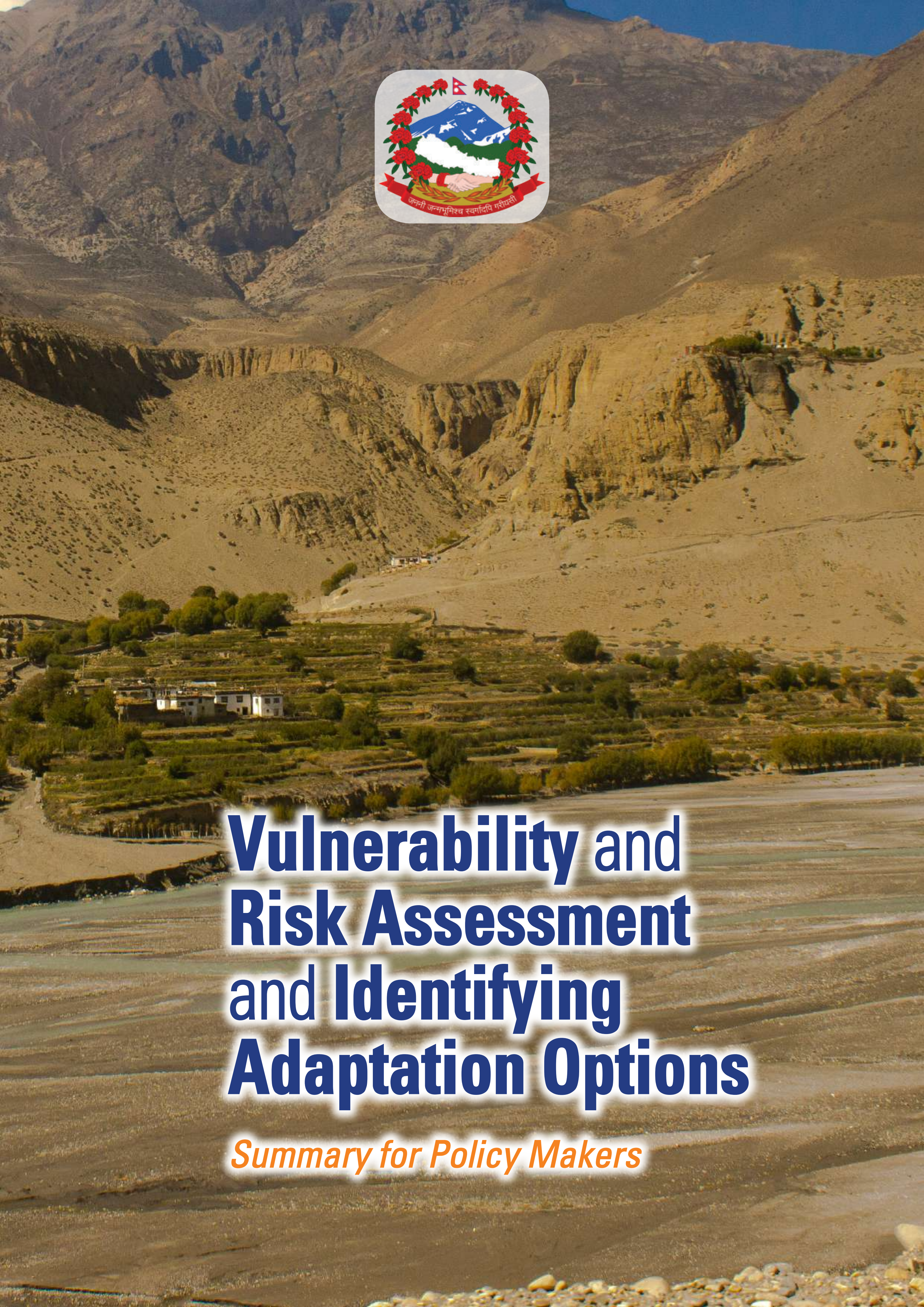


Vulnerability and Risk Assessment and Identifying Adaptation Options

Summary for Policy Makers

Vulnerability and **Risk Assessment** and **Identifying Adaptation Options**

Summary for Policy Makers

Published By
Government of Nepal
Ministry of Forests and Environment
Singh Durbar, Kathmandu, Nepal
Telephone: 977-14211567
Toll-Free Number: 16600101000
Fax: 977-1-4211868
Email: info@mofe.gov.np

Date of Publication
First Date of Publication: June 4, 2021
Updated Version: August 21, 2021

Supported By
British Embassy Kathmandu (BEK)
Policy and Institutions Facility (PIF), Oxford Policy Management (OPM)

Editorial Team
Dr Bimal Raj Regmi, Apar Paudyal, Rajan Thapa, Regan Sapkota, Smriti Shah, Gita GC, Rojy Joshi, and Dr Ram Prasad Lamsal

Technical Committee
Dr Radha Wagle, Dr Arun Prakash Bhatta, Srijana Shrestha, Raju Sapkota, Dr Indira Kadel, Hari Pandey, Gyanendra Karki, and Dr. Bimal Raj Regmi

Contributors
Basana Sapkota, Dr Shiba Banskota, Dr Kalyan Gauli, Dr Eak Rana, Dr Bhogendra Mishra, Dr Pashupati Chaudhary, Dr Dilip Kumar Gautam, Dr Yadav Prasad Joshi, Dr Nilhari Neupane, Pabitra Gurung, Dr Pashupati Nepal, Pratik Ghimire, Dinanath Bhandari, Dr Keshab Raj Goutam, Bamshi Acharya, and Prashamsa Thapa

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

Cover page photographs Credits: Bimal Raj Regmi, Anju Pandit, Regan Sapkota, and Krity Shrestha

Design and Print: Worldwide Print Solution (WPS), tel 5550289, email wpsnepal@gmail.com

Government of Nepal
Ministry of Forests and Enviroment

Ref.No.

P.O.Box No.3987
Singha Durbar,Kathmandu

Date:-

The impacts of climate change on different sectors constitute a serious threat to Nepal's economy and society. The Government of Nepal (GoN) is committed to responding to climate change risks and impacts through integrated policies and affirmative actions. Nepal as a party to the United Nations Framework Convention on Climate Change (UNFCCC), initiated the National Adaptation Plan (NAP) formulation process led by the Ministry of Forests and Environment (MoFE).

The National Climate Change Policy (2019) identifies eight thematic areas and four cross-cutting areas impacted by climate change. There is a pressing need to understand where to invest and how. Without adequate information on risk and vulnerability, it will be difficult to translate the policy into action. To plan and implement a successful adaptation strategy, it is vital to understand the patterns of a changing climate, the impacts on different sectors and communities, and, in particular, how they are likely to evolve in the future.

NAP needs to be developed based on a strong scientific foundation and reliable evidence. This includes data and information about how the climate has evolved in the past and how it may alter in the future. To provide for this need, the MoFE has carried out detailed Vulnerability and Risk Assessments (VRAs) in thematic areas identified by the National Climate Change Policy and looked into vulnerability and risk contexts for different sectors, municipalities, districts, geographies, and regions. The VRA framework and methodology presented in the report are based on the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) and the NAP technical guidelines.

This VRA report contributes to establishing a strong baseline for climate change impacts, risks, and vulnerabilities in Nepal. In particular, it presents relevant information on the impacts of climate change on the sectors, and exposure, sensitivity, adaptive capacity, vulnerability, and risk. Besides, It also offers a range of adaptation options for addressing the adverse impact of climate change in the respective sectors.

On behalf of MoFE, I appreciate the guidance and input provided by Dr. Radha Wagle, Dr. Maheshwar Dhakal, all the members of the VRA Technical Committee, and the Thematic Working Groups (TWGs). Also, I acknowledge the input provided by federal, provincial, and local governments, national and international organization, community-based organization, and communities. Besides, I highly recognize the funding and technical support of the British embassy and Policy and Institutions Facility (PIF) /Oxford Policy Management Limited.

Bishwa Nath Oli, PhD
Secretary

Secretary:- 4211567 Fax:- 4211868

Government of Nepal
Ministry of Forests and Environment

Acknowledgement

The Ministry of Forests and Environment (MoFE) has carried out detailed Vulnerability and Risk Assessments (VRAs) in eight thematic areas, and one cross-cutting areas identified by the National Climate Change Policy. The VRA assessed the vulnerability and risk contexts for different sectors, municipalities, districts, geographies, and regions. Conducting a VRA is a critical step in the preparation of the National Adaptation Plan (NAP) and implementation. This VRA report contributes to establishing a strong baseline for adaptation planning and decision-making. It summarises the information presented in the thematic and cross-cutting sectoral VRA reports. Besides, it presents relevant information on the impacts of climate change on thematic and cross-cutting areas, and exposure, sensitivity, adaptive capacity, vulnerability, and risk. It also offers a range of adaptation options for addressing the adverse impact of climate change in the respective sectors.

On behalf of the Climate Change Management Division (CCMD), I would like to extend my appreciation to all the members of the Thematic Working Groups (TWGs) for providing guidance and input in the VRA process. Also, I acknowledge the input provided by federal, provincial, and local governments, national and international organization, community-based organization, and communities.

Special thank goes to the technical committee members Raju Sapkota, Dr. Arun Bhatta, Srijana Shrestha, Hari Pandey, Dr. Indira Kandel, Gyanendra Karki, and Dr. Bimal Raj Regmi who supported and facilitated the VRA process. We would also like to thank Hari Laudari, Yamnath Pokharel, Muna Neupane, Milan Dhunganna, Surendra Pant, Narayan Rayamajhi, Ram P Awasthi, Somnath Gautam, Srijana Bhusal, Apar Paudyal, Dr. Ram Prasad Lamsal, Dr. Pashupati Nepal, Dr. Pashupati Chaudhary, Dr. Eak Rana, Rajan Thapa, Smriti Shah, Dr. Yadav Joshi, Gita GC, Dr. Kalyan Gauli, Pabitra Gurung, Dr. Dilip Gautam, Basana Sapkota, Dr. Shiba Satyal Banskota, Nilhari Neupane, Dr. Bhogendra Mishra, Regan Sapkota, Pratik Ghimire, Rojy Joshi, Dinanath Bhandari, Bamshi Acharya, Goma Pandey, Dr. Keshab Gautam, Dr. Menaka Pant Neupane, and Prashamsa Thapa, who provided technical insights and were involved in producing this report.

Besides, I also take this opportunity to acknowledge the funding and technical support of the British embassy Nepal, and Policy and Institutions Facility (PIF) /Oxford Policy Management Limited.

Radha Wagle, PhD
Joint Secretary

Contents

List of Tables

List of Figures

Executive Summary

1. Context of the study

The Government of Nepal (GoN) recognizes the importance of Vulnerability and Risk assessment (VRA) in adaptation planning and implementation. The main goal of this assessment is to help Nepal's National Adaptation Plan (NAP) process assess climate-related hazards, vulnerabilities, and risks, as well as identify practical adaptation options at the municipal, sectoral, and provincial levels. The Vulnerability and Risk Assessment (VRA) embraces eight thematic sectors, including one cross-cutting sector identified in the National Climate Change Policy (2019), as well as municipalities, 77 districts, seven Provinces, and five physiographic regions. However, due to a lack of data, a comprehensive assessment was conducted for 293 urban municipalities and a basic assessment for 460 rural municipalities.

The VRA process includes a framework and methodological steps that contribute to a comprehensive picture of current and future climate extreme events, vulnerabilities and risks, and related opportunities. This will serve as the foundation for developing adaptation strategies and plans for the formulation of the National Adaptation Plan (NAP). The VRA process employs a top-down and bottom-up assessment approach. To validate and make the process acceptable to all, consultations were held across sectors, crosscutting areas, thematic working groups, and government line agencies at all levels, Civil Society Organizations, youths, women, indigenous groups, and other relevant stakeholders. National data and other government-approved data were used as authentic sources for the VRA process.

2. Climate change trend and scenarios

According to a study conducted by the Department of Hydrology and Meteorology (DHM) on climate trend analysis (2017), the annual maximum temperature trend is increasing by 0.056°C/yr, while the minimum temperature trend is increasing by 0.002°C/yr, which is insignificant. The minimum temperature is decreasing in a few mountainous districts such as Humla and Manang, while it is increasing in the central Tarai region of Province two and the Middle Mountainous region across Nepal from East to West. The increased maximum temperature is uniformly higher from East to West in the mountainous districts and lowest in the Tarai districts. The Manang district experienced extreme temperature conditions at both the minimum and maximum levels, as it has the fastest decreasing rate of minimum temperature and the fastest increasing rate of maximum temperature. On the contrary, on average, Nepal's annual precipitation has declined by 1.3 mm per year over the observed period (i.e., 1971-2014). According to a report released by the Ministry of Forests and Environment (MoFE) and the International Center for Integrated Mountain Development (ICIMOD), average annual precipitation is expected to rise in both the medium-term (2030) and long-term (2050). Besides, the annual average temperature will continue to rise. According to the study, average annual precipitation may increase by 2-6 percent in the medium term (2016-2045) and by 8-12 percent in the long term (2036-2065). In addition, the average temperature may rise by 0.92-1.07 °C in the medium term and 1.30-1.82 °C in the long term. The post-monsoon season is expected to have the highest rates of mean temperature increase (1.3-1.4 °C in the medium-term and 1.8-2.4 °C in the long-term) and the winter season (1.0-1.2 °C in the medium-term and 1.5-2.0 °C in the long-term). Furthermore, the study shows that seasonal precipitation will rise in all seasons except the pre-monsoon, which is expected to fall by 4-5 percent in the medium term. Besides, the post-monsoon season may have the greatest increase in precipitation for the reference period, increasing by 6-19 percent in the medium term and 19-20 percent in the long term. As a result, the extreme temperature and precipitation variations are likely to harm food production, water resource management, and other livelihood resources.

3. Socio-economic trend and scenarios

Aside from physical factors, this study examines socioeconomic trends and scenarios. The analysis reveals an increasing trend of key demographic factors which influence climate change and its impacts, such as population dynamics (male and female population growth patterns and trends), population density, urbanization trend, and the growth of female-headed households. According to future projections, Nepal's population will reach 34 million by 2031 and 42 million by 2050. From the current urban population of 20 percent, the urban population will increase to 48 percent by 2051. There will be an overall reduction in poverty at the national level, but projections indicate that the rate of reduction will be slow in Province two. Furthermore, the projection shows a rapid increase in male labour migration, primarily in Province two, Bagmati Province, and Lumbini Province. The migration of young household members increases the sensitivity of those left behind (elderly people, children, and women) and increases the number of female-headed households (de-facto household head). If current trends continue, female-headed households will increase to 3.1 million by 2051, up from 1.3 million today. These findings indicate that, as a result of demographic and socioeconomic changes, future exposure and sensitivity to climate change will be greater, resulting in increased climate change risks and vulnerabilities impacting the women and girls, Indigenous Peoples, poor and marginalized households.

4. Observed impact of climate change

Overall losses and damages: In terms of disaster losses and damages, between 1971 and 2019, 647 people died in Nepal each year as a result of climate-induced disasters. Except for road accidents, this accounts for approximately 65 percent of all disaster-related deaths. In 2001, the greatest number of people died as a result of a climate-induced disaster. The average annual economic loss is NPR 2,778 million, or about 0.08 percent of the FY2018/19 GDP (at the current price). During the Tarai floods in 2017, the maximum economic loss of NPR 63,186 million occurred, accounting for approximately 2.08 percent of the FY2017/18 GDP (at the current price). The most devastating climate-induced disasters in Nepal are floods, landslides, epidemics, and fires. A comparison of hazard-related deaths, population losses, and economic losses revealed that epidemics killed the most people (52.8 percent), followed by landslides (16.7 percent), floods (12.7 percent), and the rest of the hazards (17.8 percent). However, statistics show that floods affect approximately 71 percent of the total affected population, followed by landslides (9.5 percent), epidemics (8.2 percent), and others (10.9 percent). Furthermore, fires cause the most economic losses (56.6 percent), followed by floods (31 percent), landslides (3.7 percent), and others (8.7 percent). It is predicted that the losses and damages caused by climate-induced disasters will increase in the future. Besides, due to the severity of climate-induced hazards, the economic and non-economic Loss and Damage (L&D) will increase in the future. However, there are uncertainties in the attribution.

Agriculture and food security: Climate change has had a wide-ranging impact on agriculture and the people who rely on it. The direct economic cost of current climate variability in agriculture is equivalent to 1.5 to 2 percent of the country's GDP. A 2–4 percent annual drop in GDP due to climate change will demand USD 2.4 billion in adaptation costs by 2030. Weather or meteorological events increased temperatures, and hazards such as erratic rainfall, drought, and floods caused by them account for approximately 90 percent of crop loss in Nepal. Climate change causes the equivalent of 10 percent to 30 percent of production losses when crops, livestock, and fisheries are combined. Drought is the most serious hazard which accounted for 38.9 percent of all losses caused by weather and climate-related events between 1971 and 2007, while floods accounted for 23.2 percent. Rising temperatures have a negative impact on animal and fisheries weight gain, reproduction, breeding patterns, feed intake, and conversion efficiency. They exacerbate heat stress, morbidity, vector-borne diseases (such as ticks and flies), parasitic diseases (liver fluke and nematodes), ectoparasite infestation, and new skin diseases in animals.

The findings revealed that changes in maximum temperature, minimum temperature, and precipitation have a direct effect on major crop yield. Due to changing temperature and precipitation, an IFAD study predicts a 6.77 percent decline in rice yield and a 5.66 percent increase in wheat yield by 2050, and a 12.90 percent decline in rice yield and a 9.77 percent decline in wheat yield by 2080, compared to 2011. Rice and wheat yields will decrease in the Tarai, while maize yields will increase in Sunsari but decline in Banke and Rupandehi. Rice, maize, and wheat yields in the Hills will decrease in 2070 compared to 2030. In the mountains, Jumla and Mustang will experience a decline in rice yields while Solukhumbu will experience increase maize yields in 2070 compared to 2030, while wheat yields will increase in Jumla but decline in Mustang and Solukhumbu. Although the temperature rise has some positive effects in some parts of Nepal, the majority of the country will experience decrease in productivity (both quality and quantity) of major crops including livestock and fisheries, an increase in pest and insect populations, degradation, and loss of productive land, and social and economic hardship for women, young, and marginalized farmers.

Forest, biodiversity, and watersheds: The vegetation and species range in Nepal's northern mountains are shifting upward due to changes in temperature and precipitation patterns. Conifer species such as *Abies spectabilis*, *Betula utilis*, and *Pinus wallichiana* have been observed spreading upslope in almost every region of Nepal. Plant and tree species' phenological cycles, such as flowering, fruiting, and leaf shedding, are changing as a result of rising temperature and precipitation variability. *Rhododendron arboreum*, *Myrica esculenta* (Kafal), and *Alnus nepalensis*, for example, are now flowering 15 to 30 days earlier. Climate change is expected to alter tree composition through vegetation shifts, phenological changes, and changes in functional and physiological traits, affecting species-level floral diversity. Climate change is affecting the availability and regeneration pattern of forests and Non-Timber Forest Products (NTFPs), according to mounting evidence.

Alien plant species invasion and rapid expansion pose a significant threat to both wetland and terrestrial species diversity, particularly fauna and endemic plant species. With the high intensification of wetlands habitat and short grassland, the rapid expansion of *Mikania micrantha* poses a threat to rhinoceros habitat in Chitawan National Park. Climate change is also a threat to mountain fauna. Climate change, for example, is predicted to reduce snow leopard and blue sheep habitat by 14.57 percent in 2030 and 21.57 percent in 2050 across Nepal from the current suitable habitat (5,435 km^2). There is also evidence that climate extreme events and variability are playing a role in the degradation of wetlands and watersheds.

Tourism, Natural, and Cultural Heritage (TNCH): Nepal's tourism industry is primarily focused on nature. The changing length and quality of tourism seasons have direct impacts on the TNCH, while indirect impacts include loss of biodiversity, reduced landscape aesthetics, infrastructure damage, including cultural heritage sites, and the presence or appearance of new water-borne diseases. Furthermore, high mountains are expected to be more vulnerable to avalanches and Glacial Lake Outburst Floods (GLOFs); hills to landslides, flash floods, and debris flow; and the Tarai lowlands to floods and forest fires, all of which will have an impact on the TNCH sector. It has been reported that a one percent increase in average maximum temperature leads to a 9.36 percent increase in total tourism GDP. However, the same level of decrease in minimum temperature leads to a 3.66 percent decrease in total tourism GDP.

Water resources and energy: Changes in precipitation and temperature patterns, as well as extreme events (such as floods and droughts), affect water availability and timing, prompting water-related disasters. Floods, flash floods, and landslides are common in hilly areas in Nepal due to the monsoon-dominated seasons. Total water availability in Nepal's river basins will increase in the near and medium-term. According to the analysis included in the 2019 Irrigation Master Plan (DWRI), the impact of climate change on water resources analyzed for the medium term (the 2030s) and long term (2050s) projection of scenarios using Representative Concentration Pathways (RCP) 4.5 and 8.5 shows that annual water availability parameters will increase in most districts while decreasing in other. There are, however, spatial imbalances and temporal variations in water availability.

Climate change has an impact on hydroelectricity production as well. Hydroelectric plants rely on predictable run-off patterns and are thus vulnerable to climate change. Increased/decreased average water availability will result in increased/decreased power outputs. Nepal's electricity generation is primarily based on run-of-river hydropower plants, and some river flows are insufficient to operate critical hydropower plants during the dry season, a situation that will worsen as a result of climate change. Climate variability's impact on electricity production suggests that economic costs could be equivalent to 0.1 percent of GDP per year on average, and 0.3 percent in extremely dry years.

Health, drinking water, and sanitation: Nepal has been experiencing rising temperatures, fluctuating precipitation, and extreme weather events. These have a significant impact on the seasonal and temporal trends of Vector-Borne Diseases (VBDs), Water-Borne Diseases (WBDs), respiratory diseases, food-borne diseases, nutrition-related diseases, injuries, and mental illnesses. It has been discovered that 52 percent of the total population in Nepal is at risk of malaria, 87 percent of Lymphatic Filariasis (LF), 54 percent of Japanese encephalitis, 30 percent of Kala-azar, and the entire population is at risk of water, food-borne disease, and non-communicable diseases.

The impacts of climate change also increase the risks of cardiovascular diseases. A rise in hot and cold average minimum and maximum daily temperatures are positively correlated with deaths and heart disease morbidity. Water-related infectious diseases, such as diarrhoea, cholera, etc., are a major threat to mortality and morbidity worldwide and outbreak frequently occurs after a severe precipitation event. A staggering 15 percent of post-natal deaths (first 59 months) in Nepal occur due to diarrhoeal diseases.

Water availability and quality are being impacted by climate change. In Nepal, where precipitation does hold significant ground for source yield, approximately 5 percent of water supply schemes were discovered to be dry. In the mid-hill region, springs are the primary source of water. Despite high demand, spring discharge has been steadily declining by 30 percent over the last 30 years. The Tarai region of Nepal which is more prone to flooding has been experiencing health and hygiene issues during disasters. Floods and landslides damage and disrupt infrastructures and services in the health, drinking water supply, and sanitation systems, resulting in poorer sanitary conditions, fecal contamination, and health disorders.

Rural and urban settlements: Rural and urban settlements are primarily impacted by floods, landslides, droughts, epidemics, heatwaves, coldwaves, and fire events. The consequences are massive which include loss of lives, damages to property, physical and social infrastructures, cultural heritage, impacts on markets, and increased economic burdens. The key factors which can increase the risks and vulnerabilities in the sector are i) increasing rate of urbanization and rapid urban growth beyond the carrying capacity with scarce urban infrastructure and provision of urban services; ii) failure to integrate climate change in municipal policies and plans, and adopt sustainable land-use plans; iii) uncontrolled structural design of houses and buildings in the proximity to risk-prone areas; iv) a lack of affordable housing, which leads to squatter settlements and urban slums; v) an increase in impervious land surface areas, insufficient drainage, and increased surface runoff, resulting in urban flooding and inundation; and vi) non-compliance with standard regulations and building codes during infrastructure construction. The urban population is growing and will likely peak in the future, and how this is planned for and managed will have a significant impact on the extent to which adaptation limits the costs of climate change.

Industry, transport, and physical infrastructure: Climate change has a significant impact on Nepal's industry, transportation, and infrastructure sector. Extreme weather events and climate-related disasters, such as floods and landslides, have posed a significant threat to the industry. Central Nepal was hit by a massive cloudburst in 1993. It washed away six bridges on the Prithvi and Tribhuvan highways, cutting off access to Kathmandu. For 21 days, the Kathmandu Valley was cut off from the rest of the country (there was no land transport connection). In August 2000, a land failure in Krishnabhir caused the closure of the main arterial road connecting Kathmandu to the Tarai plains and thus to India for 11 days. Out of the 488 landslides reported in 2020, 59 occurred along roadsides and 62 occurred on roads, obstructing vehicular flow. Every year during the monsoon, the impact of climate change on roads grows due to landslides caused by rains and constant toe cutting caused by flooding rivers. The studies show that climate-related loss and damage to the industry, transportation, and physical infrastructure are expected to rise sharply in the future.

GESI, livelihood, and governance: Individuals, households, and communities are exposed to varying levels of climate-induced hazards even within the same municipality, district, or locality. Poverty, marginalization, and exclusion shape vulnerability and impacts in specific contexts. More vulnerable are livelihoods and households with limited asset flexibility, as well as those who face disadvantages and marginalization due to gender, age, class, race, (dis)ability, or ethnicity.

Women's and men's experiences of climate stressors and impact differ due to existing gender norms and practices. Women, girls and Indigenous Peoples (IPs) have been disadvantaged in terms of access to information, knowledge, technologies, services, and support networks as a result of socio-structural inequalities, limiting their ability to respond to climate-related challenges. Cultural norms, as well as gender disparities in access to assets, financial capital, and livelihood options, have also hindered their adaptive capacity.

5. Hazard, exposure, vulnerability, and risks

Hazards/extreme events: The trend analysis reveals that extreme precipitation events (indices) exhibit significant (positive and negative) trends, particularly in northwestern or northern districts. Furthermore, the extremely warm temperature indices showed significant increasing trends in the majority of districts. Extreme cool temperature indices are rising significantly, primarily in the country's northwest. Rainy days are becoming more common, particularly in the northwestern districts. Extreme climatic events, particularly those related to temperature, are likely to become more frequent and severe. Intense precipitation events are expected to become more common, with extremely wet days increasing at a faster rate than very wet days. There are some differences between consecutive dry and dry days. Warm days and nights are expected to become more common in the future. Cold days and nights, on the other hand, are expected to decrease in the future. The findings also indicate that the duration of warm spells of at least six days with high maximum temperatures is likely to increase dramatically. This is in line with rising temperature trends and more warm days in the future. Furthermore, the duration of cold spells is expected to decrease in the future, as indicated by the cold spell duration index, which is consistent with rising temperature trends and fewer cold days.

The climate extreme indices were combined in this assessment to create a composite index. According to the overall composite index of baseline climate extreme events, the districts of Sankhuwasabha, Morang, Chitawan, and Jhapa are experiencing high extreme events. Furthermore, the following districts have experienced higher extreme events: Dhading, Makawanpur, Sunsari, Rautahat, Sindhupalchok, Tanahu, Kavrepalanchok, Parbat, Syangja, Kailali, Siraha, Rupandehi, Palpa, Sindhuli, Bara, Dhanusha, Nawalpur, Kaski, Taplejung, Panchthar, Sarlahi, Mahottari, Parasi, Parsa, Saptari, and Ilam districts. Climate extreme events have the greatest impact on Province one, Province two, Bagmati Province, and Gandaki Province. All of the districts in Province two have experienced high to extremely high extreme events. Similarly, higher climate extreme events were observed in the Tarai and mountain districts of Province one. According to the composite index of climate extreme events in 2030 under RCP 4.5 and RCP 8.5, most districts in Province one, Province two, Bagmati Province, and Gandaki Province are most likely to experience high to very high incidences of climate extreme events in 2030. Extreme events will become more common in all Tarai districts and Province two districts. Similarly, the eastern districts of Province one will experience a high frequency of extreme events. In both RCP scenarios, the Humla, Mugu, and Mustang districts will experience very few climate extreme events.

The composite index of climate extreme events in 2050 reveals an even more concerning image. The majority of districts, under both RCPs, will most likely see an increase in extreme events. Climate extreme events will be much more common in 51 of the 77 districts. Except for the districts of Humla, Mugu, Dolpa, Bajura, and Mustang, all of the districts under RCP 4.5 will see an increase in the frequency of extreme events. Climate extreme events will be less common in the districts of Humla, Mugu, Dolpa, Mustang, and Bajura.

Future projections of climate-induced hazards are difficult because it is challenging to quantify the attribution of climate extreme events or climate parameters to naturally occurring historical hazards. However, the studies revealed that as climate change progresses, and climatic hazards may become more frequent, widespread, long-lasting, or intense, there could be multiple events happening at the same time in different municipalities and provinces, all of which could be disastrous. Climate-induced hazards, when combined with degrading ecosystems, biophysical processes, and other challenges, such as COVID, have the potential to cause chronic stress and catastrophic shocks.

Exposure to climate induced hazards/climate extreme events: In this assessment, exposure is defined as the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected by climate induced hazards or climate extreme events. According to the findings, exposure is high in Province two and Bagmati Province. Furthermore, some districts in Gandaki Province, Province one, and Lumbini Province are highly exposed to climatic stressors. Kailali district is particularly exposed in the Sudurpaschim Province. One of the major contributors to high exposure is the district's total population.

Exposure is also determined by the areas of land that are vulnerable to various climatic hazards or extreme events. Rupandehi and Kapilbastu, for example, have high to very high exposure. This is primarily because these two districts have more land under cereal crops than other Tarai districts.

Another determinant of high exposure is exposure to infrastructure and resources. For example, Kathmandu, Kaski, and Morang districts are particularly exposed to climatic hazards due to their superior infrastructure and resources in comparison to other districts.

In terms of exposure at the urban municipality, the overall findings show that 26 municipalities are exposed to climate change to varying degrees. The majority of highly exposed municipalities established or declared in 2011 or earlier are densely populated and have significant infrastructure investments in roads, irrigation, health, and education infrastructure, cultural heritage sites, and market centers that provide services and functions. The remaining 267 municipalities in Nepal are characterized by moderate to low exposure to climate change. These municipalities are less populated and have less developed infrastructure. In the case of rural municipalities (Gaupalikas), the Tarai and mid-hills rural municipalities are more exposed than the mountain municipalities. The demographic and resource concentration in the rural municipalities, in particular, played a significant role in increasing exposure to climate-induced hazards.

Sensitivity to climate-induced hazards/climate extreme events: The exposed units' physical, biological, socioeconomic, and structural characteristics differentiate sensitivity. A composite sensitivity index is generated in this assessment by combining all of the sectoral sensitivity values. The results show that all of the hill and mountain districts of Lumbini Province, Karnali Province, and Sudurpaschim Province are highly sensitive to the effects of climate change. Only the mountain districts of Province one have a high to a very high level of sensitivity. Province two's districts have a medium to very low level of sensitivity.

In terms of municipal sensitivity, the overall findings show that 121 municipalities spread across all seven Provinces have a high to a very high level of sensitivity. The municipalities are sensitive to climate change because of their geological features, such as slope, geology, and soil characteristics, which make them more sensitive to climate extreme events and hazards. Municipalities in the hilly and mountain regions are more sensitive than those in the Tarai region. However, some districts in the Tarai region (particularly in flood-prone municipalities) have a higher population density and infrastructure, making them more susceptible to annual flood events. Also, the findings for rural municipalities show that the majority of palikas in Tarai and mid-hill across all Provinces are highly sensitive to climate-induced extreme events and hazards. The sensitivity is highest in the mid-hills of Bagmati Province and Gandaki Province. Tarai and mid-hill palikas are more sensitive in Lumbini Province. In Province one, palikas from the Tarai region have the highest sensitivity.

Adaptive capacity to respond effectively to climate change impacts: The adaptive capacity is assessed based on the ability of systems, institutions, humans, and other organisms to adapt to potential damage, capitalize on opportunities, or respond to the consequences of climate change. According to the assessment, the districts of Lalitpur, Chitawan, Morang, Jhapa, and Kathmandu have a very high adaptive capacity and can adapt well to the adverse effects of climate change. These districts have higher HDI, GDP, and literacy rates, as well as better access to infrastructure, health, and other services. On the contrary, the majority of districts in Karnali Province and Sudurpaschim Province have a low adaptive capacity. In comparison to other Provinces, access to services, technologies, and infrastructure is limited in the Provinces. The findings further show that capacity to cope or adapt are limited and constraints due to socio-economic and technological limitations.

Findings for urban municipalities show that 40 municipalities are found to have high to very high adaptive capacity, while 179 municipalities have low to very low adaptive capacity. Older municipalities established before 2011 have greater adaptive capacity. In comparison to newly established/declared municipalities, these municipalities made significant investments in urban planning and local development. Biratnagar, Birgunj, Damak, Kathmandu, Butwal, Itahari, Pokhara Lekhnath, and other municipalities have a high to very high adaptive capacity. The adaptive capacity of the 55 municipalities in Province two, 32 municipalities in Sudurpaschim Province, 31 municipalities in Province one, and 24 municipalities in Karnali Province is low to very low. Furthermore, the findings show that the majority of rural municipalities in Province two, Karnali Province, and Sudurpaschim Province have lower adaptive capacity. Low adaptive capacity is primarily caused by a lack of access to resources and services, which includes a lower HDI and a higher incidence of poverty in the Provinces and respective rural municipalities.

Vulnerability: In this assessment, vulnerability is defined as the difference between sensitivity or susceptibility to harm and a lack of capacity to cope and adapt. The findings show that the majority of the districts are vulnerable to the effects of climate change. In all mountainous regions, there is a high to a very high level of vulnerability. Furthermore, all of the mid-hills and mountain districts of Karnali Province and Sudurpaschim Province are extremely vulnerable. The Kathmandu district, of Bagmati Province has the lowest vulnerability. The districts of Lalitpur, Bhaktapur, and Chitawan of Bagmati Province, are also classified as low vulnerability. With poverty incidences of (0.076) and (0.076), respectively, Lalitpur and Kathmandu have very low vulnerability. Besides, Sunsari, Bhaktapur, Rupandehi, Bara, Chitawan, and Jhapa districts are also less vulnerable to climate change.

Because of high adaptive capacity and comparatively lower sensitivity, the vulnerability in the Tarai appears moderate to low in the majority of districts. Although multidimensional poverty and severity of hazards are prevalent, other factors such as remoteness, access to resources, and existing facilities influence vulnerability. The vulnerability is also influenced by a variety of factors, including improved access to roads and infrastructure, diverse biodiversity, and access to energy.

When it comes to physiographic regions, the results suggest that high mountains and mid hills are more vulnerable than other areas. Within the provinces, there is a wide range of physiographic vulnerability. This is, however, context-dependent and varies by sector.

The majority of sectoral analyses indicate that vulnerability is greater in the hills and mountain districts than in the Tarai. The sectoral vulnerability, on the other hand, varies. The vulnerability in the Karnali Province and Sudrupaschim Province is high in agriculture, forestry, health, water resources and energy, transportation, tourism, and GESI. In terms of health, vulnerability is persistent in Province two.

According to the municipal assessment, 37 municipalities are very highly vulnerable, 52 are high, 42 are moderate, 58 are low, and 104 are very low. Pokhara Lekhnath, Kathmandu, Biratnagar, Lalitpur, Dhangadi, Dharan, Dhankuta, and other long-established metropolitan, sub-metropolitan, and municipal areas have the very high adaptive capacity and low vulnerability to climate change. These municipalities have a high human development index, adequate livelihood assets, access to urban services and functions, economically sound, resilient physical and social infrastructure, and institutional capacity to plan and act to effectively prepare for and respond to climate-induced shocks and stresses.

The vulnerability of rural municipalities is concentrated in Province two, Bagmati Province, Lumbini Province, Karnali Province, and Sudurpaschim Province. A few municipalities in the Gandaki Province are also vulnerable. Furthermore, the Provinces' vulnerability is influenced by higher sensitivity of population and resources, as well as a lower capacity to respond to the effects of climate change. Province two's case is particularly intriguing. Overall vulnerability in the sector is low, but contextual vulnerability (municipalities) is high, indicating the fact that vulnerability varies on a scale.

This study shows that it is also highly likely that future vulnerabilities will also increase across the majority of the municipalities and provinces due to the projection of increased hazards, the socio-economic downfalls due to COVID-19 and the political instability in Nepal. Among others, the poor, marginalized, women, children, elderly, disabled will be more vulnerable to the impacts.

Risk of climate change impact: The risk is the function of exposure, vulnerability, and hazards. According to the analysis, under the baseline scenarios, districts impacted by floods, landslides, fires, windstorms, and hailstorms, among other hazards, have experienced a very high impact from climate-induced disasters. In the future, under RCP 4.5 in 2030, 15 districts are classified as very high-risk, while 17 are classified as high-risk. Except for a few exceptions under RCP 4.5, nearly all districts in the Tarai, mid-hills, and mountains are classified as high-very high risk. Similarly, under RCP 8.5 in 2030, 19 districts are classified as very high-risk, while 17 are classified as high-risk. In Province two, it is important to note that, while the Province's vulnerability is low, the risk of climate change impact is high. The analysis also reveals that, among the Provinces, Province two ranks first in terms of disaster events and their impact. On the contrary, despite the higher level of vulnerability, the risk of climate change impact appears to be low in the Karnali Province and Sudurpaschim Province.

According to the results of the municipal level assessment, the risk level for Bhanu and Byas in Gandaki Province and Sitganga in Lumbini Province increased from high to very high-risk under RCP (4.5, 8.5) in 2030 as compared to Baseline risk. In RCP 4.5, the number of very high-risk municipalities climbed from two in the baseline to six, while the risk level in the high-risk category increased from 44 in the baseline to 80 in 2030. Furthermore, under RCP 8.5, the number of very high-risk municipalities climbed from 2 in the baseline to 5, while the risk level in the high-risk category increased from 44 in the baseline to 69 in 2030. Furthermore, risk assessments in rural municipalities show that the risk of climate change in 2030 is greater in mid-hills and Tarai. However, in both scenarios, some mountain municipalities in Bagmati and Province one face a high risk of climate extreme events in 2030.

In 2050, 19 districts are classified as very high risk under RCP 4.5, while 21 are classified as high risk. Meanwhile, RCP 8.5 categorizes 33 districts as very high risk, and 16 as high risk. In addition in 2050, 12 districts were added to the high-risk category in RCP 8.5 compared to RCP 4.5. According to the results of the municipal level assessment, Nilakantha from Bagmati Province has switched from high to very high-risk status in RCP 4.5 (2050). Furthermore, under RCP 4.5 in 2050, Jitpur Simara in Province Two, Sworgadwary and Rajapur in Lumbini Province, and Patan in Sudurpaschim Province have gone from moderate to high risk as compared to RCP 4.5 in 2030. In 2050, under RCP 8.5, Rupakot Majhuwagadhi from Province one, Janakpur from Province two, Nilkantha from Bagmati Province, and Kushma from Gandaki Province shifted from high to very high rank in comparison to RCP 8.5 in 2030. Furthermore, Sunwarshi, Bhojpur, and Chaudandigadhi from Province one; Jitpur Simara from Province two; Chandragiri, Ramechhap, Rapti and Ratnanagar from Bagmati; Sundarbajar, Shuklagandaki, and Madhyabindu from Gandaki Province; Buddhavumi, Bhumekasthan, Pyuthan and Rajapur from Lumbini Province, Sharada and Gurbhakot from Karnali Province and Parashuram and Patan from Sudurpaschim Province have shifted from moderate risk to high risk as compared to RCP 8.5 in 2030. Besides, the risk of climate extreme events is higher in rural municipalities spreading all the Provinces. It is interesting to note that in 2050, under both the RCP scenarios, the risks from climate extreme events are increasing and also evident in the mountain rural municipalities of Province one, and Bagmati Province.

6. Adaptation options

This assessment identifies adaptation options based on expert opinions, a literature review, and consultations with key stakeholders. Context-specific and transformational adaptation options are needed to deal with the differentiated impact, risk, and vulnerability in respective sectors. Adaptation options in the COVID-19 context must consider the wider socioeconomic context and contribute to the green recovery. Adaptation options include interventions that raise awareness and capacity of actors and agencies; provide technological options and solutions while recognizing indigenous knowledge and practices to deal with climate adversity by reducing the risk posed by climate-induced hazards and extreme events; and improve the communication and information system. Adaptation options also include policy and legal measures to ensure compliance with environmental and climate-resilient codes, as well as the adoption of climate-resilient pathways and the incorporation of climate change into sectoral development policies and plans, including the local government planning and budgeting process. Besides the options further include improving governance structures that ensure that women, indigenous groups, poor and disadvantaged households, and communities benefit from the adaptation financing. However, there are also limits to adaptation and DRR technology and practices. The transformative options are thus needed to fill the adaptation gaps.

7. Conclusion and Way forward

Climate change has affected a variety of sectors, including water, forestry, biodiversity, agriculture, and human well-being. Impacts on these sectors are likely to undermine local communities' livelihoods and undo previous development gains. Impacts, vulnerabilities, and hazards vary depending on resource usage trends, socioeconomic factors, and other factors.

Overall vulnerability and risk are rising in Nepal and are expected to rise even faster in the future. The overall vulnerability and risk are increasing across Nepal and are projected to increase rapidly in the future. In terms of vulnerability, Karnali Province and Sudurpaschim Province are highly vulnerable. However, in terms of risks of climate change impact, Province one, Province two, Bagmati Province, Gandaki Province, and Lumbini Province have observed higher risks of climate change impact. COVID-19's heightened risks and vulnerabilities intensify the current socio-economic and health crisis, including the annual loss and damage caused by climate-related disasters. The poor, women, IPs, the marginalized, and smallholder households and communities will be particularly hard hit.

The findings indicate that a vulnerability and livelihood focussed approach to climate change adaptation is appropriate in the Karnali Province and Sudurpaschim Province. This means that, in the short term (2030), adaptation options should focus more on improving adaptive capacity and addressing some of the physical, socioeconomic, and structural issues governing the sensitivity of population and the livelihood resources they rely on. Province two requires an integrated vulnerability risk-based approach to adaptation that focuses on reducing the impact of climate-induced extreme events and hazards through improved forecasting, risk communication, risk transfer, and other disaster risk reduction activities. Furthermore, other Provinces must focus on both increasing adaptive capacity and risk reduction activities.

The data provided in this evaluation is useful to a broad range of stakeholders, including policy-makers, planners, and practitioners. Municipalities, geographic areas, districts, and Provinces with high vulnerability and risk can be identified using the vulnerability and risk index and map. Furthermore, the data is useful in developing tailored policies and plans to resolve the climate change issue, considering the COVID-19 context, and to allocate climate financing based on needs.

This vulnerability and risk assessment does, however, have some flaws. Choosing a scale was difficult due to the lack of information. Studies like this need a single unit of analysis for comparison and, later, for taking responsibility in terms of implementation, which is why the Ministry of Forests and Environment selected districts and municipalities as the units of analysis.

Acronyms

ADB	Asian Development Bank
AC	Adaptive Capacity
AEPC	Alternative Energy Promotion Centre
AHP	Analytical Hierarchy Process
AR	Assessment Report
BEK	British Embassy Kathmandu
CBS	Central Bureau of Statistics
CD	Cold Days
CDD	Consecutive Dry Days
CI	Confidence Interval
CIA	Central Intelligence Agency
CL	Confidence Level
CMIP5	Coupled Model Intercomparison Project Phase 5
CN	Cold Nights
COP	Conference of the Parties
CSDI	Cold Spell Duration Index
CWD	Consecutive Wet Days
DEM	Digital Elevation Model
DHM	Department of Hydrology and Meteorology
DOED	Department of Electricity Development
DOFSC	Department of Forests and Soil Conservation
DOS	Department of Survey
DWRI	Department of Water Resource and Irrigation
EWD	Extreme Wet Days
GCM	Global Circulation Models

GDI	Gender Development Index
GDP	Gross Domestic Product
GESI	Gender Equality and Social Inclusion
GII	Gender Inequality Index
GLOF	Glacial Lake Outburst Flood
GNI	Gross National Income
GoN	Government of Nepal
GPCC	Global Precipitation Climatology Centre (GPCC)
GrADS	GRid Analysis and Display
HDI	Human Development Index
HI-AWARE	Himalayan Adaptation, Water and Resilience
IAPS	Invasive Alien Plant Species
ICIMOD	International Centre for Integrated Mountain Development
IOM	International Organization for Migration
IPs	Indigenous Peoples
IPCC	Intergovernmental Panel on Climate Change
IRS	Indoor Residual Spraying
IWMI	International Water Management Institute
IWRM	Integrated Water Resource Management
JE	Japanese Encephalitis
L&D	Loss & Damage
LAPA	Local Adaptation Plans for Action
LDCs	Least Developed Countries
LEG	LDCs Expert Group
LF	Lymphatic Filariasis
LLINs	Long-Lasting Insecticidal Nets
LOESS	Locally Estimated Scatterplot Smoothing
MOE	Ministry of Environment
MOF	Ministry of Finance
MOPE	Ministry of Population and Environment
MOFSC	Ministry of Forests and Soil Conservation
MOFE	Ministry of Forests and Environment
MOHA	Ministry of Home Affairs
MOCTCA	Ministry of Culture, Tourism, and Civil Aviation
MOLES	Ministry of Labour, Employment and Social Security
MPI	Multidimensional Poverty Index

MW	Mega Watt
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NARC	Nepal Agricultural Research Council
NEA	Nepal Electricity Authority
NPC	National Planning Commission
NPs	National Parks
NTFP	Non-timber Forest Product
NUS	Neglected and Underutilized Species
PAs	Protected Areas
PCI	Participatory Crop Improvement
PDGL	Potentially Dangerous Glacial Lakes
PPB	Participatory Plant Breeding
PVS	Participatory Variety Selection
RCP	Representative Concentration Pathways
RECP	Resource Efficient and Cleaner Production
SPI	Standarized Precipitation Index
SRN	Strategic Road Network
TWG	Thematic Working Group
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
USGS	United States Geological Survey
VBD	Vector Borne Disease
VRA	Vulnerability and Risk Assessment
VWD	Very Wet Days
WASH	Water, Sanitation and Hygiene
WB	World Bank
WBD	Water Borne Disease
WD	Warm Days
WFDEI	Watch Forcing Data ERA Interim
WHO	World Health Organisation
WN	Warm Nights
WSDI	Warm Spell Duration Index

Chapter 1

Introduction

This introductory chapter provides a country background highlighting the geography and climate of Nepal including the demographic and socio-economic context. Besides, this chapter introduces the National Adaptation Plan (NAP) process and the objectives and scope of the Vulnerability and Risk Assessment.

1.1 Country Background

Geography and climate

Nepal is a landlocked country in South Asia bordered on the north by China and the south, east, and west by India. The nation is 885 kilometers long from east to west and 193 kilometers wide from north to south, with a total area of 147,181 square kilometers. It is located between the latitudes of 28^0N and 84^0E. Nepal is located north of the Tropic of Cancer, in the temperate region.

Nepal is divided into five physiographic regions. The Tarai flatlands (below 500 m), Lower Hills (Chure or Siwalik, between 500–1,000m), Hills (1,000–3,000 m), Middle Mountains (3000–5,000m), and High Mountains (above 5,000 m). The lowest point is 60 meters above sea level in the eastern Tarai's Jhapa District, and the highest point is 8,848 meters above sea level in the north's Mount Everest. The valleys of the Siwalik (Dun valleys), tropical valleys and elevated plains of the Hills, subtropical valleys of the Middle Mountains, and the dry Trans-Himalayan area of the High Mountains all have significant heterogeneity within each physiographic zone. Monsoons in the Hills range from mild to cold. The climate in the Middle Mountains is cool temperate to sub-alpine. The climate in the High Mountains ranges from alpine to tundra.

Because of the rapid change in altitude within a short north-south distance, there are significant variations in climatic conditions. Lower tropical, upper tropical, iii) sub-tropical, IV) temperate, v) sub-alpine, VI) alpine, vii) Trans-Himalayan, and viii) Nival/arctic are the eight ecological zones that make up Nepal. Tropical and sub-tropical areas make up 58 percent of the country's surface area. The temperate, subalpine, alpine, Trans-Himalayan, and Nival areas, meanwhile, account for 12 percent, 9 percent, 8 percent, 8 percent, and 5 percent of the total. The Himalayan mountain range and the South Asian monsoon affect Nepal's climate. From north to south, and east to west, the climate (temperature and rainfall) varies. The southeast monsoon, which occurs from June to September, and the westerly rain, which occurs from December to February, both contribute to local climate variations. Pre-monsoon (March-May), monsoon (June-September), post-monsoon (October-November), and Winter (December-February) are the four distinct seasons. The annual rainfall averages 1,530 millimeters (mm). Annual rainfall rises to 3,000 meters, then decreases with elevation and latitude, as well as from east to west (NAPA, 2010).

Demography and socio-economic context

Nepal's population is projected to cross 34 million by 2031, according to CBS (2014) population projections. It would reach 42 million by 2051 if the same growth rate is maintained. This means that by 2031, 2041, and 2051, the base population of 2011 would have increased by 28 percent, 44 percent, and 62 percent, respectively. Nepal's population is currently rising at a relatively fast rate of 1.85 percent, following a slight decline from 2011 to 2014. In the next three decades, the rate of population growth is projected to slow significantly. Since 1980, Nepal's population has grown at a faster pace than it has decreased. The average annual rate of demographic change between 1980 and 1985 was 2.31 percent. By 1990–95, the rate had risen to 2.64 percent. However, between 2005 and 2010, the annual growth rate fell to 1.05 percent. Over the last decade, Nepal's growth trend (average annual rate of 1.11 percent) has been lower than that of its South Asian neighbors (1.42 percent) and slightly lower than that of Least Developed Countries (LDCs), which is estimated at 2.37 percent[1].

The Nepalese GDP is $30.6 billion, with an annual growth rate of 7 percent in 2018/19 (according to World Bank). Agricultural GDP has decreased over time, from 41 percent in 1996 to 28.1 percent in 2017/18, whereas non-agricultural sectors such as wholesale and retail trade, real estate transportation, communication, financial intermediation, and other related services have increased from 36 percent to 71.9 percent over the same time (MoF, 2018). The industrial sector, which includes manufacturing, has dropped from 23 percent to 15 percent of non-agriculture GDP, while other service sectors, such as hotels and restaurants, and transportation, and communication, health and education services, etc. have shown significant growth (MoF, 2018). However, due to the impact of COVID-19, the GDP has fallen sharply and coming years will be challenging.

In 1996, 41.8 percent of people lived in poverty, 31 percent in 2005, and 25.2 percent of people lived in poverty in 2010 (NPC, 2018). According to a recent multidimensional poverty calculation, 28.6 percent of the population is multi-dimensionally poor (NPC, 2018), implying that people who earn more than the poverty line may nonetheless face deprivations in health, education, and/or living standards (NPC, 2018). In contrast to the global average of 5.42 percent, the unemployment rate in Nepal is relatively low, at 1.5 percent. Wage labour, which is extremely volatile to the external environment, including climate change, accounts for 24 percent of total jobs (World Bank, 2020).

The national economy is becoming increasingly dependent on migration. There are two million Nepalese labour migrants employed abroad. Nepal earned USD 6.9 billion in remittances in 2018/19, accounting for 27 percent of the country's GDP (IOM, 2019; World Bank, 2020). Seasonal labour migration to India and the associated remittance flow are poorly recorded. The number of migrants and remittance statistics was significantly higher than the data's structured reporting. In the 1990s, the number of remittances was 55 million, and it has risen 126 times in the last three decades (World Bank, 2020). As more men migrate than women, the number of female-headed households has steadily increased, from 13.6 percent in 1995/96 to 19.6 percent in 2003/04 and 26.6

1 NPC. 2017. Demographic changes in Nepal: Trend and policy implications. Government of Nepal.

percent in 2010/2011, a trend that is particularly pronounced in rural areas (UNDP, 2014). Internal migration accounts for a greater proportion of overall migration in Nepal. The rate of rural-to-urban migration in Nepal is projected to be about 3 percent per year (CIA, 2015).

1.2 National Adaptation Plan (NAP) Process

The government of Nepal has recognized climate change adaptation as critical to protecting vulnerable communities, ecosystems, and climate-sensitive sectors from the effects of climate change. In 2009, Nepal developed the National Adaptation Programme of Action (NAPA) to address the most pressing and immediate adaptation needs. Considering the importance of continuing and expediting adaptation actions to assist climate-vulnerable people and natural resources in adapting and building resilience to climate change impacts, the parties to the United Nations Framework Convention on Climate Change (UNFCCC) decided to launch a process to assist LDCs in formulating and implementing National Adaptation Plans (NAPs) at its Sixteenth Session (COP 16) in Cancun in 2010.

Nepal has started the NAP formulation process based on subsequent COP decisions and 'initial guidelines (Decision 5/CO.17)' and technical guidelines developed by the LDC Expert Group (LEG). The NAP has two main goals: (i) reducing vulnerability to the effects of climate change by increasing adaptive capacity and resilience; and (ii) facilitating the integration of climate change adaptation into relevant new and existing policies, programs, and activities in a coherent manner. In particular, development planning processes and strategies should be included in all relevant sectors and at various levels, as appropriate.

The Environment Protection Act of 2019 and the National Climate Change Policy (2019) are recently approved by the Government of Nepal. The Act clearly states that the MoFE is responsible for carrying out VRA every five years and updating NAP every ten years. Eight thematic areas/sectors and four cross-cutting areas/sectors are identified in the climate change policy. Although the policy provides strategic direction on thematic priorities, there is still a lack of clarity on where and how to invest. It will be difficult to put the policy into action if there is insufficient information about the risks and vulnerabilities. The Ministry of Forests and Environment (MoFE) had decided to carryout out detailed Vulnerability and Risk Assessments (VRA).

A Vulnerability and Risk Assessment (VRA) is an important step in adaptation planning and implementation. Element B of the LEG Guidelines (UNFCCC/LEG, 2012) reflects this strongly. Identification and implementation of adaptation plans are difficult without a systematic assessment of climate vulnerability and risk. This vulnerability and risk assessment work will help to establish a solid foundation for adaptation planning and decision-making. In light of the usefulness and wider application of the NAPA's Vulnerability Assessment Report from 2010, this assessment is expected to be a cornerstone in Nepal's development planning process.

1.3 Objectives and Scope of Vulnerability and Risk Assessment (VRA)

The ultimate aim of VRA is to improve climate-vulnerable people and populations, geographical areas, physical infrastructure, and ecosystems' adaptive ability and resilience. Medium and long-term adaptation activities will be incorporated into the development planning process at the state, regional, and local levels as a result of this process. VRA and the identification of adaptation options will aid sectors in strategically promoting Nepal's climate change adaptation agenda. This assessment's main goal is to help Nepal's NAP mechanism evaluate climate-related hazards, risks, and vulnerabilities, as well as define realistic adaptation options at the sectoral, provincial, and national levels. The specific objectives include:

- Assessing vulnerability to climate impacts across sectors and physiographic regions through applicable frameworks; and ranking/categorizing associated climate risks and vulnerabilities.
- Identifying and categorizing adaptation options to these risks, at multiple scales, to address priority climate risks and vulnerabilities.

The Vulnerability and Risk Assessment (VRA) examined eight thematic areas, as well as one cross-cutting area (Table 1) listed in the National Climate Change Policy (2019), seven Provinces, and five physiographic regions (High Mountain, Middle Mountain, Hill, Siwalik/chure, and Terai). However, to assess vulnerability and risk in Provinces and physiographic regions, the assessment process relied on district-level results. A systematic evaluation was also conducted for 293 municipalities in the Rural and Urban sectors. Due to the lack of a full dataset, a standardized evaluation was conducted for the 460 Rural Municipalities. In addition, since the VRA is focused on indicators, indicators with a full data set for all 77 districts and municipalities were taken into account.

Table 1: Thematic areas covered by VRA

Thematic Areas/Sectors to be covered by VRA
1. Agriculture and Food Security
2. Forests, Biodiversity, and Watershed Conservation
3. Disaster Risk Reduction and Management
4. Health, Drinking Water, and Sanitation
5. Rural and Urban Settlements
6. Tourism, Natural and Cultural Heritage
7. Water Resources and Energy
8. Transport, Industry, and Physical Infrastructure
9. Cross-cutting: Gender & Social Inclusion, Livelihoods, and Governance

This study compiles and summarizes the main findings from each of the nine thematic studies. Along with this study, separate thematic reports will be published. Aside from that, the VRA approach and methodology document will also be published separately.

1.4 Using this report

This report can be used to inform decision-making in many different ways. These may include:

- Giving policymakers a better understanding of risks and vulnerabilities in Nepal: the Executive Summary provides this overview.
- To assess whether current or planned policies can be improved to address risks and vulnerabilities set out in the report: see chapters five and six.
- As evidence to inform resource allocation, in particular supporting the targeting of support to particularly vulnerable groups and locations: see chapters six and seven.
- For decision-makers in particular locations (such as provinces or local governments): the information in chapters four, five, and six.
- For decision-makers in key sectors: chapters four, five, and six provide a starting point. Detailed sectoral reports have also been prepared and are available.

Chapter 2

Vulnerability and Risk Assessment (VRA) Framework, Process and Methodological Steps

This chapter describes the framework, process, and methodological steps involved in performing the Vulnerability and Risk Assessment (VRA). The contents, in this chapter, provide more information and clarification on the structure and methodological approaches established by the government as part of the initial NAP process in 2017.

2.1 Introduction

Human-induced climate change is already affecting many weather and climate extremes in every region across the globe. The latest IPCC report (AR6) confirms that human activities have changed our climate and led to the more frequent heatwaves, floods, droughts, and wildfires that we have seen recently. The evidence is incontrovertible. This highly influential report provides the evidence base and impetus to develop policy strategies and practices that will help people around the world and in Nepal live with and adapt to change.

The Vulnerability and Risk Assessment (VRA) has been recognized globally as a critical step in adaptation planning and implementation (IPCC, 2014). Many climate change adaptation efforts aim to address the implications or risks of potential changes in the frequency, intensity, and duration of weather and climate events that affect human and natural systems. To reduce risk effectively, it is essential to understand how the vulnerability is generated, how it increases, and how it builds up (O'Brien et al., 2004). Vulnerability describes a set of conditions among people that derive from both historical and prevailing cultural, social, environmental, political, and economic contexts. In this sense, vulnerable groups are not only at risk because they are exposed to a hazard, but also as a result of marginality, of everyday patterns of social interaction and organization, and access or lack of access to resources (Morrow,1999; Watts and Bohle, 1993).

VRA is an important element in the NAP formulation process in particular aligning its guiding principles to ensure the process is a country-driven, gender-sensitive, participatory, and fully transparent approach, taking into consideration vulnerable groups, communities, and ecosystems. Adhering to this, the climate vulnerability and risk analysis will help Nepal identify adaptation deficits, and will guide the selection of vulnerable and at-risk geographical areas, physiographic regions, municipalities populations, and resources. This will facilitate the identification of adaptation options and ultimately guide in compiling the medium and long-term adaptation needs and priorities of the country while devising strategies for mainstreaming climate change adaptation in development policies and plans.

The following section provides an overview of the approach and methodological steps adopted to assess the national level vulnerability and risk in different sectors, Provinces, municipalities, and physiographic regions.

2.2 Vulnerability and Risk Assessment Approach and Methodological Process

The VRA process incorporates methodological steps (Figure 1) to assess climate change impact and risk in all eight thematic sectors and one cross-cutting sector. These steps aim to provide a comprehensive picture of current and future climate vulnerabilities and risks and related opportunities as a basis for identifying adaptation strategies and plans for the ongoing NAP formulation process. The details of each sector-specific indicator for hazard, exposure, sensitivity, and adaptive capacity and their respective index computation are explained in a separate document entitled *Overarching Methodological Guidelines for Vulnerability and Risk Assessment (VRA) and Identifying Adaptation Options.*

For the VRA method, a mixed evaluation methodology (top-down and bottom-up) was used. The process has taken into account cross-sectoral connections as well as the flow of data and information. Consultations were conducted across sectors, crosscutting regions, thematic working groups, and government line agencies at all levels, Civil Society Organizations, youths, women, indigenous groups, and other related sectors to validate and make the process appropriate to all. The following section focuses on the specifics of each phase in the VRA method.

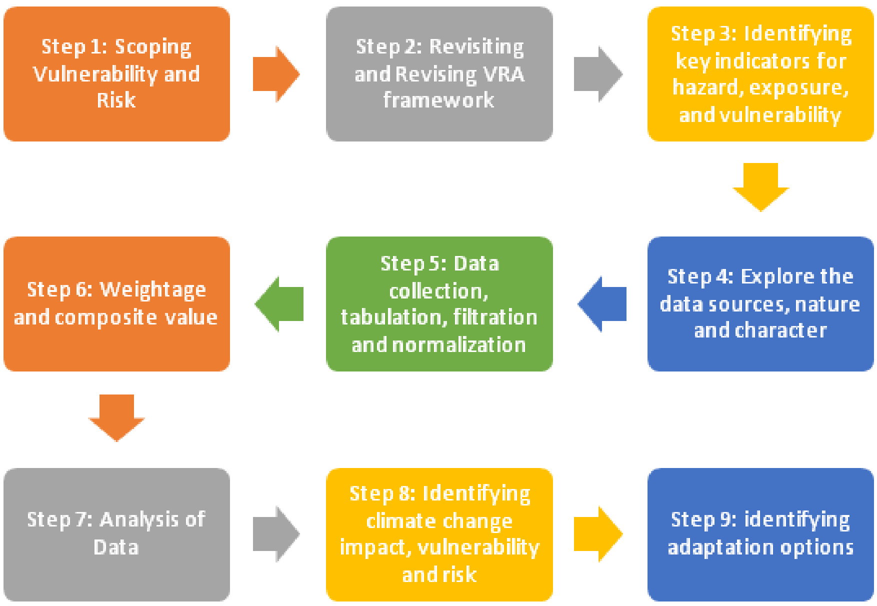


Figure 1: Steps for Vulnerability and Risk Assessment

Step 1: Scoping vulnerability and risk

The scoping exercise on vulnerability and risk assessment in different municipalities (rural and urban), sectors[2], Provinces, and physiographic regions[3] required an understanding of the context of a) current climate conditions and scenarios, including slow onset and extreme events; b) an assessment of potential impacts of climate extremes and climate change on potentially vulnerable sectors; and c) an analysis of other underlying factors (biophysical, technical, and socio-economic factors) that can influence climate risks. The scoping of vulnerability and risk in the assessment units was a key starting point.

The process of assessment was based on municipality and district-level data. The assessment and analysis of climate trend and scenario and climate-induced hazards was based on information and outputs of two published reports namely a) Observed Climate Trend Analysis of Nepal (DHM, 2017); and b) Climate Change Scenarios for Nepal (MoFE, 2019). Furthermore, the VRA carried out an analytical assessment of the socio-economic conditions, sectoral impact, risks, and vulnerability based on available literature and consultations with stakeholders.

1.1 **Climate trend analysis[4]**: Two types of data were used in this analysis. For temperature analysis, daily temperature data from 93 climate stations are used. Stations were selected based on the data length and results on quality control tests. For precipitation analysis, 0.05^0 APHRODITE (Yatagai et al., 2009, 2012) daily gridded data was used. This database for Nepal was based only on DHM rain-gauge data. The daily temperature data of 92 DHM stations were first quality checked using RClimdex software. After the quality check procedure and filling of high-altitude missing data, the daily temperature data from 1971 to 2014 was interpolated at the grid size 1x1 km using Co-Kriging (in R environment). Area averaged daily time series (i.e. For 77 districts and 5 physiographic regions for 1971-2014 period) of maximum temperature, minimum temperature, and precipitation were extracted from gridded data using publicly available GrADS (Grid Analysis and Display, http://cola.gmu.edu/grads/grads.php) software. From daily area-averaged time series of corresponding districts and physiographic regions, monthly time series (1971-2014) were calculated for every 77 districts and every 5 physiographic regions.

Combined Mann- Kendall test and Sen's Slope method were used to analyze the type, magnitude, and significance of the trend in climate time series data. In this analysis, significance tests at the level of 0.001, 0.01, and 0.05 or confidence level (CL) at 99.99 percent, 99 percent, and 95 percent were used. Each significance level (0.001, 0.01, and 0.05) indicates the probability (0.1 percent, 1 percent, and 5 percent) that the observed trend could have occurred by chance. These extreme indices were identified by the NAP team, ICIMOD, and DHM together after mapping the sectoral requirement and need for NAP. The time series of extreme indices for each district was calculated by using a program in Fortran. Significance and slope of the trend of output indices were estimated using Mann-Kendall and Sen's method in MS-Excel. Time series of extreme indices were obtained from GrADS extracted area-averaged data.

1.2 **Analysis of climate change scenarios in Nepal[5].** The assessment carried out by ICIMOD and MoFE used an ensemble approach of choosing four GCMs, which provide a range

2 Eight thematic sectors (Agriculture and Food Security; Forest, Biodiversity and Watershed Management; Water Resources and Energy; Rural and urban Settlements; Disaster Risk Reduction and Management; Tourism, Cultural and Natural Heritage; Industry, Transport and Physical Infrastructure) and one cross cutting sectors- GESI, Livelihood & Governance).

3 High Mountain, Middle Mountain, Hill, Siwalik/Chure, and Tarai.

4 The methodological description is drawn from DHM Trend Analysis Report, 2017.

5 The methodological descriprition is drawn from MoFE & ICIMOD Report on Climate Scenarios, 2019.

of possible future scenarios for RCP 4.5 and RCP 8.5 instead of pinpointing a change in just one future direction. While some approaches provide a future change in a definite value (such as 2.5 °C by 2050), an ensemble approach provides a possible range of change by considering the chosen RCPs. This approach has been used by Lutz et al. (2016) to select representative climate models for the Himalayan region. GCMs are used to simulate global atmospheric processes. These models operate at a spatial resolution ranging from approximately 100 to 250 km^2. Since GCMs tend to neglect regional heterogeneity (such as climatic processes), these resolutions are too general to carry out any specific assessment at regional scales (such as at a catchment level). Therefore, these GCMs were further downscaled to a finer resolution. We selected two ensembles containing four GCM runs from the CMIP5 database. One ensemble for the medium stabilization scenarios RCP 4.5 and the other for the very high radiative forcing scenario RCP 8.5. The mitigation scenario leading to a very low radiative forcing level (RCP 2.6) was not included. By selecting RCP 4.5 and RCP 8.5, the study covered the possible range of radiative forcing resulting from RCP 4.5, RCP 6.5, and RCP 8.5.

For reference climate dataset, the dataset generated by Lutz and Immerzeel (2015) as a part of the HI-AWARE project was used. The reference climate dataset is developed from the Watch Forcing Data ERA-Interim (WFDEI) dataset (Weedon et al., 2014) which was based on the WATCH methodology (Weedon et al., 2011), integrated with the ERA-Interim dataset (Dee et al., 2011). Precipitation in the WFDEI dataset was bias-corrected using the Global Precipitation Climatology Centre (GPCC) dataset (Schneider et al., 2013). Besides, precipitation data were corrected using observed glacier mass balance data according to the methodology developed by (Immerzeel et al., 2012, 2015). The air temperature data were bias-corrected with data from observed stations from the region. The raw daily mean air temperature from the WFDEI dataset was spatially interpolated from a 50 km grid to a 1 km spatial resolution vertical temperature lapse rate. Precipitation data in WFDEI were interpolated from a 50 km to 1 km grid by cubic spline interpolation. This dataset is one of the complete dataset (precipitation, maximum and minimum temperature) for a longer period available for the whole of Nepal at a higher resolution (10 km grid) with a different level of bias corrections.

The ICIMOD and MoFE study used an advanced envelop-based selection approach described by Lutz et al. (2016) to select a representative ensemble of GCMs was used. The NAP process had defined eleven indices (five for precipitation and six for temperature) of climate extreme to understand the historic and future change of climatic parameters. These indices were selected as they represent the most important climate change indicators in Nepal.

1.3 **Analysis of socio-economic trends and scenarios**: This VRA assessment analyzed socio-economic trends and scenarios. There are various tools and complicated models for scenario development. In our case, we analyzed the historical trends and found out the growth trend which was linear, exponential, or mixed exponential. Based on past trends, a future scenario was developed by selecting a suitable growth model. In this case, Excel Forecast Tool was used to suffice the objective of the study. This tool is considered a powerful tool for socio-economic scenario development and user friendly. The following example (equation 1.0 and 2.0) illustrates to development scenario for linear growth. Similarly, an exponential function is used if growth follows geometric growth or a mixed exponential function if the growth is higher during an earlier point in time and slower growth in later years. Excel forecast tool is flexible to capture such varied growth functions.

$$P_{t+1} = P_t + b(n) \quad \ldots\ldots\ldots\ldots 1.0$$

$$b = \frac{{}_t^d P_t - P_{t-1}}{m} \quad \ldots\ldots\ldots\ldots 2.0$$

Where,
P_{t+1} = population at a particular point of time in the future, P_t = population at the last census, P_{t-1} = population at the prior census, n = number of unit time for the projection, b = average growth rate per unit of time, d = data of the last census, m = number of the historical interval, t = time index (year or decade).

For some socio-economic indicators with sufficiently long historical data, both the Mann-Kendall test and Sen's slope were employed to analyze the trend, its magnitude, and significance of the trend. M-Kendall test is a non-parametric method that tests the significance of monotonic positive or negative trends based on the historical data. On the other hand, Sens's slope estimates the magnitude of the linear trend. This coefficient was used to estimate the future value. MS-Excel program Version 1.0 was used to estimate the magnitude and significance of the trend[6].

Step 2- Revisiting and refining the VRA Framework
In 2017, the GoN published the Vulnerability and Risk Assessment framework and indicators for the National Adaptation Plan (NAP) formulation process. The assessment of national vulnerability and risk has adopted the same national framework, which is based on the Intergovernmental Panel on Climate Change (IPCC)- fifth assessment report (AR 5 - 2014) and Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX).

In the fourth Assessment Report of the IPCC (2007), vulnerability is a core concept that describes which a natural or social system is susceptible to/unable to cope with the adverse effects of climate change. In the latest IPCC AR 5, this concept has been replaced by the concept of risk of climate change impacts that may harm a system. Risk is described as a result of the interaction of vulnerability, exposure, and hazard. The vulnerability of a system has become one component of the risk that may increase or decrease the potential consequence of a hazard.

The national framework, published by MoPE in 2017, unpacks the elements of risk and customizes as per the needs and applicability of the national context. The framework assumes that the risk of climate-related impacts results from the interaction of climate-related hazards (including climate extreme events) with the exposure and vulnerability of human and natural systems. The changes in the climate system (trends and scenarios), biophysical system, and socioeconomic processes (including governance and adaptation and mitigation actions) are drivers of hazards, exposure, and vulnerability (IPCC, 2014). The national level vulnerability and risk analysis are based on measurable and quantifiable available data, both primary and secondary. Figure 1 describes the adopted assessment framework.

Following upon the GoN conceptual framework (Figure 2) and based on Equation I and Equation II, the methodological framework has been made more clear with additional information and steps. They are i) analytical steps for slow-onset disasters (such as - drought, forest fire, Glacial Lake Outburst Flood, etc.) has been added to the existing national framework for the comprehensiveness of the assessment process; and ii) identifying and appraising adaptation options step was added into the nine steps process.

6 MS-Excel template of Mann-Kendall test available at: https://help.xlstat.com/s/article/mann-kendall-trend-test-in-excel-tutorial?language=en_US Accessed 21st March 2021.

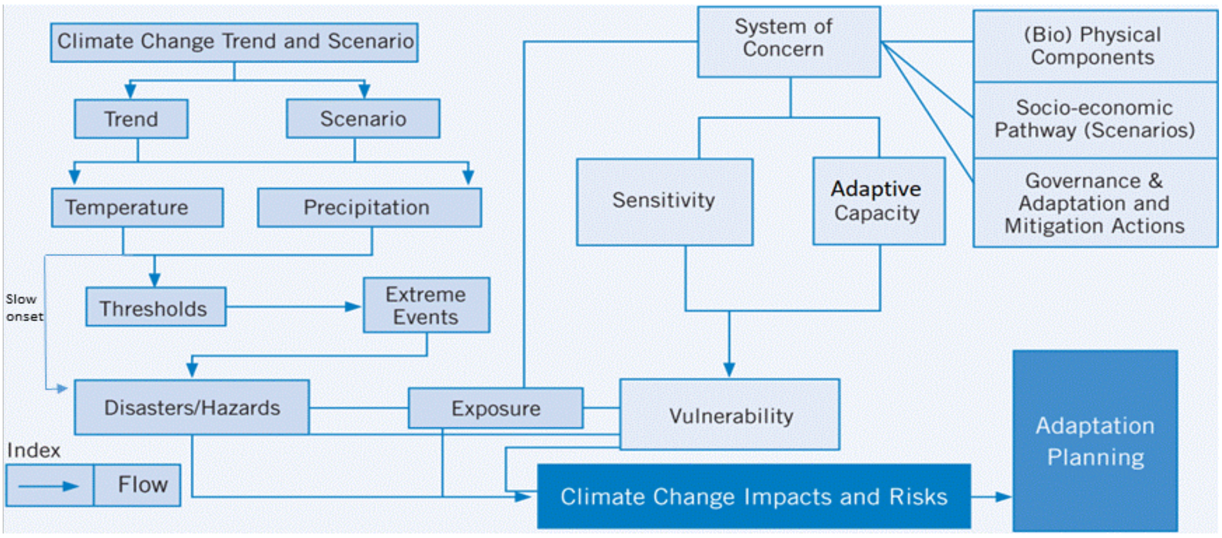


Figure 2: Climate change vulnerability and risk assessment framework

Source: MoPE, 2017

The national Vulnerability and Risk Assessment (VRA) process has analyzed hazard, exposure, sensitivity, adaptive capacity, vulnerability, and risk as to the key components of the assessment. The below equation describes vulnerability as a function of Sensitivity and Adaptive Capacity while equation ii describes risk[7] as a function of Hazard, Exposure, and Vulnerability.

$V_{Index} = (S_{Index} - AC_{Index})$ ………………………………… (equation I)

where,

Vulnerability will justify, if $(S_{Index} - AC_{Index}) \geq 0$

And

$R_{Index} = (H_{Index} \times E_{Index} \times V_{Index})$ …………………… (equation II)

where,

V_{Index} : Vulnerability Index

E_{Index} : Exposure Index

S_{Index} : Sensitivity Index

H_{Index} : Hazard Index

AC_{Index} : Adaptive Capacity Index and

R_{Index} : Risk Index

Step 3 - Identifying key indicators for Hazard, Exposure & Vulnerability (sensitivity and adaptive capacity) for different thematic and cross-cutting areas

In this step, the most relevant indicators[8] to thematic and cross-cutting areas to measure and assess trends in climatic hazards/stressors, exposure elements, state of sensitivity, and adaptive capacity were listed. The indicators were used to measure and assess trends in hazards, exposure elements, state of sensitivity, and adaptive capacity of people and systems. Besides, the indicators were used for both quantifying and qualifying the extent, trends, and scenarios of the assessment units.

7 Risk here is understood as risks of climate change impact.

8 Indicators – are parameters which provide information about specific states r condition which are nod directly measurable (Meyer, 2011). The purpose of use of indicators is to this quantified information to compare against critical thresholds or previous measurements. Good indicators – valid and relevant, reliable, precise meaning, clear in its direction, practical and affordable, appropriate.

SMART indicators were identified based on literature review, and review of previously published VRA framework, and stocking documents (MoPE, 2017). A total of 591 indicators were used covering all the thematic sectors which included 128 exposure indicators, 249 sensitivity indicators, and 214 adaptive capacity indicators. For a rural municipality, a total of 36 indicators were used. An example of the indicators is included in Annex 1 while the complete list of indicators can be found in the nine sectoral reports which will be published along with this consolidated report. The indicator-based approach to VRA is widely used and is one of the methods but there could be several other methods that could be used in the future. If there are time-series data available for all the indicators, it will be very useful to do the modeling and statistical analysis which is more accurate.

Step 4 - Exploring data sources, nature, and character

For this study, a variety of data sources were used (Table 2). The Department of Hydrology and Meteorology (DHM) provided district-level seasonal and climate patterns data, while climate scenarios were obtained from MoFE/ICIMOD, along with data from several other regional and global centers. The Central Bureau of Statistics (CBS), Department of Survey (DoS), DHM, related Ministries, development organizations, and international organizations such as ICIMOD, United States Geological Survey, and others were the primary sources of secondary data. For all quantitative datasets, a metric measurement method was used. For all qualitative and quantitative datasets, collection of corresponding geospatial information that may be a coordinate or address i.e., associated administrative units were ensured.

Table 2: A Base Data requirement for the Indicators in water resources and energy sector

Data name	Data Source	Format	Coverage
DEM	USGS	Raster	All Nepal
Land Use Land Cover[9]	DOS, ICIMOD	Vector	All Nepal
Soil Class	DOS	Vector	All Nepal
River Networks	ICIMOD	Vector	All Nepal
Watershed Boundary	DOFSC	Vector	All Nepal
Ecological, Provincial, & District Boundary	DOS	Vector	All Nepal
Past Climatic Data	DHM	Tabulated	District wise
Hydrological Data	DWRI, IWMI, UOG	Tabulated	District wise
Future Climate Data	MOFE	Tabulated	District wise
Hydropower	DoED, NEA, AEPC	Tabulated (Geospatial)	District Wise
Alternative Energy	AEPC	Tabulated (Geospatial)	District Wise

Step 5 - Data collection, tabulation, filtering, and normalization

The VRA was carried out using secondary data (spatial or non-spatial) obtained from published or unpublished sources. The information came mostly from government sources, which were credited and acknowledged by the government. Interviews, one-on-one meetings, exploratory surveys, and consultations with experts and related stakeholders and individuals were also valuable data collection methods. Survey software and Google Form were used for the questionnaire survey. Extraction of information was also accomplished by the use of other correspondence methods such as the telephone, Skype, and email. Consultations in all seven provinces and at the national level, as well as field visits to selected local governments, were used to verify the knowledge obtained from secondary sources. The filtering, cleaning, and normalization process was conducted to ensure the collected or tabulated data were correct, complete, relevant, unique, properly formatted, and with a uniform unit. A min-max method was adopted to normalize the quantitative dataset. The method transforms the values between 0 and 1 by subtracting the minimum score and dividing it by the range of indicator values as shown in equation III.

9 This includes all the land surface coverage types, such as Forest, Agriculture land, Settlements, River, Snow, Glacier, etc.

$$x_{norm\_i} = \frac{x_i - x_{min}}{x_{max} - x_{min}}$$ ……………………..……….. (equation III)

As an example, the calculation for the annual precipitation of Tanahu district (1925 mm) where maximum precipitation is 2710 mm in Kaski and minimum is 257 mm in Mustang. The normalized value for Tanahu is:

$$\frac{1925-257}{2710-257} = 0.679$$

Step 6 - Weightage and composite value

Every normalized data was given weightage by using a pair-wise comparison (Uribe et al., 2014) as indicated in the Analytical Hierarchy Process (AHP) model to prioritize the related decision indicators. A slight modification of AHP is done particularly to adjust the prioritization of a long list of indicators. For this study, due to a large set of indicators, a pairwise comparison of each indicator with all other indicators was not possible. Hence, a set of indicators was presented to experts who gave numerical value using Saaty's 9-point scale (Satty, 1984) based on their relative importance as given in Table 3. For this, a set of questionnaires was administered to at least 10-15 respondents including members of the Thematic Working Group (TWG), experts represent from the governments, I/NGOs, and the private sector. The respondents were requested to respond to each possible pair of criteria and rate one relative to the other on a scale from "equal importance" to "extremely important". Based on relative importance, a pairwise comparison matrix was developed which was later used to compute the weight of each indicator through the Eigenvalue and Eigenvector analysis. In this process, the relative comparison of indicators from at least ten experts for each thematic and cross-cutting sector was collected. The composite values were then calculated based on the computed weightage.

Table 3: Score for the importance of variable (Saaty Scale)

Intensity of importance	Definition of Important Scale
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very to extremely strong importance
9	Extreme importance

The individual judgments were converted into group judgments (for each one of the paired comparisons) using their geometrical average. A comparison of all possible pairs results in a so-called ratio-matrix. The numerical weights were then determined by normalizing the eigenvector associated with the maximum eigenvalue of the ratio matrix.

The aggregated value of each indicator of exposure, sensitivity, and adaptive capacity was calculated by using the weighted linear summation method which is a linear combination of standardized values using weights as shown in equation IV.

$$AC = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i} \text{ -- (IV)}$$

Where;
AC is an aggregated indicator, e.g., aggregated adaptive capacity,
x_i is an individual indicator of the adaptive capacity of a vulnerability component, and
w_i is the weight assigned to the corresponding indicator x_i. The preferred alternative is that with the minimum value of AC.

Step 7- Analysis of data
The data was analyzed, and the findings were presented in a variety of ways, including trend, scenario, pattern, danger, risk, and so on. The socioeconomic, demographic, and sector-specific data were analyzed using descriptive and inferential statistical analysis, as well as scenario-based economic modeling, to determine which categories are more vulnerable to climate change, as well as which regions or communities have better adaptation potential. Municipal, sectoral, regional, physiographic area, and district-level results were produced. The analysis identified key "climate-vulnerable hotspots" based on the data and maps prepared for five physiographic regions, municipalities, and seven Provinces by eight thematic sectors and one cross-cutting sector.

Step 8 - Identifying climate change impacts, vulnerability, and risk
The vulnerability of the identified sub-sectors within a sector and the aggregate of these sub-sectors of each sector were analyzed with an aggregated value of sensitivity and adaptive capacity as shown in equation V and Figure 2. According to IPCC- AR5, vulnerability is a function of Sensitivity and Adaptive Capacity. Figure 2 illustrates a typical process and analysis of the chain of vulnerability and risk with the indicator-wise data of sensitivity, adaptive capacity, and exposure.

$$V = S - AC \text{ .... (V)}$$

Where;
V is the composite vulnerability indicator,
S is the sensitivity component of vulnerability and
AC is the adaptive capacity component of vulnerability

Similarly,
Sub-sector-wise and cumulative risk of the forests and biodiversity, and watershed management was estimated as a function of Hazard Intensity, Exposure, and Vulnerability as shown in (VI).

$$R = H_{intensity} \times V \times E \text{ .... (VI)}$$

Where;
R is the risk index
$H_{intensity}$ is the hazard intensity,
V is the vulnerability and
E is an exposure.

The final risk was rescaled by dividing the outcome values by the maximum risk values of all administrative units as in equation (VII).

$$scale = R/\max(R), R \in \{admin\ units\} \text{ .... (VII)}$$

The climate change vulnerabilities and risks were ranked into five categories (very low, low, moderate, high, and very high) for their threats or impacts at sectoral, provincial, physiographic region, and district level by using the Jenks natural breaks (Jenks, 1967) method. The Jenks natural break is widely used for categorizing data. The VRA created the classes in such a way that the best groups of similar values come together and maximizes the differences between classes. The features are divided into classes whose boundaries are set where there are relatively big differences in the data values. The natural break classes are characterized based on the variety of data an indicator possesses thus the natural break value may differ with the dataset/indicators. The ranking was further validated through a consultative process with key stakeholders.

From the analysis of data, maps and indices for existing climate trends and projected scenarios for climate hazards, vulnerabilities and risks were generated. The climate change impact on each sector was further analyzed from available literature and based on the analysis of generated maps for each municipality, sector, Province, and physiographic region.

Step 9 - Identifying adaptation options

Adaptation options have been identified based on information generated by vulnerabilities and risk ranking. The most appropriate or relevant adaptation options for considerations were identified using a set of criteria aligned with national goals and targets for sustainable development, as well as national policy, sectoral policy, and national development goals related to climate change. The long-listed adaptation options were chosen based on criteria such as timing/urgency for action, cost, co-benefits, efficacy, flexibility, and robustness (LEG, 2012). The process adopted in this assessment were:

- Identification of a potential list of adaptation options based on literature review particularly those successful adaptation practices, effective local knowledge and practices, efficient technologies, and practices.
- Identification of potential adaptation options based on the impacts, vulnerability, and risk maps and tables generated by the analysis of secondary data.
- Consultation with relevant experts and stakeholders to map effective adaptation strategies in the sector and sub-sector.
- Consultation at the Province level to identify adaptation options in the context of the existing risk and vulnerability.
- Validation of adaptation options in Thematic Working Groups (TWGs) and Technical Committee.

The NAP project will carry out further prioritization through multi-criteria analysis, cost-effectiveness analysis, and cost-benefit analysis. Besides, the project will assess the cost of each action prioritized, for all of the defined long lists of adaptation options.

Chapter 3

Socio-Economic Trends and Scenarios

While most aspects of climate forecasts are focused on well-understood physical processes, our knowledge of the basic structure and causal factors operating in socio-economic systems, as well as their evolution, is minimal. Socioeconomic patterns and scenarios are realistic, internally consistent, and coherent accounts of historical trends and potential future states of the world that are used to guide policy decisions. The essence of the framework that is subjected to climate change in countries like Nepal will determine the effects of climate change. This chapter discusses the socioeconomic trends and scenarios that influence vulnerability and risk. The data used is primarily based on secondary data collected at the national level.

3.1 Demographic Trends and Projections

The population in 2020 is nearly reaching 30 million. Based on the population projection of CBS (2014)[10], Nepal's population is expected to reach 34 million by 2031. If the same growth rate is followed, it will reach 42 million by 2051. There is a slightly higher female population in Nepal based on the 2011 census, which should reach 21.9 million by 2051 while the male population will reach 20.9 million during the same time (Table 4). Similarly, there will be more urban population in the future with a reduction in the rural population. Better public services, economic opportunities, rapid population growth, and government policies are the key factors causing rapid urbanization in Nepal (Thapa and Murayama, 2010). An increasing trend of rural to urban migration also contributes to a rapid increase in urban population (Tiwari, 2008). In the current federal system, the urbanization trend is also expected to rapidly increase outside Kathmandu valley. For example, rapid urbanization is expected to increase in the Eastern Tarai with a corresponding decrease in cultivated land. This will have negative implications for food security and the environment (Rimal et al., 2019).

10 CBS. (2014). National Population and Housing Census, 2011. Population Projection of Nepal has projected population upto 2031. Projection for 2041 and 2051 was done using the same growth rate.

Table 4: Current and projected population at national level

Population	2011	2016	2021	2026	2031	2041	2051
Total (million)	26.49	28.46	30.52	32.47	34.18	38.27	42.86
Male (million)	12.84	13.80	14.81	15.77	16.61	18.64	20.92
Female (million)	13.64	14.66	15.71	16.70	17.56	19.63	21.94
Urban population (million)	4.52	5.55	6.93	8.53	10.31	15.30	20.57
Rural population (million)	21.97	22.90	23.59	23.94	23.86	22.96	22.28
Urban population (percent)	17.07	20	23	26	30	40	48
Rural population (percent)	82.93	80	77	74	70	60	52

Source: CBS, 2014 and own calculation

3.2 Labour Migration

Migration, displacement, refugees are the major social issues that have a direct relationship with climate change and natural disasters (Kaczan and Orgill-Meyer, 2020; Kolmannskog and Trebbi, 2010). In Nepal, natural hazards (mainly floods and landslides) are one of the major driving forces inducing labour migration (Jaquet et al., 2019). The majority of the labour force depends on agriculture and this sector is badly impacted by recurrent floods, droughts, and landslides. As a result, the agricultural labour force, particularly the young, tends to move away from the agriculture sector and explore employment opportunities in the service sector and labour market outside of the country (Sunam and McCarthy, 2016).

The migration trend has increased in Nepal with a corresponding increase in remittances. Each year, more than 400,000 labour mostly agriculture labour travel abroad for work, mostly to India and the Gulf (MoLES, 2020). Figure 3 shows the contribution from remittances over time. If the same trend continues, remittances are expected to grow by 128 percent and 194 percent in 2020 and 2030 in comparison to the baseline remittance volume of 2017 which was USD 678 million.

The recent data show that the volume of remittances is almost equivalent to the agricultural GDP which was almost negligible a decade ago. Remittances are playing a crucial role to supplement household incomes, child education, and other household consumptive uses. On the contrary, the outmigration has led to shortages of hired agricultural labour and increasing roles of women in agriculture. There is already 73 percent of the female workforce in agriculture, compared to 56 percent of men (Paudel et al., 2020).

Women and children are responsible for the land, as the only ones left in villages. However, women's land ownership is lower compared to males. Male outmigration has a multi-dimensional impact on women's role in agriculture (Paudel et al., 2020). The increasing role of women at both the household and community level has created opportunities for them. However, social and cultural factors along with a non-supportive policy and institutional environment have not contributed to empowering agriculture-dependent women or increasing their ownership and control over productive resources (Tamang et al., 2014). Besides, labour migration has created agricultural labour scarcity which has resulted in more fallow land in Nepal and an increasing trend of women participation in agriculture.

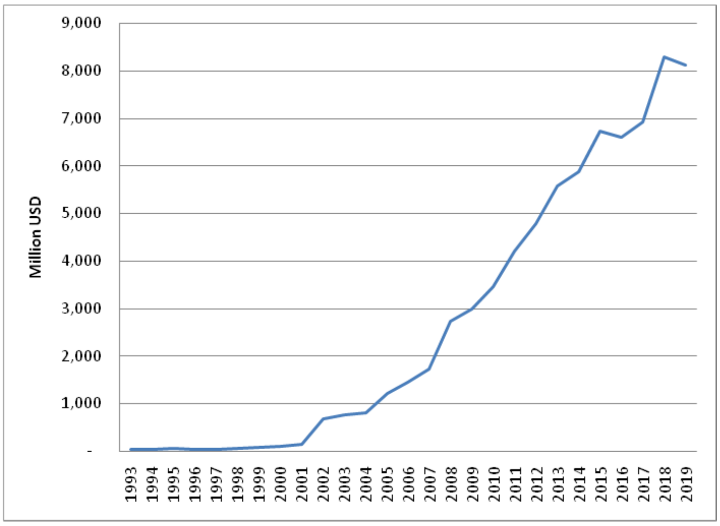
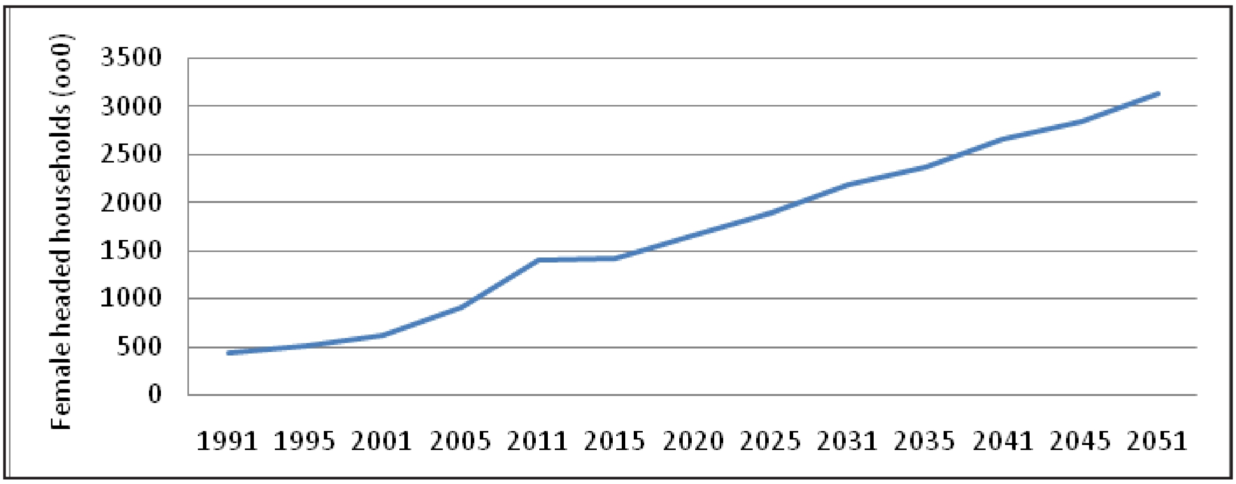


Figure 3: Trend of remittance flow in Nepal (million USD)
Source: World Bank, 2020

3.3 Female-Headed Households in Nepal

Women in the developing world tend to take care of their household when their male counterparts migrate for a long period, or if she is a widow or divorcee; or sometimes if she is the wife of a physically handicapped man. There are two kinds of household headship: de jure and de-facto. The latter is more prominent in our context. Female-headed households are one of the most vulnerable groups in society confronting many climate change challenges (Bohle et al., 1994; Hahn et al., 2009).

Because of their poor access to physical and financial resources, technologies, and skills, low level of awareness, and literacy, they are unlikely to make decisions on adaptation options in comparison to their male peers. Trends in female-headed households in Nepal show that they have significantly increased over the past three decades (Figure 4). There were altogether 439,000 female-headed households in Nepal during the 1991 census which became 621,000 in the 2001 census (an over 41 percent increase). Then, it jumped to 1.3 million in 2011, showing a 125 percent increase during this time. If female-headed households follow the same growth trend as in 1991-2011, they will reach 1.6 million in 2020/21, 2.1 million in 2030/31, 2.6 million in 2040/41, and 3.1 million in 2050/51.

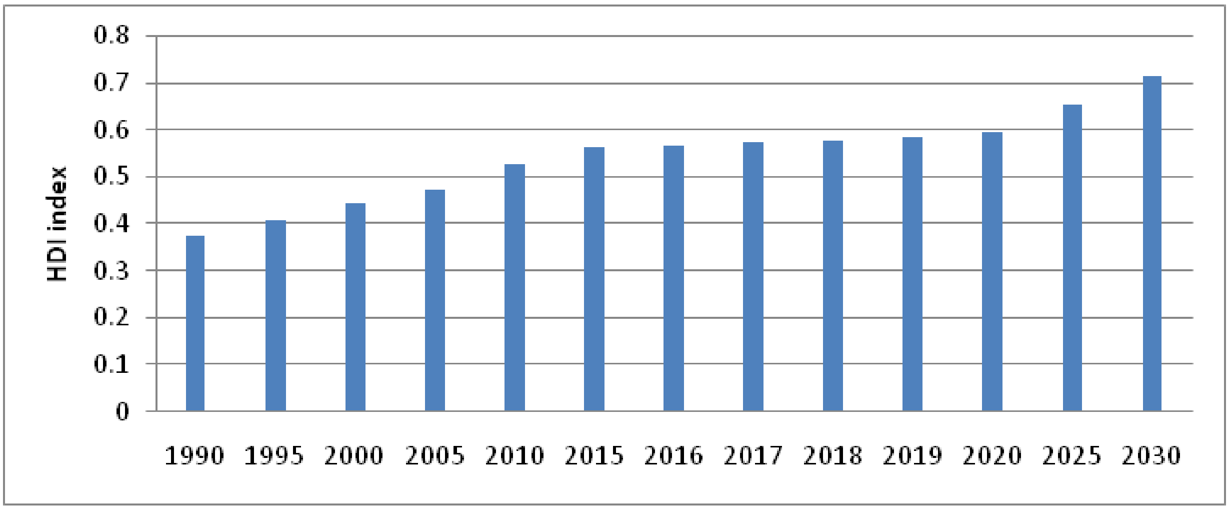


Sources: CBS, 1991, 2001 and 2011

Figure 4: Trend and projection of female-headed households at the national level

3.4 Human Development Index (HDI)

The Human Development Index (HDI) is a composite index. It reflects the overall socio-economic dimension of a country or region based on three basic dimensions: a long and healthy life, access to knowledge, and a decent standard of living (measured by life expectancy mean years of schooling among the adult population and per-capita GNI). HDI is considered very important for capacity building and awareness-raising and ultimately building resilience and adaptive capacity of a society. Figure 5 shows the HDI trend at the national level from 1990-2019. Between 1990 and 2019, Nepal's HDI value increased from 0.387 to 0.587, an increase of 55.3 percent over three decades. It has increased with an annual growth rate of 1.90 percent per year. Nepal's HDI value has made significant progress during the last decade (2010-2019). The growth rate seems almost to stagnate especially after 2015. If the average annual growth rate achieved during the last decade is considered, HDI is projected to reach 0.655 by 2025 and 0.717 by 2030 (NPC, 2018; UNDP, 2020).



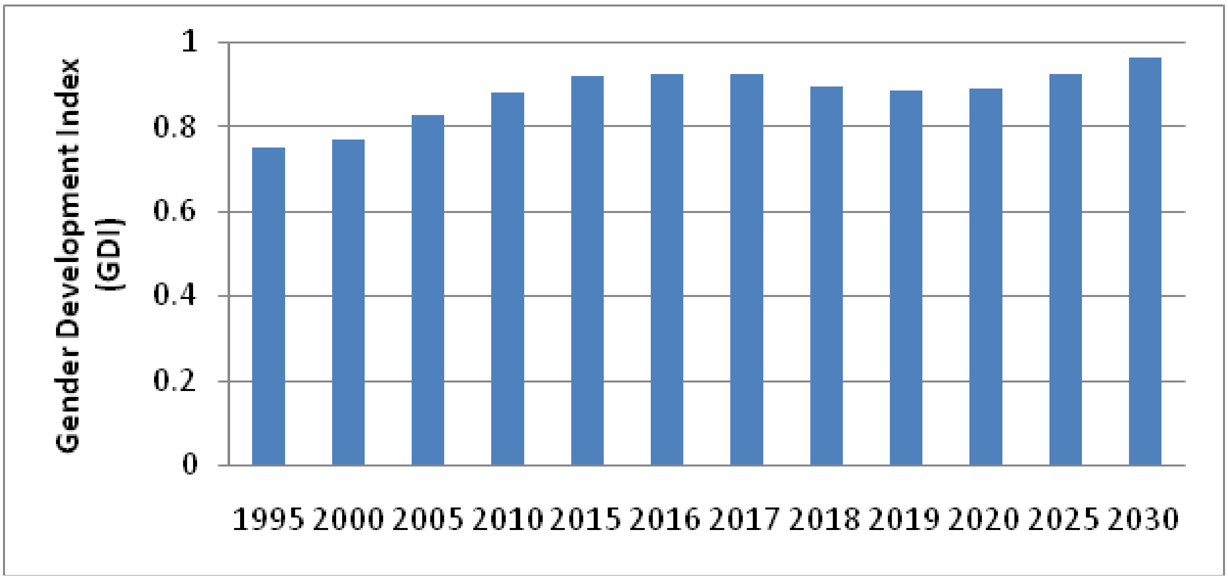
Source: Computation based on UNDP (2020)

Note: Projection-based on HDI historical trends. Bar 1990 to 2019 represent a trend and 2020-2030 represents projection based on historical trends.

Figure 5: HDI trends and projection at the national level

The overall trend of two HDI components i.e. life expectancy, years of schooling is presented in the annex. Nepal's life expectancy at birth increased by 16.4 years, mean years of schooling increased by 3.0 years which lead to increased HDI of Nepal over time.

3.5 Gender Development (GDI)



Source: Computation based on UNDP (2020)

Figure 6: Trends and Projection of Gender Development Index (GDI) in Nepal

Nepal's GDI value reached 0.886 in 2019 from 0.75 in 1995 (Figure 6), an increase of 18 percent during two and a half decades with an annual growth rate of 0.75. The trend has shown significant growth during 1995-2015. After 2015, the GDI remained stagnant or slightly reduced. The higher GDI value in the past is due to the higher participation of women in education (Pokharel, 2010). Considering the same growth rate for GDI observed from 1995 to 2019 i.e. 0.75, it is projected that it will be 0.92 by 2025 and 0.96 by 2030. Improvement in GDI indicates gender disparity in the future will be relatively improved (UNDP, 2020).

3.6 Gender Inequality Index (GII)

Based on the Human Development Report (2020), the Gender Inequality Index (GII) for Nepal from 1995 to 2019 has decreased by 34.44 percent (Figure 7) with an annual reduction of 1.35 percent. Since 2015, the GII score has remained fairly stagnant at around 0.479. Nepal's GII is below the South Asia average (0.501) reflecting its better position in terms of overall gender inequality (UNDP, 2020). Nepal's female representation in Parliament, reduction in maternal mortality, and improvement of adult females with secondary education are some of the reasons for the improvement in GII in Nepal (UNDP, 2020). Considering the same growth rate for GII observed from 1995 to 2019 i.e. – 1.35 percent, it is projected that it will be 0.440 by 2025 and 0.410 by 2030.

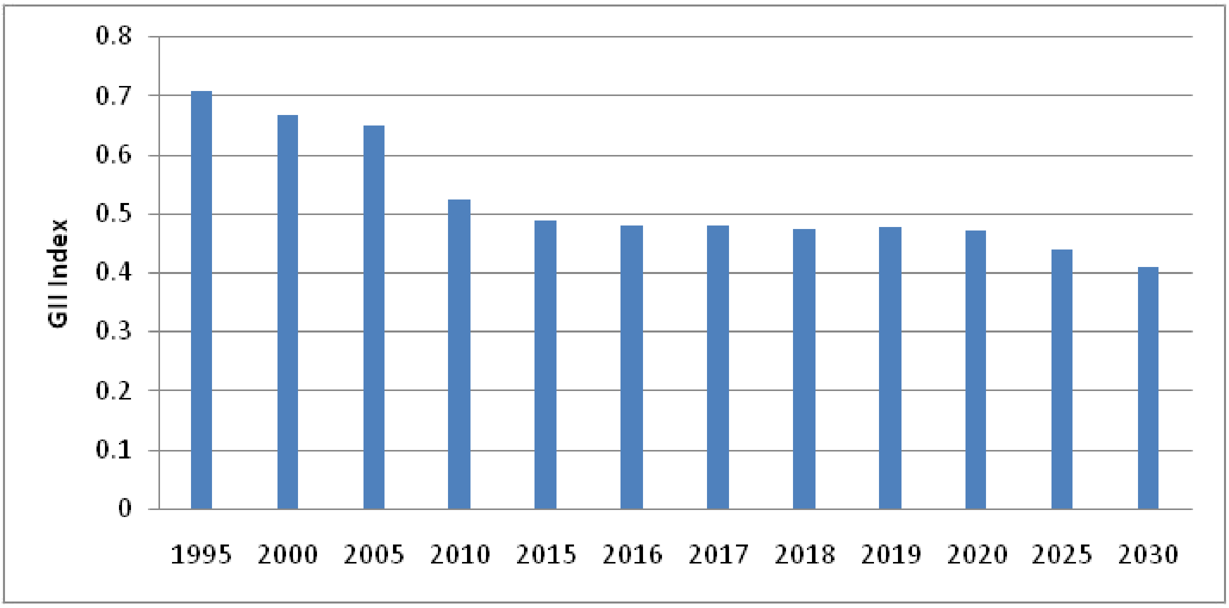


Figure 7: Trends and Projection of Gender Inequality Index (GII) in Nepal

Note: Projection-based on GII historical trends. Bar 1990 to 2019 represent a trend and 2020-2030 represents projection based on historical trends.

3.7 Poverty Trends

Poverty is a major driver of people's vulnerability to climate-related shocks and stressors. People interwoven in poverty traps are likely to be affected by climate change quickly (Marotzke et al., 2020). Poverty also induces labour migration directly and indirectly. Therefore, poverty trends and scenarios are important for climate change adaptation planning. Due to the different approaches of poverty measurement adapted in the past, it is difficult to calculate poverty trends and future projections. In 2003-04, 31 percent of the population was poor in Nepal, compared to 42 percent in 1995-96 (Table 5). Thus, the occurrence of poverty in Nepal declined by 11 percent over eight years, a decline of 3.25 percent per year. The incidence of poverty in urban areas reduced by more than 50 percent (it declined from 22 to 10 percent, a reduction of 7 percent per year). While poverty in rural areas also declined appreciably, at 2.5 percent per year. However, its incidence has remained higher than in urban areas. In 2010-11, 25 percent of the population was poor in Nepal compared to 31 percent in 2003-04. In this period of seven years, poverty was reduced by 18.44 percent at the rate of 2.63 percent reduction per year. The reduction rate is lower than the previous timeframe. In the later phase, poverty reduction is higher in rural areas while urban poverty is increasing during the same time. International labour migration is playing a vital role to reduce rural poverty along with other factors (Sunam, 2017; Sunam and McCarthy, 2016). International labour has been a major source of income and livelihood options for rural households, which is contributing to increasing access of women and children to basic services like health and education.

In 2018, Nepal has calculated the Multi-dimensional Poverty Index (MPI) measurement using 2014 survey data. It shows that Nepal MPI is 12.7 percent which was 31.3 percent in 2011 (NPC, 2018).

Table 5: Trends of poverty headcount from 1995-2011

	1995-96	2003-04	Change in percent	Annual reduction (percent) (1996-2004)	2010-11	Change percent	Annual reduction (percent) (2003-2011)
Nepal	41.76	30.85	-26	-3.25	25.16	-18.44	-2.63
Urban	21.55	9.55	-56	-7.0	15.46	61.88	8.84
Rural	43.27	34.62	-20	-2.5	27.43	-20.76	-2.96

Source: CBS (2005), Khanal (2012)

3.8 GDP Trends at National Level

The Nepalese economy is experiencing fluctuating GDP growth, still oscillating between 1 to 8 percent. Before the 1990s, there is evidence of negative GDP growth (Figure 8). To date, the agriculture sector plays a significant role in the national GDP (27 percent of total contribution). Reductions in agriculture production due to extreme weather (floods or droughts) directly correlate with GDP. Nepal has shown significant progress during the last three consecutive years (2017 to 2019) with a 7.3 percent GDP growth rate. However, due to the ongoing COVID-19 pandemic which has created a widespread impact on the national economy, the GDP growth rate is expected to decline sharply during 2020. The World Bank has forecasted there will only be a 0.6 percent growth rate in 2020 due to the pandemic.

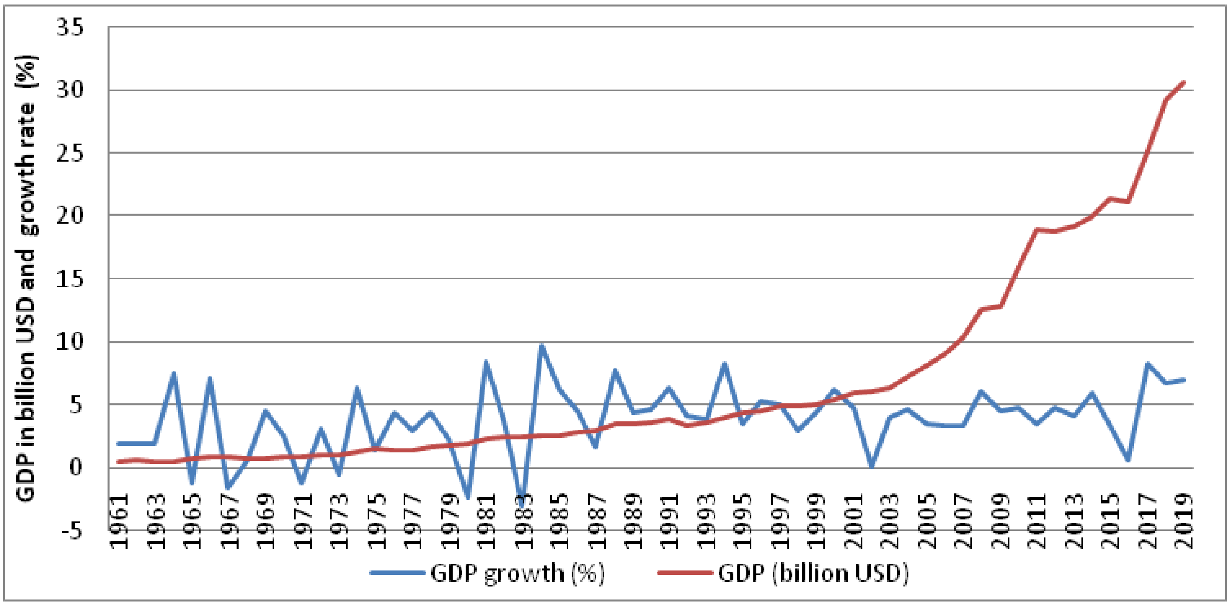


Figure 8: Trends of GDP growth and its value at current price 2019 (billion USD)

Source: World Bank online database

Chapter 4

Climate Change Trends and Scenarios

The climate change trend and scenarios for Nepal in the medium (2030) and long-term periods (2050) are included in this study. The key objectives of this chapter are to (i) understand the trend and predict potential changes in precipitation and temperature trends in Nepal's districts and physiographic zones at the annual and seasonal levels, and ii) evaluate and select climate severe indices for two RCP scenarios to understand the extent of changes in the past and future periods. The analysis is based on the previous studies carried out by the Department of Hydrology and Meteorology (DHM)[10], Ministry of Forests and Environment (MoFE)[11].

4.1 All Nepal Normal Precipitation and Temperature

Maximum and minimum temperatures vary across the country, primarily from north to south with low temperatures in high-altitude areas and high temperatures in the Southern plain. The annual minimum temperature, aggregated by district, varies from -4 to 19°C while the maximum temperature varies from 4 to 30°C. Manang district has the lowest (<5°C) annual average maximum temperature while most of the Southern plain districts have the highest normal annual maximum temperature that is usually above 30°C (Figure 10). In physiographic regions, the High Himalayas have the lowest normal annual maximum temperature (5°C to 10°C) whereas the Tarai region has the highest normal annual maximum temperature above 30°C.

The analysis of 44 years (1971-2014) of temperature data reveals that the lowest (<0°C) normal annual minimum temperature is observed in Humla, Mugu, Dolpa, Mustang, and Manang and the highest normal annual minimum temperature (15°C-20°C) in the southern districts including Surkhet, Tanahu, Makwanpur, Sindhuli and Udayapur (Figure 9 (a), (b)). The High Himalayas have the lowest normal annual minimum temperature which ranges between -5°C and 0°C. The Siwaliks and the Tarai regions have the highest normal monsoon minimum temperature that lies in between 15°C and 20°C.

10 DHM. (2017). *Observed Climate Trend Analysis in the Districts and Physiographic Regions of Nepal (1971-2014).* Department of Hydrology and Meteorology, Kathmandu.

11 MoFE. (2019). *Climate change scenarios for Nepal for National Adaptation Plan (NAP).* Ministry of Forests and Environment, Kathmandu.

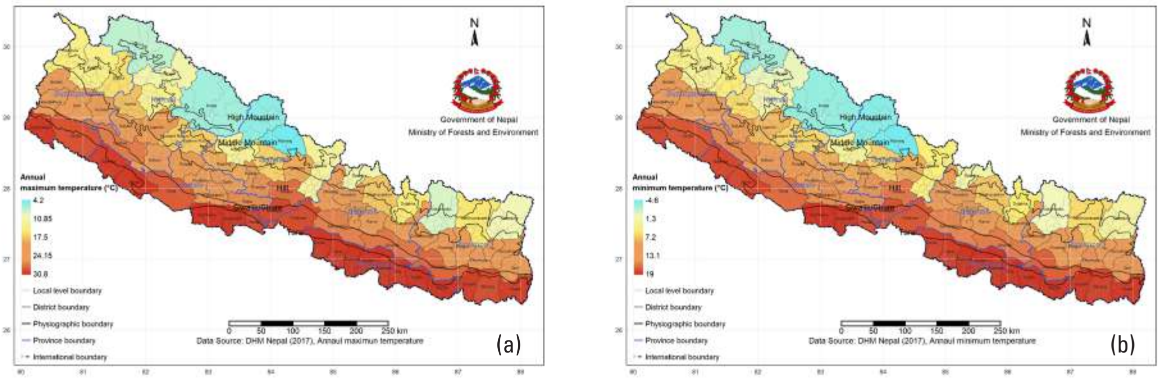


Figure 9: Annual average temperature of Nepal: a) maximum temperature; and b) minimum temperature

The district-wise annual precipitation is presented in Figure 10. The Kaski district, of Gandaki Province, received the highest amount of precipitation that is above 2700 mm/yr. Other districts, namely Parbat, Tanahu, Lamjung, Nuwakot, Sindhupalchok, Sankhuwasabha, Ilam, and Jhapa received more than 2000 mm/yr of precipitation between 1971 and 2014. Except for the Tarai district Jhapa and High Mountain district Sankhuwasabha, all other districts receive a higher amount of precipitation and are located in Hill, and Middle Mountain region and across in Province one, Bagmati Province, and Gandaki Province. The Mustang district, a high mountainous district of Gandaki, is the driest district with less than 400 mm/yr of precipitation. Besides, the western mountainous districts receive less than 1000 mm/yr. On the contrary, precipitation is gradually increasing in the central and eastern parts of the country. All districts of Province two, mountainous districts of Province one, and southern districts of Lumbini Province, and almost all districts of Karnali Province received between 800 and 1200 mm/yr of rainfall.

The annual precipitation is highest in the Hills of Gandaki Province with an aggregated annual precipitation of 2021 mm. The lowest annual precipitation occurs in the high mountain of Karnali with aggregated 622 mm/yr. While considering seasonal precipitation patterns, the Hill of Gandaki receives the highest precipitation during the pre-monsoon season. Precipitation is lowest in the High Mountain of Karnali Province and the Tarai region of Lumbini Province. During winter, Chure and Tarai of Province one received the lowest amount of precipitation, while the Hill of Sudurpaschim Province received the highest amount.

During monsoon, the Hills of Gandaki Province receives the highest precipitation with 1623 mm/yr while the High Mountain of Karnali Province receives the lowest precipitation. A pattern shows that the central Hill region receives more precipitation. During post-monsoon, the eastern part receives more precipitation.

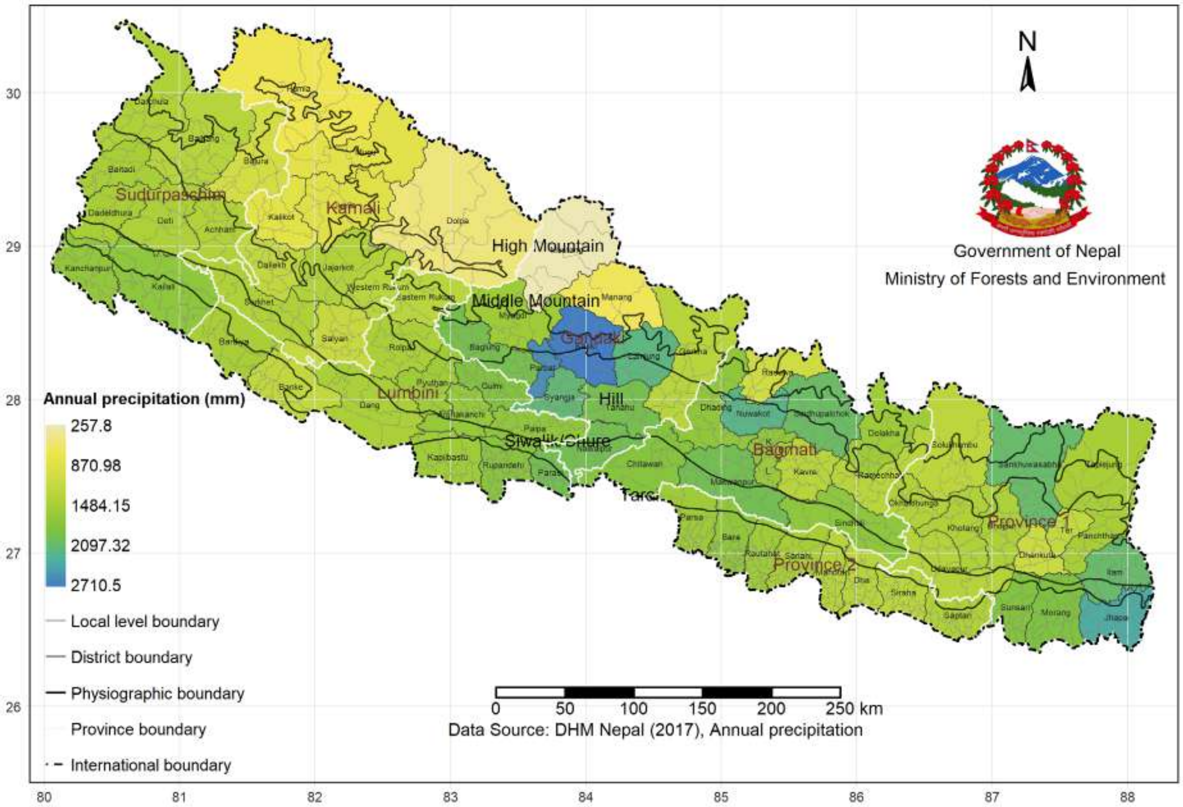


Figure 10: Average annual precipitation (1971 - 2010) across Nepal

4.2 Climate Trends

This subsection illustrates the trend in temperature, precipitation, and climate extreme events. Based on the observed Climate Data Analysis of Nepal (1971-2014), significant positive trends are observed in annual and seasonal maximum temperature. However, no significant trend is observed in precipitation in any season.

4.2.1 Temperature Trends

The annual maximum temperature is increasing by 0.056°C/yr while the minimum temperature trend is observed to be increased by 0.002°C/yr which is insignificant. The minimum temperature is found to be a negative trend in a few mountainous districts like Humla and Manang. However, the increase in temperature trend is the highest in central Tarai of Province two and the Middle Mountainous region across Nepal. The increased maximum temperature is uniformly higher in the mountainous district from east to west and the lowest in the Tarai districts. The Manang district has experienced extreme temperature conditions, as it possesses the highest decreasing rate of minimum temperature and the highest increasing rate of maximum temperature. Figure 11 illustrates the district-wise annual maximum and minimum temperature trend since 1971.

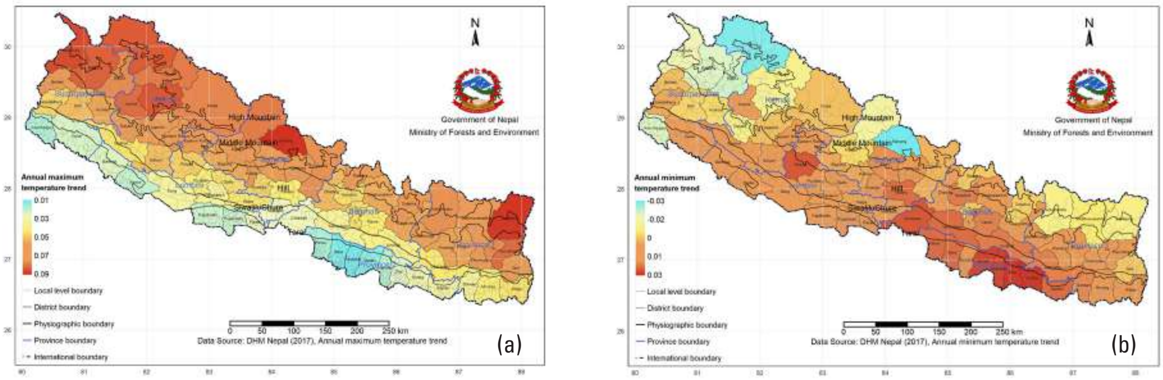


Figure 11: Annual temperature trend (a) maximum temperature (b) minimum temperature

4.2.2 Precipitation Trends

Different precipitation trend is observed in different districts across physiological regions and the Provinces. The precipitation is increasing in Syangja (8.99 mm/yr), and Bardiya (7.86 mm/yr) with the highest rate. Also, Gulmi, Tanahu, Nawalpur, Parasi, Banke, Dhanusha, and Kanchanpur districts experienced more than 4 mm/yr of precipitation. Kaski (-11.44 mm/yr), Ilam (-9.56 mm/yr), Ramechhap (-9.56 mm/yr) are the district having decreased precipitation during 1971 and 2014. A large part of Bagmati Province, northeast of Gandaki Province, west of Province one, and southeastern part of Karnali Province have a decreasing precipitation trend. The rate of change is almost -12 to 9 mm/y across the districts. All the districts of Sudurpaschim Province show an increasing precipitation trend. The Gandaki Province has the highest variation. The Tarai region of all Provinces (if applicable) has increased trend with the highest in the Tarai region of Sudurpaschim and the lowest in Province two. The Chure of Sudurpaschim Province and Gandaki Province observed an increasing trend while it is decreasing in Bagmati Province. The eastern part of the country is receiving less precipitation than before while it is slightly increasing in the western part. Figure 12 shows the annual precipitation trend in the 77 districts of Nepal.

While comparing the Provinces, Bagmati Province is experiencing the highest decreasing precipitation trend. The hill and high mountainous areas of Bagmati Province are affected more severely. A very clear precipitation pattern of decreasing precipitation from west to east during winter is observed.

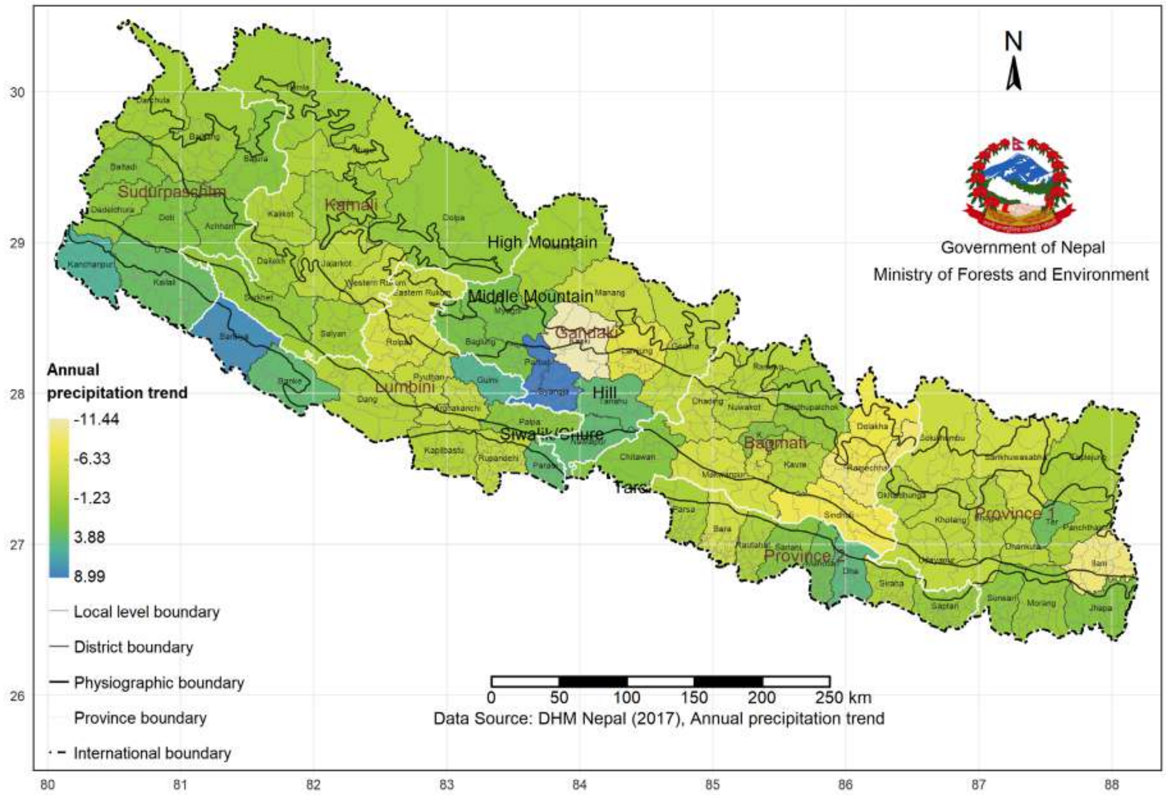


Figure 12: Annual precipitation trend

4.2.3 Extreme Events Trends

The incidence of climatic conditions beyond the regular pattern is the climate extreme events. The trend of such events reflects climate change at any location. In this subsection, the climate extreme events in a district, Province, and physiography by Province-level are presented. The considered extreme climate indices include a number of rainy days, very wet days, extreme wet days, consecutive dry days, consecutive wet days, cool days, cool nights, warm nights, warm days, warm spell duration, and cold spell duration is presented in Table 6.

Table 6: Changes in the extreme events

Number of rainy days	The number trend is mixed across the country. It is increasing in the High Mountain district of Karnali, such as Humla with one day/yr of an increasing trend. The other districts such as Mugu, Dolpa, Jumla, Bajura Eastern and Western Rukum, Bhojpur, Khotang, and Tehrathum of Hill, Middle Mountain, and High Mountain also have a higher positive trend. On the other hand, districts from Tarai to High Mountain and east to west receive rain in a fewer number of days. The highest rate of decreasing rainy days is observed in Rasuwa with 1.2 days/yr.
Consecutive dry days	A consecutive dry day trend shows a matching pattern but reverses, with a number of rainy days. Consecutive dry days are decreasing in High Mountain districts, such as Humla, Mugu, Dolpa of Karnali. While in many other districts in the Tarai to High Mountain and east to west have an increasing trend. Rasuwa observes the highest increasing trend (1.6 days/yr) of consecutive dry days, while Nuwakot, Dhading, Manang, and Mustang have the higher increasing rate of consecutive dry days.
Consecutive wet days	The consecutive wet days have a very similar pattern to the number of rainy days but reverse with the consecutive dry days. Humla, a High Mountain district of Karnali Province, observes the highest positive trend with 0.9days/yr while Rasuwa, another High Mountain district in Bagmati Province, depicts the highest negative trend with 0.8 days/yr. Other districts such as Dolpa, Eastern and Western Rukum, Bajura, Bhojpur, Khotang, Lamjung, and Gulmi have a clear positive trend. A negative trend is observed in many other districts such as Nuwakot, Dhading, Morang, and Sunsari.

Very wet days	There is no clear pattern of very wet days trend. However, most of the districts in Tarai of Lumbini, Province two and Province one, including and the Hill districts of Gandaki Province, Karnali Province, and Sudurpaschim Province have a clear increasing trend. Contrary to that, High and Middle Mountain districts such as Eastern and Western Rukum, Humla, Manang, Dolakha, and Ramechhap experience a decreasing trend.
Extreme wet days trend	Extreme wet days trend shows a very clear pattern of decreasing in High Mountain and Middle Mountain districts while it is near 0, no substantial change, in Hill, Chure, and Tarai. However, Syangja has the highest increasing extreme wet days trend, while Kanchanpur, the only district in the Tarai which observed decreased extreme wet days.
Warm days trend	The increasing warm days trend varies district by district. The highest increasing warm days trend is observed in the High and Middle Mountain and Hilly districts of Taplejung, Panchthar, and Tehrathum. A clear pattern of higher increasing warm days trend is shown in the High mountain and the Middle mountain. In the Hill districts, the warm days trend is moderate while, there is either no or very low increasing trend of warm days in the Tarai and Chure districts.
Cool days trend	A physiographical pattern can be observed in the cool days trend. A number of cool days depict a positive trend in several districts in the Tarai with the highest trend in Saptari 0.2 days/yr. The cool days trend is decreasing in all the High and Middle Mountain districts, except in Kalikot of Karnali Province and in Kaski of Gandaki Province where it is increasing. Tehrathum district depicts the highest negative cool days trend.
Warm Spell Duration trend (WSDI)	The warm spell duration is an increasing trend across the country except for one exception, Rautahat - a Tarai district of Province two. Many High Mountain districts in Province one, Bagmati Province, and Gandaki Province depict a clear increasing trend. Similarly, Kanchanpur, Baitadi, Darchula, Bajura, Dailekh, and Jajarkot of Sudurpaschim Province and Karnali Province also experience a substantial increasing trend.
Warm Nights trend	A mixed pattern of warm nights trend is observed across the country over forty years. The trend is higher in most of the districts in the central part of the country rather than far east and west. The highest negative trend is observed in the Manang while the highest positive trend exists in Tanahu.
Cool nights trend	The cool night shows a mixed pattern of increasing and decreasing trends. The eastern Tarai districts of Province one and two have a clear decreasing trend while it is an increasing trend in the High Mountain with a maximum of 0.7 days/yr in Humla.
Cold Spell Duration Index (CSDI) trend	The cold spell duration is in increasing in the west rather than in the eastern part of the country. Seven of eight districts of Sudurpaschim Province have a positive CSDI trend with 0.3 days/yr. Similarly, eight of nine districts of Province two, mostly in the Tarai region, observed the negative CSDI trend. Besides, Rolpa, of Lumbini Province depicts the negative CSDI trend.

4.3 Climate Change Scenarios

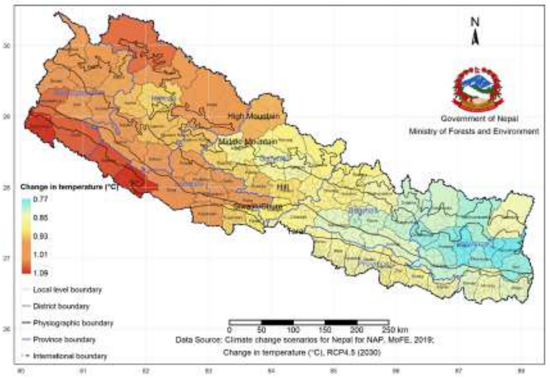
In this assessment, two possible trajectories – RCP 4.5, and 8.5 were selected as representative of an extreme future scenario for the medium-term (2016 – 2045) and the long-term period (2036 –2065) corresponding with the 2030s and 2050s timeframe agreed in the NAP process with the reference period 1981-2010. The details of the various climatic variables and extreme climatic conditions have been explained based on different administrative units and physiographic regions in the subsequent sub-section. Overall, the findings from the study suggest that precipitation and temperature will be higher in the future than in the reference period. Specifically, temperature variables are expected to increase continuously throughout the century. Annual precipitation might increase overall but vary seasonally.

4.3.1 Temperature Scenarios

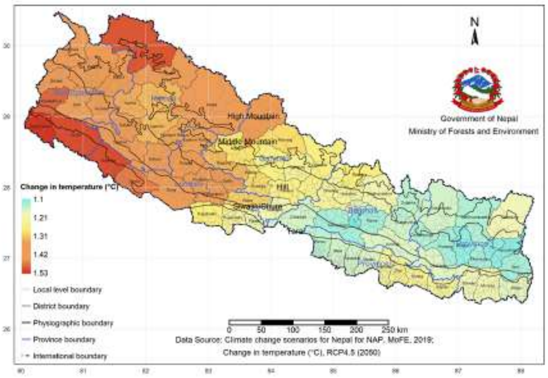
In the medium term of RCP 4.5, the average annual temperature change is projected to increase by 0.92°C with a variation of 0.77°C to 1.09°C. Also, it is expected to increase by 1.3°C on average with the variation from 1.1°C to 1.53°C in the long-term (Figure 13 a and b). The spatial variation is high in both periods. Kanchanpur, Banke, and Humla are observed to have a higher change while

Khotang, Okhaldhunga, Bhojpur, Tehrathum, and Panchthar are expected to observe minimum changes in the mid-term. Besides, in the long term, the spatial variability with higher changes will be noticed in the Sudurpaschim Province and Karnali Province. However, the variability will be lowest in Bagmati Province and Province one.

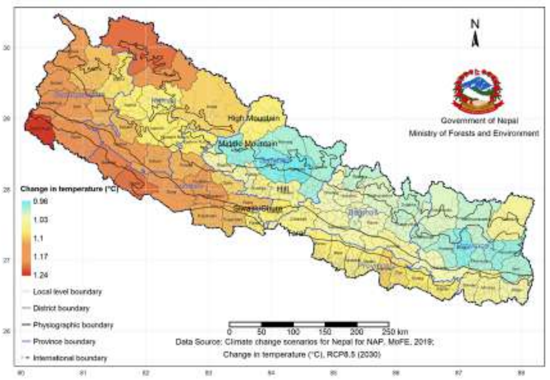
In the RCP 8.5, Figure 13 (c), and (d), the general pattern of the temperature change is very similar to that of RCP 4.5 with slight variation in intensity. The Tarai, Chure, and Middle and High Mountain districts of Sudurpaschim Province and Karnali Province are projected to have the highest positive change of temperature while the lowest increment is expected in the Hill districts of Gandaki Province and Province one. The average annual changes in the mid-term period are 1.02°C with a maximum of 1.24°C and a minimum is 0.96°C. In the long-term period of RCP 8.5, the average national change of temperature is projected by 1.82°C with the maximum changes (positive) is expected in the Kanchanpur district of Sudurpaschim Province with 2.09°C. A minimum of 1.64°C is expected in the Tehrathum and Panchthar, Hill districts of Province one.



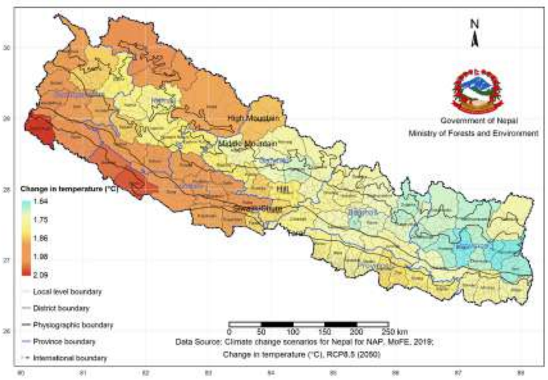
(a)



(b)



(c)



(d)

Figure 13: Mid-term and long-term temperature scenario in RCP 4.5 and 8.5[12]

4.3.2 Precipitation Scenarios

In the medium term of RCP 4.5, the average annual precipitation change is projected to increase by 2.1 percent while a 7.9 percent increment is projected in the long term. The spatial variation is high in both periods, which varies from -0.32 percent to 5.51 percent. The highest increment is expected in Mahottari of Province two, while it is expected to decrease in Jumla and Kalikot of Karnali Province. However, in the long-term period, the precipitation is projected to increase across the

12 Figure 13 shows the projected temperature in two RCP scenarios in medium-term (2030) and long-term (2050) periods across Nepal. The upper panel shows the changes of temperature for RCP 4.5 and the lower panel shows the changes of temperature for RCP 8.5 in the medium term.

country with the highest increment i.e. 12.28 percent in Mustang, and lowest in the High, and Middle mountain district of Province one with a 3.27 percent increment. In RCP 8.5 medium term, the average annual precipitation is projected to increase by 6.4 percent while it is 12.1 percent in the long-term period (Figure 14).

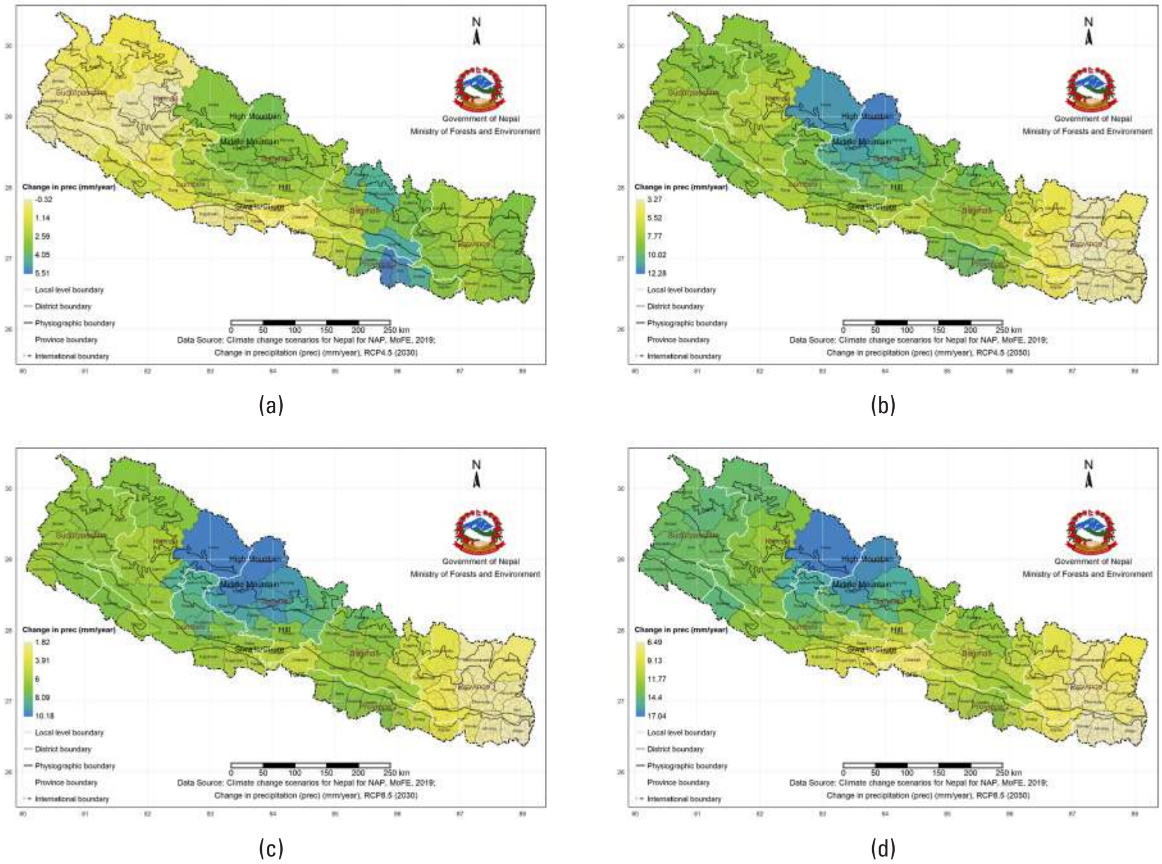


Figure 14: Mid-term and long-term precipitation scenario in RCP 4.5 and 8.5[13]

4.3.3 Extreme Events Scenarios

The considered extreme climate indices for this assessment include a number of rainy days, very wet days, extreme wet days, consecutive dry days, consecutive wet days, cool days, cool nights, warm nights, warm days, warm spell duration, and cold spell duration, which are is presented in Table 7. The findings below show that extreme climatic events, especially related to temperature, are likely to be more frequent and more severe.

13 Figure 14 shows the projected precipitation in two RCP scenarios in medium-term (2030) and long-term (2050) periods across Nepal. The upper panel, Figure 14 (a) medium-term and (b) long-term, shows the changes of precipitation for RCP 4.5 and the lower panel shows the changes of precipitation for RCP 8.5 in the medium term- left.

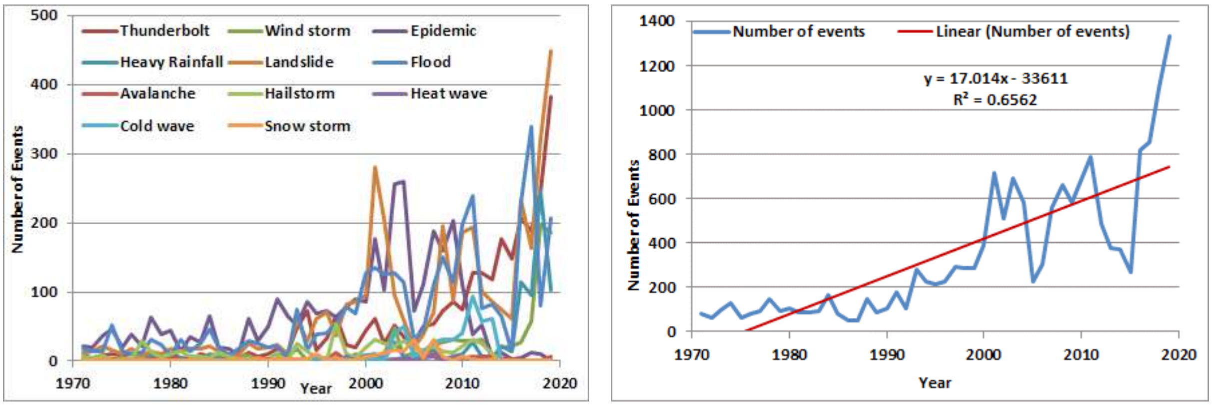
Table 7: Future Climate Extreme Indices

Extreme indices	Projected changes
Change in Very Wet Days (VWD) %	The very Wet Days (VWD) are projected to increase in most of the districts in both medium (2030) and long-term (2050) scenarios. However, most of the districts of Karnali Province and Sudurpaschim Province in RCP 4.5 (2030) are projected to experience a decrease in very wet days.
Change in Extreme Wet Days (EWD) %	In RCP 4.5 (2030), the eastern region of the country has a higher increment in the EWD whereas the increment is decreasing as we move towards the western region. In RCP 8.5 2030, most of the districts of Lumbini Province and Karnali Province are expected to experience more EWD (percent) compared to districts of other Provinces. The western part of the Gandaki Province is expected to observe more change (increase) in EWD compared to districts east of Gandaki Province.
Change in number of rainy days %	The number of rainy days under RCP 4.5 (2030) is projected to decrease in all districts. The change in the number of rainy days is less in Province one as compared to other Provinces. In RCP 8.5 (2030), the number of rainy days is projected to decrease significantly in most of the districts of Province two as compared to other Provinces. Arghakhanchi (0.12) is the only district to have an increase in the number of rainy days.
Change in Consecutive Wet Days (CWD) %	The changes in CWD are increasing in some part of the country while decreasing in other in both RCPs for the medium (2030) and long-term (2050). Specifically, in RCP 4.5 scenarios the districts of Chure and Tarai are predicted to have a decrease in CWD. In the RCP 8.5 scenario, the eastern region of the country is predicted to have a negative charge, but the western region of the country is predicted to have positive change. The range of the change is also high as we move from medium-term (2030) and long-term (2050) in both scenarios i.e., RCP 4.5 and RCP 8.5.
Change in Warm Days (WD) %	Warm Days (WD) are predicted to increase in both the medium and long-term in both the RCPs scenarios. Moreover, the rate of increase in WD is also more in RCP 8.5 than in RCP 4.5. More specifically, the eastern part of the country is predicted to have more warm days as compared to the western part. Among the Provinces, Province one is predicted to have more WD as compared to other Provinces. The rate of the change keeps increasing as we move from medium-term (2030) and long-term (2050) in both scenarios i.e., RCP 4.5 and RCP 8.5.
Change in Warm Nights (WN) %	Warm Nights (WN) are predicted to increase in all districts in both the medium and long term under the RCPs scenarios. Moreover, the rate of increase in WN is also more in the long term than in the medium term or in RCP 8.5 than in RCP 4.5. More specifically, the Tarai and the Siwalik regions are predicted to have more warm nights in the future. On the contrary, the mountainous districts, especially of Gandaki Province, Karnali Province, and Sudurpaschim Province are predicted to have less increase in warm nights. The rate of the change keeps increasing as we move from medium-term (2030) and long-term (2050) in both scenarios i.e., RCP 4.5 and RCP 8.5.
Change in Cold Days (CD) %	Cold days are predicted to decrease in both medium and long-term in both RCPs scenarios. More specifically, the western part of the county is predicted to experience the lowest rate of decrease in Cold Days (CD) as compared to the eastern part. Among the Provinces, Province one is predicted to have a lower rate of decrease in CD than other Provinces. In RCP 4.5 scenarios, Province two is predicted to experience the lowest rate of decrease in CD. On the contrary, in RCP 8.5 scenarios the mountainous districts of Province one are predicted to experience the highest rate of decrease in cold days in the future.
Change in Cold Nights (CN) %	Cold Nights (CN) are predicted to decrease in both the medium and long-term in both RCPs scenarios. More specifically, the western part is predicted to experience the lowest rate of decrease in CN as compared to the eastern part. Among the Provinces, Province two in RCP 4.5 scenarios are predicted to experience the lowest rate of decrease in CN. On the contrary, in RCP 8.5 scenarios the Tarai and Siwalik districts of Province one are predicted to experience the lowest rate of decrease in cold nights.
Consecutive Dry Days (CDD) %	In RCP 4.5 (2030), the Consecutive Dry Days (CDD) is projected to increase in all the districts. More specifically CDD is projected to increase more in the districts of Lumbini Province. Whereas, CDD is predicted to increase less in the districts of Province one compared to other Provinces.
Warm Spell Duration Index (WSDI) %	Warm Spell Duration (WSDI) is projected to increase in all districts in RCP 4.5 2030. The WSDI in the eastern region of the country is projected to increase more whereas the change will decrease as we move towards the western part of the country.
Cold Spell Duration Index (CSDI) %	The CSDI is predicted to decrease in most of the districts in both medium and long-term under the RCPs scenarios. The Saptari district of Province two under RCP 8.5 in 2030 is predicted to experience a slight increase in CSDI. Moreover, the western Provinces/districts in both RCPs are predicted to have lesser CSDI than the central and the eastern districts. Province-wise comparison shows that Province two is expected to experience a minimum rate of decrease in CSDI as compared to other Provinces. The rate of the change keeps increasing as we move from medium-term (2030) and long-term (2050) in both scenarios i.e., RCP 4.5 and RCP 8.5.

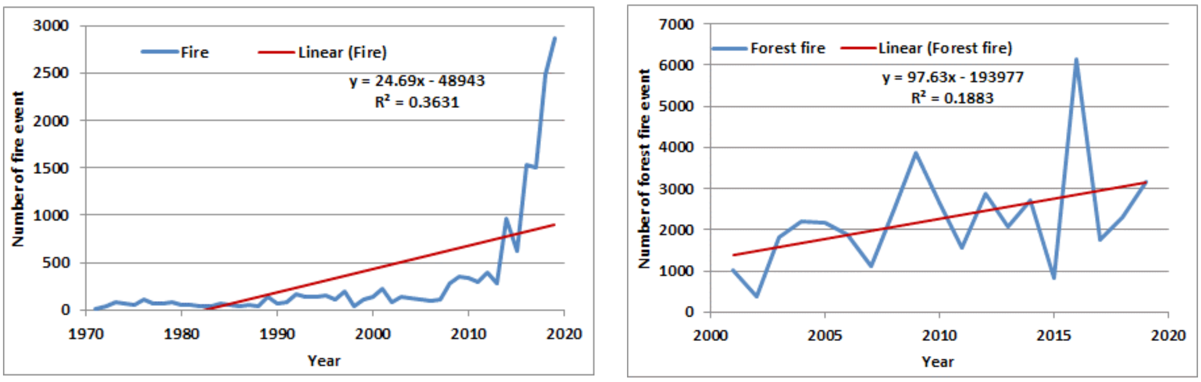
4.4 Climate-Induced Hazards

4.4.1 Trend of Climate-induced Hazards

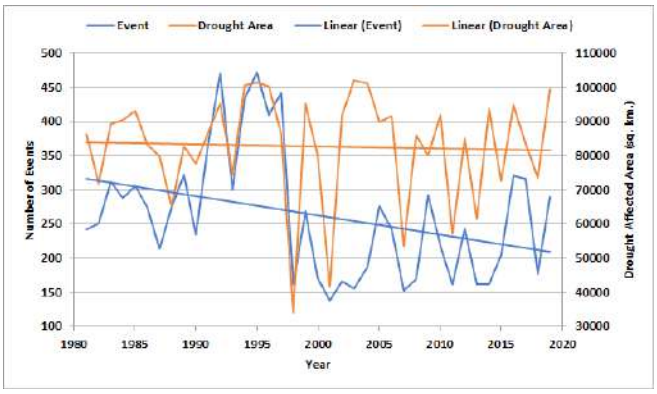
The trend of several climatic hazards was examined using data from the DesInventar database and the Nepal Disaster Risk Reduction Portal encompassing 49 years (1971-2019). The trend analysis of 11 climatic hazards (Thunderbolt, Windstorm, Epidemic, Heavy Rainfall, Landslide, Flood, Avalanche, Hailstorm, Heatwave, Coldwave, and Snowstorm) revealed a significant increase in climatic hazards, particularly after 1990. The trend of 11 climatic hazards in Nepal is illustrated in Figure 15.



a) Trend of 11 climatic hazards and the impact



b) Trend of fire and forest fire events



c) Trend of drought events and areas

Figure 15: All Nepal trends of climatic hazards in Nepal: a) trend of 11 hazards; b) trend of fire and forest fire; c) trend of drought events and areas

The most common hazards are fires and forest fires. The International Centre for Integrated Mountain Development created the Forest Fire Detection and Alert Information System for Nepal using data from the National Aeronautics and Space Administration's (NASA) Moderate Resolution Imaging Spectroradiometer sensors (MODIS) . ICIMOD provided forest fire data from 2001 to 2019. Figure 15b shows fire and forest fire event trends. Both fire and forest fire events are becoming more common. The meteorological droughts are defined as the events with the Standardized Precipitation Index (SPI) values less than or equal to -1. The raster data of SPI from 1981 to 2019 was obtained from ICIMOD. The analysis of SPI from 1981 to 2019 showed that the average duration of drought is about 3.4 months (102 days) per year. On average, about 56 percent area of Nepal is affected by drought. Figure 15c shows the trends of drought events in the month and drought-affected areas from 1981 to 2019. There are also reported drought cases in 2020/2021 in Nepal impacting the agriculture sector. However, both drought events (months) and drought-affected areas are in decreasing trend but the trends are not statistically significant.

Table 8 below presents the results of the Mann-Kendall test and Sen's slope for 14 climatic hazard events. Among 14 climatic hazards, all-hazards except drought are in increasing trend. The drought events are in decreasing trend. However, the contextual drought cases may have increased such as specific drought in some regions and districts. While trends of epidemic, avalanche, hailstorm, and drought are statistically insignificant, the trends of the other 12 hazards are statistically significant at a 5 percent level.

Table 8: Mann-Kendall test statistics for linear trend of 14 climatic hazard events

Hazard	Z-statistic	P-value	Sen's Slope	Significance (5 percent)
Fire	6.40	0.00	7.32	Yes
Thunderbolt	7.44	0.00	2.70	Yes
Windstorm	5.23	0.00	0.57	Yes
Epidemic	1.63	0.10	1.16	No
Heavy Rainfall	4.53	0.00	0.25	Yes
Landslide	6.62	0.00	2.70	Yes
Flood	5.43	0.00	2.64	Yes
Avalanche	1.61	0.11	0.03	No
Hailstorm	0.34	0.74	0.00	No
Heat wave	2.18	0.03	0.00	Yes
Cold wave	3.70	0.00	0.00	Yes
Snowstorm	2.60	0.01	0.04	Yes
Forest fire	1.96	0.05	83.50	Yes
Drought	-1.73	0.08	-2.39	No

The survey conducted by the Central Bureau of Statistics (CBS) of the Government of Nepal provided data on people's knowledge and perception about climate change, climate-induced disasters, human and socio-economic impacts, and adaptation practices (CBS, 2017). The survey revealed that most households are observing climate change and increase in different climate-induced disasters including floods, landslides, drought, hailstorms, and disease/insects in the last 25 years. About 99.33 percent of respondents have observed ascending incidences of drought in the last 25 years, followed by disease/insects (97.69 percent), landslides (78.12 percent), and inundations (51.47 percent). Similarly, all households in the central mountain region reported an increase in coldwaves while they observed a decrease in coldwave in central hills. Likewise, 56.25 percent of eastern Tarai households have observed an increase in heatwaves. All sub-alpine households perceived an increase in droughts, landslides, avalanches, and diseases/insects. The majority of households (64.05 percent) in the temperate zone observed an increase in fires in the last 25 years.

Flood: The quantitative baseline context of climatic hazards is obtained for historical climate using the indicators. Baseline context and district-wise rank of flood hazard based on historical climate (1971-2019) are given in Figure 16 and Table 9 respectively. The district-wise rank of flood hazard based on the historical climate shows that Sunsari, Kailali, Morang, Jhapa, Rautahat, Bardiya, Sarlahi, and Saptari districts are the most flood-prone districts and identified as "Flood Hazard Hotspots".

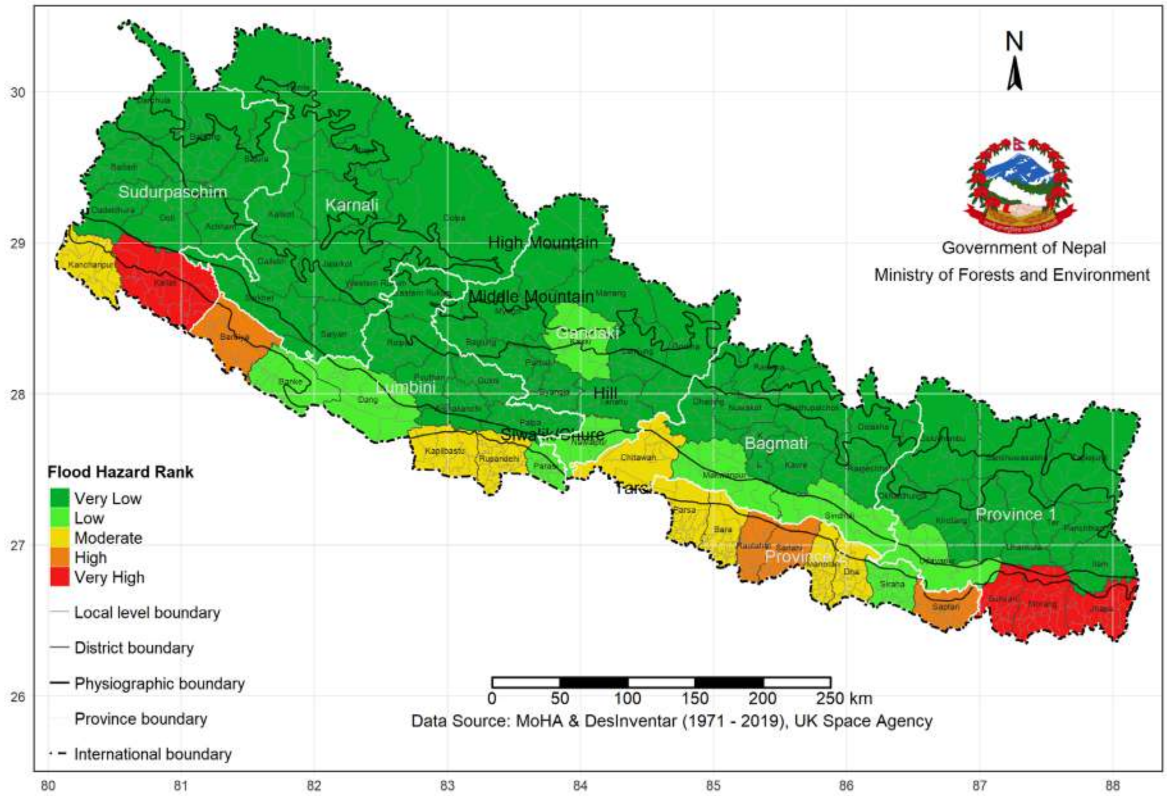


Figure 16: **Baseline context of flood hazard based on historical climate**

Table 9: District wise rank of baseline context of flood hazard based on historical climate

Hazard Rank	Districts for baseline context of flood hazard (1971-2019)
Very High (0.731 - 1)	Sunsari, Kailali, Morang, Jhapa
High (0.595 - 0.730)	Rautahat, Bardiya, Sarlahi, Saptari
Moderate (0.412 - 0.594)	Kapilbastu, Rupandehi, Bara, Chitawan, Dhanusha, Kanchanpur, Mahottari, Parsa
Low (0.170 - 0.411)	Makawanpur, Udayapur, Banke, Siraha, Sindhuli, Dang, Nawalpur, Kaski, Parasi
Very Low (0 - 0.169)	Dhading, Rolpa, Humla, Mugu, Rasuwa, Myagdi, Lamjung, Dolakha, Dhankuta, Terhathum, Nuwakot, Sankhuwasabha, Baglung, Western Rukum, Sindhupalchok, Gorkha, Solukhumbu, Lalitpur, Tanahu, Kavrepalanchok, Dailekh, Bhaktapur, Parbat, Pyuthan, Darchula, Syangja, Dolpa, Surkhet, Achham, Arghakhanchi, Baitadi, Palpa, Bhojpur, Salyan, Mustang, Doti, Manang, Eastern Rukum, Khotang, Okhaldhunga, Bajura, Kalikot, Taplejung, Panchthar, Jajarkot, Jumla, Bajhang, Gulmi, Ramechhap, Kathmandu, Dadeldhura, Ilam

Landslide: Baseline context and district-wise rank of landslide hazard based on historical climate (1971-2019) are given in Figure 17 and Table 10 respectively. District wise rank of landslide hazard based on the historical climate shows that Dhading, Sankhuwasabha, Baglung, Sindhupalchok, Dolpa, Taplejung, Rolpa, Makawanpur, Myagdi, Lamjung, Dolakha, Nuwakot, Gorkha, Solukhumbu, Kavrepalanchok, Dailekh, Darchula, Syangja, Palpa, Khotang, Bajura, Kalikot, Kaski, Jajarkot, Bajhang, Gulmi and Ilam districts are the most landslide-prone districts and identified as "Landslide Hazard Hotspots".

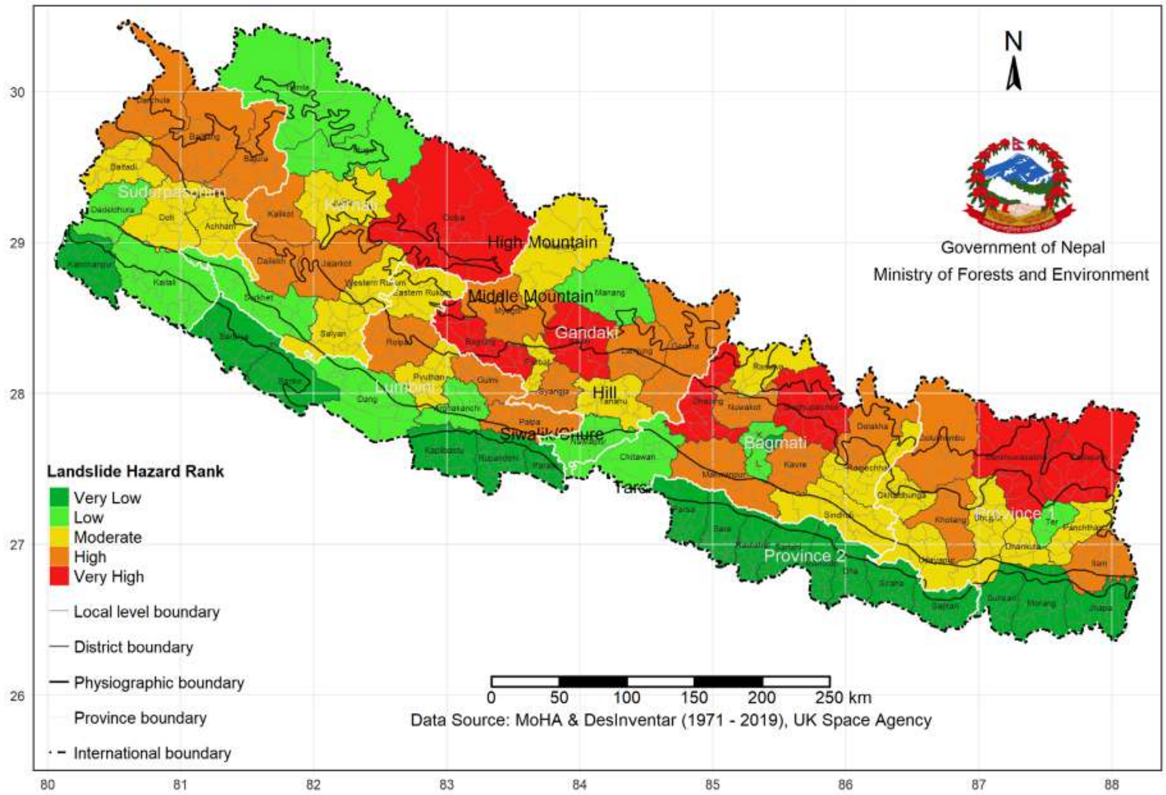


Figure 17: Baseline context of landslide hazard based on historical climate

Table 10: District wise rank of baseline context of landslide hazard based on historical climate

Hazard Rank	Districts for baseline context of Landslide Hazard (1971-2019)
Very High (0.757 - 1)	Dhading, Sankhuwasabha, Baglung, Sindhupalchok, Dolpa, Kaski, Taplejung
High (0.539 - 0.756)	Rolpa, Makawanpur, Myagdi, Lamjung, Dolakha, Nuwakot, Gorkha, Solukhumbu, Kavrepalanchok, Dailekh, Darchula, Syangja, Palpa, Khotang, Bajura, Kalikot, Jajarkot, Bajhang, Gulmi, Ilam
Moderate (0.366 - 0.538)	Rasuwa, Dhankuta, Western Rukum, Tanahu, Udayapur, Parbat, Pyuthan, Achham, Baitadi, Bhojpur, Sindhuli, Salyan, Mustang, Doti, Eastern Rukum, Okhaldhunga, Panchthar, Jumla, Ramechhap
Low (0.143 - 0.365)	Humla, Mugu, Terhathum, Lalitpur, Kailali, Surkhet, Arghakhanchi, Manang, Chitawan, Dang, Nawalpur, Kathmandu, Dadeldhura
Very Low (0 - 0.142)	Kapilbastu, Sunsari, Rautahat, Bardiya, Bhaktapur, Banke, Siraha, Rupandehi, Morang, Bara, Dhanusha, Kanchanpur, Jhapa, Sarlahi, Mahottari, Parasi, Parsa, Saptari

Heatwave and cold wave: The heatwaves have increased in recent years in Banke, Bara, Bardiya, Kapilbastu, Parsa, Rautahat, Rupandehi, Saptari, and Sunsari districts. These districts have also shown an increasing trend in annual maximum temperature and warm spell duration. The cold wave affected districts are Mahottari, Saptari, and Rautahat. However, these districts have shown an increasing trend in annual minimum temperature and a decreasing trend in cold spell duration in recent years, and hence cold waves are expected to decrease in these districts in the future (Figure 18).

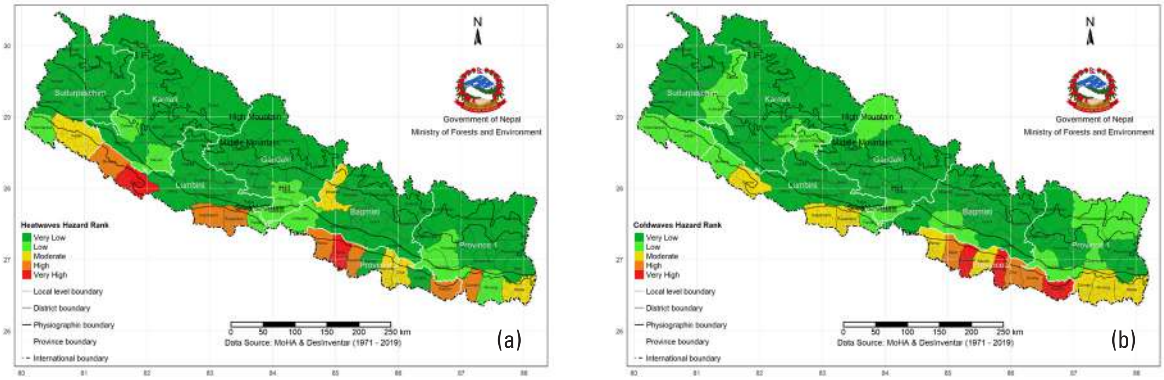


Figure 18: Baseline hazard Map: a) Heatwave, b) Cold Wave

Snowstorms: The trend analysis of snowstorms from 1971 to 2019 shows an increasing trend (Figure 19). The most snowstorm-affected districts are Humla, Jumla, Dolpa, and Taplejung. These districts have also shown decreasing trend in winter minimum temperature. However, with an increase in temperature, the snowstorms may decrease in the future.

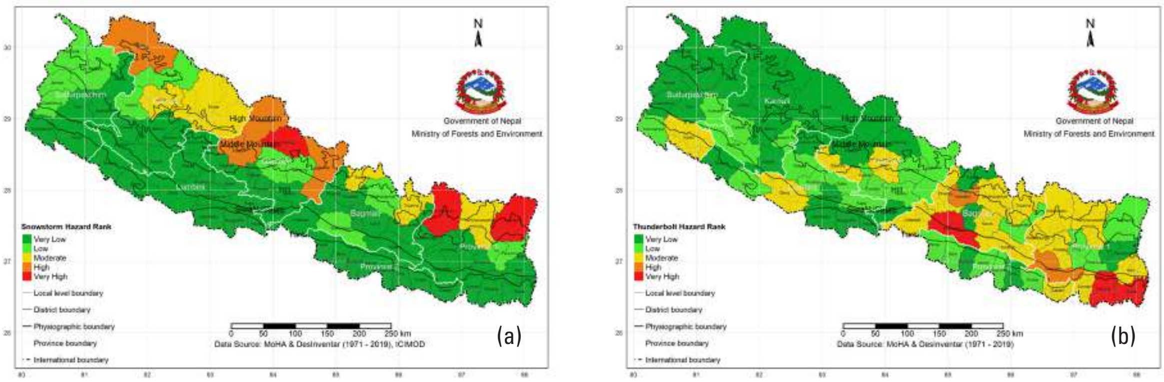


Figure 19: Baseline hazard Map: a) Snowstorm, b) Thunderbolts

Thunderbolts: Thunderbolts or lightning have increased in recent years in Makawanpur, Jhapa, Morang, and Udaypur districts. The trend of thunderbolt events in the Makawanpur district was compared with the trend of the annual average temperature and rainfall. Figure 20 shows the trend of thunderbolt events and annual average temperature and their relationship in Makawanpur district. Both trends for thunderbolt events and annual temperatures are increasing. The number of thunderbolt events increases when the annual temperature increases.

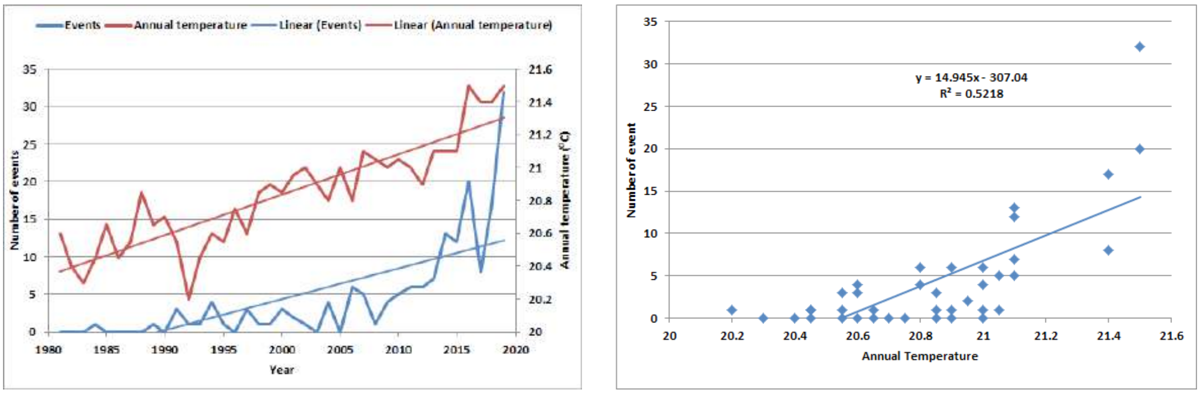


Figure 20: Trend of thunderbolt events and annual average temperature and their relationship

Similarly, Figure 21 shows the trend of thunderbolt events and annual rainfall and their relationship in the Makawanpur district. Both thunderbolt events and annual rainfall are in increasing trend. The number of thunderbolt events increases when the annual rainfall increases.

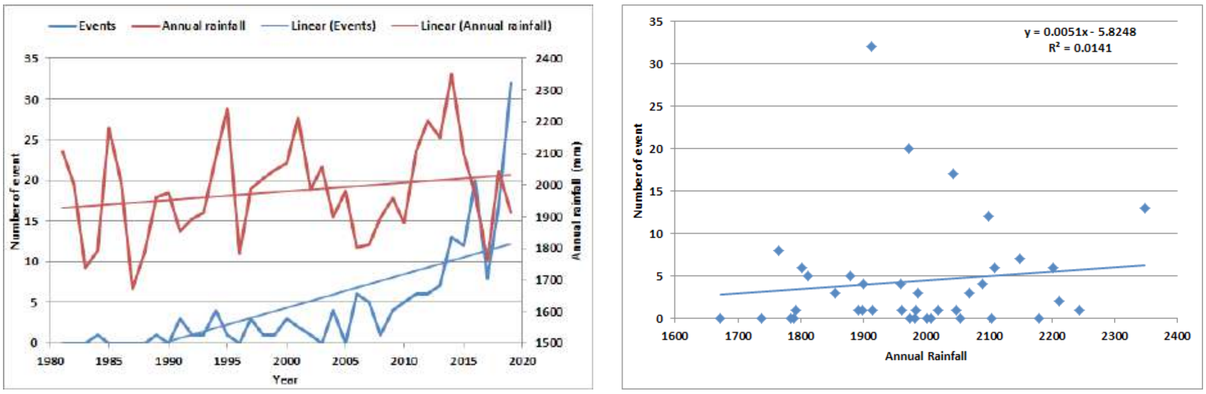


Figure 21: Trend of thunderbolt events and annual rainfall and their relationship

Windstorm: In Nepal, windstorm hazards are increasing in recent years in Achham, Morang, Saptari, Kailali, and Bardiya districts. Figure 22 shows the trend of the windstorm events and annual maximum temperature and their relationship in the Morang district. Both the windstorm events and annual maximum temperature are in increasing trend. The number of windstorm events increases when the annual maximum temperature increases.

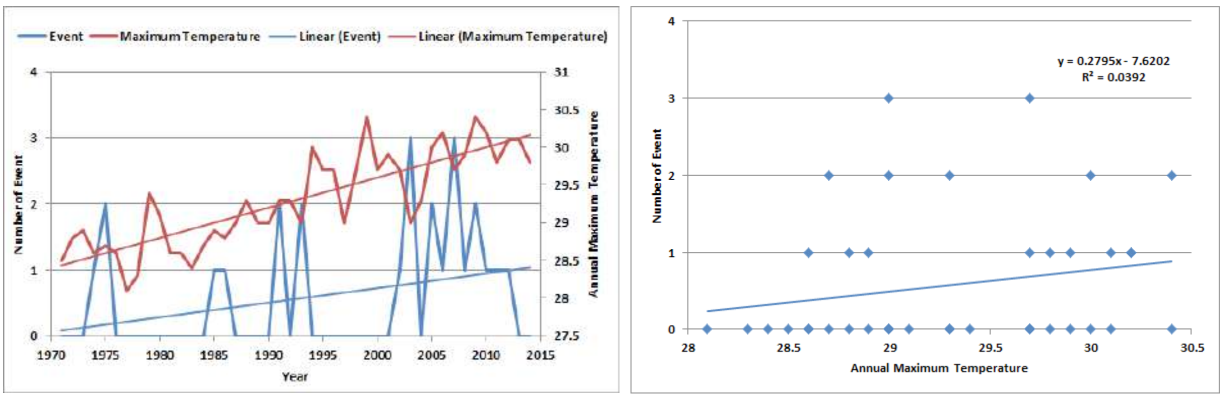


Figure 22: Trend of windstorm events and annual maximum temperature and their relationship

Hailstorm: Hailstorm hazards are increasing in recent years but they are not statistically significant. The most hailstorm-affected districts are Kaski, Parbat, Tanahu, Syangja, and Myagdi. In the last 49 years (1971-2019), 569 hailstorm events have occurred in various districts of Nepal (Figure 23).

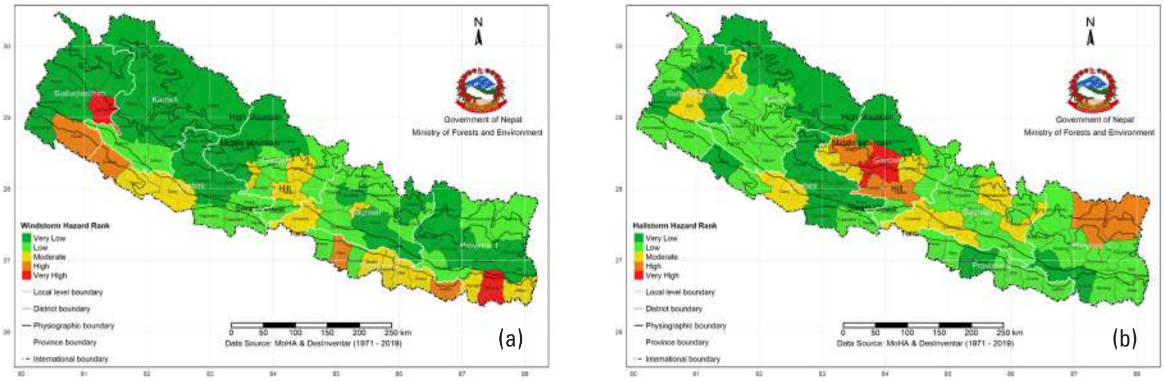


Figure 23: Baseline hazard Map: a) Windstorm, b) Hailstorm

Avalanche: The trend analysis of avalanche hazards shows an increasing trend in recent years in Solukhumbu, Kaski, Manang, and Dolpa districts but they are not statistically significant. With an increase in temperature in the future, avalanches are expected to increase (Figure 24).

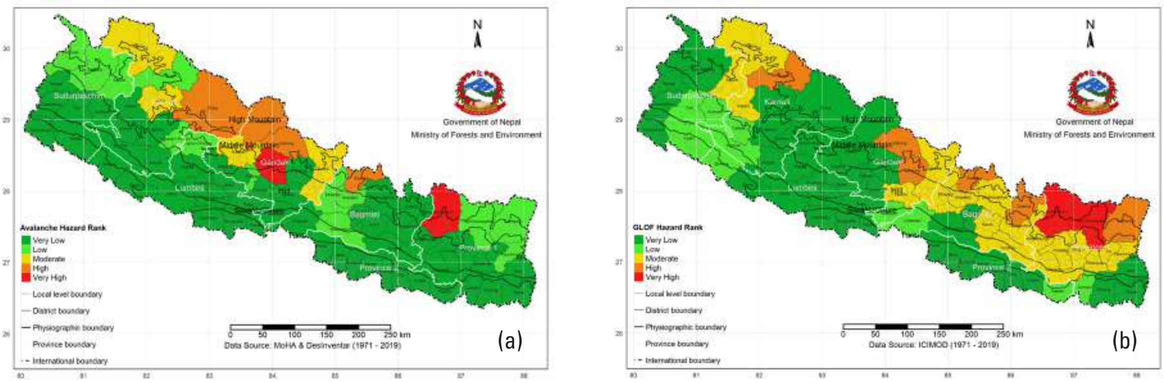


Figure 24: Baseline hazard Map: a) Avalanche, b) GLOFs

Glacial Lake Outbursts Floods (GLOFs): In response to climate fluctuations, glaciers grow and shrink in length, width, and depth. Receding and wasting glaciers are a sign of global climate change. With the melting of glaciers, glacial lakes are created on the lower sections. Several of these lakes have burst in the past-producing catastrophic floods (Glacial Lake Outburst Floods) that have destroyed infrastructure and taken human lives in the valleys downstream. Eventually, 47 glacial lakes were identified as potentially dangerous. These include 42 lakes in the Koshi, 3 in the Gandaki, and 2 in the Karnali basins (Figure 24). Of these, 25 Potentially Dangerous Glacial Lakes (PDGLs) are in the Tibetan Autonomous Region, China, and flow across the border into Nepal, 21 PDGLs are situated in Nepal, and one is located in India (Table 11).

Table 11: Potentially Dangerous Glacial Lakes (PDGLs) in Nepal

Basin	Sub-basin	Potentially dangerous glacial lakes
Koshi	Tamor	4
	Arun	4
	Dudh Koshi	9
	Tama Koshi	1
	Sunkoshi	0
Gandaki	Trishuli	1
	Marsyangdi	1
	Kali	0
Karnali	Humla	1

Drought: Dolpa, Humla, Gorkha, Mugu, and Kailali are the most drought-prone districts (Figure 25). The trend of the drought-prone areas in the Dolpa district was compared with the trend of annual rainfall. Figure 26 shows the trend of the drought-prone areas and annual rainfall and their relationship in the Dolpa district. The drought-prone areas are in decreasing trend whereas the annual rainfall has no distinct trend. However, monsoon rainfall, the number of rainy days, and consecutive wet days are in increasing trend in the Dolpa district (DHM, 2017). Besides, the drought-prone area decreases when the rainfall increases.

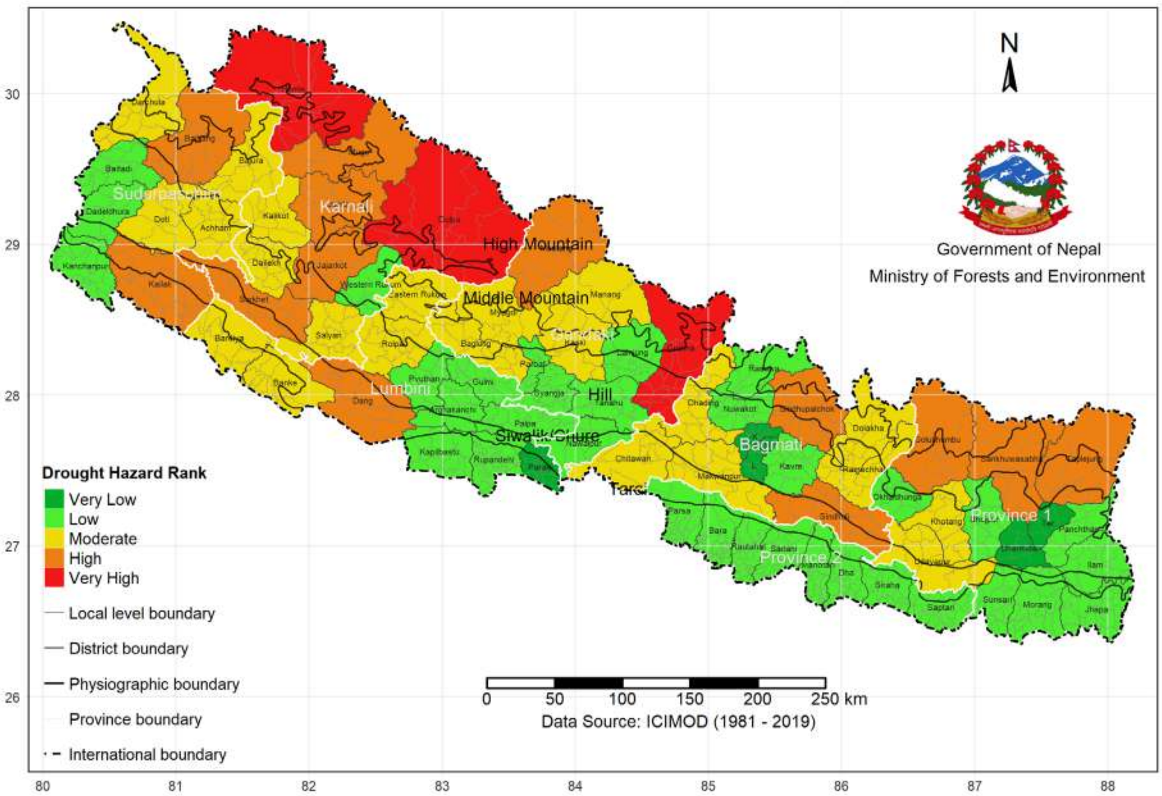


Figure 25: Baseline hazard Map of Drought

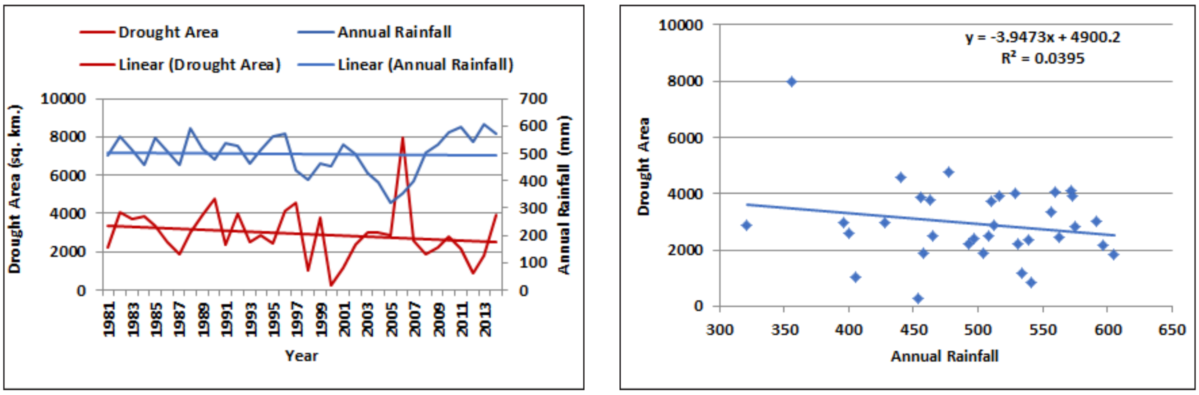


Figure 26: Trend of drought-prone areas and annual rainfall in Dolpa district

Fire and Forest Fire: Climate change may result in longer fire seasons in some parts of the country, easier ignition, and, therefore, potentially a greater number of fires, faster fire spread, increased fire intensities, more prolonged fire, and greater areas/settlements burned. It may result in more difficult fire suppression and increase fire suppression costs and damages.

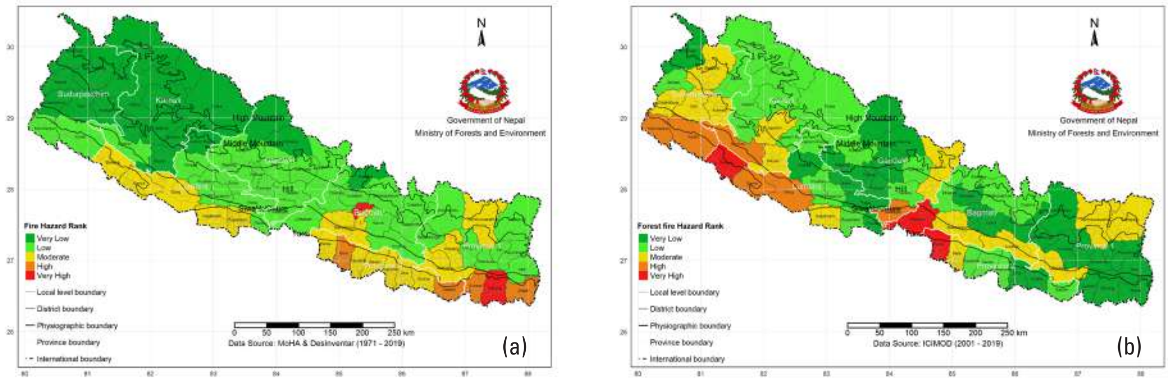


Figure 27: Baseline hazard Map: a) Fire, b) Forest Fire

Weather elements influence the spread and control of fire. The key weather elements that increase fire risk and danger are temperatures, humidity, wind speed, and rainfall. The interaction between increasing temperature and wind speed and decreasing rainfall and humidity in each region are key influences on fire risk. Potentially hotter, windier, and drier weather in the future will increase fire risk.

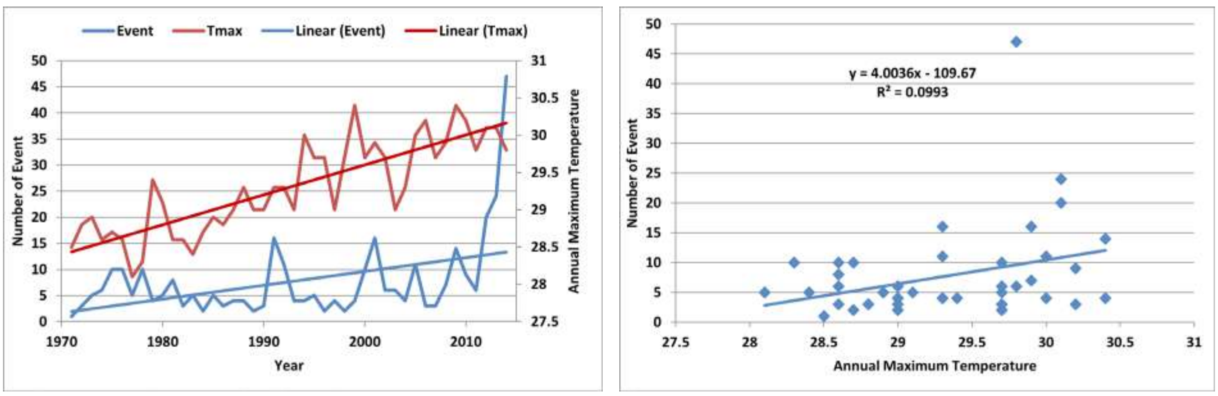


Figure 28: Trend of fire events and annual maximum temperature and their relationship

In Nepal, fire hazards are increasing in recent years in Kathmandu, Morang, Saptari, Sunsari, and Jhapa districts (Figure 27). The trend of the fire events in the Morang district was compared with the trend of the annual maximum temperature and rainfall. Figure 28 shows the trend of the fire events and annual maximum temperature and their relationship in the Morang district. Both fire events and annual maximum temperature are in increasing trend. The number of fire events increases when the annual maximum temperature increases. Similarly, Figure 29 shows the trend of fire events and annual rainfall and their relationship in the Morang district. The fire events are in increasing trend. However, annual rainfall has no distinct trend. The number of fire events decreases when the annual rainfall increases. However, the occurrence of fire is triggered by many factors and climatic parameters are just the triggering factors.

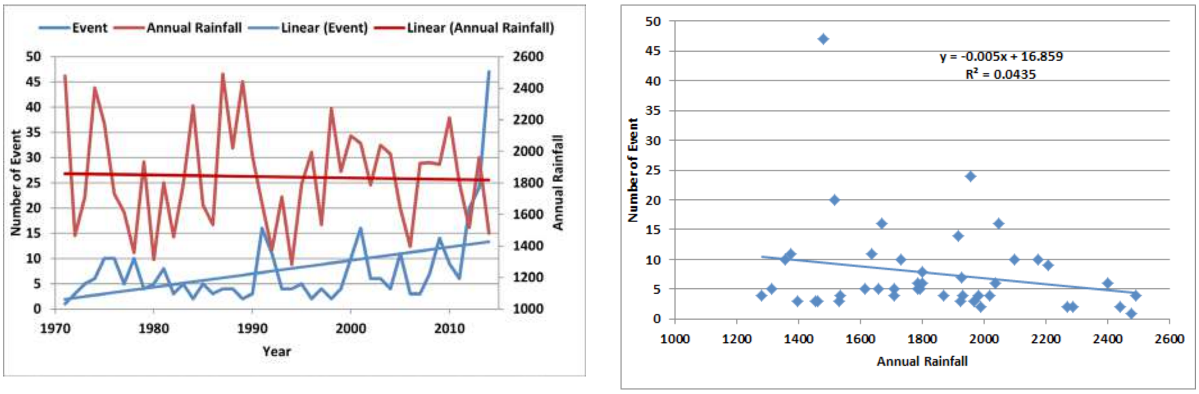


Figure 29: Trend of fire events and annual rainfall and their relationship

In Nepal, forest fire hazards are increasing in recent years in Bardiya, Chitawan, Parsa, and Surkhet districts. The trend of forest fire events in the Bardiya district was compared with the trend of pre-monsoon rainfall and annual maximum temperature. Figure 30 shows the trend of forest fire events and pre-monsoon rainfall and their relationship in the Bardiya district. Forest fire events are in increasing trend whereas pre-monsoon rainfalls are in decreasing trend. The number of forest fire events decreases when the pre-monsoon rainfall increases.

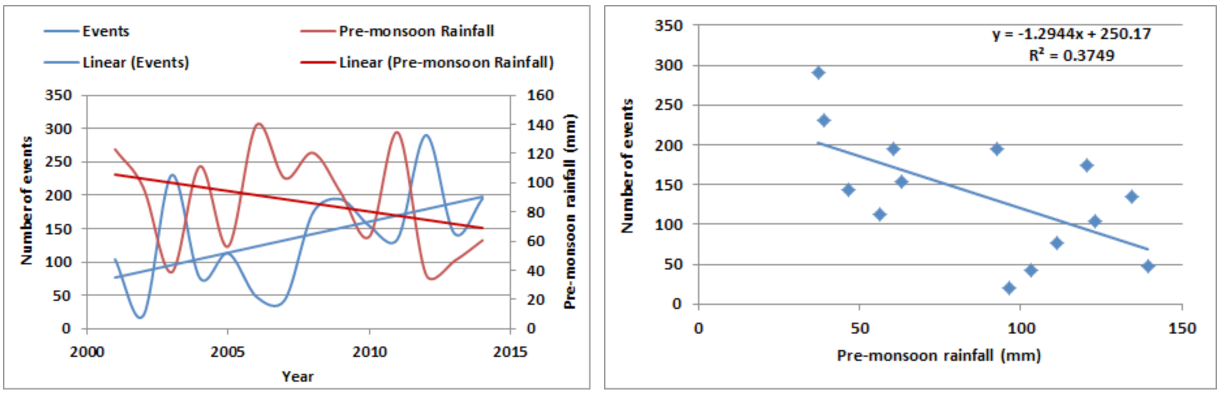


Figure 30: Trend of forest fire events and pre-monsoon rainfall and their relationship

Similarly, Figure 31 shows the trend of forest fire events and annual maximum temperature and their relationship in the Bardiya district. Both forest fire events and annual maximum temperature are in increasing trend. The number of forest fire events increases when the annual maximum temperature increases.

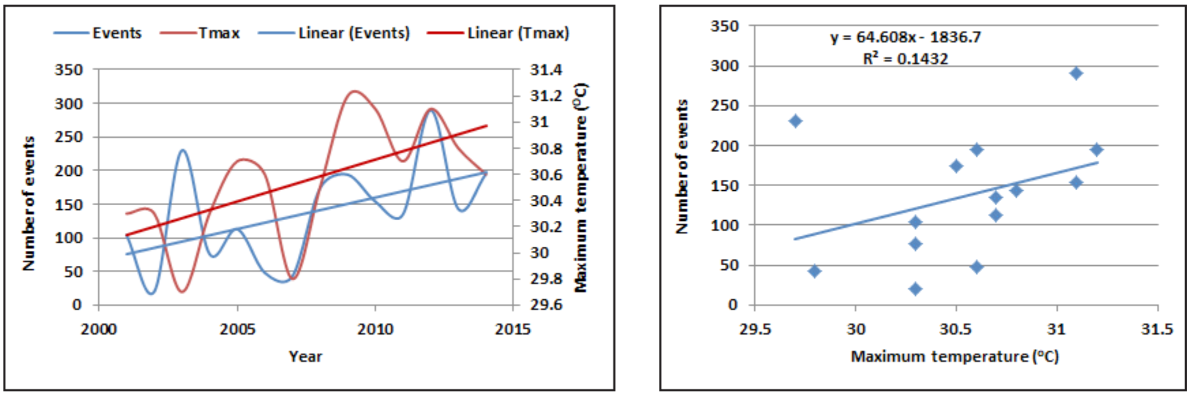


Figure 31: Trend of forest fire events and annual maximum temperature and their relationship

However, it is important to note that forest fire occurrence in the protected areas and national and community forests might be influenced by controlled burning practices that happen every year to ensure the growth of grassland.

Epidemics: Analysis of 49 years (1971-2019) of epidemics data revealed that Morang, Dang, Jajarkot, and Banke are the most epidemics-affected districts in Nepal. The trend of the epidemic events in the Dang district was compared with the trend of the annual rainfall and annual maximum temperature. Figure 32 shows the trend of the epidemic events and annual rainfall and their relationship.

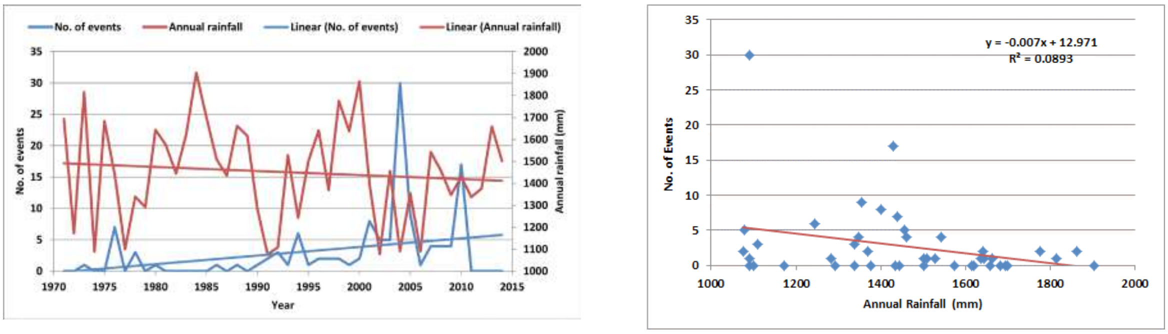


Figure 32: Trend of epidemic events and annual rainfall in Dang district

Similarly, Figure 33 shows the trend of epidemic events and annual maximum temperature and their relationship. The epidemic events are in increasing trend whereas the annual rainfalls are in slightly decreasing trend and maximum temperatures are in increasing trend. Observed climate trend analysis by DHM (2017) showed that annual rainfall in Dang district is in decreasing trend and consecutive dry days are in increasing trend. Similarly, annual temperature, warm days, and warm spell duration are in increasing trend. A warm and dry climate provides a favorable condition for the growth and spread of vector-borne and water-borne diseases.

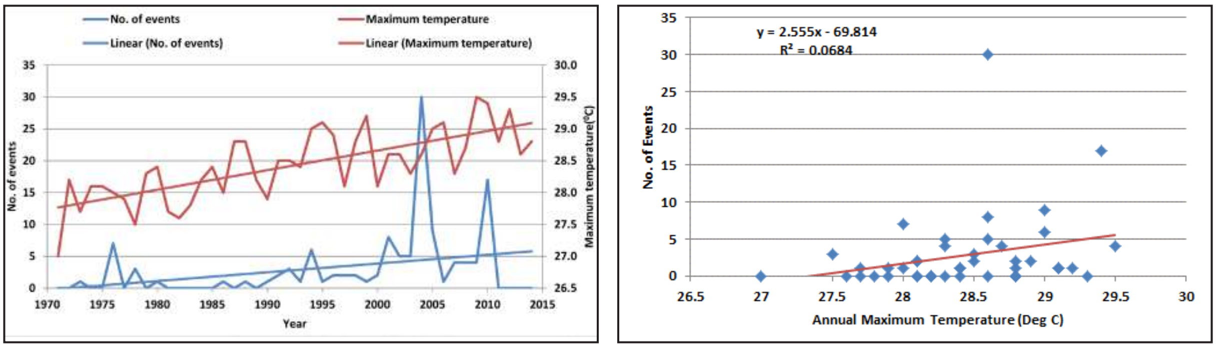


Figure 33: Trend of epidemic events and annual maximum temperature in Dang district

Summary: The significant increasing trends in the frequency of several climatic hazards show a strong linkage between climate change and an increase in climatic hazards. The observed increase in climatic hazards may be attributed to a "complex set of interactions between the physical earth system, human interference with the natural world and increasing vulnerability of human communities[14]". The IPCC (2014) also suggests that there is very high confidence that "in urban areas climate change is projected to increase risks for people, assets, economies, and ecosystems, including risks from heat stress, storms, and extreme precipitation, inland flooding, landslides, air pollution, drought, and water scarcity".

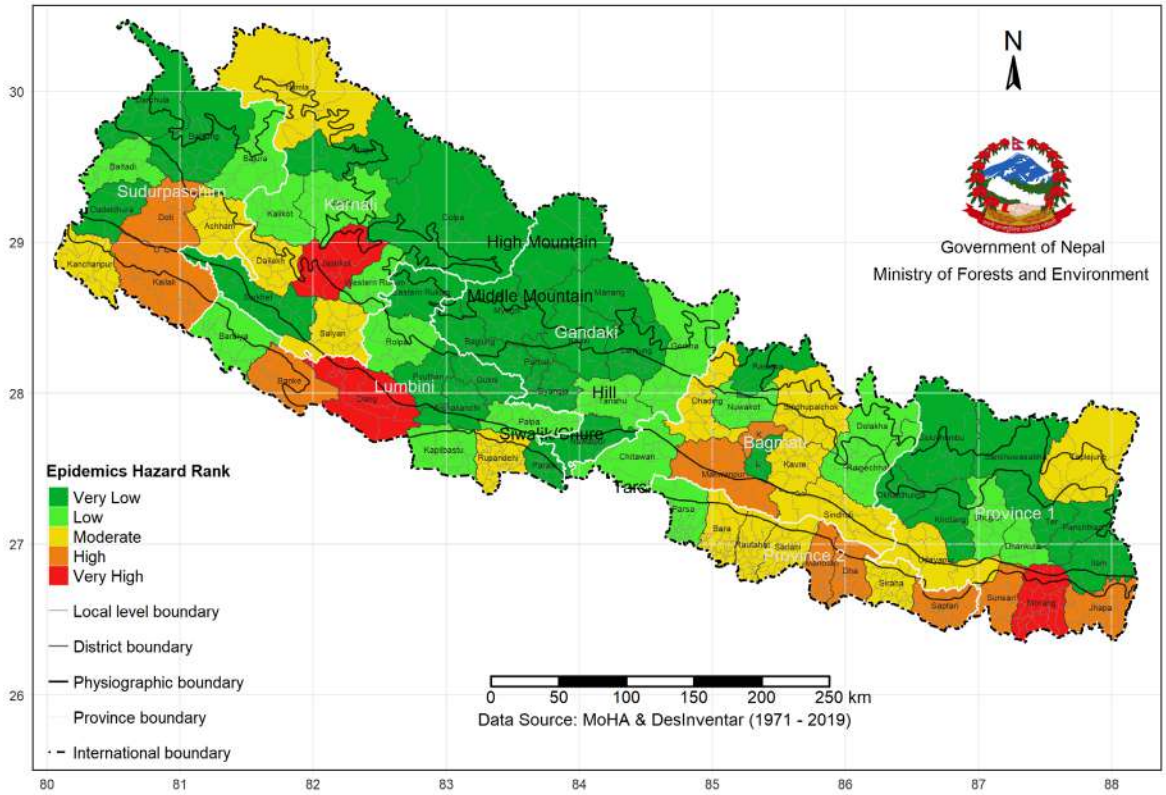


Figure 34: Baseline hazard Map of Epidemics

14 https://theconversation.com/explainer-are-natural-disasters-on-the-rise-39232 Accessed 21st March 2021.

4.4.2 Future Scenarios of Climatic Hazards

Information that enables the characterization of a future climatic hazard scenario is sourced either from the data from past hazard occurrence (Sharma and Patwardhan, 2008) or models (Lung et al., 2013; Metzger et al., 2006). However both sources, past hazard-based and model-based information, at best enable an approximation of the anticipated hazard and thus involve uncertainty (Jagmohan and Ravindranath, 2019). Future scenarios of climatic hazards can be inferred using the scenarios of temperature, precipitation, and climate extreme indices as indicators which can be expressed in descriptive terms.

The climatic hazards may become more frequent, widespread, long-lasting, or intense under future climate change. There might be multiple events at the same time across different regions, which may turn to be catastrophic. Coupled with degrading ecosystems and biophysical processes under climate change, the climatic hazards may create chronic stresses and catastrophic shocks. The manifestation of climate change may be observed in the following forms (European Aid, 2010):

Change in variability and extremes:
- Rainfall variability, seasonality – droughts, predictability
- Changes in peak precipitation intensity (flood and landslide risk)
- Changes in storm activity/behavior/geographic distribution
- Heatwaves, wildfires, pollution events, etc.

Long term changes/trends in average conditions:
- Warmer, wetter, drier, more saline groundwater
- Shifts in climatic zones, ecological/species ranges

Abrupt /singular changes:
- Monsoon shifts, circulation changes
- Landscape and ecosystem transitions
- Glacial lake outbursts

Climate-induced hazards in Nepal will be intense and more damaging in the future. Chapter six presents the descriptive scenarios of climatic hazards under future climate change inferred from the scenarios of climate variables and extreme indices as indicated in the same chapter.

Chapter 5

Observed and Perceived Impact of Climate Change

Climate change has had an impact on natural and human systems throughout Nepal. This chapter presents the loss and damage, as well as the observed and perceived climate change impacts on key sectors. Climate variability and climate-induced disaster events are attributed to the evidence of climate change impacts, which is largely drawn from the literature review and consultations with stakeholders. The impact of recent climate-related extreme events reveals significant vulnerability and exposure to climate variability in ecosystems, livelihood resources, and human systems.

5.1 Loss and Damage from Climate-Induced Hazards/extreme events

The trend of the number of deaths and economic losses from climate-induced disasters were analyzed from 1971 to 2019. Figure 35 shows climate-induced disaster deaths and economic losses from 1971 to 2019 and Locally Estimated Scatterplot Smoothing (LOESS) lines indicate the trends. While climate-induced disaster-related deaths are decreasing in recent years mainly due to improved early warning systems and better mitigation structures, there is an increasing trend of economic losses due to increased exposure and vulnerabilities.

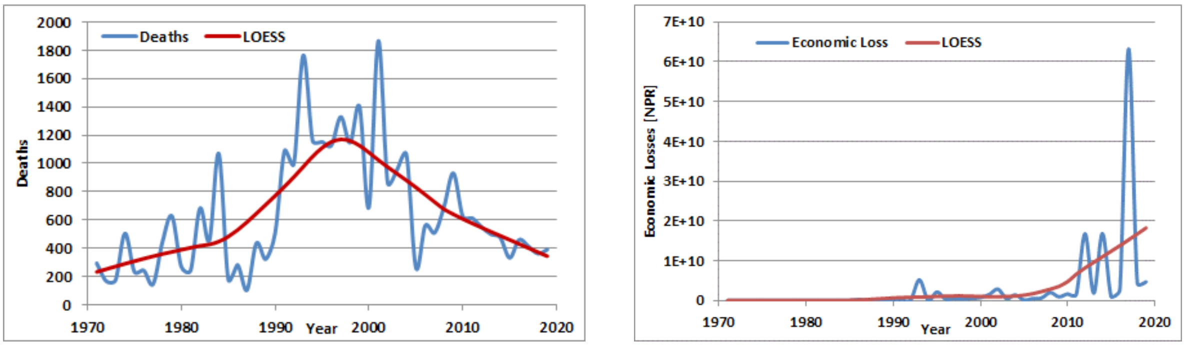


Figure 35: All Nepal trend of climate-induced disaster deaths

On average, 647 people die from climate-induced disasters in Nepal each year which is about 65 percent of the total deaths from all disaster events except road accidents (MoHA, 2018). The maximum number of climate-induced disaster deaths occurred in 2001. In 2001 alone, 1,866 people lost their lives due to due to epidemics, landslides, thunderbolts, fire, flood, heavy rainfall, and windstorm. The average economic loss per year is NPR 2,778 million which is about 0.08 percent of GDP (at the current price) of FY2018/19. The maximum economic loss of NPR 63,186 million occurred in 2017 during the Tarai floods (NPC, 2017), which is about 2.08 percent of GDP (at current price) of FY2017/18 (MoF, 2018).

Floods, landslides, epidemics, and fire are the most devastating climate-induced disasters in Nepal. Figure 36 shows the percentage of deaths, affected population, and economic losses due to 13 types of climate-induced disasters in Nepal from 1971 to 2019. Hazard-wise comparison of deaths affected population and economic losses revealed that epidemics cause the most deaths (52.8 percent) followed by landslides (16.7 percent) and floods (12.7 percent). However, statistics point out that floods affect about 71 percent of the total affected population followed by landslides (9.5 percent) and epidemics (8.2 percent). Fire causes the most economic losses (56.6 percent) followed by floods (31 percent) and landslides (3.7 percent).

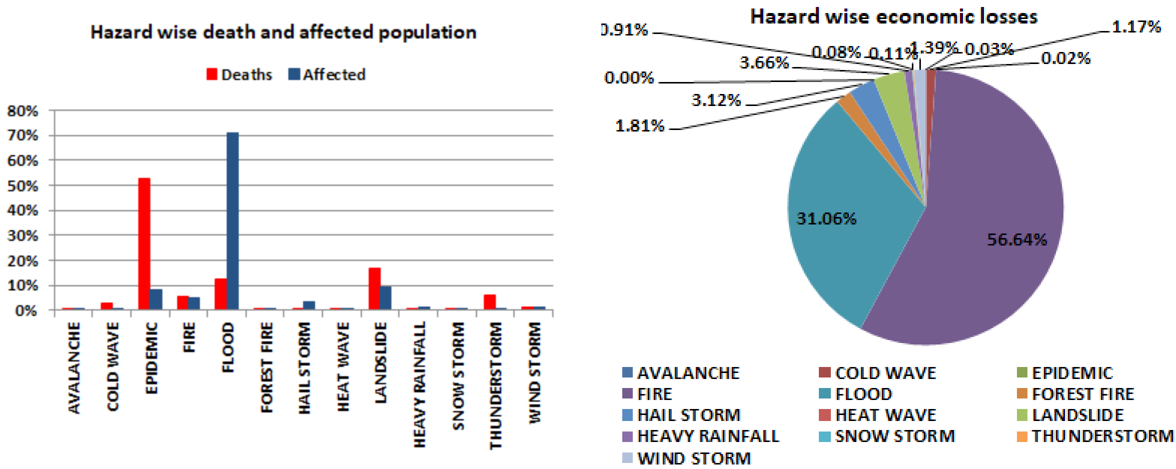


Figure 36: Hazard wise deaths, affected people, and economic losses due to climate-induced disasters

The findings show the district-wise climate-induced disaster deaths per year. Kailali, Makwanpur, Banke, and Sarlahi districts have more than 20 deaths per year on average. It further shows the number of people injured per year and figures 36 show the number of people affected annually by climate-induced disasters in Nepal. On average, more than 9,000 people have been affected yearly by climate-induced disasters in Mahottari and Saptari districts. Besides, the analysis shows the economic losses per year by climate-induced disasters. The districts with high economic losses are Siraha, Surkhet, and Bardiya. Figure 37 shows the overall (human and economic) impact of climate-induced disasters under historical climate.

Table 12 presents the district-wise rank of the overall impact of climate-induced disasters. Based on impacts, Makawanpur, Rautahat, Banke, Kailali, Siraha, Morang, Doti, Chitawan, Dhanusha, Sarlahi, Mahottari, Parsa, Saptari, Sunsari, Sindhupalchok, Dang, Kaski, Kanchanpur, and Jhapa districts are the climate-related "disaster hotspots".

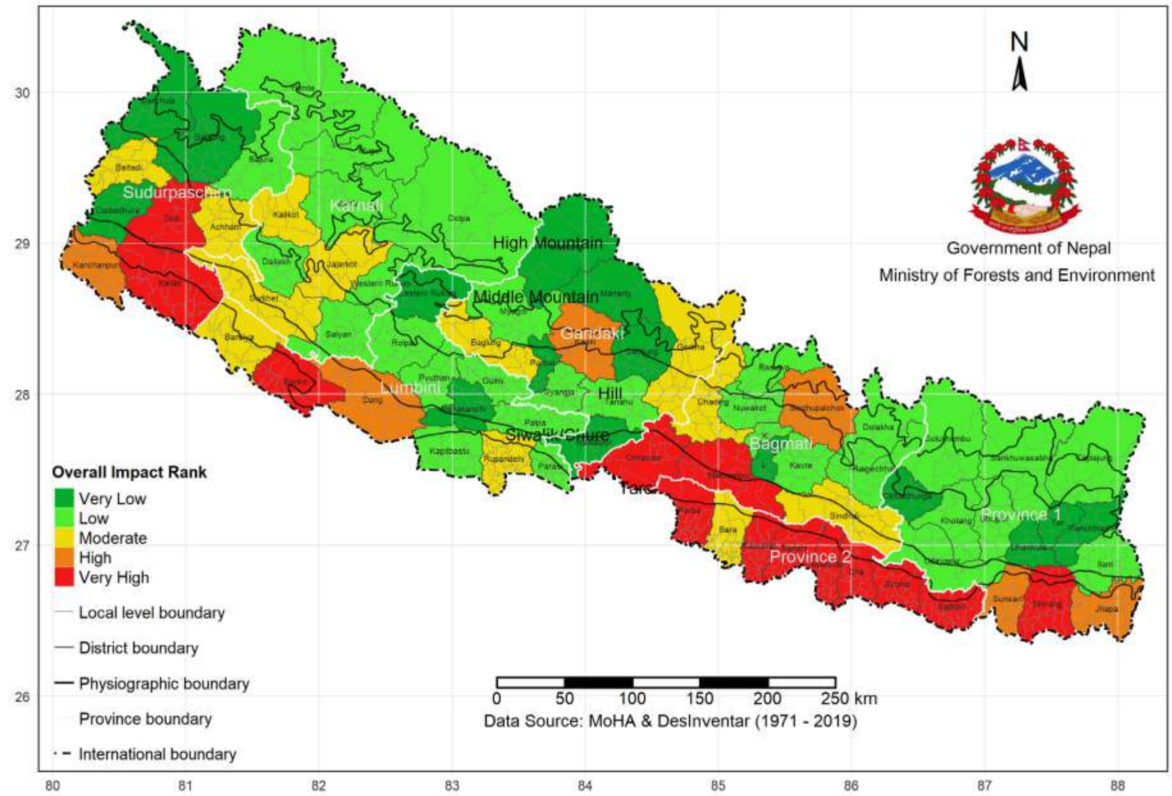


Figure 37: Overall impact of climate-induced disasters

Table 12: District wise rank of the overall impact of climate-induced disasters

Impact Rank	Districts for Historical Impact Trend (1971-2019)
Very High (0.715 - 1)	Makawanpur, Rautahat, Banke, Kailali, Siraha, Morang, Doti, Chitawan, Dhanusha, Sarlahi, Mahottari, Parsa, Saptari
High (0.512 - 0.714)	Sunsari, Sindhupalchok, Dang, Kaski, Kanchanpur, Jhapa
Moderate (0.317 - 0.511)	Dhading, Baglung, Bardiya, Gorkha, Surkhet, Achham, Baitadi, Rupandehi, Sindhuli, Bara, Kalikot, Jajarkot
Low (0.146 - 0.316)	Rolpa, Humla, Kapilbastu, Mugu, Rasuwa, Myagdi, Dolakha, Nuwakot, Sankhuwasabha, Western Rukum, Solukhumbu, Tanahu, Kavrepalanchok, Dailekh, Udayapur, Pyuthan, Syangja, Dolpa, Palpa, Bhojpur, Salyan, Khotang, Bajura, Taplejung, Jumla, Parasi, Gulmi, Ramechhap, Kathmandu, Ilam
Very Low (0 - 0.145)	Lamjung, Dhankuta, Terhathum, Lalitpur, Bhaktapur, Parbat, Darchula, Arghakhanchi, Mustang, Manang, Eastern Rukum, Okhaldhunga, Nawalpur, Panchthar, Bajhang, Dadeldhura

In Nepal, the Loss and Damage (L&D) due to climate change is increasing and is projected to increase in the future, but it will not be easy to assess them for two reasons. First, the ability to attribute impacts to specific weather events has not been established. Second, there is no globally accepted approach to assessing climate change-induced L&D.

5.2 Observed Impacts on Sectors

5.2.1 Observed Impacts on Agriculture and Food Security

Crop, horticulture, and grazing land: The key extreme events and hazards impacting the agriculture sector include droughts, floods, hailstorms, cold waves, heatwaves, thunderstorms, and insect and disease pests. Climate-related extreme events and hazards impact large tract of agricultural land in different crop growing seasons. For instance, between 2002 and 2009, the largest area affected was rice followed by maize, and the biggest impact was experienced in 2002 followed by 2006 and 2004 (IFAD, 2013). Among all hydro-meteorological hazards in Nepal, drought, a slow onset widespread disaster, ranks top in terms of impact on crops. Drought and slow onset of monsoon act to delay planting (Bhatta et al., 2016; Chaudhary and Aryal, 2009), which in turn leads to poor crop germination, flowering/grain, and fruit setting and eventually declining productivity. There were 16 major drought events recorded between 1972 and 2016 in different parts of the country, which caused crop loss ranging from 56,000 (2013) to 917,260 (1992) metric tons each year (Adhikari, 2018). Between 1971 and 2007, nearly 850,000 ha of crops were lost to weather- and climate-related events. Droughts accounted for 38.9 percent of lost crops and floods for 23.2 percent (UNDP, 2009). In 2006, drought contributed to the loss of 11 percent rice yield and 7 percent wheat yield in Nepal. The continuous rainfall between August 11 and 14, 2017 flooded 35 districts (18 districts severely affected) and inundated about 80 percent of the land along the Tarai region. A total 58 percent of the total loss and damage caused by the flood was accounted for agriculture, livestock, and irrigation infrastructure (NPC, 2017).

Hailstorms, cold waves, and heatwaves adversely affect crop yield mainly in the mid-hills and the Tarai region of Nepal. Hailstorms damage cereal crops, vegetables, and fruits at all stages thus causing a yield decline. Cold waves affect crops particularly belonging to the solanaceous family such as potatoes, tomatoes, and chilies. Insects and disease pests are also major hazards affecting agriculture. Between 1971 and 2007, 847,648 hectares of land sustained crop loss due to different climate-related extreme events of which drought alone accounted for 329,332 hectares (40 percent of total loss). The 1998 winter cold wave drastically reduced crop yields such as chickpeas by 38 percent, lentils by 37.6 percent, leaf mustards by 36.5 percent, potatoes by 27.8 percent, and mustard seeds by 11.2 percent (NARC, 1987/88 to 1997/98).

The recent analysis revealed that the changes in maximum temperature, minimum temperature, and precipitation have a direct contribution to the yield of major crops. The existing literature on projection and scenario analysis shows that climate change will have a substantive impact on crop yield and production. An IFAD report shows a 6.77 percent decline in rice yield and a 5.66 percent increase in wheat yield by 2050 and a 12.90 percent decline in rice yield and a 9.77 percent decline in wheat yield by 2080 in comparison to 2011 due to changing temperature and precipitation (GoN/MoPE, 2016) Rice and wheat yields will decline across the Tarai while maize yields will increase in Sunsari and decrease in Banke and Rupandehi (Devkota et al., 2017). In the Hills, rice, maize, and wheat yields will decline in 2070 compared to 2030. In the mountains, Jumla and Mustang will lose and Solukhumbu will gain rice yields but lose maize yields in 2070 compared to 2030, whereas wheat yields will increase in Jumla but decline in Mustang and Solukhumbu Districts.

Agrobiodiversity: Climate change has also impacted agricultural biodiversity. Depending on their nature, extent, and intensity, sometimes whole crops, varieties, or genes are wiped out from a locality. It is reported that farmers cannot harvest anything at all when droughts affect growth and reproduction, floods inundate entire land for days, insect and disease damage crops, and weeds outperform crops. On the contrary, positive impacts have been observed in higher altitude regions where new crops, vegetables, and fruit trees such as maize, tomato, chilly, mango, litchi, etc., have been introduced (Chaudhary and Aryal, 2009; Chaudhary and Bawa, 2011). In 2005, drought caused about 10 percent of agricultural land to become fallow in some areas, while in the mid-western Tarai heavy rain along with floods reduced crop production by 30 percent (Regmi, 2007).

Livestock and animal husbandry: Livestock, poultry, and fishery are found impacted by rising temperatures by negatively affecting weight gain, reproduction, breeding pattern, feed intake and conversion efficiency, heat stress, morbidity, vector (such as ticks and flies) borne diseases, parasitic diseases (liver fluke and nematodes), ectoparasite infestation, and new skin diseases in animals (KC, 2014). Fatigue, foot and mouth diseases, cough, cold are also reported as the consequences triggered by climate change (Chaudhary and Aryal, 2009; Chaudhary et al., 2011). Livestock productivity is affected when various management activities such as the timing of herd movement and fodder and forage productivity are influenced by weather and climate change (Pokhrel and Pandey, 2011; Sherpa and Kayastha, 2009). The population of indigenous livestock breeds is in sharp decline mainly because of disease outbreaks linked to climate. However such breeds of goats and yaks are more resilient to water and fodder and forage shortages in some regions (Koirala and Bhandari, 2019). There are six major impacts of climate change on livestock which include increasing incidence of disease pests, depleting grass and feed, stress due to heat, appetite loss, and, as a result, decreasing milk production, and death of animals (Shrestha and Baral, 2018). The incidence is felt in diseases and external parasites in animals, loss of forages and fodders, heat stress, water scarcity, infertility, the decline in the milk yield, and lactation period (Dhakal et al., 2013). These changes cause negative impacts on livestock production, growth performance, and reproductive functions (Koirala and Bhandari 2019).

Fishery and aquaculture: The temperature rise has led to the deterioration in the quality of water-induced stresses and new diseases in fish. It also degrades fishery habitat, prompts the decline of fishery stocks, reduces the productivity of freshwater aquaculture, leads to the decline of local species, hits the economy, and livelihood of fishing communities (Wagle, 2011). Flooding is one of the main causes of fish productivity decline. There has been massive damage by the 2017 flood in fishponds of the Chitawan (Storming, 2017).

5.2.2 Observed Impacts on Forests, Biodiversity, and Watershed Management

Loss and Damage on species and human population: In terms of the sector, the increase in temperature, precipitation change, extreme events, and climate-induced disasters have both positive and negative impacts. However, negative impacts are more numerous. For example, a growing incidence of animal death, injury, and wild animals being swept away are observed in and around Tarai protected areas, especially in Chitawan National Park during heavy rainfall and flash floods. Riverine forests and waterholes along the Narayani and Rapti rivers are foraging habitats for several wild animals including rhinoceros (Subedi et al., 2017). During rainy seasons rhinoceros' calves and other animals are highly susceptible to flash flooding (NTNC, 2020; Subedi et al., 2017).

Forests in Nepal are permanent livelihood sources and safety nets for over 65 percent of the population (Amatya, 2013). The impact of climate change on the livelihoods of forest-dependent populations and communities has become severe for women, IPs, Dalit, and poor households. They are the ones who mostly rely on forest resources for their survival, income sources, and employment opportunities (Goodrich et al., 2017; UNEP, 2010). These social groups are already discriminated against for accessing quality forest resources. The diminished availability of forests product will further aggravate access to quality forest resources (Khanal et al., 2019). The usual working hours for women of Western Nepal are reported to be over 18 hours a day mostly for collecting fuelwood, grass, and fodder (Gum et al., 2009; Sugden et al., 2014).

Increased incidences of a forest fire: Forest fires in Nepal are a serious risk to forest degradation with the increase in observed climate variability including droughts, long-warm days, and heatwaves. An increasing trend of forest fire incidences are reported in the high-value lowland forests of Tarai and Siwaliks (Bhujel et al., 2020; Rimal et al., 2015) and the year 2016 was the year with the highest number of incidences (about 10,658) recorded across Nepal (Bhujel et al., 2018).

Invasive plant and animal species: Several types of impact on species diversity have been observed due to climate-induced hazards and risks (Pant et al., 2019, 2020). The invasion and rapid expansion of alien species have emerged as a major threat to both wetland and terrestrial species diversity especially fauna and endemic plants (Siwakoti et al., 2016; Shrestha and Shrestha, 2019). The distribution and occurrence of invasive alien plant species (IAPS) are found to be gradually increasing at a faster rate in recent years spreading across all forest management regimes including community forests, government-managed forests, and protected areas impacting floral and faunal biodiversity (Bhatta et al., 2020; Chaudhary et al., 2020; Khaniya and Shrestha, 2020; Lamichhane et al., 2018; Rai and Scarborough, 2012; Shiwakoti et al., 2016; Shrestha, 2017). The IAPS expansion previously restricted to Tarai, Siwalik, and lower hills is now increasingly reported in high mountains areas where 24 species distribution are found across 70 districts (Shrestha and Shrestha, 2019).

The rapid expansion of *Mikania micrantha* has posed a threat of shrinking and destruction of rhino habitat in the Chitawan National Park with high intensification in wetlands habitat and short grassland (Lamichhane et al., 2014). Rhinoceros are likely to be moderately vulnerable under climate change due to invasive species invasion, floods, habitat fragmentation, small population size, droughts, and forest fires in protected areas (Pant et al., 2020). Adhikari and Shah (2020) projected a loss of suitable habitats of rhinoceros by 51.25 percent and 56.54 percent under RCP 4.5 for 2050 and 2070 respectively.

Alien plant invasive fauna has become an emerging threat especially to faunal diversity conservation in Nepal (Budha, 2015, GoN, 2014). The status, distribution, and impact of these invasive alien fauna on biodiversity conservation in the face of climate change are poorly investigated and documented. Budha (2014) has identified 69 species of alien fauna in Nepal that comprise insects (21 species), freshwater prawn (one species), platyhelminths (one species), fish (16 species), wild mammals (2 species), birds (3 species), and livestock breeds (25 improved breeds). Invasive alien fish species such as *Nile tilapia* have been reported to be problematic to native fish species in Nepal and other freshwater species (Husen, 2014).

Infestation of insects, pests, and pathogens: Several cases of loss and degradation of both natural and plantation forests have been reported due to the infestation of insects, pests, and pathogens. Seedlings in forest nurseries were recorded in feeble condition due to various fungal diseases (Pokharel, 2017). Nepal's major tree species including Sal, Teak, Eucalyptus, Rajbrikschha (Cassia fistula), and Vijayasal *(Pterocarpus marsupium)* forests were documented to be impacted by insects and pests' outbreaks (Malla and Pokharel, 2018). The infestation of pests and diseases and their impact on forests will likely grow with a rise of climate-induced predisposing events including the spread of wildfires, temperature, and expansion of warm days (MoE, 2010; MoFE, 2019c; NCVST, 2009). The outbreak of foot and mouth diseases and parasitic infections have been reported in isolated Blackbucks (*Antelope cervicapra*) (Chaudhari and Maharjan, 2017).

Vegetation shift and habitat destruction: With the changes in temperature and precipitation patterns, the vegetation and species range are shifting upward in the northern mountain region of Nepal. The conifer species *Abies spectabilis*, *Betula utilis*, and *Pinus wallichiana* are spreading upslope in almost all regions of Nepal (Bhuju et al., 2016; Dhakal et al., 2016; Gaire et al., 2014; Gaire et al., 2017; Thapa et al., 2014). The estimated annual rate of these shifts varied by species and the regions (e.g., annual shifts of *A. spectabilis* were 2.61 m in Manaslu area, 0.93 m in Sagarmatha, 2.4 m in Kanchenjunga, Rara, and Api-Nampa-Darchula, and annual shift of B. utilis was 0.42 m in Sagarmatha National Park) (Bhuju et al., 2016; Gaire et al., 2011; Gaire et al., 2014; Shakya et al, 2013). The vegetation and species range shift appeared also in Nepal's Siwalik region with a gradual expansion of C4 plants[15] from 8.5 Ma and culminating 5.2 Ma (Neupane et al., 2019).

Most studies indicated a range shift/distribution as species-level impacts of climate change pose threats to mountain fauna. For example, Forrest et al. (2012) projected a loss of around 30 percent of snow leopard habitat in the Himalayas due to shifting tree lines and consequent shrinking of the alpine zone. Aryal et al. (2016) have also predicted a decrease of snow leopard and blue sheep habitat across Nepal by 14.57 percent in 2030 and by 21.57 percent in 2050 from the current suitable habitat (5,435 km^2) due to climate change. Similarly, water stress arising from prolonged droughts and increased temperatures has led to a decrease in the number of deer, monkeys, porcupines, pangolins, and bird species in the mid-hills of Nepal (TU, 2018). The red monkeys previously found in the Siwaliks are now seen in the Mahabharat range. This may be due to a change in their habitats associated with climate change dynamics (MoFSC, 2016).

There is an increased distribution of invasive alien species in the Tarai's PAs. This has degraded the habitats of flagship wild faunas including rhinoceros (Bhatta et al., 2020; Chaudhary et al., 2020; Lamichhane et al., 2018). The findings of a PA-scale analysis of climatic patterns using 1971-2014 data show a gradually increased annual maximum temperature over the analysis period (i.e., 1971-2014) with the maximum temperature ranging from 0.019°C to 0.095°C. A similar trend indicates consistent and continuous warming after the mid-1970s with maximum temperatures rising at an annual rate of 0.04°C to 0.06°C in the country (Patra and Terton, 2017). The high-altitude PAs including Rara National Park (RNP), Khaptad National Park (KNP), Manaslu Conservation Area (MCA), Annapurna Conservation Area (ACA), and Shey-Phoksundo National Park (SPNP) have experienced a higher increase in maximum temperature. These PAs are home to many endangered species such as Snow Leopard, Red Panda, and Musk Deer and harbor numerous endangered flora such as *Rauvolfia serpentina*, *Neopicrorhiza scrophulariiflora*, *Dactylorhiza hatagirea*, and *Nardostachys grandiflora* (Chaudhary et al., 2010). An increasing temperature trend will alter and degrade habitats along with the species interaction, distribution, physiology, biological potential, and reduce food availability thereby resulting in a loss of species.

Phenological changes: The changes in phenological cycles such as flowering, fruiting, and leaf shedding behavior of plant and tree species are affected by rising temperature and precipitation variability. For example, the flowering of *Rhododendron arboreum*, *Myrica esculenta* (kafal), and *Alnus nepalensis* are reported 15-30 days earlier than normal (Panta and Mandal, 2019).

The vegetation shift, phenological change, and change in functional and physiological traits due to climate change will alter the tree composition thereby affecting species-level floral diversity. There is growing evidence that climate change affects forests and NTFP in their availability and regeneration pattern. The production and availability of NTFPs such as Panch aule *(Dactylorhiza hatageria)*, Shilajit *(Rock exudates)*, Amala *(Phyllanthus emblica)*, Ritha *(Sapnidus mukurosii)*, Timur *(Zanthoxylum armatum)*, Bel *(Aegle marmelos), D. butyracea*, *M. esculenta*, and *P. odoratissima* were found to be lesser (Chitale et al., 2014; MoFSC, 2016; Pandey and Bhargava, 2010).

15 C4 plants are plants which cycle carbon dioxide to 4-carbon sugar compounds in order to enter the C3 or the Calvin cycle. The C4 plants are very productive in climatic conditions that are hot and dry and produce a lot of energy. Some of the plants that we usually consume are C4 plants such as pineapple, corn, sugar cane, etc (Wang et al., 2012).

Watershed and wetland degradation*:* Climate variability and changing patterns of precipitation with heavy rainfall during summer are major challenges for watershed conservation in Nepal. Nepal is prone to several forms of land and watershed degradation arising from natural events such as floods, landslides, soil erosion, and debris flow (Thapa and Joshi, 2018). Climate-related stressors such as heavy rainfall events have triggered these natural events along with increasing soil erosion and mass movements and decreasing water holding capacity in recent years. This has a considerable effect on the degradation of watersheds and watershed resources (Chalise et al., 2019). Insufficient water availability and prolonged drought during winter (CBS, 2016; GoN, 2019) may again impair the hydrological cycle and nutrient supply. This in turn will accelerate soil loss and wind erosion, which ultimately degrade watersheds (Chalise et al., 2018, 2019). Besides, the irregularity of the water flow exacerbates overall watershed quality, thereby reducing productivity and degrading watershed resources (UN-habitat, 2015).

Climate change impact is also seen in wetland resources. Nepal's wetlands comprise diverse forms of water bodies including rivers, lakes, reservoirs, ponds, marshy land, and irrigated paddy fields distributed in all ecological regions (Bhuju et al., 2010, MoFE, 2018c). Most of these are prone to multiple climate extreme events and hazards (Lamsal et al., 2017). The majority of Ramsar and non-Ramsar wetlands in the lowlands and mid-hills of Nepal are fed by either glacier melt or riverine flood (MoE, 2012). Changes in water flow and availability due to changes in the volume of glaciers arising from climate dynamics could change the water level of the wetlands (Shrestha and Aryal, 2010). This would then lead to the degradation of wetland resources and the shrinkage of wetland areas (Lamsal et al., 2019; Ouyang et al., 2013).

The invasion of several alien flora (e.g., water hyacinth) and fauna (e.g., Nile tilapia) could degrade habitats for micro-and micro wetlands fauna. Such changes alter wetland habitat through the formation of new assemblages such as planktonic and hydrophyte (Lou et al., 2015). The habitat alternation could further jeopardize many endangered wetlands and freshwater-dependent animals including fauna (MoFE, 2018c). Such phenomenon appears problematic to some species such as *Crocodylus palustris, Kachuga kachuga, and Gavialis gangeticus* with very poor dispersal capacity to respond to the altered habitats (Lamsal et al., 2017, p. 922). Similarly, the effects of wetland degradation will be critical to both migratory and resident waterbird communities in low-land wetlands in Nepal that use wetlands as feeding, resting, and breeding habitats (Adhikari et al., 2018).

5.2.3 Observed Impact on Water Resources and Energy

Climate change impact on the hydrology of Nepal: The impact of climate change on the hydrology of Nepal is evident. The changes in precipitation and temperature pattern, including extreme weather events (such as floods and droughts), are affecting water availability and timing, and cause water-related disasters. Due to the monsoon-dominated seasons in Nepal, floods, flash floods, and landslides are very common in hilly areas. These water-related hazards are increasing the frequency, magnitude of events. Rising temperatures cause glaciers to shrink and enhance glacier melt. It is observed there is more rainfall than snow due to high temperatures in high altitude areas. It is likely that due to climate change, runoff from glaciated areas will increase in the short term, but in the long run, it is expected to decrease when glacier storage diminishes (Bates et al., 2008; Eriksson et al., 2009). Total water availability at river basins in Nepal will increase in both the near future and the medium future scenarios of RCP 4.5 and RCP 8.5 (Ghimire et al., 2019; IWMI, 2019; Pandey et al., 2019, 2020; Pandit, 2020). However, there are variations in seasonal and sub-basin level projected water availability.

Based on the analysis included in the Irrigation Master Plan 2019 (DWRI, 2019), the impact of the climate change scenario on water resources has been further analyzed for the near future (the 2030s) and medium future (2050s) projection of scenarios RCP 4.5 and RCP 8.5 at the district level. According to the climate change projection scenarios, the annual water availability parameters will increase in most of the districts, while decreasing in some districts. However, spatial imbalance and temporal variabilities of water availability do exist. The future changes of flow in the non-monsoon seasons (October to May) will be within the past ranges, whereas the future changes of flow in the monsoon (June to September) will be higher than in the past. This will have adverse effects on the water demands of people, as well as the ecosystem due to the high demand for energy and industrial development.

The change in the ground-water flow which contributes to the flow of springs and local streams will primarily have an impact on community-level water demands (such as drinking water, Pico/micro hydropower, biomass production, and micro-irrigation). Whereas the change in net water yield, which contributes to the larger flow of streams, will primarily have an impact on water demands of small-scale water services (such as urban water supply, mini/small hydropower, small irrigations, and small industries). Similarly, the change in total water volume (discharge) of the river will have an impact on larger-scale water demands (such as medium/mega hydropower, medium/large/major irrigation, and mega water supply projects).

Climate change impact on the energy sector: Climate variability affects hydroelectricity production. Hydroelectric plants are dependent on predictable run-off patterns, and thus sensitive to climate variability (OECD, 2003). The impact of an increase/decrease in average water availability will lead to increased/reduced power outputs. Nepal's electricity generation relies mostly on the run-of-river hydropower plants, and some river flows are insufficient to operate important plants during the dry season, which will worsen due to climate change. The changes in seasonal and inter-annual variation in inflows (water availability) will shift in seasonal and annual power output, floods, and lost output in the case of higher peak flows. Likewise, extreme precipitation causing floods will have direct and indirect (by debris carried from flooded areas) damage to dams and turbines, lost output due to releasing water through bypass channels.

The impact of climate variability on electricity production indicates that economic costs could be equivalent to 0.1 percent of GDP per year on average, and 0.3 percent in very dry years (IDS-Nepal et al., 2014).

They are also subject to the risks of floods and droughts – including risks from Glacial Lake Outburst Floods with an economic loss in the energy sectors. For example, a GLOF in 1985 in the Dudh Koshi River Basin damaged the nearly completed Namche Small Hydroelectric Project and caused other damage further downstream (ICIMOD, 2011; OECD, 2003). The loss of micro-hydro plants from floods has also been reported (Paudyal, 2011). The Zhangzangbo GLOF (July 11, 1981) caused substantial damage to the diversion weir of the Sun Koshi Hydropower Plant, the Friendship Bridge at the Nepal-China border, two other bridges, and extensive road sections of the Arniko Highway. These amounted to a total loss of more than USD 3 million. Similarly, the Dig Tsho GLOF (4 August 1985) in the Khumbu region (Eastern Nepal) destroyed, over 42 km, the small Namche hydroelectric plant with an estimated loss of USD 1.5 million, 14 bridges, 30 houses, trails, farmlands, the properties of many families, and three human lives. On 3 September 1998, the Tam Pokhari GLOF in the Dudh Koshi Basin (Eastern Nepal) destroyed 6 bridges and farmlands (with an estimated loss of USD 2 million), including two human lives (ICIMOD, 2011).

The heavy sediments and debris flow from GLOFs can create problems in downstream projects. Breaching of glacial lake dams from a close distance poses high risks to hydro projects; a case in point is the flood damage in Bhote Koshi Project on 5 July 2016 from a GLOF originating from Tibet, China. Recently, there have been cases of landslide-induced damming and impounding of a large volume of water behind these dams (for example, the Jure landslide in Sun Koshi River in August 2014) impacting hydro plants downstream. Nearly 10 percent of the nation's hydropower capacity, some 67 MW, was severed by the landslide, submerging a 5 MW power plant. It disconnected the power supply with Bhotekoshi hydropower (45 MW) and Sunkoshi hydropower (10 MW) and washed out over 400 houses, killing over 200 people. The landslide-induced dam broke catastrophically but, fortunately, no human casualties occurred. The impact of hydropower projects downstream is not known. Higher monsoon peak flows could increase the risks of extreme flows and floods, leading to damage of hydroelectricity plants, with the costs of repair and lost revenues. As an example, there have been recent losses of smaller hydro plants (e.g. Khudi hydropower plant) due to floods (Byers et al., 2019).

Climate change influences the integrity and reliability of electricity grids. In Nepal, floods, landslides, snowstorms, and other hazards damage the electricity grids, transmission lines, and powerhouses. Although there is no actual assessment of how much is lost annually through disasters, there are common views that losses and damages are huge and will increase. The consultations at the Provinces revealed that transmission lines in Tarai are at threat of floods while in the mountains it's mostly landslides, avalanches, and GLOF that create damage.

5.2.4 Observed Impact on Health and WASH

Nepal has been observing increasing temperatures, variations in precipitation, and extreme weather events that have profound impacts on the seasonal and temporal trend fluctuation of Vector-Borne Diseases (VBDs), Water Borne Diseases (WBDs), respiratory diseases, food-borne diseases, nutrition-related diseases, injuries, and mental illnesses (NPC, 2020; Regmi et al., 2016a). It is found that out of the total population in Nepal, 52 percent are at risk of malaria, 87 percent at risk of Lymphatic Filariasis (LF), 54 percent at risk of Japanese Encephalitis (JE), 30 percent at risk of Kala-azar, and all the population is at risk of water/food-borne diseases and non-communicable diseases (Health NAP MoHP, 2016).

Impact on emergence and outbreak of vector-borne and water-borne diseases: Climate variables that directly influence VBDs are mainly temperature and rainfall. The distribution of common endemic VBDs in Nepal such as malaria, dengue, Kala-azar, JE, and LF are not uniform throughout the country. Initially, they were confined in the Tarai districts but now especially malaria, JE, and filaria are spreading over the hills and mountains (Joshi et al., 2020). The analysis in this study shows that annual variations of VBD cases with maximum temperature were positively associated in Kailali ($r^2 = 0.14$) and Kanchanpur ($r^2 = 0.04$). A previous study also found that an increasing number of VBD cases in different periods and locations coincide with a rising average temperature in Nepal (Dhimal, et. al., 2014). The climate change effects on VBDs are marked in the shifting of diseases and their vectors in highlands areas of Nepal (Dhakal et al., 2011). In recent years, Chikungunya, West Nile virus, and scrub typhus have become a threat to the Nepalese population (Joshi et al., 2020). Other studies provide details on malarial cases with altitudinal shifts. The malaria vector was found at 1820 masl, with higher densities in the post-monsoon season (Dhimal et al., 2014). A study conducted in two districts that are highly endemic for malaria showed that a 1 °C increase in minimum and mean temperatures increased the incidence of malaria by 27 percent and 25 percent respectively (Dhimal et al., 2014).

Water-related infectious diseases, such as diarrhoea, cholera, etc, are a major threat to mortality and morbidity worldwide. Outbreaks frequently occur after a severe precipitation event. A sizeable 15 percent of post-natal deaths (first 59 months) in Nepal are due to diarrheal diseases (WHO, 2015). Diarrhoeal diseases show a definite monthly pattern or seasonal pattern in a year in different physiographic regions of Nepal (Dhimal et al., 2016). An analysis of data on temperature and diarrhoea from July 2002 to June 2014 estimated that for a 1°C increase in ambient temperature, the incidence of diarrhoeal diseases in Nepal rose by 4.39 percent (Dhimal et al., 2016). The analysis in this study also shows that variation in local weather patterns in temperature and precipitation influences the distribution of WBDs. Based on the data record from 2005 to 2014, a close relationship between annual rainfall and maximum temperature was found with the WBDs in Aacham and Kalikot districts.

Increasing cardiovascular diseases: The impacts of climate change increase the risks of cardiovascular diseases. An increase in environmental temperatures and humidity increases cardiovascular disease mortality (Kovats and Hajat, 2008; Parsons, 2014). A rise in hot and cold average minimum and maximum daily temperature is positively correlated with deaths and heart disease morbidity (Shrestha et al., 2016). Likewise, the incidence and severity of diseases from climate-sensitive respiratory pathogens have become a challenge in recent years.

The analysis carried out in this study shows that between 2005 to 2018, heart disease patients were found to be the most numerous in Kathmandu (n=346,385) followed by Kaski (n=215,609), Morang (n=143,292), and Chitawan (n=133,313). Similarly, Bagmati Province and Karnali Province recorded the highest (n= 836,143) and the lowest (56,609) number of heart disease cases, respectively. Over 14 years of observation among the 2,690,251 heart disease cases, 97 percent hypertension and 3 percent ischemic heart diseases were reported.

A rise in hot and cold average minimum and maximum daily temperatures are positively correlated with deaths and heart disease morbidity (Shrestha et al., 2016). The assessment shows that the annual variations of the number of heart disease cases with maximum temperature show a positive association in Dhankuta (r^2=0.07), and Kailali (r^2 = 0.06), Dhading (r^2 = 0.06), and Kathmandu (r^2 = 0.03).

Extreme weather events, such as heatwaves, floods, storms, drought, and wildfires, change the incidence of respiratory infections (Mirsaeidi et al., 2016). The poison regression analysis carried out in this study for respiratory diseases shows that cases of one year were associated with extreme weather events, nutrition status, FCHVs, and a literacy rate of the same year in the Tarai and Hill regions. In the Tarai region, a 1°C increase in mean temperature was associated with a 0.57 percent (95 percent confidence interval (CI) 0.54 percent - 0.60 percent)) increase of respiratory disease cases. An additional increase of warm days was associated with a 0.39 percent (95 percent (CI) 0.39 percent - 0.28 percent)) increase in respiratory disease cases. A unit increase of drought events was associated with a 0.95 percent (95 percent (CI): 0.94 percent - 0.96 percent).) maximum increase of respiratory disease cases. A one-unit increase in literacy rate was associated with a maximum -0.68 (95 percent (CI): -0.68 percent -0.67 percent) decrease in respiratory disease cases. Similarly, in the Hill region, a one-unit increase of cold wave was associated with a 4.11 percent (95 percent (CI): 4.07 percent - 4.14 percent) maximum increase of respiratory disease cases. On the other hand, a one-unit increase of warm days was linked to a -15.1 percent (95 percent (CI): -15.2 percent- -14.9 percent) decrease in cases. The numbers of cold wave events in the Hill region were positively associated with the increase of respiratory disease cases (r^2 = 0.18). The co-morbidity of cardiovascular and respiratory diseases ranges from 17 percent to 35 percent. The correlation between the annual sum of heart diseases and respiratory diseases is higher in the Mountain region (r^2 = 0.38) than Tarai and Hill (r^2 = 0.30).

Malnutrition: Climate change and malnutrition in all its forms, including obesity and undernutrition, constitute the greatest threats to the population and human health. Climate change has an indirect impact on the health system. Climate change has led to major weather events, crop failures, food insecurity, and other adverse health consequences. Despite several efforts, malnutrition in Nepal is alarming. It has become a serious health problem and is a major threat to the health of infants, adolescent girls, and pregnant and lactating mothers (Devine and Lawlis, 2019).

WASH issues: Climate change is having an impact on water availability and quality. Around 5 percent of water supply schemes were found dried (Helvetas, 2011) in Nepal where precipitation does hold significant ground for source yield. Springs are the major source of water in the mid-hill region of the country. But despite high demand, there has been a steady 30 percent decline of the spring discharge in over 30 years (Chapagain, 2019). The increase in temperature also causes melting and thawing of glaciers, snow, sea ice, and frozen ground leading to changes in the seasonality of river flows and leading to a reduction in water availability in summer in the downstream flow of water (Erikssion et al., 2014; UNICEF, 2014).

The water quality issue is also on the rise because of the contamination of water sources and changes in water source quality with different climatic and non-climatic stressors (Panthi, 2018). An increase in precipitation and severe weather cause flooding, pollution of wells, inaccessibility of water sources, flooding of latrines, damage to infrastructures, landslides around water sources, sedimentation and turbidity, challenges to the sustainability of sanitation and hygiene behaviors, and water-borne diseases. An increase in temperature causes heatwaves leading to damage to infrastructures, increase in pathogens in water leading to increased risk of diseases (WHO, 2015). The increasing arsenic in water sources in the Tarai region has raised many health issues (Shrestha, 2017). Increased exploitation of groundwater resources in urban areas is leading to rising levels of groundwater pollution from natural chemical contamination such as arsenic in the Tarai belt. The warm and damp condition often leads to an increased incidence of water-related diseases.

Impact on health and WASH infrastructure and services: Floods and landslides pose a major risk to health infrastructures. In the Tarai area, there are about 704 health facilities in Province one. Out of these, there are 69 health facilities within 25m of a river, comprising 54 health posts and 15 hospitals (NHSSP, 2017). Landslides have been one of the major causes of loss and damages where health facilities are located on steep slopes. For example: In Ramechhap 30 out of a total 51 facilities (59 percent); in Baglung 28 out of a total 70 facilities (40 percent); in Kavre 25 out of a total 68 facilities (37 percent) and in Dolakha 21 out of a total 38 facilities (55 percent) suffered loss and damages due to landslides.

Climate change is likely to lead to increasing risks on the infrastructure used in service provision. Water-related extremes exacerbated by climate change increase risks to water, sanitation, and hygiene (WASH) infrastructure, such as damaged sanitation systems or flooding of sewer pumping stations. Major climate-related events during monsoon often damage water collection tanks, drinking water facilities, pipes, and distributing channels. The Tarai region of Nepal is more susceptible to flooding, which affects both health and hygiene. Health infrastructures and services, drinking water supplies, and sanitation systems get damaged and disrupted by floods leading to poorer sanitary, fecal contamination, health disorders, poor operation and maintenance, and disruption of essential power systems among the exposed and vulnerable communities (Howard, 2016). Open defecation prevails making the population of Tarai more susceptible to WASH-related health vulnerabilities (Baidya, 2017).

5.2.5 Observed Impact on Rural and Urban Settlements

There is mounting evidence that the impact of climate change on human settlements is complex, with interconnections between various systems and subsystems in the natural and human-built environments (UN-Habitat, 2019). The primary climate change impacts on human settlements and the natural environment include: (i) housing or shelter, (ii) the surrounding community, neighborhood, village, or relevant social unit in which individuals live, (iii) supporting physical and public infrastructure (e.g., transportation, roads, water and sanitation services, industry, and communications links), and (iv) social and cultural serendipity; social and cultural services (e.g. health services, education, police protection, recreational services, parks, museums, etc.) (IPCC, 2014b).

Observed impact on socio-economic sectors: The observed key socio-economic impacts on rural and urban livelihoods are loss and damage to life and property, impeded access to basic services leading towards inconvenience, issues related to health, sanitation, and hygiene problems, air and water pollution, elevated poverty, migration, destitution, and desperation in the settlement. The impact is generally higher for children, women, the elderly, expectant mothers, people with chronic health problems, and disadvantaged population groups (FAO, 2009; Gupte and Bogati, 2014: p. 30; Shrestha, 2013). From 2016 to 2018, about 427,000 households were displaced due to disasters. Out of these, 384,000 households alone were displaced in 2017, suggesting that the August 2017 Tarai flood was the cause of such an increased figure and accompanying swell in the slum population (IOM, 2019; UNSD, n.d.). Kathmandu valley experienced water stress of approximately 60 million m^3 and water scarcity of 40 million m^3 in 2000 (OECD, 2003). With increasing urbanization in the valley, the present situation is even worse. A higher incidence of respiratory diseases is found in urban areas compared to rural areas leading to negative health outcomes and economic burdens to the population (CBS, 2017).

Climate change impact on buildings and settlements: The observed climate change impact on rural and urban sector buildings and settlements are primarily loss and damage including economic burdens to the population. There were several cases of flooding and inundation reported in the Kathmandu valley mainly impacting buildings and settlements. About 48 percent of squatter houses are temporary structures and only 2 percent were durable (pukka) structures with cement, brick, or concrete block walls (UN, 2013). In 2017[16], flash floods in the Bhaktapur district inundated various areas. This is huge because buildings and roads have encroached on the floodplains and banks of the Valley's rivers. In 2018, the river inundated many squatter settlements and private priorities in the Balkhu area. Almost 20 houses were flooded. In 2002, the river destroyed a garment factory on the Balkhu corridor.

In the rural and urban Tarai areas, over 92 percent of slum houses are temporary (UN, 2013). They provide less protection from annual monsoon rains or heat (UN-Habitat, 2010: p. 40). Most of the urban settlements in the Tarai are prone to flooding after intense rainfall events due to improper drainage provisions. The inundation of Nepalgunj in July 2007 is an example of drainage congestion owing to deficient urban planning and management. In urban areas of Nepal, the gradual increase in temperature has led to a rise in health concerns and puts pressure on energy use for cooling purposes, inducing the urban heat island effect (MoPE, 2016). Waste heat, from traffic or air conditioning units, plays an auxiliary role in contributing to the heating of the urban environment (UN-Habitat, 2019).

Observed impact on infrastructure: The observed climate change impact on physical infrastructure varies widely across geography and location. In general, the prominent physical infrastructure impact observed in rural and urban areas are in the houses, buildings, communication means, bridges, transmission lines, water pipes, drainage congestion, damage to hydropower, traffic congestion, water pollution, and drying up of water sources leading to failure of water and irrigation schemes (Adhikari, 2013; IPCC, 2007; NAPA, 2010; NPC, 2017).

The observed impact on social infrastructure is mainly related to disruption of services and their functions such as less accessible health and education infrastructure, damage of health, education, and market infrastructure due to their location, destruction of cultural heritage due to their

16 https://tkpo.st/36Lg4wM Accessed on 13th February 2021.

proximity to the risk-prone area, and weathering effects on the cultural heritage sites. The lack of infrastructure construction standards regulations and disregard for compliance lead to increased risk and vulnerability. In the Hanumante river basin, damage to two schools, two hospitals, and one bridge in Dadhikhet was reported during the 2018 flooding (Jha, 2019).

Public market areas could become uninhabitable during extreme and prolonged high temperatures, severely disrupting economic activities (DUDBC and MoSTE, 2014). Market areas and cultural heritage sites without proper drainage are flooded or destroyed, severely disrupting economic activities (DUDBC and MoSTE, 2014). Flash floods are particularly dangerous for museums and archives, especially when parts of collections are stored underground (World Bank, 2017). Many cultural heritage sites are located near rivers and could be destroyed or heavily damaged by rising river waters or flash floods (DUDBC and MoSTE, 2014).

5.2.6 Observed Impact on Industry, Transport, and Physical Infrastructure

Physical impact: Climate extreme events have a biophysical impact on industry, transport, and infrastructure in Nepal. Floods, landslides, mass wasting, debris flow, rock falls, mudflows, sedimentation, erratic rainfall, windstorms, glacial floods, and rise in groundwater levels, are found to damage infrastructures, lead to the collapse of industrial buildings and properties, increase the exhaustion of infrastructures, silt drains, increase the instability of land through the weakening of riverbanks or hill toes or land subsidence, damage road drainage structures, breach road embankments, scour bridge foundation, block the flow of traffic, washouts and inundation and submerge infrastructures (UNECE, 2019).

In 1993, central Nepal faced a massive cloudburst that seriously affected the Prithvi and Tribhuvan highways. It washed away six bridges along the highways and severed connectivity to Kathmandu. The Kathmandu Valley remained isolated (no land transport connection) for 21 days from the rest of the country. In August 2000, a land failure in Krishnabhir led to the closure of the key arterial road linking Kathmandu with the Tarai plains and thus with India for 11 days (NCVST, 2009). Out of the total 488 landslides reported in 2020, 59 occurred along roadsides while 62 have occurred on roads and, as a result, obstructed vehicular flow (GoN, 2020). A landslide that occurred in a newly widened road took the lives of nine people in Waling Municipality, Syangja (Shrestha, 2020).

Social and economic impacts: The impacts of climate change may, together with the exclusion of women from adaptation and mitigation actions, aggravate the various obstacles and socio-economic vulnerabilities that lead to decent work deficits among women (Nellemann et al., 2011). Transportation systems are critical for effective disaster response and the disturbance in transportation means less access to health, education, and agricultural extension services (Shrestha, 2007). Besides, the Strategic Road Network (SRN) in Nepal is 13,447.62 km and two district headquarters (Humla and Dolpa) are yet to be connected to the road network (DoI, 2019). In 2017, USD 584.7 million physical damages occurred due to rainfall-triggered disasters in Nepal (NPC, 2017). A significant impact has been seen on the annual budget allocation of periodic road maintenance cost which has increased from 1.19 billion to 3 billion NPR in the last four years (2016/17-2019). The rapid increase in the length of rural roads in the last 30 years also corresponds to an increase in investment in the Local Road Network. However, the preference is for building faster without following basic norms or standards, using inappropriate techniques, and cutting corners in costs. Every year, during the monsoon season, the impact on roads increases due to landslides triggered by rains and constant toe cutting by flooding rivers.

5.2.7 Observed Impact on Tourism, Natural and Cultural Heritage

Direct impacts on the TNCH include the changing length and quality of climate-dependent tourism seasons. Indirect impacts are loss of biodiversity, reduced landscape aesthetics, damage to infrastructure including cultural heritage sites, and the presence or appearance of new water-borne diseases (Simpson et al., 2008). High mountains are more exposed to avalanches and Glacial Lake Outburst Floods (GLOFs); hills to landslides, flash floods and debris flows, whilst the Tarai lowlands are more exposed to floods, all affecting the TNCH sector (Nyaupane & Chhetri, 2009). These climate-related hazards destroy infrastructures, including roads, bridges, trails, resorts, temples, and monuments (Bhandari, 2014).

Impact on the national economy: The tourism sector is a key contributor to the national economy as it is one of the sources of foreign exchange in Nepal. It is reported that a 1 percent increase in average maximum temperature leads to an increase in total tourism GDP by 9.36 percent. The same level of decrease in minimum temperature leads to a decrease in total tourism GDP by 3.66 percent (MoCTCA, 2018). The report further shows that a 1 percent increase in average maximum temperature leads to an increase in leisure and recreational tourism GDP by 34.45 percent. The same level of decrease in minimum temperature leads to a decrease in leisure and recreational tourism GDP by 11.7 percent. In contrast, the study showed that there is no significant relationship between precipitation and tourism activities. This could be because the monsoon season is the off-season for tourism activities in Nepal. The significant reduction in tourist arrivals will have serious employment impacts and generate further poverty. The tourist flow, diversity of tourist visits, and their expenditure are influenced by weather conditions, disaster events, and other climatic stressors like heat waves and cold waves. There is a close relationship between climate and tourism in the ecosystem of tourism, mountain tourism, and nature-based tourism (K.C. and Thapa, 2014a). Weather and climate affect tourist demand, comfort, satisfaction, tourism industries, and natural resources important to the tourism industry. Most of the nature-based tourism activities in the Himalayas are weather-sensitive so rain and foggy conditions significantly decrease the quality of the trekking experience. Tourists can opt for a change of destination within the country if the weather continues to disappoint them (Rayamajhi, 2012).

Impact on natural heritage: Tourism activities in Nepal are largely nature-based. It is found that climate change has impacted tourism infrastructures and nature itself. Trekking and mountaineering in Nepal are concentrated in PAs, which are at high risk of floods, landslides, glacier melt, avalanches, and GLOF (ICIMOD, 2011). Tourism that depends on certain weather, such as trekking, mountaineering, and safari is impacted by changing monsoon patterns (Nyaupane and Chhetri, 2009). Over the years, the aesthetic value of mountains diminishes as the white snow-covered mountains are gradually turning into black rock mountains (KC, 2017). Climate change is creating a pronounced impact on forests in the protected areas of Nepal, with visible signs of an upward shift in vegetation with temperature rises (Bhuju et al., 2016; Dhakal et al., 2016; Gaire et al., 2017; Shakya, 2013). These phenomena have the potential to change the aesthetic value of the destinations. Climate change impacts all faunal species including mammals, herpetofauna, avian, fishes in the vertebrate group, and butterfly and mollusks in the invertebrate group. For instance, a massive flood in Chitawan National Parks in 2017 killed four rhinoceroses and a wild buffalo. Additionally, ten rhinoceroses have swept away to India (DNPWC, 2018; Subedi et al., 2017). Increased forest fires are a threat to wildlife and their habitat (MFSC, 2014).

Impact on cultural heritage: There is very little research on the impact of climate change on cultural heritage in Nepal. Landslides and floods are damaging archaeological sites (Aryal, 2016). In Mustang, the decrease of snow in winter and the increase in rainfall after the winter months have affected the cultural traditional construction of mud and stone flat-roofed houses (Dahal, 2020). Seepage has affected historic monuments due to consecutive rainy days damaging wooden structures and walls made from mud and stones/bricks. Furthermore, changes in the ecological characteristics of wetlands, lakes, and rivers can change their significance as cultural and religious tourism sites (ICIMOD, 2010).

Impact on people and livelihoods: Climate-induced disasters cause loss of life and property, adversely affect the ecological and physical system, and impede development. Impacts can include major destruction of assets and disruption to economic sectors, loss of human lives, loss and impacts on plants, animals, and ecosystem services. Climate change and inclement weather have put the lives of trekkers, mountaineers, and associated human resources at threat (Sangraula, 2010). Unexpected weather conditions have adverse implications on the mobility of tourists including trip cancellation to national parks and disruption of tourism supply chains (Nyaupane and Chettri, 2009; Sangraula, 2010). Besides, hazards, such as GLOF, avalanches, and landslides are killing people and destroying their property. For example, the Dudh Koshi GLOF, caused by an outburst of Dig Tsho glacier lakes on 4 August 1985, killed 5 people and destroyed 30 houses. It also broke 14 bridges and disconnected trekking trail networks, further impacting the livelihoods of traders, trekkers, guides, and porters (ICIMOD, 2011). In 2014, 12 Nepali guides died and 4 went missing in a Mount Everest avalanche. In November 2014, unseasonal snowfall and avalanches resulting from the effects of Cyclone *Hudhud* killed at least 43 trekkers and guides.

Tourism operations demand substantial water resources (Gössling et al., 2012; Lama, 2010). Uncertainty of water availability was reported in the Everest region (Faulon and Sacareau, 2020). Climate-induced drought can amplify the problem of water scarcity in areas where water is already limited. Water crises increase the workload of women as they are the de facto manager of many hospitality businesses, including homestays, restaurants, hotels, and tea shops. They are the ones responsible for providing basic facilities to tourists (Tenzin et al., 2019; Rayamajhi, 2013). Water scarcity is directly affecting the sanitation condition of the destinations and may provoke health problems in tourists and tourism-dependent people (Nicholson et al., 2016).

5.2.8 Observed Impacts on the GESI & Livelihood

Context-specific conditions of marginalization shape multidimensional vulnerability and differential impacts (IPCC, 2014). Lack of income, ownership of land/property, access to credit/market, and lack of capacity for diversification of livelihoods, increase the risk further, drastically amplifying the effects of climate change. There is a strong correlation showing households with fewer years of schooling and lower wealth are considerably more likely to be affected, experience higher casualties, and incur livelihood losses because of floods and landslides (Shrestha et al., 2016). Most households exposed to flooding are in the low-lying Tarai region where population densities are comparatively higher.

Poverty, marginalization, and vulnerability: There is an established relationship between climate change, poverty, and migration in Nepal (Gentle et al., 2014; Joshi, 2011; Regmi et al., 2016a) to cope and adapt to the impacts of climate change. Migration is not a new phenomenon in Nepal. In the Mustang district, for example, people have migrated from one village to another as a coping strategy against climate-related and natural resource constraints (Sherchan, 2019). Climate change has been a push factor for men to seek employment overseas or neighboring countries leaving behind women to carry out all farming and household responsibilities in rural areas (Dhimal et al., 2017; Gartaula et al., 2010; Raney et al., 2011; Shrestha, 2017). The need for livelihood diversification has triggered outmigration (predominantly men, with 12 percent women migrant workers). Although male migration leads to women's comparative control over income and household activities, women are particularly vulnerable to natural disasters such as floods, due to loss of family support networks and increased responsibilities at home.

Impact on resources/livelihoods: Climate change alters livelihoods negatively by destroying assets: physical (homes, land, and infrastructure), human health), social (social networks), cultural (sense of belonging and identity), and financial (savings) (Goodrich et al., 2017; Gurung and Bisht, 2014; MoFE, 2018). Agriculture-based livelihood systems that are already vulnerable to food insecurity face immediate risks of increased crop failures and susceptibility to new types of pests and diseases. Impacts of climate change not only affect biodiversity but the livelihoods of millions of local and indigenous people who depend on it (Chitale et al., 2018). Drought severely affects the livelihood of small-scale farmers and herders, threatening their food security (FAO, 2009).

Differential impact on women, children, elderly, poor, and indigenous groups: Exposure to climate change impacts is higher among children, girls/women, pregnant women, the elderly, and people with disabilities with increased mortality and morbidity (MoFE, 2018). Marginalized or indigenous groups, particularly Majhi, Raute, Chepang, Satar, are more vulnerable to food insecurity due to disasters like floods, landslides, and fire.

Heat and cold waves impact those working outside, the poor, women, children, and the elderly. Diseases like malaria put pregnant women 3 times more at risk of severe malaria than non-pregnant women (Rijken et al., 2012). Extreme climatic events such as droughts and floods increased the prevalence of water-borne diseases like typhoid, cholera, and other diarrhoeal diseases which mostly impact children below the age of 5 (Eriksson et al., 2008). Flood-related fatalities are 13.3 per 1000 girls aged 2–9 years, 9.4 per 1000 boys aged 2–9 years, 6.1 per 1000 adult women, and 4.1 per 1000 adult men in Nepal (Bartlett et al., 2008).

Evidence from studies shows that female-headed households are more vulnerable to climate shocks as they grow fewer crop types (Gentle et al., 2014; Regmi et al., 2016b). Men, who have more control over cropping choices, choose to plant highly nutritious crops such as buckwheat, which is labour-intensive and increases women's workload, and reduces their time available for other livelihood activities (Onta and Resurreccion, 2011). Decreased availability of natural resources leads to girls spending longer hours collecting firewood/water, sometimes even resulting in school dropouts (Nellemann et al., 2011). It is reported that women worked up to 18 hours a day collecting fuel, fodder, and water (Gum et al., 2009; Haigh et al., 2010; Oxfam, 2009; Sugden et al., 2014). When women must walk long distances with heavy loads to obtain water and fuelwood, they become prone to injuries, harassment, or sexual assault (Leduc and Bhattarai, 2008) adversely impacting their reproductive health and making them prone to uterine prolapse (Dhimal, 2015). A lack of clean water and sanitation poses serious health challenges to women, especially during menstruation and pregnancy (Birch et al., 2012).

5.3 Perceived Impact of climate change

The findings from the consultation at the federal, provincial, and local levels revealed that stakeholders perceived that temperature has increased in Nepal across all the 7 provinces and local levels ranging from mountain to mid-hill and Terai region and from east to the west. According to the majority of the stakeholders consulted, the precipitation patterns have changed and there is extreme variability observed in both monsoon and other events. There is more or less consensus among stakeholders that nowadays heavy rainfall is observed within a shorter period which has often negative impacts. Stakeholders also perceived that climate-induced hazards like flood, landslide, fire, GLOF, and drought have become more frequent and often devastating. In terms of impact, the local communities are more concerned with loss and damage by the disasters, including the impact on agriculture, water resources, and health. The provincial stakeholders mostly felt that climate change impacts are visible having negative impacts on both human and natural systems. Some stakeholders have also perceived the positive impact of climate change mostly in the high mountains where it is now favorable for growing some of the crops and vegetables. It was also revealed that climate change impact is hitting hard the poor, marginalized, resource-dependent household and communities and among them, the women, children, elderly, disabled, and ethnic minorities are impacted.

The above perception of the impact is also similar to the perception survey carried out by CBS. The survey result shows that 74.29 percent of total households have observed changes in water sources whereby 84.47 percent observed a decrease in the amount of surface water. Likewise, the majority of households (74.56 percent) in the mountain regions have reported complete drying up of surface water. Likewise, the majority of households across all regions and strata observed early flowering/fruiting of plants. Also, the survey reveals that maximum households (60.25%) have observed new Diseases emerging on crops. Moreover, maximum households (66.09%) observed the appearance of new insects (CBS, 2016).

Chapter 6

Hazards, Exposure, Vulnerability, and Risk

This chapter presents the findings on the differences in hazards, exposure, vulnerability, and risk at the municipality, district, Province, and physiographic levels. The composite index is created by adding all of the sectoral indexes together except for rural and urban settlements. Due to a lack of scenario data on climate-induced hazards, the study relied on eleven indices of climate extreme (five for precipitation and six for temperature) to understand the historic and future change of climatic parameters. These indices were chosen because they are the most important indicators of climate change in Nepal. These extreme indices are available in DHM (2017) for the historical period and in MoFE and ICIMOD for the future period (2019). Two possible concentration pathways, RCP 4.5, and RCP 8.5, based on different socioeconomic developmental trajectories, were selected to identify extreme scenarios of the future. These scenarios were analyzed for the medium-term (2030) and the long-term (2050) periods.

6.1 Climate Extreme Events

The current trend of extreme events: As indicated above, 11 extreme events indices were used for the assessment. The baseline climate extreme events overall composite index shows that Sankhuwasabha, Morang, Chitawan, Jhapa, and Ilam districts are experiencing high extreme events. Besides, the districts which have observed higher extreme events are the following: Dhading, Makawanpur, Sunsari, Rautahat, Sindhupalchok, Tanahu, Kavrepalanchok, Parbat, Syangja, Kailali, Siraha, Rupandehi, Palpa, Sindhuli, Bara, Dhanusha, Nawalpur, Kaski, Taplejung, Panchthar, Sarlahi, Mahottari, Parasi, Parsa, and Saptari districts. Among the Provinces, Province two, Province one, Bagmati Province, and Gandaki Province are the most impacted by climate extreme events. All the districts in Province two have observed high to very high extreme events. Likewise, the Tarai and the mountain districts in Province one observed higher climate extreme events. The eastern, central, and western mountains seem to have high extreme events which are mostly due to the higher occurrence of avalanches, landslides, and GLOFs. Likewise, the Tarai region seems to have more extreme events compared to other reasons.

On the contrary, the mountain region of Gandaki Province, Karnali Province, and Sudurpaschim Province seems to have very low climate extreme events. Humla, Mugu, Dolpa, Mustang, Manang, and Bajura districts fall in the very low category. Also, the mid-hills of Karnali Province and Sudurpaschim Province have experienced fewer climate extreme events (Figure 38 and Table 13).

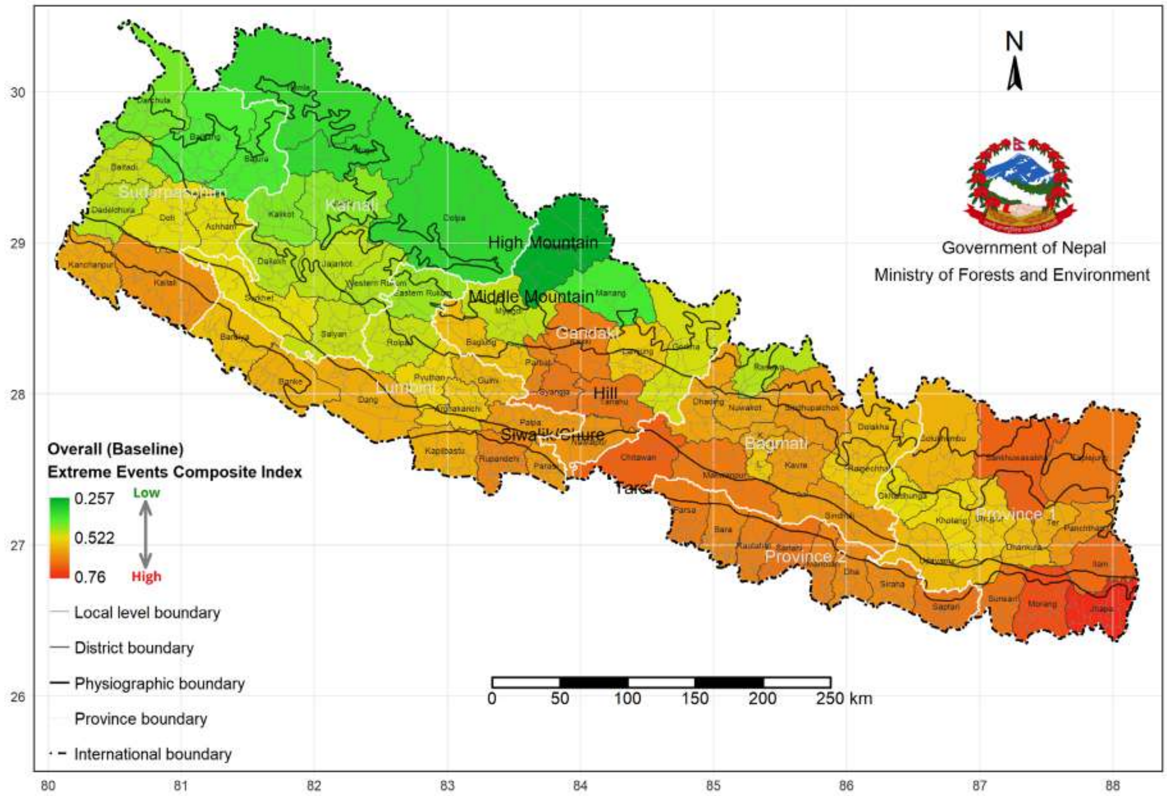


Figure 38: Overall (baseline) Extreme Events Composite Map

Table 13: Baseline Extreme Events Composite Index

Baseline Extreme Events Composite Index Rank	District
(0.651 - 0.760)	Sankhuwasabha, Morang, Chitawan, Jhapa
(0.578 - 0.650)	Dhading, Makawanpur, Sunsari, Rautahat, Sindhupalchok, Tanahu, Kavrepalanchok, Parbat, Syangja, Kailali, Siraha, Rupandehi, Palpa, Sindhuli, Bara, Dhanusha, Nawalpur, Kaski, Taplejung, Panchthar, Sarlahi, Mahottari, Parasi, Parsa, Saptari, Ilam
(0.504 - 0.577)	Kapilbastu, Lamjung, Dolakha, Dhankuta, Terhathum, Nuwakot, Baglung, Bardiya, Gorkha, Solukhumbu, Lalitpur, Udayapur, Bhaktapur, Pyuthan, Banke, Surkhet, Achham, Arghakhanchi, Bhojpur, Doti, Khotang, Okhaldhunga, Dang, Kanchanpur, Gulmi, Ramechhap, Kathmandu
(0.381 - 0.503)	Rolpa, Rasuwa, Myagdi, Western Rukum, Dailekh, Darchula, Baitadi, Salyan, Eastern Rukum, Kalikot, Jajarkot, Jumla, Bajhang, Dadeldhura
(0.256 - 0.380)	Humla, Mugu, Dolpa, Mustang, Manang, Bajura

The climate trend analyzed in the earlier chapter revealed that the precipitation is increasing in Syangja (8.99 mm/yr), and Bardiya (7.86 mm/yr) with the highest rate. Also, Tanahu, Nawalpur, Parasi, and Dhanusha, districts experienced more than 4 mm/yr of precipitation. Kaski (-11.44 mm/yr), and Ilam (-9.56 mm/yr), are the district having decreased precipitation during 1971 and 2014. A large part of Bagmati Province, Northeast of Gandaki Province, West part of Province one, and southeastern part of Karnali Province have a decreasing precipitation trend. The rate of change is almost -12 to 9 mm/yr across the districts. All the districts of Sudurpaschim Province show the increasing precipitation trend. The Gandaki Province has the highest variation. The Tarai region has the most increased trend with the highest in the southern belt of Sudurpaschim Province and the lowest in Province two. The Chure of Sudurpaschim Province and Gandaki Province have an increasing trend while it is decreasing in Bagmati Province.

In Nepal, the most flood-prone districts are Jhapa, Morang, Sunsari, Rautahat, Saptari, and Sarlahi. The Jhapa district is one of the highly flood-prone districts with the highest number of flood events from 1971 to 2019. Thunderbolts or lightning have increased in recent years in Makawanpur, Jhapa, and Morang districts. Syangja, Taplejung Sankhuwasabha, and Dhading are the most landslide-prone districts. The heatwaves have increased in recent years in Parsa, Rautahat, Saptari, and Sunsari districts. Morang and Saptari district have experienced high windstorms in recent days. In the last 49 years (1971-2019), the most hailstorm-affected districts are Kaski, Tanahu, and Syangja. Fire hazards are increasing in recent years in Morang, Saptari, Sunsari, and Jhapa districts. The analysis of 49 years (1971-2019) of epidemics data revealed that Morang is the most epidemics-affected district in Nepal.

Table 14 below presents the Province-wise major climate-induced hazards, the ranking of Provinces based on climatic hazards and their impacts, and disaster hotspots. A Province-wise comparison of the combination of baseline context of 15 climatic hazards based on the historical climate shows that Province two is the most affected by climatic hazards followed by Province one and Gandaki Province. Similarly, a Province-wise comparison of the impact of climatic hazards shows that Province two is the most impacted Province followed by Bagmati Province and Sudurpashchim Province. This may be due to the high cross-cutting (socio-economic, GESI, resources, and services) exposure and vulnerability in Province two.

Table 14: Ranking of Provinces based on climatic hazards and their impacts

Province	Major Hazards	Hazard Rank	Impact Rank	Climate-induced Disaster Hotspots
Province one	Epidemics, Fire, Flood, Landslide, GLOF	2	6	Jhapa, Morang, Sunsari, Udayapur
Province two	Epidemics, Fire, Flood, Forest fire, Hailstorm	1	1	Saptari, Sarlahi, Mahottari, Siraha
Bagmati	Epidemics, Fire, Flood, Landslide, Thunderbolt	4	2	Chitawan, Makwanpur, Sindhupalchok
Gandaki	Avalanche, Epidemics, Hailstorm, Landslide, Thunderbolt	3	7	Gorkha, Kaski, Baglung
Lumbini	Epidemics, Fire, Flood, Forest fire, Landslide	7	5	Banke, Dang, Rupandehi
Karnali	Epidemics, Fire, Flood, Forest fire, Thunderbolt	6	4	Surkhet, Jajarkot, Kalikot, Dailekh
Sudurpashchim	Epidemics, Fire, Flood, Forest fire, Landslide	5	3	Kailali, Doti, Kanchanpur, Achham

Future scenarios of climate extreme events: This section describes the change in extreme indices that are selected as the major climate change indicators for Nepal. It indicates a range of possible changes in the future, based on 11 indices of climate extremes (six indices about temperature, and five for precipitation).

The composite index of climate extreme events in 2030 under the RCP 4.5 and RCP 8.5 shows that most of the districts of Province one, Province two, Bagmati Province, and Gandaki Province are most likely to experience high-very high incidences of climate extreme events in 2030. All the Tarai districts and districts of Province two will observe increased extreme events in the future. Likewise, the eastern districts of Province one will experience a very high incidence of extreme events. There is not much variation under the RCP scenarios. Humla, Mugu, and Mustang districts in both scenarios will experience very low climate extreme events. Figure 39, and Table 15 show that the climate extreme events will be more intense and cover larger areas of Nepal compared to the current baseline context. However, when analyzing individual climate extreme events, the results will be different.

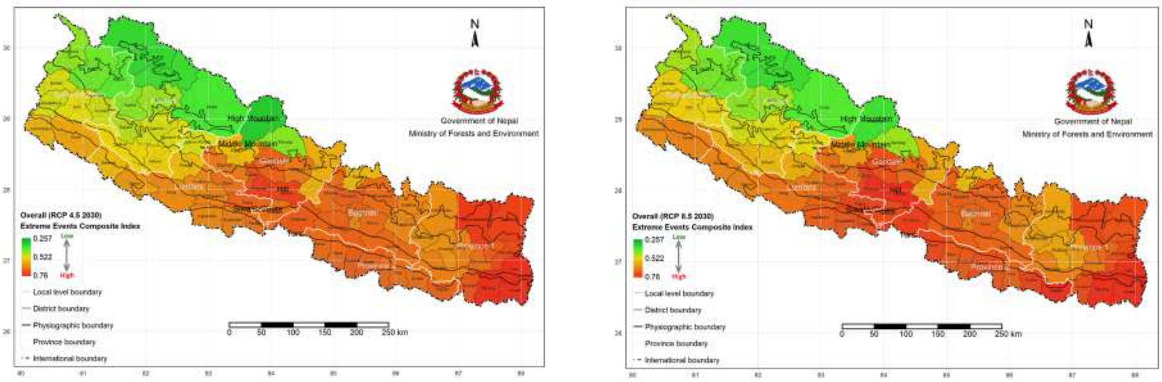


Figure 39: Climate Extreme events map under RCPs in 2030 a) RCP 4.5; b) RCP 8.5

Table 15: Extreme Events Composite Index - 2030

Extreme Events Composite Index Rank 2030	Districts (RCP 4.5)	Districts (RCP 8.5)
(More than 0.650)	Dhading, Makawanpur, Sunsari, Terhathum, Nuwakot, Sankhuwasabha, Rautahat, Tanahu, Kavrepalanchok, Parbat, Syangja, Palpa, Sindhuli, Morang, Bara, Chitawan, Kaski, Taplejung, Panchthar, Jhapa, Sarlahi, Mahottari, Kathmandu, Saptari, Ilam	Dhading, Makawanpur, Kapilbastu, Lamjung, Sunsari, Terhathum, Nuwakot, Sankhuwasabha, Rautahat, Sindhupalchok, Tanahu, Kavrepalanchok, Parbat, Syangja, Siraha, Arghakhanchi, Rupandehi, Palpa, Sindhuli, Morang, Bara, Chitawan, Dhanusha, Nawalpur, Kaski, Taplejung, Panchthar, Jhapa, Sarlahi, Mahottari, Parasi, Parsa, Gulmi, Kathmandu, Saptari, Ilam
(0.578 - 0.650)	Kapilbastu, Lamjung, Dolakha, Dhankuta, Baglung, Sindhupalchok, Solukhumbu, Lalitpur, Udayapur, Bhaktapur, Pyuthan, Banke, Siraha, Arghakhanchi, Rupandehi, Bhojpur, Khotang, Okhaldhunga, Dhanusha, Dang, Nawalpur, Parasi, Parsa, Gulmi, Ramechhap	Myagdi, Dolakha, Dhankuta, Baglung, Bardiya, Solukhumbu, Lalitpur, Udayapur, Bhaktapur, Pyuthan, Banke, Kailali, Bhojpur, Okhaldhunga, Dang, Kanchanpur, Ramechhap
(0.504 - 0.577)	Rolpa, Rasuwa, Myagdi, Western Rukum, Bardiya, Gorkha, Kailali, Surkhet, Baitadi, Salyan, Doti, Kanchanpur	Rolpa, Rasuwa, Western Rukum, Gorkha, Dailekh, Surkhet, Achham, Baitadi, Salyan, Doti, Eastern Rukum, Khotang, Jajarkot, Dadeldhura
(0.381 - 0.503)	Dailekh, Darchula, Achham, Manang, Eastern Rukum, Bajura, Kalikot, Jajarkot, Jumla, Bajhang, Dadeldhura	Darchula, Dolpa, Manang, Bajura, Kalikot, Jumla, Bajhang
(Less than 0.381)	Humla, Mugu, Dolpa, Mustang	Humla, Mugu, Mustang

The compositive index of climate extreme events in 2050 shows an alarming situation. A majority of the districts under both RCPs will experience a higher increase in extreme events. Out of 77 districts, 51 will experience a much higher incidence of climate extreme events. Except, Humla, Mugu, Dolpa, Bajura, and Mustang districts, all the districts under RCP 4.5 will experience a higher incidence of extreme events. Humla, Mugu, Dolpa, Mustang, and Bajura districts will experience lower incidences of climate extreme events. Except for a slight variation in the mountain districts of Karnali Province and Sudurpaschim Province districts, all other Provinces and the respective districts within it will experience a higher incidence and very likely a high impact of climate extreme events (Figure 40).

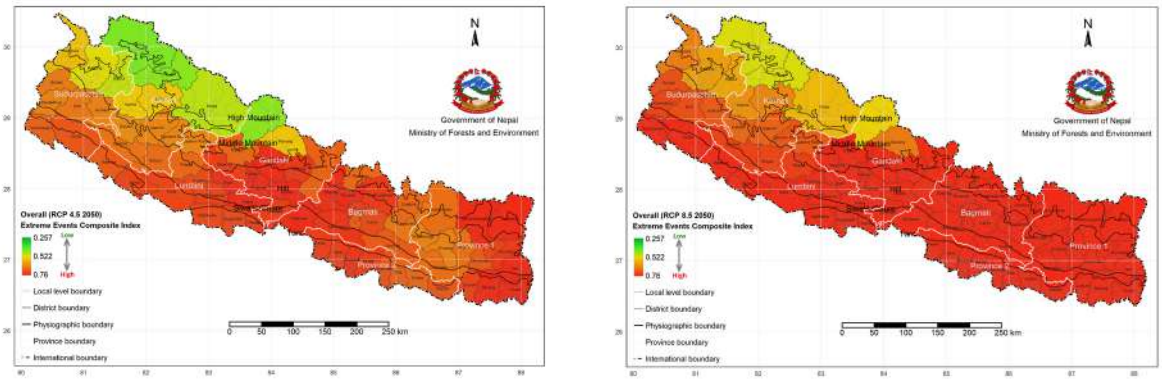


Figure 40: Map of Composite Climate Extreme events under RCPs in 2050

Under RCP 8.5, the climate extreme events will be more intense and spreading. Out of the total number of districts, 67 will experience a higher incidence of climate extreme events. Darchula, Manang, Kalikot, Jumla, and Bajhang districts will experience moderate to slightly high extreme events. Whereas, Humla, Mugu, Dolpa, Mustang, and Bajura will have a moderate incidence of climate extreme events.

The result show that in 2050, climate extreme events will increase immensely and expand to new areas such as Karnali Province and Sudurpaschim Province. The scenario also shows that climate extreme events will be higher compared to 2030. For example, the baseline context shows only five districts having a higher incidence of extreme events whereas in 2050 the number of districts that will be impacted will increase to 51 under RCP 4.5 and 67 districts under RCP 8.5.

The future projection of climate-induced hazards is challenging as it is difficult to determine the exact attribution of climate extreme events or climate parameters to the naturally occurring historical hazards. However, the above chapter revealed that the climatic hazards may become more frequent, widespread, long-lasting, or intense under future climate change. There might be multiple events at the same time across different regions, which may turn to be catastrophic. Coupled with degrading ecosystems and biophysical processes under climate change, the climatic hazards may create chronic stresses and catastrophic shocks.

Table 16: Extreme Events Composite Index - 2050

Extreme Events Composite Index Rank 2050	District (RCP 4.5)	District (RCP 8.5)
(More than 0.651)	Dhading, Rolpa, Makawanpur, Kapilbastu, Rasuwa, Myagdi, Lamjung, Sunsari, Dolakha, Dhankuta, Terhathum, Nuwakot, Sankhuwasabha, Rautahat, Baglung, Sindhupalchok, Bardiya, Gorkha, Lalitpur, Tanahu, Kavrepalanchok, Bhaktapur, Parbat, Pyuthan, Syangja, Banke, Kailali, Siraha, Arghakhanchi, Rupandehi, Palpa, Sindhuli, Morang, Bara, Chitawan, Dhanusha, Dang, Nawalpur, Kaski, Kanchanpur, Taplejung, Panchthar, Jhapa, Sarlahi, Mahottari, Parasi, Parsa, Gulmi, Kathmandu, Saptari, Ilam	Dhading, Rolpa, Makawanpur, Kapilbastu, Rasuwa, Myagdi, Lamjung, Sunsari, Dolakha, Dhankuta, Terhathum, Nuwakot, Sankhuwasabha, Rautahat, Baglung, Western Rukum, Sindhupalchok, Bardiya, Gorkha, Solukhumbu, Lalitpur, Tanahu, Kavrepalanchok, Dailekh, Udayapur, Bhaktapur, Parbat, Pyuthan, Syangja, Banke, Kailali, Surkhet, Achham, Siraha, Arghakhanchi, Baitadi, Rupandehi, Palpa, Bhojpur, Sindhuli, Salyan, Morang, Bara, Doti, Eastern Rukum, Khotang, Okhaldhunga, Chitawan, Dhanusha, Dang, Nawalpur, Kaski, Kanchanpur, Taplejung, Panchthar, Jajarkot, Jhapa, Sarlahi, Mahottari, Parasi, Parsa, Gulmi, Ramechhap, Kathmandu, Saptari, Dadeldhura, Ilam

(0.578 - 0.650)	Western Rukum, Solukhumbu, Dailekh, Udayapur, Surkhet, Achham, Baitadi, Bhojpur, Salyan, Doti, Eastern Rukum, Khotang, Okhaldhunga, Jajarkot, Ramechhap, Dadeldhura	Darchula, Manang, Kalikot, Jumla, Bajhang
(0.504 - 0.577)	Darchula, Manang, Kalikot, Jumla, Bajhang	Humla, Mugu, Dolpa, Mustang, Bajura
(0.381 - 0.503)	Humla, Mugu, Dolpa, Mustang, Bajura	

Future scenarios of climate-induced disasters

The projection of climate-induced hazards is challenging due to the lack of baseline data. However, the literature shows that the climate-induced hazards will be intense and more damaging in the future. The Climate Risk Country Profile of Nepal by the World Bank Group and the Asian Development Bank has reported that the probability of drought and heatwave is projected to increase while the probability of coldwave is projected to decrease in Nepal. An increase in a median annual drought probability of at least 10 percent is projected by 2080-2099 under all emission pathways. The probability of heatwave[17] is projected to increase significantly, potentially as high as 27 percent by the 2090s under the highest emissions pathway (RCP 8.5). Simultaneously, the probability of coldwave is projected to decrease significantly, to less than one percent annually over the same period.

The descriptive scenarios of climate variables and extreme indices, as described earlier, under future climate change can be expressed as in Table 17 below (MoFE, 2019).

Table 17: Descriptive scenarios of climate variables and extreme indices under future climate change

Climate Variables and Extreme Indices	Medium Term Scenario	Long Term Scenario
Increase in temperature	*Likely*	*Likely*
Increase in precipitation	*Likely*	*Likely*
Increase in very wet days	*Likely*	*Likely*
Increase in extreme wet days	*Likely*	*Likely*
Decrease in rainy days	*Likely*	*Likely*
Increase in consecutive dry days	*About as likely as not*	*About as likely as not*
Increase in consecutive wet days	*About as likely as not*	*About as likely as not*
Increase in warm days and nights	*Likely*	*Likely*
Decrease in cold days and nights	*Likely*	*Likely*
Increase in warm spell duration	*Likely*	*Likely*
Decrease in cold spell duration	*Likely*	*Likely*

Table 18 below presents the descriptive scenarios of climatic hazards under future climate change inferred from the scenarios of climate variables and extreme indices as given in Table 17 above.

17 A 'Heat Wave' is defined as a period of 3 or more days where the daily temperature is above the long-term 95th percentile of daily mean temperature (World Bank, 2021, pp 11-13).

Table 18: Descriptive scenarios of climatic hazards under future climate change

Climate Hazard	Medium Term Scenario	Long Term Scenario
Increase in heatwaves	*Likely*	*Very likely*
Decrease in cold waves	*Likely*	*Very likely*
Increase in heavy rainfall	*Likely*	*Very likely*
Decrease in snowstorms	*Likely*	*Likely*
Increase in thunderbolts	*Likely*	*Likely*
Increase in windstorms	*Likely*	*Likely*
Increase in hailstorms	*About as likely as not*	*About as likely as not*
Increase in floods	*Likely*	*Likely*
Increase in landslides	*Likely*	*Likely*
Increase in GLOFs	*Likely*	*Likely*
Increase in droughts	*About as likely as not*	*About as likely as not*
Increase in forest fires	*Likely*	*Likely*
Increase in fires	*Likely*	*Likely*
Increase in avalanches	*Likely*	*Likely*
Increase in epidemics	*Likely*	*Likely*

Note: virtually certain 99–100 percent probability, very likely 90–100 percent, likely 66–100 percent, about as likely as not 33–66 percent, unlikely 0–33 percent, very unlikely 0–10 percent, exceptionally unlikely 0–1 percent.

Studies also have shown that there will be an increase in the frequency of extreme river flows. What would historically have been a 1 in 100-year flow is projected to become a 1 in 50-year or 1 in the 25-year event in Nepal. The risk of GLOFs is also likely to increase (World Bank, 2021). For example, flood-related studies show that the damages by the flood will be massive. An increase in potential flooding impact is also projected by Paltan et al. (2018) who demonstrate that even under lower emissions pathways coherent with the Paris Climate Agreement almost all Asian countries face an increase in the frequency of extreme river flows. This increased severity of extreme river floods can be seen in estimates by Willner et al. (2018) who projected that an additional 8,000–43,000 people will be affected by an extreme flood event by 2035–2044 as a result of climate change (World Bank, 2021, pp 13-14).

The study on the assessment of flood hazard and quantitative agricultural damage in the Bagmati River basin including the Lal Bakaiya River basin of Nepal under climate change conditions showed that flood inundation area and agricultural damage area may increase in the future by 41.09 percent and 39.05 percent in the case of 50-year flood, while 44.98 percent and 40.76 percent in the case of a 100-year flood (Shrestha, 2019). A similar analysis in the Bagmati river basin revealed that climate change will result in more extreme precipitation events in monsoon months and less precipitation in other months resulting in a significant increase in the flood events in the future. The range of change in 2-100 year return period floods was from 24-40 percent (Mishra and Srikantha, 2014).

6.2 Exposure to Climate-induced hazards/Extreme events

The exposure in this assessment comprises of the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected. The composite index of exposure is prepared by combining all the relevant sectors included in this study. Due to the uneven distribution of infrastructure and population, Kathmandu, Morang, and Rupandehi have significantly higher exposure value than other districts, therefore this study has considered it as an outlier in the mapping. Also, due to a lack of district-specific information, the urban and rural settlements are not included in this composite exposure index and map.

The exposure index shows that among the Provinces, exposure is high in Province two and Bagmati Province. Also, some districts in Gandaki Province, the Tarai of Province one, and the Tarai of Lumbini Province are exposed to climatic stressors. In Sudurpaschim Province, Kailali is highly exposed.

The results show that Kapilbastu, Kailali, Rupandehi, Morang, and Kathmandu districts have very high exposure to climate stressors. Also, Sunsari, Gorkha, Kavrepalanchok, Sindhuli, Bara, Chitawan, Dang, Kaski, Jhapa, and Saptari districts have high exposure to climate-induced hazards. The total population of a district is one of the major contributions to the exposure component. Morang has 0.9 million inhabitants which are higher than adjoining districts Jhapa and Sunsari. The latter two districts have a population of 0.8 million and 0.7 million respectively and are categorized as high exposure districts. Districts such as Solukhumbu, Sankhuwasabha, and Taplejung are low exposure districts, and their respective population is 0.10, 0.15, and 0.13 million, significantly lower than highly exposed districts. In Bagmati Province, Kathmandu has very high exposure because it has 1.7 million inhabitants, a lot more than adjoining districts Lalitpur (0.4 million) and Bhaktapur (0.3 million).

Mountain districts such as Gorkha show higher exposure due to their larger district area despite the population size. Other factors have also contributed to this. Districts such as Rasuwa, Manang, Tehrathum, Dhankuta, Rasuwa, Nuwakot, Lamjung, Manang, Myagdi, Parbat, Argakhachi, Western Rukum, and Kalikot in this category have lower populations and smaller areas contributing to low exposure.

Exposure is also determined by the areas of land exposed to several climatic hazards. For example, Rupandehi and Kapibastu fall in the very high exposure category. This is mainly because of the higher land area under cereal crops in these two districts compared to other neighboring Tarai districts: Banke (61,172 ha), Bardiya (69,580 ha), Kapilbastu (95,749 ha), Nawalpur (34,902 ha), and Parasi (33,868 ha). The total land area exposed to climate change is also higher in Rupandehi and Kapilbastu. Similarly, some Tarai districts including Dang, and Chitawan were also ranked with a high degree of exposure. The attributing factors include large forest areas, wetland areas, agro-ecosystems, a large number of households involved in forests and biodiversity management, forest-based enterprises, and the presence of forest-related infrastructures such as forest roads, fire lines, view towers, and buildings.

Another determinant of high exposure to hazards is related to exposure to infrastructure and resources. Healthcare infrastructure such as hospitals, health posts, sub-health posts, and other governmental and non-governmental infrastructures are higher in Kathmandu, Kaski, Chitawan, and Morang. The highest number of functional water and sludge treatment plants can be found in Kathmandu (Figure 41 and Table 19).

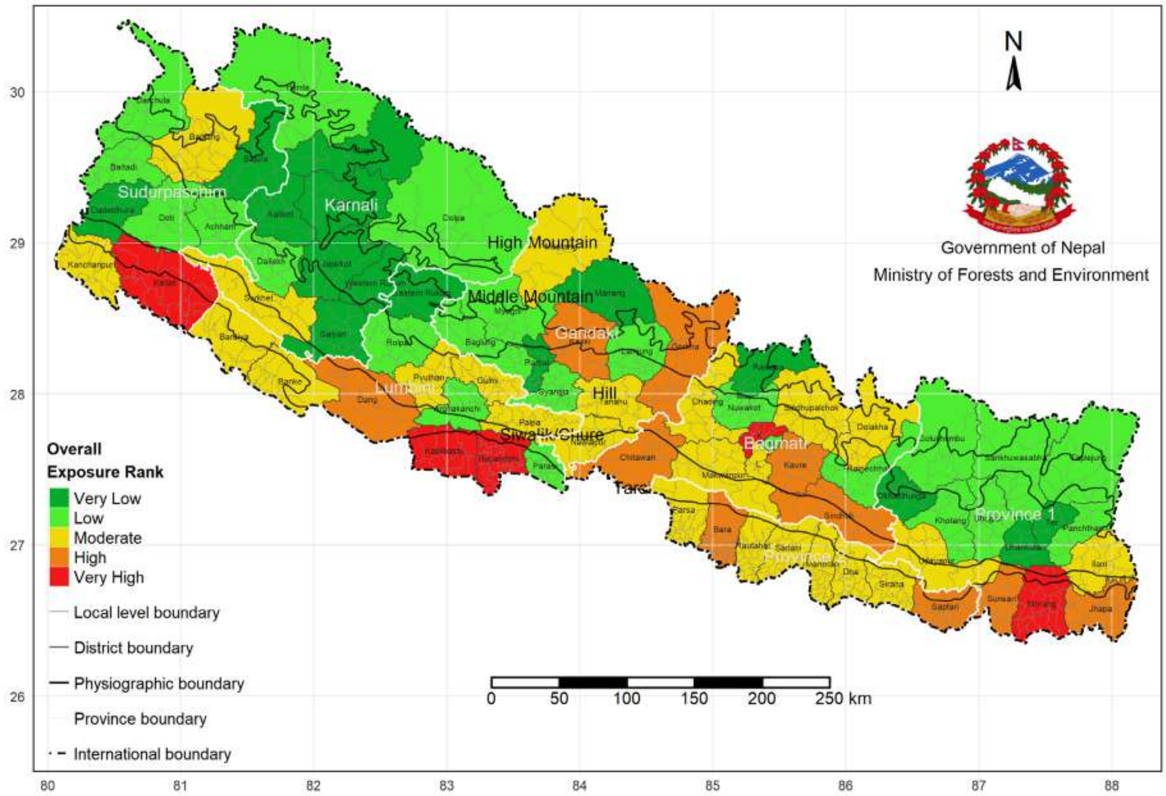


Figure 41: Exposure map of Nepal

Table 19: Overall exposure index of Nepal

Overall Exposure Rank	District
Very High (0.820 - 1)	Kapilbastu, Kailali, Rupandehi, Morang, Kathmandu
High (0.636 - 0.819)	Sunsari, Gorkha, Kavrepalanchok, Sindhuli, Bara, Chitawan, Dang, Kaski, Jhapa, Saptari
Moderate (0.473 - 0.635)	Dhading, Makawanpur, Dolakha, Rautahat, Sindhupalchok, Bardiya, Lalitpur, Tanahu, Udayapur, Pyuthan, Banke, Surkhet, Siraha, Palpa, Mustang, Dhanusha, Nawalpur, Kanchanpur, Sarlahi, Mahottari, Bajhang, Parsa, Gulmi, Ilam
Low (0.335 - 0.472)	Rolpa, Humla, Myagdi, Lamjung, Nuwakot, Sankhuwasabha, Baglung, Solukhumbu, Dailekh, Bhaktapur, Darchula, Syangja, Dolpa, Achham, Arghakhanchi, Baitadi, Bhojpur, Doti, Khotang, Taplejung, Panchthar, Parasi, Ramechhap
Very Low (0.218 - 0.334)	Mugu, Rasuwa, Dhankuta, Terhathum, Western Rukum, Parbat, Salyan, Manang, Eastern Rukum, Okhaldhunga, Bajura, Kalikot, Jajarkot, Jumla, Dadeldhura

Karnali and Sudurpaschim districts have low exposure. In these districts, the total population and infrastructure are low. Because of their difficult geography, these regions have few or no transportation links and infrastructure. Humla, Mugu, Rasuwa, Myagdi, Terhathum, Western Rukum, Darchula, Dolpa, Manang, Kalikot, Jajarkot, and Jumla districts, for example, have low to very low exposure in the drinking water, sanitation, and hygiene sector. This category includes the majority of mountainous districts.

The overall findings show that 26 municipalities represent a high to a very high degree of exposure to climate change (Figure 42a). Biratnagar, Lalitpur, Kathmandu, Birgunj, Bharatpur, Pokhara Lekhnath, Ghorahi, Tulsipur are the older and bigger towns developed as metropolitan and sub-metropolitan cities and are very highly exposed municipalities. The majority of highly exposed municipalities that have been established or declared in 2011 or earlier are highly populated with high infrastructure investments in roads, irrigation, health and education infrastructures, cultural heritage sites, and market centers that provide services and functions at the municipalities. The rest of the other 267 municipalities across Nepal are characterized by moderate to very low exposure to climate change. These municipalities are less populated and have limited infrastructure development. Very less exposed municipalities include the newly declared municipalities with low population and infrastructure and resources.

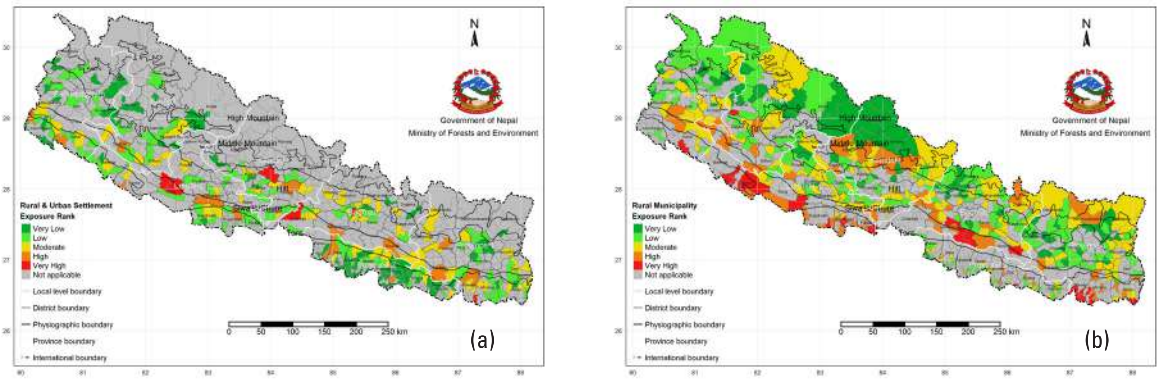


Figure 42: Exposure map of the a) urban municipalities; b) rural municipalities

In the case of rural municipalities, exposure is high in the Tarai and mid-hills rural municipalities compared to the mountain rural municipalities. The Tarai of Province one, Lumbini Province, Sudurpaschim Province has higher exposure. Besides, the mid-hills of Bagmati Province and Gandaki Province are highly vulnerable (Figure 42b). Mostly the demographic and resource concentration in the rural municipalities played a major role in increasing the exposure to climate-induced hazards.

6.3 Sensitivity to climate-induced hazards/climate extreme events

Sensitivity is understood as the predisposition of society and ecosystems to suffer harm as a consequence of intrinsic and context conditions making it plausible that such systems once impacted will collapse or experience major loss and damage due to the influence of a climatic hazard event. Often susceptibility is determined or differentiated by physical, biological, socio-economic, and structural characteristics of the exposed units. In this assessment composite sensitivity index is prepared to combine all the sectoral sensitivity values of the 77 districts. Mostly the sensitivity indicators are related to a) Demography and socio-economic differences; b) System and practices; b) Status of resource use: demand, supply, and use; c) Gender and socio-structural differences; d) Proximity and severity of impact; e) Location; f) Geological factors: slope, soil; g) Types of resources: forest types, agriculture types; h) Types and Conditions: health status, functionality; i) Others.

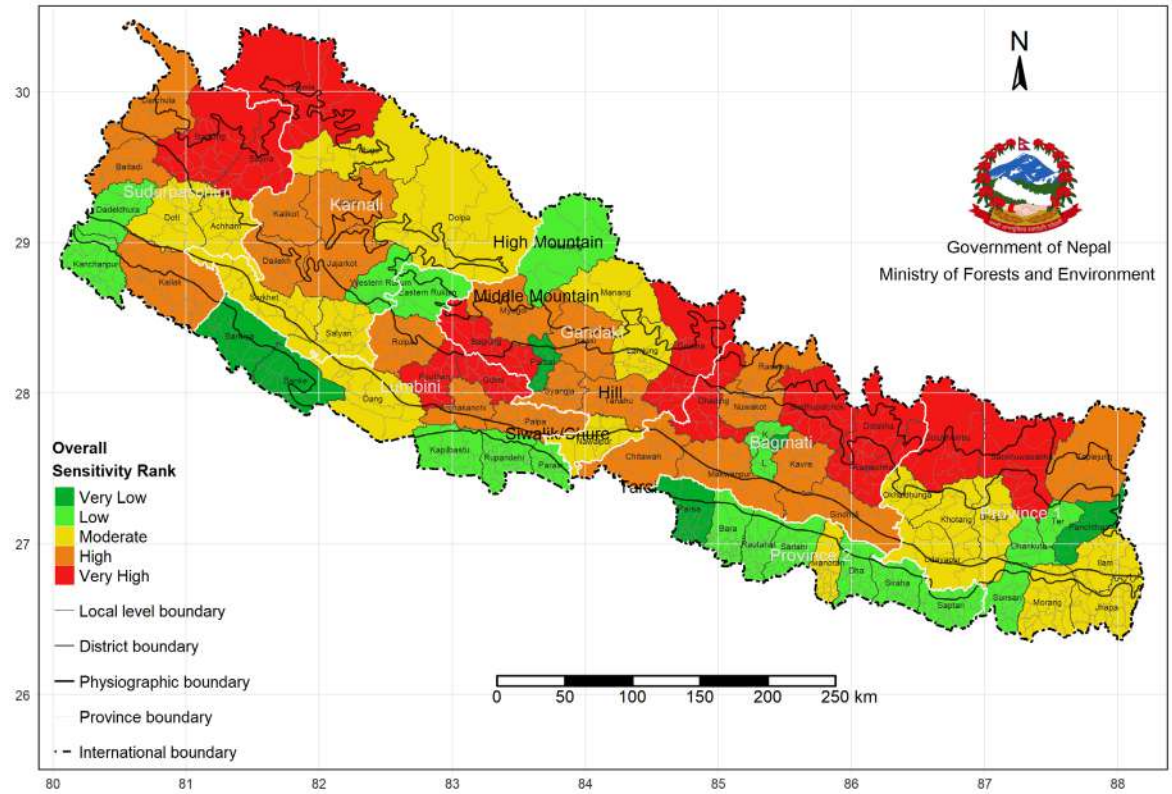


Figure 43: Sensitivity map of Nepal

The result shows that all the hill and mountain districts of Lumbini Province, Karnali Province, and Sudurpaschim Province are high to very highly sensitive to climate change impacts. In Gandaki Province, Gorkha, Baglung, Myagdi, Syangja, Tanahu, and Kaski districts experience a high to a very high degree of sensitivity to climate change impacts. Besides, leaving Kathmandu, Lalitpur, and Bhaktapur districts, all the hill and mountain districts of Bagmati Province fall in the high to very high sensitive category. Province one districts have mixed results. Only the mountain districts of Province one have a high to a very high degree of sensitivity. Except for Mahottari, which falls in the moderate sensitivity category, all other districts in Province two falls in low to a very low degree of sensitivity.

The results show that the sensitivity to climate change is very high in Dhading, Humla, Dolakha, Sankhuwasabha, Baglung, Sindhupalchok, Gorkha, Solukhumbu, Pyuthan, Bajura, Bajhang, Gulmi, and Ramechhap districts. On the contrary, Bardiya, Bhaktapur, Parbat, Banke, Panchthar, and Parsa districts fall in the very low sensitivity category (Figure 43 and Table 20).

Table 20: Overall sensitivity index of Nepal

Sensitivity Rank	District
Very High (0.914 - 1)	Dhading, Humla, Dolakha, Sankhuwasabha, Baglung, Sindhupalchok, Gorkha, Solukhumbu, Pyuthan, Bajura, Bajhang, Gulmi, Ramechhap
High (0.860 - 0.913)	Rolpa, Makawanpur, Rasuwa, Myagdi, Nuwakot, Tanahu, Kavrepalanchok, Dailekh, Darchula, Syangja, Kailali, Arghakhanchi, Baitadi, Palpa, Sindhuli, Chitawan, Kalikot, Kaski, Taplejung, Jajarkot, Jumla
Moderate (0.784 - 0.859)	Mugu, Lamjung, Udayapur, Dolpa, Surkhet, Achham, Bhojpur, Salyan, Morang, Doti, Manang, Khotang, Okhaldhunga, Dang, Nawalpur, Jhapa, Mahottari, Ilam
Low (0.683 - 0.783)	Kapilbastu, Sunsari, Dhankuta, Terhathum, Rautahat, Western Rukum, Lalitpur, Siraha, Rupandehi, Mustang, Bara, Eastern Rukum, Dhanusha, Kanchanpur, Sarlahi, Parasi, Kathmandu, Saptari, Dadeldhura
Very Low (0.575 - 0.682)	Bardiya, Bhaktapur, Parbat, Banke, Panchthar, Parsa

There are variations within sectors in terms of degree of sensitivity to climate change. For example, in the transport, industry, and physical infrastructure sector, the analysis shows that Kathmandu, Lalitpur, and Kaski fall in the high to very highly sensitive districts. Also, Lalitpur, Kathmandu, and Kaski fall in the very low sensitivity category in the socio-economic sectoral analysis. In the agriculture and food security sector, the analysis shows the majority of districts in Gandaki Province, Lumbini Province and Karnali Province fall under the very-high sensitivity category. Highly sensitive districts are spread across the mid-hill and high-hill regions from east to west. The Tarai districts have either low or very low degree of sensitivity.

In the water and energy sector, the result shows that all the districts of Tarai and Siwalik, except Kailali and Morang, have comparatively lower sensitivity to climate change. The districts in the hills of Gandaki Province and Lumbini Province, and Baitadi, Dailekh, Kavrepalanchok, and Okhaldhunga have comparatively high sensitivity. Similarly, most of the districts in the middle and high mountains have also comparatively high sensitivity to climate change. On contrary, most Tarai districts such as Parsa, Rautahat, Dhanusha, Siraha, Saptari, and Sunsari have very low sensitivity.

Urban and rural settlements are not included in the overall assessment. The assessment of sensitivity includes 293 municipalities only. The overall findings show that 121 municipalities exhibit a high to a very high level of sensitivity (Figure 44a). Among them, the majority of the municipalities scattered across all seven Provinces in Nepal exhibit sensitivity to climate change. This is because their geological features such as slope, geology, and soil characteristics increase susceptibility to climate extreme events and hazards. The municipalities in the hilly region and mountain region are more sensitive than that of the Tarai region except in some flood-prone municipalities where they have a higher number of exposed population and infrastructures increasing their respective sensitivity to annual flood events. According to the findings, 18 municipalities in Province One and 23 municipalities in Bagmati Province are classified as very high and high sensitivity due to their fragile landscape features such as steep slope, geology, and soil. Similarly, 9 municipalities in Lumbini Province, 22 municipalities in Gandaki Province, 19 municipalities each in Karnali Province and Sudurpaschim Province are classified as very high and high sensitivity, respectively, due to their proximity to flood-prone and landslide-prone areas.

Development practices such as rampant construction of buildings, expansion of unplanned settlements, the rapid development of physical infrastructure, and social infrastructure in disaster risk-prone municipal areas have also contributed to increased sensitivity to climatic hazards. Sensitivity to climatic hazards further increases due to lack of building code compliance, fragile and feeble road networks, maladaptive water schemes, and irrigation infrastructure. This study shows that only 46 municipalities have only implemented building codes.

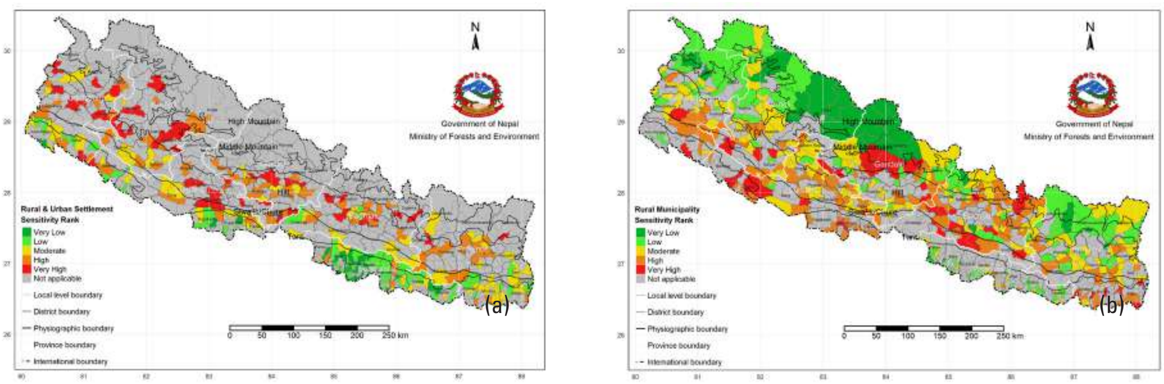


Figure 44: Sensitivity map of the a) urban municipalities; b) rural municipalities

In the case of the rural municipalities, the findings show that most of the Tarai and mid-hill rural municipalities in all the Provinces are highly sensitive to climate-induced extreme events and hazards. The sensitivity is high in the mid-hills of Bagmati Province and Gandaki Province. In Lumbini Province, Tarai and mid-hill rural municipalities have higher sensitivity. In the case of Province one, the higher sensitivity is found in rural municipalities of the Tarai region (Figure 44b).

6.4 Adaptive Capacity

The adaptive capacity is the ability of systems, institutions, humans, and other organisms such as plant and faunal species to adjust to potential damage, to take advantage of opportunities, or to respond to the consequences of climate change. In this assessment, adaptive capacity was assessed in terms of socio-economic capability such as the Human Development Index (HDI), Gender Inequality Index (GII), Gross Domestic Product (GDP), savings; institutional capability: access to goods and services (hospitals), adoption of policies and plans, codes and standards, actors and agencies; physical and technological: access to technology and practices, access to climate-resilient infrastructure, Early Warning Systems (EWS), well functional system; financial: access to insurance, access to financial institutions, budget flow, available fund; resourcefulness: access to safe drinking water and improved sanitation (Figure 45, Table 21).

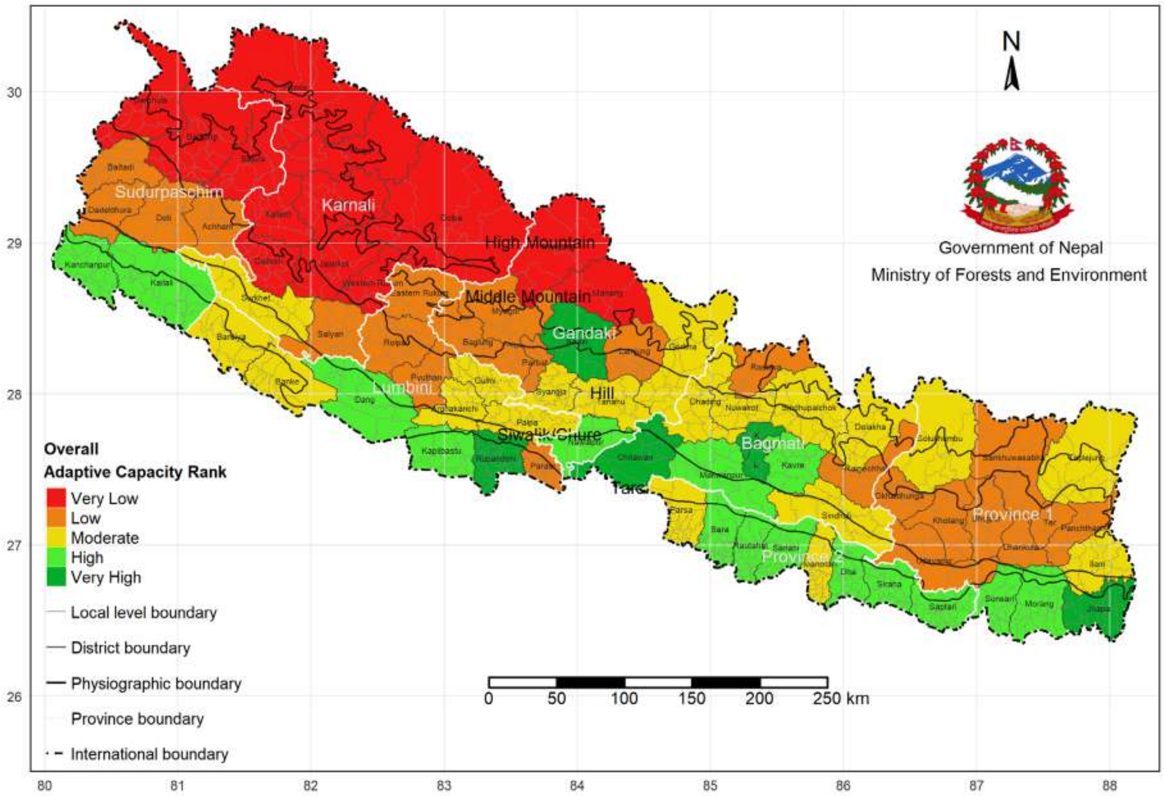


Figure 45: Adaptive capacity map of Nepal

Table 21: Overall adaptive capacity index of Nepal

Adaptive Capacity Rank	District
Very High (0.721 - 1)	Lalitpur, Rupandehi, Chitawan, Kaski, Jhapa, Kathmandu
High (0.587 - 0.720)	Makawanpur, Kapilbastu, Sunsari, Rautahat, Kavrepalanchok, Bhaktapur, Kailali, Siraha, Morang, Bara, Dhanusha, Dang, Nawalpur, Kanchanpur, Sarlahi, Saptari
Moderate (0.486 - 0.586)	Dhading, Dolakha, Nuwakot, Sindhupalchok, Bardiya, Gorkha, Solukhumbu, Tanahu, Syangja, Banke, Surkhet, Arghakhanchi, Palpa, Sindhuli, Taplejung, Mahottari, Parsa, Gulmi, Ilam
Low (0.364 - 0.485)	Rolpa, Rasuwa, Myagdi, Lamjung, Dhankuta, Terhathum, Sankhuwasabha, Baglung, Udayapur, Parbat, Pyuthan, Achham, Baitadi, Bhojpur, Salyan, Doti, Eastern Rukum, Khotang, Okhaldhunga, Panchthar, Parasi, Ramechhap, Dadeldhura
Very Low (0.237 - 0.363)	Humla, Mugu, Western Rukum, Dailekh, Darchula, Dolpa, Mustang, Manang, Bajura, Kalikot, Jajarkot, Jumla, Bajhang

The assessment shows that Lalitpur, Rupandehi, Chitawan, Kaski, Jhapa, and Kathmandu districts have a very high adaptive capacity with the ability to adjust well to the adverse effect of climate change. These districts have higher HDI, higher GDP, higher literature rate, improved access to infrastructure, health, and other services such as access to finance, access to government services, access to safe and clean drinking water, access to electricity, food sufficiency status due to access, access to information and technology, etc. Besides, Morang of Province one also falls into the category of high adaptive capacity. Economically active population, labour productivity, per-capita income are the major contributing factors to enhance the adaptive capacity of those districts in comparison to adjoining districts. Morang has a higher economically active population which is 3,77,0003 (29,000 in Jhapa). Labour productivity for Morang is NPR 1,29,000, and 1,22,000 for Jhapa. Per capita income is USD 1250 for Morang and USD 1226 for Jhapa.

Among the Provinces, Karnali Province, and Sudurpaschim Province have low to very low adaptive capacity. Except for Surkhet, Kailali, and Kanchanpur districts, all other districts in the hills and mountain region have low to very low adaptive capacity. Adaptive capacity is also lower in many hilly districts of the Lumbini Province and Gandaki Province. The mountain districts, particularly Mustang and Manang districts, of the Gandaki Province fall in very low adaptive capacity.

Moreover, most districts in the mid-hill and high-hill regions of Province one have low adaptive capacity. This is supported by many sectoral adaptive capacity assessments. In the agriculture and food security sector, the majority of the districts in Karnali Province, and Sudurpaschim Province fall under the low to very low adaptive capacity category particularly because of the high incidence of poverty and food insecurity. On the contrary, there is sectoral variation in terms of adaptive capacity. For example, in water resources and energy, Achham, Pyuthan, Gorkha, and Dolakha districts have a higher adaptive capacity. Besides, in the forest, watersheds, and biodiversity sector, the Far-western region represented high adaptive capacity mainly due to the implementation of some watershed interventions (e.g., in Doti, Dadeldhura, and Achham activities).

Besides, all the districts of Province two have moderate to low adaptive capacity. Except for Parsa, and Mahottari, all other districts are in the high adaptive capacity category. In the forest, watershed, and biodiversity sectors, both Tarai and Siwalik regions generally have high to very high adaptive capacity. Siwalik region represented the east-west distinction of adaptive capacity: the eastern part of the region is characterized by low adaptive capacity, while the western part exhibits very high adaptive capacity. The opposite is true in the Tarai region: the eastern Tarai has a very high adaptive capacity, while few parts of the western Tarai exhibit high adaptive capacity.

The adaptive capacity analysis was not included in the composite map and table for urban and rural settlements. The analysis of 293 urban municipalities shows that 40 municipalities have high to very high adaptive capacity whereas 179 municipalities have low to very low adaptive capacity (Figure 46a). The higher adaptive capacity was found in old municipalities established before 2011. These municipalities have received huge investments in urban planning and local development compared to newly established/declared municipalities. Municipalities such as Biratnagar, Birgunj, Damak, Kathmandu, Butwal, Itahari, Pokhara Lekhnath, etc., exhibit high to very high adaptive capacity. According to the findings, 28 municipalities in Province one, 51 municipalities in Province two, 10 municipalities in Bagmati Province, and 18 municipalities in Gandaki Province have low to very low adaptive capacity. In addition, 17 municipalities in Lumbini Province, 24 municipalities in Karnali Province, and 31 municipalities in Sudurpaschim Province have low to very low adaptive capacity. The major cause of low adaptive capacity is a higher incidence of poverty, inadequate infrastructure development and access, and other prevailing local development challenges. The majority of municipalities of Province two have small land holding areas with few inhabitants and infrastructures in comparison to other provinces which reflected the relatively lower value of adaptive capacity. While comparing with other provinces, Gandaki Province, Bagmati Province, and Lumbini Province have a better adaptive capacity due to high HDI, improved access to services and infrastructures, greater investment in the sector, etc.

Most of the old urban towns and cities of Nepal like Kathmandu, Pokhara, and Biratnagar have access to resources, access to information, and resilient and standard development practices. Therefore municipalities that have developed and implemented long-term periodic and integrated plans, including disaster preparedness plans, with adequate human resources for resilient construction of infrastructure, and prioritized investments in urban planning and local development have the higher adaptive capacity and vice versa.

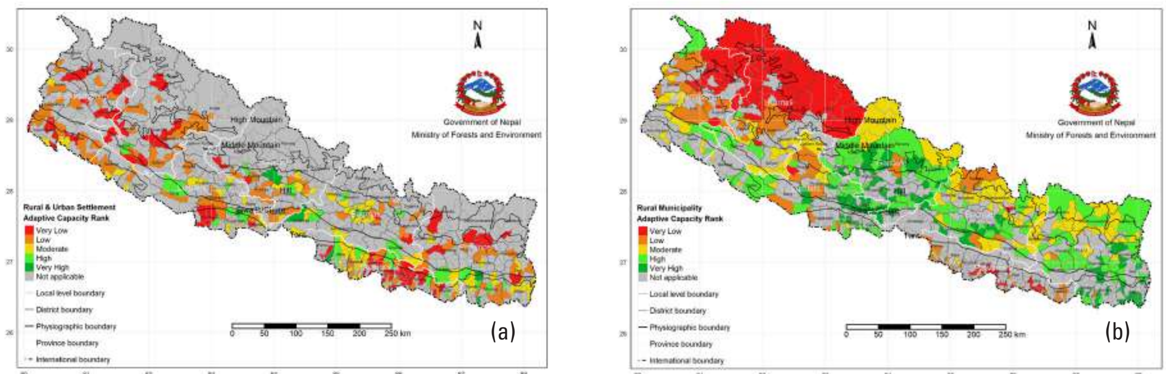


Figure 46: Adaptive capacity map of the a) urban municipalities; b) rural municipalities

Besides, the findings show that most of the rural municipalities in Province two, Karnali Province, and Sudurpaschim Province have lower adaptive capacity. The low adaptive capacity is mostly triggered by a lack of access to resources and services, including lower HDI and higher incidence of poverty in the Provinces and respective rural municipalities (Figure 46b).

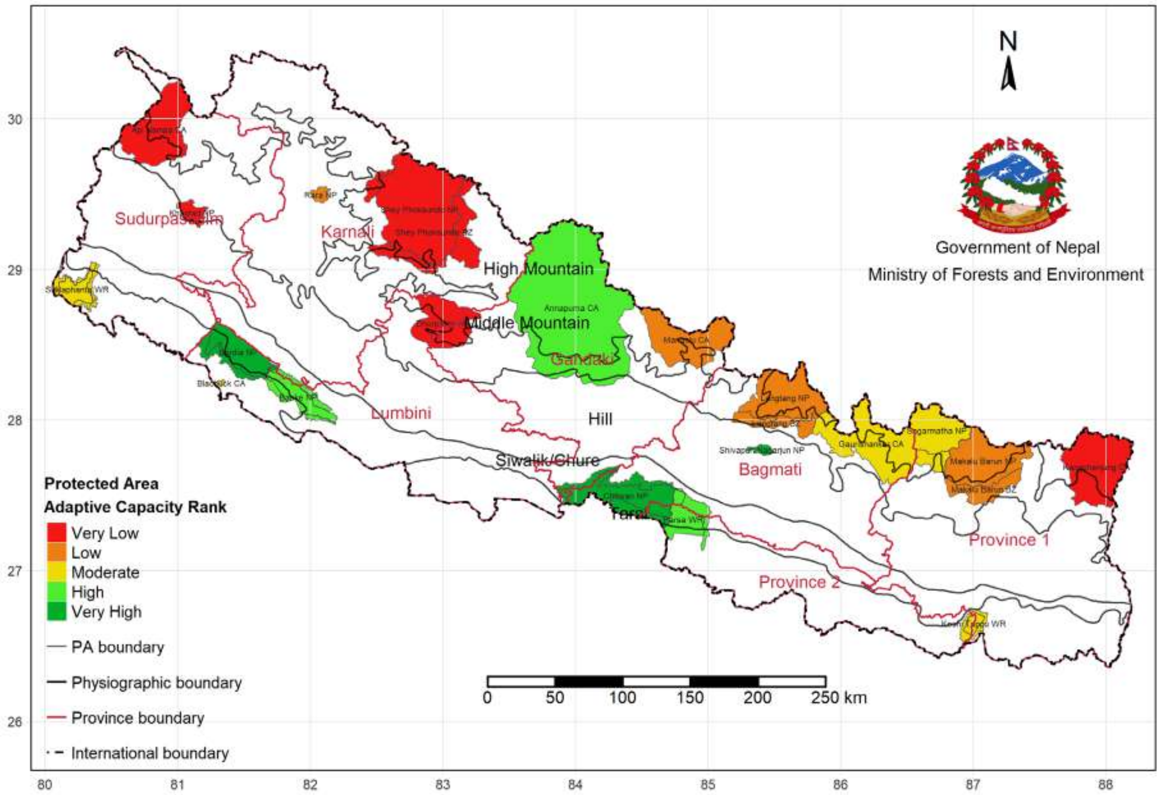


Figure 47: Adaptive capacity map of the protected areas

In the tourism sector, the Protected Areas (PAs) which are major tourist destinations are analyzed separately. The findings show that Bardiya, Banke, and Chitawan National Parks have a higher adaptive capacity. These protected areas are situated in plain areas (Figure 47). They have good access to strategic roads, have a sizeable number of hotels and restaurants, financial institutions, and health service facilities in the districts, where the PAs are located. By contrast, the majority of the PAs in the eastern and central mountain region of Province one and Bagmati Province, including Karnali Province and Sudurpashim Province have comparatively low adaptive capacity.

6.5 Vulnerability

In this assessment, vulnerability is defined as sensitivity or susceptibility to harm, as well as a lack of capacity to cope and adapt. It is influenced by a variety of conditions varying in their sensitivity, such as demographic, socioeconomic, ecological, physical, and geological characteristics, as well as the status and condition of resources and infrastructures. Furthermore, it is dependent on adaptability, which is influenced by socioeconomic assets, the existence of policy and regulations, access to power, access, control, and ownership over resources.

According to the findings, the majority of the districts (50) have a high-very high vulnerability level. Furthermore, the majority of these districts are located in hilly or mountainous terrain. Dhading, Rolpa, Humla, Mugu, Rasuwa, Myagdi, Dolakha, Sankhuwasabha, Baglung, Sindhupalchok, Gorkha, Dailekh, Pyuthan, Darchula, Dolpa, Baitadi, Salyan, Manang, Bajura, Kalikot, Jajarkot, Jumla, Bajhang, and Ramechhap districts are among those. Furthermore, all mountain districts are classified as highly vulnerable. Makawanpur, Lamjung, Dhankuta, Terhathum, Nuwakot, Western Rukum, Solukhumbu, Tanahu, Udayapur, Syangja, Surkhet, and Achham Arghakhanchi, Palpa, Bhojpur, Sindhuli, Mustang, Doti, Eastern Rukum, Khotang, Okhaldhunga, Taplejung, Mahottari, Gulmi, Dadeldhura, and Ilam are the high-vulnerability districts (Figure 48, Table 22).

All of the districts in Karnali Province are vulnerable to varying degrees. Except for Surkhet, Western Rukum, and Eastern Rukum districts, all other districts are extremely vulnerable. Except for Kailali and Kanchanpur districts, all other districts in Sudurpaschim Province are vulnerable to varying degrees. Sudurpaschim Province and Karnali Province are particularly vulnerable. Bagmati Province is vulnerable in a variety of ways. The Kathmandu district of Bagmati Province has the lowest vulnerability. The districts of Lalitpur, Bhaktapur, and Chitawan are classified as low vulnerability. Similarly, the Kavrepalanchowk district is classified as moderate. The rest of Bagmati Province's districts are classified as high to very high in terms of vulnerability. In the Gandaki Province, the districts of Kaski, Parbat, and Nawalpur are classified as moderately vulnerable. The remaining districts in the Gandaki Province are vulnerable to varying degrees. Myagdi, Baglung, Manang, and Gorkha districts are among those with extremely high vulnerability. Furthermore, the Lumbini Province has a mixed vulnerability distribution. Except for Morang, Sunsari, Jhapa, and Panchthar, all hilly and mountain districts in Province one are vulnerable to a high-very high degree. Sankhuwasaba district is classified as extremely vulnerable. Furthermore, except Mahottari, which falls into the high vulnerability category, all districts in Province two fall into the moderate to low vulnerability category. In Province two, the districts of Rautahat, Bara, Dhanusha, Parsa, and Saptari are classified as low vulnerability, while Siraha and Sarlahi are classified as moderate vulnerability.

Because of high adaptive capacity and comparatively lower sensitivity, the vulnerability in the Tarai appears moderate to low in the majority of districts. One of the reasons is that many rural municipalities do not have forests within their borders. Although multidimensional poverty and hazards are prevalent, other factors such as remoteness, access to resources, and existing facilities influence vulnerability. It is influenced by a variety of factors, including improved access to roads and infrastructure, diverse biodiversity, and access to energy.

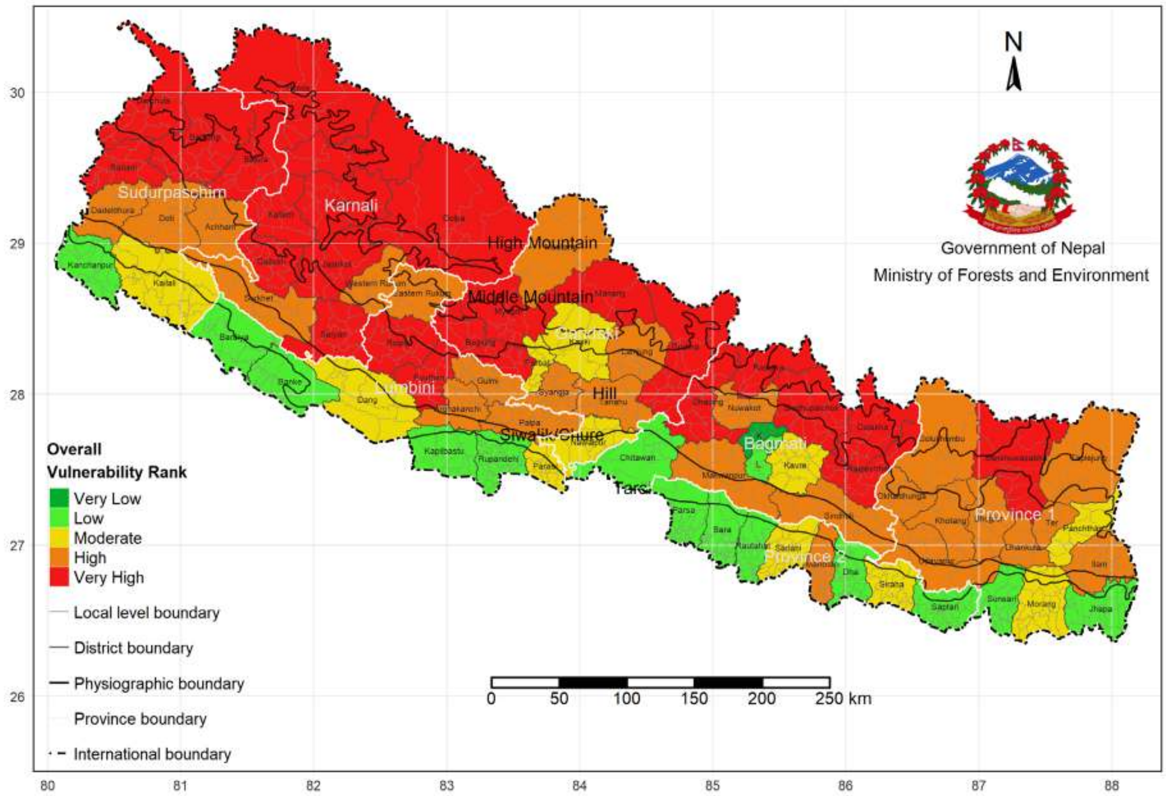


Figure 48: **Vulnerability map of Nepal**

Table 22: Overall vulnerability index of Nepal

Vulnerability Rank	District
Very High (0.778 - 1)	Dhading, Rolpa, Humla, Mugu, Rasuwa, Myagdi, Dolakha, Sankhuwasabha, Baglung, Sindhupalchok, Gorkha, Dailekh, Pyuthan, Darchula, Dolpa, Baitadi, Salyan, Manang, Bajura, Kalikot, Jajarkot, Jumla, Bajhang, Ramechhap
High (0.623 - 0.777)	Makawanpur, Lamjung, Dhankuta, Terhathum, Nuwakot, Western Rukum, Solukhumbu, Tanahu, Udayapur, Syangja, Surkhet, Achham, Arghakhanchi, Palpa, Bhojpur, Sindhuli, Mustang, Doti, Eastern Rukum, Khotang, Okhaldhunga, Taplejung, Mahottari, Gulmi, Dadeldhura, Ilam
Moderate (0.502 - 0.622)	Kavrepalanchok, Parbat, Kailali, Siraha, Morang, Dang, Nawalpur, Kaski, Panchthar, Sarlahi, Parasi
Low (0.179 - 0.501)	Kapilbastu, Sunsari, Rautahat, Bardiya, Lalitpur, Bhaktapur, Banke, Rupandehi, Bara, Chitawan, Dhanusha, Kanchanpur, Jhapa, Parsa, Saptari
Very Low (0 - 0.178)	Kathmandu

The outcome of this assessment differs slightly from the outcome of NAPA's vulnerability mapping in 2010 (Table 23). For example, Kathmandu and Bhaktapur, which were previously classified as highly vulnerable to climate change, are now classified as low and very low vulnerable. However, there are some similarities with districts such as Jhapa, Banke, Rauttahat, and Rupandehi. In 2010, these districts were classified as having low vulnerability. The current assessment was completed after nearly 10 years. There is also a slight difference in the methodology employed. NAPA, for example, used the IPCC's AR Four framework as a reference, whereas this VRA used the AR Five framework.

Table 23: Overall climate change vulnerability Index during NAPA, 2010

Vulnerability Ranking	Districts
Very High (0.787-1.000)	Kathmandu, Ramechhap, Udayapur, Lamjung, Mugu, Bhaktapur, Dolakha, Saptari, Jajarkot
High (0.601-0.786)	Mahottari, Dhading, Taplejung, Siraha, Gorkha, Solukhumbu, Chitwan, Okhaldhunga, Achham, Manang, Dolpa, Kalikot, Khotang, Dhanusha, Dailekh, Parsa, Salyan
Moderate (0.356-0.600)	Sankhuwasabha, Baglung, Sindhuli, Bhojpur, Jumla, Mustang, Rolpa, Bajhang, Rukum, Rautahat, Panchthar, Parbat, Dadeldhura, Sunsari, Doti, Tanahu, Makawanpur, Myagdi, Humla, Bajura, Baitadi, Bara, Rasuwa, Nawalparasi, Sarlahi, Sindhupalchok, Darchula, Kaski
Low (0.181-0.355)	Nuwakot, Dhankuta, Kanchanpur, Bardiya, Kapilbastu, Terhathum, Gulmi, Pyuthan, Surkhet, Arghakhanchi, Morang, Dang, Lalitpur, Kailali, Syangja, Kavrepalanchowk
Very Low (0.000-0.180)	Ilam, Jhapa, Banke, Palpa, Rupandehi

Source: MoE/NAPA Project (2010) *Climate change vulnerability mapping for Nepal.*

When it comes to physiographic regions, the results suggest that high mountains and mid-hills are more vulnerable than other areas. Within the provinces, there is a wide range of physiographic vulnerability. This is, however, context-dependent and varies by sector.

The sectoral vulnerability, on the other hand, varies. In the agriculture sector, high sensitivity and poor adaptive capacity have made most districts in Karnali Province and Sudurpaschim Province extremely vulnerable. In all Provinces, there is a high level of vulnerability in a few mid and high-hill districts. Furthermore, except Nawalpur and Parasi, all Tarai districts have very low vulnerability because they are less sensitive and have a greater capacity to adapt (Figure 49a). Besides, high vulnerability is observed in hills and mountain districts in the forest and biodiversity sector, with Mugu, Sankhuwasabha, Dolpa, and Kalikot districts having very high vulnerability (Figure 49b).

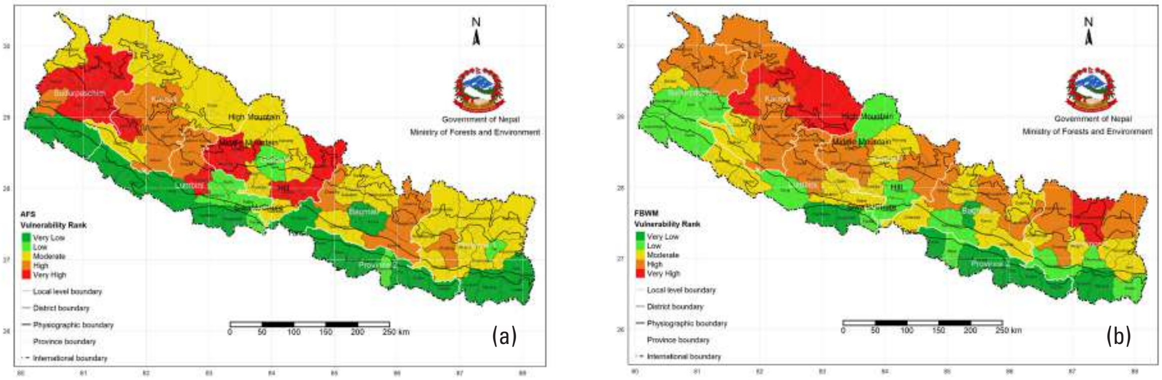


Figure 49: Vulnerability of a) Agriculture and food security sector; b) Forest, Biodiversity and Watershed sector

Vulnerability in the water resource and energy sectors is concentrated in the Bagmati Province, Gandaki Province, Lumbini Province, Karnali Province, and Sudurpaschim Province. However, there are a few districts in Province one that is also highly vulnerable (Figure 50). The findings show that most of the watersheds in Bagmati Province, Gandaki Province, Lumbini Province, Karnali Province, and Sudurpaschim Province are highly vulnerable (Figure 51a). Furthermore, the result shows that the sub-basins of the Karnali river basin have a higher vulnerability to climate change impacts (Figure 51 b).

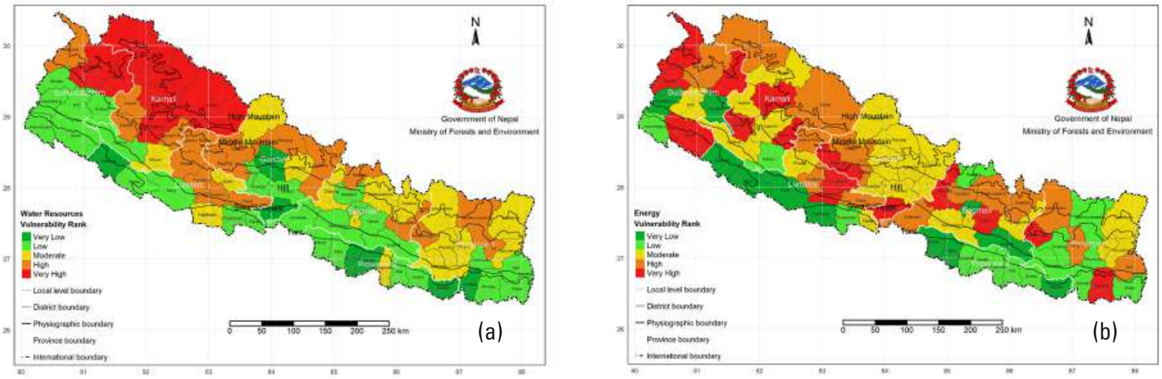


Figure 50: Vulnerability of water resources and energy sector

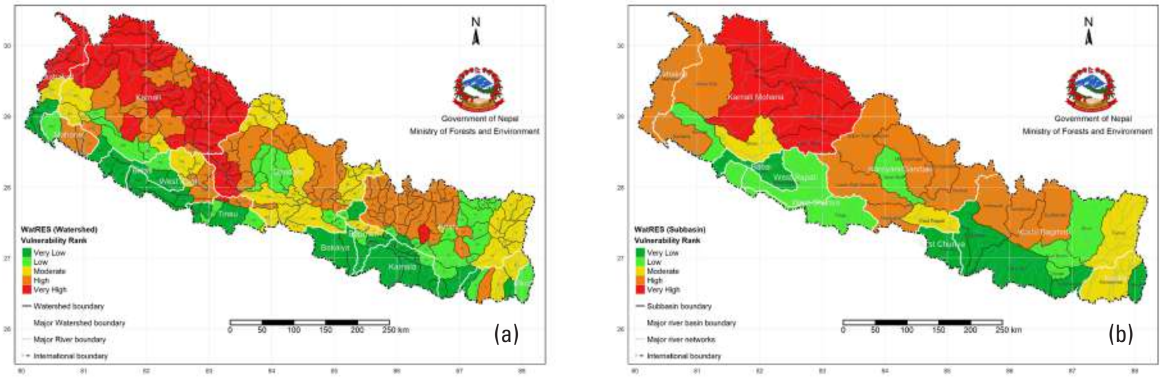


Figure 51: Vulnerability of a) Watershed, b) Sub-basin

Apart from Karnali Province and Sudurpaschim Province, vulnerability appears to be higher in Province two in the health (Figure 52a) and WASH sectors (Figure 52b). These Provinces have a higher population that is vulnerable to climate-related hazards like epidemics. There is also a higher proportion of women, children, and people with health problems. Furthermore, the districts' adaptive capacity was hampered by a lack of access to hospitals, safe drinking water, and improved sanitation

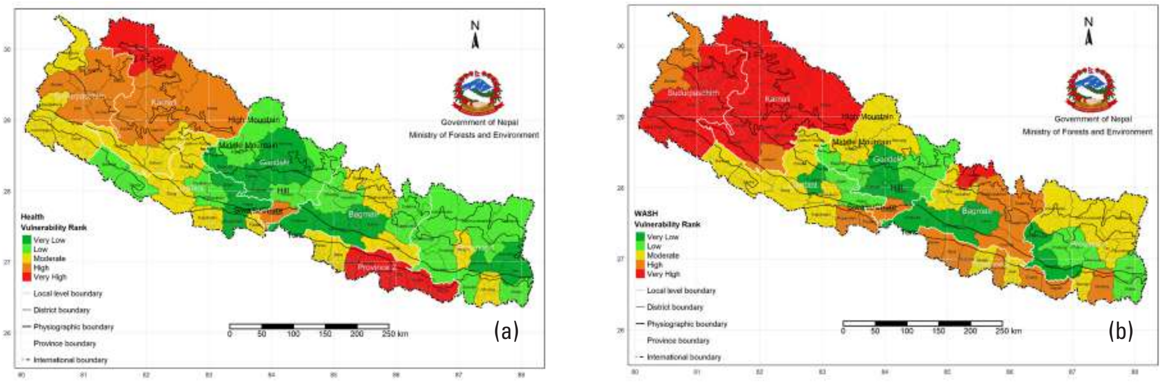


Figure 52: Vulnerability of: a) health sector; b) WASH sector

In the case of the tourism sector, the vulnerability in the cultural heritage sub-sector shows that mostly mountain districts of Province one, Bagamati Province, Gandaki Province, Karnali Province, and Sudurpaschim Province have high vulnerability compared to other region and Provinces (Figure 53a). In the protected areas, the vulnerability is higher in the mountains compared to other locations (Figure 53b). In the Transport, Industry, and Physical Infrastructure sector, the vulnerability is highly concentrated in the mid-hills and mountain districts. The vulnerability is higher in Province two, Bagmati Province, Gandaki Province, Lumbini Province, and Karnali Province.

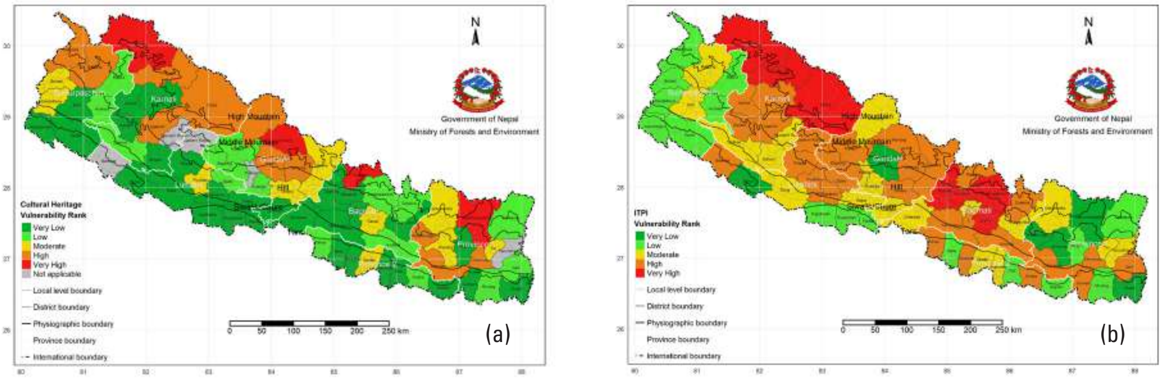


Figure 53: Vulnerability of a) Cultural heritage sites- tourism; b) Transport, Industry, and Physical Infrastructure sector

In terms of GESI, livelihood, and governance, vulnerability is higher in the Karnali Province and Sudurpaschim Province, due to increased sensitivity as a result of higher poverty incidence, food insecurity, low income, lower HDI, and GDI, and low adaptive capacity. Such vulnerability as a result of increased sensitivity and very low adaptive capacity is an indication of persistent vulnerability (Figure 54). Besides, few districts in Province two and Bagmati Province (mostly in the Chure region) are vulnerable.

The vulnerability analysis of urban municipalities also reveals that the majority of vulnerable municipalities are concentrated in the Karnali Province and Sudurpaschim Province. Among the 293 municipalities assessed, 37 are classified as very high, 52 as high, 42 as moderate, 58 as low, and 104 as very low vulnerable (Figure 55a). Pokhara Lekhnath, Dharan, Kathmandu, Biratnagar, Lalitpur, Dhangadi, Dharan, Dhankuta, and additional long-established metropolitan, sub-metropolitan, and municipal areas have the very high adaptive capacity and low vulnerability to climate change. These municipalities have a high level of human development index, adequate livelihood assets, and access to urban services and functions. They are also economically sound, have a resilient physical and social infrastructure, and have the institutional capacity to plan for and respond to climate-induced shocks and stress effectively. As a result, long-established municipalities have adequate capacity to deal with climate-related shocks and stresses.

Furthermore, municipalities with low vulnerability rankings are better positioned to protect and improve people's lives, secure development gains, and foster an investible environment. Municipalities in the high to very high vulnerability category were found in all seven Provinces, including 21 municipalities in Province one, 9 municipalities in Province two, 17 municipalities in Bagmati Province, 19 municipalities in Gandaki Province, 18 municipalities in Lumbini Province, 21 municipalities in Karnali Province, and 21 municipalities in Sudurpaschim Province. The main reason for the high vulnerability found in municipalities across all Provinces is their extreme sensitivity and limited adaptive capacity.

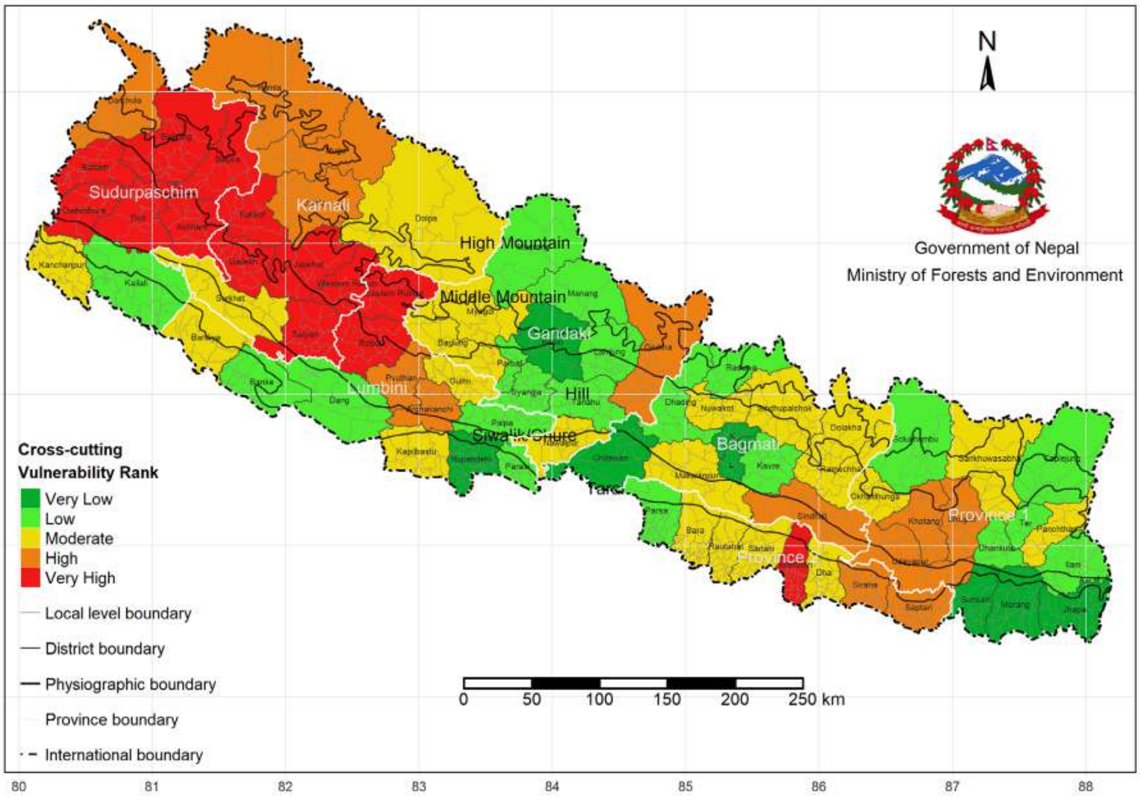


Figure 54: Vulnerability of GESI, Livelihood, and Governance sector

Many municipalities face severe climate and development challenges, such as proximity to risk-prone areas where administrative and technical solutions are lacking. The vulnerability in rural municipalities is concentrated in Province two, Bagmati Province, Lumbini Province, Karnali Province, and Sudurpaschim Province. Few municipalities in the Gandaki Province are also vulnerable. Except for Province one and Gandaki Province, the vulnerability is distributed across all physiographic regions of the remaining provinces. Karnali Province and Sudurpaschim Province are the most vulnerable of the Provinces. Furthermore, the Provinces' vulnerability is influenced by higher sensitivity of population and resources, as well as a lower capacity to respond to the effects of climate change (Figure 55b).

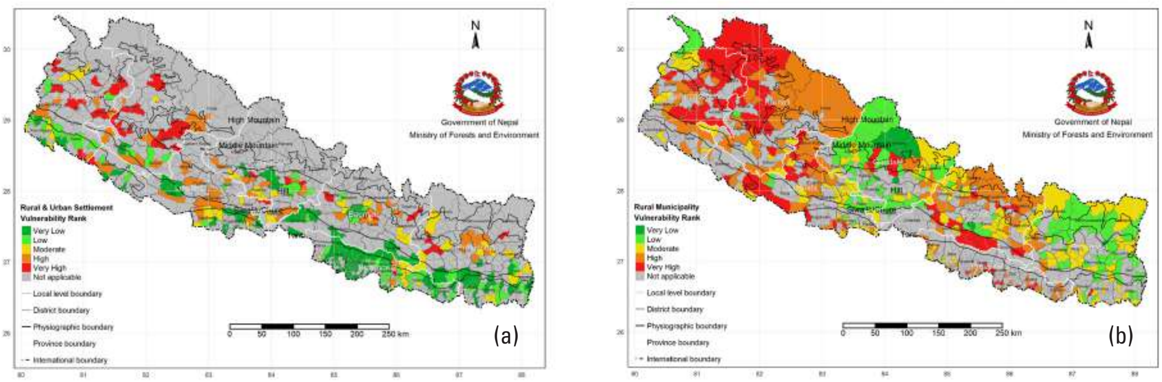


Figure 55: Vulnerability of a) the urban municipalities; b) rural municipalities

In summary, it is also highly likely that future vulnerabilities will also increase across the majority of the municipalities and provinces due to the projection of increased hazards, the socio-economic downfalls due to COVID-19, and other issues, including the political instability in Nepal. The extreme events and climate-induced hazards are projected to increase and impact mostly Province one, Province two, Bagamati Province, and Gandki Province in the medium term. However, the climate extreme events will be impacting all the provinces in 2050. This increases the sensitivity of the population and livelihood resources, including other basic infrastructures and services. The findings in the previous chapter also show that there will be increasing migration to the urban areas making urban poverty a major issue. Besides, it shows that the development progress in Province two, Karnali Province and Sudupaschim Province will be sluggish. All these circumstances lead to the inadequate adaptive capacity of the provinces to respond to climate change impact. Among others, findings show that the poor, marginalized, women, children, elderly, disabled will be more vulnerable to the impacts.

6.6 Risk of climate change impact

Risk is determined by factors such as exposure, vulnerability, and hazards. The exposure and vulnerability in this study are based on the current context, while the hazard is based on climate extreme events in the mid-term (2030) and long-term (2050) periods under two climatic scenarios, RCP 4.5 and RCP 8.5. As a result, the overall risk scenarios are dependent on the hazard scenario. The function of climate extreme events is a hazard. Floods, for example, are affected by precipitation, wet spell duration, and the number of extreme wet days; similarly, landslides are affected by precipitation and the number of extreme wet days; and hailstorms are affected by temperature and precipitation.

Baseline risk of climate change impact

The overall baseline risk of climate change impact is calculated by taking current hazards, exposure, and vulnerability into account. Because it is an aggregated risk index and map, it may not accurately represent sector-specific baseline risks. According to the findings, climate-induced disasters had a significant impact on the districts of Dhading, Makawanpur, Sindhupalchok, Gorkha, Kailali, Sindhuli, Morang, and Jhapa. Furthermore, climate-induced disasters had a significant impact on the districts of Dolakha, Nuwakot, Sankhuwasabha, Tanahu, Kavrepalanchok, Udayapur, Pyuthan, Siraha, Chitawan, Dang, Kaski, Mahottari, and Saptari (Figure 56 and Table 24).

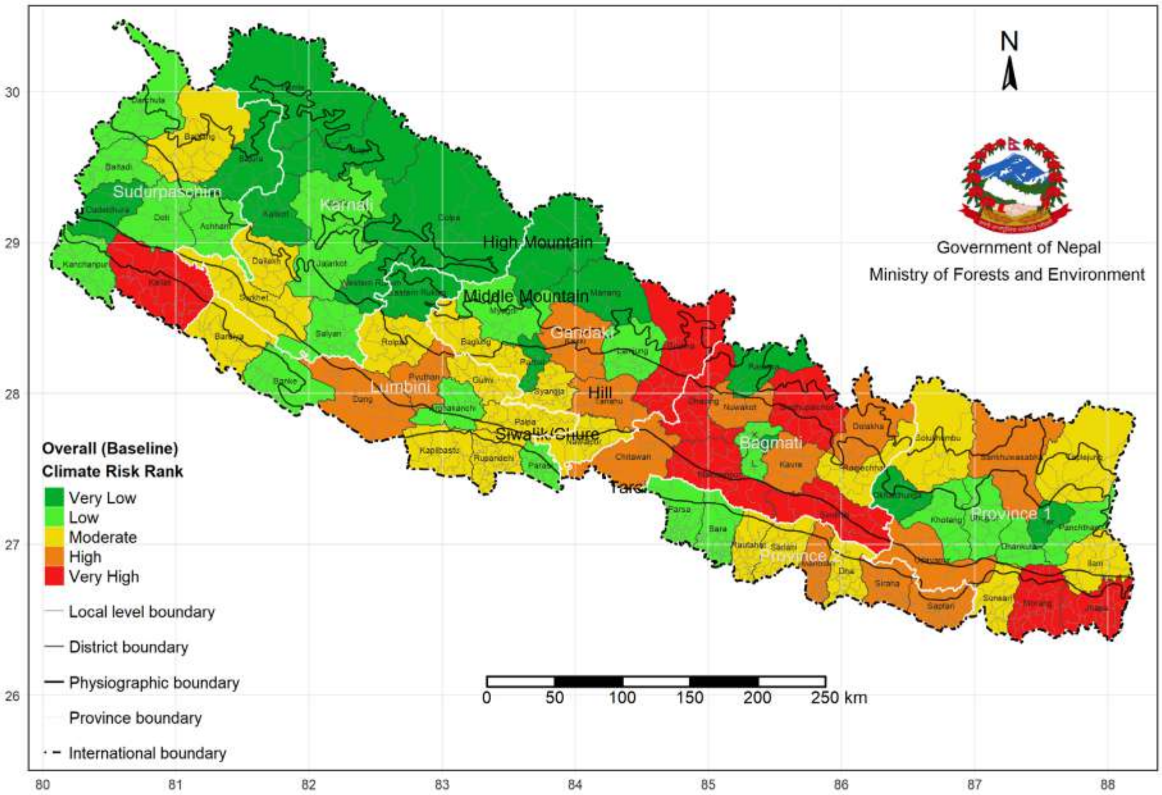


Figure 56: Baseline risk of climate change impact in Nepal

Table 24: Overall baseline risk index of Nepal

Baseline Risk Rank	District
Very High (0.584 - 0.719)	Dhading, Makawanpur, Sindhupalchok, Gorkha, Kailali, Sindhuli, Morang, Jhapa
High (0.468 - 0.583)	Dolakha, Nuwakot, Sankhuwasabha, Tanahu, Kavrepalanchok, Udayapur, Pyuthan, Siraha, Chitawan, Dang, Kaski, Mahottari, Saptari
Moderate (0.358 - 0.467)	Rolpa, Kapilbastu, Sunsari, Rautahat, Baglung, Bardiya, Solukhumbu, Dailekh, Syangja, Surkhet, Rupandehi, Palpa, Dhanusha, Nawalpur, Taplejung, Sarlahi, Bajhang, Gulmi, Ramechhap, Ilam
Low (0.252 - 0.357)	Myagdi, Lamjung, Dhankuta, Lalitpur, Darchula, Banke, Achham, Arghakhanchi, Baitadi, Bhojpur, Salyan, Bara, Doti, Khotang, Kanchanpur, Panchthar, Jajarkot, Jumla, Parasi, Parsa, Kathmandu
Very Low (0.120 - 0.251)	Humla, Mugu, Rasuwa, Terhathum, Western Rukum, Bhaktapur, Parbat, Dolpa, Mustang, Manang, Eastern Rukum, Okhaldhunga, Bajura, Kalikot, Dadeldhura

On the other hand, disasters have had little effect in the districts of Humla, Mugu, Rasuwa, Terhathum, Western Rukum, Bhaktapur, Parbat, Dolpa, Mustang, Manang, Eastern Rukum, Okhaldhunga, Bajura, Kalikot, and Dadeldhura. Myagdi, Lamjung, Dhankuta, Lalitpur, Darchula, Banke, Achham, Arghakhanchi, Baitadi, Bhojpur, Salyan, Bara, Doti, Khotang, Kanchanpur, Panchthar, Jajarkot, Jumla, Parasi, Parsa, and Kathmandu were among the districts that experienced little damage from disasters. Only 20 districts in Nepal are classified as having a moderate baseline risk (Figure 56 and Table 24).

Table 25 shows that, despite their high vulnerability, Humla, Mugu, Dolpa, Manang, and Bajhang currently face a low risk and impact from climate change. It is mostly because climate severe events occur infrequently. Furthermore, despite witnessing higher climate severe events and high exposure, the districts of Jhapa, Chitawan, Rupandehi, Kapilvastu, and Kathmandu have low to very low vulnerability. In addition, the districts of Rolpa, Rasuwa, and Myagdi have low climate risk and exposure but high vulnerability.

Table 25: Districts with high extreme events, exposure, and vulnerability

Elements of Risks	High -Very high	Low – Very low
Climate extreme events	Very high: Sankhuwasabha, Morang, Chitawan, Jhapa High: Dhading, Makawanpur, Sunsari, Rautahat, Sindhupalchok, Tanahu, Kavrepalanchok, Parbat, Syangja, Kailali, Siraha, Rupandehi, Palpa, Sindhuli, Bara, Dhanusha, Nawalpur, Kaski, Taplejung, Panchthar, Sarlahi, Mahottari, Parasi, Parsa, Saptari, Ilam	Very low: Humla, Mugu, Dolpa, Mustang, Manang, Bajura Low: Rolpa, Rasuwa, Myagdi, Western Rukum, Dailekh, Darchula, Baitadi, Salyan, Eastern Rukum, Kalikot, Jajarkot, Jumla, Bajhang, Dadeldhura
Exposure	Very high: Kapilbastu, Kailali, Rupandehi, Morang, Kathmandu High: Sunsari, Gorkha, Kavrepalanchok, Sindhuli, Bara, Chitawan, Dang, Kaski, Jhapa, Saptari	Very Low: Mugu, Rasuwa, Dhankuta, Terhathum, Western Rukum, Parbat, Salyan, Manang, Eastern Rukum, Okhaldhunga, Bajura, Kalikot, Jajarkot, Jumla, Dadeldhura Low: Rolpa, Humla, Myagdi, Lamjung, Nuwakot, Sankhuwasabha, Baglung, Solukhumbu, Dailekh, Bhaktapur, Darchula, Syangja, Dolpa, Achham, Arghakhanchi, Baitadi, Bhojpur, Doti, Khotang, Taplejung, Panchthar, Parasi, Ramechhap
Vulnerability	Very high: Dhading, Rolpa, Humla, Mugu, Rasuwa, Myagdi, Dolakha, Sankhuwasabha, Baglung, Sindhupalchok, Gorkha, Dailekh, Pyuthan, Darchula, Dolpa, Baitadi, Salyan, Manang, Bajura, Kalikot, Jajarkot, Jumla, Bajhang, Ramechhap High: Makawanpur, Lamjung, Dhankuta, Terhathum, Nuwakot, Western Rukum, Solukhumbu, Tanahu, Udayapur, Syangja, Surkhet, Achham, Arghakhanchi, Palpa, Bhojpur, Sindhuli, Mustang, Doti, Eastern Rukum, Khotang, Okhaldhunga, Taplejung, Mahottari, Gulmi, Dadeldhura, Ilam	Very low: Kathmandu Low: Kapilbastu, Sunsari, Rautahat, Bardiya, Lalitpur, Bhaktapur, Banke, Rupandehi, Bara, Chitawan, Dhanusha, Kanchanpur, Jhapa, Parsa, Saptari

Projected risks of climate change impact in the medium-term (2030) and long-term scenarios (2050)

Table 26 illustrates the scenarios of the extreme climate events in medium-term and long-term duration under RCP 4.5 and 8.5 scenarios. The hazards are likely to increase in all scenarios consequently increasing overall risk. Extreme wet days are projected to increase, referring to the increase of floods, landslides, and all hazards triggered by heavy and continuous rainfall that consequently increase the risk (despite the number of rainy days decreasing). Their impact is reflected accordingly in the risk.

In RCP 8.5, cold days will increase, as well as cold nights, warm spells duration, and cold spells duration by -75 percent, -74 percent, 244.8 percent, -73.3 percent respectively. Very wet days and extreme wet days will increase by 18.6 percent and 59.8 percent respectively. Meanwhile, dry days such as CDD, and CWD will decrease slightly in the long term. While considering the medium-term duration cold spell duration index will decrease by -55.8 percent, -54 percent, 157.4 percent, -55.1 percent respectively. Very wet days and extreme wet days are projected to increase by 12.1 percent and 28 percent respectively.

In RCP 4.5, cold days will increase, as well as cold nights, warm spell duration, and cold spell duration by -52.6 percent, -53.6 percent, 149 percent, -63.3 percent respectively. Very wet days and extreme wet days are projected to increase by 12 percent and 41.3 percent respectively. Dry days such as CDD, and CWD will decrease slightly in the long term. While considering the medium-term duration cold spell duration index will decrease by -42 percent, -40.7 percent, 110 percent, -515.8 percent respectively. Very wet days and extreme wet days are projected to increase by 1.5 percent and 26.3 percent respectively.

Table 26: Percentage change in extreme climatic conditions in the medium-term and long-term periods under RCP 4.5 and 8.5

Indices	No. of mean annual days in the reference period	RCP4.5				RCP8.5			
		Medium-term		Long-term		Medium-term		Long-term	
		%	Days	%	Days	%	Days	%	Days
P95	18.1	1.5	0.3	12	2.2	12.1	2.2	18.6	3.4
P99	3.5	26.3	0.9	41.3	1.4	28	10	59.8	2.1
Rainy days	166.4	-1.8	-3	-1	-1.7	-0.9	-1.6	-0.5	-0.8
CDD	45.3	6	2.7	2.4	1.1	-1.6	-0.7	-2.9	-1.3
CWD	78.1	-4.2	-3.3	-1.3	-1	3.1	2.5	2.2	1.7
Warm days	36.5	64.5	23.9	87.3	32.3	71.4	26.4	124.7	46.1
Warm nights	36.5	81.4	30.5	115.7	43.3	101	37.8	159.2	59.6
Cold days	36.5	-42	-15.4	-52.6	-19.3	-55.8	-20.5	-75	-27.5
Cold nights	36.5	-40.7	-15	-53.5	-19.7	-54.1	-19.9	-74	-27.3
Warm spell duration index	17.6	110	19.3	149	26.2	157.4	27.6	244.8	43
Cold spell duration index	20.3	-51.8	-10.5	-63.9	-12.9	-55.1	-11.2	-73.3	-14.8

Source: MoFE, 2019

Projected risks of climate change impact in 2030 with projected increases of temperature by 0.9–1.1 degrees Celsius (°C)

Under RCP 4.5 in 2030, a total of 15 districts fall in the very high-risk category while 17 districts fall in the high-risk category. Except for some exceptions under RCP 4.5, almost all districts in the Tarai, mid-hills, and mountains fall under high-very high risks. Likewise, under RCP 8.5 in 2030, a total of 19 districts fall in the very high-risk category while 17 districts fall in the high-risk category. Most districts in

Province one, Province two, Bagmati Province, Gandaki Province, and Lumbini Province fall in a high-risk category under both RCP scenarios. Relatively the Karnali Province and Sudurpaschim Province seems to be at low risk under both scenarios in 2030. The majority of the southern districts of Province two and Province one are likely to experience a high risk of climate change (Figure 57, and Table 27).

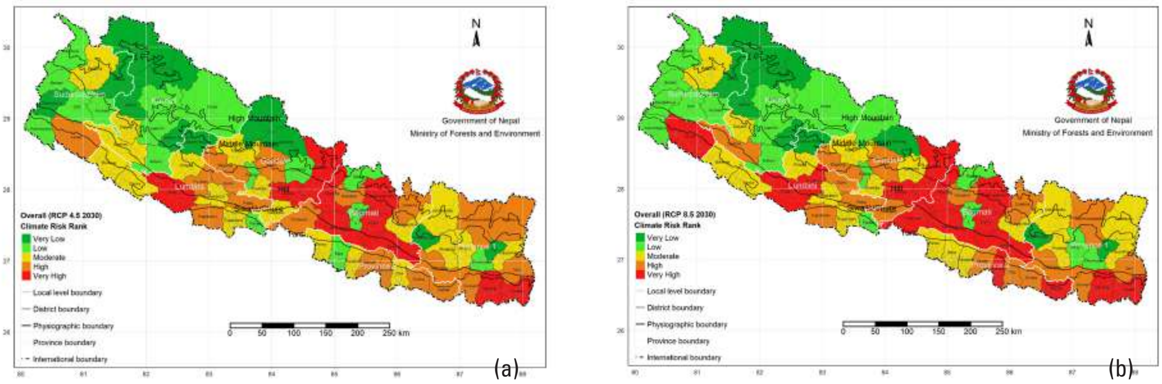


Figure 57: **Risk Scenarios a) RCP 4.5 2030; b) RCP 8.5 2030**

In urban municipalities, the findings show that, the risk level for Bhanu and Byas in Gandaki Province and Sitganga in Lumbini Province increased from high to very high-risk under RCP (4.5, 8.5) in 2030. In RCP 4.5 2030, the number of very high-risk municipalities climbed from two in the baseline to six, while the risk level in the high-risk category increased from 44 in the baseline to 80. The primary explanation for this is the likelihood of an increase in climate extreme events, such as temperature rises. Other socio-economic factors like governmental policies influence the likelihood of risk, as they shape the sensitivity and vulnerability of those municipalities.

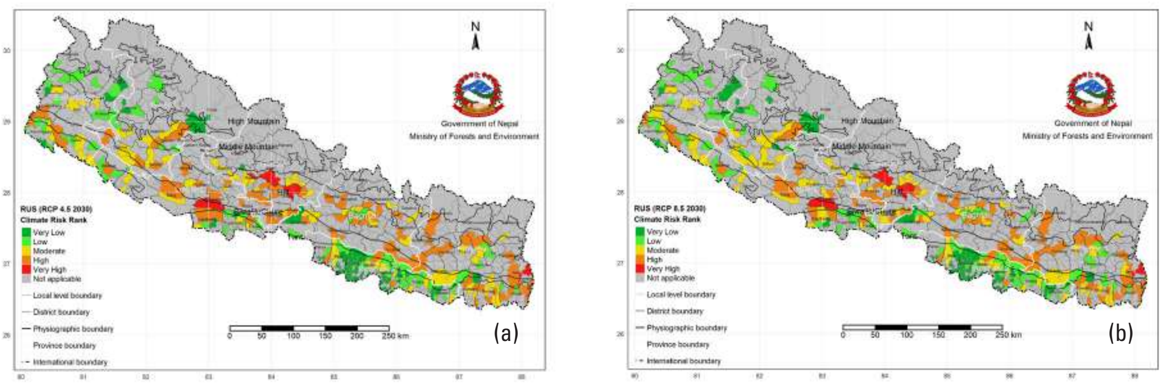


Figure 58: **Risk scenarios of urban municipalities in 2030 under a) RCP 4.5; b) RCP 8.5**

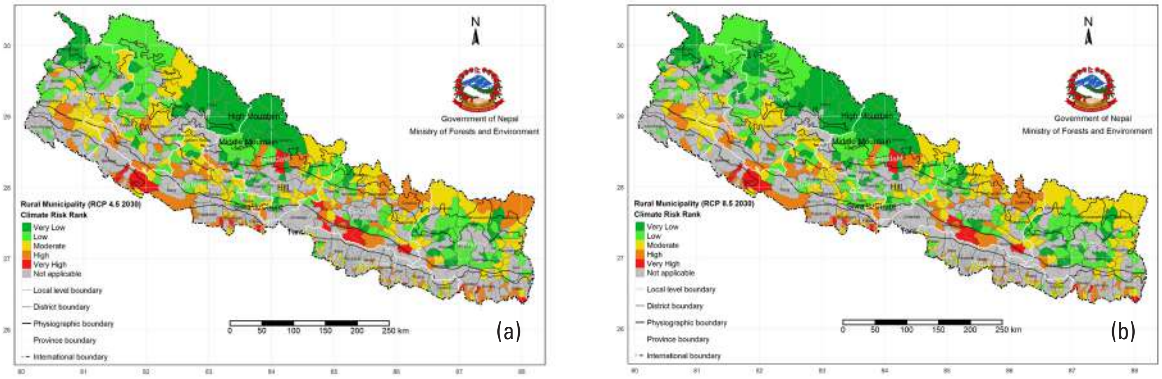


Figure 59: Risk scenarios of Rural Municipalities in 2030 a) RCP 4.5, b) RCP 8.5

Table 27: Risk Scenarios under RCP 4.5 and 8.5 (2030)

Risk Rank	District (RCP 4.5 2030)	District (RCP 8.5 2030)
Very High (More than 0.583)	Dhading, Makawanpur, Sindhupalchok, Gorkha, Tanahu, Kavrepalanchok, Sindhuli, Morang, Dang, Jhapa	Dhading, Makawanpur, Sindhupalchok, Gorkha, Tanahu, Kavrepalanchok, Pyuthan, Kailali, Sindhuli, Morang, Chitawan, Dang, Jhapa, Mahottari, Saptari
High (0.468 - 0.583)	Kapilbastu, Sunsari, Dolakha, Nuwakot, Sankhuwasabha, Baglung, Udayapur, Pyuthan, Kailali, Siraha, Palpa, Chitawan, Kaski, Taplejung, Sarlahi, Mahottari, Gulmi, Saptari, Ilam	Kapilbastu, Sunsari, Dolakha, Nuwakot, Sankhuwasabha, Baglung, Udayapur, Surkhet, Siraha, Palpa, Dhanusha, Nawalpur, Kaski, Sarlahi, Gulmi, Ilam
Moderate (0.358 - 0.467)	Rolpa, Myagdi, Rautahat, Bardiya, Solukhumbu, Dailekh, Syangja, Banke, Surkhet, Arghakhanchi, Rupandehi, Bhojpur, Khotang, Dhanusha, Nawalpur, Panchthar, Bajhang, Parsa, Ramechhap	Rolpa, Myagdi, Lamjung, Rautahat, Bardiya, Solukhumbu, Dailekh, Syangja, Banke, Arghakhanchi, Rupandehi, Bara, Khotang, Taplejung, Panchthar, Bajhang, Parsa, Ramechhap
Low (0.252 - 0.357)	Rasuwa, Lamjung, Dhankuta, Lalitpur, Parbat, Darchula, Dolpa, Achham, Baitadi, Salyan, Bara, Doti, Kanchanpur, Jajarkot, Jumla, Parasi, Kathmandu	Rasuwa, Dhankuta, Lalitpur, Parbat, Darchula, Dolpa, Achham, Baitadi, Bhojpur, Salyan, Mustang, Doti, Kanchanpur, Jajarkot, Jumla, Parasi, Kathmandu, Dadeldhura
Very Low (Less than 0.252)	Humla, Mugu, Terhathum, Western Rukum, Bhaktapur, Mustang, Manang, Eastern Rukum, Okhaldhunga, Bajura, Kalikot, Dadeldhura	Humla, Mugu, Terhathum, Western Rukum, Bhaktapur, Manang, Eastern Rukum, Okhaldhunga, Bajura, Kalikot

In 2030, under RCP 8.5, the number of very high-risk municipalities climbed from 2 in the baseline to 5, while the risk level in the high-risk category increased from 44 in the baseline to 69 (Figure 58). The potential reason for this is the compounding likely impact of climate extreme events, specifically the potential for flooding due to intense and heavy rainfall, an increase in heatwaves and cold waves, and so on (Figure 59).

Projected risks of climate change impact in the long term (2050) with a projected increase of temperature by 1.3–1.8 °C

More districts and Provinces will be at high risk under both scenarios in 2050. Under RCP 4.5 in 2050, a total of 19 districts fall in the very high risk category while 21 districts fall in the high-risk category. Meanwhile, 33 districts fall in the very high risk category, and 16 districts in the high risk category. Additionally, 12 districts were added in the high-risk category in RCP 8.5 compared to RCP 4.5. Most of the districts of Province one, Province two, Bagmati Province, Gandaki Province, and Lumbini Province will have high to a very high degree of risks. Compared to the medium term (2030), the climate risk will increase in the long term (2050) in Lumbini Province, Karnali Province, and Sudurpaschim Province. Largely climate extreme events are projected to increase rapidly in 2030 and 2050 which will have an overall impact on the status of risk in the Provinces. However, the vulnerability might change in the future due to demographic, socio-economic, and ecological changes which might contribute to either increased or decreased risks in the districts and Provinces. Looking at the current trends, it might be unlikely that changes will be positive (Figure 60 and Table 28).

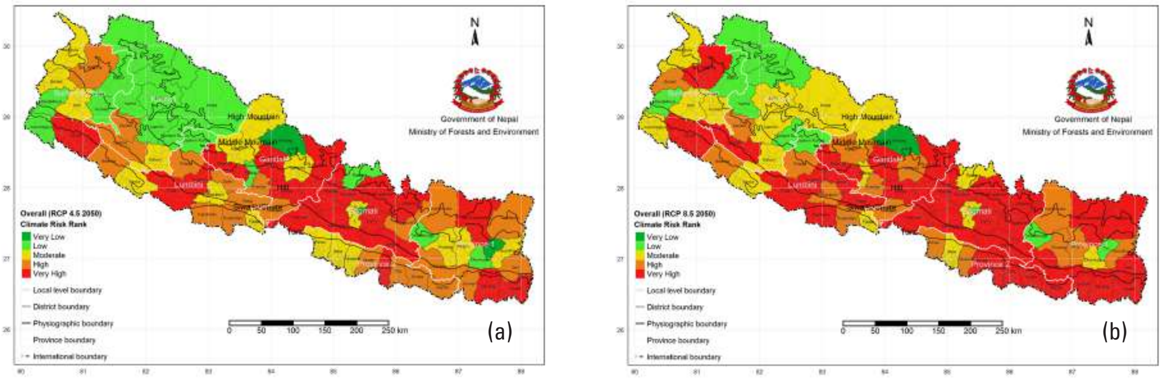


Figure 60: Risk of climate change impact Scenarios a) RCP 4.5 2050; b) RCP 8.5 2050

Table 28: Risk Scenarios index in RCP 4.5 and RCP 8.5 (2050)

Risk Rank	District (RCP 4.5, 2050)	District (RCP 8.5, 2050)
Very High (More than 0.583)	Dhading, Makawanpur, Dolakha, Nuwakot, Sankhuwasabha, Baglung, Sindhupalchok, Gorkha, Tanahu, Kavrepalanchok, Pyuthan, Kailali, Sindhuli, Morang, Chitawan, Dang, Kaski, Jhapa, Mahottari	Dhading, Makawanpur, Kapilbastu, Sunsari, Dolakha, Nuwakot, Sankhuwasabha, Baglung, Sindhupalchok, Gorkha, Tanahu, Kavrepalanchok, Udayapur, Pyuthan, Kailali, Surkhet, Siraha, Palpa, Sindhuli, Morang, Chitawan, Dhanusha, Dang, Kaski, Taplejung, Jhapa, Sarlahi, Mahottari, Bajhang, Gulmi, Ramechhap, Saptari, Ilam
High (0.468 - 0.583)	Rolpa, Kapilbastu, Sunsari, Bardiya, Solukhumbu, Dailekh, Udayapur, Syangja, Surkhet, Siraha, Rupandehi, Palpa, Dhanusha, Nawalpur, Taplejung, Sarlahi, Bajhang, Gulmi, Ramechhap, Saptari, Ilam	Rolpa, Myagdi, Lamjung, Rautahat, Bardiya, Solukhumbu, Dailekh, Syangja, Arghakhanchi, Baitadi, Rupandehi, Bhojpur, Khotang, Nawalpur, Panchthar, Parsa
Moderate (0.358 - 0.467)	Myagdi, Lamjung, Rautahat, Lalitpur, Darchula, Banke, Arghakhanchi, Baitadi, Bhojpur, Salyan, Mustang, Bara, Doti, Khotang, Panchthar, Parasi, Parsa, Kathmandu	Rasuwa, Dhankuta, Lalitpur, Parbat, Darchula, Banke, Dolpa, Achham, Salyan, Mustang, Bara, Doti, Kanchanpur, Jajarkot, Jumla, Parasi, Kathmandu
Low (0.252 - 0.357)	Humla, Mugu, Rasuwa, Dhankuta, Western Rukum, Parbat, Dolpa, Achham, Eastern Rukum, Okhaldhunga, Bajura, Kalikot, Kanchanpur, Jajarkot, Jumla, Dadeldhura	Humla, Mugu, Terhathum, Western Rukum, Bhaktapur, Eastern Rukum, Okhaldhunga, Bajura, Kalikot, Dadeldhura
Very Low (Less than 0.251)	Terhathum, Bhaktapur, Manang	Manang

There is a sectoral assessment that shows similar trends. For example, in the agriculture sector under RCP 4.5 and RCP 8.5 emissions pathways scenarios, the districts with the very high-risk category will likely increase under both scenarios in 2030 and 2050. The risk of climate change is higher in Lumbini Province, Gandaki Province, Bagmati Province, Province two, and Province one (Figure 61). The risk will change modestly under RCP 4.5 in 2050 compared to 2030. This is mostly influenced by precipitation and temperature-related climate extreme events. A similar trend is also observed in other sectors (Table 29).

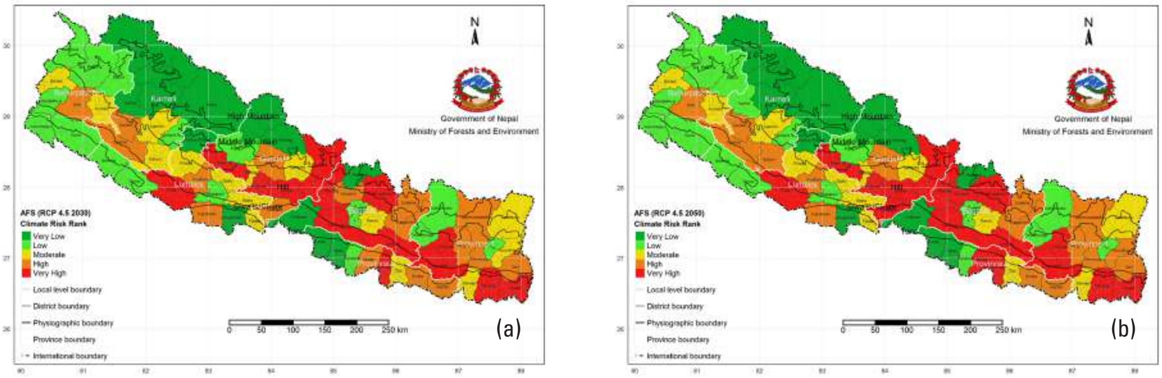


Figure 61: Risk of climate change impact in Agriculture and food security sector under RCP 4.5 in 2030 and 2050

Table 29: Risk of Climate Change Impact in the sectors

Sectors	Risk of climate change impact
Forestry, Biodiversity, and Watershed	Under two RCPs 4.5 and 8.5 for 2030 and 2050, there will be a unidirectional shift of climate risk towards the higher level in the future in all scales – district, physiographic regions, and provinces. High and middle mountain regions and districts of these regions are expected to experience a very high risk of climate change impact. Such shifts towards higher risk levels will also occur in the Chure and Siwalik (from moderate to very high) and Hill region (low to moderate).
GESI, Livelihood, and Governance	Nine districts fall into the very high-risk category. These include only one district from Province one (Morang); six districts from Province two (Saptari, Siraha, Dhanusha, Mahottari, Sarlahi and Bara, Saptari, Siraha, Dhanusha, Mahottari, Sarlahi, and Bara); one from Lumbini (Dang); and one from Sudhurpaschim Province (Kailali). All the districts ranked in the high risks category are from the Tarai region of Nepal.
Health	Sunsari, Dhankuta, Terhathum, Sankhuwasabha, Tanahu, Parbat, Syangja, Morang, Taplejung, Panchthar, Jhapa, and Ilam districts will have a very high risk of climate change impact in the health sector.
WASH	In both 2030 and 2050, under RCP 4.5, most of the Terai districts, the majority of the Siwalik, and some hilly districts will be at risk from the impact of climate change. Among the provinces, Province two will be at very high risk due to several reasons. In the case of RCP 8.5 2050, districts like Bajura, Humla, Dolpa, and Mustang are expected to move from low to moderate risk in RCP 8.5, 2030.
Transport, Industry, and Physical Infrastructure	In the medium-term period, under RCP 4.5, the risk of climate change impact will be high to very high mostly in Bagmati Province (except Bhaktapur, Rasuwa, and Ramechhap). Whereas, in the long-term period, the risk is likely to increase in the additional districts in Lumbini and Province one. In the medium-term period for RCP8.5, the risk scenario is observed similar to RCP4.5-2030. Besides, in the long-term period of RCP 8.5, more districts (except Ramechhap) in Bagmati Province fall in high to very high risk. Besides, three districts fall in very high riks and the remaining five districts in high risk category in Province two followed by Lumbini Province having a high to moderate level of projected risk.
Tourism, Natural and Cultural Heritage	In the case of cultural heritage, the risk of climate change impact will be very high to high in Bagmati Province and Gandaki Province in the medium term (2030) RCP scenarios. In 2050, under both the RCPs, besides Bagmati Province and Gandaki Province, parts of Province One, and Sudurpaschim Province will have a high risk from climate change impacts. Besides, under both the scenarios in 2030 and 2050, the majority of the protected areas located in the Provinces will be at high risk from climate change impacts.
Water Resources and Energy	Energy: The Risk of climate change impact under both the scenarios in 2030 will be high to very high in the majority of the districts of Bagmati Province and Gandaki Province. Whereas, few districts in Province one, and Sudurpaschim Province will experience high risk of climate change impact in the same period. The Risk of climate change impact in 2050, under both scenarios, will be very high to high in most of the districts of Gandaki Province and Bagmati Province. The risk will also high to Province one and Lumbini Province and Sudurpaschim Province. Water resources: Most of the districts in Bagmati Province and Gandaki Province will have a very high risk of climate change impact in 2030 under both scenarios. In 2050, under RCP 8.5, some districts of Bagmati Province, Gandaki Province, Karnali Province, and Province one will have a very high risk of climate change impact.

According to the results of the municipal level assessment, Nilakantha from Bagmati Province has switched from high to very high-risk status in RCP 4.5 (2050). Furthermore, under RCP 4.5 in 2050, Jitpur Simara in Province Two, Sworgadwary and Rajapur in Lumbini Province, and Patan in Sudurpaschim Province have gone from moderate to high risk as compared to RCP 4.5 in 2030. In 2050, under RCP 8.5, Rupakot Majhuwagadhi from Province one, Janakpur from Province two, Nilkantha from Bagmati Province, and Kushma from Gandaki Province shifted from high to very high rank in comparison to RCP 8.5 in 2030. Furthermore, Sunwarshi, Bhojpur, and Chaudandigadhi from Province one; Jitpur Simara from Province two; Chandragiri, Ramechhap, Rapti and Ratnanagar from Bagmati; Sundarbajar, Shuklagandaki, and Madhyabindu from Gandaki Province; Buddhavumi, Bhumekasthan, Pyuthan and Rajapur from Lumbini Province, Sharada and Gurbhakot from Karnali Province and Parashuram and Patan from Sudurpaschim Province have shifted from moderate risk to high risk as compared to RCP 8.5 in 2030 (Figure 62b). Besides, the risk of climate extreme events is higher in rural municipalities spreading all the Provinces. It is interesting to note that in 2050, under both the RCP scenarios, the risks from climate extreme events are increasing and also evident in the mountain rural municipalities of Province one, and Bagmati Province (Figure 63).

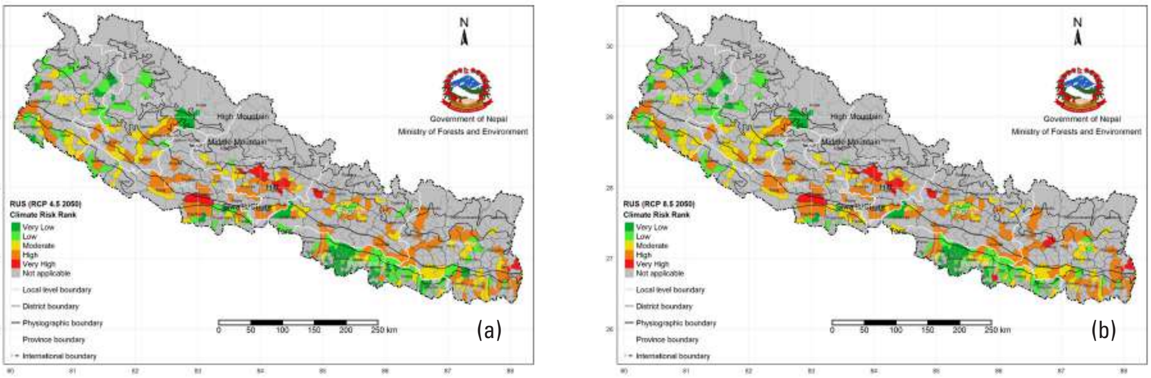


Figure 62: Risk of Urban municipalities in 2050 a) RCP 4.5; b) RCP 8.5

Based on the geographic positions of municipalities and the existence of hazards, there are compounding and contextual impacts on climate severe events. Increases in temperature and precipitation, for example, could cause landslides in hilly municipalities, while flooding and heat and cold waves are more likely in Tarai municipalities. In addition, both hilly and Tarai municipalities are likely to see a rise in fires and epidemics.

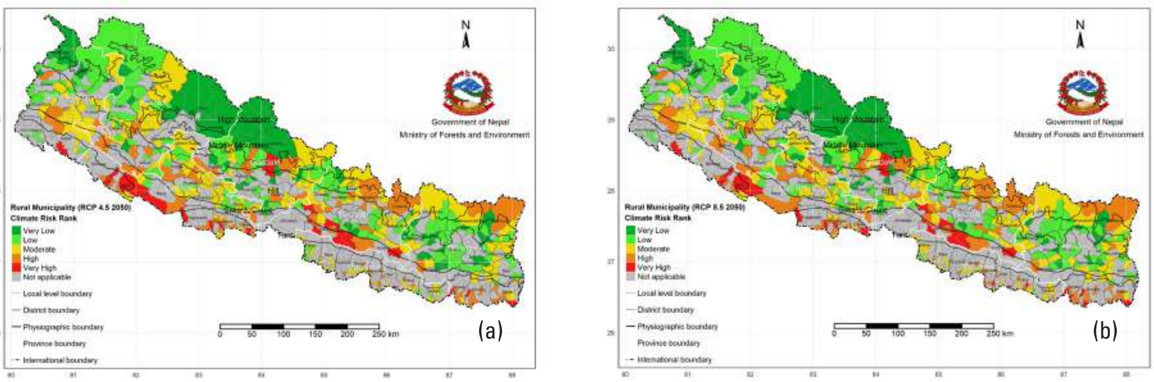


Figure 63: Risk of Rural Municipalities in 2050 a) RCP 4.5, b) RCP 8.5

Uncertainties and variation in risks projection

Agriculture, water, energy, biodiversity, health, urban planning, and livelihoods are all expected to be impacted by the risk scenarios. However, there are some unknowns. A higher level of uncertainties exists in the models. Furthermore, socioeconomic scenarios govern the risk of climate change's impact in the future. As a result, the findings of this assessment should be regarded as indicative rather than absolute. Having said that, the study's preliminary findings capture a wide range of future climate variability and are extremely useful in assisting policymakers in developing appropriate strategies for reducing the risk and vulnerability for the years to come. In other words, underlying uncertainties should always be considered while designing risk reduction measures.

Chapter 7

Adaptation Options

Adaptation means reducing impact, risk, and vulnerability, looking for opportunities and strengthening the capacity to adapt and enforce policies on climate change in nations, regions, towns, the private sector, communities, individuals, and natural systems (Tompkins et al., 2010). The option of adaptation consists of various activities divided into three main categories: structural/physical, social, and institutional.

Table 30: Types of adaptation options

Types	Categories
Sectoral	Agriculture, forestry, water resources and energy, health and sanitation, urban and rural, transport, tourism, GESI, etc.
Physiographic	High mountains, Middle mountains, Hills, Chure/Siwalik, and Tarai
Administrative	Local (753), District (77), Province (7), National
Time scale- priority	Short term (1-5 years), Medium-term (10 years), Long term (more than 10 years)
Types of measures or interventions	Structural, institutional, policy, etc. Soft measures (policy, capacity); Hard measures (technology, infrastructures)
Against hazard and risks	Interventions targeted Drought, Forest Fire, Flood, Landslide, Heat and Cold waves, Avalanches, GLOFs, Snowstorms, Epidemics, etc.

The technical guidelines for the NAP outline adaptation options such as management and operations strategies, infrastructure changes, policy changes, and capacity building. There are numerous ways to categorize the range of available adaptation options (Burton, 1996), so any categorization is unlikely to be universally agreed upon, but this aims to take into account the diversity of adaptation options for different sectors and stakeholders. National, sectoral, or local adaptation plans may include a variety of measures that are implemented concurrently in various categories, such as structural, institutional, and social options (Table 30 and Figure 64).

However, it is important to note that adaptation is a place and context-specific process, with no single approach to risk reduction that is applicable in all settings. Adaptation planning and implementation can be improved by combining efforts at all levels, from individuals to governments. The first step in preparing for future climate change is to reduce vulnerability and exposure to current climate variability (IPCC, 2014).

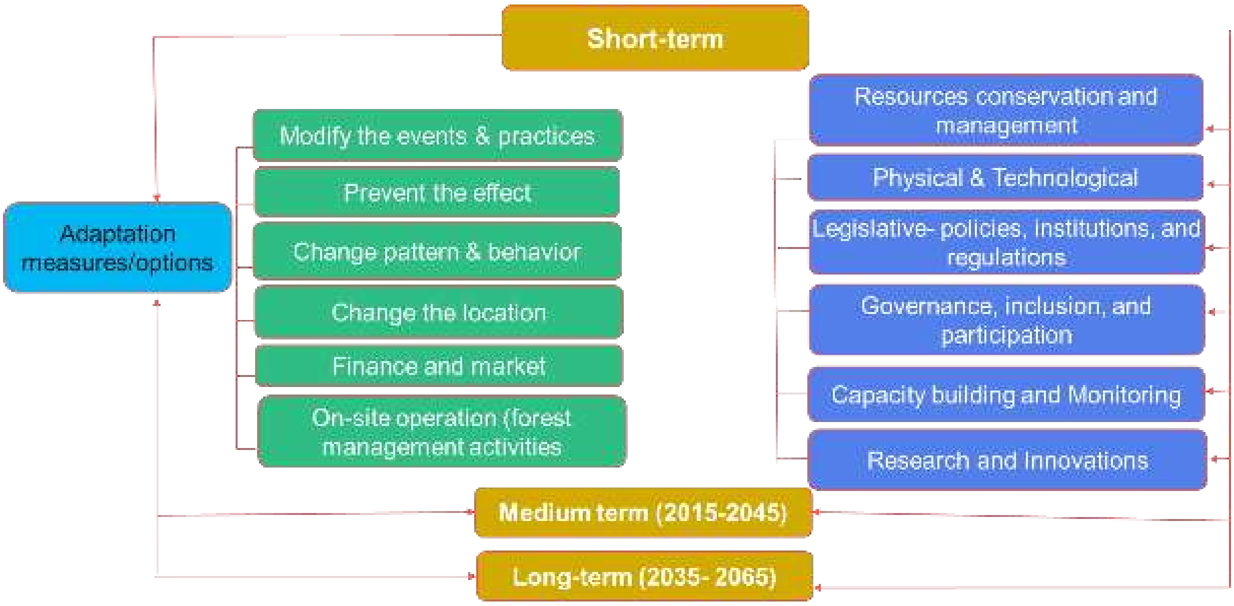


Figure 64: Adaptive Management[18]

Adaptation options in this assessment were identified based on experts' views, literature review, and consultations with key stakeholders. To make this process more participatory and inclusive, consultations were held with provincial and local stakeholders. Similarly, to make adaptation options more relevant to present and future context, short-term, medium-term, and long-term actions are proposed. Table 31 below suggests an indicative list of adaptation options relevant in different sectors to address specific risks and vulnerabilities. However, each measure applies differently to all physiographic regions, provinces, districts, municipalities, and even communities in the context of change in climatic variation across the region.

18 https//en.wikipedia.org/wiki/Climate_change_and_ecosystems

Table 31: Adaptation Options in the sectors

Sector and major Risks and vulnerabilities	Adaptation Options		
	Short-term (2025)	**Mid-term (2030)**	**Long-term (2050)**
Agriculture and Food Security Risks and vulnerabilities: Risk of the declining crop, fisheries, and livestock production; Land degradation issues, and Outbreak of pests and diseases; Risk of reduced agricultural productivity of those dependent on rainfed or irrigated agriculture, or high-yield varieties, and inland fisheries; Risk of food insecurity and decrease in incomes of smallholder farmers; Risk of irreversible harm due to short recovery time between droughts, approaching a tipping point in rainfed farming system; Risk of higher weather uncertainties leading to stress and burden for farmers.	Promote climate-resilient farming practices such as organic farming, bio-pesticides and organic manure, integrated pest management, and integrated nutrient management Promote Climate-Smart Practices such as micro-irrigation, conservation farming practices, home gardening, etc.	Promote participatory Crop Improvement (PCI): Participatory Plant Breeding (PPB), Participatory Variety Selection (PVS), Grassroots Introduce breeding with the inclusion of local varieties as a parent	Conserve agriculture practices (e.g., cover crop, mixed cropping, crop rotation, mulching, legume integration) to preserve water moisture in the soil and increase agricultural productivity
	Introduce short-duration and drought-tolerant crops and varieties to avoid drought during maturity time	Promote planting climate-resilient and genetically diverse local crops and varieties including Neglected and Underutilized Species (NUS)	Promote new crops, varieties, and seeds/seedlings along with short-duration crops to avoid weather-related damage
	Develop climate resilient strategy and action plan for the livestock and fisheries sector	Promote climate-smart practices such as improvements in the cultivation of specific fodder crops, feed processing as well as manure and pasture management	Promote and scale up early warning systems, weather indexed insurance, agroforestry practices
	Promote culture-based fisheries for climate resilience Ensure better forecasting, information; change or improve processes and technologies	Improve farm siting and design; individual/cluster insurance; use indigenous or non-reproducing stocks to minimize climate change impacts	Promote efficient water management, feeds, handling; selective breeding/genetic improvements; adjust harvest and market schedules
	Adopt agriculture/crop calendar based on projected climate change trend and scenario	Promote ICT-based agro-advisory services Promote Climate field school in all the 753 Palikas	Promote seed cleaning, drying, and storing machine for proper seed management to keep the viability
	Promote weather Index-based crop insurance to compensate for the loss caused by extreme weather events and climate hazards Promote Agro-meteorological forecasting targeting the smallholder and marginalized farmers	Establish a mechanism to credit from micro-finance institution and cooperatives to invest in profitable agricultural activities	Ensure financial scheme and policy instrument to promote sustainable agriculture
	Invest in women and farmer's empowerment to increase access to financial resources for the promotion of sustainable farming.	Promote joint land ownership to increase women's decision-making and access to credit for investment in agriculture.	Invest in agro-enterprise and entrepreneurship targeting women and girls.
	Assess the loss and damage in the agriculture sector and devise a strategy to mitigate it. Develop climate change thresholds of major food crops including some vegetation and fruits	Engage private sector engagement in collaborative research and technology innovations on climate change	Develop a long-term strategy of NARC on climate change research and development and ensure the implementation of the strategy

Forests, Biodiversity, and Watershed Management <u>Major risks and vulnerabilities:</u> Vegetation shift, Habitat degradation, Phenological changes, and Outbreak of pests and diseases; Risk Reduction of biodiversity and potential losses of important ecosystem services; Risk of loss of endemic species, mixing of ecosystem types, and increased dominance of invasive organisms; Risk of production losses both quality and quantity; Risk of increasing loss and damage from fire, flood, and landslides; declining of species due to temperature rise in higher altitudes; degradation and drying of wetlands; Risk of loss of plant, animal species due to flood, landslide, and other climate hazards; Riks of GHG emissions due to increased rate of forest degradation and deforestation in some areas.	Promote agroforestry in private and public lands to reduce land degradation, forest dependency and enhance biological corridors	Reforest short-rotational and fast-growing tree species to improve fire resilience and resist potential disturbances	Scale-up ecosystem-based adaptation approaches, particularly in high forest and biodiversity dependent communities (possibly in mid-hills and mid-mountains)
	Promote a comprehensive and hierarchical approach to watershed conservation (Basin, sub-basin, watersheds, sub-watersheds, and micro-watersheds) Implement integrated river basin management strategy and ensure integration of climate change	Regulate water recycling, utilization, reuse, enhance multiple uses of water, stabilize land slopes and regulate water flows	Strengthen sustainable management of upland resources (wetlands, rangelands, pasturelands, and watersheds) and floodplains for maintenance of regular and efficient water flows Set up efficient institutional mechanism and strengthen the basin management offices
	Rehabilitate and restore degraded forests and watersheds – through both protective and conservation measures and acceleration of natural recovery	Promote landscape connectivity (biological corridor) through mainstreaming the biodiversity conservation roles of community-based forest groups	Promote habitat restoration and rehabilitation interventions to allow multiple habitats for several wild animals thereby maintaining biodiversity
	Train and mobilize the Rapid Flood Rescue Team and equip them with skills and an Early Warning System	Enhance the capacity and facilities of community-based forest-user groups to integrate biodiversity conservation and climate change adaptation activities into their operational plans; as required by the National Conservation Strategy and the Climate Initiative	Scale-up LAPA and CAPA initiatives across the country through local institutions such as forestry groups, women's groups, youth groups, and conservation groups in coordination with local government
	Carry out inventory and survey of dynamics of IAPS, plant pathogens/diseases/pests to understand and document the biological process and infestation pattern	Establish a national IAPS Information Centre to maintain a database and to facilitate the cross-sharing about the IAPS management practices	Promote systematic research on the socio-economic impact of IAPS to harness the beneficial impact of IAPS on local livelihoods
	Establish sustainable financing for long-term ecological research and studies to review vulnerability and risk thereby identify adaptive options Develop strategies to build the resilience of key flagship faunal species impacted by climate change and ensure the implementation of resilence plan	Strengthen provision and practice of biodiversity monitoring in community-based forest groups and formulate comprehensive watershed management policy	Integrate adaptation initiatives with climate change mitigation objective to fulfill the spirit of National Climate Change Policy, National REDD+ Strategy, and National Forest Policy)
	Diversify forests and non-forest-based income sources (off-farm income activities) targeted to women, IPs, and vulnerable groups to reduce pressure on forests and protected area	Integrate biodiversity conservation initiative with the improvement of local livelihood to generate synergies between Ecosystem-Based Adaptation, Biodiversity Conservation, and Livelihood Improvement	Integrate transhumance system and customary forest management practices Develop participatory river-basin-level watersheds conservation by engaging upstream-downstream communities
	Develop REDD Implementation Cenre as centre of excellence on mitigation and carbon trading	Establish a climate change research unit within the FRTC	Ensure that new forest survey and biodiversity mapping include the assessment of climate change risks, vulnerabilities, and threats

Health <u>Major Risks and Vulnerabilities:</u> Risk of a larger burden of disease and increased food insecurity for particular Population groups; Increasing the risk that progress in reducing mortality and morbidity from undernutrition may slow or reverse; Increasing health risks due to changing spatial and temporal distribution of diseases strains public health systems, especially if this occurs in combination with economic downturn	Launch program on the expansion of Indoor Residual Spraying (IRS) and distribution of Long-lasting Insecticidal nets (LLINs) in VBDs risk areas	Establish regular national surveillance for disease incidence and vector populations	Promote the IVM technology and biological control of vectors
	Provide access to the regular and safe drinking water supply to all populations	Implement technological improvements such as wastewater treatment, water harvesting, and improved sanitation	Facilitate the testing of water quality in WBD and VBD in high-risk areas
	Carry out studies looking at the impacts of climate change on the burden of heart disease	Promote early detection of heart diseases within the community	Carry out cardiovascular risk reduction activities through lifestyle and behavior and environmental modification
	Build capacity of health sector professions and other related stakeholders on the health impacts of climate change Develop long-term strategy in the Health sector to deal with climate change in the context of other existing diseases and COVID-19	Establish Institutional linkage and co-ordination to generate evidence on climate change	Improve diseases surveillance and forecasting system
Water and Sanitation <u>Risks and vulnerabilities:</u> Risk that the progress to date in reducing childhood deaths from diarrheal disease is compromised; Risk of overload the capacity of sewer systems and water and wastewater treatment plants more often, and increased occurrences of low flows will lead to higher pollutant concentrations; Risk of failure of water and sanitation infrastructure due to climate change leading to higher diarrhea risk Children, pregnant women, and those with compromised health status	Map potential recharge and alternative drinking water sources while constructing water supply schemes	Promote conservation practices such as collecting rainwater from the ground surface, small reservoirs, and micro-watersheds to increase spring capacity	Promote infiltration areas, wetlands, ponds within the community, and planting activities to develop the vegetative buffer
	Integrate climate-resilient water and sanitation practices in both rural and urban contexts	Endorse operation and maintenance guideline of water supply schemes	Develop a guideline for the protection and conservation of various water sources and incentives for rainwater harvesting as important components of climate-resilient WASH
	Improve the capacity of service providers and equip them with new knowledge and skills on climate resilient health and sanitation system	Promote raised pit latrines; septic tanks; relocation of latrines: small-scale biological systems	Promote climate-resilient technology, innovations, and infrastructure: 'pit latrines', 'low-flush septic systems', 'ecosan latrines' and 'high-volume septic tanks'
	Integrate climate change in the WASH policy and plans as a key adaptation strategy	Build capacity to strengthen Integrated Water Resource Management (IWRM) practices	Improve access to climate financing e.g. the Green Climate Fund and other sources

Rural and Urban Settlement Risks and Vulnerabilities Risk of damage to dwellings, businesses, and public infrastructure. Risk of loss of function and services; Risks from constraints on urban water provision services to people and industry with human and economic impacts; Risk of damage and loss to urban ecology and its services including urban and peri-urban agriculture; Risk that rural settlements experience will be the major impacts on water availability and supply, food security, infrastructure, and agricultural incomes, including shifts in the production areas of food and non-food crops	Increase operations and maintenance for assessing the condition of public assets and social infrastructure	Develop climate-resilient design guidelines for critical infrastructure, improve the security and resilience of new infrastructure in high-risk areas	Increase access for vulnerable urban and rural households and populations to disaster preparedness and response, such as early warning, rescue technology, knowledge and skills
	Ensure provision of insurance system for physical properties and livelihood recovery mechanism against climate-induced hazards for the population at risk	Develop a system at the municipal level to identify and update the database regularly to plan and regulate the squatting of the area and rehabilitate and relocate displaced migrants	Revise building codes and implement the building permit system
	Deploy a rapid response team, empower the community, and allocate resources for emergency services at the municipal level	Design smart regulations for infrastructure development and land-use planning that address climate risk at all local levels	Integrate data and ICT networks and ensure digital connectivity for all communities to ensure easily accessible, affordable, and reliable information on weather extremes and potential risk
Industry, Transport and Physical Infrastructure Risks and vulnerabilities: Higher risk of damage to infrastructure, industries, and transport systems due to increased climate induced hazards; Increased risks of development failure (haphazard road construction) leading to increase disasters; Increased risk of economic turmoil due to blockage of roads and aviation.	Identify vulnerable areas of climate-induced disaster on industrial facilities and prepare hazard maps of all physiographic region	Develop a system for the timely dissemination of short-term weather predictions and regular weather reports/ information flow mechanisms	Retrofit, modify the existing scope of industries, physical structure, and update the industrial policy and standard in light of the future climate projection
	Promote the concepts of circular economics and industrial ecology to improve resilience and sustainability	Adopt Resource Efficient and Cleaner Production (RECP) approach in the industrial sector	Formulate and implement appropriate policy and plan for construction and manufacturing industries for consolidation of the low carbon economy
	Develop and Implement climate-proofing infrastructure design practices including slope protection in Mountainous and hilly roads (more than 300 of inclination) to reduce the Landslide vulnerability	Establish a georeferenced long-term database to enable modelling and assessment of road and physical infrastructure projects	Promote the use of Early Warning Systems for readiness to extreme weather events and events related hazards
	Adjust safety factors in codes and standards (or other measures) to reflect increasing uncertainties and increased variability or range of climate extremes in values and growing risks for new infrastructure under changing climate conditions	Demolish, replace or relocate unsafe structures or abandon high-risk locations in all municipalities	Develop certification standards for climate-proofing transport infrastructure and establishing enforcement measures to ensure compliance
	Ensure the transition towards carbon-neutral, mass-transit systems and promote non-motorized transport (Electric vehicle, Cycling, and walking)	Ensure cooperation amongst the sectoral bodies responsible for transport and mass-transit systems along with federal, Province, and Rural/municipal administrations	Integrate climate-resilient building practices into the construction and maintenance of key airports, national highways, and connecting roads

Water Resources and Energy <u>Risks and Vulnerabilities:</u> Risk of water stress and lower water availability during the winter season; Risk of damage to energy infrastructure including dams, hydropower, and transmission lines; Risk of drying of springs in the hills and water shortages in rural and urban areas; Risk of Glacial lake outburst flood (GLOF) and hydrological hazards.	Assess the current facilities and storage options according to the future water availability	Identify and map critical watersheds, spring-sheds, and technological interventions to restore the water resources	Develop and implement climate-resilient watershed management plans for critical river basin and watersheds
	Establish and strengthen effective early warning systems (coverage and risk zoning) for the water and climate-induced disaster Carry out study and research to understand the implications of water variability during different season and the loss and damage due to climate-induced disasters	Expand hydrological and meteorological network to improve spatial coverage (particular focus to more station mountainous region and watersheds) of hydro-climatic information	Integrate all the forms of the water cycles in technological interventions (surface and groundwater, freshwater storage as snow and glaciers, water quantity and quality, land use systems, soil class, topography, ecosystems, etc.)
	Improve the existing system of short-term weather forecast or develop improved forecasting methods for improved reservoir and emergency operations	Downscale the climate change scenarios at the local and river basin and watersheds level	Develop large-scale water infrastructure that will provide the needed buffering capacity, robustness, and resilience to withstand variability of climate change
	Launch participatory cascade management programs in the watersheds for the efficient use of water, and for the proper groundwater recharging to maintain constant flows of water in water sources and springs Promote water recharging interventions upstream of water sources	Ensure land zoning laws in benefit of the environment and ecological protection Implement a targeted program to build the resilience of the most vulnerable and impacted groups such as women, girls, poor, IPs, and others. For example, reducing the women's stress in water fetching	Promote landscape and watershed management plan and actions including controlling mechanism of river mining Develop and implement strategy and action plan for managing seasonal water variability and scarcity in the lean periods through better management of existing water flow during monsoon season
	Develop guidelines to ensure climate change is considered of hydro plans, dams, transmission lines, and other infrastructures	Ensure climate-resilient design and construction of energy facilities, including good site selection, promote flood modeling, dam-break modeling, for energy infrastructure, effective permitting, licensing, standards regulation regimes, and enforcement	Identify the spots for a reservoir in every river basin and develop relevant infrastructure to control the sediment and regularize the river flows Ensure appropriate incentive mechanisms for attracting private sector investment in green growth
	Enhance municipal capacity in renewable energy development opportunities	Promote the implementation of the renewable energy program at the municipal level	Explore alternatives for maximizing the use of renewable energy facilities
Tourism Natural and Cultural Heritage <u>Risks and Vulnerabilities:</u> Increased risk and socio-economic losses due to disruption on tourism business; High risks of loss and damage (physical property and infrastructures) due to landslides, flood, GLOF, fire, etc	Conduct periodic inventory of flagship species including that of tourist attractions in all protected areas	Implement conservation financing in key tourism destinations in coordination with the private sector and local government	Translocate flagship wild species to minimize the risk of disaster
	Promote local and indigenous culture, food, and products (e.g. handicrafts) that directly benefit local communities	Conserve cultural heritage sites through community/ indigenous people participation	Reinforce/retrofit of physical structures in the cultural heritage sites
	Establish real-time early warning information dissemination mechanism and enforce GPS tracking system, particularly to mountaineers and trekkers so that they can be well tracked in case of emergency	Relocate existing tourism facilities to low-risk areas; for instance, relocation of hotels and homestay from landslide-prone area to a safer area	Establish a reliable weather information system targeting major tourism destinations, particularly for mountaineering and trekking
	Conduct education and awareness programs on the impact of climate change and possible adaptation options targeting tourism value chain actors	Allocate adequate, dedicated, trained, and equipped human resources for rescue at strategic points of the tourism destinations	Increase private sector's investment in the development of climate-resilient tourism infrastructures with incentive measures

Socio-Economic including GESI, Livelihood, and Governance <u>Risks and vulnerabilities:</u> Increased workload and other stresses for women headed households; Risk of irreversible harm due to short time for recovery between droughts, approaching tipping point in rainfed farming system and/or pastoralism; Risks that Hazard combined with vulnerability to shift populations from transient to chronic poverty due to persistent and irreversible socio-economic and political marginalization; Risk of loss of rural livelihoods, severe economic losses in agriculture, and damage to cultural values and identity; mental health impacts; Risk of increased morbidity and mortality due to heat stress, among male and female workers, children, and the elderly, limited protection due to socioeconomic discrimination and inadequate responses; Risk of domestic violation and other forms of discrimination during the time of disasters.	Roll out of GESI and climate change strategy and action plan mostly implementing it.	Integrate GESI and CC strategy and action plan in the province and local governments	Help local governments champion GESI and climate change agenda.
	Ensure meaningful representation of women, Indigenous Peoples, and youth in a leadership role in climate adaptation planning and implementation Build women's capacity for effective participation in key policymaking positions at all levels	Devise affirmative measures for gender equality and empowerment of women by challenging discriminatory norms, values, and practices that intensify vulnerability	Establish a mechanism for multi-sectoral coordination and integration of climate change adaptation commitments in sectoral development plans at levels Integrate GESI in multi-sectoral plans, policies, strategies, and budgets
	Promote climate change knowledge/information on differential impacts and adaptation measures through the formal and informal education system	Ensure GESI responsive livelihood planning and adequate institutional and financial provisions in CCA/DRR multi-sectoral plans, policies, strategies, and budgets	Implement sectoral priorities identified in cc policies through participatory, transparent, and gender and socially inclusive approaches
	Improve equitable access to safe and affordable drinking water, sanitation, and hygiene for women and marginalized populations including slum dwellers, Indigenous Peoples, and other vulnerable groups	Promote livelihood diversification (farm/non-farm) for women/youth, IPs, and vulnerable populations through increased access to skills and formal markets to bridge the gap between production and productivity	Promote public-private partnerships to create opportunities for nature-based solutions and decent employment in the formal sector, with a focus on women and marginalized communities
	Build capacity of women and marginalized on climate-smart technologies for production, commercialization (e.g. food processing) to enhance the livelihood of women and marginalized groups based on local/cultural specificity to reduce the drudgery and time poverty	Integrate distinctive knowledge of women and indigenous groups into programs or policies to strengthen climate resilience and facilitate the process of building their 'agency' through GESI responsive climate measures and actions	Enhance technical and institutional capacity on climate change at local and provincial levels i.e. build farmers, IPs, youths, and women's capacity for effective participation in key policymaking positions
	Increase women's, Indigenous Peoples, and farmers access to financial resources to increase their participation in the economy	Invest in adaptive social protection to reach economic and socially vulnerable groups, such as single mothers, children, and persons with disabilities	Integrate social and structural priorities (poverty, inequality, food security, employment, etc.) in climate change adaptation planning using a holistic and integrated approach
Cross-cutting areas (Enabling environment for adaptations options to function effectively)	Support in rolling out climate change policy, strategy, and action plans particularly targeting the province and local government Develop communication strategy in terms of rolling out climate change agenda at the local level Strengthen the knowledge management and climate change database system in MoFE or DHM Develop GoN capacity on international negotiations, communications, and reporting and ensure that process is inclusive	Support in developing loss and damage strategy and action plan and operationalize it Support local and provincial governments to develop legal and institutional mechanism to manage climate financing Strengthen the climate change integration within the federal ministries by building the capacity of the climate change unit or focal sections	Help government (MoF, MoFE), AEPC, NTNC, and other Accredited entities and stakeholders to access, mobilize climate financing. Help government operationalize climate change research centre as per climate change policy 2019 for strengthening the research and development

This study further identified adaptation options that apply to all sectors. The majority of these are related to the need to increase investments in studies and research on the impact of climate change on major socio-economic sectors; monitoring the changes and impacts, and communicating regularly to inform policy decisions. In addition, options include improving data generation, forecasting, modeling, and other assessment methods. Besides, adaptation options include tracking the effectiveness of adaptation interventions.

Adaptation options can also be tailored to address specific contextual hazard risks and vulnerabilities. According to Table 14, the prevalence of hazards and vulnerable hotspots differ across Provinces. GLOF, for example, is a one-of-a-kind hazard in Province one. Avalanche is a major threat in Gandaki Province. Similarly, floods are a major threat to the Tarai districts and Province two, whereas landslides are a concern in almost all Provinces except Province two. In addition, fires and epidemics are common in all Provinces. According to the analysis, hailstorms are a major problem in Province two and Gandaki Province. Furthermore, thunderbolt is a problem in the Gandaki Province, Bagmati Province, and Karnali Province. Adaptation options, therefore, need to be tailored based on the specific hazards and the need of the local actors and communities. Some general adaptation options are presented in Table 32.

Table 32: Adaptation options to address specific climate-induced hazards risk and vulnerability

Adaptation Options (Medium Term 1-10 years)	Adaptation Options (Long Term 1-30 years)
Engineered and built environment: • Pursue structural measures to lower the lake level for reducing the glacial lakes outburst risk of the potential hazardous glacial lakes • Construct water conservation/ flood retention ponds, the rainwater harvesting system • Construct flood-resistant food and seed storage facilities	**Engineered and built environment:** • Pursue the structural measures for flood and landslide risk reduction (embankment, reservoir, check-dam, slope stabilization, geometry modification, surface erosion control, improved drainage, etc.) • Construct urban drainage system to overcome the issues of flash flooding in the urban areas
Technological: • Develop and operate forecasting and early warning systems for major hazards like flood, GLOF, landslide, drought, thunderbolt, windstorm, heatwave, cold wave, fire, wildfire, and epidemic	**Technological:** • Enhance lead time and accuracy of forecasting and warning system for major hazards • Pursue the principle of green development and “build back better” in reconstruction
Ecosystem-based: • Promote the local resource-based green infrastructure • Promote bio-dykes	**Ecosystem-based:** • Promote watershed protection, and restoration of floodplain for flood and landslide risk reduction
Services: • Link social security programs to climate and disaster resilience • Enhance emergency medical services at the Province level • Develop effective search and rescue, relief, and rehabilitation system at the Province level	**Services:** • Link insurance services to climate risk sharing • Enhance emergency medical services at the local level • Develop effective search and rescue, relief, and rehabilitation system at the local level
Educational: • Conduct training and capacity development program for stakeholders, professionals, and vulnerable communities on climate and disaster risk management	**Educational:** • Develop human and technical capacity on weather and climatic hazards forecasting • Conduct research on climatic hazards forecasting models

Informational: • Establish a robust database to document and monitor climate-induced hazards, losses, and damages overtime at the Province level • Develop and operationalize geographic information system based Climate Risk Information Management System	**Informational:** • Establish a robust database to document and monitor climatic hazards, losses, and damages overtime at the local level • Conduct assessment and mapping of all climate induced hazard risks at the local level • Promote bilateral, regional, and international cooperation in climate risk information sharing
Behavioural: • Promote indigenous knowledge and practices in climate risk management	**Behavioural:** • Implement a gender-sensitive and inclusive approach in all processes of Climate and Disaster Risk Management
Financial: • Develop and promote alternative and innovative financial instruments, such as forecast-based financing, micro-investment, microcredit, insurance, reinsurance, etc. • Promote microfinance, interest-free loan, conditional cash transfer, etc. for climate-induced disaster-affected individual and community	**Financial:** • Establish Local Adaptation Fund • Promote disaster insurance for public buildings, schools, hospitals, health posts, and critical infrastructures and review existing relevant insurance policies • Promote public-private partnership to attract participation and investment of private sector in Climate and Disaster Risk Insurance, Risk-sharing programs (e.g. Micro Insurance, emergency fund, low-interest credit plan)
Laws and Regulation: • Prepare and implement the Climate and Disaster Risk Sensitive Land Use Plans • Implement guidelines for infrastructures design and operation for climate risk reduction incorporating climate change scenarios • Prepare Standard Operating Procedure and Directive for establishment and operation of multi-hazard Early Warning System	**Laws and Regulation:** • Implement guidelines for mainstreaming DRR and CCA into sectoral development plans • Implement SOP for a multi-hazard Early Warning System • Relocate settlements of high-risk areas to the low-risk areas • Establish Fire Services at the Federal, Provincial and Local level and build their capacities • Develop community-based Early Warning System in all disaster hotspots

The recommendations for adaptation options, from this study, at the local level are impractical. According to the LAPA framework 2019, all rural municipalities will prepare and implement LAPAs based on their climate change vulnerability and risk context, as well as their respective capabilities. To improve the adaptive capacity of vulnerable households, communities, ecosystems, livelihood assets and resources, and critical areas, more contextual, practical, and effective adaptation options must be identified and promoted. Local adaptation options should also consider the possibility of making development investments more climate-resilient, as well as mainstreaming climate change into policies and plans (Regmi et al., 2016 c). To sustain adaption initiatives, local government and communities have to be supported with finance, capacity building, and human resource development. The list of adaptation options applicable for the local municipality is included in the Annex of LAPA framework 2019.

Chapter 8

Conclusion

The findings of the climate trend analysis, carried out by DHM (2017), show that significant positive trends are observed in annual and seasonal maximum temperature in Nepal. The all Nepal minimum temperature shows a significantly positive trend only in the monsoon season. No significant trend is observed in precipitation in any season. Extreme events (indices) associated with precipitation show significant trends (positive and negative) specifically in northwestern or northern districts. On contrary, the extremely warm temperature indices showed significantly increasing trends in the majority of districts. The extreme temperature indices are increasing significantly, mainly in the northwestern parts of the country.

The findings of the future scenario analysis, carried out by MoFE and ICIMOD (2019), show that the climate in Nepal will be warmer and wetter by mid-century, and those trends could continue till the end of the century. Extreme events are also likely to increase. Average annual precipitation is likely to increase in both the medium-term and long-term periods, under both scenarios. The monsoon, post-monsoon, and winter seasons may receive higher precipitation, but pre-monsoon precipitation might decline for both future periods and RCPs. Winter and post-monsoon temperatures will increase at a higher rate than in other seasons for both future periods and RCPs. The temperature rise will be sharper in the high mountains than in areas at lower elevations. Extreme climatic events, especially related to temperature, are likely to be more frequent and more severe. Besides, findings from this assessment show that climate-induced hazards are more frequent and destructive. Among climatic hazards, all hazards except drought are in increasing trend. The drought events are in decreasing trend. The loss and damage from climate induced hazards is increasing and projected to increase in future. It has high economic and non-economic costs for the human and natural systems.

Climate-related changes, such as variability in temperature, precipitation, and extreme weather events, have affected the environment and a wide range of sectors, such as water, disaster risk reduction, agriculture, industry, as well as recreational activities. Impact on these sectors has affected the livelihood of local communities. The impact of climate change is visible in agriculture and food security where the production of some of the major crops has declined. Likewise, there has been an increase in pests and diseases threatening crop quality and production. The increase in temperature, rainfall variation, and occurrence of extreme events have posed a greater threat to biodiversity and forest and ecosystem composition. The impact can be observed in terms of vegetation shift, loss of habitat, changes in penological behaviour of plants, and spread of invasive species. The impact on biodiversity and nature is having negative consequences for nature-based tourism in Nepal.

Climate change impact is also observed in the water resources sector. The major issue there is the declining quality and quantity of water resources. There is clear evidence showing the impact on the hydrological system creating water scarcity and decreasing the quantity of water during the winter. Besides, it is evident that glaciers are retreating quicker, rainfall patterns are changing, glacial lakes are forming, and springs are drying up. The impact on water resources is also creating issues in the hygiene and sanitation sector. Increased temperatures and changes in precipitation and extreme events are also the major cause of the emergence and outbreak of vector and water-borne diseases. There are new issues such as an increase in cardiovascular diseases, heat and cold stresses, and malnutrition. Besides, climate change is affecting urban and rural settlements. The changing dynamics of urban and rural areas are often prone to climate-induced stressors such as heat and cold stresses, water scarcity, risk of inland flooding, etc. Climate-induced disasters are also a threat to infrastructures such as roads, bridges, airports, buildings, and industries.

Climate change impacts are also evident at the provincial and local levels, according to stakeholders' perceptions. Climate change had an impact on the majority of people who depend on natural resources for their livelihood. Stakeholders also believed that climate-related hazards had become more common and frequently severe. It was also discovered that the loss and damage from disasters have been increasing every year and thus creating an additional burden to the local governments.

Apart from physical factors, this assessment specifically analyzes the socio-economic trend and scenarios. The analysis shows an increasing trend of key demographic factors such as population dynamics (growth pattern and trend of male and female population), population density, urbanization trend, and the growth of female-headed households. The future projection shows that the population of Nepal is expected to reach 34 million by 2031 and 42 million by 2050. The urban population will reach 48 percent by 2051 from the current urban population of 20 percent. There will be an overall reduction in poverty at the national level, but projections show that the rate will be sluggish for Province two. Besides, the trend analysis also indicates a rapid increase in male labour migration predominantly in Province two, Bagmati Province, and Lumbini Province. The migration of young household members in a family increases the sensitivity of those left behind (elderly, children, and women) and leads to an increase in female-headed households (de-facto household heads). Female-headed household members are projected to reach 3.1 million by 2051 from the current 1.3 million if the same growth trend is followed.

In understanding vulnerabilities and risks, the exposure, sensitivity, adaptive capacity were assessed. The exposure in this assessment comprises of the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected. The composite index of exposure is prepared by combining all the relevant sectors included in this study. The exposure is high in Province two and Bagmati Province. Also, some districts in Gandaki Province, the Tarai region of Province one, and Lumbini Province are exposed to climatic-induced hazards. In the case of the Sudurpaschim Province, Kailali is highly exposed. The total population of the particular district is one of the major contributors to high exposure.

Exposure is also determined by the areas of land exposed to several climatic hazards. For example, Rupandehi and Kapibastu fall in the high to very high exposure category. This is mainly because of the higher land area under cereal crops in these two districts compared to other neighboring Tarai districts. Another determinant of high exposure to hazards is related to exposure to infrastructure and resources. For example, Kathmandu, Kaski, and Morang districts have high exposure to climatic hazards. Healthcare infrastructure such as hospitals, health posts, and sub-health posts, are higher in these districts.

In terms of exposure at the municipality level, the findings show that 26 municipalities represent a high to a very high degree of exposure to climate change. Biratnagar, Lalitpur, Kathmandu, Birgunj, Bharatpur, Pokhara Lekhnath, Ghorahi, Tulsipur are the older and bigger towns developed as metropolitan and sub-metropolitan and are the very highly exposed municipalities. The majority of the highly exposed municipalities that have been established or declared in 2011 or earlier are highly populated with high infrastructure investments in roads, irrigation, health and education infrastructures, cultural heritage sites, and market centers that provide services and functions at the municipalities. The rest of the other 267 municipalities across Nepal are characterized by moderate to very low exposure to climate change. In the case of rural municipalities, the exposure is high in the Tarai and mid-hills municipalities compared to the mountain municipalities. Mostly the demographic and resource concentration in the municipalities played a major role in increasing the exposure to climate-induced hazards.

Sensitivity is differentiated by the physical, biological, socio-economic, and structural characteristics of the exposed units. In this assessment, the composite sensitivity index is combining all the sectoral sensitivity values. The result shows that all the hill and mountain districts of Lumbini Province, Karnali Province, and Sudurpaschim Province are high to very highly sensitive to climate change impacts. Only the mountain districts of Province one have high to a very high degree of sensitivity. The districts of Province two observe a medium to a very low degree of sensitivity. Except for Mahottari districts, all other districts of Province two observe a low to a very low degree of sensitivity. Meanwhile, Province one districts have mixed results. Only the mountain districts of Province one have a high to a very high degree of sensitivity.

In terms of the sensitivity of municipalities, the overall findings show that 121 municipalities exhibit a high to a very high level of sensitivity category. Among them, the majority of municipalities scattered across the seven Provinces exhibits sensitivity to climate change. This is because their geological features such as slope, geology, and soil characteristics increase susceptibility to climate extreme events and hazards. The municipalities in the hilly region and mountain region are more sensitive than that of the Tarai region. However, there are some districts in the Tarai region particularly some flood-prone municipalities with more exposed populations and infrastructures increasing their sensitivity to annual flood events. In the case of the rural municipalities, the findings show that most of the Tarai and mid-hill municipalities in all the Provinces are highly sensitive to climate-induced extreme events and hazards. The sensitivity is high in the mid-hills of Bagmati Province and Gandaki Province. In Lumbini Province, Tarai and mid-hill municipalities have higher sensitivity. In the case of Province one, the higher sensitivity is found in municipalities of the Tarai region.

Adaptive capacity is assessed based on the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to the consequences of climate change. The assessment shows that Lalitpur, Chitawan, Morang, Jhapa, and Kathmandu districts have a very high adaptive capacity with the ability to adjust well to the adverse effect of climate change. These districts have higher HDI, higher GDP, and higher literacy rates, improved access to infrastructure, health, and other services. On the contrary, most of the districts of Karnali Province and Sudurpaschim Province have low adaptive capacity. The access to services, technologies, and infrastructure is poor in the Provinces compared to others.

On the contrary, most districts in the mid-hill and high-hill regions are either in very low or low adaptive capacity categories. For example, the majority of districts of Lumbini Province, Karnali Province, and Sudurpaschim Province fall in the low to very low adaptive capacity. Likewise, most of the mid-hill and mountain districts of Province one fall in the low to very low adaptive capacity category. Besides, the districts of Province one have mixed categories of adaptive capacity. There is moderate to high adaptive capacity of the districts in Province two.

In the case of the urban municipalities, findings show that 32 municipalities are found to have high to very high adaptive capacity whereas 179 municipalities have low to very low adaptive capacity. The higher adaptive capacity was found in old municipalities which were established before 2011. These municipalities had huge investments in urban planning and local development compared to the newly established/declared municipalities. Moreover, 18 municipalities in Province One and 23 municipalities in Bagmati Province are classified as very high and high sensitivity due to their fragile landscape features such as steep slope, geology, and soil. Similarly, 9 municipalities in Lumbini Province, 22 municipalities in Gandaki Province, and 19 municipalities each in Karnali Province and Sudurpaschim Province are classified as very high and high sensitivity, respectively, due to their proximity to flood-prone and landslide-prone areas. The major cause of low adaptive capacity in these Provinces is a higher incidence of poverty, inadequate infrastructure development and access, and other prevailing local development challenges. Besides, the findings show that most of the rural municipalities in Province two, Karnali Province, and Sudurpaschim Province have lower adaptive capacity. The low adaptive capacity is mostly triggered by a lack of access to resources and services, including lower HDI and higher incidence of poverty in the Provinces and respective municipalities.

After analyzing the sensitivity and adaptive capacity, vulnerability is calculated. Vulnerability in this assessment is the difference between sensitivity or susceptibility to harm and lack of capacity to cope and adapt. The findings show that most of the districts are vulnerable to climate change impacts. A high to a very high degree of vulnerability is experienced in all the mountainous regions. Besides, all the mid-hills and mountain districts of Karnali Province and Sudurpaschim Province experienced a very high degree of vulnerability. The Bagmati Province has mixed types of vulnerability. The lowest vulnerability is observed in the Kathmandu district of Bagmati Province. Lalitpur, Bhaktapur, and Chitawan districts fall in the low vulnerability criteria. Gandaki Province and Lumbini Province have also a mixed type of vulnerability distribution. However, except Morang, Sunsari, Jhapa, and Panchtar all the hilly and mountain districts fall in a high to a very high degree of vulnerability.

The vulnerability in the Tarai seems moderate to low in the majority of the districts because of high adaptive capacity and comparatively lower sensitivity. One of the reasons is that a large number of rural municipalities do not have forests within their municipalities. Although the multi-dimension poverty and hazards are high, other factors influence vulnerability such as remoteness, access to resources, and existing facilities. Out of many, it is also influenced by improved access to roads and infrastructures, rich biodiversity, and access to energy.

When it comes to physiographic regions, the results suggest that high mountains and mid-hills are more vulnerable than other areas. Within the provinces, there is a wide range of physiographic vulnerability. This is, however, context-dependent and varies by sector.

However, there are variations within sectoral vulnerability. In the agriculture, forestry, health, water resources and energy, transport, tourism, and GESI sector, vulnerability is high in the Karnali Province and Sudrupaschim Province. In the case of health, the vulnerability is also concentrated in Province two. The majority of the sectoral analysis shows that vulnerability is more in the hills and mountain districts compared to the Tarai.

The municipalities-wise vulnerability analysis shows that among 293 municipalities assessed, 37 municipalities fall under the very high, 52 high, 42 moderate, 58 low, and 104 in a very low vulnerable category. The old-established metropolitan, sub-metropolitan, and municipalities such as Pokhara Lekhnath, Dharan, Kathmandu, Biratnagar, Lalitpur, Dhangadi, Dharan and Dhankuta have a very high adaptive capacity and therefore exhibit a very low vulnerability to climate change. These municipalities show a high level of human development index, access to adequate livelihood assets, access to urban services and function, economically sound, resilient physical and social infrastructure, and institutional capacity to plan and act to prepare and respond effectively to climate-induced shocks and stress. In the case of rural municipalities, the vulnerability is concentrated in Province two, Bagmati Province, Lumbini Province, Karnali Province, and Sudurpaschim Province. Few of the rural municipalities in the Gandaki Province are also highly vulnerable. Also, the major factors affecting vulnerability in the Provinces are due to higher sensitivity of population and resources and lower capacity to respond to the impacts of climate change.

It is also highly likely that future vulnerabilities will also increase across the majority of the municipalities and provinces due to the projection of increased hazards, the socio-economic downfalls due to COVID-19 and other issues, and the political instability in Nepal. Among others, the poor, marginalized, women, children, elderly, disabled will be more vulnerable to the impacts.

Risk is a function of exposure, vulnerability, and hazards. The overall baseline risks of climate change impact are calculated by considering the current hazard, exposure, and vulnerability. The analysis shows that districts that are impacted by floods, landslides, fire, windstorms, and hailstorms, etc., have observed a very high impact from climate-induced disasters. Under RCP 4.5 in 2030, a total of 15 districts fall in the very high-risk category while 17 districts fall in the high-risk category. Except for some exceptions under RCP 4.5, almost all districts in the Tarai, mid-hills, and mountains fall under high-very high risks. Likewise, under RCP 8.5 in 2030, a total of 19 districts fall in the very high-risk category while 17 districts fall in the high-risk category.

According to the results of the municipal level assessment, the risk level for Bhanu and Byas in Gandaki Province and Sitganga in Lumbini Province increased from high to very high-risk under RCP (4.5, 8.5) in 2030. In RCP 4.5, the number of very high-risk municipalities climbed from two in the baseline to six, while the risk level in the high-risk category increased from 44 in the baseline to 80 in 2030. Furthermore, under RCP 8.5, the number of very high-risk municipalities climbed from 2 in the baseline to 5, while the risk level in the high-risk category increased from 44 in the baseline to 69 in 2030. Besides, risk assessments in rural municipalities show that the risk of climate change in 2030 is higher in municipalities of mid-hills and Tarai. However, under both scenarios, some of the mountain rural municipalities in Bagmati Province and Province one face a high risk of climate extreme events in 2030.

According to the results of the municipal level assessment, Nilakantha from Bagmati Province has switched from high to very high-risk status in RCP 4.5 (2050). Furthermore, under RCP 4.5 (2050), Jitpur Simara in Province Two, Sworgadwary and Rajapur in Lumbini Province, and Patan in Sudurpaschim Province have gone from moderate to high risk as compared to RCP 4.5 (2030).

Similarly, in 2050, under RCP 8.5, Rupakot Majhuwagadhi from Province one, Janakpur from Province two, Nilkantha from Bagmati Province, and Kushma from Gandaki Province shifted from high to very high rank in comparison to RCP 8.5 in 2030. Furthermore, Sunwarshi, Bhojpur, and Chaudandigadhi from Province one; Jitpur Simara from Province two; Chandragiri, Ramechhap, Rapti and Ratnanagar from Bagmati; Sundarbajar, Shuklagandaki, and Madhyabindu from Gandaki Province; Buddhavumi, Bhumekasthan, Pyuthan and Rajapur from Lumbini Province, Sharada and Gurbhakot from Karnali Province and Parashuram and Patan from Sudurpaschim Province have shifted from moderate risk to high risk as compared to RCP 8.5 in 2030. In the case of the rural municipality, the risk of severe climate events is higher across all Provinces. It's worth noting that, under both RCP scenarios, the chances of climate extreme events are rising in 2050, as seen in the mountain palikas of Province one and the Bagmati Province.

Different development sectors, such as agriculture, water, disaster management, energy, forest, biodiversity, health, urban planning, and livelihoods, are expected to be impacted by risk scenarios. However, climate projections are fraught with uncertainty. Furthermore, socioeconomic scenarios govern the risk of climate change in the future. As a result, the findings of this assessment should be regarded as indicative rather than absolute when developing adaptation options and strategies, and uncertainties should not be overlooked. Having said that, the study's preliminary findings capture a wide range of future climate variability and are extremely useful in assisting policymakers in developing appropriate adaptation plans and strategies. Besides, the evidences presented in this report will be useful for government of Nepal to advance Loss and Damage debate at the national and international level.

In conclusion, the overall loss and damage, vulnerability and risk are increasing across Nepal and are projected to increase rapidly in the future. In terms of vulnerability, Karnali Province and Sudurpaschim Province are highly vulnerable. However, in terms of risks of climate change impact, Province one, Province two, Bagmati Province, Gandaki Province, and Lumbini Province have observed higher risks of climate change impact. Besides, COVID-19’s heightened risks and vulnerabilities, intensify the current socio-economic and health crisis, including the annual loss and damage caused by climate-related disasters. The poor, women, Indigenous Peoples, youth, children, the marginalized, and smallholder households and communities will be particularly hard hit.

Adaptation options are thus crucial to address the vulnerable hotspots, critical ecosystems, and vulnerable and marginalized communities. The findings suggest that in Karnali Province and Sudurpaschim Province a vulnerability and livelihood focussed approach to climate change adaptation is relevant. This means, in the short term (2025), adaptation options should focus more on improving the adaptive capacity and addressing some of the physical, socio-economic, and structural issues governing susceptibility of the population and the livelihood resources they depend on. Province two needs risks based approach to adaptation focussing more on reducing the risk of impact from climate-induced extreme events and hazards by improving the forecasting, risk communication, risk transfer, and disaster risk reduction activities. Besides, other Provinces need to focus both on increasing adaptive capacity as well as risk reduction activities.

The findings, in particular, suggest that context-specific adaptation options are required to deal with the differentiated impact, risk, and vulnerability in various thematic sectors. Soft and hard measures have been identified as adaptation options for the sectors. They include interventions that increase actors' and agencies' awareness and capacity, provide technological options and solutions to deal with climate adversity by reducing the risk posed by climate-induced hazards and extreme events, promote the efficient use and management of natural resources, and improve the communication and information system to protect people and their assets. Policy and legal measures to ensure compliance with environmental and climate-resilient codes, adoption of climate-resilient pathways, and integration of climate change into sectoral development policies and plans, including local government planning and budgeting processes, are also options. Options also include strengthening governance mechanisms to ensure that poor and vulnerable households and communities receive priority in adaptation funding. Also, adaptation options in the COVID-19 context must consider the wider socioeconomic context and contribute to green growth and recovery. However, there are also limits to adaptation and DRR technology and practices. The transformative options are thus needed to fill the adaptation gaps. These include approaches that change the system so that people and livelihoods exposed to risk are safeguarded. These approaches include relocation of settlement from landslide-prone areas, providing people access to new livelihood options such as the shift from traditional sustenance farming to the service sector, etc.

There are some limitations to this vulnerability and risk assessment. Due to data availability constraints, deciding on a scale proved difficult. Studies like this, which are conducted at the national level, require a consistent unit of analysis for comparison and, later, for taking ownership in terms of implementation, which is why the MoFE decided to use districts and urban municipalities as a unit of assessment. However, some sectors necessitated the use of different units of analysis. This study couldn't, for example, look into the settlements and had to rely on municipalities as a unit in both rural and urban settlements. Similarly, in the tourism sector, the assessment focused solely on protected areas and cultural assets.

Vulnerability and Risk Assessment will be carried out every five years, according to the Environment Protection Act (2019). There is a chance to fill the vacuum. However, there is a need to invest in research and data generation to have downscaled climate and other socioeconomic, demographic, and sectoral specific information and assessments covering all 753 local governments, as well as thematic sectors, sub-sectors, and appropriate scales (settlements, watershed, river basins, forests, and biodiversity types). There is, for example, a need to downscale climate trends and projections at the municipality level, which includes systematic data generation and storage. Also, hydrological modelling of major river basins and watersheds is needed in depth to understand the dynamics of changes in water resources. Besides, more data needs to be collected on vegetation shift, changes in the phenology of trees, plants, and crops, changes in water availability including the climate thresholds for major food crops.

References

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*,16(3):268–81

Adhikari, S. (2018). Drought Impact and Adaptation Strategies in the Mid-Hill Farming System of Western Nepal. *Sustainability*, *5*, 101; doi:10.3390/environments5090101. www.mdpi.com/journal/environments

Adhikari, S., Baral, H., and Nitschke, C. (2018). Adaptation to Climate Change in Panchase Mountain Ecological Regions of Nepal. Environments 5(3): 42

Amatya, S.M. (2013). Financing for Sustainable Forests Management in Nepal. INDUFOR, Auckland, New Zealand. Available on: http://www.un.org/esa/forests/

Aryal, A., Shrestha, U.B., Ji, W., Ale, S.B., Shrestha, S., Ingty, T., Maraseni, T., Cockfield, G., & Raubendheimer, D. (2016). Predicting the distribution of predators (snow leopard) and prey (blue sheep) under climate change in the Himalayas. Ecology and Evolution, 6(12): 4065–4075

Bartlett, S. (2008). The implications of climate change for children in lower-income countries. Children Youth and Environments, 18(1), 71-98

Byers, A.C., Rounce, D.R., Shugar, D.H. (2019). A rockfall-induced glacial lake outburst flood, Upper Barun Valley, Nepal. Landslides 16, 533–549. https://doi.org/10.1007/s10346-018-1079-9

Bhatta, K.P., Thapa, K., Gautam, S., Khattri-Chhetri, A., Chaudhary, P., Rana, R.B., Dhakal, B., Gurung, K.D., & Bhattarai, B. (2016). Scaling-up Climate Smart Agriculture in Nepal-Baseline Report. Local Initiatives for Biodiversity, Research, and Development (LI-BIRD) and The Consultative Group for International Agricultural Research's (CGIAR) Research Program on Climate Change, Agriculture, and Food Security (CCAFS), Kaski, Nepal

Bhatta, S., Joshi, L. R., and Shrestha, B.B. (2020). Distribution and impact of invasive alien plant species in Bardia National Park, western Nepal. Environmental Conservation 47(3):1-9. DOI: 10.1017/S0376892920000223

Bhujel, K.B., Byanju, R.M., Gautam, A.P., & Mandal, R.A. (2018). Wildfires Dynamics and Occasional Precipitation during Active Fire Season in Tropical Lowland of Nepal. Environment and Natural Resources Journal 2018; 16(1):1-8

Bhujel, K.B., Byanju, R.M., Gautam, A.P., Sapkota, R.P., & Khadka, U.R. (2020). Fire-induced carbon emissions from tropical mixed broad-leaved forests of the Tarai-Siwalik region, central Nepal. (2020). https://doi.org/10.1007/s11676-020-01256-x

Bhuju, D.R., Shah, S.K., & Gaire, N.P. (2016). Environmental Reconstruction and Impact of Climate Change on Vegetation at Tree-Lines of Nepal Himalaya, Annual Report of Pro Natura Foundation Japan Vol. 24 (2016)

Bhuju, U.R., Khadka, M., Neupane, P.K. & Adhikari, R. (2010). A Map-based Inventory of Lakes in Nepal. Nepal Journal of Science and Technology 11: 173–180. doi:10.3126/njst.v11i0.4141

Birch, E. L., Meleis, A., &Wachter, S. (2012). The urban water transition: Why we must address the new reality of urbanization, women, Water, and sanitation in sustainable development. wH2O: The Journal of Gender and Water, 1(1), 1

Bohle, H. G., Downing, T. E., & Watts, M. J. (1994). Climate change and social vulnerability: toward a sociology and geography of food insecurity. Global environmental change, 4(1), 37-48

Budha, P.B. (2014). Invasive Alien Fauna of Nepal: Current Situation and Future Perspective. In. Thapa, G.J., Subedi, N., Pandey, M.R., Thapa, S.K., Chapagain, N.R., and Rana, A. (Eds.). Proceeding of the International Conference on Invasive Alien Species Management (March 25-27, 2014), National Trust for Nature Conservation, Nepal (pp. 60-80)

CBS. (1991). Nepal-National Population Census 1991. Available at: https://nada.cbs.gov.np/index.php/catalog/55/datacollection

CBS. (1995). Nepal Living Standard Survey. Central Bureau of Statistics (CBS), Kathmandu

CBS. (2001). Nepal-National Population Census 2001. Available at: https://nada.cbs.gov.np/index.php/catalog/42

CBS. (2005). Poverty Trends in Nepal (1995-96 and 2003-04). National Planning Commission Secretariat and Central Bureau of Statistics, Thapathali, Kathmandu Nepal. Available at: https://nada.cbs.gov.np/index.php/catalog/9

CBS. (2011). Nepal-National Population Census 1991. Available at: https://nada.cbs.gov.np/index.php/catalog/54

CBS. (2014). National Population and Housing Census, 2011. Population Projection of Nepal has projected population upto 2031. Projection for 2041 and 2051 was done using the same growth rate

CBS. (2017). National Climate Change Impact Survey 2016. A Statistical Report. Central Bureau of Statistics, Kathmandu, Nepal

Chalise, D., Kumar, L., Shriwastav, C.P., & Lamichhane, S. (2018). Spatial Assessment of Soil Erosion in a Hilly Watershed of Western Nepal. Environmental Earth Sciences 77(19). DOI: 10.1007/s12665-018-7842-3

Chaudhary, P., & Aryal, K. P. (2009). Global warming in Nepal: Challenges and policy implications. *Journal of Forest and Livelihood,* 8(1):4-13

Chaudhary, P., & Bawa, K.S. (2011). Local perceptions of climate change, validated by scientific evidence in the Himalayas. *Biology Letters*, 7(5): 641-643

Chaudhary, R.B. and Maharjan, M. (2017). Parasitic infection in blackbuck (Antilope cervicapra Linnaeus, 1758) of Blackbuck Conservation Area, Bardiya and Shuklaphanta Wildlife Reserve, Kanchanpur, Western Nepal. Nep J Environ Sci (2017), 5, 9-17

Chaudhary, R.P., Uprety, U., Devkota, S., Adhikari, S., Rai, S.K., & Joshi, S.P. (2020). Plant Biodiversity in Nepal: Status, Conservation Approaches, and Legal Instruments under New Federal Structure. Plant Diversity in Nepal, 2020. 167-206. In. Siwakoti, M., Jha, P.K., Rajbhandary, S., Rai, S.K. (Eds.). Botanical Society of Nepal, Kathmandu

Chaulagain, N. P. (2009). Climate Change Impacts on Water Resources of Nepal with Reference to the Glaciers in the Langtang Himalayas. *Journal of Hydrology and Meteorology*, *6*(1), 58–65. https://doi.org/10.3126/jhm.v6i1.5489

Chitale, V., Silwal, R., & Matin, M. (2018). Assessing the Impacts of Climate Change on Distribution of Major Non-Timber Forest Plants in Chitawan Annapurna Landscape, Nepal. Resources, 7(4), 66

Dee, D. P., Uppala, S. M., Simmons, A. J., Berrisford, P., Poli, P., Kobayashi, S., ... & Vitart, F. (2011). The ERA-Interim reanalysis: Configuration and performance of the data assimilation system. *Quarterly Journal of the royal meteorological society*, *137*(656), 553-597

Devine, A. & Lawlis, T. (2019). Nutrition and Vulnerable Groups. *Nutrients*, 11(5),:1066

Dhakal, C.K., Regmi, P.P., Dhakal, I., Khanal, B., Bhatta, U.K., Barsila, S.R. & Acharya, B. (2013). Perception, impact, and adaptation to climate change: an analysis of livestock system. *Nepal. J. Anim. Sci. Adv.* 3(9): 462-471

Dhakal, S., Joshi, D. D. & Chand, P. (2011). Geographical expansion of Japanese encephalitis and research needs in Nepal. *Zoonoses and Food Hygiene News*, 17(4): 2-4

Dhakal, Y.R., Gaire, N. P., Aryal, S., Shah, S.K., Bhandari, S., Kunwar, U., & Rayamajhi, S. (2016). Treeline shift in Central Nepal Himalaya and Climate Reconstruction of Past Millennia. In. Building Knowledge for Climate Resilience in Nepal Research Brief. In. Bhuju, D., McLaughlin, K., Sijapati, J, Devkota, B., Shrestha, N., Ghimire, G, and Neupane, P.K. (Eds.). Nepal Academy of Science and Technology, Khuamaltar, Lalitpur (pp. 60-70)

Dhimal, M., Karki, K. B., Aryal, K. K., Shrestha, S. L., & Pradhan, B. (2016). Final report on assessment of effects of climate factors on diarrheal diseases at national and sub-national levels in Nepal. *Kathmandu: Nepal Health Research Council and Word Health Organization Country Office for Nepal*

Dhimal, M., O'Hara, R. B., Karki, R., Thakur, G. D., Kuch, U., & Ahrens, B. (2014). Spatio-temporal distribution of malaria and its association with climatic factors and vector-control interventions in two high-risk districts of Nepal. *Malaria journal*, *13*(1), 1-14

Dhimal, M., Pote-Shrestha, R. R., Groneberg, D. A., & Kuch, U. (2017). Health-sector responses to address the impacts of climate change in Nepal. WHO South-East Asia journal of public health, 6(2), 9

DHM. (2017). *Observed Climate Trend Analysis in the Districts and Physiographic Regions of Nepal (1971-2014).* Department of Hydrology and Meteorology, Kathmandu

DNPWC. (2018). Annual Report, Chitawan National Parks, Department of National Park and Wildlife Conservation, Nepal

DoI. (2020). *Industrial Statistics. The fiscal Year 2076/77 (2019/20)*. Government of Nepal Ministry of Industry, Commerce and Supplies, Department of Industry. Planning, monitoring and industrial statistics section Tripureswor, Kathmandu https://www.doind.gov.np/index.php/publications/industry-statistics

DUDBC & MoSTE. (2014). Urban Sector Adaptation Plan Framework for Guidelines: Synthesis Report on Adaptation to Climate Change. Prepared by ICEM - International Centre Environmental Management with the Nepal Ministry of Science, Technology, and Environment (MoSTE) and Department of Urban Development and Building Construction (DUDBC) as part of TA – 7984 NEP: Mainstreaming Climate Change Risk Management in Development Project supported by ADB with funding from the Climate Investment Fund (CIF)

Eriksson, M., Fang, J., and Dekens, J. (2008). How does climate change affect human health in the Hindu Kush-Himalaya region. In Regional Health Forum 12(1)-11-15

Eriksson, M., Jianchu, X., Shrestha, A. B., Vaidya, R. A., Nepal, S., & Sandström, K. (2009). *The Changing Himalayas Impact of climate change on water resources and livelihoods in the greater Himalayas*. Kathmandu: ICIMOD

European Aid. (2010). Climate risk Assessment. An introduction- Training material European Commission, Available online: http://capacity4dev.ec.europa.eu/public-environment-climate/document/training-material-climate-risk-assessment

FAO. (2009). FAO's role in the Syria Drought Response Plan 2009. Food and Agriculture Organization, Rome, Italy, www.fao.org/fileadmin/templates/tc/tce/pdf/ app_syriadrought2009.pdf

Faulon, M. & Sacareau, I. (2020). Tourism, Social Management of Water and Climate Change in an Area of High Altitude: the Everest Massif in Nepal. *Journal of Alpine Research*. 108 (1)

Forrest, J.L., Wikramanayake, E., Shrestha, R., Areendran, G., Gyeltshen, K., Maheshwari, A., Mazumdar, S., Naidoo, R., Thapa, G.J., & Thapa, K. (2017). Conservation and climate change: Assessing the vulnerability of snow leopard habitat to treeline shift in Himalaya. Biological Conservation. 150(2014): 129-135

Gaire N.P. Dhakal, Y.R., Lekhak, H.C., Bhuju, D.R., and Shah, S.K. (2011). Dynamics of Abies Spectabilis in relation to Climate Change at the Treeline Ecotone in Langtang National Park. Nepal Journal of Science and Technology 12 (2011) 220-229

Gaire, N.P., Koirala, M., Bhuju, D.R., & Carrer, M. (2017). Site-and species-species treeline response to climate variability in eastern Nepal Himalaya, *Dendrochronologia* 41 (2017): 44–56

Gaire, N.P., Koirala, M., Bhuju, D.R., and Borgaonkar, H.P. (2014). Treeline Dynamics with Climate Change at the Central Nepal Himalaya. Clim. Past, 10, 1277–1290, 2014. doi:10.5194/cp-10-1277-2014

Gartaula, H. N., Niehof, A., & Visser, L. (2010). Feminisation of Agriculture as an Effect of Male Out-migration: Unexpected Outcomes from Jhapa District, Eastern Nepal. *International Journal of Interdisciplinary Social Sciences*, *5*(2)

Gentle P, Thwaites R, Race D, Alexander K. (2014). Differential impacts of climate change on communities in the middle hills region of Nepal. Nat Hazards 74(2):815–836

Ghimire, U., Akhtar, T., Shrestha, N., & Daggupati, P. (2019). Development of Asia Pacific Weather Statistics (APWS) dataset for use in Soil and Water Assessment Tool (SWAT) simulation. *Earth System Science Data Discussions*, *November*, 1–30. https://doi.org/10.5194/essd-2019-178

GoN. (2014). Nepal National Biodiversity Strategy and Action Plan (2014-2020). The Government of Nepal. Ministry of Forests and Soil Conservation, Kathmandu, Nepal

GoN. (2019). Climate Change Policy, 2076 (2019). The Government of Nepal

GoN. (2020). Economic Survey 2018/2019, Government of Nepal, Ministry of Finance. Singhadurbar, https://www.mof.gov.np/uploads/document/file/compiled percent20economic percent20Survey percent20english percent207-25_20191111101758.pdf

Goodrich, C. G., Manjari, M., & Suman, B. (2017). Status of gender, vulnerabilities and adaptation to climate change in the Hindu Kush Himalaya: impacts and implications for livelihoods, and sustainable mountain development (2017). ICIMOD Working Paper, (2017/3)

Gössling, S., Peeters, P., Michael Hall, C., Ceron, J.P., Dubois, G., Lehmann, L. V., & Scott D. (2012). Tourism and water use: Supply, demand, and security. An international review. *Tourism Management*. 33:1-15

Gum, W., Singh, P. M., & Emmett, B. (2009). 'Even the Himalayas have stopped smiling': climate change, poverty and adaptation in Nepal. 'Even the Himalayas have stopped smiling': climate change, poverty and adaptation in Nepal

Gupta, J. & Bogati, S. (2014). Key Challenges of Security Provision in Rapidly Urbanising Contexts: Evidence from Kathmandu Valley and Tarai Regions of Nepal. IDS Evidence Report No. 69. Brighton: Institute of Development Studies. http://bit.ly/1iZi1fB

Gurung, D.D, Bisht, S. (2014).Women's empowerment at the frontline of adaptation: emerging issues, adaptive practices, and priorities in Nepal (International Centre for Integrated Mountain Development, Kathmandu, Nepal)

Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009). The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique. *Global environmental change*, *19*(1), 74-88

Haigh, C., and Vallely, B. (2010). Gender and the Climate Change Agenda: The impacts of climate change on women and public policy. Women's Environmental Network, London

ICIMOD. (2010). Climate Change Impact and Vulnerability in the Eastern Himalayas – Synthesis Report. ICIMOD

ICIMOD. (2011). Glacial lakes and glacial lakes outburst floods in Nepal. Kathmandu: ICIMOD

ICIMOD. (2011). The Status of Glaciers in the Hindu Kush-Himalayan Region. In S. R. Bajracharya & B. Shrestha (Eds.), *Mountain Research and Development*. International Centre for Integrated Mountain Development (ICIMOD). http://dx.doi.org/10.1659/mrd.mm113

IDS-Nepal, PAC, & GCAP. (2014). Economic Impact Assessment of Climate Change in Key Sectors in Nepal. *IDS-Nepal, Kathmandu, Nepal*

IFAD. (2013). http://operations.ifad.org/documents/654016/e98f365b-705f-416f-85acef6d85a87b2f

Immerzeel, W. W., Pellicciotti, F., & Shrestha, A. B. (2012). Glaciers as a proxy to quantify the spatial distribution of precipitation in the Hunza basin. *Mountain research and development*, *32*(1), 30-38

Immerzeel, W. W., Wanders, N., Lutz, A. F., Shea, J. M., & Bierkens, M. F. P. (2015). Reconciling high-altitude precipitation in the upper Indus basin with glacier mass balances and runoff. *Hydrology and Earth System Sciences*, *19*(11), 4673-4687

IOM. (2019). Glossary on Migration. International Organization for Migration (IOM), Geneva. Available at: https://publications.iom.int/system/files/pdf/iml_34_glossary.pdf

IOM. (2019). Migration in Nepal, A country Profile, 2019

IPCC. (2007). Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change 2007a." Assessment of Practices, Options, and Constraints, and Capacity." Chapter 17 in Climate Change 2007. M.L Parry, O.F Canziani, J.P Palutikot. P.J Van Der Liden, and C.E Hanson, Cambridge: Cambridge University Press

IPCC. (2014). Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment report of the Intergovernmental Panel on Climate Change available at www.ipcc.ch/report/ar5/wg2/

IPCC. (2014a). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment *Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp

IPCC. (2014b). Climate Change 2014: Impacts, Adaptation, and Vulnerability, Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, VR, Field, CB, Dokken, DJ, Mastrandrea, MD, Mach, KJ, Bilir, TE, Chatterjee, M, Ebi, KL, Estrada, YO, Genova, RC, Girma, B, Kissel, ES, Levy, AN, MacCracken, S, Mastrandrea, PR and White, LL (eds)]. Cambridge University Press, Cambridge

IPCC. (2014c). *Climate Change 2014: Impacts, Adaptation, and Vulnerability.* Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros

IWMI. (2019). *Sustainable, just and productive water resources development in Western Nepal under current and future conditions*. http://djb.iwmi.org/

Jaquet, S., Kohler, T., & Schwilch, G. (2019). Labour migration in the middle hills of Nepal: Consequences on land management strategies. Sustainability, 11(5), 1349

Jenks, G. F. (1967). The data model concept in statistical mapping. *International yearbook of cartography*, *7*, 186-190

Jha N. (2019). An assessment of urban flood risk: A case study from Hanumante river, Bhaktapur. 2019

Joshi, Y.P., Ghimire, Y.C., Pokherel, Y.R., Pant, S., Pokherel, K.P. (2020). Landscape analysis of vector bore disease research studies in Nepal, 2020.Vector Borne Disease and Research Training Center (VBDRTC), Ministry of Health, Nepal

Kaczan, D. J., & Orgill-Meyer, J. (2020). The impact of climate change on migration: a synthesis of recent empirical insights. Climatic Change, 158(3), 281-300

KC, A., & Thapa Parajuli, R. B. (2015). Climate change and its impact on tourism in the Manaslu conservation area, Nepal. Tourism Planning & Development, 12(2), 225-237

KC, R.K. (2014). Aquaculture and fisheries development in Nepal: present status, future potential, opportunities, and challenges. Paper presented in Terminal Workshop of FAO/TCP/NEP/3303 on Improving National Carp Seed Production System in Nepal. Dhulikhel, Nepal

Khanal, P. (2012). Trends and Scenario of Poverty in Nepal. Available at: https://core.ac.uk/download/pdf/211605849.pdf

Khanal, P., Wagle, B.H., Upadhaya, S., Ghimire, P., & Acharya, S. (2019). Perceived Climate Change Impacts and Adaptation Strategy of Indigenous Community (Chepang) in Rural Mid-hills of Nepal. Forestry: Journal of Institute of Forestry, Nepal,17, 48- 61

Khaniya, L. and Shrestha, B.B. (2020). Forest regrowth reduces the richness and abundance of invasive alien plant species in community-managed Shorea robusta forests of central Nepal. Journal of Ecology and Environment, 44(12).

Koirala, A., & Bhandari, P. (2019). Impact of Climate Change on Livestock Production, *Nepalese Veterinary Journal*, 36, pp. 178-183. doi: 10.3126/nvj.v36i0.27778

Kolmannskog, V., & Trebbi, L. (2010). Climate change, natural disasters and displacement: a multi-track approach to filling the protection gaps. Int'l Rev. Red Cross, 92, 713

Kovats, R. S., Hajat, S. (2008). Heat stress and public health: a critical review. *Annual Review of Public Health*, 29: 41–55

Lama, A. K. (2010). *The vulnerability of nature-based tourism to climate change: stakeholders' perceptions of and response to climate change in the lower Mustang Region of the Annapurna conservation area* (Doctoral dissertation, Lincoln University)

Lamsal P., Atreya, K., Ghos, M.K., & Pant, K.P. (2019). Effects of population, land cover change, and climatic variability on wetland resource degradation in a Ramsar listed Ghodaghodi Lake Complex, Nepal. Environ Monit Assess. 2019 Jun 6;191(7):415

Lamsal, P., Kumar, L., Atreya, K., and Pant, K.P. (2017). Vulnerability and impacts of climate change on forests and freshwater wetland ecosystems in Nepal. A review. Ambio

Leduc, B., & Bhattarai, B. (2008). Case Study: Gender and Climate Change in the Hindu Kush Himalayas of Nepal. https://www.wedo.org/wp-content/uploads/nepalcasestudy.pdf

Liu, M., Chen, N., Zhang, Y., & Deng, M. (2020). Glacial lake inventory and lake outburst flood/debris flow hazard assessment after the Gorkha earthquake in the Bhote Koshi Basin. Water, 12(2), 464

Lou, Y., Zhao, K., Wang, G., Jiang, M., Lu, X., and Rydin, H. (2015). Long-term changes in marsh vegetation in Sanjiang Plain, northeast China. Journal of Vegetation Science 26: 643–650. doi:10.1111/jvs.12270

Lung T, Lavalle C, Hiederer R, Dosio A. and Bouwer LM, (2013). A multi-hazard regional level impact assessment for Europe combining indicators of climatic and non-climatic change, Glob. Environ. Chang. 23 522–36

Lutz, A. F., & Immerzeel, W. (2016). Reference climate dataset for the Indus, Ganges, and Brahmaputra river basins

Lutz, A. F., Ter Maat, H. W., Biemans, H., Shrestha, A. B., Wester, P., & Immerzeel, W. W. (2016). Selecting representative climate models for climate change impact studies: an advanced envelope based selection approach, *International Journal of Climatology*

Malla, R., & Pokharel, K. K. (2018). Forest Pests and Pathogens Problems in different forest types of Nepal. Department of Forest Research and Survey, Kathmandu, Nepal

Metzger, M., Rounsevell, M. D. A., Acosta-Michlik, L., Leemans, R., & Schröter, D. (2006). The vulnerability of ecosystem services to land use change. Agriculture, ecosystems & environment, 114(1), 69-85.

Mirsaeidi, M., Motahari, H., Taghizadeh Khamesi, M., Sharifi, A., Campos, M., & Schraufnagel, D. E. (2016). Climate change and respiratory infections. *Annals of the American Thoracic Society*, *13*(8), 1223-1230

MoE. (2010). National Adaptation Programme of Action (NAPA) to Climate Change. Ministry of Environment, Kathmandu, Nepal

MoF. (2018). Economic Survey 2017/18, Government of Nepal, Ministry of Finance, K

MoFE. (2018). Climate Change Vulnerability, Impact, and Adaptation Assessment. A Report Submitted to Government of Nepal Ministry of Forests and Environment Third National Communication Project Singh Durbar, Kathmandu by Central Department of Environmental Science Institute of Science and Technology Tribhuvan University Kirtipur, Nepal. Available at https://mofe.gov.np/noticefile/Report_VIA_Final-2019_1562308949.pdf

MoFE. (2018c). National Ramsar Strategy and Action Plan Nepal (2018-2024). Ministry of Forests and Environment, Kathmandu, Nepal

MoFE. (2019). *Climate change scenarios for Nepal for National Adaptation Plan NAP*. Ministry of Forests and Environment, Kathmandu

MoFE. (2019c). National Forest Policy, 2075, Ministry of Forests and Environment, Singh Durbar, Kathmandu, Nepal

MoFSC. (2014). Nepal Biodiversity Strategy and Action Plan, 2014-2020 Ministry of Forests and Soil Conservation (MoFSC), Kathmandu, Nepal

MoFSC. (2016). Forestry Sector Strategy, 2016-2025. Ministry of Forests and Soil Conservation (MoFSC), Kathmandu, Nepal

MoHA. (2018). National Disaster Risk Reduction Policy, 2018, Government of Nepal

MoLES. (2020). Labour Migration Report 2020. Ministry of Labour, Employment and Social Security, Government of Nepal. Available at: https://moless.gov.np/wp-content/uploads/2020/03/Migration-Report-2020-English.pdf

MoPE. (2016). Stocktaking Report on Urban Settlement and Infrastructure. National Adaptation Plan Formulation Process in Nepal. Ministry of Population and Environment, Government of Nepal

MoPE. (2017). *Vulnerability and Risk Assessment Framework and Indicators for National Adaptation Plan (NAP)*. Formulation Process in Nepal, Ministry of Population and Environment (MoPE), Kathmandu

Morrow, B.H. (1999). Identifying and mapping community vulnerability, Disasters, 23(1), 1-18

NARC. (Nepal Agricultural Research Council) (2010). Annual Reports, 1987-1998, Kathmandu" Nepal Agricultural Research Council.NATWGs. In Paudel, M.N. 2012. Adaptation mechanisms in agriculture for climate change in Nepal". Hydro Nepal, Special issue, April 2012, 82-85

NCVST. (2009). Vulnerability through the Eyes of Vulnerable: Climate Change Induced Uncertainties and Nepal's Development Predicaments. Institute for Social and Environmental Transition-Nepal (ISET-N), Kathmandu

Nellemann, C., Verma, R., and Hislop, L. (eds). (2011). *Women at the frontline of climate change: Gender risks and hopes.* A Rapid Response Assessment. United Nations Environment Programme, GRID-Arendal

Neupane, P.C., Gani, M.R., Gani, N.D., and Huang, Y. (2019). Neogene Vegetation Shift in the Nepalese Siwalik, Himalayas: A compound-specific Isotopic Study of Lipid Biomarkers. The Journal of the International Association of Sedimentologists. DOI: 10.1002/dep2.91

NHHSP. (2017). A Final Report on Climate Change and Health Infrastructure Framework. Nepal Health Sector Support Programme (NHHSP)

Nicholson, K., Hayes, E., Neumann, K., Dowling, C., & Sharma, S. (2016). Drinking water quality in the Sagarmatha national park, Nepal. *Journal of Geoscience and Environment Protection*, *4*(04), 43

NPC. (2017). Demographic changes in Nepal: Trend and policy implications. Government of Nepal

NPC. (2017). Nepal flood 2017: Post-flood recovery needs assessment. Government of Nepal, National Planning Commission, Kathmandu

NPC. (2017). Nepal's Sustainable Development Goals. Status and roadmap 2016-2030. National Planning Commission. Government of Nepal

NPC. (2017). Post Flood Recovery Assessment, Nepal Flood 2017. National Planning Commission. Government of Nepal

NPC. (2018). Nepal Multidimensional Poverty Index: Analysis towards action (2018). National Planning Commission, Government of Nepal.https://www.npc.gov.np/images/category/Nepal_MPI.pdf

NPC. (2020). Nepal's Sustainable Development Goals Progress Assessment Report 2016–2019. National Planning Commission (NPC), Government of Nepal, Kathmandu

Nyaupane, G.P., and Chhetri, N (2009). Vulnerability to Climate Change of Nature-Based Tourism in the Nepalese Himalayas. Tourism Geographies Vol. 11 (1), 95–119

o'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., ... & West, J. (2004). Mapping vulnerability to multiple stressors: climate change and globalization in India. Global environmental change, 14(4), 303-313.

OECD. (2003). *Development and climate change in Nepal: Focus on water resources and hydropower* (S. Agrawala, V. Raksakulthai, P. Larsen, J. Smith, & J. Reynolds (eds.))

Onta N, Resurreccion BP. (2011). The role of gender and caste in climate adaptation strategies in Nepal. Mt Res Dev 31(4):351–356

Ouyang, Z., Beckar, R., & Wade Shaver, J.C. (2013). Evaluating the sensitivity of wetlands to climate change with remote sensing techniques. Hydrological Proces

Paltan, H., Allen, M., Haustein, K., Fuldauer, L., & Dadson, S. (2018). Global implications of 1.5 C and 2 C warmer worlds on extreme river flows. Environmental Research Letters, 13(9), 094003

Pandey, A.K., and Bhargava, P. (2010). Impact of Climate Change on Non-Timber Forest Products: An Overview. Journal of Tropical Forestry, 26(IV)

Pandey, V. P., Dhaubanjar, S., Bharati, L., & Thapa, B. R. (2019). Hydrological response of Chamelia watershed in Mahakali Basin to climate change. *Science of the Total Environment*. https://doi.org/10.1016/j.scitotenv.2018.09.053

Pandey, V. P., Dhaubanjar, S., Bharati, L., & Thapa, B. R. (2020). Spatio-temporal distribution of water availability in Karnali-Mohana Basin, Western Nepal: Hydrological model development using multi-site calibration approach (Part-A). *Journal of Hydrology: Regional Studies*, *29*, 100690. https://doi.org/10.1016/j.ejrh.2020.100690

Pandit, K. (2020). *Quantifying Uncertainties in Climate Projections & Hydrologic Modeling in Gandaki River Basin, Nepal*. Indian Institute of Technology Roorkee, India

Pant, G., Maraseni, T., Apan, A., & Allen, B. (2020). Climate Change Vulnerability of Asia's most Iconic Megaherbivore: Greater One-horned Rhinoceros *(Rhinoceros unicornis)*. Global Ecology and Conservation 23 (2020) e01180

Panta, M., & Mandal, R.A. (2019). Impact of Climate Change on Phenology of Rhododendron arboretum Sm., Myrica esculenta Buch-Ham. Ex D Don and *Alnus nepalensis*. Journal of Forest Science 2019 (4). .68–79

Parsons, K. (2014). Human thermal environments: the effects of hot, moderate, and cold environments on human health, comfort, and performance. ed. CRC Press

Patra, J. & Terton, A. (2017). Review of current and planned adaptation action in Nepal. CARIAA Working Paper no. 20. International Development Research Centre, Ottawa, Canada, and UK Aid, London, United Kingdom. Available online at www.idrc.ca/cariaa

Paudel, B., Wu, X., Zhang, Y., Rai, R., Liu, L., Zhang, B., ...& Nepal, P. (2020). Farmland abandonment and its determinants in the different ecological villages of the Koshi River Basin, Central Himalayas: Synergy of high-resolution remote sensing and social surveys. Environmental Research, 109711

Pokharel, T. (2010). Gender Equality and Economic Growth of Nepal: A Positive Synergy Hypothesis. Nepal Population Journal, 15(14), 79-88

Pokhrel, D.M., & Pandey, B. (2011). Climate change adaptation: strategic vision in agriculture. *Journal of Agriculture and Environment*, 12, 104-112

Rai, R. K., & Scarborough, H. (2012). Valuing the Damage Caused by Invasive Plant Species in a Low-income Community in Nepal. SANDEE working papers, 74-12. Kathmandu: SANDEE

Raney, T., Anríquez, G., Croppenstedt, A., Gerosa, S., Lowder, S. K., Matuschke, I., & Skoet, J. (2011). The role of women in agriculture

Rayamajhi, S. (2013). The linkage between Tourism and Climate Change: A Study of the Perceptions of Stakeholders along the Annapurna Trekking Trail. Nepal Tourism and Development Review 2 (1)

Regmi, B. R., Star, C., Pradhan, B., & Pandit, A. (2016 a). Climate Change and Human Health Impact and Adaptation Responses in Nepal. In Climate Change and Human Health Scenario in South and Southeast Asia (pp. 131-152). Springer, Cham

Regmi, B. R., Star, C., & Leal Filho, W. (2016 b). An overview of the opportunities and challenges of promoting climate change adaptation at the local level: a case study from a community adaptation planning in Nepal. Climatic Change, 138(3), 537-550

Regmi, B. R., Star, C., Paudyal, A., & Karki, R. C. (2016 c). Strengthening Climate Change Adaptation in Nepal: Needs and Perspectives. In Climate change in the Asia-Pacific region (pp. 245-262). Springer, Cham

Regmi, H.R. (2007). Effect of unusual weather on cereal crops production and household food security. *The Journal of Agriculture and Environment*, 8:20-29

Rijken, M. J., McGready, R., Boel, M. E., Poespoprodjo, R., Singh, N., Syafruddin, D., ... & Nosten, F. (2012). Malaria in pregnancy in the Asia-Pacific region. The Lancet infectious diseases, 12(1), 75-88

Rimal, B., Karki, G., Trines, E. & Goor, W.V. (2015). Analytical Study on Assessing the Value of Forests, the Political Economy of Land Use, and the Carbon Emissions from the Drivers of DD: An Assessment of Drivers of Deforestation and Forest Degradation in Nepal. GoN/MoFSC/REDD Cell, Kathmandu, Nepal

Rimal, B., Keshtkar, H., Sharma, R., Stork, N., Rijal, S., & Kunwar, R. (2019). Simulating urban expansion in a rapidly changing landscape in eastern Tarai, Nepal. Environmental monitoring and assessment, 191(4), 1-14

Saaty, T. L. (1984). The analytic hierarchy process: Decision making in complex environments. In *Quantitative Assessment in Arms Control* (pp. 285-308). Springer, Boston, MA

Sakya, R. (2013). Shift Assessment of Upper Tree Species Limit and Tree Line Recruitments in Manaslu Area, Nepal. MSc. A thesis submitted to Tribhuvan University, Nepal

Sangraula, B. (2010). 1,000 Tourists Stranded in Lukla Due to Week-Long Flight Shutdown, Republica

Schneider, U., Becker, A., Finger, P., Meyer-Christoffer, A., Ziese, M., & Rudolf, B. (2014). GPCC's new land surface precipitation climatology based on quality-controlled in situ data and its role in quantifying the global water cycle. *Theoretical and Applied Climatology*, *115*(1), 15-40

Sharma, U., and Patwardhan, A., (2008). Methodology for identifying vulnerability hotspots to tropical cyclone hazard in India, Mitig. Adapt. Strateg. Glob. Chang. 13 703–17

Sharma, J., & Ravindranath, N. H. (2019). Applying IPCC 2014 framework for hazard-specific vulnerability assessment under climate change. *Environmental Research Communications,* 1(5), 051004

Sherpa, Y.D., & Kayastha, R.B. (2009). A study of livestock management by socio-economic factors and climate change, Kathmandu University. *Journal of Science, Engineering and Technology*, 5, 110-120

Shrestha, A., & Baral, S. (2018). Impacts of climate change on livestock and livestock produces: a case study of Banke District, Nepal. *Sarhad Journal of Agriculture*, 34(4): 760-766

Shrestha, M. (2017). Push and pull: A study of international migration from Nepal. The World Bank

Shrestha, P.M. (2020, 27 September). Local governments must take its advice on roads, Department of Roads says The Kathmandu Post. Retrieved April 04, 2018, from https://kathmandupost.com/national/2020/09/27/haphazard-road-construction-leads-to-increased-landslides-blocking-the-highways

Shrestha, S. K. (2007). Green Roads and rural development. The Himalayan Times. Retrieved April 04, 2018, from https://thehimalayantimes.com/opinion/topicsgreen-roads-and-rural-development/

Shrestha, S. L., Shrestha, I. L. & Shrestha, N. (2016). Region-wise effects of climate sensitive variables on some specific disease burdens in Nepal. *The Open Atmospheric Science Journal*, 10: 63-83

Shrestha, S., Bajracharya, A.R. and Babel, M.S. (2016). Assessment of risks due to climate change for the Upper Tamakoshi Hydropower Project in Nepal. Climate Risk Management, 14, pp.27–41

Shrestha, B. B., (2019). Assessment of Flood Hazard and Agriculture Damage under Climate Change in the Bagmati River Basin of Nepal. International Journal of Environment, 8(2), 55-69

Shrestha, U.B., & Shrestha, B.B. (2019). Climate Change amplifies plant invasion hotspots in Nepal. Diversity and Distribution. 2019; 25:1599-1612

Simpson, M.C., Gössling, S., Scott, D., Hall, C.M., & Gladin E. (2008). Climate Change Adaptation and Mitigation in the Tourism Sector: Frameworks, Tools, and Practices. UNEP, University of Oxford, UNWTO, WMO: Paris, France

Siwakoti, M. (2016). Assessment of the Effects of Climate Change on Distribution of Invasive Alien Plant Species in Nepal. In. Bhuju, D., McLaughlin, K., Sijapati, J, Devkota, B., Shrestha, N., Ghimire, G, & Neupane, P.K. (Eds.), Building Knowledge for Climate Resilience in Nepal Research Brief. Nepal Academy of Science and Technology, Khuamaltar, Lalitpur (pp. 50-55)

Stroming, S. (2017). After the Flood: Fish Farming and Climate Change Adaptation in Chitawan, Nepal. Independent Study Project (ISP) Collection. 2739. https://digitalcollections.sit.edu/isp_collection/2739

Subedi, N., Lamichhane, B.R., Amin, R., Jnawali, S.R., Jhala, Y.V. (2017). Demography and viability of the largest population of greater one-horned rhinoceros in Nepal. Global Ecology and Conservation. 12(2017) 241-252

Sugden, F., Silva, S. D., Clement, F., Maskey-Amatya, N., Ramesh, V., Philip, A., and Bharati, L. (2014). A framework to understand gender and structural vulnerability to climate change in the Ganges River Basin: lessons from Bangladesh, India and Nepal. IWMI Working Paper, (159)

Sunam, R. K., & McCarthy, J. F. (2016). Reconsidering the links between poverty, international labour migration, and agrarian change: critical insights from Nepal. The Journal of Peasant Studies, 43(1), 39-63

Tamang, S., Paudel, K.P., &Shrestha K.K. (2014). Feminization of Agriculture and its implications for food security in rural Nepal. Journal of Forest and Livelihood, 12(1), 20-32

Tenzin, K., Mee-Udon, F., & Prampesit, R. (2019). Community opinion towards a village homestay program in Soe, a small nomadic community in the North-West of Bhutan. *African Journal of Hospitality, Tourism and Leisure*, *8*(3), 1-10

Thapa, R. B., & Murayama, Y. (2010). Drivers of urban growth in the Kathmandu valley, Nepal: Examining the efficacy of the analytic hierarchy process. *Applied Geography*, *30*(1), 70-83

Tompkins, E. L., Adger, W. N., Boyd, E., Nicholson-Cole, S., Weatherhead, K., & Arnell, N. (2010). Observed adaptation to climate change: UK evidence of transition to a well-adapting society. *Global environmental change*, *20*(4), 627-635

TU. (2018). Climate Change Vulnerability, Impact, and Adaptation Assessment. A Report Submitted to Ministry of Forests and Environment, Third National Communication Project, Singh Durbar, Kathmandu, Nepal

UN. (2013). A Country analysis with a human face. Kathmandu: United Nations Country Team in Nepal. http://un.org.np/sites/default/files/Nepal_CountryAanalysis_2011_Feb2013.pdf

UNDP. (2020). Nepal Human Development Report 2020. Available at: https://www.np.undp.org/content/nepal/en/home/library/Nepal-Human-Development-Report-2020.html

UNDP. (2009). Nepal Human Development Report 2009, UNDP, Nepal.

UNECE. (2019). Inland transport committee, Retrieved April 04, 2018, from https://unece.org/transport/inland-transport-committee

UNEP. (2010). Integrated solutions for biodiversity, climate change, and poverty. Ecosystem Management. Policy Brief 1

UNFCCC/LEG. (2012). National Adaptation Plans: Technical guidelines for the national adaptation plan process. UNFCCC/LEG (LDC expert group)

UN-Habitat. (2010). Nepal Urban Housing Sector Profile. Nairobi: United Nations Human Settlements Programme. http://un.org.np/sites/default/files/NEPAL percent20Housing percent20Profile_2.pdf

UN-Habitat. (2015). Cities and Climate Change Initiatives, A bridge report Kathmandu Valley, Nepal - Climate Change Vulnerability Assessment. United Nations Human Settlements Programme- UN-Habitat

UN-Habitat. (2019). Addressing Urban and Human Settlement Issues in National Adaptation Plans - A Supplement to the UNFCCC Technical Guidelines on the National Adaptation Plan Process

Uribe, D., Geneletti, D., Del Castillo, R. F., & Orsi, F. (2014). Integrating stakeholder preferences and GIS-based multicriteria analysis to identify forest landscape restoration priorities. *Sustainability*, *6*(2), 935-951

Wagle, S.K., Gurung, T.B., Pradhan, N., & Raymajhi, A. (2011). Climate change implication for fisheries and aquaculture in Nepal, In Gurung, T.B., Pokharel, P.K., & Wright, I. (eds) Climate change: Livestock and Vulnerability in Nepal. Proceedings of the consultative technical workshop on Kathmandu, Nepal, 156 pp

Watts, M.J. and H.G. Bohle. (1993). The space of vulnerability: the causal structure of hunger and famine. Progress in Human Geography, 17(1), 43-67

WHO. (2015). Strengthening health resilience to climate change. World Health Organization (WHO). Climate-ADAPT Dec 19, 2016

WHO, UNFCC. (2015). Climate and Health Country Profile-2015. World Health Organization (WHO), United Nations Framework Convention on Climate Change (UNFCC)- Nepal

Willner, S., Levermann, A., Zhao, F., Frieler, K., (2018). Adaptation required to preserve future highend river flood risk at present levels. *Science Advances: 4:1*

World Bank Data. (2020). https://data.worldbank.org/country/Nepal

World Bank, (2021). Climate Risk Country Profile: Nepal (2021): The World Bank Group and the Asian Development Bank

World Bank, GFDRR. (2017). Promoting Disaster Resilient Cultural Heritage

Yatagai, A., Arakawa, O., Kamiguchi, K., Kawamoto, H., Nodzu, M. I., & Hamada, A. (2009). A 44-year daily gridded precipitation dataset for Asia based on a dense network of rain gauges. *Sola*, *5*, 137-140

Yatagai, A., Kamiguchi, K., Arakawa, O., Hamada, A., Yasutomi, N., & Kitoh, A. (2012). APHRODITE: Constructing a long-term daily gridded precipitation dataset for Asia based on a dense network of rain gauges. *Bulletin of the American Meteorological Society*, *93*(9), 1401-1415

Annex

Annex 1. Key Exposure, Sensitivity, and Adaptive capacity indicators

Exposure indicators

- Human population: Male, Female, population size, density, number of households
- Animal and Wildlife population: Livestock population - dairy cattle, goat, sheep, pig, poultry, duck, fish; Wildlife population
- Resources: Forest, NTFPs, protected areas, water bodies (groundwater, river, snow cover, glaciers), wetlands and Watershed area, Built-up and municipal area, Area under key cereal crops, Land area under permanent meadows and pasture
- Services and Infrastructures: Airport, Road, Bridges, Buildings, Hospitals, Dams, Hydropower, and transmission lines, Drinking water supply schemes, industries, vehicles, fish farms and ponds, trekking routes, hotels, surface irrigation schemes, cultural and archaeological sites
- Others

Sensitivity Indicators

- Demographic characteristics: Gender (Male and Female); Urban and Rural population, Age group (children, elderly, youth, adult), population density, Economic status (poor, rich)
- Socio-economic characteristics: Population growth, population density, sex ratio, Dalit and Janajati population, Differently abled, and people with health issues, Poverty incidences, Female household population, smallholder farmers, landless population, refugees, slum dwellers, orphans, the dependency ratio
- Characteristics of infrastructures: types of infrastructures, age of infrastructures, location of infrastructures (proximity to hazards), Build-up and types, repair and maintenance status, strength and robustness, etc.
- Biophysical factors: Slope, Soil types, topography, the trend of change land use and land cover, the trend of change snow cover, water flow, forest types, species richness
- Intrinsic characters: forest types, slope, landslide & flood intensity
- Disturbance regimes: forest fire, invasive alien plants, degradation, and fragility status, pest, and diseases susceptibility
- Others: Drainage density, sedimentation yield, demand and supply

Adaptive capacity indicators

- Socio-economic capability: HDI, GNI, GDI, GDP, Economically active population, labour productivity, land ownership by female
- Access to goods and services: Access to roads, infrastructures, communication, technology, education, health facilities, seeds, and planting materials and fertilizers, HH with radio and television, market services, rescue, and rehabilitation centres, fire management equipment, waste disposal, water purification, and refinement, standardized roads and alternative means of transportation
- Access to technology: Climate-smart and climate-resilient technologies, risk reduction and risk management technologies, water-efficient technologies, soil and land management technologies, crop management technologies, Early warning systems, Bioengineering technologies, sustainable forest management, Agro advisories
- Access to finance: Investments and allocations, Budget, Insurance, credit, and grants facilities, blending and lending
- Policy and institutions: Law, policy, plans, number of active agencies working, networks and groups, reinforcement of building codes
- Awareness and knowledge: local and indigenous knowledge, knowledge on climate change and response measures
- Human Resources: Skilled HR on DRRM, Skilled HR in other areas
- Others

Annex 2. Consolidated Exposure, Sensitivity, Adaptive capacity and Vulnerability index

District	Exposure	Sensitivity	Adaptive capacity	Vulnerability
Achham	0.366	0.848	0.476	0.733
Arghakhanchi	0.389	0.889	0.503	0.747
Baglung	0.451	0.933	0.47	0.817
Baitadi	0.379	0.881	0.419	0.812
Bajhang	0.547	0.94	0.341	0.934
Bajura	0.29	0.914	0.297	0.948
Banke	0.555	0.626	0.541	0.472
Bara	0.656	0.711	0.678	0.43
Bardiya	0.561	0.64	0.532	0.41
Bhaktapur	0.396	0.576	0.587	0.385
Bhojpur	0.345	0.839	0.436	0.759
Chitawan	0.79	0.86	0.778	0.481
Dadeldhura	0.331	0.76	0.446	0.678
Dailekh	0.393	0.907	0.363	0.885
Dang	0.754	0.848	0.631	0.597
Darchula	0.378	0.872	0.361	0.854
Dhading	0.536	0.989	0.496	0.845
Dhankuta	0.295	0.764	0.461	0.668
Dhanusha	0.624	0.753	0.68	0.469
Dolakha	0.5	0.988	0.5	0.841
Dolpa	0.356	0.852	0.238	0.943
Doti	0.387	0.832	0.453	0.738
Eastern Rukum	0.23	0.741	0.364	0.649
Gorkha	0.722	0.966	0.509	0.812
Gulmi	0.501	0.932	0.554	0.742
Humla	0.36	0.927	0.252	1
Ilam	0.509	0.851	0.52	0.697
Jajarkot	0.296	0.897	0.34	0.896
Jhapa	0.802	0.806	0.721	0.482
Jumla	0.318	0.875	0.284	0.924
Kailali	0.82	0.88	0.64	0.62
Kalikot	0.233	0.885	0.294	0.925
Kanchanpur	0.473	0.683	0.62	0.455
Kapilbastu	1	0.734	0.69	0.441
Kaski	0.695	0.905	0.762	0.537
Kathmandu	1	0.741	1	0.178
Kavrepalanchok	0.662	0.871	0.627	0.622
Khotang	0.398	0.835	0.464	0.73
Lalitpur	0.609	0.734	0.784	0.36

Lamjung	0.35	0.858	0.463	0.753
Mahottari	0.563	0.784	0.534	0.623
Makawanpur	0.631	0.908	0.629	0.655
Manang	0.232	0.806	0.333	0.817
Morang	1	0.845	0.662	0.569
Mugu	0.321	0.855	0.254	0.931
Mustang	0.605	0.741	0.347	0.746
Myagdi	0.386	0.903	0.417	0.834
Nawalpur	0.517	0.8	0.598	0.583
Nuwakot	0.457	0.885	0.486	0.758
Okhaldhunga	0.288	0.851	0.46	0.749
Palpa	0.512	0.894	0.565	0.698
Panchthar	0.335	0.657	0.402	0.539
Parasi	0.466	0.715	0.433	0.502
Parbat	0.228	0.669	0.395	0.556
Parsa	0.497	0.648	0.586	0.452
Pyuthan	0.58	0.941	0.452	0.838
Ramechhap	0.409	0.929	0.474	0.808
Rasuwa	0.307	0.886	0.384	0.848
Rautahat	0.512	0.712	0.614	0.488
Rolpa	0.411	0.909	0.44	0.82
Rupandehi	1	0.737	0.789	0.359
Salyan	0.321	0.809	0.382	0.778
Sankhuwasabha	0.471	0.958	0.458	0.849
Saptari	0.691	0.734	0.639	0.486
Sarlahi	0.571	0.754	0.611	0.529
Sindhuli	0.636	0.902	0.527	0.738
Sindhupalchok	0.575	1	0.518	0.836
Siraha	0.605	0.772	0.623	0.535
Solukhumbu	0.452	0.957	0.575	0.747
Sunsari	0.702	0.751	0.673	0.472
Surkhet	0.523	0.842	0.503	0.704
Syangja	0.405	0.875	0.538	0.704
Tanahu	0.525	0.887	0.558	0.697
Taplejung	0.421	0.886	0.57	0.685
Terhathum	0.221	0.763	0.39	0.73
Udayapur	0.499	0.837	0.485	0.715
Western Rukum	0.219	0.772	0.341	0.697

Annex 3. Consolidated Extreme events/hazards and Risk index

District	Baseline context of climate extreme events	Climate extreme events composite (RCP4.5 2030)	Climate extreme events composite (RCP4.5 2050)	Climate extreme events composite (RCP8.5 2030)	Climate extreme events composite (RCP8.5 2050)	Baseline Risk	RCP 4.5 2030 Risk	RCP 4.5 2050 Risk	RCP 8.5 2030 Risk	RCP 8.5 2050 Risk
Achham	0.515	0.499	0.616	0.523	0.686	0.301	0.305	0.353	0.31	0.382
Arghakhanchi	0.543	0.615	0.721	0.666	0.821	0.316	0.366	0.441	0.404	0.511
Baglung	0.549	0.625	0.73	0.647	0.821	0.463	0.523	0.627	0.555	0.722
Baitadi	0.492	0.51	0.625	0.531	0.703	0.316	0.327	0.418	0.353	0.487
Bajhang	0.381	0.411	0.512	0.418	0.58	0.375	0.407	0.513	0.422	0.591
Bajura	0.38	0.396	0.49	0.413	0.572	0.212	0.224	0.274	0.236	0.318
Banke	0.564	0.586	0.711	0.618	0.791	0.365	0.381	0.436	0.391	0.472
Bara	0.609	0.659	0.734	0.685	0.83	0.325	0.353	0.387	0.359	0.437
Bardiya	0.551	0.554	0.682	0.605	0.769	0.444	0.446	0.508	0.459	0.545
Bhaktapur	0.554	0.649	0.708	0.644	0.815	0.177	0.205	0.228	0.205	0.269
Bhojpur	0.538	0.619	0.644	0.586	0.79	0.323	0.374	0.396	0.36	0.478
Chitawan	0.662	0.68	0.769	0.724	0.869	0.571	0.563	0.641	0.608	0.746
Dadeldhura	0.48	0.501	0.618	0.537	0.713	0.234	0.245	0.285	0.257	0.319
Dailekh	0.472	0.481	0.599	0.504	0.661	0.371	0.379	0.468	0.399	0.518
Dang	0.567	0.601	0.712	0.637	0.797	0.558	0.597	0.679	0.612	0.737
Darchula	0.417	0.441	0.55	0.464	0.624	0.264	0.282	0.364	0.307	0.425
Dhading	0.578	0.654	0.748	0.666	0.839	0.682	0.754	0.872	0.779	0.999
Dhankuta	0.555	0.646	0.681	0.625	0.821	0.263	0.306	0.324	0.3	0.376
Dhanusha	0.6	0.647	0.669	0.667	0.841	0.414	0.454	0.472	0.463	0.578
Dolakha	0.555	0.607	0.658	0.608	0.809	0.501	0.542	0.599	0.558	0.759
Dolpa	0.334	0.375	0.478	0.39	0.553	0.235	0.259	0.322	0.266	0.365
Doti	0.513	0.514	0.632	0.532	0.701	0.341	0.345	0.407	0.353	0.443
Eastern Rukum	0.453	0.503	0.603	0.521	0.683	0.188	0.211	0.252	0.218	0.286
Gorkha	0.504	0.564	0.669	0.575	0.751	0.653	0.723	0.857	0.745	0.969

Gulmi	0.556	0.648	0.752	0.679	0.838	0.417	0.49	0.58	0.521	0.657
Humla	0.343	0.342	0.43	0.359	0.509	0.224	0.223	0.289	0.245	0.348
Ilam	0.65	0.76	0.788	0.79	0.924	0.448	0.532	0.562	0.556	0.689
Jajarkot	0.482	0.501	0.605	0.507	0.663	0.287	0.299	0.356	0.305	0.392
Jhapa	0.76	0.842	0.868	0.89	1	0.648	0.718	0.742	0.746	0.841
Jumla	0.437	0.449	0.536	0.454	0.608	0.247	0.255	0.313	0.265	0.362
Kailali	0.594	0.571	0.692	0.617	0.781	0.595	0.555	0.691	0.602	0.788
Kalikot	0.427	0.433	0.533	0.443	0.594	0.217	0.221	0.27	0.228	0.304
Kanchanpur	0.57	0.561	0.672	0.596	0.783	0.299	0.297	0.348	0.309	0.398
Kapilbastu	0.565	0.606	0.709	0.677	0.808	0.435	0.473	0.561	0.535	0.641
Kaski	0.62	0.672	0.78	0.704	0.883	0.505	0.535	0.623	0.569	0.717
Kathmandu	0.573	0.668	0.73	0.657	0.826	0.291	0.331	0.358	0.325	0.409
Kavrepalanchok	0.585	0.655	0.709	0.663	0.841	0.57	0.632	0.696	0.653	0.856
Khotang	0.522	0.594	0.618	0.574	0.77	0.339	0.387	0.405	0.379	0.484
Lalitpur	0.538	0.612	0.675	0.624	0.793	0.288	0.325	0.365	0.337	0.447
Lamjung	0.541	0.626	0.736	0.651	0.831	0.31	0.358	0.434	0.386	0.506
Mahottari	0.618	0.659	0.695	0.697	0.854	0.516	0.562	0.59	0.585	0.7
Makawanpur	0.629	0.665	0.745	0.678	0.836	0.636	0.673	0.746	0.681	0.834
Manang	0.372	0.437	0.544	0.453	0.627	0.123	0.145	0.189	0.159	0.224
Morang	0.699	0.755	0.785	0.779	0.913	0.717	0.765	0.807	0.783	0.959
Mugu	0.339	0.355	0.442	0.356	0.506	0.199	0.212	0.277	0.225	0.327
Mustang	0.257	0.32	0.44	0.357	0.526	0.181	0.25	0.363	0.29	0.447
Myagdi	0.487	0.551	0.656	0.583	0.761	0.328	0.372	0.454	0.405	0.539
Nawalpur	0.59	0.645	0.731	0.707	0.849	0.398	0.438	0.496	0.485	0.58
Nuwakot	0.574	0.679	0.767	0.676	0.855	0.487	0.569	0.65	0.576	0.74
Okhaldhunga	0.519	0.594	0.616	0.582	0.771	0.206	0.245	0.267	0.25	0.35
Palpa	0.589	0.672	0.766	0.711	0.86	0.415	0.477	0.553	0.512	0.629
Panchthar	0.591	0.708	0.737	0.708	0.874	0.309	0.377	0.403	0.381	0.489
Parasi	0.585	0.642	0.728	0.704	0.846	0.279	0.313	0.358	0.344	0.418
Parbat	0.606	0.702	0.808	0.731	0.896	0.217	0.256	0.309	0.277	0.357

Parsa	0.628	0.65	0.735	0.713	0.847	0.353	0.367	0.408	0.391	0.467
Pyuthan	0.528	0.605	0.707	0.635	0.795	0.503	0.58	0.692	0.622	0.793
Ramechhap	0.539	0.604	0.635	0.597	0.79	0.385	0.435	0.469	0.444	0.599
Rasuwa	0.475	0.557	0.66	0.554	0.753	0.234	0.275	0.335	0.277	0.392
Rautahat	0.623	0.674	0.743	0.683	0.832	0.372	0.412	0.442	0.404	0.487
Rolpa	0.49	0.549	0.656	0.563	0.73	0.36	0.402	0.477	0.411	0.529
Rupandehi	0.604	0.624	0.707	0.69	0.822	0.395	0.405	0.468	0.451	0.554
Salyan	0.491	0.532	0.65	0.55	0.713	0.323	0.35	0.397	0.352	0.419
Sankhuwasabha	0.665	0.738	0.783	0.709	0.921	0.519	0.567	0.604	0.557	0.698
Saptari	0.631	0.669	0.688	0.777	0.877	0.477	0.52	0.531	0.594	0.656
Sarlahi	0.638	0.679	0.734	0.704	0.862	0.458	0.505	0.533	0.508	0.602
Sindhuli	0.586	0.651	0.684	0.659	0.835	0.64	0.709	0.731	0.71	0.858
Sindhupalchok	0.588	0.65	0.736	0.664	0.862	0.664	0.719	0.829	0.754	1
Siraha	0.6	0.645	0.659	0.723	0.821	0.464	0.506	0.517	0.562	0.63
Solukhumbu	0.559	0.598	0.646	0.579	0.774	0.417	0.426	0.47	0.425	0.578
Sunsari	0.641	0.697	0.723	0.708	0.861	0.44	0.487	0.502	0.492	0.597
Surkhet	0.517	0.522	0.642	0.559	0.719	0.466	0.474	0.551	0.491	0.599
Syangja	0.631	0.725	0.831	0.755	0.91	0.387	0.444	0.501	0.46	0.544
Tanahu	0.632	0.721	0.826	0.754	0.9	0.55	0.624	0.71	0.654	0.777
Taplejung	0.633	0.719	0.765	0.693	0.893	0.42	0.466	0.5	0.452	0.587
Terhathum	0.568	0.683	0.713	0.661	0.855	0.184	0.229	0.248	0.227	0.309
Udayapur	0.553	0.624	0.644	0.624	0.797	0.481	0.541	0.56	0.546	0.663
Western Rukum	0.469	0.512	0.611	0.529	0.691	0.194	0.213	0.264	0.228	0.307

Annex 4. Consolidated Vulnerability and risk index of urban municipalities

District	Palika	Exposure	Sensitivity	Adaptive Capacity	Vulnerability	Climate Extreme events baseline	Climate extreme event RCP 4.5 2030	Climate extreme event RCP 4.5 2050	Climate extreme events RCP 8.5. 2030	Climate extreme events RCP 8.5. 2050	Baseline Risk	Risk RCP 4.5 2030	RIsk RCP 4.5. 2050	Risk RCP 8.5. 2030	Risk RCP 8.5 2050
Taplejung	Phungling	0.154	0.812	0.377	0.752	0.757	0.871	0.889	0.836	0.904	0.224	0.258	0.263	0.248	0.268
Sankhuwasabha	Khandbari	0.218	0.652	0.321	0.566	0.798	0.907	0.92	0.883	0.961	0.302	0.344	0.348	0.335	0.364
Sankhuwasabha	Panchakhapan	0.213	0.63	0.323	0.521	0.798	0.907	0.92	0.883	0.961	0.288	0.328	0.332	0.319	0.347
Sankhuwasabha	Chainpur	0.26	0.682	0.315	0.636	0.798	0.907	0.92	0.883	0.961	0.375	0.427	0.433	0.416	0.452
Sankhuwasabha	Madi	0.109	0.561	0.361	0.314	0.798	0.907	0.92	0.883	0.961	0.129	0.147	0.149	0.143	0.156
Sankhuwasabha	Dharmadevi	0.164	0.706	0.327	0.653	0.798	0.907	0.92	0.883	0.961	0.239	0.272	0.276	0.265	0.288
Solukhumbu	Solududhakunda	0.331	0.624	0.371	0.413	0.594	0.68	0.683	0.656	0.732	0.312	0.357	0.358	0.344	0.384
Okhaldhunga	Siddhicharan	0.288	0.919	0.476	0.752	0.567	0.667	0.657	0.652	0.728	0.314	0.37	0.364	0.361	0.403
Khotang	Halesi Tuwachung	0.324	0.777	0.351	0.74	0.558	0.659	0.65	0.639	0.725	0.345	0.408	0.403	0.396	0.449
Khotang	Rupakot Majhuwagadhi	0.422	0.739	0.458	0.45	0.558	0.659	0.65	0.639	0.725	0.382	0.451	0.445	0.438	0.496
Bhojpur	Shadananda	0.324	0.676	0.349	0.554	0.6	0.708	0.701	0.677	0.765	0.336	0.396	0.392	0.379	0.428
Bhojpur	Bhojpur	0.245	0.733	0.424	0.508	0.6	0.708	0.701	0.677	0.765	0.247	0.292	0.289	0.279	0.315
Dhankuta	Mahalaxmi	0.235	0.716	0.458	0.405	0.631	0.739	0.746	0.721	0.801	0.234	0.274	0.276	0.267	0.297
Dhankuta	Pakhribas	0.171	0.729	0.407	0.537	0.631	0.739	0.746	0.721	0.801	0.184	0.216	0.218	0.211	0.234
Dhankuta	Dhankuta	0.232	0.582	0.528	0.012	0.631	0.739	0.746	0.721	0.801	0.173	0.203	0.205	0.198	0.22
Terhathum	Myanglung	0.167	0.699	0.441	0.409	0.663	0.789	0.785	0.763	0.836	0.175	0.208	0.207	0.201	0.221
Terhathum	Laligurans	0.151	0.734	0.427	0.504	0.663	0.789	0.785	0.763	0.836	0.168	0.2	0.199	0.193	0.212
Panchthar	Phidim	0.304	0.645	0.394	0.405	0.706	0.831	0.827	0.796	0.868	0.339	0.399	0.397	0.382	0.416
Ilam	Illam	0.302	0.599	0.472	0.157	0.791	0.902	0.899	0.875	0.945	0.317	0.362	0.361	0.351	0.379
Ilam	Deumai	0.275	0.531	0.449	0.079	0.791	0.902	0.899	0.875	0.945	0.272	0.31	0.309	0.301	0.325
Ilam	Mai	0.229	0.585	0.323	0.438	0.791	0.902	0.899	0.875	0.945	0.291	0.332	0.331	0.322	0.348

Ilam	Suryodaya	0.399	0.646	0.413	0.368	0.791	0.902	0.899	0.875	0.945	0.486	0.554	0.552	0.538	0.581
Jhapa	Mechinagar	0.398	0.475	0.497	0	0.855	0.968	0.963	0.948	1	0.357	0.404	0.402	0.396	0.418
Jhapa	Arjundhara	0.259	0.65	0.509	0.178	0.855	0.968	0.963	0.948	1	0.299	0.339	0.337	0.332	0.35
Jhapa	Kankai	0.172	0.58	0.516	0.029	0.855	0.968	0.963	0.948	1	0.177	0.201	0.2	0.197	0.207
Jhapa	Shivasataxi	0.308	0.532	0.502	0	0.855	0.968	0.963	0.948	1	0.302	0.341	0.34	0.334	0.353
Jhapa	Damak	0.274	0.485	0.656	0	0.855	0.968	0.963	0.948	1	0.174	0.197	0.196	0.193	0.204
Jhapa	Gauradhaha	0.268	0.609	0.458	0.207	0.855	0.968	0.963	0.948	1	0.316	0.358	0.356	0.35	0.37
Jhapa	Birtamod	0.296	0.606	0.498	0.12	0.855	0.968	0.963	0.948	1	0.327	0.37	0.369	0.363	0.383
Jhapa	Bhadrapur	0.269	0.701	0.55	0.19	0.855	0.968	0.963	0.948	1	0.313	0.354	0.353	0.347	0.366
Morang	Letang	0.209	0.576	0.492	0.074	0.725	0.834	0.831	0.817	0.869	0.189	0.217	0.217	0.213	0.227
Morang	Sundarharaicha	0.294	0.589	0.413	0.26	0.725	0.834	0.831	0.817	0.869	0.305	0.352	0.35	0.344	0.366
Morang	Belbari	0.373	0.578	0.621	0	0.725	0.834	0.831	0.817	0.869	0.267	0.307	0.306	0.301	0.32
Morang	Patahrishanishchare	0.279	0.621	0.442	0.26	0.725	0.834	0.831	0.817	0.869	0.29	0.334	0.333	0.327	0.348
Morang	Uralabari	0.185	0.609	0.421	0.281	0.725	0.834	0.831	0.817	0.869	0.195	0.224	0.223	0.22	0.234
Morang	Ratuwamai	0.251	0.581	0.417	0.236	0.725	0.834	0.831	0.817	0.869	0.256	0.295	0.294	0.289	0.307
Morang	Sunwarshi	0.229	0.623	0.382	0.388	0.725	0.834	0.831	0.817	0.869	0.259	0.298	0.297	0.292	0.311
Morang	Rangeli	0.259	0.665	0.408	0.413	0.725	0.834	0.831	0.817	0.869	0.298	0.343	0.341	0.336	0.357
Morang	Biratnagar	0.693	0.674	0.802	0	0.725	0.834	0.831	0.817	0.869	0.398	0.458	0.457	0.449	0.478
Sunsari	Dharan	0.454	0.543	0.887	0	0.654	0.767	0.753	0.757	0.808	0.112	0.131	0.128	0.129	0.138
Sunsari	Barah	0.478	0.519	0.564	0	0.654	0.767	0.753	0.757	0.808	0.31	0.363	0.356	0.358	0.382
Sunsari	Ramdhuni	0.332	0.524	0.521	0	0.654	0.767	0.753	0.757	0.808	0.237	0.278	0.272	0.274	0.292
Sunsari	Itahari	0.519	0.607	0.61	0	0.654	0.767	0.753	0.757	0.808	0.361	0.423	0.415	0.417	0.445
Sunsari	Duhabi	0.3	0.542	0.452	0.091	0.654	0.767	0.753	0.757	0.808	0.248	0.291	0.285	0.287	0.306
Sunsari	Inaruwa	0.287	0.596	0.475	0.145	0.654	0.767	0.753	0.757	0.808	0.247	0.29	0.284	0.286	0.305
Udayapur	Belaka	0.268	0.71	0.662	0	0.577	0.692	0.677	0.676	0.739	0.178	0.213	0.208	0.208	0.227
Udayapur	Chaudandigadhi	0.31	0.696	0.52	0.24	0.577	0.692	0.677	0.676	0.739	0.253	0.303	0.296	0.296	0.323
Udayapur	Triyuga	0.416	0.566	0.642	0	0.577	0.692	0.677	0.676	0.739	0.221	0.265	0.259	0.259	0.283
Udayapur	Katari	0.36	0.717	0.454	0.417	0.577	0.692	0.677	0.676	0.739	0.33	0.396	0.387	0.387	0.423

Saptari	Saptakoshi	0.112	0.524	0.49	0	0.604	0.711	0.692	0.701	0.746	0.078	0.092	0.089	0.09	0.096
Saptari	Kanchanrup	0.18	0.476	0.472	0	0.604	0.711	0.692	0.701	0.746	0.12	0.141	0.138	0.139	0.148
Saptari	Shambhunath	0.146	0.445	0.339	0.145	0.604	0.711	0.692	0.701	0.746	0.116	0.137	0.133	0.135	0.143
Saptari	Khadak	0.143	0.448	0.396	0.029	0.604	0.711	0.692	0.701	0.746	0.104	0.122	0.119	0.12	0.128
Saptari	Surunga	0.171	0.441	0.408	0	0.604	0.711	0.692	0.701	0.746	0.12	0.141	0.138	0.14	0.148
Saptari	Bode Barsain	0.14	0.479	0.341	0.202	0.604	0.711	0.692	0.701	0.746	0.116	0.137	0.133	0.135	0.144
Saptari	Dakneshwori	0.165	0.468	0.394	0.07	0.604	0.711	0.692	0.701	0.746	0.124	0.146	0.142	0.144	0.153
Saptari	Rajbiraj	0.204	0.64	0.623	0	0.604	0.711	0.692	0.701	0.746	0.135	0.159	0.155	0.157	0.167
Saptari	Hanumannagar Kankalini	0.309	0.549	0.43	0.149	0.604	0.711	0.692	0.701	0.746	0.246	0.29	0.283	0.286	0.304
Siraha	Lahan	0.345	0.559	0.581	0	0.586	0.69	0.666	0.683	0.728	0.208	0.244	0.236	0.242	0.258
Siraha	Dhangadhimai	0.217	0.506	0.363	0.207	0.586	0.69	0.666	0.683	0.728	0.175	0.206	0.199	0.204	0.218
Siraha	Golbazar	0.205	0.486	0.333	0.231	0.586	0.69	0.666	0.683	0.728	0.168	0.198	0.191	0.196	0.209
Siraha	Mirchaiya	0.175	0.461	0.352	0.145	0.586	0.69	0.666	0.683	0.728	0.135	0.159	0.153	0.157	0.168
Siraha	Karjanha	0.096	0.5	0.292	0.343	0.586	0.69	0.666	0.683	0.728	0.085	0.1	0.097	0.099	0.106
Siraha	Kalyanpur	0.169	0.477	0.334	0.215	0.586	0.69	0.666	0.683	0.728	0.137	0.161	0.156	0.16	0.17
Siraha	Sukhipur	0.184	0.585	0.346	0.388	0.586	0.69	0.666	0.683	0.728	0.168	0.198	0.191	0.196	0.209
Siraha	Siraha	0.254	0.56	0.384	0.264	0.586	0.69	0.666	0.683	0.728	0.214	0.252	0.243	0.25	0.266
Dhanusha	Ganeshman Charnath	0.143	0.533	0.33	0.326	0.581	0.691	0.676	0.685	0.74	0.124	0.148	0.144	0.146	0.158
Dhanusha	Dhanusadham	0.14	0.471	0.317	0.236	0.581	0.691	0.676	0.685	0.74	0.115	0.136	0.133	0.135	0.146
Dhanusha	Mithila	0.149	0.689	0.389	0.496	0.581	0.691	0.676	0.685	0.74	0.145	0.172	0.168	0.17	0.184
Dhanusha	Chhireshwornath	0.179	0.763	0.319	0.781	0.581	0.691	0.676	0.685	0.74	0.203	0.242	0.236	0.24	0.259
Dhanusha	Mithila Bihari	0.158	0.417	0.245	0.281	0.581	0.691	0.676	0.685	0.74	0.134	0.159	0.156	0.158	0.17
Dhanusha	Hansapur	0.133	0.53	0.361	0.256	0.581	0.691	0.676	0.685	0.74	0.111	0.131	0.128	0.13	0.141
Dhanusha	Sabaila	0.162	0.621	0.354	0.442	0.581	0.691	0.676	0.685	0.74	0.152	0.181	0.177	0.179	0.193
Dhanusha	Sahidnagar	0.189	0.581	0.334	0.405	0.581	0.691	0.676	0.685	0.74	0.173	0.206	0.201	0.204	0.221
Dhanusha	Kamala	0.155	0.543	0.305	0.393	0.581	0.691	0.676	0.685	0.74	0.141	0.168	0.164	0.166	0.18
Dhanusha	Bideha	0.154	0.501	0.313	0.298	0.581	0.691	0.676	0.685	0.74	0.132	0.157	0.153	0.156	0.168

Dhanusha	Janakpur	0.404	0.722	0.399	0.541	0.581	0.691	0.676	0.685	0.74	0.402	0.477	0.467	0.473	0.511
Dhanusha	Nagarain	0.128	0.601	0.341	0.43	0.581	0.691	0.676	0.685	0.74	0.119	0.142	0.139	0.141	0.152
Mahottari	Bardibas	0.294	0.532	0.622	0	0.584	0.701	0.691	0.697	0.746	0.154	0.185	0.182	0.184	0.197
Mahottari	Gaushala	0.249	0.476	0.403	0.066	0.584	0.701	0.691	0.697	0.746	0.181	0.217	0.214	0.215	0.231
Mahottari	Aurahi	0.092	0.465	0.364	0.128	0.584	0.701	0.691	0.697	0.746	0.07	0.084	0.083	0.083	0.089
Mahottari	Bhangaha	0.152	0.482	0.32	0.252	0.584	0.701	0.691	0.697	0.746	0.126	0.151	0.149	0.15	0.161
Mahottari	Loharpatti	0.135	0.526	0.375	0.219	0.584	0.701	0.691	0.697	0.746	0.11	0.132	0.13	0.131	0.14
Mahottari	Balwa	0.125	0.523	0.409	0.145	0.584	0.701	0.691	0.697	0.746	0.096	0.115	0.114	0.115	0.123
Mahottari	Ramgopalpur	0.087	0.521	0.373	0.215	0.584	0.701	0.691	0.697	0.746	0.071	0.085	0.083	0.084	0.09
Mahottari	Manra Siswa	0.122	0.513	0.341	0.264	0.584	0.701	0.691	0.697	0.746	0.102	0.123	0.121	0.122	0.131
Mahottari	Matihani	0.093	0.448	0.375	0.074	0.584	0.701	0.691	0.697	0.746	0.068	0.081	0.08	0.081	0.086
Mahottari	Jaleswor	0.168	0.464	0.478	0	0.584	0.701	0.691	0.697	0.746	0.104	0.125	0.124	0.125	0.133
Sarlahi	Lalbandi	0.369	0.513	0.438	0.066	0.603	0.732	0.728	0.712	0.761	0.274	0.333	0.331	0.324	0.347
Sarlahi	Hariwan	0.171	0.42	0.379	0.012	0.603	0.732	0.728	0.712	0.761	0.122	0.148	0.148	0.144	0.154
Sarlahi	Bagmati	0.152	0.314	0.489	0	0.603	0.732	0.728	0.712	0.761	0.07	0.085	0.084	0.082	0.088
Sarlahi	Barahathawa	0.242	0.395	0.477	0	0.603	0.732	0.728	0.712	0.761	0.137	0.166	0.165	0.162	0.173
Sarlahi	Haripur	0.248	0.47	0.345	0.178	0.603	0.732	0.728	0.712	0.761	0.202	0.245	0.244	0.239	0.255
Sarlahi	Ishworpur	0.224	0.542	0.373	0.252	0.603	0.732	0.728	0.712	0.761	0.192	0.234	0.232	0.227	0.243
Sarlahi	Haripurwa	0.093	0.427	0.371	0.041	0.603	0.732	0.728	0.712	0.761	0.068	0.083	0.082	0.08	0.086
Sarlahi	Kabilasi	0.211	0.401	0.342	0.054	0.603	0.732	0.728	0.712	0.761	0.155	0.189	0.188	0.184	0.196
Sarlahi	Balara	0.135	0.317	0.48	0	0.603	0.732	0.728	0.712	0.761	0.064	0.077	0.077	0.075	0.081
Sarlahi	Godaita	0.145	0.423	0.335	0.107	0.603	0.732	0.728	0.712	0.761	0.112	0.136	0.135	0.133	0.142
Sarlahi	Malangawa	0.111	0.393	0.369	0	0.603	0.732	0.728	0.712	0.761	0.077	0.094	0.093	0.091	0.098
Rautahat	Brindaban	0.303	0.46	0.733	0	0.607	0.743	0.743	0.704	0.754	0.098	0.12	0.12	0.113	0.122
Rautahat	Gujara	0.205	0.371	0.519	0	0.607	0.743	0.743	0.704	0.754	0.1	0.123	0.123	0.116	0.125
Rautahat	Phatuwa Bijayapur	0.125	0.465	0.43	0	0.607	0.743	0.743	0.704	0.754	0.088	0.108	0.108	0.102	0.11
Rautahat	Katahariya	0.108	0.34	0.417	0	0.607	0.743	0.743	0.704	0.754	0.063	0.077	0.077	0.073	0.078
Rautahat	Brindaban	0.139	0.359	0.488	0	0.607	0.743	0.743	0.704	0.754	0.071	0.087	0.087	0.083	0.089

Rautahat	Gadhimai	0.105	0.361	0.47	0	0.607	0.743	0.743	0.704	0.754	0.057	0.069	0.069	0.066	0.07
Rautahat	Madhav Narayan	0.111	0.363	0.469	0	0.607	0.743	0.743	0.704	0.754	0.06	0.074	0.074	0.07	0.075
Rautahat	Garuda	0.204	0.472	0.525	0	0.607	0.743	0.743	0.704	0.754	0.122	0.149	0.149	0.142	0.152
Rautahat	Dewahhi Gonahi	0.096	0.368	0.439	0	0.607	0.743	0.743	0.704	0.754	0.056	0.069	0.069	0.065	0.07
Rautahat	Maulapur	0.075	0.367	0.437	0	0.607	0.743	0.743	0.704	0.754	0.044	0.054	0.054	0.051	0.055
Rautahat	Baudhimai	0.103	0.369	0.555	0	0.607	0.743	0.743	0.704	0.754	0.046	0.056	0.056	0.053	0.057
Rautahat	Paroha	0.097	0.466	0.411	0.033	0.607	0.743	0.743	0.704	0.754	0.071	0.087	0.087	0.082	0.088
Rautahat	Rajpur	0.128	0.472	0.426	0.012	0.607	0.743	0.743	0.704	0.754	0.092	0.113	0.113	0.107	0.115
Rautahat	Rajdevi	0.11	0.405	0.476	0	0.607	0.743	0.743	0.704	0.754	0.064	0.078	0.078	0.074	0.079
Rautahat	Gaur	0.125	0.425	0.506	0	0.607	0.743	0.743	0.704	0.754	0.071	0.087	0.087	0.082	0.088
Rautahat	Ishanath	0.112	0.365	0.401	0	0.607	0.743	0.743	0.704	0.754	0.07	0.086	0.086	0.082	0.088
Bara	Nijgadh	0.198	0.563	0.546	0	0.621	0.744	0.753	0.719	0.768	0.136	0.164	0.165	0.158	0.169
Bara	Kolhabi	0.223	0.372	0.545	0	0.621	0.744	0.753	0.719	0.768	0.104	0.125	0.126	0.121	0.129
Bara	Jitpur Simara	0.453	0.55	0.634	0	0.621	0.744	0.753	0.719	0.768	0.255	0.306	0.31	0.296	0.316
Bara	Kalaiya	0.401	0.421	0.576	0	0.621	0.744	0.753	0.719	0.768	0.195	0.234	0.237	0.226	0.242
Bara	Simraungadh	0.144	0.527	0.491	0	0.621	0.744	0.753	0.719	0.768	0.103	0.124	0.125	0.12	0.128
Bara	Pacharauta	0.131	0.437	0.536	0	0.621	0.744	0.753	0.719	0.768	0.073	0.087	0.088	0.084	0.09
Bara	Mahagadhimai	0.157	0.504	0.538	0	0.621	0.744	0.753	0.719	0.768	0.099	0.119	0.12	0.115	0.123
Parsa	Parsagadhi	0.149	0.439	0.341	0.124	0.625	0.733	0.75	0.726	0.778	0.121	0.142	0.145	0.141	0.151
Parsa	Birgunj	0.598	0.692	0.825	0	0.625	0.733	0.75	0.726	0.778	0.293	0.344	0.352	0.34	0.365
Parsa	Bahudaramai	0.129	0.437	0.303	0.198	0.625	0.733	0.75	0.726	0.778	0.111	0.13	0.133	0.129	0.138
Parsa	Pokhariya	0.08	0.569	0.359	0.335	0.625	0.733	0.75	0.726	0.778	0.075	0.088	0.09	0.088	0.094
Dolakha	Jiri	0.163	0.813	0.405	0.698	0.622	0.709	0.704	0.694	0.77	0.19	0.216	0.214	0.211	0.235
Dolakha	Bhimeshwor	0.317	0.929	0.58	0.554	0.622	0.709	0.704	0.694	0.77	0.341	0.388	0.385	0.38	0.421
Sindhupalchok	Melamchi	0.317	0.765	0.516	0.38	0.631	0.74	0.75	0.719	0.792	0.31	0.364	0.369	0.354	0.39
Sindhupalchok	Chautara SangachokGadhi	0.33	0.775	0.425	0.583	0.631	0.74	0.75	0.719	0.792	0.365	0.429	0.434	0.416	0.459
Sindhupalchok	Barhabise	0.185	0.759	0.453	0.5	0.631	0.74	0.75	0.719	0.792	0.195	0.228	0.231	0.222	0.244

Dhading	Nilakantha	0.323	1	0.518	0.818	0.618	0.751	0.768	0.699	0.765	0.397	0.483	0.494	0.449	0.492
Dhading	Dhunibesi	0.229	0.842	0.552	0.45	0.618	0.751	0.768	0.699	0.765	0.23	0.279	0.285	0.26	0.284
Nuwakot	Bidur	0.357	0.8	0.633	0.207	0.626	0.771	0.778	0.715	0.781	0.308	0.38	0.383	0.352	0.384
Nuwakot	Belkotgadhi	0.301	0.754	0.5	0.393	0.626	0.771	0.778	0.715	0.781	0.295	0.363	0.367	0.337	0.368
Kathmandu	Shankharapur	0.14	0.698	0.537	0.211	0.632	0.779	0.767	0.711	0.782	0.122	0.151	0.149	0.138	0.152
Kathmandu	Kageshwori Manahora	0.23	0.551	0.544	0	0.632	0.779	0.767	0.711	0.782	0.159	0.196	0.193	0.179	0.197
Kathmandu	Gokarneshwor	0.364	0.547	0.559	0	0.632	0.779	0.767	0.711	0.782	0.243	0.3	0.295	0.274	0.301
Kathmandu	Budhanilakantha	0.313	0.616	0.525	0.083	0.632	0.779	0.767	0.711	0.782	0.248	0.306	0.301	0.279	0.307
Kathmandu	Tokha	0.26	0.612	0.596	0	0.632	0.779	0.767	0.711	0.782	0.181	0.223	0.219	0.203	0.224
Kathmandu	Tarakeshwor	0.274	0.604	0.519	0.07	0.632	0.779	0.767	0.711	0.782	0.215	0.265	0.261	0.242	0.266
Kathmandu	Nagarjun	0.21	0.595	0.511	0.07	0.632	0.779	0.767	0.711	0.782	0.165	0.204	0.201	0.186	0.205
Kathmandu	Kathmandu	0.728	0.659	1	0	0.632	0.779	0.767	0.711	0.782	0.167	0.206	0.202	0.188	0.207
Kathmandu	Kirtipur	0.207	0.555	0.523	0	0.632	0.779	0.767	0.711	0.782	0.15	0.185	0.182	0.168	0.185
Kathmandu	Chandragiri	0.322	0.601	0.52	0.062	0.632	0.779	0.767	0.711	0.782	0.251	0.31	0.305	0.282	0.311
Kathmandu	Dakshinkali	0.196	0.682	0.553	0.149	0.632	0.779	0.767	0.711	0.782	0.164	0.202	0.198	0.184	0.202
Bhaktapur	Changunarayan	0.356	0.632	0.855	0	0.638	0.775	0.764	0.711	0.791	0.138	0.167	0.165	0.153	0.171
Bhaktapur	Bhaktapur	0.211	0.559	0.741	0	0.638	0.775	0.764	0.711	0.791	0.094	0.115	0.113	0.105	0.117
Bhaktapur	Madhyapur Thimi	0.228	0.545	0.633	0	0.638	0.775	0.764	0.711	0.791	0.131	0.159	0.157	0.146	0.162
Bhaktapur	Suryabinayak	0.364	0.492	0.714	0	0.638	0.775	0.764	0.711	0.791	0.148	0.18	0.177	0.165	0.183
Lalitpur	Mahalaxmi	0.256	0.596	0.522	0.05	0.617	0.75	0.749	0.709	0.791	0.193	0.235	0.234	0.222	0.248
Lalitpur	Lalitpur	0.681	0.675	0.865	0	0.617	0.75	0.749	0.709	0.791	0.281	0.342	0.341	0.323	0.36
Lalitpur	Godawari	0.382	0.77	0.57	0.277	0.617	0.75	0.749	0.709	0.791	0.341	0.415	0.414	0.392	0.438
Kavre	Mandandeupur	0.176	0.708	0.401	0.508	0.632	0.763	0.754	0.722	0.799	0.187	0.226	0.223	0.214	0.236
Kavre	Banepa	0.269	0.86	0.406	0.785	0.632	0.763	0.754	0.722	0.799	0.333	0.401	0.397	0.38	0.421
Kavre	Dhulikhel	0.24	0.765	0.511	0.388	0.632	0.763	0.754	0.722	0.799	0.237	0.286	0.283	0.271	0.3
Kavre	Panchkhal	0.239	0.936	0.371	1	0.632	0.763	0.754	0.722	0.799	0.327	0.395	0.391	0.374	0.414
Kavre	Namobuddha	0.195	0.748	0.414	0.558	0.632	0.763	0.754	0.722	0.799	0.213	0.257	0.255	0.244	0.27

Kavre	Panauti	0.284	0.876	0.489	0.645	0.632	0.763	0.754	0.722	0.799	0.326	0.393	0.388	0.372	0.412
Ramechhap	Ramechhap	0.266	0.636	0.358	0.459	0.596	0.694	0.681	0.674	0.749	0.258	0.301	0.296	0.292	0.325
Ramechhap	Manthali	0.34	0.697	0.42	0.45	0.596	0.694	0.681	0.674	0.749	0.328	0.383	0.376	0.372	0.413
Sindhuli	Dudhouli	0.381	0.616	0.518	0.095	0.6	0.728	0.713	0.705	0.764	0.29	0.352	0.345	0.341	0.369
Sindhuli	Kamalamai	0.432	0.591	0.576	0	0.6	0.728	0.713	0.705	0.764	0.286	0.347	0.34	0.336	0.364
Makawanpur	Thaha	0.269	0.819	0.447	0.624	0.635	0.764	0.778	0.723	0.791	0.306	0.368	0.375	0.349	0.381
Makawanpur	Hetauda	0.507	0.603	0.554	0	0.635	0.764	0.778	0.723	0.791	0.376	0.453	0.461	0.429	0.468
Chitawan	Rapti	0.358	0.696	0.677	0	0.649	0.778	0.789	0.736	0.809	0.254	0.305	0.309	0.288	0.317
Chitawan	Kalika	0.224	0.601	0.509	0.083	0.649	0.778	0.789	0.736	0.809	0.182	0.219	0.222	0.207	0.227
Chitawan	Bharatpur	1	0.486	0.997	0	0.649	0.778	0.789	0.736	0.809	0.027	0.032	0.033	0.03	0.033
Chitawan	Ratnanagar	0.342	0.566	0.496	0.045	0.649	0.778	0.789	0.736	0.809	0.27	0.324	0.329	0.307	0.337
Chitawan	Khairahani	0.309	0.724	0.571	0.19	0.649	0.778	0.789	0.736	0.809	0.273	0.327	0.332	0.31	0.34
Chitawan	Madi	0.23	0.568	0.524	0	0.649	0.778	0.789	0.736	0.809	0.174	0.208	0.211	0.197	0.217
Gorkha	Palungtar	0.298	0.712	0.394	0.529	0.541	0.647	0.678	0.614	0.671	0.274	0.328	0.344	0.311	0.34
Gorkha	Gorkha	0.31	0.74	0.56	0.244	0.541	0.647	0.678	0.614	0.671	0.237	0.283	0.297	0.269	0.294
Myagdi	Beni	0.21	0.612	0.642	0	0.544	0.652	0.676	0.636	0.687	0.115	0.137	0.142	0.134	0.145
Kaski	Pokhara Lekhnath	0.998	0.856	0.77	0.029	0.69	0.801	0.831	0.778	0.834	0.827	0.96	0.997	0.933	1
Lamjung	MadhyaNepal	0.199	0.841	0.419	0.723	0.653	0.765	0.802	0.736	0.795	0.246	0.288	0.302	0.277	0.299
Lamjung	Besishahar	0.265	0.721	0.518	0.293	0.653	0.765	0.802	0.736	0.795	0.254	0.297	0.312	0.286	0.309
Lamjung	Sundarbazar	0.226	0.805	0.444	0.603	0.653	0.765	0.802	0.736	0.795	0.262	0.307	0.322	0.295	0.319
Lamjung	Rainas	0.197	0.799	0.39	0.702	0.653	0.765	0.802	0.736	0.795	0.241	0.283	0.296	0.272	0.294
Tanahu	Bhanu	0.454	0.653	0.473	0.256	0.725	0.867	0.886	0.827	0.871	0.47	0.562	0.575	0.537	0.565
Tanahu	Byas	0.466	0.742	0.617	0.128	0.725	0.867	0.886	0.827	0.871	0.439	0.525	0.537	0.502	0.528
Tanahu	Shuklagandaki	0.297	0.61	0.534	0.05	0.725	0.867	0.886	0.827	0.871	0.263	0.315	0.322	0.3	0.316
Tanahu	Bhimad	0.274	0.666	0.412	0.405	0.725	0.867	0.886	0.827	0.871	0.314	0.375	0.384	0.358	0.377
Nawalpur	Gaidakot	0.283	0.838	0.46	0.632	0.653	0.779	0.784	0.744	0.815	0.334	0.398	0.4	0.38	0.416
Nawalpur	Devchuli	0.21	0.761	0.459	0.488	0.653	0.779	0.784	0.744	0.815	0.228	0.272	0.273	0.259	0.284
Nawalpur	Kawasoti	0.314	0.822	0.48	0.562	0.653	0.779	0.784	0.744	0.815	0.355	0.424	0.427	0.405	0.443

Nawalpur	Madhyabindu	0.246	0.717	0.435	0.455	0.653	0.779	0.784	0.744	0.815	0.261	0.312	0.314	0.298	0.326
Syangja	Putalibazar	0.28	0.774	0.455	0.521	0.739	0.878	0.897	0.838	0.885	0.35	0.416	0.425	0.397	0.419
Syangja	Bhirkot	0.172	0.702	0.422	0.455	0.739	0.878	0.897	0.838	0.885	0.207	0.246	0.251	0.235	0.248
Syangja	Chapakot	0.252	0.656	0.422	0.368	0.739	0.878	0.897	0.838	0.885	0.287	0.342	0.349	0.326	0.344
Syangja	Waling	0.292	0.7	0.422	0.45	0.739	0.878	0.897	0.838	0.885	0.349	0.415	0.424	0.396	0.418
Syangja	Galyang	0.281	0.773	0.441	0.55	0.739	0.878	0.897	0.838	0.885	0.358	0.425	0.434	0.406	0.428
Parbat	Kushma	0.301	0.895	0.462	0.736	0.726	0.857	0.879	0.822	0.868	0.417	0.492	0.505	0.472	0.498
Parbat	Phalebas	0.188	0.74	0.404	0.562	0.726	0.857	0.879	0.822	0.868	0.237	0.279	0.286	0.268	0.283
Baglung	Baglung	0.342	0.607	0.584	0	0.605	0.728	0.753	0.694	0.746	0.231	0.277	0.287	0.264	0.284
Baglung	Dhorpatan	0.173	0.726	0.344	0.657	0.605	0.728	0.753	0.694	0.746	0.192	0.23	0.238	0.22	0.236
Baglung	Galkot	0.243	0.747	0.454	0.475	0.605	0.728	0.753	0.694	0.746	0.242	0.291	0.302	0.278	0.299
Baglung	Jaimini	0.198	0.694	0.378	0.529	0.605	0.728	0.753	0.694	0.746	0.203	0.244	0.253	0.233	0.25
Rolpa	Rolpa	0.357	0.765	0.462	0.488	0.503	0.628	0.643	0.57	0.626	0.299	0.373	0.382	0.339	0.372
Pyuthan	Pyuthan	0.267	0.858	0.487	0.612	0.549	0.691	0.702	0.64	0.691	0.261	0.329	0.334	0.305	0.329
Pyuthan	Sworgadwary	0.255	0.822	0.473	0.574	0.549	0.691	0.702	0.64	0.691	0.245	0.308	0.313	0.285	0.308
Gulmi	Musikot	0.269	0.793	0.48	0.508	0.615	0.757	0.777	0.721	0.765	0.278	0.342	0.351	0.326	0.346
Gulmi	Resunga	0.24	0.776	0.593	0.24	0.615	0.757	0.777	0.721	0.765	0.209	0.257	0.264	0.245	0.26
Arghakhanchi	Bhumekasthan	0.253	0.811	0.44	0.624	0.576	0.718	0.732	0.68	0.744	0.262	0.326	0.333	0.309	0.338
Arghakhanchi	Sandhikharka	0.334	0.9	0.491	0.682	0.576	0.718	0.732	0.68	0.744	0.357	0.445	0.453	0.421	0.461
Arghakhanchi	Sitganga	0.451	0.817	0.462	0.587	0.576	0.718	0.732	0.68	0.744	0.457	0.569	0.581	0.539	0.591
Palpa	Rampur	0.281	0.922	0.462	0.785	0.653	0.794	0.802	0.746	0.809	0.359	0.436	0.441	0.41	0.445
Palpa	Tansen	0.365	0.793	0.495	0.475	0.653	0.794	0.802	0.746	0.809	0.392	0.476	0.481	0.448	0.485
Parasi	Bardaghat	0.231	0.559	0.523	0	0.653	0.779	0.784	0.744	0.815	0.174	0.207	0.208	0.198	0.217
Parasi	Sunwal	0.251	0.705	0.4	0.504	0.653	0.779	0.784	0.744	0.815	0.276	0.329	0.331	0.314	0.344
Parasi	Ramgram	0.202	0.641	0.366	0.455	0.653	0.779	0.784	0.744	0.815	0.214	0.255	0.257	0.244	0.267
Rupandehi	Devdaha	0.277	0.569	0.584	0	0.614	0.728	0.729	0.701	0.764	0.178	0.211	0.211	0.203	0.221
Rupandehi	Butwal	0.433	0.659	0.968	0	0.614	0.728	0.729	0.701	0.764	0.114	0.135	0.136	0.131	0.142
Rupandehi	Sainamaina	0.271	0.585	0.597	0	0.614	0.728	0.729	0.701	0.764	0.174	0.207	0.207	0.199	0.217

Rupandehi	Tillotama	0.452	0.445	0.655	0	0.614	0.728	0.729	0.701	0.764	0.184	0.219	0.219	0.211	0.23
Rupandehi	Siddharthanagar	0.211	0.538	0.543	0	0.614	0.728	0.729	0.701	0.764	0.138	0.164	0.164	0.158	0.172
Rupandehi	Lumbini Sanskritik	0.191	0.477	0.49	0	0.614	0.728	0.729	0.701	0.764	0.125	0.148	0.148	0.142	0.155
Kapilbastu	Banganga	0.327	0.708	0.431	0.446	0.58	0.718	0.729	0.676	0.743	0.307	0.38	0.386	0.357	0.393
Kapilbastu	Buddhabhumi	0.297	0.547	0.338	0.335	0.58	0.718	0.729	0.676	0.743	0.26	0.321	0.326	0.302	0.333
Kapilbastu	Shivaraj	0.27	0.654	0.291	0.632	0.58	0.718	0.729	0.676	0.743	0.283	0.35	0.355	0.329	0.362
Kapilbastu	Krishnanagar	0.216	0.547	0.303	0.409	0.58	0.718	0.729	0.676	0.743	0.198	0.245	0.249	0.231	0.254
Kapilbastu	Maharajgunj	0.19	0.487	0.298	0.302	0.58	0.718	0.729	0.676	0.743	0.163	0.201	0.204	0.189	0.208
Kapilbastu	Kapilbastu	0.27	0.368	0.651	0	0.58	0.718	0.729	0.676	0.743	0.083	0.102	0.104	0.096	0.106
Dang	Ghorahi	0.687	0.595	0.677	0	0.529	0.662	0.676	0.61	0.669	0.329	0.411	0.419	0.378	0.415
Dang	Tulsipur	0.626	0.602	0.72	0	0.529	0.662	0.676	0.61	0.669	0.275	0.344	0.351	0.317	0.347
Dang	Lamahi	0.252	0.706	0.386	0.537	0.529	0.662	0.676	0.61	0.669	0.228	0.285	0.291	0.263	0.288
Banke	Kohalpur	0.326	0.56	0.429	0.169	0.507	0.615	0.64	0.58	0.646	0.222	0.269	0.28	0.254	0.283
Banke	Nepalgunj	0.476	0.469	0.535	0	0.507	0.615	0.64	0.58	0.646	0.231	0.28	0.292	0.264	0.295
Bardiya	Bansagadhi	0.23	0.547	0.485	0.033	0.513	0.605	0.64	0.579	0.642	0.142	0.168	0.178	0.16	0.178
Bardiya	Barbardiya	0.321	0.747	0.421	0.541	0.513	0.605	0.64	0.579	0.642	0.282	0.333	0.352	0.318	0.353
Bardiya	Thakurbaba	0.168	0.595	0.411	0.273	0.513	0.605	0.64	0.579	0.642	0.124	0.147	0.155	0.14	0.156
Bardiya	Rajapur	0.26	0.795	0.384	0.707	0.513	0.605	0.64	0.579	0.642	0.251	0.296	0.314	0.283	0.314
Bardiya	Madhuwan	0.197	0.713	0.414	0.492	0.513	0.605	0.64	0.579	0.642	0.168	0.198	0.21	0.19	0.21
Bardiya	Gulariya	0.262	0.521	0.465	0.025	0.513	0.605	0.64	0.579	0.642	0.161	0.19	0.201	0.181	0.201
Dolpa	Tripurasundari	0.185	0.762	0.421	0.57	0.282	0.376	0.395	0.331	0.388	0.091	0.121	0.127	0.107	0.125
Dolpa	Thuli Bheri	0.162	0.767	0.406	0.607	0.282	0.376	0.395	0.331	0.388	0.082	0.109	0.114	0.096	0.112
Mugu	Chhayanath Rara	0.233	0.839	0.345	0.868	0.33	0.423	0.421	0.351	0.409	0.157	0.201	0.2	0.167	0.194
Jumla	Chandannath	0.165	0.662	0.391	0.442	0.465	0.566	0.563	0.497	0.552	0.124	0.151	0.15	0.132	0.147
Kalikot	Raskot	0.148	0.644	0.346	0.5	0.403	0.51	0.525	0.442	0.496	0.1	0.126	0.13	0.11	0.123
Kalikot	Khandachakra	0.125	0.912	0.384	0.926	0.403	0.51	0.525	0.442	0.496	0.106	0.134	0.138	0.116	0.13
Kalikot	Tilagufa	0.176	0.874	0.395	0.831	0.403	0.51	0.525	0.442	0.496	0.142	0.18	0.186	0.156	0.175
Dailekh	Aathabis	0.166	0.904	0.362	0.955	0.44	0.546	0.572	0.5	0.553	0.155	0.193	0.202	0.176	0.195

Dailekh	Chamunda Bindrasaini	0.153	0.848	0.337	0.905	0.44	0.546	0.572	0.5	0.553	0.14	0.174	0.182	0.159	0.176
Dailekh	Dullu	0.221	0.836	0.335	0.884	0.44	0.546	0.572	0.5	0.553	0.2	0.248	0.26	0.227	0.252
Dailekh	Narayan	0.21	0.864	0.404	0.793	0.44	0.546	0.572	0.5	0.553	0.182	0.226	0.236	0.207	0.229
Jajarkot	Chhedagad	0.277	0.72	0.349	0.636	0.478	0.594	0.608	0.531	0.587	0.239	0.298	0.305	0.266	0.294
Jajarkot	Bheri	0.262	0.837	0.365	0.822	0.478	0.594	0.608	0.531	0.587	0.25	0.311	0.318	0.278	0.307
Jajarkot	Nalagad	0.227	0.788	0.343	0.777	0.478	0.594	0.608	0.531	0.587	0.211	0.263	0.269	0.235	0.26
Western rukum	Aathbiskot	0.383	0.833	0.399	0.748	0.487	0.601	0.605	0.542	0.598	0.358	0.442	0.445	0.399	0.44
Western rukum	Musikot	0.186	0.868	0.451	0.707	0.487	0.601	0.605	0.542	0.598	0.17	0.21	0.212	0.189	0.209
Western rukum	Chaurjahari	0.128	0.786	0.341	0.777	0.487	0.601	0.605	0.542	0.598	0.122	0.15	0.151	0.135	0.149
Salyan	Bangad Kupinde	0.28	0.571	0.427	0.198	0.494	0.607	0.633	0.565	0.614	0.19	0.233	0.243	0.217	0.236
Salyan	Bagchaur	0.311	0.64	0.445	0.289	0.494	0.607	0.633	0.565	0.614	0.225	0.276	0.288	0.257	0.279
Salyan	Sharada	0.297	0.728	0.401	0.545	0.494	0.607	0.633	0.565	0.614	0.252	0.31	0.323	0.288	0.313
Surkhet	Lekbeshi	0.261	0.567	0.391	0.264	0.489	0.584	0.615	0.551	0.608	0.183	0.219	0.231	0.207	0.228
Surkhet	Gurbhakot	0.313	0.729	0.365	0.62	0.489	0.584	0.615	0.551	0.608	0.274	0.328	0.345	0.309	0.341
Surkhet	Bheriganga	0.259	0.66	0.304	0.616	0.489	0.584	0.615	0.551	0.608	0.226	0.27	0.285	0.255	0.282
Surkhet	Birendranagar	0.516	0.581	0.629	0	0.489	0.584	0.615	0.551	0.608	0.246	0.294	0.31	0.277	0.306
Surkhet	Panchpuri	0.325	0.704	0.37	0.566	0.489	0.584	0.615	0.551	0.608	0.276	0.33	0.347	0.311	0.343
Bajura	Budhinanda	0.15	0.716	0.321	0.686	0.357	0.459	0.471	0.406	0.462	0.1	0.128	0.131	0.113	0.129
Bajura	Badimalika	0.149	0.908	0.346	1	0.357	0.459	0.471	0.406	0.462	0.115	0.149	0.152	0.131	0.15
Bajura	Budhiganga	0.11	0.851	0.297	0.992	0.357	0.459	0.471	0.406	0.462	0.085	0.109	0.112	0.097	0.11
Bajura	Tribeni	0.109	0.589	0.394	0.298	0.357	0.459	0.471	0.406	0.462	0.057	0.074	0.075	0.065	0.074
Bajhang	Bungal	0.241	0.586	0.347	0.388	0.392	0.494	0.513	0.437	0.493	0.147	0.186	0.193	0.164	0.186
Bajhang	JayaPrithivi	0.186	0.947	0.445	0.868	0.392	0.494	0.513	0.437	0.493	0.149	0.188	0.194	0.166	0.187
Darchula	Mahakali	0.176	0.873	0.392	0.839	0.461	0.548	0.572	0.503	0.558	0.163	0.194	0.202	0.178	0.197
Darchula	Shailyashikhar	0.155	0.88	0.392	0.851	0.461	0.548	0.572	0.503	0.558	0.145	0.172	0.179	0.158	0.175
Baitadi	Purchaudi	0.228	0.569	0.348	0.355	0.507	0.601	0.629	0.556	0.621	0.177	0.209	0.219	0.194	0.216
Baitadi	Dasharathchanda	0.191	0.691	0.528	0.215	0.507	0.601	0.629	0.556	0.621	0.134	0.159	0.167	0.147	0.165

Baitadi	Melauli	0.143	0.65	0.448	0.302	0.507	0.601	0.629	0.556	0.621	0.107	0.127	0.133	0.117	0.131
Baitadi	Patan	0.265	0.798	0.386	0.707	0.507	0.601	0.629	0.556	0.621	0.253	0.3	0.314	0.278	0.31
Dadeldhura	Amargadhi	0.155	0.768	0.443	0.533	0.499	0.586	0.611	0.555	0.618	0.132	0.155	0.161	0.147	0.163
Dadeldhura	Parashuram	0.314	0.694	0.387	0.512	0.499	0.586	0.611	0.555	0.618	0.264	0.31	0.323	0.294	0.327
Doti	Shikhar	0.252	0.845	0.389	0.789	0.478	0.573	0.604	0.527	0.59	0.236	0.283	0.298	0.26	0.292
Doti	Dipayal Silgadi	0.236	0.855	0.381	0.826	0.478	0.573	0.604	0.527	0.59	0.225	0.27	0.285	0.248	0.278
Achham	Panchadewal Binayak	0.157	0.679	0.369	0.521	0.449	0.546	0.576	0.5	0.563	0.119	0.145	0.153	0.133	0.15
Achham	Sanphebagar	0.238	0.754	0.439	0.517	0.449	0.546	0.576	0.5	0.563	0.181	0.22	0.232	0.201	0.226
Achham	Mangalsen	0.198	0.806	0.38	0.736	0.449	0.546	0.576	0.5	0.563	0.17	0.207	0.218	0.189	0.213
Achham	Kamalbazar	0.149	0.814	0.342	0.826	0.449	0.546	0.576	0.5	0.563	0.134	0.163	0.171	0.149	0.168
Kailali	Godawari	0.38	0.606	0.407	0.306	0.531	0.618	0.647	0.587	0.652	0.298	0.346	0.363	0.329	0.365
Kailali	Gauriganga	0.214	0.507	0.375	0.186	0.531	0.618	0.647	0.587	0.652	0.154	0.18	0.188	0.171	0.189
Kailali	Ghodaghodi	0.334	0.577	0.415	0.231	0.531	0.618	0.647	0.587	0.652	0.249	0.29	0.303	0.275	0.305
Kailali	Lamkichuha	0.256	0.533	0.415	0.149	0.531	0.618	0.647	0.587	0.652	0.179	0.209	0.219	0.198	0.22
Kailali	Tikapur	0.26	0.756	0.397	0.607	0.531	0.618	0.647	0.587	0.652	0.246	0.286	0.299	0.272	0.301
Kailali	Bhajani	0.233	0.866	0.421	0.764	0.531	0.618	0.647	0.587	0.652	0.24	0.279	0.292	0.265	0.294
Kailali	Dhangadhi	0.534	0.669	0.57	0.087	0.531	0.618	0.647	0.587	0.652	0.357	0.416	0.436	0.395	0.438
Kanchanpur	Krishnapur	0.243	0.574	0.349	0.364	0.531	0.618	0.64	0.581	0.654	0.198	0.231	0.239	0.217	0.244
Kanchanpur	Shuklaphanta	0.177	0.5	0.335	0.252	0.531	0.618	0.64	0.581	0.654	0.134	0.156	0.162	0.147	0.165
Kanchanpur	Bedkot	0.217	0.453	0.448	0	0.531	0.618	0.64	0.581	0.654	0.127	0.148	0.153	0.139	0.157
Kanchanpur	Bhimdatta	0.474	0.602	0.432	0.244	0.531	0.618	0.64	0.581	0.654	0.357	0.416	0.431	0.391	0.441
Kanchanpur	Mahakali	0.157	0.558	0.333	0.368	0.531	0.618	0.64	0.581	0.654	0.128	0.149	0.155	0.141	0.158
Kanchanpur	Punarbas	0.188	0.577	0.377	0.314	0.531	0.618	0.64	0.581	0.654	0.148	0.172	0.179	0.162	0.183
Kanchanpur	Belauri	0.189	0.441	0.469	0	0.531	0.618	0.64	0.581	0.654	0.104	0.122	0.126	0.114	0.129

Annex 5. Consolidated Vulnerability and risk index of rural municipalities

Palika	Exposure	Sensitivity	Adaptive Capacity	Vulnerability	Climate Extreme events baseline	Climate extreme event RCP 4.5 2030	Climate extreme event RCP 4.5 2050	Climate extreme events RCP 8.5 2030	Climate extreme events RCP 8.5. 2050	Baseline Risk (hazard)	Risk RCP 4.5 2030	RIsk RCP 4.5 2050	Risk RCP 8.5 2030	Risk RCP 8.5 2050
Phaktanglung	0.409	0.513	0.607	0.549	0.757	0.871	0.889	0.836	0.904	0.301	0.346	0.353	0.332	0.359
Mikwakhola	0.22	0.268	0.535	0.409	0.757	0.871	0.889	0.836	0.904	0.121	0.139	0.142	0.133	0.144
Meringden	0.255	0.359	0.562	0.461	0.757	0.871	0.889	0.836	0.904	0.157	0.181	0.185	0.174	0.188
Maiwakhola	0.209	0.306	0.559	0.418	0.757	0.871	0.889	0.836	0.904	0.117	0.135	0.137	0.129	0.14
Aathrai Tribeni	0.162	0.363	0.562	0.465	0.757	0.871	0.889	0.836	0.904	0.101	0.116	0.118	0.111	0.12
Pathibhara Yangwarak	0.222	0.45	0.557	0.543	0.757	0.871	0.889	0.836	0.904	0.161	0.186	0.19	0.178	0.193
Sirijangha	0.362	0.391	0.607	0.445	0.757	0.871	0.889	0.836	0.904	0.216	0.248	0.253	0.238	0.258
Sidingba	0.263	0.347	0.558	0.454	0.757	0.871	0.889	0.836	0.904	0.16	0.184	0.188	0.177	0.191
Bhotkhola	0.432	0.406	0.539	0.523	0.757	0.871	0.889	0.836	0.904	0.303	0.348	0.355	0.334	0.361
Makalu	0.488	0.315	0.616	0.372	0.757	0.871	0.889	0.836	0.904	0.243	0.28	0.286	0.268	0.29
Silichong	0.356	0.288	0.577	0.386	0.757	0.871	0.889	0.836	0.904	0.184	0.212	0.216	0.203	0.22
Chichila	0.204	0.185	0.529	0.345	0.757	0.871	0.889	0.836	0.904	0.094	0.108	0.111	0.104	0.113
Sabhapokhari	0.25	0.29	0.535	0.428	0.757	0.871	0.889	0.836	0.904	0.143	0.165	0.168	0.158	0.171
Khumbupasanglahmu	0.366	0.395	0.581	0.473	0.798	0.907	0.92	0.883	0.961	0.244	0.278	0.282	0.27	0.294
Mahakulung	0.31	0.197	0.569	0.316	0.798	0.907	0.92	0.883	0.961	0.138	0.157	0.159	0.153	0.167
Sotang	0.242	0.281	0.54	0.416	0.798	0.907	0.92	0.883	0.961	0.142	0.162	0.164	0.157	0.171
Dudhkoshi	0.301	0.327	0.574	0.422	0.798	0.907	0.92	0.883	0.961	0.179	0.204	0.207	0.198	0.216
Thulung Dudhkoshi	0.272	0.386	0.612	0.436	0.798	0.907	0.92	0.883	0.961	0.167	0.19	0.193	0.185	0.202
Nechasalyan	0.214	0.309	0.594	0.387	0.798	0.907	0.92	0.883	0.961	0.117	0.133	0.135	0.129	0.141
Likhupike	0.142	0.301	0.504	0.467	0.594	0.68	0.683	0.656	0.732	0.07	0.08	0.08	0.077	0.086
Chisankhugadhi	0.243	0.409	0.52	0.544	0.594	0.68	0.683	0.656	0.732	0.139	0.159	0.16	0.153	0.171
Molung	0.236	0.537	0.541	0.632	0.567	0.667	0.657	0.652	0.728	0.15	0.176	0.173	0.172	0.192
Khijidemba	0.311	0.464	0.539	0.573	0.567	0.667	0.657	0.652	0.728	0.179	0.21	0.207	0.206	0.23
Likhu	0.244	0.37	0.538	0.493	0.567	0.667	0.657	0.652	0.728	0.121	0.142	0.14	0.139	0.155

Champadevi	0.297	0.458	0.524	0.582	0.567	0.667	0.657	0.652	0.728	0.173	0.204	0.201	0.199	0.223
Sunkoshi	0.317	0.588	0.553	0.665	0.567	0.667	0.657	0.652	0.728	0.211	0.249	0.245	0.243	0.271
Manebhanjyang	0.329	0.573	0.6	0.607	0.567	0.667	0.657	0.652	0.728	0.2	0.236	0.232	0.23	0.257
Kepilasagadhi	0.289	0.406	0.61	0.455	0.567	0.667	0.657	0.652	0.728	0.132	0.155	0.153	0.152	0.169
Ainselukhark	0.262	0.424	0.615	0.465	0.567	0.667	0.657	0.652	0.728	0.122	0.144	0.142	0.141	0.157
Rawa Besi	0.236	0.368	0.616	0.417	0.567	0.667	0.657	0.652	0.728	0.099	0.116	0.114	0.114	0.127
Sakela	0.178	0.323	0.588	0.405	0.558	0.659	0.65	0.639	0.725	0.071	0.084	0.083	0.081	0.092
Diprung	0.32	0.478	0.625	0.502	0.558	0.659	0.65	0.639	0.725	0.159	0.187	0.185	0.182	0.206
Khotehang	0.358	0.531	0.64	0.532	0.558	0.659	0.65	0.639	0.725	0.188	0.222	0.219	0.215	0.244
Jantedhunga	0.248	0.39	0.6	0.451	0.558	0.659	0.65	0.639	0.725	0.11	0.13	0.129	0.126	0.143
Barahapokhari	0.27	0.374	0.593	0.443	0.558	0.659	0.65	0.639	0.725	0.118	0.139	0.138	0.135	0.153
Salpasilichho	0.324	0.357	0.56	0.461	0.6	0.708	0.701	0.677	0.765	0.159	0.187	0.185	0.179	0.202
Tyamkemaiyung	0.313	0.479	0.622	0.506	0.6	0.708	0.701	0.677	0.765	0.168	0.198	0.196	0.19	0.214
Arun	0.274	0.465	0.567	0.547	0.6	0.708	0.701	0.677	0.765	0.159	0.188	0.186	0.18	0.203
Pauwadungma	0.245	0.378	0.55	0.488	0.6	0.708	0.701	0.677	0.765	0.127	0.15	0.148	0.143	0.162
Ramprasad Rai	0.289	0.512	0.591	0.563	0.6	0.708	0.701	0.677	0.765	0.173	0.204	0.202	0.195	0.22
Hatuwagadhi	0.304	0.522	0.599	0.564	0.6	0.708	0.701	0.677	0.765	0.182	0.215	0.213	0.205	0.232
Aamchowk	0.32	0.453	0.585	0.519	0.6	0.708	0.701	0.677	0.765	0.176	0.208	0.206	0.199	0.225
Chhathar Jorpati	0.274	0.435	0.733	0.361	0.631	0.739	0.746	0.721	0.801	0.11	0.129	0.131	0.126	0.14
Shahidbhumi	0.307	0.411	0.663	0.408	0.631	0.739	0.746	0.721	0.801	0.14	0.164	0.165	0.16	0.177
Sangurigadhi	0.334	0.58	0.735	0.482	0.631	0.739	0.746	0.721	0.801	0.18	0.21	0.212	0.205	0.228
Chaubise	0.346	0.448	0.7	0.403	0.631	0.739	0.746	0.721	0.801	0.156	0.182	0.184	0.178	0.198
Aathrai	0.378	0.53	0.726	0.448	0.663	0.789	0.785	0.763	0.836	0.199	0.236	0.235	0.229	0.25
Phedap	0.297	0.42	0.713	0.368	0.663	0.789	0.785	0.763	0.836	0.128	0.153	0.152	0.148	0.162
Menchayam	0.157	0.213	0.641	0.26	0.663	0.789	0.785	0.763	0.836	0.048	0.057	0.057	0.055	0.06
Chhathar	0.279	0.39	0.682	0.372	0.663	0.789	0.785	0.763	0.836	0.122	0.145	0.144	0.14	0.153
Yangwarak	0.357	0.499	0.658	0.488	0.706	0.831	0.827	0.796	0.868	0.218	0.256	0.255	0.245	0.268
Hilihang	0.412	0.638	0.715	0.552	0.706	0.831	0.827	0.796	0.868	0.284	0.334	0.333	0.32	0.349
Falelung	0.374	0.523	0.67	0.497	0.706	0.831	0.827	0.796	0.868	0.232	0.273	0.272	0.262	0.285
Falgunanda	0.366	0.519	0.707	0.457	0.706	0.831	0.827	0.796	0.868	0.209	0.246	0.245	0.236	0.257

Kummayak	0.304	0.354	0.577	0.442	0.706	0.831	0.827	0.796	0.868	0.168	0.198	0.197	0.189	0.206
Tumbewa	0.251	0.296	0.618	0.353	0.706	0.831	0.827	0.796	0.868	0.111	0.13	0.13	0.125	0.136
Miklajung	0.397	0.564	0.674	0.528	0.706	0.831	0.827	0.796	0.868	0.262	0.308	0.307	0.295	0.322
Maijogmai	0.33	0.57	0.781	0.43	0.791	0.902	0.899	0.875	0.945	0.199	0.226	0.226	0.22	0.237
Sandakpur	0.301	0.438	0.661	0.432	0.791	0.902	0.899	0.875	0.945	0.182	0.207	0.207	0.201	0.217
Fakphokthum	0.398	0.506	0.764	0.391	0.791	0.902	0.899	0.875	0.945	0.218	0.248	0.247	0.241	0.26
Mangsebung	0.358	0.435	0.657	0.434	0.791	0.902	0.899	0.875	0.945	0.217	0.248	0.247	0.241	0.26
Chulachuli	0.307	0.427	0.739	0.348	0.791	0.902	0.899	0.875	0.945	0.149	0.17	0.17	0.165	0.179
Rong	0.305	0.447	0.672	0.43	0.791	0.902	0.899	0.875	0.945	0.184	0.209	0.209	0.203	0.219
Buddhashanti	0.501	0.709	0.999	0.338	0.855	0.968	0.963	0.948	1	0.256	0.29	0.288	0.284	0.3
Kamal	0.544	0.749	0.883	0.484	0.855	0.968	0.963	0.948	1	0.398	0.451	0.449	0.442	0.466
Gauriganj	0.417	0.576	0.735	0.479	0.855	0.968	0.963	0.948	1	0.302	0.342	0.34	0.335	0.353
Jhapa	0.441	0.661	0.725	0.561	0.855	0.968	0.963	0.948	1	0.374	0.424	0.421	0.415	0.438
Barhadashi	0.428	0.624	0.798	0.459	0.855	0.968	0.963	0.948	1	0.297	0.336	0.335	0.329	0.348
Haldibari	0.402	0.557	0.742	0.456	0.855	0.968	0.963	0.948	1	0.277	0.314	0.312	0.307	0.324
Kachankawal	0.628	0.674	0.798	0.502	0.855	0.968	0.963	0.948	1	0.477	0.54	0.537	0.529	0.558
Miklajung	0.395	0.537	0.686	0.493	0.725	0.834	0.831	0.817	0.869	0.25	0.287	0.286	0.281	0.299
Kerabari	0.485	0.597	0.796	0.439	0.725	0.834	0.831	0.817	0.869	0.273	0.314	0.313	0.308	0.327
Kanepokhari	0.503	0.679	0.783	0.52	0.725	0.834	0.831	0.817	0.869	0.335	0.386	0.385	0.378	0.402
Gramthan	0.569	0.572	0.713	0.497	0.725	0.834	0.831	0.817	0.869	0.363	0.417	0.416	0.409	0.435
Budhiganga	0.692	0.705	0.371	0.94	0.725	0.834	0.831	0.817	0.869	0.834	0.96	0.956	0.94	1
Katahari	0.69	0.567	0.783	0.425	0.725	0.834	0.831	0.817	0.869	0.376	0.433	0.431	0.424	0.451
Dhanpalthan	0.548	0.57	0.663	0.544	0.725	0.834	0.831	0.817	0.869	0.382	0.44	0.438	0.431	0.458
Jahada	0.665	0.582	0.708	0.51	0.725	0.834	0.831	0.817	0.869	0.435	0.5	0.499	0.49	0.521
Koshi	0.767	0.718	0.726	0.609	0.654	0.767	0.753	0.757	0.808	0.54	0.634	0.622	0.626	0.668
Bhokraha Narsingh	0.736	0.622	0.768	0.487	0.654	0.767	0.753	0.757	0.808	0.415	0.486	0.477	0.48	0.512
Gadhi	0.675	0.537	0.717	0.463	0.654	0.767	0.753	0.757	0.808	0.362	0.424	0.416	0.419	0.447
Harinagar	0.728	0.537	0.674	0.505	0.654	0.767	0.753	0.757	0.808	0.425	0.499	0.49	0.492	0.526
Dewanganj	0.621	0.505	0.658	0.492	0.654	0.767	0.753	0.757	0.808	0.353	0.415	0.407	0.409	0.437
Barju	0.607	0.441	0.691	0.406	0.654	0.767	0.753	0.757	0.808	0.285	0.334	0.328	0.33	0.352

Rautamai	0.403	0.574	0.636	0.573	0.577	0.692	0.677	0.676	0.739	0.236	0.283	0.277	0.276	0.302
Sunkoshi	0.201	0.306	0.42	0.553	0.577	0.692	0.677	0.676	0.739	0.113	0.136	0.133	0.133	0.145
Tapli	0.248	0.349	0.553	0.461	0.577	0.692	0.677	0.676	0.739	0.117	0.14	0.137	0.137	0.149
Udayapurgadhi	0.487	0.653	0.646	0.631	0.577	0.692	0.677	0.676	0.739	0.314	0.376	0.368	0.367	0.402
Agnisair Krishna Savaran	0.341	0.397	0.351	0.697	0.604	0.711	0.692	0.701	0.746	0.254	0.299	0.291	0.295	0.314
Rupani	0.325	0.421	0.356	0.712	0.604	0.711	0.692	0.701	0.746	0.247	0.291	0.283	0.287	0.305
Balan Bihul	0.274	0.325	0.398	0.59	0.604	0.711	0.692	0.701	0.746	0.173	0.203	0.198	0.2	0.213
Belhi Chapena	0.376	0.363	0.39	0.63	0.604	0.711	0.692	0.701	0.746	0.253	0.298	0.29	0.294	0.313
Bishnupur	0.281	0.344	0.38	0.624	0.604	0.711	0.692	0.701	0.746	0.187	0.221	0.215	0.217	0.231
Mahadeva	0.317	0.384	0.404	0.634	0.604	0.711	0.692	0.701	0.746	0.215	0.253	0.246	0.249	0.265
Tirahut	0.282	0.304	0.339	0.629	0.604	0.711	0.692	0.701	0.746	0.19	0.223	0.217	0.22	0.234
Tilathi Koiladi	0.363	0.449	0.392	0.701	0.604	0.711	0.692	0.701	0.746	0.272	0.32	0.312	0.316	0.336
Chhinnamasta	0.325	0.421	0.391	0.679	0.604	0.711	0.692	0.701	0.746	0.236	0.278	0.27	0.274	0.291
Naraha	0.463	0.262	0.259	0.67	0.586	0.69	0.666	0.683	0.728	0.322	0.379	0.365	0.375	0.4
Bishnupur	0.296	0.28	0.27	0.674	0.586	0.69	0.666	0.683	0.728	0.207	0.244	0.235	0.241	0.257
Arnama	0.274	0.316	0.269	0.707	0.586	0.69	0.666	0.683	0.728	0.201	0.236	0.228	0.234	0.249
Laxmipur Patari	0.558	0.365	0.275	0.743	0.586	0.69	0.666	0.683	0.728	0.43	0.506	0.488	0.501	0.534
Sakhuwanankarkatti	0.311	0.32	0.274	0.705	0.586	0.69	0.666	0.683	0.728	0.227	0.268	0.258	0.265	0.282
Bhagawanpur	0.283	0.336	0.334	0.661	0.586	0.69	0.666	0.683	0.728	0.194	0.228	0.22	0.226	0.241
Nawarajpur	0.344	0.317	0.304	0.674	0.586	0.69	0.666	0.683	0.728	0.24	0.283	0.273	0.28	0.299
Bariyarpatti	0.359	0.409	0.29	0.766	0.586	0.69	0.666	0.683	0.728	0.285	0.336	0.324	0.332	0.354
Aurahi	0.28	0.372	0.228	0.794	0.586	0.69	0.666	0.683	0.728	0.23	0.271	0.262	0.269	0.286
Bateshwor	0.475	0.303	0.297	0.669	0.581	0.691	0.676	0.685	0.74	0.327	0.388	0.38	0.385	0.416
Lakshminiya	0.444	0.437	0.355	0.726	0.581	0.691	0.676	0.685	0.74	0.331	0.394	0.385	0.391	0.422
Janaknandani	0.605	0.611	0.343	0.887	0.581	0.691	0.676	0.685	0.74	0.552	0.656	0.642	0.65	0.703
Aaurahi	0.346	0.384	0.329	0.707	0.581	0.691	0.676	0.685	0.74	0.251	0.299	0.293	0.296	0.32
Dhanauji	0.307	0.304	0.302	0.664	0.581	0.691	0.676	0.685	0.74	0.21	0.249	0.244	0.247	0.267
Mukhiyapatti Musarmiya	0.32	0.357	0.365	0.649	0.581	0.691	0.676	0.685	0.74	0.213	0.254	0.248	0.252	0.272
Sonama	0.415	0.546	0.293	0.879	0.584	0.701	0.691	0.697	0.746	0.377	0.452	0.446	0.45	0.481
Samsi	0.341	0.491	0.245	0.879	0.584	0.701	0.691	0.697	0.746	0.31	0.372	0.366	0.37	0.396

Ekdanra	0.333	0.426	0.229	0.839	0.584	0.701	0.691	0.697	0.746	0.289	0.346	0.342	0.344	0.369
Mahottari	0.319	0.428	0.246	0.824	0.584	0.701	0.691	0.697	0.746	0.272	0.326	0.321	0.324	0.347
Pipra	0.464	0.537	0.275	0.889	0.584	0.701	0.691	0.697	0.746	0.426	0.512	0.504	0.509	0.544
Parsa	0.225	0.314	0.256	0.717	0.603	0.732	0.728	0.712	0.761	0.172	0.209	0.208	0.203	0.217
Bramhapuri	0.292	0.41	0.277	0.778	0.603	0.732	0.728	0.712	0.761	0.242	0.294	0.293	0.286	0.306
Chandranagar	0.35	0.437	0.275	0.804	0.603	0.732	0.728	0.712	0.761	0.3	0.364	0.362	0.354	0.379
Chakraghatta	0.303	0.356	0.319	0.693	0.603	0.732	0.728	0.712	0.761	0.224	0.272	0.27	0.264	0.283
Basbariya	0.257	0.311	0.305	0.668	0.603	0.732	0.728	0.712	0.761	0.183	0.222	0.221	0.216	0.231
Dhankaul	0.258	0.333	0.271	0.719	0.603	0.732	0.728	0.712	0.761	0.198	0.24	0.239	0.234	0.25
Ramnagar	0.302	0.367	0.282	0.737	0.603	0.732	0.728	0.712	0.761	0.237	0.288	0.287	0.28	0.3
Bishnu	0.262	0.34	0.311	0.687	0.603	0.732	0.728	0.712	0.761	0.192	0.233	0.232	0.227	0.242
Kaudena	0.288	0.35	0.275	0.73	0.603	0.732	0.728	0.712	0.761	0.224	0.272	0.271	0.265	0.283
Yemunamai	0.34	0.378	0.186	0.839	0.607	0.743	0.743	0.704	0.754	0.306	0.375	0.375	0.355	0.381
Durga Bhagwati	0.343	0.365	0.223	0.792	0.607	0.743	0.743	0.704	0.754	0.292	0.357	0.357	0.338	0.362
Parwanipur	0.408	0.261	0.389	0.544	0.621	0.744	0.753	0.719	0.768	0.244	0.292	0.296	0.282	0.302
Prasauni	0.52	0.28	0.374	0.574	0.621	0.744	0.753	0.719	0.768	0.328	0.393	0.398	0.38	0.406
Bishrampur	0.39	0.274	0.391	0.553	0.621	0.744	0.753	0.719	0.768	0.237	0.284	0.287	0.274	0.293
Pheta	0.399	0.304	0.386	0.583	0.621	0.744	0.753	0.719	0.768	0.256	0.306	0.31	0.296	0.316
Karaiyamai	0.38	0.318	0.497	0.489	0.621	0.744	0.753	0.719	0.768	0.204	0.245	0.248	0.236	0.252
Baragadhi	0.297	0.394	0.476	0.574	0.621	0.744	0.753	0.719	0.768	0.187	0.224	0.227	0.217	0.232
Adarshkotwal	0.305	0.463	0.407	0.698	0.621	0.744	0.753	0.719	0.768	0.234	0.28	0.284	0.271	0.289
Devtal	0.331	0.311	0.455	0.523	0.621	0.744	0.753	0.719	0.768	0.19	0.228	0.231	0.22	0.235
Suwarna	0.308	0.376	0.409	0.622	0.621	0.744	0.753	0.719	0.768	0.21	0.252	0.255	0.244	0.26
Thori	0.278	0.444	0.452	0.64	0.625	0.733	0.75	0.726	0.778	0.197	0.231	0.236	0.229	0.245
Jirabhawani	0.267	0.389	0.424	0.619	0.625	0.733	0.75	0.726	0.778	0.183	0.214	0.219	0.212	0.227
Jagarnathpur	0.364	0.376	0.516	0.519	0.625	0.733	0.75	0.726	0.778	0.209	0.245	0.251	0.243	0.26
Paterwasugauli	0.294	0.31	0.409	0.567	0.625	0.733	0.75	0.726	0.778	0.184	0.216	0.221	0.214	0.229
SakhuwaPrasauni	0.379	0.407	0.451	0.609	0.625	0.733	0.75	0.726	0.778	0.255	0.299	0.306	0.296	0.318
Kalikamai	0.223	0.243	0.412	0.507	0.625	0.733	0.75	0.726	0.778	0.125	0.147	0.15	0.145	0.156
Dhobini	0.209	0.236	0.398	0.514	0.625	0.733	0.75	0.726	0.778	0.119	0.139	0.143	0.138	0.148

Chhipaharmai	0.277	0.302	0.428	0.542	0.625	0.733	0.75	0.726	0.778	0.166	0.195	0.199	0.193	0.207
Pakahamainpur	0.228	0.235	0.386	0.524	0.625	0.733	0.75	0.726	0.778	0.132	0.155	0.159	0.153	0.164
Bindabasini	0.318	0.298	0.413	0.552	0.625	0.733	0.75	0.726	0.778	0.194	0.228	0.233	0.225	0.242
Gaurishankar	0.431	0.594	0.563	0.66	0.622	0.709	0.704	0.694	0.77	0.313	0.357	0.354	0.349	0.387
Bigu	0.454	0.681	0.584	0.714	0.622	0.709	0.704	0.694	0.77	0.357	0.407	0.404	0.398	0.442
Kalinchok	0.366	0.721	0.581	0.751	0.622	0.709	0.704	0.694	0.77	0.302	0.345	0.342	0.337	0.374
Baiteshwor	0.28	0.609	0.554	0.682	0.622	0.709	0.704	0.694	0.77	0.21	0.24	0.238	0.234	0.26
Tamakoshi	0.29	0.563	0.491	0.703	0.622	0.709	0.704	0.694	0.77	0.224	0.256	0.254	0.25	0.278
Melung	0.301	0.631	0.534	0.72	0.622	0.709	0.704	0.694	0.77	0.238	0.272	0.27	0.266	0.295
Sailung	0.295	0.609	0.559	0.676	0.622	0.709	0.704	0.694	0.77	0.219	0.25	0.248	0.245	0.272
Bhotekoshi	0.336	0.621	0.536	0.709	0.631	0.74	0.75	0.719	0.792	0.266	0.312	0.316	0.303	0.334
Jugal	0.407	0.55	0.506	0.677	0.631	0.74	0.75	0.719	0.792	0.308	0.361	0.366	0.35	0.386
Panchpokhari Thangpal	0.381	0.521	0.493	0.666	0.631	0.74	0.75	0.719	0.792	0.283	0.332	0.337	0.323	0.356
Helambu	0.312	0.554	0.466	0.719	0.631	0.74	0.75	0.719	0.792	0.25	0.294	0.298	0.285	0.314
Indrawati	0.393	0.653	0.565	0.708	0.631	0.74	0.75	0.719	0.792	0.311	0.364	0.369	0.354	0.39
Balefi	0.283	0.643	0.52	0.743	0.631	0.74	0.75	0.719	0.792	0.235	0.275	0.279	0.267	0.295
Tripurasundari	0.292	0.505	0.226	0.909	0.631	0.74	0.75	0.719	0.792	0.296	0.347	0.352	0.338	0.372
Lisangkhu Pakhar	0.23	0.377	0.478	0.557	0.631	0.74	0.75	0.719	0.792	0.143	0.168	0.17	0.163	0.179
Sunkoshi	0.258	0.524	0.608	0.557	0.631	0.74	0.75	0.719	0.792	0.16	0.188	0.191	0.183	0.201
Gosaikunda	0.34	0.499	0.434	0.704	0.618	0.751	0.768	0.699	0.765	0.262	0.318	0.325	0.296	0.324
Parbati Kunda	0.169	0.187	0.362	0.507	0.618	0.751	0.768	0.699	0.765	0.094	0.114	0.116	0.106	0.116
Uttargaya	0.169	0.366	0.381	0.642	0.618	0.751	0.768	0.699	0.765	0.119	0.144	0.147	0.134	0.147
Kalika	0.173	0.354	0.782	0.245	0.618	0.751	0.768	0.699	0.765	0.046	0.056	0.058	0.052	0.057
Naukunda	0.225	0.339	0.411	0.59	0.618	0.751	0.768	0.699	0.765	0.145	0.176	0.18	0.164	0.18
Rubi Valley	0.291	0.387	0.481	0.563	0.618	0.751	0.768	0.699	0.765	0.179	0.218	0.223	0.203	0.222
Khaniyabash	0.252	0.33	0.54	0.458	0.618	0.751	0.768	0.699	0.765	0.126	0.153	0.157	0.143	0.156
Gangajamuna	0.285	0.444	0.598	0.499	0.618	0.751	0.768	0.699	0.765	0.155	0.189	0.193	0.176	0.192
Tripura Sundari	0.216	0.577	0.589	0.621	0.618	0.751	0.768	0.699	0.765	0.147	0.178	0.182	0.166	0.182
Netrawati Dabjong	0.311	0.445	0.524	0.57	0.618	0.751	0.768	0.699	0.765	0.194	0.236	0.241	0.219	0.24
Jwalamukhi	0.361	0.569	0.547	0.654	0.618	0.751	0.768	0.699	0.765	0.258	0.314	0.321	0.292	0.32

Siddhalek	0.337	0.647	0.567	0.701	0.618	0.751	0.768	0.699	0.765	0.258	0.314	0.321	0.292	0.32
Benighat Rorang	0.506	0.881	0.68	0.792	0.618	0.751	0.768	0.699	0.765	0.438	0.532	0.544	0.496	0.542
Gajuri	0.382	0.73	0.677	0.666	0.618	0.751	0.768	0.699	0.765	0.278	0.338	0.346	0.315	0.344
Galchi	0.36	0.635	0.631	0.63	0.618	0.751	0.768	0.699	0.765	0.248	0.301	0.308	0.28	0.307
Thakre	0.484	0.798	0.693	0.709	0.618	0.751	0.768	0.699	0.765	0.375	0.456	0.466	0.424	0.464
Dupcheshwar	0.347	0.685	0.537	0.763	0.626	0.771	0.778	0.715	0.781	0.293	0.361	0.364	0.335	0.366
Tadi	0.262	0.436	0.511	0.576	0.626	0.771	0.778	0.715	0.781	0.167	0.206	0.208	0.191	0.209
Suryagadhi	0.242	0.382	0.503	0.538	0.626	0.771	0.778	0.715	0.781	0.144	0.178	0.179	0.165	0.18
Kispang	0.213	0.478	0.523	0.6	0.626	0.771	0.778	0.715	0.781	0.142	0.174	0.176	0.162	0.177
Meghang	0.226	0.373	0.524	0.51	0.626	0.771	0.778	0.715	0.781	0.128	0.157	0.159	0.146	0.159
Tarkeshwar	0.207	0.4	0.527	0.529	0.626	0.771	0.778	0.715	0.781	0.121	0.149	0.151	0.139	0.151
Likhu	0.277	0.581	0.516	0.695	0.626	0.771	0.778	0.715	0.781	0.213	0.263	0.265	0.244	0.266
Panchakanya	0.215	0.479	0.474	0.648	0.626	0.771	0.778	0.715	0.781	0.154	0.19	0.192	0.176	0.192
Shivapuri	0.318	0.626	0.527	0.722	0.626	0.771	0.778	0.715	0.781	0.254	0.313	0.316	0.29	0.317
Kakani	0.405	0.619	0.59	0.655	0.626	0.771	0.778	0.715	0.781	0.294	0.362	0.365	0.336	0.367
Konjyosom	0.194	0.196	0.881	0.015	0.617	0.75	0.749	0.709	0.791	0.003	0.004	0.004	0.004	0.004
Mahankal	0.174	0.23	0.912	0.014	0.617	0.75	0.749	0.709	0.791	0.003	0.003	0.003	0.003	0.003
Bagmati	0.267	0.42	0.628	0.449	0.617	0.75	0.749	0.709	0.791	0.131	0.159	0.159	0.15	0.168
Chaurideurali	0.33	0.564	0.728	0.476	0.632	0.763	0.754	0.722	0.799	0.176	0.212	0.21	0.201	0.222
Bhumlu	0.307	0.53	0.741	0.434	0.632	0.763	0.754	0.722	0.799	0.149	0.18	0.178	0.17	0.188
Temal	0.334	0.518	0.695	0.468	0.632	0.763	0.754	0.722	0.799	0.175	0.211	0.209	0.2	0.221
Bethanchowk	0.268	0.417	0.672	0.405	0.632	0.763	0.754	0.722	0.799	0.121	0.147	0.145	0.139	0.153
Roshi	0.483	0.697	0.773	0.545	0.632	0.763	0.754	0.722	0.799	0.294	0.355	0.351	0.336	0.372
Mahabharat	0.35	0.399	0.667	0.394	0.632	0.763	0.754	0.722	0.799	0.154	0.186	0.184	0.176	0.195
Khanikhola	0.317	0.364	0.701	0.331	0.632	0.763	0.754	0.722	0.799	0.117	0.142	0.14	0.134	0.148
Umakunda	0.392	0.428	0.575	0.507	0.596	0.694	0.681	0.674	0.749	0.21	0.244	0.239	0.237	0.263
Gokulganga	0.338	0.505	0.596	0.553	0.596	0.694	0.681	0.674	0.749	0.197	0.229	0.225	0.223	0.248
Likhu Tamakoshi	0.31	0.531	0.643	0.53	0.596	0.694	0.681	0.674	0.749	0.173	0.202	0.198	0.196	0.218
Khadadevi	0.399	0.611	0.579	0.659	0.596	0.694	0.681	0.674	0.749	0.277	0.323	0.317	0.314	0.348
Doramba	0.366	0.54	0.624	0.555	0.596	0.694	0.681	0.674	0.749	0.214	0.249	0.245	0.242	0.269

Sunapati	0.274	0.494	0.584	0.556	0.596	0.694	0.681	0.674	0.749	0.161	0.187	0.184	0.182	0.202
Phikkal	0.349	0.471	0.468	0.647	0.6	0.728	0.713	0.705	0.764	0.24	0.291	0.285	0.282	0.305
Tinpatan	0.595	0.758	0.622	0.743	0.6	0.728	0.713	0.705	0.764	0.469	0.569	0.558	0.551	0.598
Golanjor	0.367	0.502	0.476	0.666	0.6	0.728	0.713	0.705	0.764	0.259	0.315	0.308	0.305	0.33
Sunkoshi	0.374	0.557	0.602	0.591	0.6	0.728	0.713	0.705	0.764	0.235	0.285	0.279	0.276	0.299
Ghanglekh	0.267	0.319	0.431	0.553	0.6	0.728	0.713	0.705	0.764	0.157	0.19	0.186	0.184	0.2
Marin	0.468	0.59	0.469	0.748	0.6	0.728	0.713	0.705	0.764	0.372	0.451	0.442	0.437	0.473
Hariharpurgadhi	0.488	0.6	0.463	0.762	0.6	0.728	0.713	0.705	0.764	0.395	0.479	0.469	0.464	0.503
Indrasarowar	0.283	0.447	0.623	0.477	0.635	0.764	0.778	0.723	0.791	0.152	0.182	0.186	0.173	0.189
Kailash	0.417	0.598	0.68	0.551	0.635	0.764	0.778	0.723	0.791	0.258	0.311	0.316	0.294	0.322
Raksirang	0.458	0.671	0.541	0.747	0.635	0.764	0.778	0.723	0.791	0.384	0.462	0.471	0.438	0.479
Manahari	0.539	0.926	0.777	0.737	0.635	0.764	0.778	0.723	0.791	0.446	0.537	0.547	0.508	0.556
Bhimphedi	0.657	0.872	0.691	0.774	0.635	0.764	0.778	0.723	0.791	0.571	0.687	0.7	0.65	0.712
Makawanpurgadhi	0.448	0.664	0.689	0.599	0.635	0.764	0.778	0.723	0.791	0.301	0.363	0.369	0.343	0.376
Bakaiya	0.733	1	0.767	0.809	0.635	0.764	0.778	0.723	0.791	0.666	0.801	0.816	0.758	0.83
Bagmati	0.699	0.706	0.325	0.985	0.635	0.764	0.778	0.723	0.791	0.773	0.931	0.948	0.881	0.963
Ichchhyakamana	0.473	0.65	1	0.287	0.649	0.778	0.789	0.736	0.809	0.156	0.187	0.189	0.177	0.194
Chum Nubri	0.427	0.449	0.561	0.539	0.541	0.647	0.678	0.614	0.671	0.22	0.263	0.276	0.25	0.273
Ajirkot	0.323	0.507	0.624	0.527	0.541	0.647	0.678	0.614	0.671	0.163	0.195	0.204	0.185	0.202
Sulikot	0.422	0.657	0.675	0.606	0.541	0.647	0.678	0.614	0.671	0.245	0.293	0.307	0.278	0.304
Dharche	0.395	0.37	0.611	0.423	0.541	0.647	0.678	0.614	0.671	0.16	0.191	0.2	0.181	0.198
Aarughat	0.366	0.659	0.717	0.567	0.541	0.647	0.678	0.614	0.671	0.199	0.238	0.249	0.225	0.246
Bhimsen	0.338	0.592	0.632	0.593	0.541	0.647	0.678	0.614	0.671	0.192	0.229	0.24	0.218	0.238
Siranchok	0.376	0.798	0.701	0.701	0.541	0.647	0.678	0.614	0.671	0.252	0.302	0.316	0.286	0.313
Sahid Lakhan	0.471	0.764	0.744	0.631	0.541	0.647	0.678	0.614	0.671	0.284	0.34	0.356	0.323	0.353
Gandaki	0.359	0.585	0.677	0.543	0.541	0.647	0.678	0.614	0.671	0.187	0.223	0.234	0.212	0.231
Narphu	0.164	0.126	0.626	0.201	0.282	0.376	0.395	0.331	0.388	0.016	0.022	0.023	0.019	0.023
Neshyang	0.174	0.161	0.655	0.203	0.282	0.376	0.395	0.331	0.388	0.018	0.023	0.025	0.021	0.024
Chame	0.063	0.064	0.648	0.127	0.282	0.376	0.395	0.331	0.388	0.004	0.005	0.006	0.005	0.005
Nashong	0.217	0.211	0.66	0.24	0.282	0.376	0.395	0.331	0.388	0.026	0.035	0.036	0.03	0.036

Dalome	0.224	0.107	0.471	0.334	0.282	0.376	0.395	0.331	0.388	0.037	0.05	0.052	0.044	0.051
Gharapjhong	0.141	0.16	0.494	0.357	0.282	0.376	0.395	0.331	0.388	0.025	0.033	0.035	0.029	0.035
Barhagaun Muktikhsetra	0.192	0.199	0.49	0.394	0.282	0.376	0.395	0.331	0.388	0.038	0.05	0.053	0.044	0.052
Lomanthang	0.174	0.16	0.478	0.372	0.282	0.376	0.395	0.331	0.388	0.032	0.043	0.045	0.038	0.044
Thasang	0.151	0.175	0.48	0.383	0.282	0.376	0.395	0.331	0.388	0.029	0.038	0.04	0.034	0.04
Annapurna	0.468	0.735	0.997	0.363	0.544	0.652	0.676	0.636	0.687	0.163	0.196	0.203	0.191	0.206
Raghuganga	0.4	0.493	0.662	0.479	0.544	0.652	0.676	0.636	0.687	0.184	0.221	0.229	0.216	0.233
Dhaulagiri	0.452	0.419	0.668	0.41	0.544	0.652	0.676	0.636	0.687	0.178	0.214	0.222	0.209	0.225
Malika	0.303	0.467	0.62	0.497	0.544	0.652	0.676	0.636	0.687	0.145	0.174	0.18	0.169	0.183
Mangala	0.275	0.432	0.655	0.433	0.544	0.652	0.676	0.636	0.687	0.115	0.137	0.142	0.134	0.145
Madi	0.477	0.809	0.4	1	0.69	0.801	0.831	0.778	0.834	0.582	0.676	0.701	0.657	0.704
Machhapuchchhre	0.45	0.687	0.976	0.342	0.69	0.801	0.831	0.778	0.834	0.188	0.218	0.226	0.212	0.227
Annapurna	0.366	0.835	0.64	0.791	0.69	0.801	0.831	0.778	0.834	0.353	0.41	0.426	0.398	0.427
Rupa	0.245	0.391	0.829	0.231	0.653	0.765	0.802	0.736	0.795	0.065	0.077	0.08	0.074	0.08
Dordi	0.344	0.598	0.686	0.545	0.653	0.765	0.802	0.736	0.795	0.217	0.254	0.266	0.244	0.264
Marsyangdi	0.483	0.748	0.739	0.622	0.653	0.765	0.802	0.736	0.795	0.347	0.407	0.426	0.391	0.423
Kwholasothar	0.226	0.391	0.648	0.405	0.653	0.765	0.802	0.736	0.795	0.106	0.124	0.13	0.119	0.129
Dudhpokhari	0.267	0.32	0.625	0.367	0.653	0.765	0.802	0.736	0.795	0.113	0.133	0.139	0.128	0.138
Myagde	0.347	0.592	0.78	0.449	0.725	0.867	0.886	0.827	0.871	0.2	0.239	0.244	0.228	0.24
Ghiring	0.359	0.429	0.719	0.37	0.725	0.867	0.886	0.827	0.871	0.17	0.204	0.208	0.194	0.205
Rhishing	0.424	0.561	0.694	0.506	0.725	0.867	0.886	0.827	0.871	0.275	0.329	0.336	0.314	0.331
Devghat	0.322	0.509	0.69	0.465	0.725	0.867	0.886	0.827	0.871	0.192	0.23	0.235	0.219	0.231
Bandipur	0.358	0.664	0.79	0.502	0.725	0.867	0.886	0.827	0.871	0.231	0.276	0.282	0.263	0.277
Anbukhaireni	0.402	0.648	0.876	0.405	0.725	0.867	0.886	0.827	0.871	0.209	0.25	0.255	0.238	0.251
Bulingtar	0.318	0.449	0.658	0.445	0.653	0.779	0.784	0.744	0.815	0.163	0.195	0.196	0.186	0.204
Bungdikali	0.267	0.34	0.638	0.372	0.653	0.779	0.784	0.744	0.815	0.115	0.137	0.138	0.131	0.143
Hupsekot	0.385	0.42	0.734	0.348	0.653	0.779	0.784	0.744	0.815	0.155	0.185	0.186	0.176	0.193
Binayee Tribeni	0.525	0.639	0.781	0.489	0.739	0.878	0.897	0.838	0.885	0.336	0.399	0.407	0.381	0.402
Phedikhola	0.235	0.352	0.76	0.264	0.739	0.878	0.897	0.838	0.885	0.081	0.096	0.098	0.092	0.097
Aandhikhola	0.297	0.522	0.776	0.394	0.739	0.878	0.897	0.838	0.885	0.153	0.182	0.186	0.173	0.183

Arjunchaupari	0.273	0.438	0.782	0.316	0.739	0.878	0.897	0.838	0.885	0.113	0.134	0.137	0.128	0.135
Biruwa	0.293	0.451	0.739	0.368	0.739	0.878	0.897	0.838	0.885	0.141	0.167	0.171	0.16	0.169
Harinas	0.331	0.415	0.715	0.362	0.739	0.878	0.897	0.838	0.885	0.157	0.186	0.19	0.178	0.188
Kaligandagi	0.291	0.471	0.755	0.37	0.739	0.878	0.897	0.838	0.885	0.141	0.167	0.171	0.16	0.169
Modi	0.368	0.775	0.761	0.625	0.726	0.857	0.879	0.822	0.868	0.295	0.349	0.358	0.334	0.353
Jaljala	0.319	0.556	0.752	0.446	0.726	0.857	0.879	0.822	0.868	0.183	0.216	0.221	0.207	0.218
Mahashila	0.163	0.287	0.63	0.334	0.726	0.857	0.879	0.822	0.868	0.07	0.083	0.085	0.079	0.084
Bihadi	0.23	0.395	0.666	0.391	0.726	0.857	0.879	0.822	0.868	0.116	0.136	0.14	0.131	0.138
Painyu	0.227	0.387	0.724	0.329	0.726	0.857	0.879	0.822	0.868	0.096	0.113	0.116	0.109	0.115
Kanthekhola	0.385	0.582	0.773	0.448	0.605	0.728	0.753	0.694	0.746	0.185	0.222	0.23	0.212	0.228
Tara Khola	0.259	0.359	0.591	0.433	0.605	0.728	0.753	0.694	0.746	0.12	0.144	0.149	0.138	0.148
Taman Khola	0.218	0.278	0.584	0.371	0.605	0.728	0.753	0.694	0.746	0.087	0.104	0.108	0.099	0.107
Nisikhola	0.388	0.697	0.635	0.679	0.605	0.728	0.753	0.694	0.746	0.282	0.339	0.351	0.323	0.348
Badigad	0.48	0.679	0.71	0.591	0.605	0.728	0.753	0.694	0.746	0.304	0.365	0.378	0.348	0.374
Bareng	0.223	0.339	0.6	0.408	0.605	0.728	0.753	0.694	0.746	0.097	0.117	0.121	0.112	0.12
Putha Uttarganga	0.407	0.51	0.46	0.687	0.503	0.628	0.643	0.57	0.626	0.249	0.311	0.318	0.282	0.31
Sisne	0.338	0.617	0.459	0.78	0.503	0.628	0.643	0.57	0.626	0.235	0.293	0.3	0.266	0.292
Bhume	0.215	0.493	0.443	0.69	0.503	0.628	0.643	0.57	0.626	0.132	0.165	0.169	0.15	0.164
Sunchhahari	0.294	0.457	0.346	0.753	0.503	0.628	0.643	0.57	0.626	0.197	0.246	0.252	0.223	0.245
Thawang	0.191	0.335	0.323	0.67	0.503	0.628	0.643	0.57	0.626	0.114	0.142	0.146	0.129	0.142
Duikholi	0.335	0.509	0.388	0.756	0.503	0.628	0.643	0.57	0.626	0.225	0.281	0.288	0.255	0.28
Sukidaha	0.321	0.457	0.468	0.634	0.503	0.628	0.643	0.57	0.626	0.181	0.226	0.232	0.205	0.225
Madi	0.281	0.44	0.598	0.495	0.503	0.628	0.643	0.57	0.626	0.124	0.155	0.158	0.14	0.154
Tribeni	0.38	0.553	0.253	0.924	0.503	0.628	0.643	0.57	0.626	0.312	0.39	0.399	0.354	0.389
Runtigadi	0.446	0.63	0.449	0.801	0.503	0.628	0.643	0.57	0.626	0.318	0.397	0.406	0.36	0.396
Suwarnabati	0.383	0.637	0.365	0.888	0.503	0.628	0.643	0.57	0.626	0.303	0.378	0.387	0.343	0.377
Lungri	0.334	0.488	0.401	0.726	0.503	0.628	0.643	0.57	0.626	0.216	0.269	0.276	0.245	0.269
Gaumukhi	0.349	0.508	0.486	0.661	0.549	0.691	0.702	0.64	0.691	0.224	0.282	0.286	0.261	0.282
Naubahini	0.426	0.606	0.497	0.734	0.549	0.691	0.702	0.64	0.691	0.304	0.382	0.388	0.354	0.382
Jhimruk	0.395	0.591	0.522	0.697	0.549	0.691	0.702	0.64	0.691	0.267	0.337	0.342	0.312	0.337

Mandavi	0.245	0.455	0.422	0.678	0.549	0.691	0.702	0.64	0.691	0.161	0.203	0.206	0.188	0.203
Mallarani	0.25	0.413	0.449	0.616	0.549	0.691	0.702	0.64	0.691	0.15	0.188	0.191	0.174	0.188
Ayirabati	0.359	0.509	0.431	0.715	0.549	0.691	0.702	0.64	0.691	0.249	0.314	0.319	0.291	0.314
Sarumarani	0.298	0.411	0.382	0.679	0.549	0.691	0.702	0.64	0.691	0.197	0.247	0.251	0.229	0.247
Kaligandaki	0.326	0.504	0.626	0.523	0.615	0.757	0.777	0.721	0.765	0.185	0.228	0.234	0.217	0.231
Satyawati	0.381	0.59	0.689	0.536	0.615	0.757	0.777	0.721	0.765	0.222	0.273	0.281	0.26	0.276
Chandrakot	0.33	0.547	0.67	0.517	0.615	0.757	0.777	0.721	0.765	0.186	0.228	0.235	0.218	0.231
Isma	0.3	0.581	0.593	0.621	0.615	0.757	0.777	0.721	0.765	0.203	0.249	0.256	0.238	0.252
Malika	0.329	0.586	0.656	0.563	0.615	0.757	0.777	0.721	0.765	0.202	0.248	0.255	0.236	0.251
Madane	0.385	0.597	0.62	0.608	0.615	0.757	0.777	0.721	0.765	0.255	0.313	0.322	0.299	0.317
Dhurkot	0.295	0.643	0.619	0.649	0.615	0.757	0.777	0.721	0.765	0.208	0.256	0.263	0.244	0.259
Gulmidarbar	0.328	0.516	0.651	0.509	0.615	0.757	0.777	0.721	0.765	0.182	0.224	0.229	0.213	0.226
Chatrakot	0.335	0.492	0.623	0.515	0.615	0.757	0.777	0.721	0.765	0.188	0.231	0.237	0.22	0.233
Ruru	0.305	0.497	0.651	0.493	0.615	0.757	0.777	0.721	0.765	0.164	0.201	0.207	0.192	0.203
Chhatradev	0.364	0.61	0.697	0.545	0.576	0.718	0.732	0.68	0.744	0.202	0.252	0.257	0.239	0.261
Malarani	0.405	0.631	0.746	0.515	0.576	0.718	0.732	0.68	0.744	0.213	0.265	0.27	0.251	0.275
Panini	0.417	0.618	0.707	0.542	0.576	0.718	0.732	0.68	0.744	0.23	0.287	0.293	0.272	0.297
Purbakhola	0.31	0.429	0.681	0.406	0.653	0.794	0.802	0.746	0.809	0.145	0.177	0.179	0.166	0.18
Rambha	0.339	0.641	0.744	0.526	0.653	0.794	0.802	0.746	0.809	0.206	0.25	0.253	0.235	0.255
Bagnaskali	0.316	0.564	0.776	0.429	0.653	0.794	0.802	0.746	0.809	0.157	0.19	0.192	0.179	0.194
Ribdikot	0.303	0.484	0.771	0.366	0.653	0.794	0.802	0.746	0.809	0.128	0.156	0.157	0.146	0.159
Rainadevi Chhahara	0.418	0.58	0.725	0.492	0.653	0.794	0.802	0.746	0.809	0.238	0.289	0.292	0.271	0.294
Tinau	0.38	0.464	0.707	0.411	0.653	0.794	0.802	0.746	0.809	0.18	0.219	0.222	0.206	0.224
Mathagadhi	0.419	0.527	0.785	0.389	0.653	0.794	0.802	0.746	0.809	0.188	0.229	0.231	0.215	0.233
Nisdi	0.417	0.506	0.715	0.439	0.653	0.794	0.802	0.746	0.809	0.211	0.257	0.26	0.242	0.262
Palhi Nandan	0.476	0.559	0.712	0.487	0.653	0.779	0.784	0.744	0.815	0.268	0.319	0.322	0.305	0.334
Sarawal	0.569	0.601	0.646	0.586	0.653	0.779	0.784	0.744	0.815	0.385	0.46	0.462	0.439	0.481
Pratappur	0.741	0.66	0.675	0.609	0.653	0.779	0.784	0.744	0.815	0.521	0.622	0.626	0.594	0.651
Susta	0.668	0.546	0.631	0.553	0.653	0.779	0.784	0.744	0.815	0.427	0.509	0.512	0.486	0.533
Kanchan	0.372	0.632	0.726	0.536	0.614	0.728	0.729	0.701	0.764	0.217	0.257	0.257	0.247	0.269

Gaidahawa	0.543	0.692	0.67	0.641	0.614	0.728	0.729	0.701	0.764	0.378	0.448	0.449	0.432	0.47
Sudhdhodhan	0.412	0.573	0.748	0.464	0.614	0.728	0.729	0.701	0.764	0.208	0.246	0.247	0.237	0.258
Siyari	0.619	0.628	0.716	0.542	0.614	0.728	0.729	0.701	0.764	0.364	0.432	0.433	0.416	0.453
Omsatiya	0.481	0.579	0.758	0.459	0.614	0.728	0.729	0.701	0.764	0.24	0.284	0.285	0.274	0.298
Rohini	0.504	0.606	0.684	0.554	0.614	0.728	0.729	0.701	0.764	0.303	0.36	0.36	0.346	0.377
Mayadevi	0.776	0.714	0.486	0.837	0.614	0.728	0.729	0.701	0.764	0.706	0.836	0.838	0.805	0.878
Kotahimai	0.442	0.607	0.616	0.62	0.614	0.728	0.729	0.701	0.764	0.298	0.353	0.353	0.34	0.37
Sammarimai	0.435	0.579	0.621	0.592	0.614	0.728	0.729	0.701	0.764	0.28	0.332	0.332	0.319	0.348
Marchawari	0.45	0.561	0.659	0.54	0.614	0.728	0.729	0.701	0.764	0.264	0.313	0.313	0.301	0.328
Bijayanagar	0.538	0.532	0.408	0.756	0.58	0.718	0.729	0.676	0.743	0.417	0.517	0.525	0.486	0.535
Yashodhara	0.462	0.542	0.444	0.73	0.58	0.718	0.729	0.676	0.743	0.346	0.428	0.435	0.403	0.443
Mayadevi	0.62	0.661	0.653	0.631	0.58	0.718	0.729	0.676	0.743	0.401	0.497	0.505	0.468	0.514
Suddhodhan	0.514	0.658	0.413	0.859	0.58	0.718	0.729	0.676	0.743	0.453	0.561	0.569	0.528	0.58
Banglachuli	0.392	0.56	0.715	0.485	0.529	0.662	0.676	0.61	0.669	0.178	0.223	0.227	0.205	0.225
Shantinagar	0.327	0.454	0.692	0.417	0.529	0.662	0.676	0.61	0.669	0.128	0.16	0.163	0.147	0.161
Babai	0.422	0.658	0.68	0.602	0.529	0.662	0.676	0.61	0.669	0.238	0.298	0.304	0.274	0.301
Dangisharan	0.367	0.336	0.566	0.438	0.529	0.662	0.676	0.61	0.669	0.15	0.188	0.192	0.173	0.19
Rapti	0.762	0.689	0.777	0.535	0.529	0.662	0.676	0.61	0.669	0.382	0.477	0.488	0.44	0.482
Gadhawa	0.605	0.638	0.636	0.628	0.529	0.662	0.676	0.61	0.669	0.356	0.445	0.454	0.41	0.45
Rajpur	0.557	0.462	0.32	0.783	0.529	0.662	0.676	0.61	0.669	0.408	0.511	0.522	0.471	0.516
Rapti Sonari	1	0.893	0.695	0.788	0.507	0.615	0.64	0.58	0.646	0.707	0.857	0.892	0.809	0.901
Baijanath	0.722	0.805	0.692	0.715	0.507	0.615	0.64	0.58	0.646	0.463	0.562	0.584	0.53	0.59
Khajura	0.84	0.753	0.697	0.667	0.507	0.615	0.64	0.58	0.646	0.503	0.61	0.634	0.575	0.64
Janki	0.676	0.552	0.575	0.614	0.507	0.615	0.64	0.58	0.646	0.372	0.452	0.47	0.426	0.474
Duduwa	0.678	0.577	0.611	0.599	0.507	0.615	0.64	0.58	0.646	0.364	0.442	0.46	0.417	0.464
Narainapur	0.478	0.537	0.59	0.586	0.507	0.615	0.64	0.58	0.646	0.251	0.305	0.317	0.287	0.32
Geruwa	0.403	0.579	0.538	0.671	0.513	0.605	0.64	0.579	0.642	0.245	0.289	0.306	0.277	0.307
Badhaiyatal	0.579	0.812	0.63	0.782	0.513	0.605	0.64	0.579	0.642	0.411	0.485	0.513	0.464	0.514
Dolpo Buddha	0.187	0.152	0.191	0.642	0.282	0.376	0.395	0.331	0.388	0.06	0.08	0.084	0.07	0.082
Shey Phoksundo	0.262	0.196	0.209	0.662	0.282	0.376	0.395	0.331	0.388	0.087	0.115	0.121	0.102	0.119

Jagadulla	0.195	0.129	0.179	0.633	0.282	0.376	0.395	0.331	0.388	0.062	0.082	0.086	0.072	0.085
Mudkechula	0.152	0.189	0.184	0.68	0.282	0.376	0.395	0.331	0.388	0.052	0.069	0.072	0.061	0.071
Kaike	0.186	0.134	0.187	0.63	0.282	0.376	0.395	0.331	0.388	0.058	0.078	0.082	0.069	0.08
Chharka Tangsong	0.214	0.16	0.184	0.655	0.282	0.376	0.395	0.331	0.388	0.07	0.093	0.098	0.082	0.096
Mugum Karmarong	0.428	0.28	0.213	0.729	0.33	0.423	0.421	0.351	0.409	0.182	0.233	0.232	0.194	0.226
Soru	0.333	0.259	0.236	0.69	0.33	0.423	0.421	0.351	0.409	0.134	0.172	0.171	0.143	0.166
Khatyad	0.285	0.499	0.269	0.862	0.33	0.423	0.421	0.351	0.409	0.143	0.184	0.183	0.153	0.178
Chankheli	0.352	0.226	0.152	0.743	0.282	0.376	0.395	0.331	0.388	0.13	0.174	0.183	0.153	0.18
Kharpunath	0.272	0.294	0.136	0.816	0.282	0.376	0.395	0.331	0.388	0.111	0.148	0.155	0.13	0.152
Simkot	0.335	0.424	0.187	0.877	0.282	0.376	0.395	0.331	0.388	0.147	0.195	0.205	0.172	0.202
Namkha	0.315	0.369	0.152	0.865	0.282	0.376	0.395	0.331	0.388	0.136	0.181	0.19	0.16	0.187
Sarkegad	0.26	0.405	0.158	0.889	0.282	0.376	0.395	0.331	0.388	0.115	0.154	0.162	0.135	0.159
Adanchuli	0.159	0.402	0.122	0.921	0.282	0.376	0.395	0.331	0.388	0.073	0.097	0.102	0.086	0.101
Tanjakot	0.144	0.283	0.102	0.839	0.282	0.376	0.395	0.331	0.388	0.06	0.08	0.084	0.071	0.083
Patrasi	0.362	0.34	0.292	0.705	0.465	0.566	0.563	0.497	0.552	0.21	0.256	0.254	0.224	0.249
Kanakasundari	0.234	0.389	0.29	0.748	0.465	0.566	0.563	0.497	0.552	0.144	0.175	0.174	0.154	0.171
Sinja	0.184	0.42	0.264	0.8	0.465	0.566	0.563	0.497	0.552	0.121	0.147	0.147	0.129	0.144
Guthichaur	0.23	0.291	0.272	0.682	0.465	0.566	0.563	0.497	0.552	0.129	0.157	0.156	0.138	0.153
Tatopani	0.331	0.476	0.318	0.796	0.465	0.566	0.563	0.497	0.552	0.217	0.264	0.262	0.232	0.257
Tila	0.257	0.481	0.279	0.837	0.465	0.566	0.563	0.497	0.552	0.177	0.215	0.214	0.189	0.21
Hima	0.191	0.271	0.257	0.68	0.465	0.566	0.563	0.497	0.552	0.107	0.13	0.129	0.114	0.127
Palata	0.334	0.326	0.255	0.729	0.403	0.51	0.525	0.442	0.496	0.174	0.22	0.226	0.19	0.214
Pachaljharana	0.225	0.321	0.223	0.755	0.403	0.51	0.525	0.442	0.496	0.121	0.153	0.158	0.133	0.149
Sanni Tribeni	0.226	0.322	0.193	0.785	0.403	0.51	0.525	0.442	0.496	0.126	0.16	0.165	0.139	0.156
Naraharinath	0.348	0.431	0.282	0.792	0.403	0.51	0.525	0.442	0.496	0.196	0.249	0.256	0.216	0.242
Mahawai	0.263	0.327	0.188	0.795	0.403	0.51	0.525	0.442	0.496	0.149	0.189	0.194	0.163	0.183
Kalika	0.623	0.302	0.617	0.359	0.403	0.51	0.525	0.442	0.496	0.159	0.202	0.208	0.175	0.196
Naumule	0.375	0.643	0.458	0.803	0.44	0.546	0.572	0.5	0.553	0.234	0.291	0.305	0.266	0.295
Mahabu	0.3	0.451	0.408	0.688	0.44	0.546	0.572	0.5	0.553	0.161	0.199	0.209	0.183	0.202
Bhairabi	0.333	0.474	0.398	0.717	0.44	0.546	0.572	0.5	0.553	0.186	0.231	0.242	0.211	0.234

Thantikandh	0.309	0.427	0.465	0.612	0.44	0.546	0.572	0.5	0.553	0.147	0.183	0.191	0.167	0.185
Bhagawatimai	0.327	0.519	0.456	0.699	0.44	0.546	0.572	0.5	0.553	0.178	0.221	0.231	0.202	0.224
Dungeshwor	0.267	0.497	0.452	0.684	0.44	0.546	0.572	0.5	0.553	0.142	0.176	0.185	0.162	0.179
Gurans	0.378	0.571	0.467	0.733	0.44	0.546	0.572	0.5	0.553	0.216	0.268	0.28	0.245	0.271
Barekot	0.433	0.409	0.351	0.707	0.478	0.594	0.608	0.531	0.587	0.259	0.322	0.329	0.288	0.318
Kuse	0.38	0.458	0.343	0.756	0.478	0.594	0.608	0.531	0.587	0.243	0.302	0.309	0.27	0.298
Junichande	0.451	0.536	0.38	0.787	0.478	0.594	0.608	0.531	0.587	0.3	0.373	0.382	0.333	0.369
Shiwalaya	0.259	0.37	0.303	0.72	0.478	0.594	0.608	0.531	0.587	0.158	0.196	0.201	0.175	0.194
Sani Bheri	0.337	0.577	0.523	0.685	0.487	0.601	0.605	0.542	0.598	0.199	0.245	0.247	0.221	0.244
Banfikot	0.324	0.443	0.524	0.569	0.487	0.601	0.605	0.542	0.598	0.159	0.196	0.197	0.177	0.195
Tribeni	0.33	0.408	0.484	0.578	0.487	0.601	0.605	0.542	0.598	0.164	0.203	0.204	0.183	0.202
Darma	0.299	0.425	0.463	0.613	0.494	0.607	0.633	0.565	0.614	0.16	0.197	0.205	0.183	0.199
Kumakhmalika	0.41	0.683	0.475	0.821	0.494	0.607	0.633	0.565	0.614	0.294	0.361	0.377	0.336	0.366
Dhorchaur	0.268	0.354	0.486	0.53	0.494	0.607	0.633	0.565	0.614	0.124	0.153	0.159	0.142	0.154
Chhatreshwori	0.347	0.553	0.52	0.666	0.494	0.607	0.633	0.565	0.614	0.202	0.248	0.259	0.231	0.251
Kalimati	0.519	0.618	0.507	0.734	0.494	0.607	0.633	0.565	0.614	0.333	0.409	0.427	0.381	0.414
Tribeni	0.273	0.46	0.54	0.568	0.494	0.607	0.633	0.565	0.614	0.136	0.167	0.174	0.155	0.168
Kapurkot	0.276	0.43	0.539	0.544	0.494	0.607	0.633	0.565	0.614	0.131	0.161	0.168	0.15	0.163
Simta	0.452	0.757	0.654	0.711	0.489	0.584	0.615	0.551	0.608	0.278	0.332	0.35	0.313	0.346
Chingad	0.275	0.454	0.628	0.478	0.489	0.584	0.615	0.551	0.608	0.114	0.136	0.143	0.128	0.141
Barahtal	0.558	0.764	0.66	0.711	0.489	0.584	0.615	0.551	0.608	0.343	0.41	0.432	0.387	0.427
Chaukune	0.472	0.621	0.694	0.557	0.489	0.584	0.615	0.551	0.608	0.227	0.272	0.286	0.256	0.283
Himali	0.358	0.348	0.194	0.805	0.357	0.459	0.471	0.406	0.462	0.182	0.234	0.24	0.207	0.236
Gaumul	0.238	0.307	0.182	0.783	0.357	0.459	0.471	0.406	0.462	0.118	0.151	0.155	0.134	0.152
Swami Kartik	0.21	0.277	0.178	0.761	0.357	0.459	0.471	0.406	0.462	0.101	0.13	0.133	0.115	0.131
Pandav Gupha	0.188	0.276	0.182	0.756	0.357	0.459	0.471	0.406	0.462	0.09	0.115	0.118	0.102	0.116
Chhededaha	0.277	0.383	0.247	0.785	0.357	0.459	0.471	0.406	0.462	0.137	0.177	0.181	0.156	0.178
Kanda	0.275	0.266	0.179	0.751	0.392	0.494	0.513	0.437	0.493	0.143	0.18	0.187	0.16	0.18
Surma	0.189	0.194	0.178	0.69	0.392	0.494	0.513	0.437	0.493	0.09	0.114	0.118	0.101	0.114
Talkot	0.289	0.333	0.205	0.783	0.392	0.494	0.513	0.437	0.493	0.157	0.198	0.205	0.175	0.197

Masta	0.236	0.284	0.205	0.741	0.392	0.494	0.513	0.437	0.493	0.121	0.153	0.159	0.135	0.153
Chabispathivera	0.262	0.417	0.216	0.843	0.392	0.494	0.513	0.437	0.493	0.153	0.193	0.2	0.171	0.193
Durgathali	0.191	0.286	0.171	0.775	0.392	0.494	0.513	0.437	0.493	0.103	0.129	0.134	0.114	0.129
Kedarseu	0.32	0.438	0.243	0.836	0.392	0.494	0.513	0.437	0.493	0.186	0.234	0.243	0.207	0.233
Bithadchir	0.237	0.366	0.18	0.835	0.392	0.494	0.513	0.437	0.493	0.137	0.173	0.18	0.153	0.173
Thalara	0.281	0.369	0.249	0.771	0.392	0.494	0.513	0.437	0.493	0.15	0.189	0.197	0.167	0.189
Khaptadchhanna	0.252	0.41	0.246	0.809	0.392	0.494	0.513	0.437	0.493	0.141	0.178	0.185	0.158	0.178
Byas	0.316	0.309	0.648	0.335	0.461	0.548	0.572	0.503	0.558	0.086	0.103	0.107	0.094	0.104
Dunhu	0.156	0.226	0.415	0.489	0.461	0.548	0.572	0.503	0.558	0.062	0.074	0.077	0.068	0.075
Naugad	0.29	0.291	0.45	0.511	0.461	0.548	0.572	0.503	0.558	0.121	0.144	0.15	0.132	0.146
Apihimal	0.277	0.204	0.402	0.483	0.461	0.548	0.572	0.503	0.558	0.109	0.13	0.135	0.119	0.132
Marma	0.312	0.321	0.448	0.538	0.461	0.548	0.572	0.503	0.558	0.137	0.163	0.17	0.149	0.166
Malikaarjun	0.294	0.404	0.495	0.564	0.461	0.548	0.572	0.503	0.558	0.135	0.161	0.168	0.148	0.164
Lekam	0.251	0.331	0.432	0.562	0.461	0.548	0.572	0.503	0.558	0.115	0.137	0.143	0.126	0.139
Dilasaini	0.385	0.618	0.443	0.797	0.507	0.601	0.629	0.556	0.621	0.275	0.326	0.341	0.302	0.337
Dogadakedar	0.411	0.627	0.467	0.781	0.507	0.601	0.629	0.556	0.621	0.288	0.341	0.357	0.316	0.353
Surnaya	0.297	0.45	0.431	0.665	0.507	0.601	0.629	0.556	0.621	0.177	0.21	0.22	0.194	0.217
Pancheshwar	0.279	0.421	0.443	0.628	0.507	0.601	0.629	0.556	0.621	0.157	0.186	0.195	0.172	0.192
Shivanath	0.251	0.358	0.39	0.626	0.507	0.601	0.629	0.556	0.621	0.141	0.167	0.175	0.155	0.173
Sigas	0.401	0.509	0.415	0.731	0.507	0.601	0.629	0.556	0.621	0.263	0.312	0.326	0.288	0.322
Nawadurga	0.304	0.465	0.495	0.616	0.499	0.586	0.611	0.555	0.618	0.165	0.194	0.202	0.184	0.205
Ajaymeru	0.274	0.418	0.494	0.577	0.499	0.586	0.611	0.555	0.618	0.14	0.164	0.171	0.155	0.173
Bhageshwar	0.28	0.373	0.468	0.563	0.499	0.586	0.611	0.555	0.618	0.139	0.163	0.17	0.155	0.172
Alital	0.369	0.486	0.491	0.638	0.499	0.586	0.611	0.555	0.618	0.208	0.244	0.254	0.231	0.257
Ganayapdhura	0.336	0.522	0.475	0.684	0.499	0.586	0.611	0.555	0.618	0.203	0.238	0.248	0.226	0.251
Purbichauki	0.362	0.524	0.423	0.735	0.478	0.573	0.604	0.527	0.59	0.225	0.27	0.284	0.248	0.278
Sayal	0.289	0.399	0.408	0.643	0.478	0.573	0.604	0.527	0.59	0.157	0.188	0.199	0.173	0.194
Adharsha	0.341	0.491	0.432	0.698	0.478	0.573	0.604	0.527	0.59	0.201	0.241	0.254	0.222	0.248
K I Singh	0.326	0.512	0.384	0.762	0.478	0.573	0.604	0.527	0.59	0.21	0.252	0.265	0.232	0.259
Bogtan	0.364	0.591	0.357	0.855	0.478	0.573	0.604	0.527	0.59	0.263	0.315	0.333	0.29	0.325

Badikedar	0.377	0.532	0.374	0.789	0.478	0.573	0.604	0.527	0.59	0.252	0.302	0.318	0.277	0.31
Jorayal	0.497	0.722	0.409	0.918	0.478	0.573	0.604	0.527	0.59	0.386	0.462	0.488	0.425	0.476
Ramaroshan	0.406	0.476	0.359	0.756	0.449	0.546	0.576	0.5	0.563	0.244	0.296	0.313	0.271	0.306
Mellekh	0.373	0.5	0.377	0.759	0.449	0.546	0.576	0.5	0.563	0.225	0.273	0.288	0.25	0.282
Chaurpati	0.396	0.576	0.37	0.83	0.449	0.546	0.576	0.5	0.563	0.261	0.317	0.335	0.291	0.327
Bannigadhi Jayagadh	0.237	0.352	0.257	0.749	0.449	0.546	0.576	0.5	0.563	0.141	0.171	0.181	0.157	0.177
Dhakari	0.364	0.48	0.305	0.811	0.449	0.546	0.576	0.5	0.563	0.234	0.285	0.301	0.261	0.294
Turmakhad	0.446	0.583	0.326	0.878	0.449	0.546	0.576	0.5	0.563	0.311	0.378	0.399	0.346	0.39
Mohanyal	0.366	0.635	0.611	0.649	0.531	0.618	0.647	0.587	0.652	0.223	0.26	0.272	0.247	0.274
Chure	0.484	0.62	0.539	0.706	0.531	0.618	0.647	0.587	0.652	0.321	0.374	0.391	0.355	0.394
Bardagoriya	0.384	0.562	0.532	0.663	0.531	0.618	0.647	0.587	0.652	0.239	0.278	0.291	0.264	0.294
Janaki	0.33	0.519	0.632	0.53	0.531	0.618	0.647	0.587	0.652	0.164	0.191	0.2	0.182	0.202
Joshipur	0.413	0.548	0.56	0.624	0.531	0.618	0.647	0.587	0.652	0.242	0.282	0.295	0.268	0.297
Kailari	0.628	0.73	0.613	0.729	0.531	0.618	0.647	0.587	0.652	0.43	0.501	0.524	0.475	0.528
Laljhadi	0.327	0.382	0.527	0.514	0.531	0.618	0.64	0.581	0.654	0.158	0.184	0.19	0.173	0.194
Beldandi	0.272	0.399	0.518	0.538	0.531	0.618	0.64	0.581	0.654	0.137	0.16	0.166	0.15	0.169