and bridges, and other infrastructures. Apart from it, windstorms, hailstones, thunderbolt, fire, erosion, and animal attacks are common hazards in Sundarharaicha municipality. Figure 10 shows some of the common

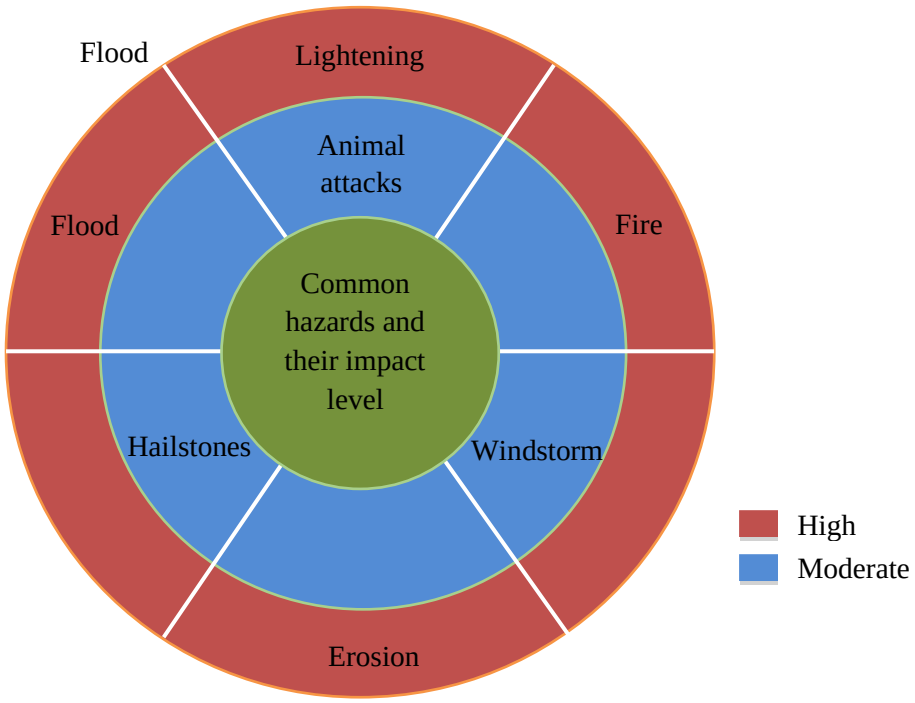

Figure 10: Common hazards and its impact level in Sundarharaicha Municipality

hazards in the city with its impact level.

Windstorms occur frequently in the city, usually blowing away the rooftop of houses as well as the occurrence of hailstones have impacted the agricultural production especially maize, paddy, vegetables, and other crops.

15 incidents of fire were recorded in Sundarharaicha in the year 2021 which were found to impact 23 families damaging their houses and properties as per the DRR Portal. Similarly, as per the municipal consultation animal attacks, especially of wild elephants and monkeys are seen in the municipality each year. Monkeys usually attack the crops during the harvesting season.

There are limited bridges in the nearby rivers which affect communities near the riverside, during the monsoon, with the increase of water level. Also, inundation of households is a major problem.

The municipal dumping site is near the community, which has directly impacted the environment of the community, especially during monsoon and flooding season. Flood has also affected agricultural production due to sedimentation and flooding of the ready to harvest products.

3.3.2 Sector-wise vulnerability and adaptation

The vulnerability and risk assessment report by the Ministry of Forests and Environment (MoFE, 2021) shows that Morang district is found to have high exposure to climatic hazards due to high exposure to the infrastructure and resources compared to other districts. Whereas, due to the very high adaptive capacity to adjust well to the adverse effects of climate change, the overall degree of vulnerability in the district is low.

However, the district is experiencing high extreme events and is ranked among the most flood prone districts of Nepal. The report also shows that the hazards such as thunderbolts/lightning, windstorm, and fire are increasing in the district which compared with the annual maximum temperature depicts that with the increase in the annual maximum temperature, the hazard events are also increasing. The district is ranked very high under the district wise rank of the overall impact of climate induced hazards (MoFE, 2021).

Table 12: Sector-wise vulnerability and coping mechanism in Sundarharaicha city

Sector	Factors	Vulnerability	Coping mechanisms
Agriculture	Erratic rainfall	Sweeping away of fertile soil, soil erosion. The agricultural productions like maize, wheat, etc. vulnerable to windstorms and hailstones	Some of the farmers in the communities have shifted to banana farming and other cash crops which are comparatively less vulnerable to flooding.
Infrastructure	Windstorms	Straw and zinc houses, specially of poor and marginalized groups are highly vulnerable to	The destroyed houses and roofs are reconstructed by the local government and other associated organizations.

		windstorms and other climate-induced disasters as the roofs are taken away by wind, and the houses are destroyed Bridges and culverts seem to be vulnerable due to the heavy rainfall events and erosion due to flood.	
Livelihood	Irregular rainfall	The decrease in crop productivity has decreased the annual income of the people	People have switched to sand and gravel extraction works and other income generating activities
	Inundation	House and property are destroyed and are much vulnerable to the inundation caused by the heavy rainfall events	Construction of raised drinking water facility and check dams.
	Animal attacks	Livelihoods are impacted by the attacks of elephant and monkey	No specific action. The local government officials are planning to plant fruit trees in the forest to overcome monkeys attack to the crops.

3.3.3 Climate-related policies and activities at the local level

Sundarharaicha Municipality is yet to prepare its own local DRRM Act as per the national guideline, but the municipality is keen to work in the sector of disaster risk reduction but is not clear about roles and responsibilities at ward and municipal level. The municipality has maintained a disaster management fund which is basically utilized for disaster response programs. However, the utilization of funds in risk reduction programs has not been practiced. A dedicated DRRM committee has not been formed.

The community-based organizations are well organized and most efficient structure at the community level, which includes tole development committees, women saving groups, senior citizen committees and some religious trusts. Apart from their main objective, these groups are active in awareness raising in different issues including women education, environmental pollution and other social issues. Community groups have been working efficiently, periodic service is being provided by the health post in schools. There is a doctor named Dr. Sunil Sharma who gives 75% discount and provides health facilities while for poor he gives full discount.

The decision on resource allocation are done by the persons in the community who require it. Different committees and youth clubs are present, so decisions are made through their joint agreement. There is a good coordination in the community. If anyone is in problem, everyone in the community support financially or provide other support.

The Tole Bikash Committee is more efficient in addressing the household disaster, health and environmental issues. Regular service and facilities have been available from the health posts. The relation with the local government is also good and the local representatives also show their concern in the community.

3.3.4 Opportunities

The list of opportunities at different phases that can be adopted in Sundarharaicha Municipality is presented in table 13.

Table 13: Short term, Mid-term and Long term opportunities in the Sundarharaicha Municipality

Short term	
Awareness	The community based organizations are well organized and most efficient structure at the community level, which includes tole development committees, women saving groups, senior citizen committees and some religious trusts. There is an opportunity to collaborate with community level CBOs, ward office and municipality to organize awareness campaign on disaster risk reduction and climate change adaptation. There was a radio program on local FM stations about climate change issues which has helped communities to understand environmental issues. This program is now discontinued and there is an opportunity to continue this program in coordination with local FM stations.
Policy support	Sundarharaicha municipality is yet to prepare a disaster management act, and the project team from Lumanti may provide technical support to draft, finalize and endorse the act.
Midterm	
Youth Mobilization	Youths in the communities and schools seem more enthusiastic about the issues of climate change and disaster risk reduction. There are opportunity to plan and implement school based DRR/ CCA activities through eco-clubs and youth clubs at the community level.
Long term	
Flood mitigation actions	Flood mitigation is a most priority of the municipal government as the municipality is recurrently inundated each year. There are opportunities to first do flood hazard mapping and design mitigation activities based on the actual need.

3.3.5 Way forward and recommendation

1. Sundarharaicha Municipality does not have a municipal disaster management committee, the municipality has realized the need to form a disaster management as mandated by the National Disaster Management/ Reduction Act, 2017. The Local Disaster Risk Reduction and Management act is also yet to be prepared. There is an opportunity to work closely with the municipal government to form the disaster management committee and develop a disaster management act.

2. The municipality has attempted some mitigation activities in the rivers with frequent flooding. Some of the intervention includes plantation, construction of check dams. The Municipality has maintained disaster management funds at the municipal level with 5 crore rupees to be used in emergencies which will be mobilized based on the need. The budget is reallocated to the Disaster management fund based on the expenditure status. Lumanti can play a significant role in planning appropriate activities and jointly implementing some of the identified activities.

3. During the community consultation, it has been observed that the tole development committees in the region are active with the record of efficiently implementing development activities. This can be a great opportunity to jointly implement some of the climate change adaptation and disaster risk reduction activities in collaboration with selected tole development committees.

4. During the consultations, it has been found that many mitigation activities have been performed, but the flooding has affected the communities each year. There is an urgent need to do flood hazard mapping as well as train communities about flood preparedness.

5. The awareness level among municipal staff and communities were found to be good, which could be attributed to a result of sensitization through local FM stations. Further scaling up of the media advocacy on disaster risk reduction and climate change can be crucial.

6. Banana is found to be a major cash crop of the region and introduction of information packages to minimize the damage to bananas from climate induced hazards could be very appropriate. Introduction of insurance schemes with easy procedures can greatly help farmers to get high returns from Banana farming.

7. No risk assessment efforts have been done in the past, there is an immediate need to conduct multi-hazard risk assessment and inform municipality about the potential hazards in each wards.

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ANNEXES

Annex 1: Checklist for Focus Group Discussion

Location		Date	
Name of facilitator		Total number of participants	
Name of note taker		Number of Men	
		Number of Women	

1. Resource availability

1. What resources are abundant?

2. What resources are scarce?

3. Does everyone have equal access to the common resources?

4. Do women have access to the resources they need?

5. Do poor have access to these resources?

6. Who makes decision on resource allocation?

7. What kind of development activities do you carry out as a whole community? Where?

8. Which resource do you have the most problem with?

2. Institutional analysis

- Which organizations/institutions/groups are working in the community?
- Which institutions/groups do the villagers regard as most important, and why?
- Which groups are addressing household Disaster, health and environmental issues?
- Are some particular groups or kind of people excluded from being members of or receiving services from certain institutions?

3. Social mapping

- What are the social structures and institutions found in the municipality?
- What religious groups are found in the municipality? Where are these religious groups living?
- What ethnic groups are found? Where are they living?
- Is caste system prevalent in the community? Which caste dominates the decision making in the community? – through observation

4. **Seasonal calendar**

Key Questions:

9. What are the busiest months of the year?
10. At what time of the year is food scarce?
11. How does income vary over the year for men and women?
12. How does expenditure vary over the year for men and women?
13. How does rainfall vary over the year?
14. How does water availability for human consumption vary over the year?
15. How does livestock forage availability vary over the year?
16. When are holidays and how many days in which month?
17. When are most agricultural work carried out by women?
18. When are most agricultural work carried out by men?
19. When is most non-agricultural work carried out by women?
20. When is most non-agricultural work carried out by men?
21. Which could be the most appropriate season for additional activities for men and women?
22. What time constraints do exist and for what reason?

5. Observed impacts

Impacts due to	Health	Education	Agriculture	Livelihood	Transportation	Access to information
Flood						
Forest fire						
Cold Wave						
Extreme rainfall						

Annex 2: Checklist for Municipal Workshop

जलवायु तथा सो जन्य प्रकोपहरु	स्थानि स्तरमा पारेको असर	यसको आबृत्ति बढ्दो, घट्दो, यथावत वा अनिश्चितताको अवस्था कस्तो छ (नगन्य/ मध्यम/ अति)	अनुकुलनका उपायहरु	यस सगं सम्बन्धित स्थानिय निकायहरु र जिम्मेबारी	कैफियत
बर्षा					
तापक्रम					
हवाहुरी					
शीतलहर					
तातो हवा					
चट्यांङ्ग					
बादल/कहिरो					
हिउँ					
हिउँ पहिरो					
असिना					
तुषारो					
सुख्खा					
बाढी					
डुबान					
पहिरो					
अन्य (खुलाउनुहोस)					

१. जलवायु परिवर्तनको अवस्था

२ विपद्को ऐतिहासिक समयरेखा

विपद्	साल र महिना	स्थान	मानवीय क्षति		प्रभावित परिवार वा घरधुरी	भौतिक क्षति		आर्थिक क्षति (रुपैयामा)	प्राकृतिक क्षति (खेती योग्य भूमी वन)	सामाजिक क्षति	उक्त विपद् जोखिमले भविश्यमा पर्न सक्ने असर	सूचना पुष्ट्याइको विधि
			मृत्यु	घाईते		घर	अन्य					
भूकम्प												
पहिरो												
बाढी												
चट्याङ												
आगलागी												
हावाहुरी												
असिना												
महामारी												

३. विपिद् तथा जलवायु परिवर्तन सम्बन्धि सुशासनको अवस्था

नगरपालिका	जोखिमको अवस्था	स्थनिय विपिद् तथा जलवायु परिवर्तन सम्बन्धि समिति(छ वा छैन)	स्थनिय विपिद् तथा जलवायु परिवर्तन सम्बन्धि निति तथा ऐनकान" अवस्था	विपिद् तथा जलवायु परिवर्तन सम्बन्धि कोषको व्यवस्थापन	अन्थ निति तथा ऐनको अवस्था

४. विपिद् तथा जलवायु परिवर्तन सम्बन्धि कार्यक्रम र भावी योजना

नगरपालिका	वडा नं	हाल भैरहेका प्रयासहरु	भावी योजना	आवश्यक कार्यक्रम तथा सिप

Annex 3: Field Photographs

Photograph 1: Municipal workshop and Consultation in Kalaiya city

Photograph 2: FGD in ward 18 of Kalaiya city

Photograph 3: Vegetable farming in Kalaiya city

Photograph 4: Cauliflower exposed to a disease

Photograph 5: Municipal workshop in Khairahani city

Photograph 6: FGD in ward 4 of Khairahani city

Photograph 7: Rapti River in Khairahani city

Photograph 8: Orientation to the Lumanti field staffs in Khairahani

Photograph 9: Municipal workshop in Sundarharaicha city

MISEREOR

Postal Address
Postfach 101545
52015 Aachen
Office Address
Mozartstrasse 9
52064 AACHEN
GERMANY
PHONE: +49/241/4420
FAX: +49/241/442188

LUMANTI

Support Group for Shelter
396 Kumaripati, Jagannath Marg
Dakshinkali Tole, Ward: 5
P.O.Box: 10546 Lalitpur, Nepal
Tel: 977-1-5535156/5535157
Email: shelter@lumanti.org.np
Website: www.lumanti.org.np