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Vulnerability and Adaptation Assessment of Climate Sensitive Diseases and Health Risks in Nepal

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Acknowledgment

I am pleased to inform that the Ministry of Health and Population (MoHP) has carried out a Vulnerability and Adaptation (V&A) assessment of Climate Sensitive Diseases (CSDs) and health risks in Nepal. In Nepal, climate change has been affecting several sectors including health, water, sanitation and hygiene, and many others. The health sector has witnessed direct and indirect impacts and increased dengue cases in recent years in the country is another example. There are several Climate Sensitive Diseases (CSDs) and many of them are emerging in new areas. This report contains an assessment of climate sensitivity, risks, vulnerability, and potential adaptation methods to support decision making for essential planning in addressing those CSDs. This report provides the novel V & A assessment of CSDs in Nepal. It is updating of earlier VAA of health sector conducted in 2015 with WHO support and is also in line with MoHP's commitments made at COP26 in 2021.

I am grateful to the Department of Health Services (DoHS), Disease Surveillance and Research section of Epidemiology and Disease Control Division (EDCD), Health Management Information System (HMIS) of Management Division, Vector-Borne Disease Research and Training Center (VBDRTC), Nepal Health Research Council (NHRC), Department of Hydrology and Meteorology (DHM) and Central Bureau of Statistics (CBS), for providing necessary data and technical inputs for this study.

My gratitude goes to all the members of the Technical Working Group (TWG), stakeholders, and experts who provided constructive recommendations to improve the quality of this study. I thank Dr. Samir Kumar Adhikari, Senior Health Administrator of the MoHP for the coordination at various levels. I would like to thank the World Health Organization (WHO) Nepal for providing the required financial and technical support. The WHO-Nepal office team's effort - Er. Raja Ram Pote Shrestha, Dr. Manish Baidya and Mr. Upendra K.C. are well appreciated in terms of providing specific technical inputs and coordination within and beyond health sector. I am also grateful to Dr. Meghnath Dhimal of the NHRC for his technical advice and useful feedback.

Last but not least, I would like to acknowledge the contribution of Dr. Yadav Prasad Joshi, Dr. Uttam Babu Shrestha, Dr. Suraj Bhattrai, and entire study team of Global Institute for Interdisciplinary Studies (GIIS) for providing technical inputs for this assessment.

Finally, I expect this V&A assessment will be extremely useful in decision-making and as well as in addressing the health burden of CSDs in Nepal.

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(Dr. Roshan Pokhrel)
Secretary

Abbreviations

ACCESS	Australian Community Climate and Earth System Simulator
AGE	Acute Gastro Enteritis
AOD	Aerosol Optical Depth
AR	Assessment Report
CDD	Consecutive Dry Days
CM	Coupled Model
CMIP	Coupled Model Intercomparison Project
COVID-19	Coronavirus disease
CSDs	Climate Sensitive Diseases
DHM	Department of Hydrology and Meteorology
DoHS	Department of Health Services
DPNet	Disaster Preparedness Network
EDCD	Epidemiology and Disease Control Division
EWARS	Early Warning and Reporting System
FBD	Food-Borne Diseases
FCHV	Female Community Health Volunteers
GCMs	General Circulation Models
GEOS	Goddard Earth Observing System
GIIS	Global Institute for Interdisciplinary Studies
GIS	Geographic Information System
HMIS	Health Management Information System
IPCC	Intergovernmental Panel on Climate Change
JE	Japanese Encephalitis
MAIAC	Multi-Angle Implementation of Atmospheric Correction
MISR	Multi-angle Imaging Spectroradiometer
MODIS	Moderate Resolution Imaging Spectroradiometer
MoFAGA	Ministry of Federal Affairs and General Administration
MoFE	Ministry of Forests and Environment
MoHA	Ministry of Home Affairs
MoHP	Ministry of Health and Population
NAPA	National Adaptation Programme of Action
NASA	National Aeronautics and Space Administration
PM	Particulate Matter
SARI	Severe Acute Respiratory Illness
SSP	Shared Socioeconomic Pathway
TWG	Technical Working Group
V&A	Vulnerability and Adaptation Assessment
VBD	Vector-Borne Disease
VRA	Vulnerability and Risk Assessment
WaSH	Water, Sanitation and Hygiene
WBD	Water-Borne Disease
WHO	World Health Organization

Executive Summary

Globally, including in Nepal, climate change poses profound impacts on human health and wellbeing. The risks of vector, water - and food-borne diseases, respiratory infections, undernutrition, and mental illness has escalated. The most vulnerable and disadvantaged communities, such as women, the elderly, children, ethnic minorities, those who are disabled, and those who are destitute and displaced are disproportionately affected by climate-sensitive diseases (CSDs) and health risks. The elevated risk of CSDs is attributed to factors such as rising occurrences of climate induced-hazards and climatic extremes; increased exposure and sensitivity to these hazards and extremes; and lower adaptive capacity. In consideration of this, the Ministry of Health and Population (MoHP) has conducted a vulnerability and adaptation (V & A) assessment of climate-sensitive health outcomes and risks. This assessment is being supported by World Health Organization (WHO).

This V&A assessment was conducted based on the recommended framework by the WHO and the Intergovernmental Panel on Climate Change (IPCC). Eight steps were followed to complete the assessment, i.e. i) planning for V & A; ii) identifying and prioritizing climate-sensitive health outcomes; iii) identifying vulnerable geographies and populations to recent climate change; iv) documenting baseline information for monitoring changes in future vulnerability; v) assessing capacity of health and health-relevant systems; vi) projecting future health risks of climate; vii) identifying prioritized policies, programs, and adaptation measures; and viii) synthesizing the assessment. In order to identify the variables of indicators, such as risk, exposure, sensitivity, and adaptive capacity, relevant data exploration, collection, tabulation, and filtration were first carried out. After normalizing the indicator values, district-level composite values of vulnerabilities and risks were computed. To identify vulnerable population, a qualitative assessment was done. The ten components of WHO's operational framework for building climate-resilient health systems were applied to identify the priority-based adaptation options for reducing the impacts of climate-induced hazards and related health risks.

To assess the current vulnerability and future risks, the temporal trends of historical climate, climatic extremes, climate-induced hazards, and future climate scenarios relevant to CSDs have been analyzed. This assessment took into account climatic data from 1980 to 2020 for temporal trends of historical climate. Annual disease data and climate-related hazard information were considered from 2004 to 2020, while monthly disease data from 2017 to 2022 were considered to assess seasonality. To arrive at conclusions and recommendations that are pertinent to policy, a qualitative examination of the institutional capacity of the health system and thorough policy assessments were conducted.

Climate sensitive health outcomes, key concerns, and challenges: Based on an extensive literature review, altogether 12 CSDs were considered for climate sensitive health outcomes. Seven Vector borne diseases (malaria, kala-azar, Japanese encephalitis, scrub typhus, dengue, zika, chikungunya), two food and water borne diseases (cholera and acute gastroenteritis), one respiratory disease (severe acute respiratory infections), and two other climate sensitive diseases (undernutrition and mental illness) were considered. Countrywide, the baseline status from 2005 to 2020 demonstrates steady reduction of Malaria and Kala-azar, however, cases were detected in

new locations, such as the non-native highland areas. Over the past decade, Malaria cases have increased in six new Hill districts (Dailekh, Gulmi, Lamjung, Nuwakot, Pyuthan, Salyan) and four new Mountain districts (Bajura, Dolakha, Humla, Mugu) locations. Likewise, Kala-azar reported cases are also rising, as eight new Hill districts (Achham, Jajarkot, Khotang, Nuwakot, Palpa, Salyan, Surkhet, Western Rukum) and two new Mountain districts (Bajura, Sankhuwasabha) reported Kala-azar over the past decade. It is possible that indigenous vector expansion or disease import from the neighboring country are to blame for the geographic spread of Vector-Borne Diseases (VBDs) into highlands, which would make disease control more challenging.

Since 2005, dengue cases have been documented in Bhojpur and Rautahat between 2013 and 2020, subsequent major outbreaks have been reported in Bhaktapur, Jhapa, Kaski, Kathmandu, Chitwan, and Rupandehi. In 2019/2020, there were 22,382 cases of dengue – a historic increase. Japanese encephalitis cases remained static in most of the districts, except frequent outbreaks in Tarai - Morang during 2005-2012 and in Chitwan and Rupandehi during 2013-2020. Scrub typhus cases have been sporadically reported in all geographical regions of Nepal, with more than 100 cases in Baitadi, Gulmi, Palpa, Dhading, Darchula, Dolakha, Kalikot, Kailali and Rupandehi between 2019-2021. In the districts of Dhading, Dang, Kanchanpur, and Parsa, sporadic reports of Chikungunya infections have been discovered. Although Nepal has not officially reported Zika cases yet, a small number of zika cases have been recorded in the Tarai districts of Nepal-India border region, indicating the high risk of Zika.

Cholera were mostly reported from the several Tarai districts, whereas, cholera outbreaks of significant proportions has sporadically occurred in Hill and Mountain regions during last decade, including Ramechap (2008-2010), Jajarkot (2008), Okhaldhunga (2009, 2011), and Kathmandu valley (2010-2011). Acute gastroenteritis (AGE) cases have drastically increased in the past decade, with majority of cases cases being reported from Tarai districts of Chitwan, Kapilvastu, Morang, Rupandehi, Saptari, and Siraha. The prevalence of undernutrition was significant in Hill (Kaski, Kathmandu, Lalitpur), Mountain (Jumla, Mugu), and Tarai (Kanchanpur, Kapilbastu, Mahottari, Morang), despite a sharp decline in national undernutrition cases from 31,000 per year in 2012-2018, to 20,830 cases in 2020. Large numbers of severe acute respiratory illness (SARI) cases were reported in Hill and Mountain districts in 2005-2012. In the years after 2012, SARI cases spread to all three geographical regions with recent outbreaks recorded in Manang, Chitwan, and Morang. Less than 6,585 instances of mental illness were reported in 2006, but this figure quickly rose and reached a peak of over 110,000 cases in 2015.

Cases of VBDs exhibit seasonality. While dengue and scrub typhus cases are their highest in August, September and October; malaria cases are at their highest in July, August and September. Dengue and scrub typhus cases rise with a drop in mean temperature and precipitation, but malaria cases rise with maximum rainfall and precipitation. The Tarai region had the largest concentration of cases of malaria (64%), and kala-azar (94%) whereas, Hill region had the highest concentration of cases of dengue (52%) and scrub typhus (44%). There are variations in the occurrences of cholera and AGE cases in three different geographic locations according to climatic conditions. While Cholera cases peak in April, July, and December; AGE cases increase in July, August, and September. In Tarai, there were more instances of cholera (66%) and AGE (47%) than elsewhere. Similar seasonal variations can be seen in influenza and SARI, with July, August and September seeing the highest number of cases. According to trends, SARI and influenza cases rise as the temperature and precipitation drop. More instances of both infections (influenza: 43% and SARI: 44%) were observed in the Tarai region.

Climate change, climate extremes and climate-induced hazards: From 1980 to 2020, Nepal's annual mean temperature rose by 0.02°C/year (p=0.0005). The annual maximum temperature climbed by 0.03°C/year during the same period, while there was no noticeable change in annual minimum temperature. From 1980 to 2020, Nepal had a substantial drop in annual precipitation at a rate of -4.8mm/year. While frost days have significantly decreased in the majority of Hill's districts, four extreme temperature indices: hottest daytime temperature, the coolest day temperature, the hottest nighttime temperature, and the coolest night temperature - showed a significant increase. In Hill regions, the frequency of hot night significantly increased while the frequency of cold day was significantly decreased. The frequency of both droughts and heavy precipitation have increased significantly in majority of Hill and Tarai areas. Over the past 41 years, the frequency and impacts of climate-induced hazards - floods, landslides, and fires have increased mostly in Hill and Tarai regions. Seventeen districts from Tarai and Hill namely: Banke, Bara, Dhading, Dhanusha, Jhapa, Kailali, Kaski, Kathmandu, Mahottari, Makawanpur, Morang, Rautahat, Rupandehi, Saptari, Sarlahi, Sunsari, and Taplejung, had a high level of climate-induced multiple hazards.

Climate change exposure, sensitivity, and adaptive capacity: Climate change exposure does have potential of health impacts. The Tarai region's Morang, Hill region's Bhaktapur and Makwanpur, and the Mountain region's Sindhupalchowk had the highest exposure scores towards climate change. High sensitivity to climate change increases the vulnerability to CSDs. The highest sensitivity among the 77 districts was found in Morang of Tarai, Kathmandu of Hill, and Bajura of Mountain region. Lower adaptive capacity is linked to higher CSDs vulnerability. Nawalpur and Kpailvastu in the Tarai, Western Rukum in the Hills, and Mugu in the Mountains scored the lowest for adaptive capacity. While Chitwan in Tarai, Kaski in Hill, and Dolakha in Mountain region were determined to have the highest adaptive potential.

Climate change vulnerability and risks: Vulnerability is the function of exposure, sensitivity, and adaptive capacity. Vulnerability scores were calculated considering the sensitivity, exposure, and adaptive capacity of districts for responding to or coping with climatic variability, and extremes. Based on the vulnerability scores, Saptari in Tarai, Western Rukum in Hill, and Humla in the Mountain region had the highest vulnerability while Chitwan in the Tarai region; Kavre in Hill region; and Myagdi in the Mountain region had the lowest vulnerability. Nine districts in Tarai (Dang, Dhanusha, Kailali, Kanchanpur, Kapilvastu, Mahottari, Saptari, Sarlahi, and Siraha); one in Hill (Salyan), and five in Mountain (Bajhang, Bajura, Humla, Kalikot, Mugu) had a high vulnerability to CSDs such as vector-borne, water-borne/food-borne, severe acute respiratory infection, malnutrition and mental illness. Saptari in Tarai, Western Rukum in Hill, and Bajhang in the Mountain region had the highest vulnerability of dengue, scrub typhus, chikungunya and zika. There are 30 districts with a high risk of dengue, 29 to scrub typhus, and 28 to Chikungunya and Zika each. The climate crises have a disproportionate impact. Climatic variability and extremes increase the health inequality gaps and put additional stress on the most vulnerable populations including women, children, the elderly, lesbian-gay-bisexual-transgender-queer-intersexed community (LGBTQI), indigenous people, and marginal and poor communities in Nepal.

Baseline and future health risks to climate change and extremes: Risk is the function of hazards and vulnerabilities. The baseline risk scores showed that nine districts (Banke, Bara, Dhanusha, Kailali, Mahottari, Morang, Rautahat, Saptari, and Sarlahi) had the high risk while 19 districts had medium, and 49 districts had low risks.

The district-wise future climate risks were analyzed using 14 different climate indicators under two scenarios (SSP2-4.5 and SSP5-8.5) for three different periods (2040, 2060, and 2100). In both scenarios, the average number of districts with a significant increase in extreme events increased in three periods. In the SSP2-4.5 (moderate) scenario, the average number of districts with significant changes in all extreme climate indicators was 5 in 2040, 9 in 2060, and 9 in 2100 while the number of districts with significant changes in all extreme climate indicators under SSP5-8.5 (extreme) scenario was 7 in 2040, 8 in 2060 and 12 in 2100. In future, there will be a significant increase in temperature and frequency of hot days and hot nights in the majority of the districts. From 2040 to 3100, and from a moderate (SSP2-4.5) to high (SSP5-8.5) climatic scenario, the number of districts and extreme indicators will cascade upward. This will potentially increase the morbidity and mortality of climate-sensitive health outcomes and enhance disease risks as those extreme climate indices aggravate climate-induced hazards and health burdens.

Adaptation assessment: The Government of Nepal has developed number of policies and initiatives as health adaptation measures to address the impacts of climate change on human health. The National Health Policy (2019) has strategies to address the environmental issues on human health. The National Climate Change Policy (2019) prioritizes preparedness, forecasting, preventive measures, and early-warning systems for the reduction of climate-induced disasters as well as their impact on human health. Similarly, establishing a multi-sectoral approach to climate change is also stressed in the Nepal Health Sector Strategy (NHSS) (2015-2020). The National Adaptation Plan (2021-2050), the Second Nationally Determined Contribution (NDC 2020), and the Health National Adaptation Plan (H-NAP 2017-2021), all place a priority on reducing vulnerability, improving adaptation strategies, and creating climate-resilient health systems. Different line ministries have identified and developed a variety of national policies, programs, and measures as adaptation options to address current and future health vulnerabilities and risks related to climate; however, the implementation aspect is weak and slow. Additionally, there is a lack of consistency and alignment across the ministries' efforts. Building climate-resilient health systems based on the WHO's six building blocks is a national priority, but there isn't a clear path to get there. The inadequate physical and human resource capability of national and sub-national health systems is a significant barrier to efforts by government and non-government players to adapt and build resilient health systems.

In conclusion, climate change and extreme weather have exacerbated climate-related hazards in Nepal and will continue to do so in future with a much bigger impact on burden of CSDs, disruption of the health system, and increasing health risks. Future climate change will make all three geographical regions vulnerable, with Tarai and Mountian districts particularly at risk for morbidity and mortality related with VBDs including dengue, scrub typhus, chikungunya, and zika. Whereas the significant increase of AGE in Tarai and widespread of SARI should also be carefully taken into account. Some of the immediate actions suggested by this assessment for a climate resilient health system includes - creating and implementing a climate-informed disease surveillance system, encouraging activities to fill in data gaps, recurring assessment of climate-health vulnerabilities and risks among vulnerable population of various geographical regions, and facilitating capacity building and resource mobilization. Decision-making for minimizing the impact of climate change on human health could be aided by strengthening institutional capacity at all three levels of government to analyze and monitor vulnerabilities and health hazards.

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1. Introduction

Human influence has unequivocally changed Earth's atmosphere, ocean, cryosphere, and biosphere (IPCC, 2021). Earth's climate is changing, with rising surface temperatures, melting ice and snow, rising sea levels, changes in land's biosphere and increasing climate variability. These changes are expected to have substantial impacts on human health and wellbeing. Climate change, together with other natural and human-made health stressors influences human health and disease in numerous ways, ranging from deaths in extremely high temperatures to changes in the patterns, impacts, and distributions of various diseases (Frumkin et al., 2008; IPCC, 2014). Globally, climate change aggravates the stress over public health systems (WHO, 2012). As a result, the leading cause of morbidity and mortality worldwide is now climate-sensitive health outcomes (Kovats et al., 2003; Ebi and Hess, 2020). The distribution of climate-sensitive health outcomes, such as food- water- and vector-borne diseases, acute to chronic respiratory illness, malnutrition, mental health problems, injury and mortality from weather events, and heat-related illness such as hyperthermia, heatstroke, heat exhaustion, heat syncope, heat cramps, and heat rash, has changed due to altered the intensity, frequency, seasonality, and extremes of global to local weather patterns - climate change (Campbell et al., 2018). In addition, heat waves can exacerbate high blood pressure related health problems, which can lead to cardiovascular disorders (Nahian et al., 2017).

Extreme temperatures are predicted to spread deadly tropical diseases to higher latitudes and low lands to higher altitudes affecting a greater population, especially the vulnerable populations (IPCC, 2014). Climate change promotes the mobility of arthropod vectors and hosts to new areas, leading to geographic expansion and seasonal variations in infectious diseases that are emerging and re-emerging (Bongaarts, 2019). With warming of 1.5°C to 2°C, the risks from various Vector-borne diseases (VBDs), such as malaria, kala-azar, dengue, and scrub typhus, are expected to rise along with the potential shifts in their geographical and altitudinal ranges (Mweya et al., 2016; Ebi et al., 2018; Dhimal et al., 2014a). Likewise, heavy precipitation events can wash away breeding grounds temporarily reducing the number of malaria-transmitting *Anopheles* mosquitoes in endemic areas, however the wash away may also provide mosquito breeding habitats in places where mosquitoes and malaria were previously uncommon. Similarly, the epidemic potential and environmental suitability for transmission of arboviruses (dengue, Chikungunya and Zika) have increased due to the influence of temperature and rainfall (Romanello et al., 2021; Caminade et al., 2016). The rise in temperature and precipitation also facilitates the spread of Water-borne diseases (WBDs) such as acute gastroenteritis (AGE) and cholera (Romanello et al., 2021). Moreover, climate change alters the environment's ability to accommodate spread of infectious disease, disrupts health infrastructures and services, and undermines people's wellbeing and livelihood across the life course and settlements (Romanello et al., 2021). Further, the pattern of health outcomes and various aspects of health systems have indeed been affected by climate change (IPCC, 2021; MoPE, 2017a).

According to the Global Climate Risk Index 2021, Nepal is one of the most climate-vulnerable countries in the world, the country is ranked 12 out of 180 (Eckstein et al., 2021). Climate change and variability are deemed the major public health threats to Nepal. Major climate-sensitive diseases (CSDs) and health risks in Nepal include VBDs, diarrhoeal diseases including cholera, malnutrition, cardiorespiratory diseases, and mental health problems (Dhimal and Bhusal, 2009). The unprecedented food scarcity has led to nutritional deficits in women and children (MoFE, 2021a). The extreme weather-related health impacts such as heatwave or heat stress and cold wave also affects the health and well-being of Nepalese – specially in Tarai region (MoPE, 2017b). For instance, extreme weather events have affected pregnant women, children, the elderly, migrants, outdoor workers, poor farmers (landless, groups with smaller landholding sizes and those living near riverside), marginalized populations (Mushar, Tharu, Dalit), and indigenous people (whose livelihood depended on fishing, non-timber forest products collection, etc.). Moreover, climate-induced hazards such as flash floods and landslides frequently damage health infrastructures including water-sanitation facilities and disrupt public health systems in Nepal (IFRC, 2021). These hazards disproportionately affect the poor, vulnerable, and marginalized populations (MoHA and DPNet, 2009; Dhimal et al., 2021).

Building climate-resilient health systems is a national priority, however, several challenges exist in the effective implementation of plans, policies, strategies, and programs (Dhimal et al., 2017). There is limited evidence and understanding regarding institutional capacities required for the preparedness and response to climate-induced impacts on the country's health systems in various geographic regions. In this regard, it is crucial for Nepal to assess Vulnerability and Adaptation (V & A) for Climate Sensitive Diseases (CSDs) and identify appropriate health adaptation measures. Likewise, it is essential to make an assessment of future health risks due to rapidly changing climate in order to raise awareness of potential climate-induced health risks. Therefore, the findings of 2015 on health sector V & A assessment of climate variability - which was carried out by the Ministry of Health and Population (MoHP) with the support of the World Health Organization, have been updated by this V & A assessment of CSDs. This assessment is a complementary document to the previous health sector Vulnerability and Risk Assessment (VRA) report of the Ministry of Forests and Environment (MoFE, 2021a), as it analyzes the specific climate-sensitive health outcomes - selected based on the rising burden of emerging and re-emerging diseases, their epidemic potential, and geographical expansion. Furthermore, the findings of this assessment will guide for the formulation and process of updating Health National Adaptation Plans (H-NAP) as well as MoHP's upcoming National Health Sector Strategy (NHSS, 2023-2030).

2. Objectives

The overall objective of this study is to conduct the vulnerability and adaptation assessment of climate sensitive diseases (CSDs) and health risks in Nepal.
The specific objectives are:

- To identify CSDs and health risks covering all three geographical regions of Nepal
- To assess the risks of current climate variability on human health in Nepal
- To analyse the trends in climate change related exposures in health sector in Nepal
- To assess the current risks of climate-sensitive health outcomes in the most vulnerable populations in Nepal

- To review the current institutional capacity of health and other sectors to manage the risks of climate-sensitive health outcomes in Nepal
- To identify appropriate adaptation options including national needs and priorities as a way forward to reduce the impact of climate change in health sector
- To update health sector V & A assessment as appropriate with due consideration of changed context
- To analyse existing national policies and programs in health sector from a climate change and health perspective

3. Framework for the assessment

The key approach of V & A assessment for CSDs is for identification, preparedness, and response to health risks. It enables country's public health authorities to develop adaptation strategies in order to manage current risks and vulnerabilities and reduce the future risks of climate change on human health (Yu et al., 2021). Finding adaptation alternatives and resources is crucial for prioritizing appropriate options for minimizing and effectively managing health risks associated to climate change and for detecting shortcomings in current and planned initiatives (WHO, 2015). This V & A assessment primarily followed the framework developed by the World Health Organization (WHO, 2021), and the fourth and fifth Assessment Reports (AR4 & AR5) of the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2007; IPCC, 2014). The assessment process has six steps: i) assessment planning, ii) vulnerability assessment, iii) capacity assessment, iv) future risk assessment, v) adaptation assessment, and vi) synthesize the assessment.

The main focus of this assessment is to identify vulnerable districts and regions and populations considering a variety of biophysical and socioeconomic factors that shape both vulnerabilities and risks to CSDs. The concepts of vulnerability and risk adopted in this study are based on the IPCC AR4 and IPCC AR5. The IPCC defined the health risks from climate change are the function of interactions between exposures to climate-related hazards, sensitivity, vulnerabilities of exposed population and natural systems, and adaptive capacity of the health systems to manage risks (IPCC, 2007; IPCC, 2014) (Figure 1).

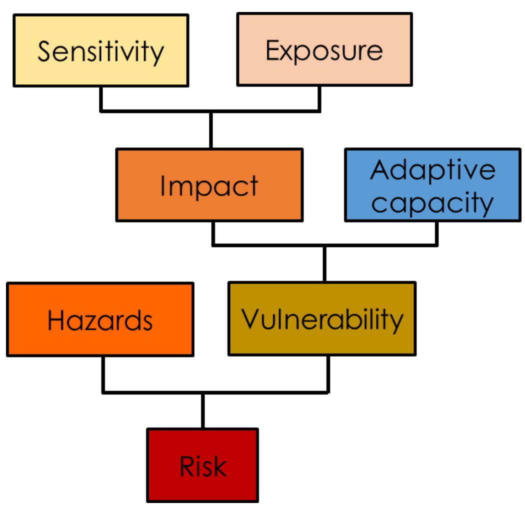

Figure 1. Conceptual framework of vulnerability and risk (Modified from IPCC AR4 and IPCC AR5).

3.1. Scope of assessment

The scope of vulnerability and adaptation assessment considered assessment at different district, and physiographic regions. Assessment of current vulnerability and future risks was the main scope of the assessment for which understanding were required on the context of a) geographical feature, b) temporal trends of historical climate, c) climate extremes, climate-induced hazards, d) future climate relevant scenarios, e) climate sensitive diseases. The operational framework for V& A assessment by WHO and IPCC AR5 and AR5 framework was a key starting point of this assessment.

a. **Geographical features:** After the state's reconstruction of administrative divisions, there are seven provinces and 77 districts in Nepal. The country has three ecological zones viz, Terai, Hills, and Mountains across different elevation. Therefore, 77 districts and three eco-regions were considered as the geographical scope for this assessment.

b. **Historical climate data:** Temperature and precipitation are the two main parameters observed for historical changes of climate in Nepal. Thus, for assessing historical climate change in Nepal, this assessment considered these two parameters since 1980 to 2020. Daily minimum and maximum temperature data from 104 weather stations and daily precipitation data from 79 weather stations were assessed. However, only 26% and 58% of weather stations had complete temperature data and precipitation data, respectively for the period of 41 years. Around 17% of weather stations did not have daily temperature data no longer than 10-year period, while 5% of stations did not have daily precipitation data no longer than 10-year period. Nevertheless, the weather data utilized in this assessment shall be considered comparatively superior, as it covered more weather stations (93 vs 104 stations) and more recent period (1971 to 2014 vs 1980 to 2020) than that of previous studies.

c. **Climate extremes and climate induced hazards:** World Meteorological Organization (WMO) suggests 27 climate extreme indices among which, 14 indices were found relevant for climate sensitive health outcomes in Nepal. Thus those 14 indices were utilized for the assessment. Among 14 climate extreme indices – eight are for temperature extremes, and six are for precipitation extremes (Table 2). Temporal trends of those 14 extreme indices from the year 1980 to 2020 at district level were calculated using daily data of temperature (maximum and minimum) and precipitation. Incidences and impacts of multiple hazards (avalanche, cold wave, heat wave, epidemic, fire, flood, landslide, forest fire, snowstorm, storm, and heavy rainfall) were aggregated and ranked to produce district-level multi-hazard maps. The district-level disaggregated incidences and climate induced impact data were collected from various sources like DesInventar and Building Information Platform Against Disaster (BIPAD) portal from the period 2004 to 2020. Impact data comprises numbers of human deaths, injuries, missing, and households affected and destroyed.

d. **Future climate extremes, and risks:** Shared Socio-economic Pathway (SSP) i.e., SSP 2-4.5 and SSP 5-8.5 scenarios adapted from IPCC sixth assessment report (AR-6) were utilized for three periods: 2040, 2060, and 2100, to predict future changes in extreme climatic indices and the possible additional burden of adverse health outcomes. SSP 2 – 4.5 is a moderate scenario that predicts an increase of temperature by 2.0°C in 2041-2060, 2.7°C in 2081-2100, and 2.1–3.5°C in 2081-2100 whereas, SSP5-8.5 is an extreme scenario that predicts an increase of temperature by 2.4°C in 2041-2060, 4.4°C in 2081-2100 and 3.3–5.7°C in 2081-2100. The district-wise future climate risks were analyzed using 14 climate indices under two scenarios (SSP2-4.5 and SSP5-8.5) for three different periods (2040, 2060, and 2100).

e. **Climate sensitive diseases:** The disease that emerge and re-emerge throughout various time periods with direct or indirect link with climate change and variability were regarded as climate sensitive diseases. Based on the recent disease burden in the country altogether 12 CSDs – seven vector borne diseases (malaria, kala-azar, Japanese encephalitis, scrub typhus, dengue, zika, chikungunya), two food and water borne diseases (cholera and acute gastroenteritis), one respiratory disease (severe acute respiratory infections), and two other climate sensitive diseases (undernutrition and mental illness) were considered. Annual disease data of the period of 2004 to 2020 from the Department of Health Services' (DoHS) annual report were taken into consideration for the assessment of health outcomes and vulnerability. Whereas, to assess seasonality, monthly disease data from Health management Information System (HMIS) from 2017 to 2022 were considered.

4. Assessment planning

In the context of Nepal, the V & A assessment determines the climate-related vulnerabilities of specific geographic areas at the level of three physiographic regions (Tarai, Hill, and Mountain) and 77 districts. Climate data from 1980 to 2020 was used to analyse trends in average and extreme climatic parameters. For future climate, analysis of extreme events and associated risks were conducted using the two Shared Socioeconomic Pathway (SSP) scenarios, i.e., SSP2-4.5 and SSP5-8.5 to project possible changes by 2040, 2060 and 2100. SSP2-4.5 is an intermediate and most likely Greenhouse gas (GHG) emission scenario in which CO_2 emissions remain around current levels until 2050, then falling but not reaching net zero by 2100 whereas SSP5-8.5 is a fossil fuel development pathway and very high GHG emission scenario in which CO_2 emissions triple by 2075. Similarly, the assessment includes altogether 12 CSDs belonging to the four different disease categories based on the recent disease burden in the country, particularly emerging and re-emerging diseases at national and sub-national levels. In this report, district-level annual CSD incidences of the last 16-year period (from 2005 to 2020) were collected from the Department of Health Services (DoHS) to define sensitivity, health risks, and outcomes. The assessment includes socio-demographic information regarding CSDs, and available gender-related disaggregated data. The vulnerabilities and risks of districts and physiographic regions were categorized into high, medium and low categories. The information available in national policies, reports, and web portals of government organizations was used for the assessment of adaptation capacity, institutional capacity and analysis of policies and programs.

Climate hazard, exposure, sensitivity, adaptive capacity, and vulnerability are the essential elements that must be established for the V&A assessment. The considerations taken into account defining those important elements for this assessment are listed below.

Climate hazard: The climate-related health hazards for CSDs identified and utilized for this assessment were temperature extremes (heatwave and cold wave), heavy precipitation, floods, landslides, avalanche, snowstorms, storms, fire, forest fires and air pollution (unhealthy concentration of $PM_{2.5}$). In 2019, air pollution caused 42,100 attributed annual deaths in Nepal (State of Global Air, 2020). Therefore, the annual presence of unhealthy air measured in terms of annual surface fine particulate matter (PM2.5) concentrations was considered as technical hazard in this assessment. Further, elevation is a major determinant for disease vector distribution in Nepal. The mean elevation of each district was calculated using digital elevation model (DEM) data gathered from the Shuttle Radar Topography Mission (STRM) (Farr et al., 2007). These hazards increase the likelihood of developing a disease or injury and can ultimately affect the frequency and spatial patterns with which the impacts of these hazards are observed at the population level (Yu et al., 2021).

Exposure: The climate change exposure indicators included the impacts of climate hazards on the total population and the number of health care and water-sanitation infrastructures such as hospitals, health posts, sub-health posts, private/nonpublic health institutions, medical stores, laboratories, water supply infrastructures, and services, drinking water supply schemes, and water treatment facilities.

Sensitivity: The sensitivity to climate change for CSDs is determined by the susceptibility to climate-induced hazards. Population characteristics particularly demographic, socio-economic, physical and altitudinal factors determine the degree of sensitivity to the population, and the resources exposed. The factors related to CSDs for example number of cases of malaria, dengue, Kala-azar, Japanese Encephalitis (JE), Cholera, Acute Gastroenteritis (AGE), Severe Acute Respiratory Illness (SARI), undernutrition below 5 years and mental illnesses such as cases of psychosis, anxiety and depression were included. The suitability scores of Zika and Chikungunya were also included as the exact data of those diseases were nonexistent in Nepal and yet the risks posed by those diseases are high.

Adaptive capacity: Adaptive capacity is related to the ability of populations to adjust to possible damage and respond to the consequence of climate impacts (IPCC, 2001) which focuses on the literacy rate, available water supply and sanitation resources and human resources in health care facilities, and access to free medicine and immunization coverage. The indicator selection prioritized the gender, governance, available resources, existing facilities, institutions, livelihood and access to information and technology that are considered to reduce vulnerability and enhance adaptation at the local level. Existing climate change policies and programs in health and other sectors were also analyzed. The sets of indicators were finalized after a review by the Technical Working Group (TWG).

Vulnerability: The vulnerability of any group is a function of its sensitivity to climate change-related health risks and its capacity for responding to or coping with climate variability and change. Both exposure and sensitivity are influenced by a wide range of social, economic, and cultural factors and processes. Individuals and communities are differentially exposed and vulnerable, and the vulnerability is based on factors such as wealth, education, race/ethnicity/religion, gender, age, class/caste, disability, and health status (Cardona et al., 2012).

The functional relationship (either direct/positive or inverse/negative) between indicators and vulnerability was identified. As the units of the indicators differ significantly, the indicators were normalized into a 0-1 scale using the min-max normalization method. The following formulas were used for analyzing vulnerability (IPCC, 2007), and risk (IPCC, 2014).

Vulnerability (V) = (exposure + sensitivity - adaptive capacity) ………………………….…. i
Risk (R) = (Hazard*Vulnerability) ………………………………………………….…ii

The disease-specific health risks for the historic climate were calculated, and health risks under future climate were predicted based on the future climate scenarios. A separate analysis for health risks was carried out for individual CSDs. The aggregated values of multi-hazards, exposure, sensitivity and adaptive capacity, vulnerability as well as disease-specific vulnerability under current and future climates were imported into Geographic Information System (GIS) environment for mapping and visualization across 77 districts and three regions (Hill, Mountain, and Tarai) of Nepal. The district-specific numerical values of multi-hazards, exposure, sensitivity, adaptive capacity, vulnerability, and risk were converted into three ordinal scales (High, Medium, and Low) using equal interval or standard deviation methods depending on the distribution of the data. The limitations of data, particularly data on health outcomes disaggregated by age and gender made it difficult to analyze quantitatively gender-specific effects of climate change on health outcomes.

The bias-corrected General Circulation Models (GCMs) for South Asia from Coupled Model Intercomparison Project-6 (CMIP-6) were used to describe potential changes in the current health risks under future climate scenarios (Mishra et al., 2020). This dataset provides daily bias-corrected data of precipitation and maximum and minimum temperatures at 0.25° spatial resolution for South Asia including Nepal. Out of 13 GCMs, and four future scenarios, only two future scenarios (SSP2-4.5, SPP5-8.5) of the GCM, ACCESS-CM2 were selected.

The shared socio-economic pathway, SSP2-4.5 is the middle-of-the-road scenario that predicts an increase of temperature by 2.0°C in 2041-2060; 2.7°C in 2081-2100; 2.1–3.5°C in 2081-2100 whereas, SSP5-8.5 is an extreme, fossil-fueled development scenario that predicts an increase of temperature by 2.4°C in 2041-2060, 4.4°C in 2081-2100 and 3.3–5.7°C in 2081-2100. The future changes in extreme climate and the possible additional burden of adverse health outcomes due to climate change were estimated.

4.1. Data for assessment

The VRA and Identifying Adaptation Options (MoFE, 2021a), Health National Adaptation Plan (MoHP, 2015a), V & A Assessment (MoHP, 2015b), National Adaptation Programme of Action (NAPA) (MoE, 2010), WHO report on quantifying the health impact and national and local levels (Campbell-Lendrum et al., 2007), and the AR5 of IPCC (IPCC, 2014) were the basis for identifying the most relevant hazards, exposure, sensitivity, and adaptive capacity indicators for this assessment. District-level data were gathered from various secondary sources such as government documents, periodic reports, policy documents, and documents released by line ministries and departments. The data from multiple sources were checked, validated, and authenticated. Priority was given to government data and published reports, which, inter alia, included data from the Department of Hydrology and Meteorology (DHM), Central Bureau of Statistics (CBS), Epidemiology and Disease Control Division (EDCD), Early Warning and Reporting System (EWARS), Health Management and Information System (HMIS), DoHS, and Ministry of Home Affairs (MoHA).

The data on incidences and impacts of climate-induced hazards such as avalanches, cold waves, epidemics, fire, floods, forest fires, landslides, snowstorms, heat waves and heavy rainfall were collected from various sources. For example, the district-level disaggregated incidences and impact data from 1971 to 2013 were collected from DesInventar (https://desinventar.net/) and from 2014 to 2021 were collected from the Building Information Platform Against Disaster (BIPAD) portal (https://bipadportal.gov.np/) of the National Disaster Risk Reduction and Management Authority (NDRRMA). Impact data comprises numbers of human deaths, injuries, missing, and households affected and destroyed. Therefore, a single value is necessary from the multiple values of different types of impacts for future analysis. To do so, the scoring process assigns scores ranging from 0 for no impact to 10 for highest impact (10 to human death, 5 to missing, 3 to injured, 1 to damaged household and 3 to household destroyed completely) following the methodology of Sharma et al. (2019). After scoring the impacts into a new value, a single impact value of multiple hazards was calculated. The hazard, exposure, sensitivity, and adaptive capacity indicators are given in annex 1. The district-level disaggregated data was compiled and grouped into a hazard, exposure, sensitivity, and adaptive capacity. A multi-collinearity test was carried out in each category to identify highly correlated variables. Highly correlated variables ($r>0.90$ or <-0.90) were dropped and the remaining 129 variables were used for final analysis. The composite value of hazard, exposure, sensitivity and adaptive capacity were calculated by aggregation of indicators. The mean annual concentration of PM2.5 was extracted from the global dataset (Hammer et al., 2020). This is generated by combining aerosol optical depth (AOD) from the NASA MODIS C6.1, MISR v23, MAIAC C6, and SeaWiFS satellite products and related to surface PM2.5 concentrations using geophysical relationships between surface PM2.5 and AOD simulated by the GEOS-Chem chemical transport model (Hammer et al., 2020). These estimates are subsequently calibrated to global ground-based observations of PM2.5 from the WHO using Geographically Weighted Regression (GWR). The spatial distribution of PM2.5 concentrations was classified into hazardous and non-hazardous categories based on the WHO guidelines. The area of a district with hazardous air and the annual number of hazardous air prevalent in a district were calculated for exposure.

4.2. Stakeholder consultation

Consultations across sectors, crosscutting areas, thematic working groups, government line agencies at all levels, civil society organizations, youths, women, indigenous groups, and other key stakeholders were held to validate and make the process acceptable to everyone. The majority of the material came from official sources, which the government recognized and gave credit to. For the V&A evaluation process, legitimate sources included national statistics as well as other data that had received government approval. To develop efficient adaptation strategies in the sector and its subsectors, consultations with relevant experts and stakeholders were held. In order to determine adaptation possibilities within the framework of the current risk and vulnerability, consultation at various levels was done. Stakeholders from both the center and the local level were consulted in order to make this process more inclusive and participatory. To verify the process and make it suitable for everyone, consultations were held with various sectors, crosscutting regions, thematic working groups, government line agencies at all levels, Civil Society Organizations, youths, women, indigenous groups, and other connected sectors. A variety of techniques were used for the consultation, including workshops, one-on-one sessions with experts, and interviews with relevant stakeholders. Information was also obtained by using various forms of communication, including the phone, Skype, and email. To validate the information learned through secondary sources, national consultations and field trips to particular local administrations were employed. The assessment's findings on climate-related health vulnerability were primarily discussed for the opinions of experts and interactions with important stakeholders.

The results of the consultation at various levels and the perspectives of the stakeholders suggested that Nepal's temperature has risen in all 7 of its provinces and at the local level, from the Terai area in the east to the mountainous mid-hills in the west. The majority of the stakeholders contacted claim that precipitation patterns have changed, and that monsoon weather and other occurrences have shown severe variability. Stakeholders generally agree that today's significant rainfall is witnessed over a shorter period of time, which frequently has negative effects. Additionally, stakeholders believed that climate-related disasters such floods, landslides, fires, GLOF, and droughts had increased in frequency and frequently had disastrous effects. Additionally, stakeholders believed that climate-related threats had increased in frequency and severity. Additionally, it was discovered that the cost of losses and damage caused by catastrophes has been rising yearly, adding to the pressure on local governments. The impact on agriculture, water supplies, and health were explored, as well as the loss and damage caused by the calamities. The majority of the stakeholders believed that both human and environmental systems are being negatively impacted by climate change. Stakeholders confirm that climate-sensitive diseases are widespread in all areas and that high hills and mountains are currently among the places where vector-borne diseases are most prevalent. It was widely acknowledged that many climate-sensitive diseases, particularly diarrheal disease, have seasonal patterns. It was widely considered that Nepal's health system lacked a useful decision-making tool to notify the public health system on the sensitivity of the climate to health. It was also noted that the poor, disadvantaged, resource-dependent households and communities, including women, children, the elderly, people with disabilities, and members of ethnic minorities, are particularly severely struck by the effects of climate change. However, few also saw some good effects of climate change, particularly in the high mountains where it is now possible to cultivate some fruits and vegetables. In conclusion, it was generally agreed that the information presented in this assessment was helpful for a wide range of stakeholders, including policymakers, planners, and practitioners.

Considering the increased health risks with evidence on impacts of climate change on health, the Ministry of Health and Population (MoHP) had extensive discussion on importance of this kind of study. And in line with Ministry's commitments at COP26 in Glasgow, 2021 the ministry included this in GEF/UNDP/WHO supported project "Building resilience of health systems in Asian LDCs to climate change" workplan as part of said project activities. The ministry supervised the study process with WHO support and completed the assessment with outsourced technical assistance.

5. Vulnerability assessment

5.1. Identification and prioritization of climate sensitive health outcomes

This assessment focused on CSDs that emerge and re-emerge throughout various time periods and included the health outcomes that have a direct or indirect link with climate change and variability. The review of government policies, plans, guidelines and documents guided in identification, description, and prioritization of climate-sensitive health outcomes and to anticipate public health impacts as a consequence of climate variability in Nepal. CSDs were mainly categorized into four categories i.e., i) VBDs; ii) food- and water-borne diseases; iii) respiratory diseases; and iv) other health risks (Louis et al., 2016; Ramirez, 2017). Based on the recent disease burden in the country - particularly emerging and re-emerging trend and association with climate variability, altogether 12 CSDs belonging to the aforementioned four categories were selected for this assessment (Table 1). For disease-specific vulnerability, the assessment of vulnerabilities and risks of Scrub typhus, Dengue, Chikungunya, and Zika was conducted.

Table 1. Climate sensitive diseases and health risks in Nepal

Disease category	**Disease/health risk**
Vector borne diseases	Malaria, Kala-azar, Japanese encephalitis (JE), Scrub typhus, Dengue, Zika[a], Chikungunya
Food and water-borne diseases	Cholera[b], Acute gastroenteritis (AGE)
Respiratory disease	Severe acute respiratory illness (SARI)[c]
Others	Undernutrition, Mental illness

[a]*Zika has not been officially reported in Nepal, however, it is considered a potential risk.*

[b]*Cholera: It is defined by WHO as an acute diarrheal infection caused by ingestion of food or water contaminated with the bacterium Vibrio cholerae. The EWARS Bulletin defines a suspected cholera case as any patient aged two years old or older presenting with acute watery diarrhea and severe dehydration or dying from acute watery diarrhea (EDCD/EWARS, 2019).*

[c]*SARI: The WHO global influenza surveillance standards define SARI case as an infection with a history of fever or measured fever >=38 degree Celsius and cough with onset within the last 10 days and require hospitalization (WHO, 2014). Other acute respiratory illnesses (LRTI, URTI, Influenza, non-severe pneumonia) are reported under ILI (defined as an acute respiratory tract infection with fever or measured temperature of >38°C and cough, with within the last 10*

days). Severe pneumonia cases were reported to EWARS and categorized as SARI, for uniformity with the current and previous VRA analyses (MoFE, 2021; EDCD/EWARS, 2019). Therefore, in both V & A assessment and trend analysis, only severe pneumonia cases are included under SARI.

The annual incidence data for malaria, Kala-azar, JE, dengue, cholera, AGE, SARI, undernutrition and mental illness was collected from the Health Management Information System (HMIS). Incidence of Scrub typhus was obtained from EDCD and records on Chikungunya were collected from literature review (Pun and Bastola, 2014; Pandey et al., 2015; Pandey et al., 2017). Zika is not reported in Nepal, therefore, district-wise Zika suitability score was calculated (as cases were not reported) based on the five factors: (i) prevalence of dengue, (ii) reporting of more than 100 dengue cases (as the vector is the same), (iii) elevation (less than 590m), (iv) human population density (> 144 people per square kilometer) and (v) adjoining border with Indian states where Zika is reported. The same factors were considered to calculate the risk of Chikungunya infection. The incidences of CSDs in different period and ecological region are given in annex 2.

A temporal trend comparison of selected CSDs overtime (2010 and 2020) reveals that AGE has the highest burden over the decade with an annual incidence rise of 18%. Mental illness has moved up from the third position to the second position; with the latest annual cases more than double than that of a decade ago. Even though the number of instances of undernutrition declined by 51% in 2019 compared to 2010, it is still one of the top 4 CSDs. On VBDs, dengue was low in the rank in 2010, but it drastically moved up to the top 4 diseases in 2020 (in FY 2076/77 BS, 17,388 cases were reported). In both 2010 and 2020, cholera remained among the top four diseases, and among the top five diseases in 2020 (Figure 2).

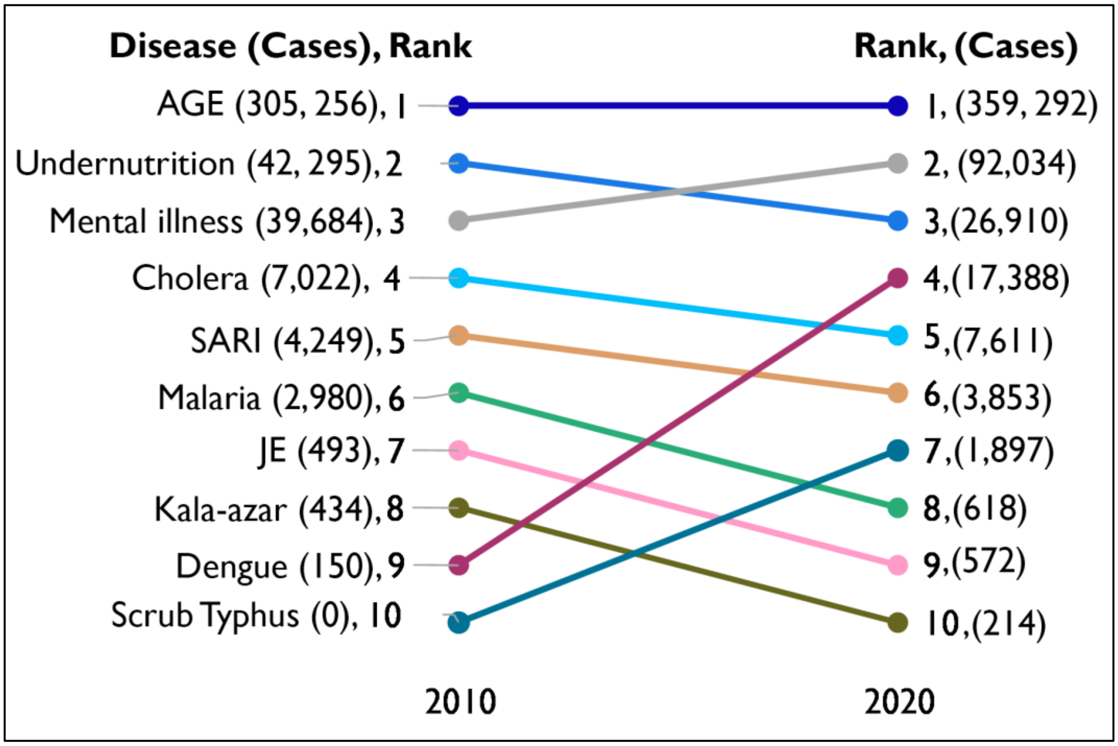

Figure 2. Change in the top 10 climate sensitive diseases between 2010 and 2020 based on annual incidence (For undernutrition, 2019 annual incidence is used).

5.2. Trend identification of climate sensitive diseases with climate factors

The monthly distribution of CSDs (malaria, dengue, cholera, influenza, SARI and AGE) as well as meteorological variables including mean temperature and precipitation were analyzed for this assessment, which observed the period from July 2017 to December 2021. HMIS and EDCD provided the disease data, while DHM provided the climate data for trend analysis. Each geographical region's monthly cases were plotted together with average of temperature and average of total precipitation for that region. Seasonal aspect of the trend has also been considered in the analysis.

Malaria: In three geographic regions, Tarai had the most instances and Mountain had the lowest instances of malaria cases. The three months - July, August and September have the highest seasonal prevalence for malaria. Higher number of malaria cases were reported till 2018 with 1,180 cases, and after that year the cases have been dropping. Tarai, Hill and Mountain had 64%, 20% and 16% of the total 3,484 malaria cases overall, respectively. With rising mean temperature and precipitation, malaria cases are on the rise (Figure 3).

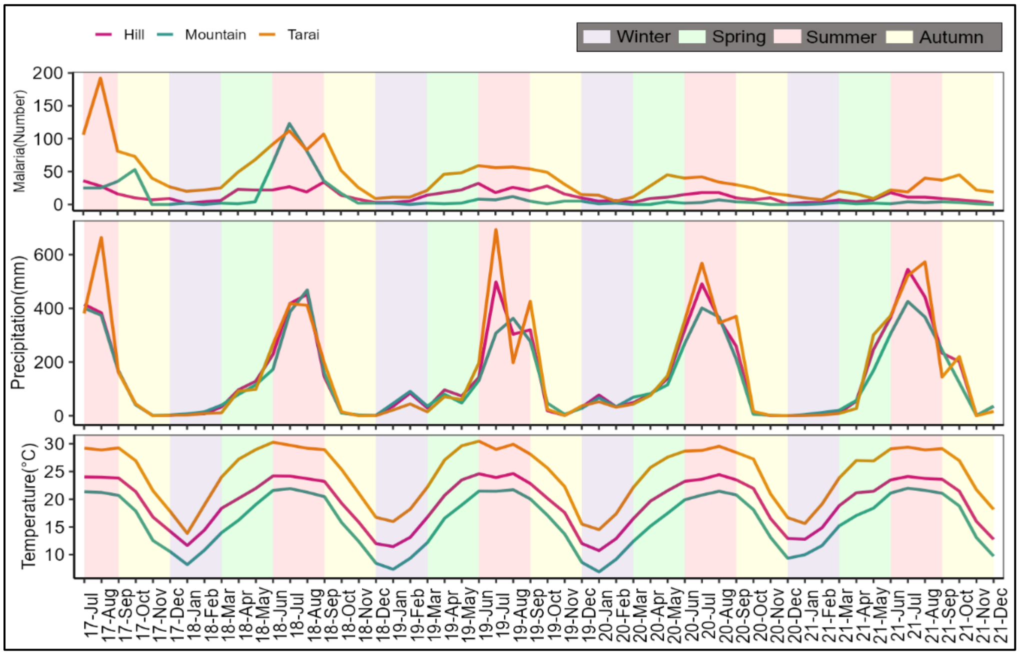

Figure 3. Monthly distributions of malaria cases with average monthly precipitation and temperature in three geographical regions of Nepal.

Kalazar: The highest number of Kala-azar cases was found in Tarai while the lowest cases are in Mountain region. The highest number of cases were discovered in October 2021 with 8,917 cases, among which 94% of those cases were from Tarai region. In 2021, the trend of Kala-azar cases in Tarai region was increasing with the decreasing of temperature and precipitation (Figure 4).

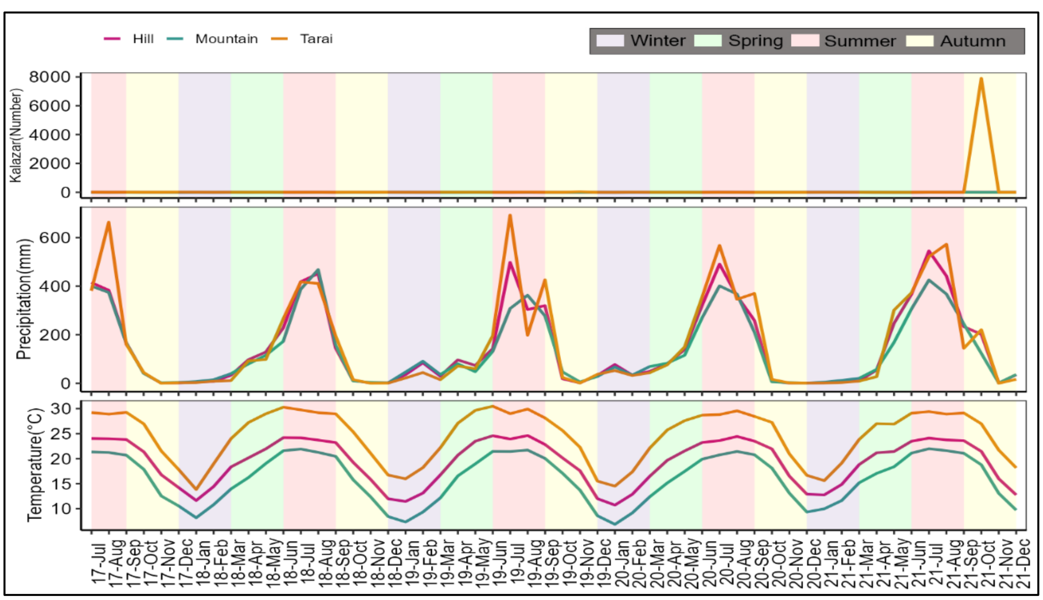

Figure 4. Monthly distributions of Kalazar cases with average monthly precipitation and temperature in three geographical regions of Nepal

Dengue: In a total of 26,490 dengue cases, Tarai, Hill and Mountain had 46%, 52% and 2% cases respectively. The highest numbers of cases (21,920) were reported in 2019. Among them, the highest were from Hill (53%) followed by Tarai (46%). In 2019, there was an outbreak of dengue in Nepal with the cases from 68 districts. The higher numbers of cases were found during August, September and October. Dengue cases tend to rise when mean temperature and precipitation are decreasing (Figure 5).

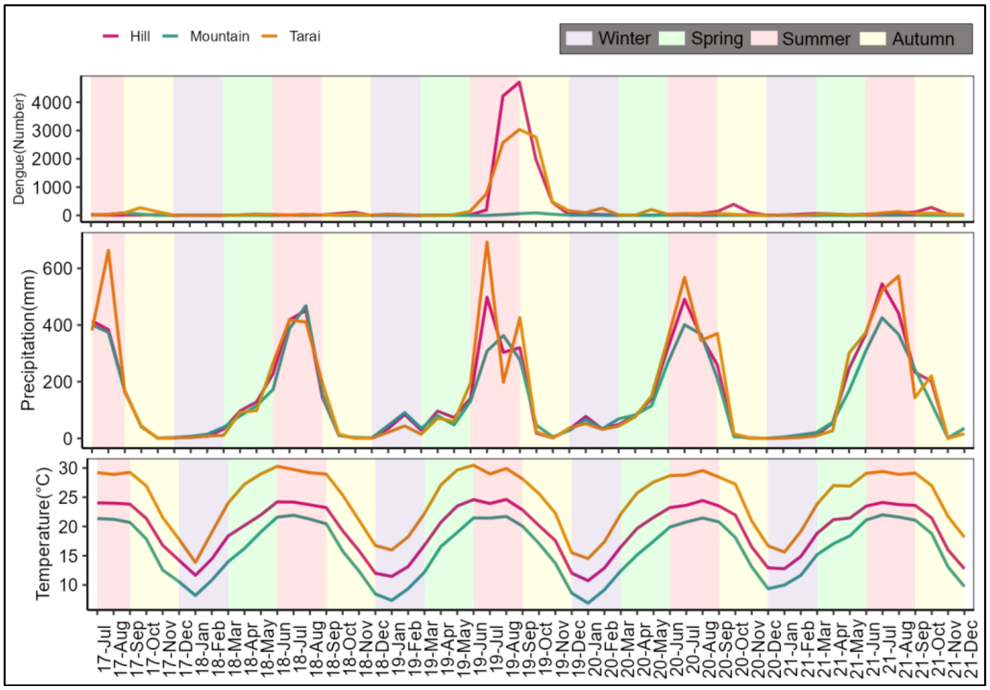

Figure 5. Monthly distributions of Dengue cases with average monthly precipitation and temperature in three geographical regions of Nepal.

Scrub typhus: Although clear epidemiological information on scrub typhus is not available in Nepal, it appeared as an emerging disease in Nepal. The cases have been reported in recent years from all three regions but Hills has the highest prevalence (n=2,202) followed by Tarai (n=1,779). Neither 2017 nor 2018 saw any cases but the year 2019 had the most instances of scrub typhus cases (1731 cases) followed by 1650 cases in 2020, and 1601 cases in 2021. In a total of 4,982 scrub typhus cases, 36%, 44% and 20% were from Tarai, Hill and Mountain regions, respectively. The disease peak is observed in August, September and November. With the gradual decrease in the mean temperature and precipitation, scrub typhus on the rise (Figure 6).

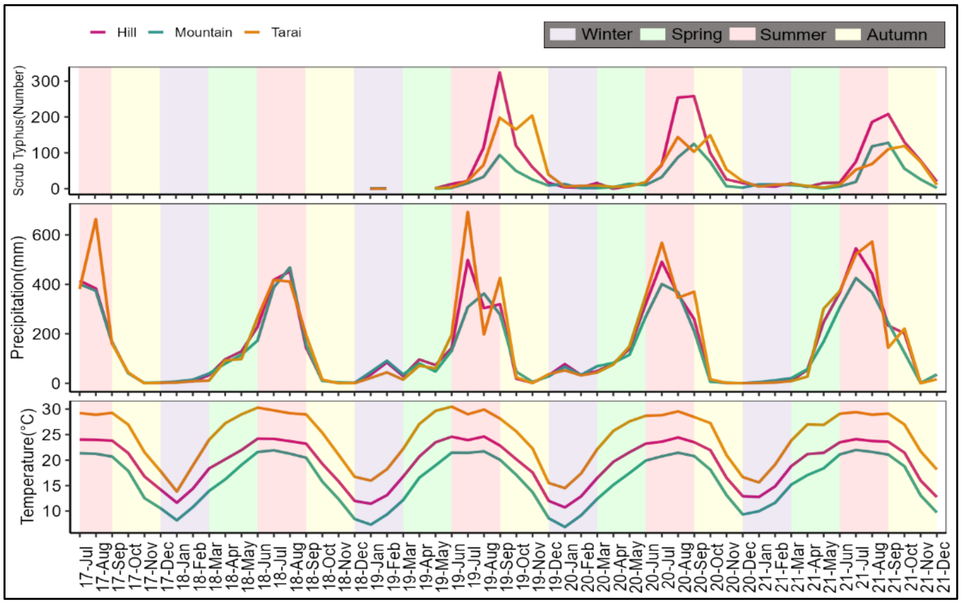

Figure 6. Monthly distributions of Scrub typhus cases with average monthly precipitation and temperature in three geographical regions of Nepal.

Cholera: Cholera cases vary according to mean temperature and precipitation in three geographical regions of Nepal. Although there were many cholera cases throughout the year, April, July, and December had the highest number of cases. In a total of 34,044 cholera cases, Tarai, Hill and Mountain had 66%, 23% and 11% of cholera cases, respectively. The highest number of cholera cases were found in 2018 with 9,552 cases, followed by 2019 with 8,860 cases. The maximum number of cholera cases (1,898) were reported in December from Tarai region. Variation of cholera cases are found with regional climate factors (Figure 7).

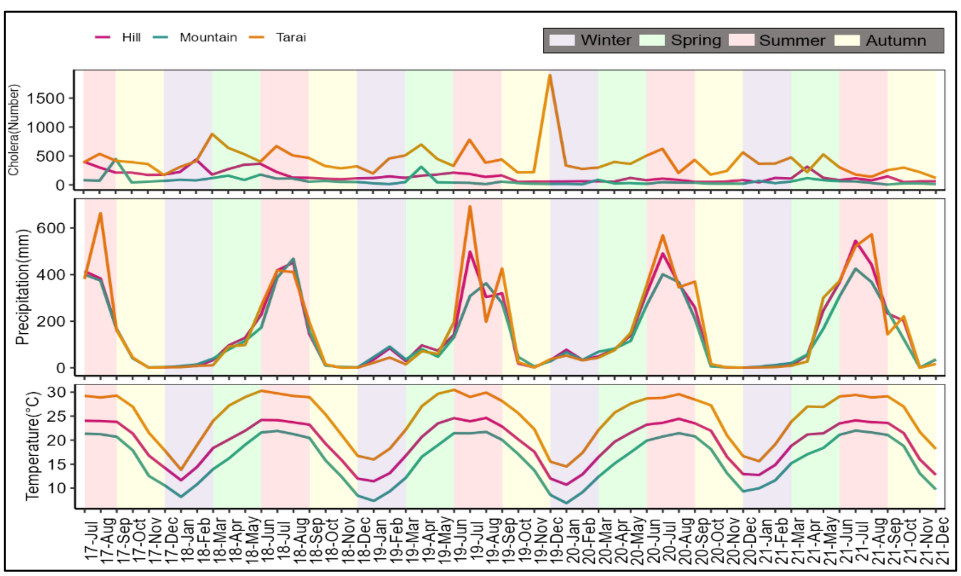

Figure 7. Monthly distributions of Cholera cases with average monthly precipitation and temperature in three geographical regions of Nepal

Acute Gastroenteritis (AGE): In all three of the country's geographic regions, AGE also shows a seasonal trend, with the peak months for cases being mostly July, August and September. A greater number (25%) of the total 1,601,058 AGE cases were discovered in the year 2019. In terms of regional distribution of cases, Tarai, Hill and Mountain had 47%, 41% and 13% of the cases, respectively. The trend of AGE is fluctuated throughout the years and regions. Distribution of AGE cases with climate factors in three regions is given in the Figure 8.

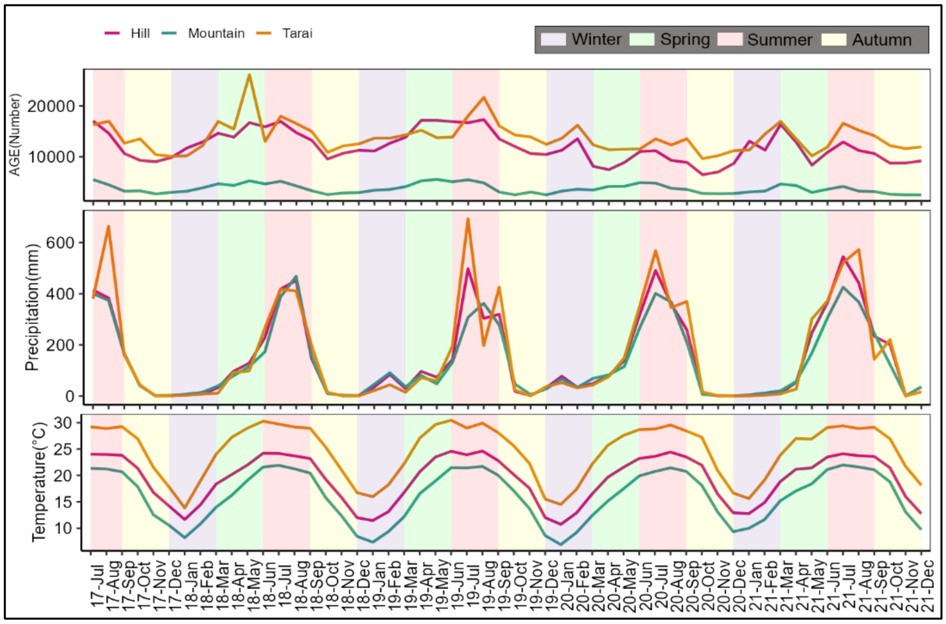

Figure 8. Monthly distributions of AGE cases with average monthly precipitation and temperature in three geographical regions of Nepal

Influenza: In all three geographical regions, influenza trend was found with a peak in July, August and September. In a total of 1,045,308 influenza cases, the highest number were found 2019 (26% cases) and in 2021 (24% cases). In terms of regional distribution, Tarai, Hill and Mountain had 43%, 40% and 17% of the cases, respectively. The trend of influenza cases is rising as the n mean temperature and precipitation are decreasing (Figure 9).

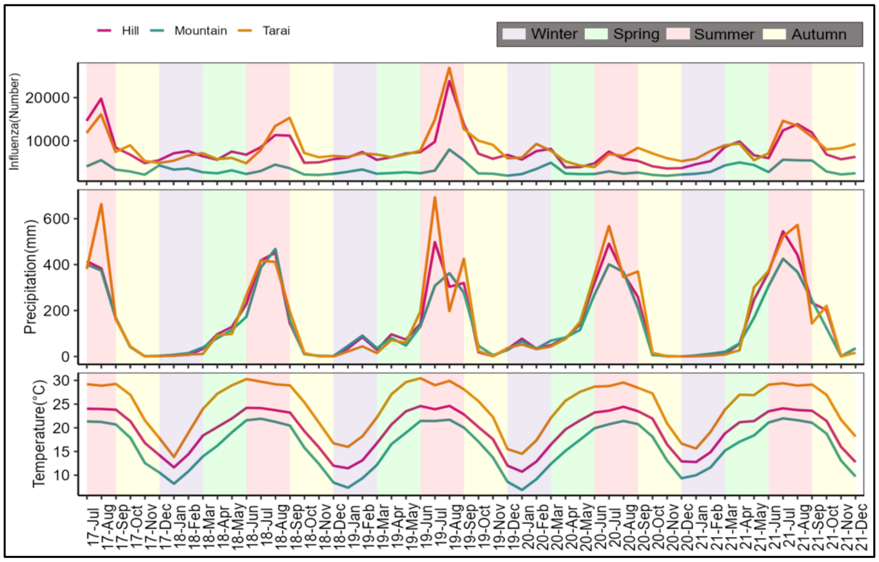

Figure 9. Monthly distributions of Influenza cases with average monthly precipitation and temperature in three geographical regions of Nepal.

Severe Acute Respiratory Illness (SARI): In three geographical regions, SARI trend was highly seasonal with the higher number of cases occurring in July, August and September. In a total of 102,043 SARI cases, the higher number (27%) was found in 2021. In regions, Tarai, Hill and Mountain had 66%, 28% and 6% of cases respectively. The trend of SARI varies with climate factors in three regions (Figure 10).

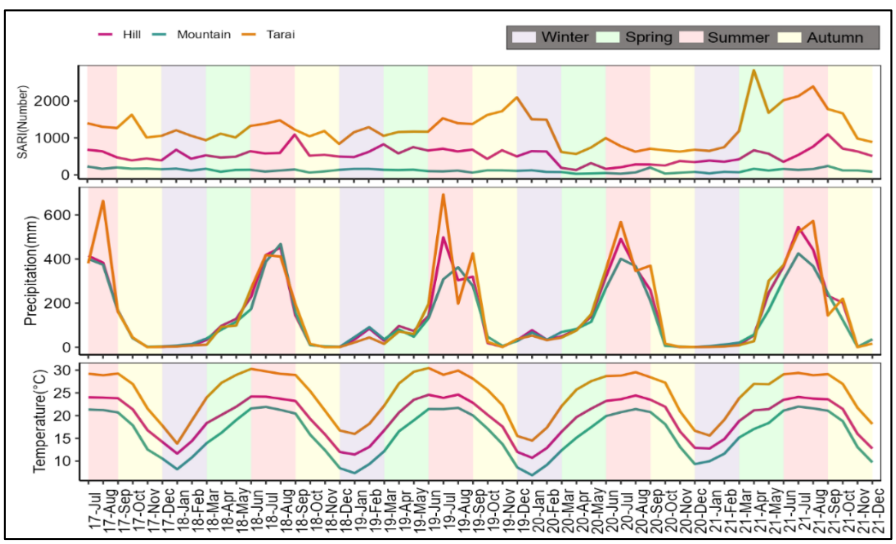

Figure 10. Monthly distributions of SARI cases with average monthly precipitation and temperature in three geographical regions of Nepal.

5.3. Climate change and health outcomes

Examining the relationships between climate variability and health outcomes is essential to assess the risk posed by climate change on human health (WHO, 2021). Climate-induced alteration of precipitation and temperature regimes are the critical factors causing the spread of disease vectors and affecting health outcomes. To understand such relationships, both quantitative and qualitative analysis of historical trends of average temperature and precipitation, climate extremes, climate-induced hazards, and their individual and cascading effects on health outcomes was conducted. Due to limited availability of ecological data of selected diseases, the quantitative association between weather variables and climate-sensitive health outcomes could not be examined. However, qualitative information derived from the literature was used to show the association between changing climate and extremes with climate-sensitive health outcomes.

5.3.1. Observed climate change

Historical changes in two major parameters of climate – temperature, and precipitation, have been observed in Nepal. From 1980 to 2020, the annual mean temperature in Nepal increased by 0.02°C/year ($p=0.0005$). In the same period, the annual maximum temperature increased by 0.03°C/year ($p<0.0001$) but no significant trend was observed in annual minimum temperature (Figure 42). Studies showed similar trends of warming but with different rates of temperature change - for example, based on an analysis of weather station data, the annual maximum temperature in Nepal has increased at the rate of 0.056ºC/year from 1971-to 2014 (DHM, 2017). Similarly, the annual mean temperature has increased by 0.03°C/year from 1979-to 2016 based on the analysis of the gridded climate data (Shrestha et al., 2019). Various factors such as the difference in the data sources, the number of weather stations included in the analysis, and the time period used for analysis might be the cause for such differences. A significant decrease in annual precipitation was found in Nepal from 1980 to 2020 with a rate of -4.8mm/year ($p= 0.016$). Out of the 77 stations, 58 stations showed decreasing trends in annual precipitation while 19 stations showed increasing trends. Similar mix trends in annual precipitation were observed by the DHM (2017) demonstrating increased annual precipitation in 28 districts while decrease in 47 districts (Figure 11). The national average annual minimum temperature and annual maximum temperature is given in annex 3.

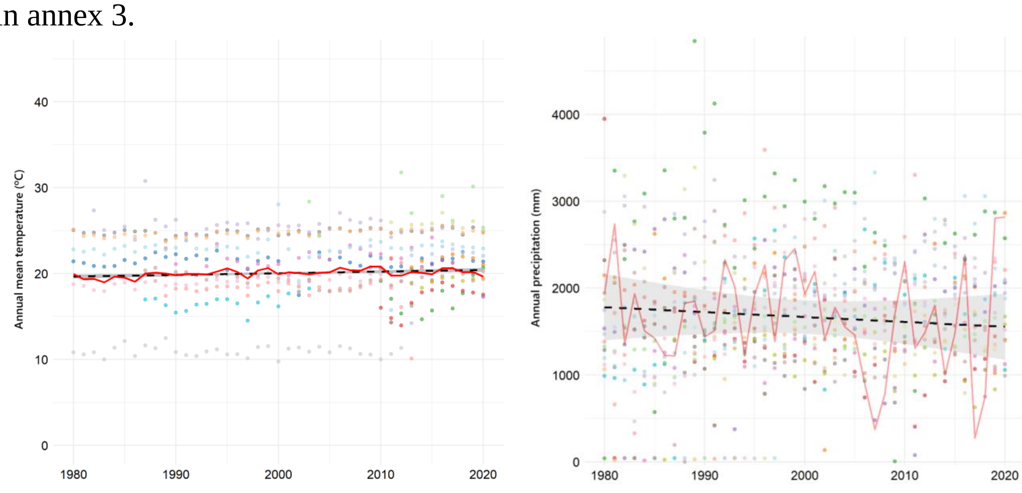

Figure 11. Trends of nationally averaged annual mean temperature (left), and annual precipitation (right), dots show values of individual stations.

5.3.2. Climate extremes and climate-induced hazards

Out of 27 climate extreme indices suggested by the World Meteorological Organization (WMO), 14 climate extreme indices (eight for temperature extremes and six for precipitation extremes) were found relevant to climate sensitive health outcomes in Nepal and were thus utilized for further analysis. Using daily data of temperature (maximum and minimum) and precipitation, trends of 14 extreme indices at the district level were calculated. Multiple values were averaged for districts with multiple stations before calculating district wise trends of extreme indices. Temporal trends of those indices from 1980 to 2020 were calculated using non-parametric Mann-Kendal test.

The number of districts with no significant trends in most of the 14 extreme indices was common (Table 2). However, four extreme indices (TXx, TXn, TNx, TNn) showed a significant increase in most of the districts. Similarly, hot night frequency (Tn90p) was significantly increased in most of the districts, while, cold day frequency (TX10p) was significantly decreased in the majority of districts. The droughts as well as the frequency of heavy precipitation have increased significantly in the majority of districts. In terms of climate extremes, an increasing number of hot days and nights, increasing annual precipitation, and heavy precipitation were observed in Nepal from 1979 to 2016 (Shrestha et al., 2019). Similarly, increasing warm days and nights, warm spell duration, consecutive wet days, and the number of rainy days have been observed in the majority of districts. Very wet days, and cool days have been observed to be decreasing in a majority of the districts (DHM, 2017). The number of districts with climate extreme indices was categorized in three categories i.e, significantly increased, significantly decreased and not significant change, and is tabulated in Table 2. Whereas, the analysis of district wise trends of climate extreme indices (significantly increased, significantly decreased and not significant change) is given in Annex 4.

Table 2. Significance level of climate extreme indices in different districts.

SN	**Climate extreme indices**	**Number of districts**		
		Significantly increased	Significantly decreased	Not significant
1	Current monthly maximum value of daily maximum temperature or hottest daytime temperature [TXx]	32	9	33
2	Current monthly minimum value of daily maximum temperature or coolest day temperature (TXn)	31	5	38
3	Current monthly maximum value of daily minimum temperature or hottest nighttime temperature (TNx)	14	9	51
4	Current monthly minimum value of daily minimum temperature or coolest night temperature (TNn)	17	5	52
5	Current daily temperature range or Diurnal temperature range (DTR)	27	19	28
6	Current number of frost days (FD)	4	8	62
7	Current percentage of days when TN > 90th percentile or hot night frequency (TN90p)	37	10	27
8	Current percentage of days when TX < 10th percentile or cold day frequency (TX10p)	11	31	32
9	Current monthly maximum consecutive 5-day precipitation or maximum 5-day precipitation (Rx5day)	0	12	62
10	Current monthly maximum 1-day precipitation or maximum 1-day precipitation (Rx1day)	0	13	61
11	Current annual count of days when PRCP≥ 20mm of wet day precipitation more than 20mm (R20mm)	1	19	54
12	Current annual total PRCP when RR > 99p or extremely wet day (R99pTOT)	1	7	66

13	Current maximum length of wet spell, maximum number of consecutive days with RR ≥ 1mm (CWD)	7	7	60
14	Current maximum length of dry spell, maximum number of consecutive days with RR < 1mm (CDD)	24	0	50

The physical geography such as rugged terrain, and remoteness in combination with social, economic, and political disparities have made the country more susceptible to climate-induced hazards (GIIS, 2021). In Nepal, climate extreme events induced various hazards such as floods, landslides, and fires. Over the last forty-one-year, extreme precipitation days have increased in most parts of the country which causes floods in downstream and landslides in hills. Incidences of climate-induced hazards such as landslides, floods, and fires have increased over the last five decades in Nepal (MoFE, 2021b) (Figure 12). In Nepal, because of heavy rainfall not only the frequency, but the duration, and intensity of floods have also been increasing every year (MoE, 2010). Flood in urban and semi-urban areas has been more frequent (Pervin et al., 2020). Excessive rainfall triggers landslides, especially in sloppy areas where slopes are further destabilized by road construction or other human activities (McAdoo et al., 2018). Although domestic fires in urban areas are caused by the short-circuiting of electrical appliances and accidental burning of materials, climatic conditions such as high temperature and prolong periods of drought also creates a conducive condition for fire outbreaks (MoLD, 2011). Therefore, increases in fire incidences in recent years might be aggregated by climate extremes.

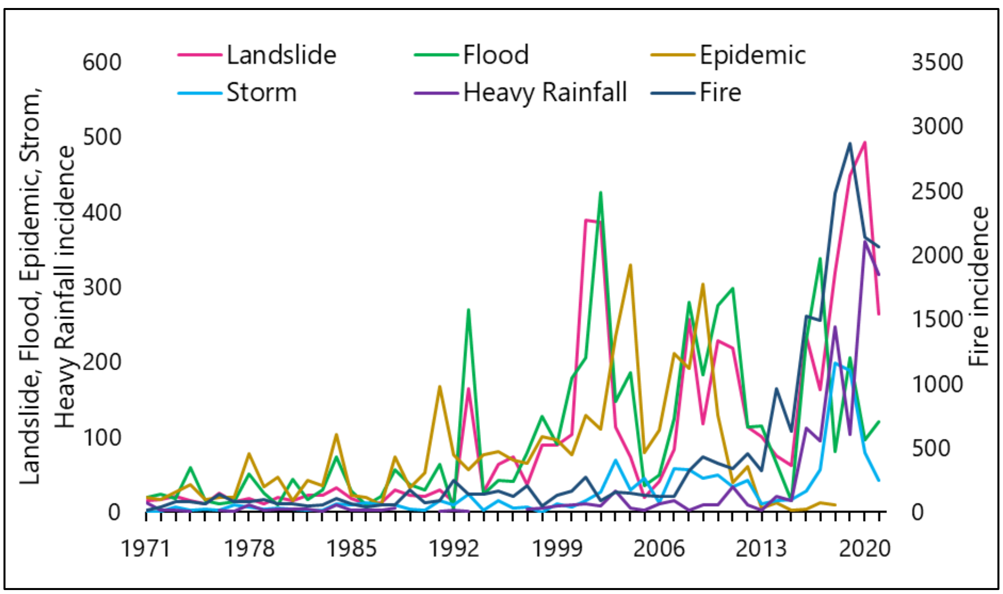

Figure 12. Trends of climate hazards from 1971-2020 in Nepal (MoFE, 2021b).

Differential distribution of climate-induced individual hazards was observed in Nepal. Hilly and mountainous districts are more susceptible to landslides whereas floods are more prevalent in the low land area of Tarai districts. Likewise, the fire incidences were reported mainly from Tarai districts and districts with urban centers (Annex 4). Incidences and impacts of multiple hazards (avalanche, cold wave, epidemic, fire, flood, forest fire, landslide, snowstorm, storm, heat wave and heavy rainfall) were aggregated and ranked to produce district-level multi-hazard maps. A high concentration of hazards was observed in 17 districts namely Banke, Bara, Dhading, Dhanusha, Jhapa, Kailali, Kaski, Kathmandu, Mahottari, Makawanpur, Morang, Rautahat, Rupandehi, Saptari, Sarlahi, Sunsari and Taplejung (Figure 13).

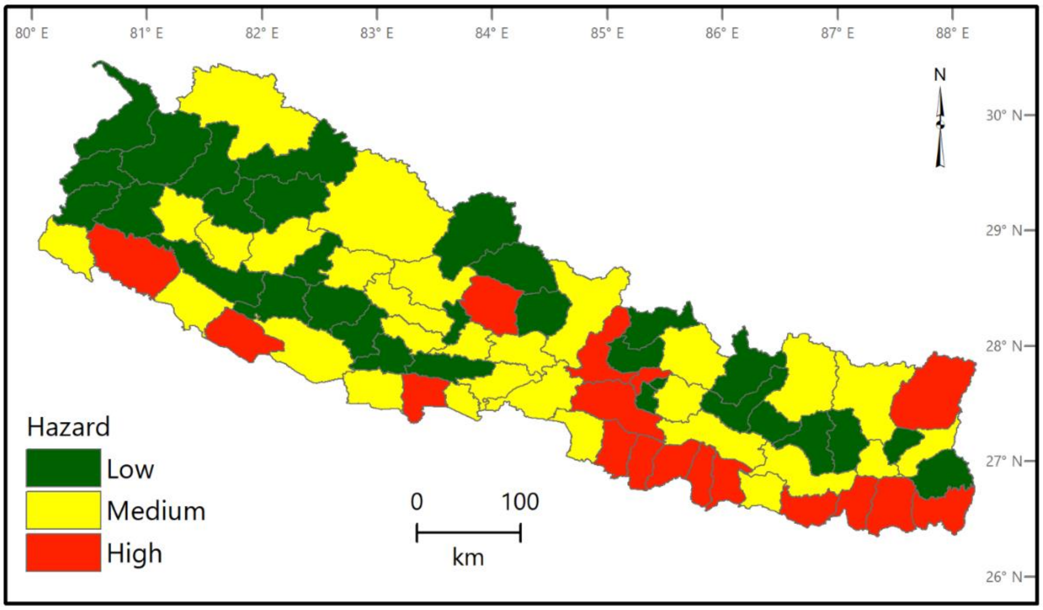

Figure 13. Ranking of district based on the impacts of multiple hazards.

5.3.3. Impacts of climate change and variability on health outcomes

Climate change poses a triple burden in the health sectors of Nepal, i.e., i) threats from disaster, ii) adverse impacts of climate change and iii) accidents, violence, and injuries (MoHP, 2015b; MoHP, 2015c). Climate-induced hazards cause biophysical and socio-economic impacts including loss of life, injuries and harm to human health; reductions in food production; damage to and destruction of property and infrastructure; damage to ecosystem and biodiversity; and reduction in public services (GoN, 2011). In Nepal, climate-induced hazards are attributed to 647 deaths and over NPR 2,778 million annual economic losses from 1971 to 2013 (MoFE, 2021b). Similarly, increasing cold waves in the Tarai region in recent years causes deaths of people - a total death of 822 were attributed to cold waves from 1974 to 2014, (MoHA & DPNet-Nepal, 2015). Mostly poor and landless people, marginalized communities including Dalit and indigenous, *Madhesi*, *Tharu*, *Muslim*, women, the elderly, children, and persons with a disability are affected severely by the climate-induced hazards in Nepal (GoN, 2021). The total number of incidences and impacts of major climate hazards in Nepal is given in Table 3.

Table 3. Total number of incidences and impacts of climate hazards in Nepal (1971-October 2021)

Hazards	Incidence	Deaths	Injured	Missing	Household destroyed	Household damaged
Epidemic	3557	5837	15917			

Fire (Domestic and Forest)	20360	807	1358		49770	2043
Flood	5104	2193	273	688	59760	69743
Landslide	5267	2530	1142	496	9494	25752
Storm (Snowstorm, Thunderstorm, Windstorm)	4624					
Heavy rainfall	1526					

***(Source: DesInventar and MoHA).**

Direct and indirect effects of climate change pose multiple threats to human health and wellbeing, it can occur simultaneously - resulting in compounding or cascading impacts for vulnerable population. Globally, climate hazards contribute to the growing number of adverse health outcomes such as a shift of malaria incidence to higher altitudes, increases in dengue, and chikungunya virus and other vector-borne, increase of diarrheal diseases including cholera and other water-borne diseases. In addition, climate extreme events such as fire, storms, and floods are followed by an increased rate of mental illness in the exposed population (IPCC, 2021).

In Nepal, rising temperature, erratic rainfall, and climate extremes such as heatwave, cold waves, storms, and heavy precipitation have a direct impact on the seasonal and temporal trends of VBDs, WBDs, respiratory diseases, cardiovascular diseases, foodborne diseases, nutrition-related diseases, injuries, and mental illnesses (NPC, 2020). Studies showed associations between the incidence of CSDs (VBDs, WBDs) and changes in temperature and precipitation trends in Nepal.

Emergence and re-emergence of VBDs observed in Nepal on different periods is attributed to the fluctuation in temperature, precipitation and extreme weather events (Dhimal and Bhusal, 2009). A time-series study of nine-year data of two high-risk malaria districts of Nepal found that the increase in the malaria incidence was up to 27% for a 1°C increase in minimum and mean temperatures (Dhimal et al., 2014b). Another visible effect of climate change on VBDs is a clear shifting and expansion of diseases and their vectors to the non-endemic high mountainous areas of Nepal in recent times (Dhakal et al., 2011; Dhimal et al., 2015a). Typically, VBDs including JE, malaria, kala-azar and dengue seem to have occurred in the warmer lowland districts. Mosquito vectors *Aedes aegypti* and *Aedes albopictus*, as well as lymphatic filariasis vector *Culex quinquefasciatus* are found in the higher mountains of central and eastern Nepal (Dhimal et al., 2015b). The incidence of dengue cases was found to rise with the increase in temperature, humidity and rainfall (Tuladhar et al., 2019a; Tuladhar et al., 2019b). In recent years, Chikungunya and Scrub typhus have also posed a threat to the Nepalese population (Joshi et al., 2020). Additionally, the environmental suitability of Aedes mosquitoes has been identified as a potential threat for outbreaks of Zika virus infection in Nepal (Dhimal et al., 2015b). In the future, geographic expansion of dengue virus infection, hotspots to the higher elevation regions by 2050-2070 was predicted by a model-based study (Acharya et al., 2018). Therefore, climate change has not only increased health vulnerability but is also likely to increase health risks in Nepal.

The climate change scenarios of Nepal reflect that the VBDs and WBDs are attributed to rising temperature and are expected to increase with the substantial attributable burden of diseases. Positive association of temperatures with VBDs and WBDs hospitalization of 3-9% and 2-12%, respectively are reported for each 1°C increase in average temperature (Shrestha, 2018). The time series analysis of temperature and diarrhea from 2002 to 2014 found that for a 1°C increase in ambient temperature, diarrheal disease incidence increased by 4.4% in Nepal. Similarly, for a one cm increase in annual rainfall, the incidence of diarrheal diseases surges by 0.28% (Dhimal, et al., 2016). The diarrheal disease shows a definite monthly pattern or seasonal pattern in a year showing its linkages with climate (MoPE, 2017a). Climate change impacts are found in water and food-borne diseases (W/FBDs) and food security in Nepal (Dhimal et al., 2018; Dhimal et al., 2021). Climate change has also enhanced the risks of food- and WBDs in the non-endemic mountain areas of Nepal (Shrestha and Aryal, 2011).

Very limited evidence exists in Nepal on the impact of climate change on non-communicable diseases (cardiovascular disease and cancer), respiratory infections, injuries, and malnutrition. An ecological study based from 2005-2015 found that each 1°C increase in mean temperature increases respiratory disease cases by 0.57% and an additional increase in warm days increases cases of respiratory disease by 0.39% in the Tarai region of Nepal (MoFE, 2021a). Climate change is exacerbating food insecurity and malnutrition in Nepal as climate extreme events like drought reduces agriculture productivity by 76%. This is because most of the cultivated land in Nepal is rain-fed which is affected by the erratic patterns of rainfall, drought, flash floods, and landslides (Krishnamurthy et al., 2013). Crops were also harmed by a lack of seasonal rainfall during the harvesting season (Ojha, 2021). Additionally, increase in the likelihood of invasive pests due to climate change will reduce food production (Shrestha and Shrestha, 2019). Decrease in food production and reduced access to food will acerbate food insecurity and malnutrition in Nepal, which eventually brings negative health outcomes (Krishnamurthy et al., 2013).
Additionally, meteorological hazards such as floods and landslides triggered by climate extremes also cause damage to the Water, Sanitation and Hygiene (WASH) system resulting in poorer sanitation conditions, contamination of water sources as well as damage to health facilities and infrastructure (MoFE, 2021c). In addition to negative impacts on the physical health of people, climate change also adversely affects mental health (IPCC, 2021). Details of the health impacts and risks of climate change and hazards, vulnerabilities and risks are provided in Annex 5.

5.4. Geographic distribution of vulnerabilities and health risks to climate change

To identify vulnerable regions, a district-level spatial mapping of hazards, exposure, vulnerability, and risk using health data under the current climate was conducted. Furthermore, vulnerable population groups who are disproportionately affected by climate change due to their inherent socio-economic and biophysical conditions were identified. The framework adopted in this assessment considers risk as a function of hazard, exposure, and vulnerability. The risk of climate change impacts is a consequence of the interactions of climate-related hazards including Spatio-temporal distribution of hazards with the exposure and vulnerability of human and natural systems (IPCC 2014). Therefore, human exposure to climate change and variability, extreme events, and climate-induced hazards directly produce adverse health outcomes or indirectly enhance risk by affecting contamination pathways, transmission dynamics, agroecological and hydrological systems, and demography.

5.4.1. Exposure to climate-induced hazards and extreme events

Human health, WaSH and health infrastructures were exposed to climate-induced hazards and extreme events. Hence those factors were considered to produce district-level exposure index - higher the score higher the exposure and vice-versa. High climate change exposure is primarily based on significant increases in climate extreme events particularly increased extreme precipitation (Rx1day, Rx5day), increased hot night frequency (TN90p), increased frequency of coolest nights (TNn) and days (TXn), increased drought (CDD). The exposure rank analysis revealed that Banke, Bardiya, Chitwan, Dang, Dhanusha, Jhapa, Kailali, Kanchanpur, Morang, Rupandehi, Saptari and Sunsari of Tarai region; Arghakhanchi, Bhaktapur, Kaski, Makawanpur, Panchthar and Udayapur districts of Hill region; and Dhading, Dolakha, Gorkha, Mustang and Sindhupalchok of Mountain region had a high exposure (Figure 14). Geographically, Morang of the Tarai region; Bhaktapur and Makwanpur of the Hill region; and Sindhupalchowk of the Mountain region had the highest exposure scores.Whereas, Rautahat of Tarai region; Kavre of Hill region and Ramechhap of the Mountain region had the lowest exposure scores. Among all, Morang is highly exposed whereas Kavre is least exposed for climate-induced hazards and extreme events.

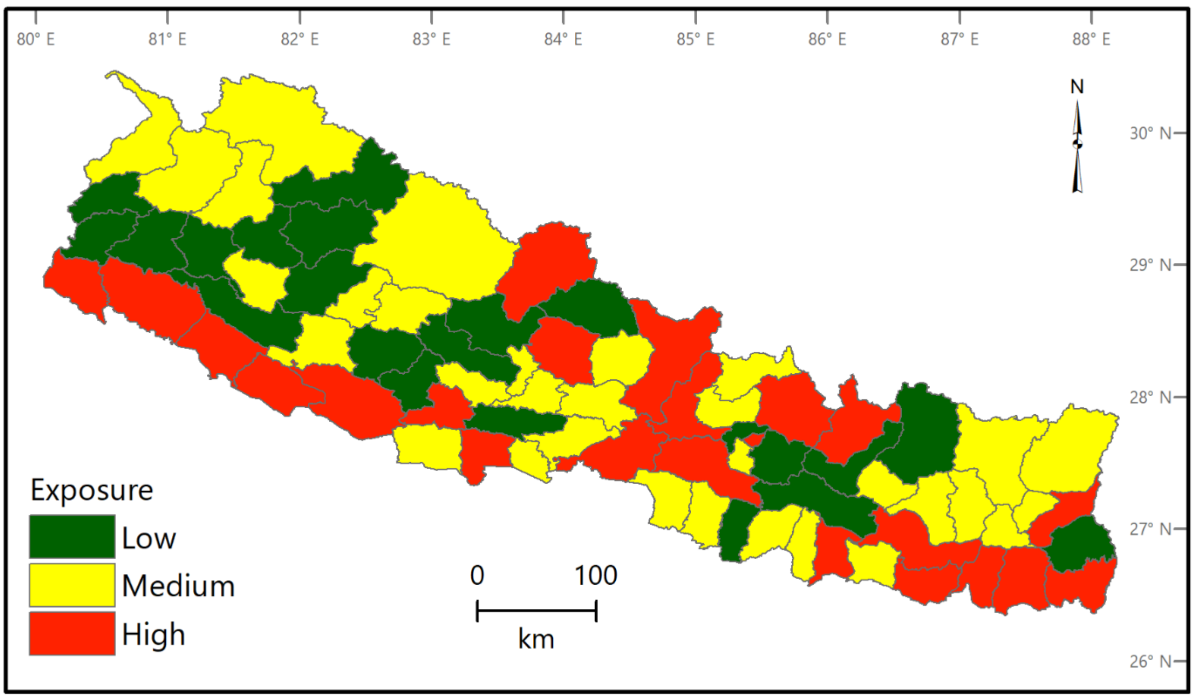

Figure 14. Distribution of aggregated exposure by districts.

5.4.2. Sensitivity to climate-induced hazards and climate extremes

Population characteristics particularly - demography, socio-economic features, as well as the local physical condition, determines the sensitivity of population to climate-induced hazards, climate-sensitive disease incidences, and climate extremes. Therefore, sensitivity scores were calculated at the district level incorporating population characteristics and physical condition of the district - higher the score more sensitive the district**.** High sensitivity of districts is determined by the high prevalence of undernutrition, cholera, AGE, JE, dengue, malaria, and scrub typhus cases, greater suitability to zika and chikungunya. In addition, large number of indigenous, urban, migrant, dalit, poor and female population, rented households with majority of the household wall and foundations being made of wood and population's relatively low access to health services contributed in determining high sensitive districts. The sensitivity rank analysis revealed that Bara, Bardiya, Dang, Dhanusha, Jhapa, Kailali, Kanchanpur, Kapilbastu, Mahottari, Morang, Rautahat, Rupandehi, Saptari, Sarlahi and Siraha of Tarai region; and Achham and Kathmandu districts of Hill region had a high climate change sensitivity (Figure 15). Geographically, the sensitivity scores showed that Morang of Tarai; Kathmandu of Hill; and Bajura of Mountain had the highest sensitivity among 77 districts whereas Nawalpur of Tarai; Bhaktapur and Lamjung of Hill region; and Mustang of Mountain region had the lowest sensitivity scores. The sensitivity index analysis shows that Morang is highly sensitive whereas Mustang is least sensitive to climate-induced hazards and climate extremes.

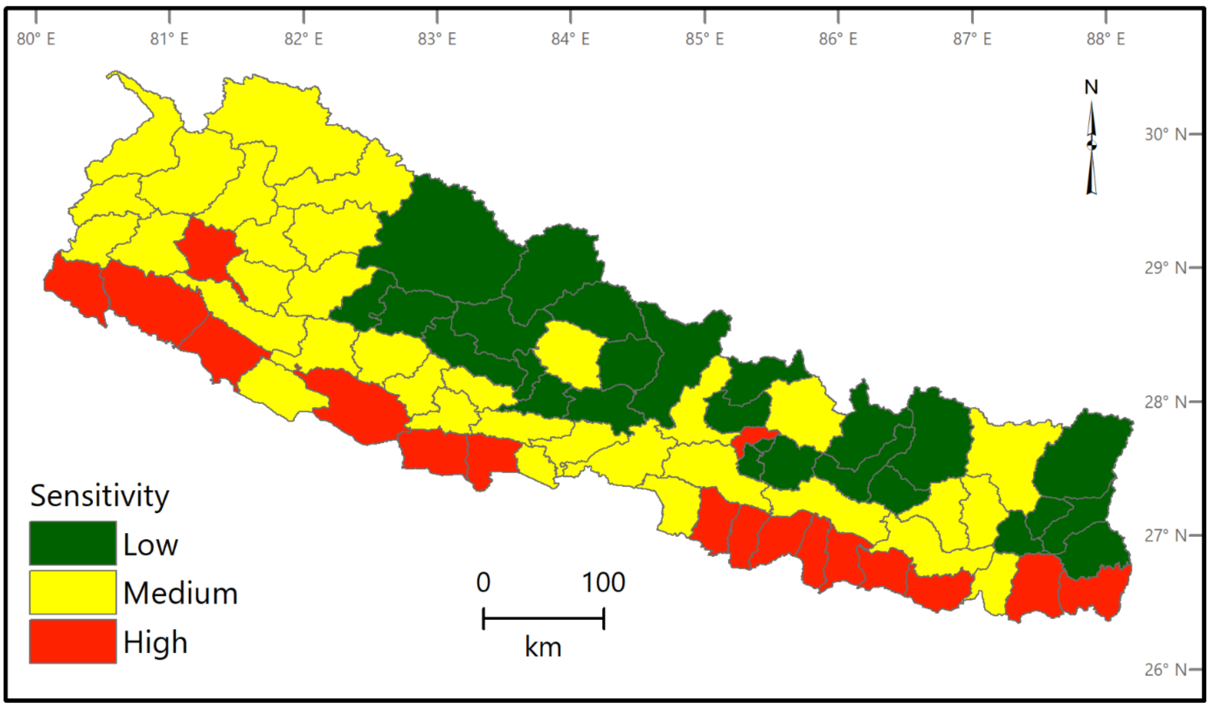

Figure 15. Distribution of aggregated sensitivity by districts.

5.4.3. Adaptive capacity

The population's capability to adapt to and adjust to potential harm caused by climate changes is governed by the effectiveness of the health systems, the availability of health related institutions, and human capabilities adjust to possible damage and respond to the consequences of climate impacts. Human capacity (e.g., education), availability of resources, availability of health facilities and institutions, livelihoods, and access to information and technology are the factors used to calculate the adaptive capacity score. High adaptive capacity of the districts is primarily based on the availability of national strategies such as drought impact reduction, and basic health related indicators such as water supply and sanitation, emergency health services, Female Community Health Volunteer (FCHV) coverage, health insurance coverage, clean energy usage for cooking, food productivity , literacy rate, usage of information and technology, and houses made of cement. Higher the score higher the adaptive capacity. The adaptive capacity rank analysis revealed that Chitwan, Jhapa, Morang, Rupandehi and Sunsari districts of the Tarai region; Baglung, Bhaktapur, Gulmi, Kaski, Kathmandu, Lalitpur, Lamjung, Okhaldhunga, Palpa, Prabat and Syangja districts of the Hill region; and Dolakha and Myagdi districts of the Mountain region had a very high climate change adaptive capacity (Figure 16). Geographically, Chitwan in Tarai, Kaski in Hill, and Dolakha in the Mountain region had the highest adaptive capacity, whereas, Nawalpur and Kapilvastu in Tarai, Western Rukum in Hill, and Mugu in the Mountain region had the lowest adaptive capacity scores. Amongst all districts, the highest adaptive district was Kaski while Western Rukum was the district with least adaptive capacity.

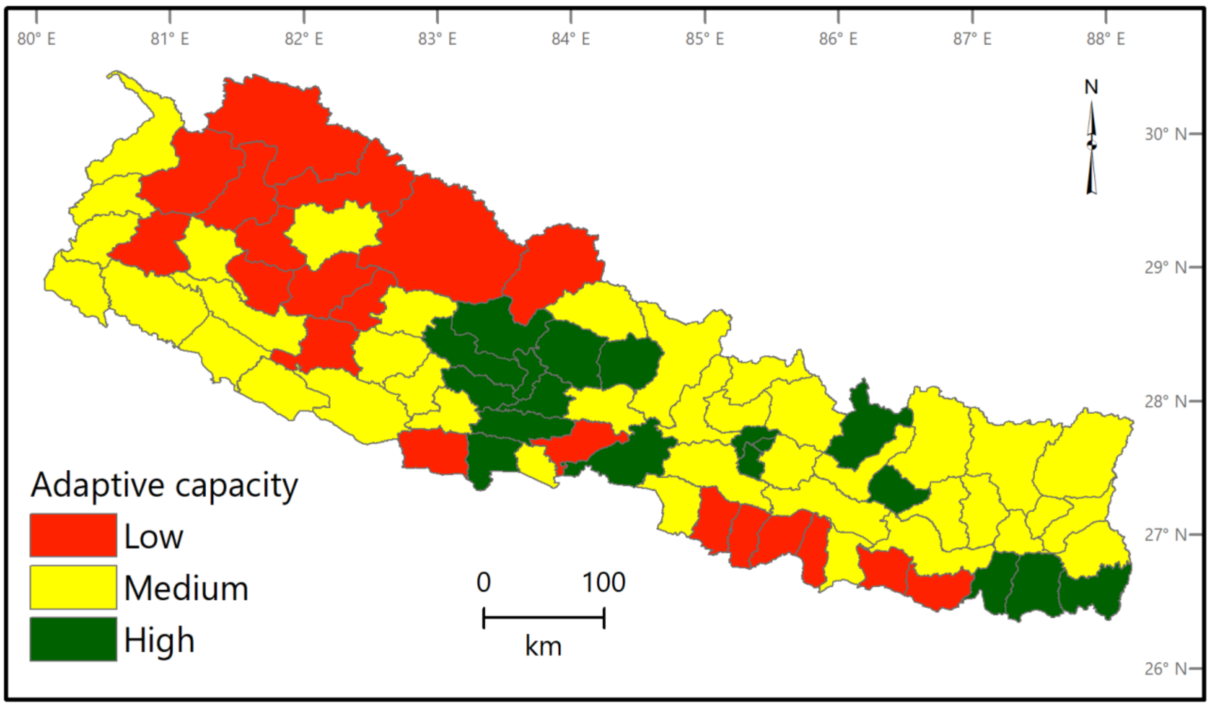

Figure 16. Distribution of aggregated adaptive capacity by districts.

5.4.4. Aggregated vulnerability to climate change and climate extremes

Vulnerability scores were calculated considering sensitivity, exposure, and adaptive capacity for responding to or cope with climate variability and extremes. An aggregated vulnerability score were calculated based on sensitivity, exposure and adaptive capacity incorporating all four disease categories (VBDs, FBDs/WBDs, SARI, mental illness and undernutrition). Additionally, considering the prospect, disease-specific vulnerability scores of selected four VBDs (Dengue, Chikungunya, Scrub typhus and Zika) were also calculated. The higher the value of the vulnerability score of a district, the more vulnerable it is to CSDs. The vulnerability rank analysis revealed that Banke, Bara, Dang, Dhanusha, Kailali, Kanchanpur, Kapilbastu, Mahottrai, Morang, Rautahat, Saptari, Sarlahi and Siraha districts of Tarai region; Dailekh, Udaypur and Western Rukum of Hill region; and Bajhang and Humla districts of Mountain region had a high vulnerability (Figure 17). Geographically, Saptari in Tarai; Western Rukum in Hill; and Humla in the Mountain region had the highest vulnerability, while, Chitwan in Tarai region; Kavre in Hill region; and Myagdi in the Mountain region had the lowest vulnerability. Among all districts, an aggregated vulnerability score showed that Saptari had the highest vulnerability while Myagdi was least vulnerable district.

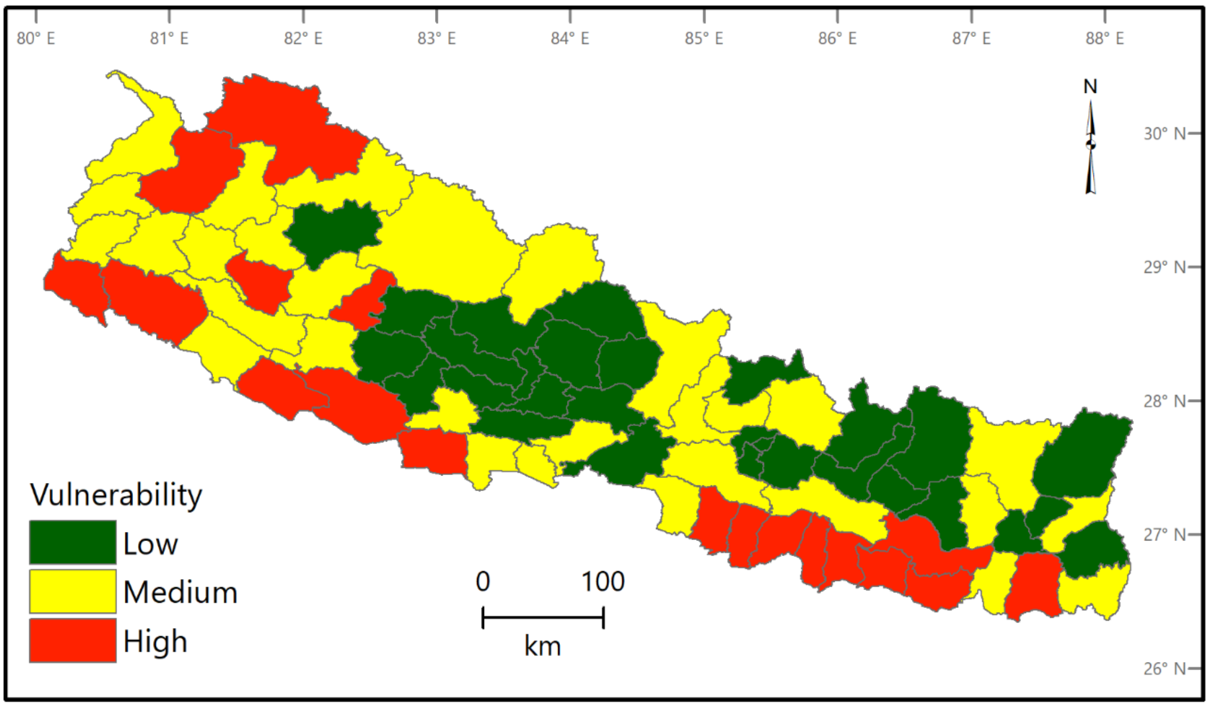

Figure 17. Distribution of aggregated vulnerability by districts.

5.4.5. Vulnerability of climate sensitive diseases

At the regional level vulnerability rank analysis, nine Tarai region districts (Dang, Dhanusha, Kailali, Kanchanpur, Kapilvastu, Mahottari, Saptari, Sarlahi and Siraha); one Hill region district (Salyan) and five Mountain region district (Bajhang, Bajura, Humla, Kalikot, Mugu) had a high vulnerability of all four disease categories (VBDs, WBDs/FBDs, SARI, malnutrition and mental illness). The composite vulnerability rank by region is given in figure 18.

In the vulnerability index assessment, among the all four disease categories, AGE and VBD had the highest value in Saptari and the lowest value in Kathmandu. In all 77 districts, SARI and undernutrition had highest score in Humla and the lowest score in Kathmandu. Similarly, climate change vulnerability score for mental health was highest in Bajhang and lowest in Kavre. Climate change vulnerability maps according to disease category (FBDs/WBDs, SARI, mental illness and malnutrition) are given in annex 6.

District	VBDs	WBDs/ FBDs	SARI	Malnutrition	Mental illness
Banke	High	High	High	High	Medium
Bara	High	High	High	High	Medium
Bardiya	High	High	High	Medium	High
Chitwan	Low	Low	Low	Low	Low
Dang	High	High	High	High	High
Dhanusha	High	High	High	High	High
Jhapa	Medium	Medium	Medium	Low	Medium
Kailali	High	High	High	High	High
Kanchanpur	High	High	High	High	High
Kapilbastu	High	High	High	High	High
Mahottari	High	High	High	High	High
Morang	High	High	High	Medium	High
Nawalparasi	Medium	Medium	Medium	Medium	Low
Parasi	Medium	Medium	Medium	Low	Low
Parsa	Medium	Medium	Medium	Medium	Medium
Rautahat	High	High	High	High	Medium
Rupandehi	Medium	Low	Low	Low	Medium
Saptari	High	High	High	High	High
Sarlahi	High	High	High	High	High
Siraha	High	High	High	High	High
Sunsari	Medium	Medium	Medium	Low	Medium

District	VBDs	WBDs/ FBDs	SARI	Malnut rition	Mental illness
Achham	Medium	Medium	Medium	Medium	High
Arghakhanchi	Medium	Medium	Medium	Medium	Medium
Baglung	Low	Low	Low	Low	Low
Baitadi	Medium	Medium	Medium	Medium	High
Bhaktapur	Low	Low	Low	Low	Low
Bhojpur	Medium	Medium	Medium	Medium	Medium
Dadeldhura	Medium	Medium	Medium	Medium	Medium
Dailekh	High	High	High	High	Medium
Dhankuta	Medium	Medium	Medium	Medium	Medium
Doti	Medium	Medium	High	High	Medium
Gulmi	Low	Low	Low	Low	Medium
Ilam	Low	Low	Low	Low	Low
Jajarkot	High	High	High	High	Medium
Kaski	Low	Low	Low	Low	Low
Kathmandu	Low	Low	Low	Low	Low
Kavre	Low	Low	Low	Low	Low
Khotang	Medium	Medium	Medium	Medium	Medium
Lalitpur	Low	Low	Low	Low	Low
Lamjung	Low	Low	Low	Low	Low
Makawanpur	High	Medium	High	Medium	Medium
Nuwakot	Medium	Medium	Medium	Medium	Medium
Okhaldhunga	Medium	Medium	Medium	Medium	Medium
Palpa	Low	Low	Low	Low	Low
Panchthar	Medium	Medium	Medium	Medium	Medium
Parbat	Low	Low	Low	Low	Low
Pyuthan	Medium	Low	Medium	Medium	Medium
Rolpa	Low	Medium	Medium	Medium	Medium
Salyan	High	High	High	High	High
Sindhuli	Medium	Medium	High	Medium	Medium
Surkhet	Medium	Medium	Medium	Medium	Low
Syangja	Low	Low	Low	Low	Low
Tanahu	Low	Low	Low	Low	Low
Terhathum	Medium	Medium	Medium	Medium	Medium
Udaypur	High	High	High	Medium	Medium
West Rukum	High	High	High	High	Medium

District	VBDs	WBDs/ FBDs	SARI	Malnut rition	Mental illness
Bajhang	High	High	High	High	High
Bajura	High	High	High	High	High
Darchula	Medium	Medium	High	High	High
Dhading	Medium	Medium	Medium	Medium	High
Dolakha	Low	Medium	Medium	Medium	Medium
Dolpa	High	High	High	High	Medium
Eastern Rukum	Medium	Medium	Medium	Medium	Medium
Gorkha	Medium	Medium	Medium	Medium	Medium
Humla	High	High	High	High	High
Jumla	Low	Medium	Medium	Medium	Low
Kalikot	High	High	High	High	High
Manang	Low	Medium	Medium	Low	Low
Mugu	High	High	High	High	High
Mustang	Medium	Medium	High	Medium	Low
Myagdi	Low	Low	Low	Low	Low
Ramechhap	Low	Low	Low	Low	Low
Rasuwa	Medium	Medium	Medium	Medium	Medium
Sankhuwasabha	Medium	Medium	High	Medium	Medium
Sindhupalchok	Medium	High	High	High	High
Solukhumbu	Medium	Medium	Medium	Medium	Medium
Taplejung	Low	Medium	Medium	Medium	Medium

Figure 18. Composite vulnerability ranking of different districts and regions (Tarai- left, Hill- middle and Mountain- right) based on climate sensitive disease category

5.4.6. Disease-specific vulnerability to climate change and climate extremes

i. Dengue

The vulnerability score shows that, Saptari had the highest and Kathmandu had the lowest vulnerability score among the 77 districts for dengue. Based on the vulnerability score, Saptari in Tarai, Western Rukum in Hill and Bajhang and Humla in Mountain had the highest vulnerability for dengue, while, Chitwan in Tarai, Kathmandu in Hill and Myagdi in Mountain had the lowest vulnerability (Figure 19).

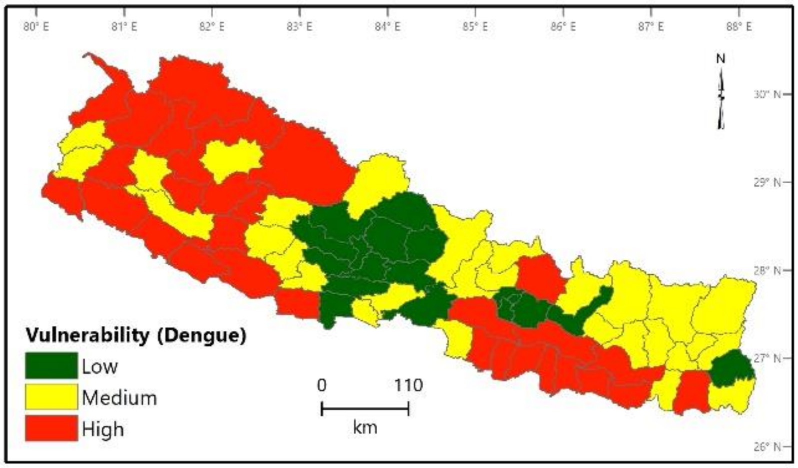

Figure 19. Distribution of Dengue, vulnerability rank by districts.

ii. Scrub typhus

The vulnerability score shows that, Saptari had the highest and Kathmandu had the lowest vulnerability score for scrub typhus among the 77 districts. Based on the vulnerability score, Saptari in Tarai, Western Rukum in Hill and Bajhang in Mountain had the highest vulnerability, while, Chitwan in Tarai, Kathmandu in Hill and Myagdi in Mountain had the lowest vulnerability for scrub typhus (Figure 20).

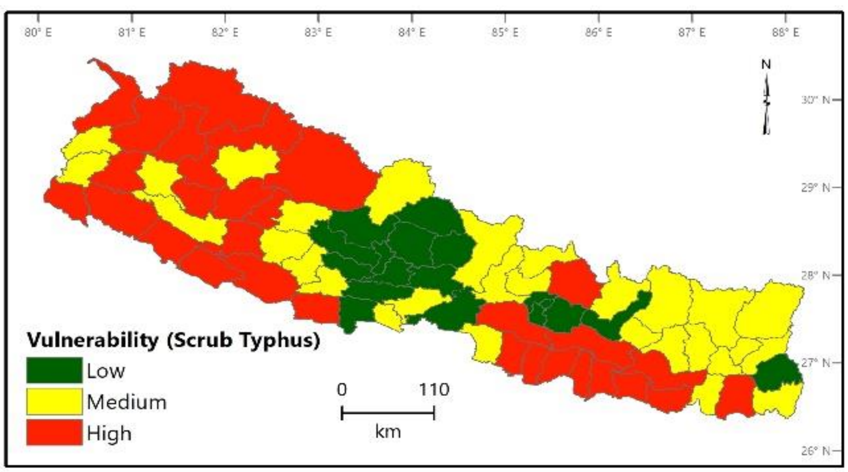

Figure 20. Distribution of Scrub Typhus vulnerability rank by districts.

For both dengue and scrub typhus, the vulnerability rank analysis revealed that Bajhang, Bajura, Banke, Bara, Bardiya, Dailekh, Dang, Darchula, Dhanusha, Dolpa, Doti, Humla, Jajarkot, Kailali, Kalikot, Kanchanpur, Kapilbastu, Mahottari, Makawanpur, Morang, Mugu, Rautahat, Salyan, Saptari, Sarlahi, Sindhuli, Sindhupalchok, Siraha, Udaypur and West Rukum had a very high vulnerability.

iii. Chikungunya

The vulnerability score shows that, Saptari had the highest and Kathmandu had the lowest vulnerability score for chikungunya among the 77 districts. Based on the vulnerability score, Saptari in Tarai, Western Rukum in Hill and Bajhang and Humla in Mountain had the highest vulnerability, while, Chitwan in Tarai, Kathmandu in Hill and Myagdi in Mountain had the lowest vulnerability for chikungunya (Figure 21).

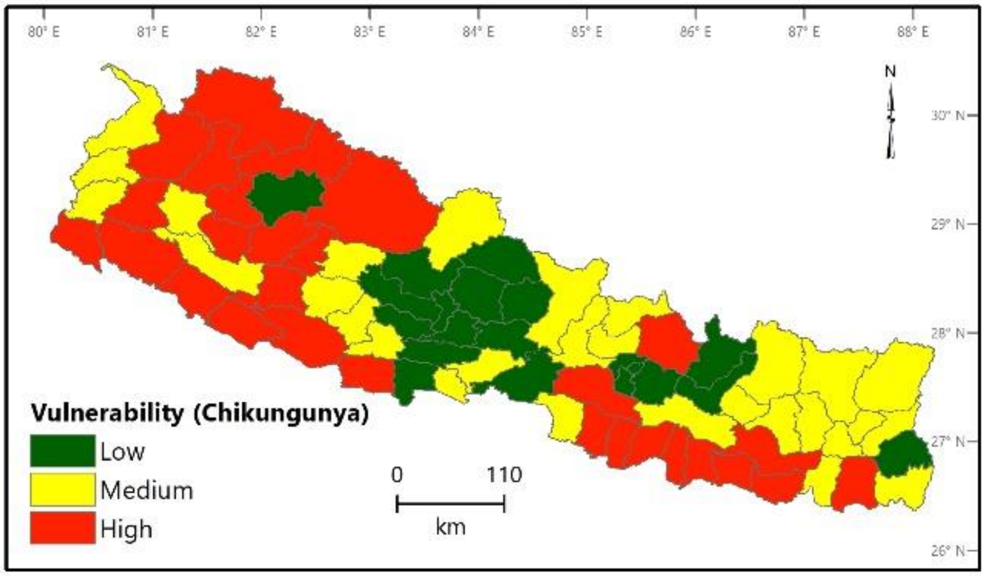

Figure 21. Distribution of Chikungunya vulnerability rank by districts.

iv. Zika

The vulnerability score shows that, Saptari had the highest and Kathmandu had the lowest vulnerability score for zika among the 77 districts. Based on the vulnerability scores, Saptari in Tarai, Western Rukum in Hill and Bajhang and Humla in Mountain had the highest vulnerability, while, Chitwan in Tarai, Kathmandu in Hill and Myagdi in Mountain had the lowest vulnerability for zika (Figure 22).

For both chikungunya and zika, the vulnerability rank analysis revealed that Bajhang, Bajura, Banke, Bara, Bardiya, Dailekh, Dang, Dhanusha, Dolpa, Doti, Humla, Jajarkot, Kailali, Kalikot, Kanchanpur, Kapilbastu, Mahottari, Makawanpur, Morang, Mugu, Rautahat, Salyan, Saptari, Sarlahi, Sindhupalchok, Siraha, Udaypur and West Rukum had a very high vulnerability.

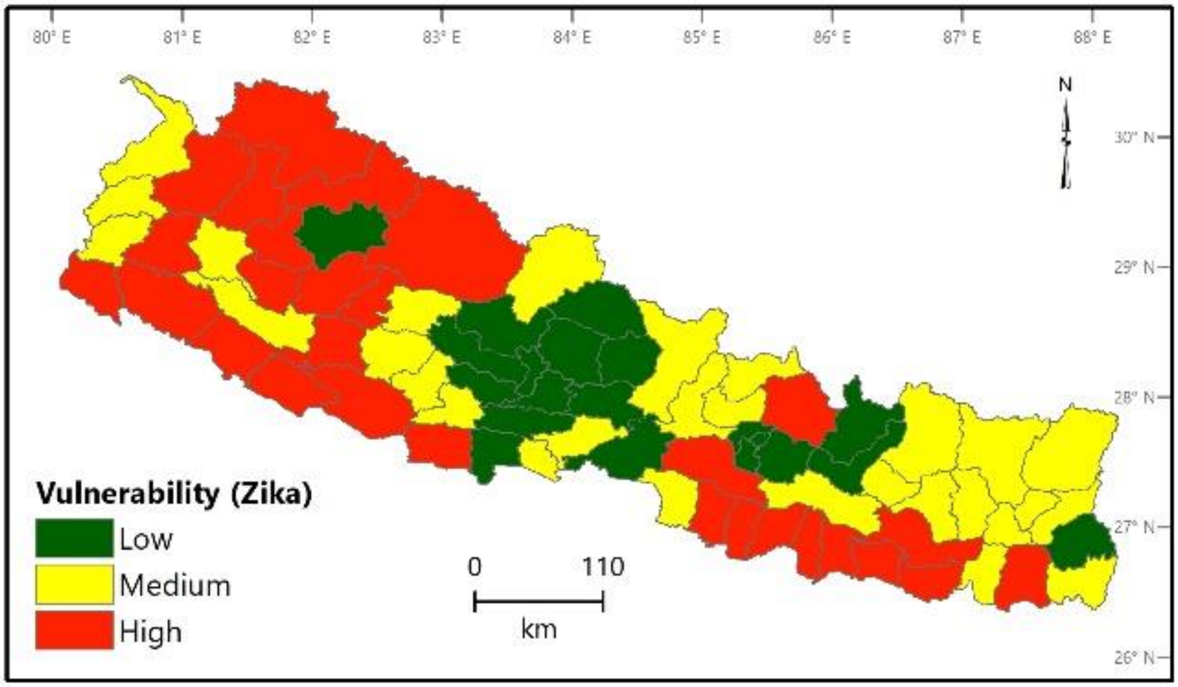

Figure 22. Distribution of Zika vulnerability rank by districts.

The regional vulnerability of dengue, Scrub typhus, Chikungunya and Zika is given in Table 4.

Table 4. Regional and district level vulnerability to Scrub typhus, Dengue, Zika and Chikungunya

Region/Disease	Scrub typhus	Dengue	Chikungunya & Zika[1]
Tarai	Dhanusha, Kailali, Kanchanpur, Kapilbastu, Mahottari, Morang, Rautahat, Saptari, Sarlahi, Siraha	Kailali, Kanchanpur, Kapilbastu, Mahottari, Morang, Nawalparasi, Rautahat, Saptari, Sarlahi, Siraha	Banke, Bara, Bardiya, Dang, Dhanusha, Kailali, Kanchanpur, Kapilbastu, Mariattarai, Morang, Rautahat, Saptari, Sarlahi, Siraha
Hill	Dailekh, Doti, Jajarkot, Makawanpur, Salyan, Udaypur Western Rukum	Dailekh, Doti, Jajarkot, Makawanpur, Salyan, Sindhuli, Udaypur, Western Rukum	Dailekh, Doti, Jajarkot, Makawanpur, Salyan, Udaypur, Western Rukum
Mountain	Bajhang, Bajura, Dolpa, Humla, Kalikot, Mugu Sindhupalchok	Bajhang, Bajura, Dolpa, Darchula, Humla, Kalikot, Mugu, Sindupalchok	Bajhang, Bajura Dolpa, Humla, Kalikot, Mugu, Sindupalchok

[1] Zika cases have not been officially reported in Nepal.

5.4.7. Risks of selected VBDs

The rising burden of dengue, scrub typhus, and chikungunya in Nepal, as well as the potential risk of zika, and their impacts on national health systems has been discussed widely. In such context, it can be assumed that the burden of these diseases will further weaken the already fragile health systems at local, provincial, and federal levels. The risks of these four VBDs and possible interventions to control them have been summarized based on the national disease control guidelines, annual health reports, and scientific literature (Table 5).

Table 5. Risks of selected VBDs on the national health systems

Risks	Possible interventions
Dengue	
• Potential outbreaks in highland areas with poor health services • Potential outbreaks in urban areas with overwhelmed health institutional capacity and higher impact on the urban poor • Worsening of clinical outcomes among comorbid and immunocompromised patient population • Unavailability or shortage of rapid diagnostic tests • Deficit of effective drugs at the time of outbreaks and epidemics, which gives space to falsified and substandard drugs, leading to the rise of drug resistance • Potential rise of insecticide resistance due to irrational use in endemic areas.	• Use of rigorous epidemiological and ecological methods (e.g. modeling, GIS to predict and map vector dynamics, disease transmission, and outbreak pattern • Integration of meteorological information into routine epidemiological updates such as EWARS bulletin • Intensifying awareness raising campaigns at household and community levels, particularly in urban areas, and effective screening and case management at institutional level • Sensitization and capacity building on detection, treatment and prevention of dengue. For example, step wise approach of case management (overall assessment; diagnosis and assessment of disease phase and severity; clinical management)[a] • Application of novel technology and interventions such as, point-of-care diagnostics (antigen test, ELISA, RT-PCR) and vaccines • Timely procurement of drugs approved by regulatory authorities and rational allocation to vulnerable areas • Surveillance based evidence generation (passive and active disease surveillance; vector surveillance) and regular update of national guidelines
Scrub typhus	
• Similar risk and impact as dengue	• Similar interventions as dengue
Chikungunya	
• Similar risk and impact as dengue; particularly, Chikungunya outbreaks may weaken health institutional capacity in the Nepal-India bordering districts, affecting identification and contact tracing of imported diseases	• Similar interventions as dengue; a scale up of screening and case detection campaigns may be needed in districts along Nepal-India border.
Zika	
• Similar risk and impact as dengue in case of Zika outbreak	• Similar interventions as mentioned above

[a]EDCD, 2019.

5.5. Vulnerable populations

A qualitative assessment of the vulnerable populations was conducted based on the existing literature on vulnerability assessment. Women and girls, the elderly populations, poor, and marginalized populations are the most vulnerable in terms of climate impacts on human health. The impacts of climate change are disproportionate among vulnerable populations as their exposure to climate-induced nature hazards is high with low adaptive capacity.

5.5.1. Women and Girls

The climate impacts on human health are augmented by socio-economic factors such as poverty, inequalities, migration, and high population density (Islam and Winkel, 2017). Drought, for example, decreases crop yields leading to food insecurity, hike in food prices, and also water shortages affecting the most vulnerable people (Sehgal et al., 2018; Salas et al., 2019). Similarly, extreme heat disproportionately impacts people with low-income levels and marginalized communities who have little or no access to sophisticated cooling devices (Hansen et al., 2013; Chambers, 2020). The impact of climate change has increased the health inequality gaps and put additional stress on the most vulnerable populations including women, children, elderly, lesbian-gay-bisexual-transgender-queer-intersexed community (LGBTQI), indigenous people, people in crisis, and marginal and poor communities. These vulnerable groups are the ones who are more exposed to climate-induced natural hazards, and they have limited capacity to adapt to, and cope with, climate change impacts (WFP and CBS, 2013).

Women and children have the lowest priority for access to food during the disaster (Nealon, 2016). Girls and women not only have different nutritional needs, but also are often last in the household food hierarchies (Watts et al., 2015, Desai and Zhang, 2021). Hence, they are more food insecure and suffer from malnutrition. Climate change also limits women's ability to seek reproductive and maternal health services, and pregnancy-related outcomes can be affected by changes in infectious diseases, temperature, and nutritional status (Sorensen, 2018). Furthermore, climate-induced disaster events lead to gender-based violence (GBV) directly and indirectly (Rezwana and Pain, 2021). GBV results in high levels of morbidity and mortality amongst women and also has long-lasting impacts on their physical, mental and reproductive health (Nakray, 2013).

In rural areas of Nepal, women are primarily responsible for climate-sensitive activities such as collecting firewood and fodder, fetching drinking water, and agricultural activities making them more vulnerable to climate change (Leduc, 2009). Women's vulnerabilities to climate-sensitive health outcomes are further acerbated by their limited participation in decision-making and the formulation of laws and policies (Wydra et al., 2010). From local to international level of negotiations on climate change, women's voice is underrepresented which has impeded gender-sensitive assessments and gender-responsible policy interventions (Van Daalen, 2020). In order to better understand the climate risks to women and detect disparities, sex-disaggregated data on health outcomes is essential. However, the gender disaggregated health data is poorly maintained in Nepal. The lack of gender-disaggregated health data restricted gender analysis hence making this assessment less gender-sensitive. Gender-sensitive health outcomes, risks, and impacts are presented in Table 6.

Table 6. Examples of disparate climate-related health impacts on women

Exposure pathway	Gender disparities in health impacts
Increasing frequency of extreme heat events and rising average seasonal temperatures	• Disproportionate heat-related morbidity and mortality • Adverse reproductive outcome: preterm delivery, congenital birth defects
Increasing frequency of climate-related disasters, including hurricanes, flooding, and wildfires	• Women suffer disproportionate mortality during natural disasters • Female survivors suffer decreased life expectancy • Women and girls are at high risk of physical and sexual violence, especially those belonging to marginalized sectors of society • Women are at higher risk for mental illness such as depression, anxiety and post-traumatic stress after disaster
Shifting rainfall and temperature patterns impair crops, livestock, and fishery yields, contributing to food insecurity	• Women suffer higher rates of macro- and micronutrient deficiencies, malnutrition and anemia • Malnutrition causes negative effects on neonatal outcomes including intrauterine growth restriction (IUGR) and perinatal mortality
Shifting rainfall and increased rates of evaporation lead to water insecurity and risk of waterborne disease	• Water scarcity forces supply from secondary sources that may be biologically and toxicologically contaminated, resulting in bacterial, viral, protozoan and helminthic infections as well as various toxic substances • Traveling long distances to procure water increases exposure to heat • Lack of access to water and sanitation creates unsafe conditions for women, especially during reproductive times
Changes in temperature, precipitation, and ecology are altering the geographic distribution of VBDs	• Exposure to mosquito-borne illnesses poses health threats to pregnant women who are exceptionally vulnerable • Pregnant women have a three-fold higher risk of severe malaria compared to nonpregnant women • Zika virus carries devastating fetal impacts, including microcephaly, Central nervous system malformations, and impaired cognitive development • Dengue virus is associated with increased risk of cesarean delivery, eclampsia, and growth restriction
Climate-induced environmental change drives human migration and/or results in "trapped" populations	• Women are more likely to undergo short-term migration (versus long-distance migration), which is often excluded from migration analysis • Women are more likely to be internally displaced by drought
	Source: Sorensen et al. (2018), Desai & Zhang (2021)

5.5.2. Other vulnerable populations

Children and elderly population are disproportionately vulnerable to the health impacts associated with climate change and extremes. Climate change is expected to increase malnutrition and infectious diseases such as gastro-intestinal illness, diarrheal diseases for children in low-income countries (Cissé et al., 2022). Elderly populations have greater risk of exposing to waterborne pathogens, higher sensitivity to dehydration (Benmarhnia et al., 2016). Poorer people often live in highly exposed locations are likely to bear more health burdens to climate change due to their inherent vulnerabilities (Gaskin et al., 2017). People living in informal settlements in urban areas are more exposed to climate change impacts (Giri et al. 2021). Likewise, indigenous people and local communities are often at greater risk of health impacts of climate change (Ford et al. 2020).

5.6. Baseline for monitoring changes in future vulnerability

The health risks for the past and current climatic conditions were analysed to prepare a baseline for estimating future health risks under future climate change scenarios. Aggregated scores of climate-induced hazards and aggregated scores of vulnerabilities were used to determine baseline risk. Saptari district had the highest risk score in Nepal while Parbat and Bhaktapur had the lowest risk scores in Nepal. Among regions, Saptari in Tarai, Makawanpur in Hill, and Dhading in Mountain region had the highest risk. The baseline risk score showed that nine districts (Banke, Bara, Dhanusha, Kailali, Mahottari, Morang, Rautahat, Saptari, and Sarlahi) had high risk while 19 districts had medium and 49 districts had low risk (Figure 23). Overall scores of hazards, exposure, sensitivity and adaptive capacity are given in annex 7.

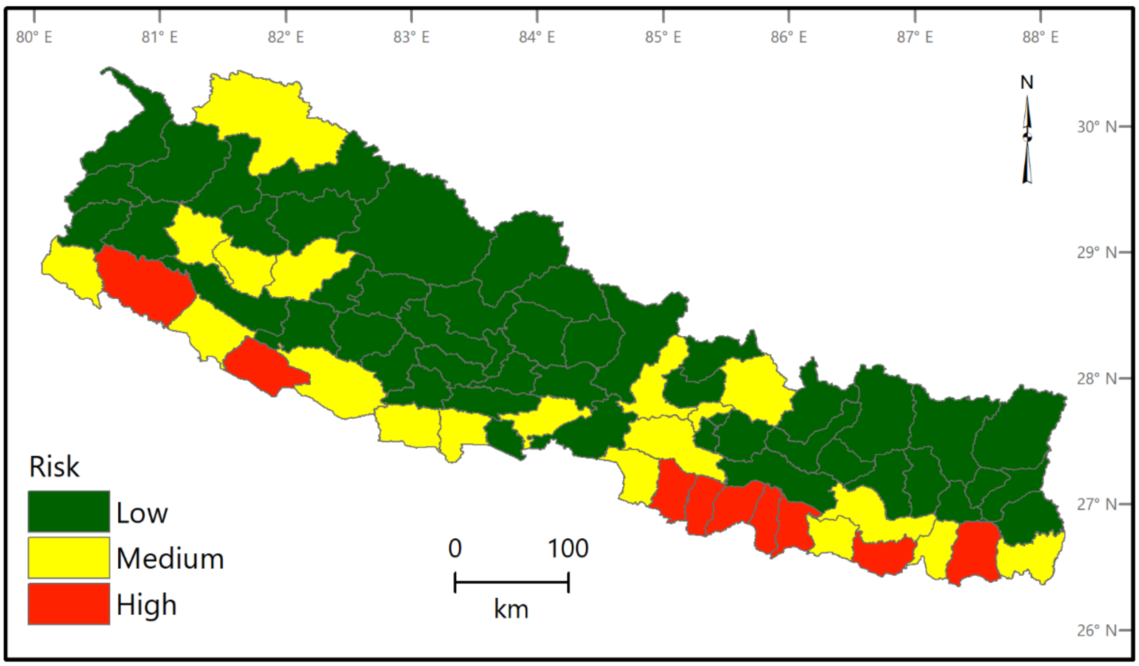

Figure 23. Risks of climate sensitive diseases under historic climate (baseline).

6. Capacity assessment

This assessment reviewed the existing capacity of Nepali health systems, with the focus on climate-relevant health policies and programs of the government, the institutional capacity of health facilities, and coordination between government units leading the education, research, and surveillance. Human resources for health, health information systems, and initiatives of other sectors to address health risks from climate change, were also focused on during the assessment.

6.1. Public health policies and programs to address climate sensitive diseases

Constitution of Nepal (2015): Constitution of Nepal has spelled out the matter of loss or damage caused by the emission of global greenhouse gases (GHGs) and the right of citizens to get compensation as per national and international laws, negotiations and treaties. Article 30(1) has guaranteed the fundamental rights of every citizen to live in a clean and healthy environment and article 30(2) has provisioned that the victim of environmental pollution or degradation shall have the right to be legally compensated by the polluter. Similarly, sub-article 1 of article 35 has stated that every citizen shall have the right to free basic health services, to be informed about their health condition, shall have equal access to health care and shall have the right to clear water and hygiene from the state.

National Health Research policy (2003): The policy promotes inter/intra sectoral and community participation in health research. The policy has assured networking and collaboration among all stakeholders in health research with a good ethical approach as well as utilization of health research findings. This policy has secured international linkage and collaboration for the conduct of health research and capacity building.

National Health Care Technology Policy (2006): This policy aims to establish strong regulatory mechanisms and develop policy guidelines for waste management and safety regulations in health institutions. It addresses equity and gender issues in the health sector which might be relevant to CSDs. The policy ensures access to health care technology for the whole population of the country irrespective of gender, ethnicity, income level and geographical variations. It gives attention to the proper distribution of health care technology in remote and rural areas of the country.

National Adaptation Programs of Actions (NAPA) to Climate Change (2010): NAPA is a strategic tool to assess climate vulnerability and systematically respond to climate change adaptation issues by developing required adaptation measures. NAPA has identified 'Public Health' as a separate thematic area. NAPA findings related to climate change impacts on human health in Nepal include increasing trends in the prevalence of CSDs, mainly VBDs such as, malaria, kala-azar, dengue, JE, filariasis; and WBDs such as diarrhea, cholera, typhoid, and malnutrition in many parts of the country. The worsening health condition of vulnerable population (poor and disadvantaged groups) from increased climate variability and increase in the disease's prevalence with the changing of settlement patterns were also discussed.

NAPA also prioritized the adaptation options to reduce the impacts of climate change on human health by strengthening the health system; empowering communities through education for responding adverse effects of climate change on public health; promoting the appropriate local adaptive knowledge on health impacts of changing climate; integrating the health impacts of climate change into broader development plans and related activities; prioritizing the research on climate change and health for evidence-based planning; and, promoting rainwater harvesting system to increase water supply and improved sanitation**.** NAPA has also recommended for piloting activities such as, investing in disease outbreaks and emergency response; scaling-up national and local programs on vector-water and food borne diseases, disasters, and strengthening forecasting/early warning and surveillance systems for climate change and health.

NAPA categorized the major health risks that included: increased injury; increased temperatures in built-up areas; disease and deaths from intense heat waves, cold waves and fire; increased risk of under-nutrition; waterborne and VBDs including dengue; damage to WaSH infrastructures from climate-related hazards; and, interruptions of WaSH and health services during displacement of people by climate-hazards.

The gaps identified in NAPA were: water quality monitoring system, coordination among the stakeholders, an understanding of climate-induced diseases to inform the health policies and strategies, and exploration of potential best practices and measures for adaptation.

National Framework on Local Adaptation Plans of Action (LAPA) (2011): LAPA was formulated in the line of NAPA as a national framework to provide effective delivery of adaptation services to the most vulnerable local communities and people at the local level LAPA framework ensures the integration of climate adaptation and resilience into the local and national level planning. LAPA has analysed 'Health, Water and Sanitation as a separate theme and its actions include integrating cost-effective climate adaptation and resilience aspects in local and national adaptation plans; identifying the most climate-vulnerable, municipalities, wards and communities and their adaptation challenges as well as opportunities - including possible activities or interventions; and, conduct the monitoring and evaluation by ensuring effective implementation of the action plan.

National Health Communication Policy (2012): This policy addresses the importance of effective and timely sharing of health and climate information to vulnerable populations. It states the following provisions: (i) provide quality health messages or information to mass citizens, particularly people living in remote villages with no media access, and those groups who are disadvantaged, poor, and marginalized (based on geography, ethnicity and gender), in an appropriate time and from appropriate media and methods; (ii) link health messages or related information and programs with services and ensure that the content is socially inclusive, gender-friendly, and right, fact and audience focused; (iii) promote and use advanced modern communication technology for dissemination of health messages and related information.

Nepal Health Sector Strategy (NHSS) (2015-2020): Nepal Health Sector Strategy (NHSS) (2015-2022) was developed with the emphasis to establish a multi-sectoral response to climate change (MoHP, 2015c). The NHSS added sanitation and hygiene, and environmental health as essential components of health services. Although the plan focused on the establishment of a knowledge network with the academia and practitioners of health and climate sectors, climate change activities were not precisely incorporated into the health institutional framework. Subsequently, Nepal Health Sector Strategy Implementation Plan (NHSP-IP III, 2016-2021) was prepared to address climate change and health impacts with an emphasis to establish a multi-sectoral response to climate change. In this plan, the government emphasizes multi-sectoral partnerships and collaborations to maintain good governance in the health sector – one of the six building blocks of health systems (WHO, 2007). Both the NHSS and NHSS-IP guides the health sector to carry out 'Health for All' spirit described in the National Health Policy 2019 as well as in the Constitution of Nepal in the context of the federal governance system in Nepal.

Nepal's National Adaptation Plan (NAP) (2016): NAP has recognized to build the capacity of professionals, government institutions and other stakeholders to support climate change adaptation-related activities by improving the physical systems and infrastructures to withstand climate risks; strengthening services and institutions to manage climate-related health risks; promoting research and development on climate change and health; addressing data issues in climate and health; reaching the unreached and most vulnerable populations and settlements with health services; and, fostering collaboration among and across sectors to promote health adaptations.

Nepal Health Sector Strategy Implementation Plan (2016-2021): The Implementation Plan enlists NHSS outputs with the evidence-based key interventions, health impacts of climate change and implementation of the NAPA - intended for national level planning and preparedness to protect people from climate change-induced disasters

Framework for Improved Management of Health Information in the Context of Federal Governance Structures in Nepal (2017): This document has mentioned the health sector data gaps in the federal context and action points for each gap which are equally relevant for reducing the health impact of climate change. It outlines key monitoring and evaluation functions to strengthen surveillance systems for improved information management in the federal context The Federal Ministry of Health can develop and implement national public health surveillance systems, e.g., civil registration and vital statistics (CRVS), integrated disease surveillance, maternal and perinatal death surveillance and response (MPDSR), EWARS; and systems for communicable, non-communicable diseases and nutrition. This framework has prioritized the development, implementation, coordination and regulation of the climate change adaptation framework for each health sector at the federal level.

Health National Adaptation Plan (H-NAP) (2017-2021): With regards to the health adaptation measures to address climate change's impact on human health, the Government of Nepal has made considerable efforts by formulating and enforcing several health sector policies, guidelines, and acts. The health sector of Nepal is primarily following the Health National Adaptation Plan (H-NAP 2017-2021), with the priority to reduce vulnerability, enhance adaptation measures, and develop climate-resilient health systems (MoHP, 2015a). The H-NAP was developed to meet the following five aims by 2020: (i) to raise awareness of climate change and its health effects, (ii) to generate evidence on the health effects of climate change through scientific studies, (iii) to reduce the morbidity of CSDs including malnutrition, (iv) to manage the health risks of extreme climate events, and (v) to protect human health from adverse climate effects through multi-sectoral response and ensure health in all policies. Additionally, in 2017, MoHP developed 'the Framework for Improved Management of Health Information in the Context of Federal Governance Structures in Nepal' for the period of 2015/16-2020/21 (NHSSP, 2017) to address health sector data gaps around healthy lifestyles and environment, climate change adaptations, and public health emergencies and outbreaks in the federal context. However, the framework has not incorporated the roles and responsibilities of existing health institutions in the planning and management of health service delivery.

National Health Policy (2019): It is guided by the principles of health equity and health system reforms, with the provision of a free Basic Healthcare Service package that ensures 'Health for All' and the Minimum Service Standards for health facilities (DoHS, 2019/20). This policy has six strategies that address environmental issues on human health: (i) access to basic emergency health services, (ii) implementation of a surveillance system on the environment, sanitation, drinking water and food items, (iii) public health impact assessment of specified industries, professions or projects, (iv) endorse the integrated preparedness and response measures to combat communicable, vector-borne and zoonotic diseases related with climate change, epidemics and disasters (v) promotion and strengthen the multisectoral coordination (vi) control and regulation of environmental pollutions. The policy has schemes such as, to promote environment-friendly technologies at national and local levels for healthcare waste management; to promote domestic and community waste management and environmental cleanness through coordination and advocacy; to immediately address disasters and epidemics through capacity development, response plans, preparedness and mobile hospital services; and to encourage citizens and community participation and contribution in health services including disaster management, risk reduction and health promotion.

National Climate Change Policy (2019): It states that a healthy living environment is essential to reduce the adverse effects of climate-induced disasters on human health with the following initiatives: (i) plan for preparedness and response, forecasting and prevention to avoid the epidemic of VBDs and communicable diseases induced by climate change; (ii) develop monitoring, forecasting and early warning system for disasters including flood, landslide, land erosion, drought, lightning, windstorm, heat-wave, wildfire, fire, epidemics, etc.; (iii) protect drinking water resources, and expand rainwater harvesting and storage technologies to ensure easy access and availability of drinking water; (iv) prioritize management of harmful and hazardous waste and segregate biodegradable waste for energy production. The policy also highlights the need for periodic national VRA.

Second Nationally Determined Contribution (NDC) 2020: NDC has highlighted the country's strategy in achieving net-zero GHGs emissions by 2050. It states that by 2030 the country should meet targets such as healthcare waste management in 1,400 health facilities through the application of non-burning technologies; 15% energy demand fulfilled from clean energy; and increased sales of electric vehicles up to 90% of all private vehicles, to reduce the emission and promote human health.

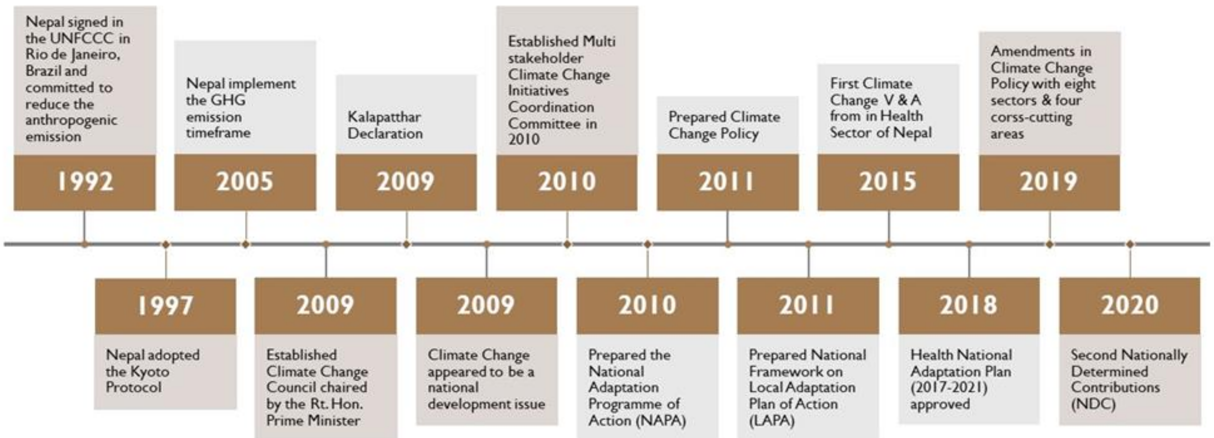

Figure 24. Key events of climate change initiatives in Nepal.

6.2. Current capacity of health systems

6.2.1. Institutional capacity

Institutional capacity can be defined as an ability to mobilize existing institutions and its resources to address policy issues, such as climate change (Willems and Baumert, 2004). In the literature, institutional aspects of adaptive capacity highlights the processes and efficiency of cooperation, negotiation, and decision-making among stakeholders, but also the capacity to mobilize resources and evaluate progress (Dany, 2015). Among resources, the studies focus on the management of human capital, finance, and technology (Willems, 2004). In the Nepali context, institutional capacity assessment helps the government to measure the progress of key stakeholders of climate change and health, including line ministries (MoHP, MoFE, MoFAGA, MoF, MoCIT), health institutions, and formal organizations (NGOs, civil society organizations) at the national and sub-national level. A general understanding of the existing capacities of the institutions would help the government while prioritizing capacity-building programs to reduce the health impacts of climate change (World Bank Institute, 2009).

The MoHP is responsible for overall policy formulation, planning, organization and coordination of the health sector at national, provincial, district and community levels. The goal of the MoHP is to improve the health of everyone living in the country through effective and efficient policy formulation, resource mobilization, monitoring and regulation for the delivery of health services by different health institutions. MoHP has three departments namely the DoHS; the Department of Drug Administration; and the Department of Ayurveda and Alternative Medicine, which has been implementing its activities through its different divisions and sections. The work related to climate change, air quality, WaSH, health care waste, chemical safety and other related environmental health activities are being performed through "Multi-sector Coordination Section" under the Health Coordination Division of MoHP (DoHS, 2020/21). The health sector is not only one of the largest areas of employment and service delivery but also has more potential for capacity building and job creation in Nepal. In the fiscal year 2019/20, 134 public hospitals, 2,071 non-public health facilities, 194 primary health care centers and 3,767 health posts, and 11,589 Primary

Health Care Outreach Clinics delivered basic health services to the needy population of Nepal. The Expanded Program of Immunization clinics provided immunization services in 16,698 sites and were supported by 53,659 Female Community Health Volunteers (FCHVs) working in 77 districts of the country (DoHS, 2019/20). It is observed that Hill districts have better institutional capacities, followed by Tarai districts, in terms of availability of health services, existing human resources for health, and academic institutions that run capacity building programs (DoHS, 2020/21). A brief analysis of the existing institutional capacity for addressing CSDs, by region, has been described in table 7.

There are 118 EWARS sentinel sites across Nepal under EDCD - DoHS, where sentinel sites report on a weekly basis (including zero report) on six priority diseases. EWARS is designed to strengthen the flow of information on outbreak-prone infectious diseases and VBDs from districts and facilitate prompt response to be carried out by rapid response teams at federal, provincial and local levels. The EDCD also performs surveillance and monitoring of drinking water quality from various sources and distribution sites. EDCD with the support of WHO has been strengthening its existing disease surveillance system from a climate change perspective. The Disease Surveillance and Research section at EDCD has initiated the Climate-sensitive Disease Surveillance (CSDS) program as its regular program. The CSDS program adopts measures to integrate meteorological data (temperature, precipitation, and relative humidity) and climate-sensitive disease data of CSDs (malaria, dengue, kala-azar, acute gastroenteritis, cholera, and severe acute respiratory infection) to monitor and forecast the probability of disease expansion. While strengthening climate-informed health surveillance, the program also promotes inter-sectoral collaboration among multi-sectoral data custodians and epidemiologists. The links between climate change and health are often complex and indirect – making the attribution of climate impacts on health outcomes challenging. The need for improved capacities for climate change adaptation through a climate-resilient health system has been realized in Nepal through several national policies and strategies like Health National Adaptation Plan (H-NAP) 2015, National health policy 2019 and Climate change policy 2019 among others (DoHS, 2020/21).

Table 7. Existing institutional capacity (health facilities and human resources) to address climate sensitive diseases

Health facilities and human resources	**Tarai**	**Hill**	**Mountain**	**Total**
Health institutions (DoHS, 2020/21)				
Public health facilities	1624	2261	978	4863
Non-public health facilities institutions (DoHS, 2020/21)	504	1481	86	2071
Registered medical stores (wholesaler and retailer: allopathic, Ayurveda & homeopathic, veterinary)	13924	8804	830	23558
Laboratories	95	308	2	405
EWARS Sentinel sites (https://edcd.gov.np/ewars)	31	64	23	118
Emergency health services institutions (DoHS, 2020/21)	22	30	9	61
Water treatment plants (http://dwssm.gov.np/en/)	22	223	86	331
Academic institutions				
Medical colleges with bachelor's and master's training in medicine (source- Nepal Medical Council, 2022)	14	1	11	26
Nursing programmes affiliated with universities and medical colleges (source- Nepal Nursing Council, 2022)	71	2	45	118
CTEVT* training programmes in health sciences (source- Nepal Nursing Council, 2022)	63	4	90	157

Human resources in health				
Government MBBS doctors (sanctioned positions)	271	337	113	721
Medical and allied professionals (practitioners, public health, nursing, paramedics, administrative staff), per 100,000 population, 2073/2074 data	1439	4586	6808	12883
Female Community Health Volunteers (FCHVs)	8833	2109	42717	53659
* Council for Technical Education and Vocational Training				

6.2.2. Health Information and Technology

The Health Management and Information System (HMIS) within the DoHS documents and monitors the progress in health sector (DoHS, 2019/20). The District Health Information System version 2.0 (DHIS-2), is a modular web-based open-source software package that provides a comprehensive and easy-to-use health information system solution for routine reporting and analysis of common (re)emerging diseases from all levels of health services in Nepal. The MoHP has also developed a separate information platform called 'Climate change and Health' under the Multi-sector Coordination Section of Health Coordination Division. The main objective of this web platform (https://climate.mohp.gov.np/) is to collect information on climate change and health issues from different sources and create an information hub. The information includes relevant policies, regulations, legal documents, guidelines, plans, official publications, reports, press releases, events updates and related materials. However, the information platform currently lacks real-time display of climate and health outcomes.

The MoHP also governs the Health Emergency Operation Centers (HEOCs) - one at the central level, seven at the province level i.e., Public Health Emergency Operation Centre (PHEOCs), and three district-level HEOC offices (Doti, Pokhara, Surkhet), which respond to health emergencies including disasters and disseminate health information to the public. The Provincial Health Directorates, functioning under either the Ministry of Social Development (MoSD) or the Ministry of Health (MoH) in the seven provinces, remain alert at the time of climate and health-related emergencies as they ensure an adequate supply of essential drugs and equipment in the designated health institutions, allocate human resource for the frontline response, and coordinate with external development partners for effective resource allocation and health service delivery.

6.2.3. Cooperation and coordination within health sector

As mentioned in the DoHS annual report, one of the country's priorities in the health sector is to develop integrated preparedness and response measures to combat communicable diseases including CSDs and health risks. Aligning with this priority, some of the initiatives taken by the MoHP, with support from the WHO Nepal, include capacity building activities for individuals (with a focus on public health professionals and clinicians), and health institutions in all seven provinces. The Coordination Division within the ministry runs advocacy and interaction programs with the provincial stakeholders regarding climate change and health impact, with a focus on air pollution and climate-informed early warning systems.

Furthermore, the National Health Education Information and Communication Center (NHEICC) is working on advocacy and strategic communication on occupational, environmental health, air pollution, and climate change (DoHS, 2019/20). Recently, the government's response to the ongoing COVID-19 pandemic has shown its ability and scope of strengthening the national and sub-national health systems, with the priority to health institutional preparedness and response, to tackle likely epidemics and pandemics in the future.

The Nepal Health Research Council (NHRC), research body of the Government of Nepal, is one of the apex organization that directly contributes to strengthening capacity of the health systems while maintaining climate resilience. The NHRC has prioritized capacity building of environment and health related human resources for developing climate resilient health systems - its training focuses on operational research. NHRC also conducts review and analysis of 'Burden of disease' studies, in collaboration with the Institute for Health Metrics and Evaluation (IHME). Similarly, the Vector-borne Disease Research and Training Center (VBDRTC) provides training to public health professionals and conducts field-level operational research on VBDs and entomological studies. Most of these activities are supported by the WHO office in Nepal. Likewise, National Health Training Center (NHTC) conducts national and provincial level training programs on climate change and health impact targeted to public health professionals. Under the Management Division of DoHS, the Environmental Health and Healthcare Waste Management Section carries out regular surveillance studies on drinking water and air, develops national laws, policies, plans, standards and protocols for health care waste management, and facilitates scientific management of health care waste in health facilities under federal, provincial and local governments (DoHS, 2020/021).

6.3. Inter-sectoral collaborations beyond health sector to address climate health risks

The Ministry of Forest and Environment (MoFE) has an important division called 'Climate Change Management Division' which prepares sector-specific NAP, including those for the health sector, by assessing vulnerability and risk and identifying prioritized adaptation options. The Division has also formed a separate thematic group on health, water, and sanitation.

On the policy aspect, there are several other policies and plans beyond the health sector that address the climate change impacts on human health. The then Ministry of Environment (MoE) prepared the National Adaptation Plan of Action (NAPA) to support the people through adaptation measures who are adversely affected by climate change (MoE, 2010). MoE prepared the national framework on LAPA to implement LAPA (MoE, 2011). The LAPA is designed to reduce the climate change impacts among vulnerable communities from the local level. Subsequently, the MoFE prepared the VRA framework and indicators for eight sectors including 'public health and WaSH' and four cross-cutting areas for the formulation of the National Adaptation Plan (NAP) in Nepal (MoPE, 2017b). Both MoHP and the Ministry of Water Supply are coordinating ministries of the 'Public Health and WaSH, thematic area in NAP. Based on this framework, MoFE has prepared the synthesis summary document of VRA and identified adaptation options for policymakers. The MoFE prepared a separate health sector VRA, identifying potential adaptation options, which has shown a link between climate change parameters at the district level and the selected health outcomes, such as VBDs, WBDs/FBDs, cardiorespiratory diseases, mental illness and malnutrition. Similarly, a separate VRA on Water, Sanitation and Hygiene has shown the impacts of climate hazards on the quantity and quality of water availability in Nepal (MoFE, 2021c).

The MoFE has also documented climate hazards, vulnerability, and identified potential adaptation options to address the climate-related health risks (MoFE, 2021a). Additionally, the Climate Change Policy (GoN, 2019) has prioritized the preparedness, forecasting, preventive measures and early-warning systems for the reduction of climate-induced disasters and their impact on human health.

The DHM collects hydrological and meteorological data throughout Nepal, processes the data, publishes it and disseminates the data to users such as water resource planners, developers, researchers and data seekers for the verification of extreme hydrological and meteorological events required for different purposes. DHM has been regularly providing the services for the General and Aviation Weather Forecast, flood forecasting and Early Warning to the public and related agencies during the period of monsoon season. DHM also forms the climate projection models for shorter and longer periods (http://dhm.gov.np/).

Similarly, the Central Bureau of Statistics (CBS) conducts the national climate change impact survey to provide data and knowledge on impacts of climate change considering multiple dimensions including climate change and health, and adaptation practices that are adopted by households to cope with the adverse situation due to changing climate (CBS, 2017). The National Planning Commission also facilitates the ministries, departments and development organizations in analyzing sector-specific climate issues with greater understanding of climate variables at the local level and in adopting to reduce the emerging and anticipated climate threats which face development plans and programms (https://npc.gov.np/en).

The World Health Organization (WHO), one of the key development partners in health sector, supports the GoN in climate change and health-related capacity building, infrastructure development, research, policy formulation, and programme implementation. Likewise, several academic institutions and universities not only incorporate climate change and health topics in their curriculum and annual work plans but also generate relevant scientific evidence on a regular basis.

7. Risk assessment

Climate change is projected to increase population exposure to climate extremes such as heat waves, and add burdens of several climate-sensitive health risks producing adverse health outcomes (Cissé, 2022). Therefore, under different scenarios of climate change, the risks of climate-sensitive health outcomes – especially for those vulnerable geographic regions (eco-regions and districts) and populations may vary. In this assessment, modeled data from the Coupled Model Inter-comparison Project Phase 6 (CMIP6) models (Eyring et al., 2016) that were used in the IPCC AR6 have been utilized for future changes in average and extreme temperature and precipitation. The projection data was at 1.0º x 1.0º (100km x 100km) resolution. CMIP6 presents five scenarios that represents possible societal development and policy paths also known as Shared Socio-economic Pathways (SSP) for meeting designated radiative forcing by the end of the century. To analyse average changes in temperature and precipitation, multi-model ensemble values of 31 models that submitted data to IPCC across all SSPs was used (CCKP, 2021) while calculating the extreme values, two SSPs (SSP2-4.5 and SSP5-8.5) were used for three different periods.

7.1. Future health risk of climate change

In the future, an increase in extreme events may increase the climate morbidity and mortality of CSDs and associated health risks. For example, an increase in hot days and heatwave events may increase heat-related morbidity and mortality (heat stress, cramps, hyperthermia, exhaustion, stroke or death) and an increase in VBDs (WHO, 2018). An increase in warm nights may worsen chronic conditions such as respiratory disease, ischemic heart disease, cerebrovascular disease, and mental illness. An increase in the number of frost days may increase the number of heart diseases, injuries, acute respiratory diseases such as flu, SARI, sore throat, cough and asthma. An increase in drought events may increase the diarrhoeal disease with dehydration, VBDs, malnutrition, pneumonia, and mental health consequences. An increase in extreme precipitation may cause diarrhoeal diseases including AGE, VBDs, and respiratory diseases.

Extreme climatic conditions may affect not only the pathogen maturation and multiplication (McMichael et al., 2012), but also the tendency of vector dispersal, the density and sensitivity of host species, and the socio-cultural aspects of human behavior (for example, due to internal displacement, overcrowding in community centers and health facilities). The future health risks may span across the life course, disease pathway, and gender differences. Particularly, children may suffer from pre-disaster anxiety and post-traumatic stress disorder; maternal health services and outcomes may be disrupted or worsened, and the elderly population may require hospitalization and critical care. Health services for chronic and immunocompromised patients may be hampered due to sudden climate extremes. Women and girls of reproductive age group may find climate extremes more disastrous than men as they may have to experience stillbirth and its emotional turmoil, on top of the increased risk of VBDs which includes Zika induced anencephaly (UN Women, 2022; Birkmann et al., 2014). Annex 5 highlights the major impacts of climate hazards, key vulnerabilities, and health risks.

7.2. Future climate change

As in other parts of the world, Nepal will witness changes in frequency, intensity, duration and extremes of precipitation and temperature in the future. Analysis of the changes in average and extreme indices of temperature and precipitation is presented below.

7.2.1. Projected climate under two SSP scenarios

Depending on the scenarios, mean annual temperature over Nepal will increase between 0.75ºC and 0.84ºC by 2020-2040, between 1.09ºC to 2.03ºC by 2041-2060, 0.92ºC to 4.03ºC by 2061-2100. Under SSP2-4.5 scenario, the temperature will increase between 0.68ºC and 0.81ºC with mean of 0.72ºC by 2020-2040, between 1.34ºC and 1.69ºC with mean of 1.46ºC by 2041-2060, and between 2.01ºC and 2.64ºC with mean of 2.24ºC by 2061-2100. Similarly, under the extreme SSP5-8.5 scenario, the average annual temperature will increase between 0.73ºC and 1.02ºC with mean of 0.84ºC by 2020-2040, between 1.76ºC and 2.42ºC with mean of 2.03ºC by 2041-2060, and between 3.45ºC and 4.95ºC with mean of 4.03ºC by 2061-2100. The range of projections from ensemble model for annual average temperature change in Nepal under five SSP scenarios is given in Table 8 and Figure 25.

Table 8. Multi-model ensemble means of change in mean temperature (◦C) in three different period under five SSP scenarios.

Scenarios	Average temperature (min-max) 2020-2040	Average temperature (min-max) 2041-2060	Average temperature (min-max) 2061-2100
SSP1-1.9	0.75 (0.56-0.88)	1.09 (0.79-1.23)	0.92 (0.57-1.16)
SSP1-2.6	0.79 (0.73-0.89)	1.28 (1.13-1.46)	1.42 (1.17-1.74)
SSP2-4.5	0.72 (0.68-0.81)	1.46 (1.34-1.69)	2.24 (2.01-2.64)
SSP3-7.0	0.69 (0.63-0.80)	1.52 (1.42-1.74)	2.98 (2.74-3.55)
SSP5-8.5	0.84 (0.73-1.02)	2.03 (1.76-2.42)	4.03 (3.45-4.95)

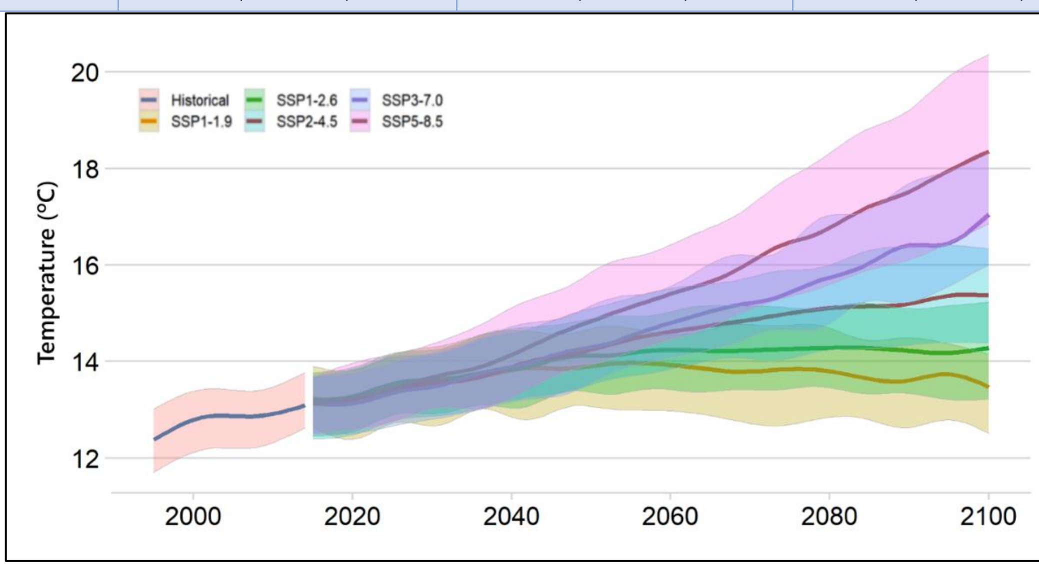

Figure 25. Projected future change in mean temperature shown by multi-model ensemble under five SSP scenarios (Ref. Period: 1995-2014). (Data source: CCKP, 2021)

In terms of precipitation, ensemble mean of multi-model precipitation showed increase in annual precipitation in future as compared to the reference period under four SSP scenarios except for SSP1-1.9 (Figure 26). However, the uncertainty is high and some models also project decrease. Except SSP1-1.9 scenario, total annual precipitation over Nepal will increase in the range of 3-5% by 2020-2039, 5-8% by 2040-2059, 9-12% by 2060-2079 and 10-12% by 2080-2099. Under SSP2-4.5 scenario, precipitation will increase by 5% from 2020-2039, by 8% from 2040-2059, and by 9% from 2060-2079 and by 10% from 2080-2099. Similarly, under the extreme SSP5-8.5 scenario, precipitation will increase by 3% from 2020-2039, by 7% from 2040-2059, and by 12% from 2060-2079 and by 20% from 2080-2099. The predicted changes in the amount of annual precipitation as compared to historical annual precipitation is given in figure 28 and the monthly precipitation anomaly is given in Figure 26.

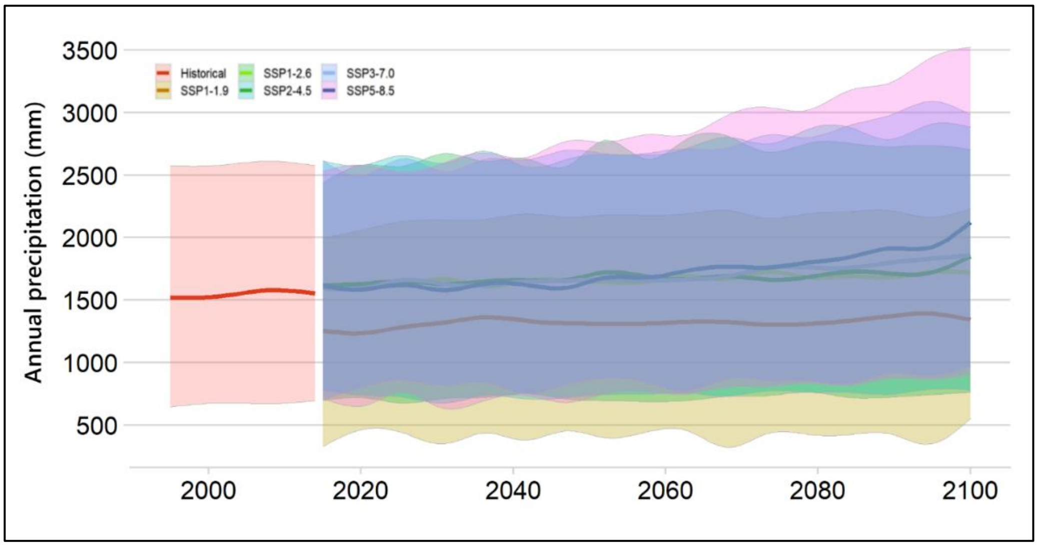

Figure 26. Projected future change in annual precipitation shown by multi-model ensemble under five SSP scenarios (Ref. Period:1995-2014). (Data source: CCKP, 2021)

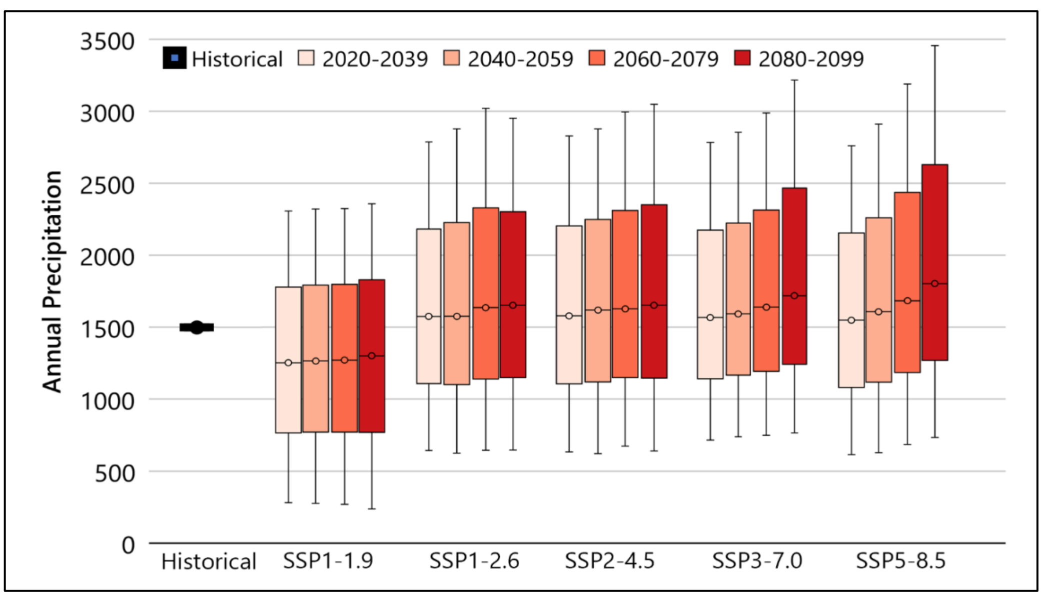

Figure 27. Change in the amount of annual precipitation under five SSP scenarios in Nepal.

7.2.2. Projected change in climate extremes

Future climate change will likely to continuously increase the hottest day temperature (TXx), coolest day temperature (TXn), coolest night temperature (TNn), hottest night time temperature (TNx) and frequencies of hottest nights (TN90p) while continuously decreasing cold day frequency (TX10p) and the number of frost days (FD) under both SSP scenarios (Figure 30). Depending on the SSP scenarios, the extreme precipitation events will vary; extreme precipitation events (Rx1day, Rx5day) will initially increase and then decrease under SSP2-4.5 scenario while the same precipitation extreme will initially decrease and then increase under SSP5-8.5 scenario (Figure 28). Not consistent changes are predicted in other precipitation extremes such as dry spell (CDD), wet spell (CWD), and wet day precipitation more than 20mm (R20mm) (Figure 29).

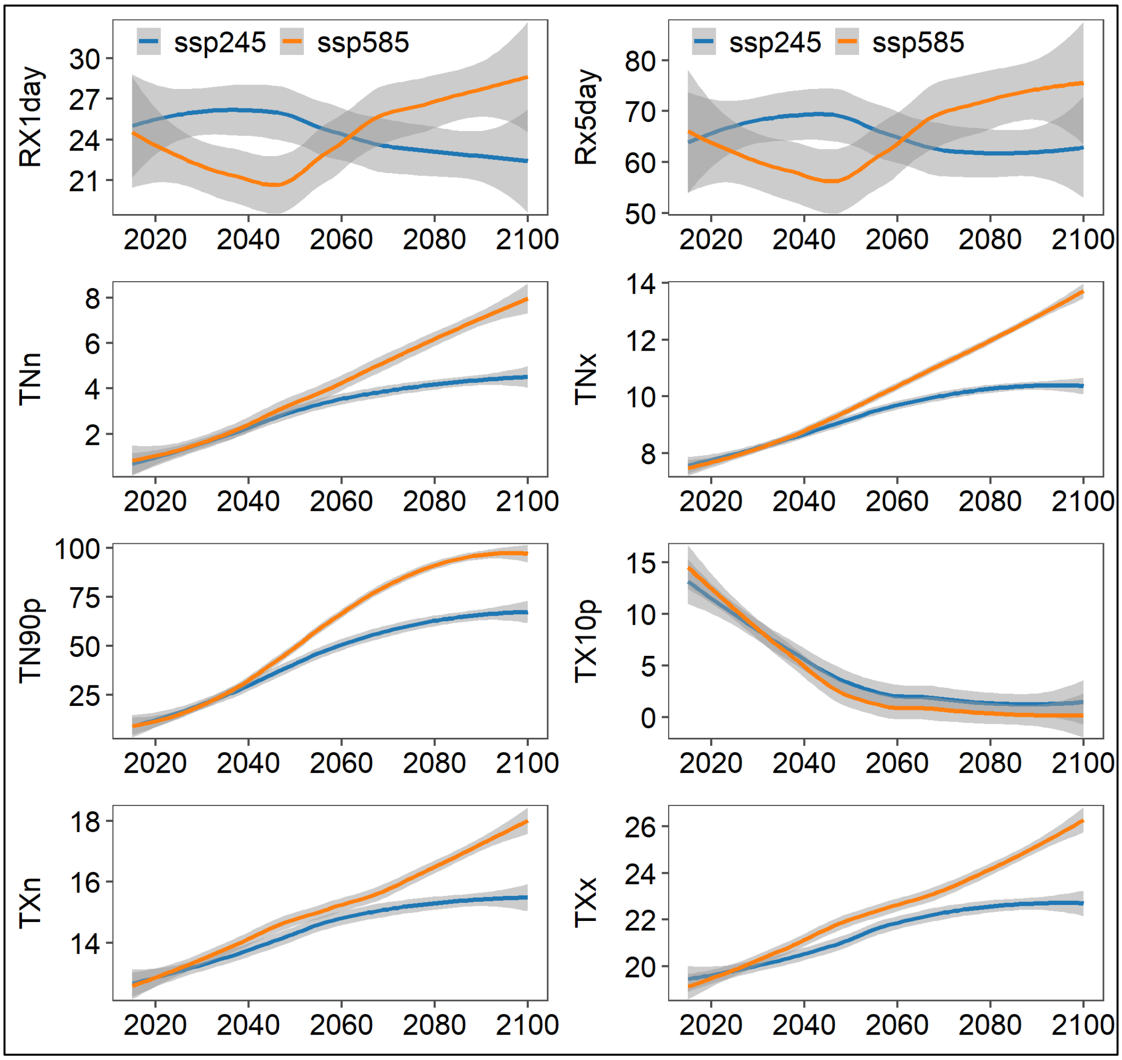

Figure 28. Projected future change in extreme climate indices under two SSP scenarios

Rx1day = monthly maximum 1-day precipitation, Rx5day = maximum 5-day precipitation, TNn =coolest night temperature, TNx = hottest nighttime temperature, TN90p =hot night frequency, TX10p =cold day frequency, TXn =coolest day temperature, TXx =hottest daytime temperature

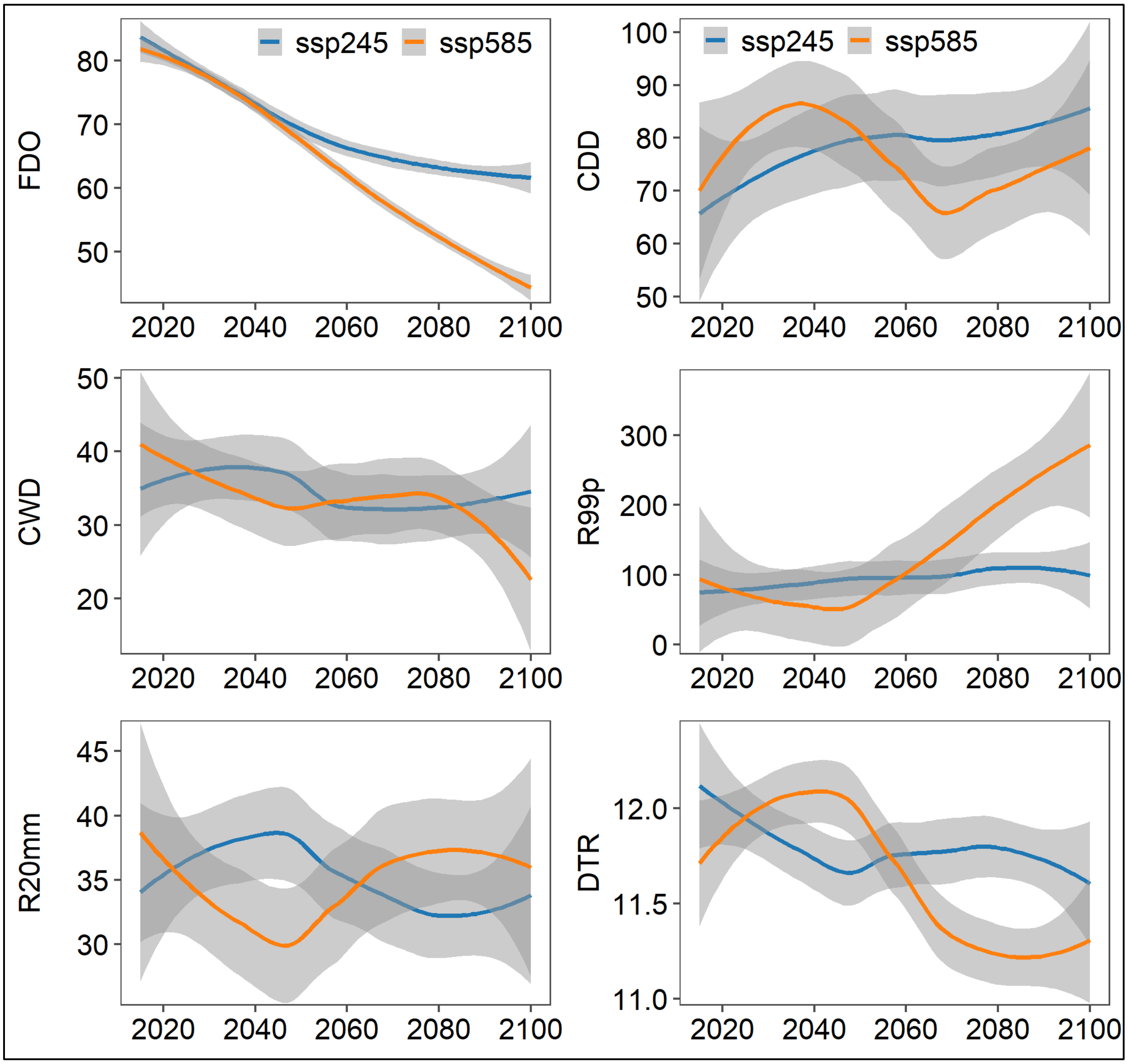

Figure 29. Projected future change in extreme climate indices under two SSP scenarios

FDO=number of frost days, CDD= dry spell or maximum number of consecutive days with RR < 1mm, CWD= wet spell or maximum number of consecutive days with RR ≥ 1mm, R99p=extremely wet day, R20mm= wet day precipitation more than 20mm, DTR= Diurnal temperature range

7.3. Change in health risks under future climate and extreme scenarios

Future risk assessment was conducted based on the predicted change in the future extreme climate indicators that have impacts on health outcomes. District-wise trends of 14 different climate indicators (Table 2) for three different periods (2040, 2060 and 2100) under two scenarios (SSP2-4.5 and SSP5-8.5) were analysed.

The district-wise average number of extreme events will increase with successive periods in both scenarios; under the SSP2-4.5 scenario, the average number of significant changes in extreme climate indicator was 4.5 in 2040, 8.5 in 2060 and 9.3 in 2100 while the number of significant changes in extreme climate indicator under SSP5-8.5 scenario was 6.5 in 2040, 8.1 in 2060 and 12.11 in 2100 (Figure 30).

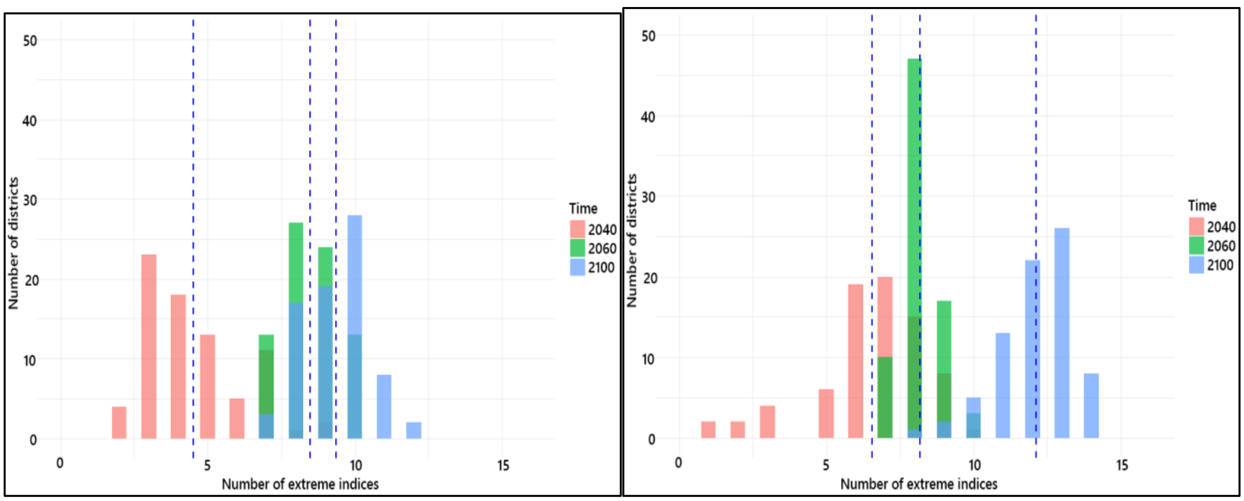

Figure 30. Changes in the average number of extreme climate indices under SSP 2-4.5(left) and under SSP 5-8.5(right) under 2040, 2060 and 2100

**Vertical dashed line are averages in periods*

The future SSP2-4.5 and SSP5-8.5 models reflect that each district will face the changes in number of climate extreme events (Figure 31).

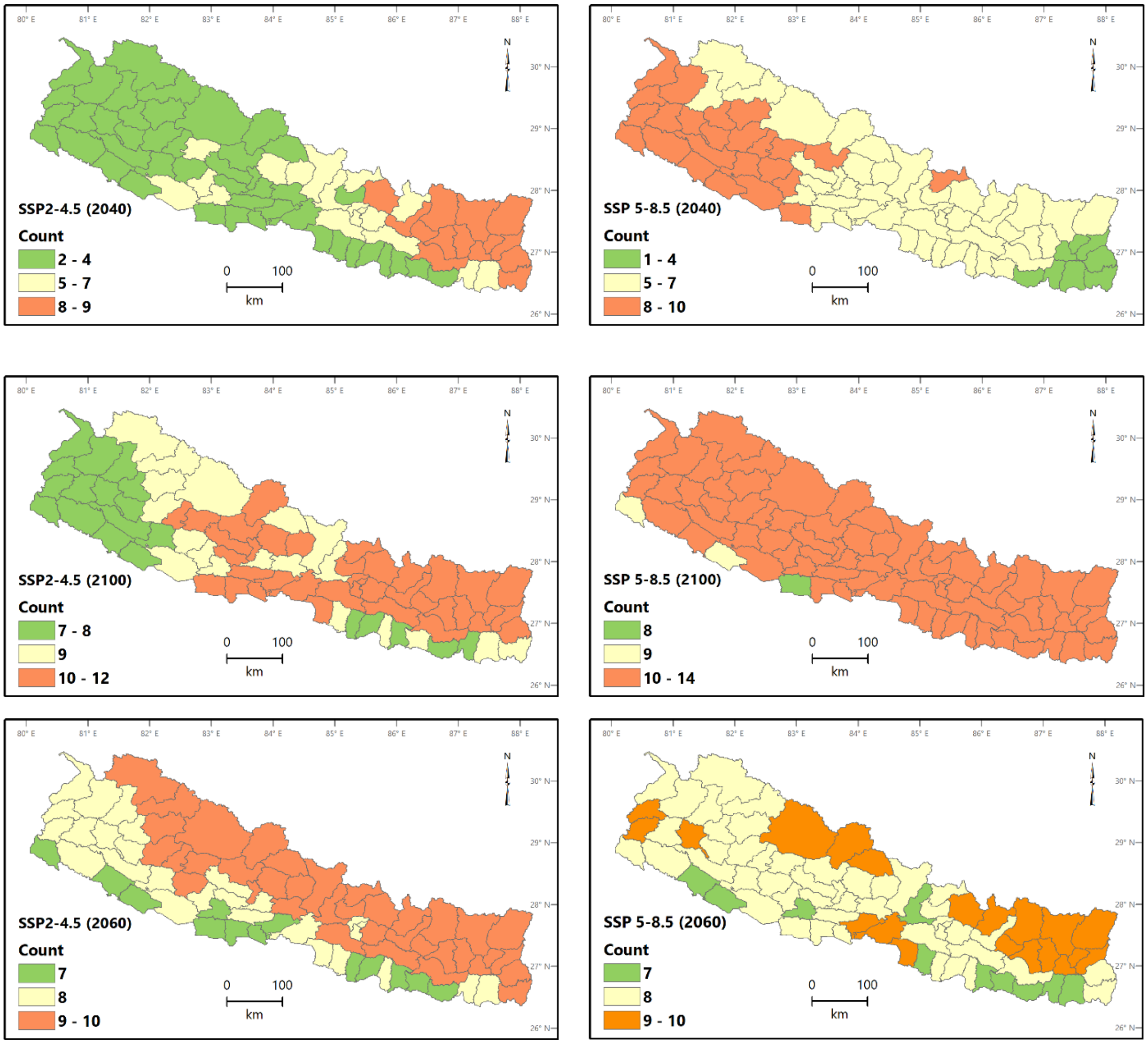

Figure 31. Spatial distribution of cumulative number of significant changes in climate extremes under two scenarios in three different periods.

More districts (8 under SSP2-4.5 and 39 under SSP 5.8.5 in 2040 and 77 districts after that in both scenarios) will have a significant decrease in the annual number of cold days in future, and the trend consistently increased from 2020-2100 in both scenarios (SSP2-4.5 and SSP5-8.5). More districts (27 under SSP2-4.5 and 68 under SSP 5.8.5 in 2040 and 77 districts after that in both scenarios) will have a significant increase in the annual number of hot days in future and the trend is consistently increased from 2020-2100 in both scenarios (SSP2-4.5 and SSP5-8.5). Almost all districts (77) will have a significant increase in the annual number of warm nights after 2040. More districts (6 under SSP2-4.5 and 72 under SSP 5.8.5 in 2040 and 77 districts after that in both scenarios) will have a significant increase in the annual number of hottest days in the future and the trend consistently increased from 2020-2100 in both scenarios. The number of districts with a number of frost days will significantly decrease in both scenarios in future (37 under SSP2-4.5 and 17 under SSP 5.8.5 in 2040).

In terms of precipitation, mixed trends in the maximum amount of rain that falls in one day and five consecutive days were found. The number of districts facing drought will consistently increase in future under the SSP2-4.5 scenario only (one in 2040, 11 in 2060 and 18 in 2100). The number of districts facing a significant increase in extreme precipitation will increase in future, the increase is drastic by the end of the century. The spatial distribution of cumulative number of significant changes in climate extremes under two scenarios and three different periods is given in Figure 31. A table with district-wise predicted change of future climate risk for three different time periods (2040, 2060 and 2100) under two scenarios (SSP2-4.5 and SSP5-8.5) is given in annex 7.

Taking into account the future climate risk in all three ecological regions, the burden of all five categories of CSDs (VBDs, WBDs/FBDs, SARI, undernutrition and mental illness) will keep on increasing in Nepal in the next 20 years and beyond if health adaptation interventions are not implemented urgently.

7.4. Data gaps

This V & A assessment was based on the annual data. Assessment has experienced a lack of break-down time-series disease data at district and local levels, and different social groups to authenticate the climate change and its impacts on the distribution and development of CSDs. There was also a huge gap in hydrometeorological data derived from the DHM. Not only the distribution of weather stations in Nepal is sparse (13 districts have no weather stations) but the data collected from those available stations are also incomplete. For this study, daily minimum and maximum temperature data of 104 stations and daily precipitation data of 79 stations were used. However, only 26% of stations have a complete temperature data and 58% of stations have a complete precipitation data for 41 years from 1980 to 2020. Around 17% of weather stations have daily temperature data no longer than 10-year period while 5% of stations have daily precipitation data no longer than 10-year period. This study used temperature data of more stations (93 stations vs 104 stations) than the previous study (DHM, 2017) on the basis of which the VRA was prepared (MoFE, 2021b). Additionally, this study covered more recent period (1971-2014 vs 1980-2020) than the previous study (DHM, 2017). Nevertheless, the gap in climate data is a major barrier to analyse a long-term variations in spatial and temporal patterns of temperature and precipitation in Nepal. The station-wise available data of this study for temperature and precipitation is given in annex 3.

8. Adaptation assessment

Understanding climate change impacts, vulnerabilities, and risks help in designing various health sector strategies, policies, programs and actions to address current and projected health risks and vulnerabilities. A rigorous desk review was performed with the grey literature, the scientific publication, relevant national policies and plans related to the health sector, and an assessment of institutional capacity and gaps. In addition, a full-day consultative workshop was organized on December 28, 2021, involving selected experts and stakeholders to share the findings of VRA, validate the adaptation options, and discuss how to best operationalize adaptation options at the different levels. Moreover, the Gender and Social Inclusion (GESI) perspective was taken into account during the V&A assessment process, to understand if certain hazards and risk factors are more common among certain vulnerable and marginalized people. Out of 33 participants of stakeholder consultations, nine were women, who echoed the voices of women and girls regarding vulnerability to health risks from changing climate.

Climate change has been presenting risks to human health and wellbeing, and these will continue in the future. However, much of the potential health burdens of climate change can be escaped through acting on the environmental and social determinants of climate-sensitive diseases, strengthening the climate resilience of health systems, and adapting to changing climate conditions (WHO, 2015). In comprehensive adaptation planning and policy-making, the effort of health sector should consider climate perspectives (DoHS, 2019/20). The potential adaptation options were identified through an extensive literature review as well as policy and program analysis, and these have been listed on par with the six building blocks of health systems (WHO, 2007), as follows.

8.1. Service delivery

- Expansion of Indoor Residual Spraying (IRS) and distribution of Long-lasting Insecticidal Nets (LLINs) in VBD risk areas;
- Strengthening disaster management program to enhance health sector emergency preparedness and response, including disaster related outbreak management;
- Development of climate resilient health facilities and strengthening of CSD surveillance system at facility level;
- Provision of safe drinking water to all citizens, with routine quality testing in disaster and epidemic hit regions;
- Waste management at household, community, and institutions (e.g., health facilities) with priority given to nun-burn technology;
- Promotion of electric vehicles in health service.

8.2. Health workforce

- Creation of opportunities for qualified human resources (parasitologists, entomologists, environmental health officers, disaster experts, public health experts, data analysts);
- Immediate actions to fulfil relevant sanctioned government positions;
- Sensitization and capacity building of health professions and public office bearers on the topics of climate change and health risks, including skill enhancement in surveillance and research activities;

- Mobilization of community youths and health volunteers including FCHVs for mass awareness campaigns on relevant topics such as, health and sanitation, control of air and water pollution.

8.3. Health information systems

- Strengthening climate-informed EWARS for the surveillance of emerging and re-emerging diseases;
- Development of a framework for an integrated surveillance and monitoring of emerging and re-emerging diseases;
- Monitoring seasonal patterns of CSDs;
- Inter-ministerial and multi-sectoral coordination and communication for sharing correct and the most relevant information to the public;
- Development and maintenance of national open-source e-database on climate factors and health indicators associated with CSDs.

8.4. Medical products, vaccines and technology

- Adequate availability of Indoor Residual Spraying (IRS) and Long-lasting Insecticidal nets (LLINs) in VBD risk areas including newly added risk areas;
- Adequate availability of rapid diagnostics and effective drugs in public/ private facilities;
- Research, development, and timely rollout of new vaccines (e.g., vaccine against rotavirus, cholera, malaria, dengue);
- Adequate availability of essential medical products including oxygen and lab supplies in all health facilities;
- Timely procurement and maintenance of biomedical equipment (ventilators, X-ray machine, CT machine, MRI, ultrasonography).

8.5. Health system financing

- Investment in the research and development of climate resilient health systems;
- Introduction of 'climate risk insurance' and establish its linkage with existing national social protection systems including national health insurance programme;
- Investment in research and development of healthcare technology that might be useful to detect and prevent CSDs;
- Access to globally available climate and health funds for surveillance and research of CSDs.

8.6. Leadership and governance

- Prioritization of climate change and health agenda in the new National Health Sector strategy (NHSS) 2022-2030;
- Implementation of vector control strategy, with execution of existing legislation;
- Implementation of climate resilient water safety plans by local government units;
- Implementation of clean cooking technology (e.g., improved cookstoves, induction cookstoves, modern cooking devices) to replace fossil fuel-based cooking;

- Strengthening health emergency preparedness and response plans at institutional and community levels learning from COVID-19 pandemic;
- Policy dialogues to facilitate integration of climate services into health decision making process and vice versa;
- Periodic assessment of gaps in national and subnational databases and reporting mechanisms for climate factors and health indicators;
- Development of urban health adaptation plans at city level;
- Development of interdisciplinary tools for the management of (re)emerging VBDs and zoonotic diseases, taking into account 'One Health' concept;
- Integration of gender and socio-economic perspectives in health adaptation plans, as per the recommended guidelines (e.g., WHO guidance - Mainstream gender in health adaptation to climate change programs);
- Engagement of political groups, mainstream media, civil society organizations, corporate sector, youth groups, and scientists in climate and health activities;
- Adequate national research funding for climate and health research, while promoting local level but advanced research and peer-reviewed publications.
- Fulfilment of government's commitments made at international forums, such as NDC 2021, COPE26.

From geographical perspectives, in the highly vulnerable districts categorized on the basis of composite vulnerability and risk rank, the following could be the potential health adaptation options (Table 9).

*Table 9. Adaptation options based on highly vulnerable districts, by region**

Region	Highly vulnerable and risk districts*	Common CSDs and Health risks	Recommended adaptations options
Tarai	Banke, Bara, Dang, Dhanusa, Kailali, Kanchanpur, Kapilvastu, Mahottari, Morang, Rautahat, Saptari, Sarlahi, Siraha	VBDs, Heat- and cold-related illness, SARI, Mental illness	- Integrated vector surveillance - Strengthening of web-based disease surveillance systems (e.g., expansion of EWARS sentinel sites) - Screening and case detection of emerging diseases at the Nepal-India points of entry (PoE) - Procurement and supply of rapid diagnostic kits to detect VBDs and SARI cases - Multi-sectoral partnership for research, academic activities, and community awareness, especially temperature related and mental illness (for e.g., utilization of medical colleges and teaching hospitals, and research institutions) - Prioritize WaSH-related public health and development activities to prevent and reduce impact of diarrheal diseases - Promote local food systems and scale up 'school nutrition program - Local level context-specific sensitization and advocacy programs on 'climate change and health'
Hill	Dailekh, Salyan, Udaypur, Western Rukum	VBDs, WBDs/FBDs,	- Strengthening of EWARS sentinel sites - Procurement and supply of rapid diagnostic kits to detect VBDs and SARI cases

		SARI, Undernutrition	- Entomological surveillance to track vector dispersal - Prioritize WaSH-related public health and development activities to prevent and reduce impact of diarrheal diseases - Promote local food systems and scale up ‘school nutrition program - Local level context-specific sensitization and advocacy programs on ‘climate change and health’
Mountain	Bajhang, Bajura, Humla, Kalikot, Mugu	VBDs, WBDs/FBDs, SARI, Mental illness, Undernutrition	- Strengthening of EWARS sentinel sites - Entomological surveillance to track vector dispersal - Prioritize evaluation of nutritional value of local and indigenous food to ensure food security - Introduce tele-health services to increase people’s access to healthcare - Local level context-specific sensitization and advocacy program on ‘climate change and health’

**These adaptation options may be equally applicable to medium and low vulnerable districts*.

8.7. Guidance for the management and monitoring of health risks of climate change

It is essential for government and its stakeholders to actively monitor and manage changes in health risks through resilient health system in changing climate. This V & A assessment supports fundamental knowledge of changes in health risks and identification of new health risks, as well as identification of vulnerabilities at different spatial and temporal scales, and communicates about the changing risks to health professionals and decision makers.

The findings of V & A are also useful to design the monitoring and evaluation systems for reducing the climate sensitive health outcomes by tracing changes in various districts and regions, seasonality, incidences, and evaluating the efficacy of adaptation measures in reducing the burden of CSDs and associated exposure to climate related hazards, as well as assessing the resilience to climate variability and change. Capacity monitoring is essential to manage the changing burdens of climate sensitive health outcomes with the increase in the frequency and intensity of extreme weather and climate events. This V & A report describes the capacity of health system. Therefore, policies design with additional interventions is indispensable to manage the risks of climate change in future. The V & A of CSDs is a requisite to increase the resilience of individuals, communities and health systems that manage future health risks by identifying the gaps and knowledge needed to support the adaptation efforts completion.

9. Conclusions and Recommendations

9.1. Conclusions

Climate change brings health burdens to human society aggravating the existing health conditions of individuals and weakening the health systems at national and subnational levels. Ecological disruption and extreme weather events have an impact on human health, further exacerbating the burden of CSDs and negatively impacting the quality of life. Vulnerability to climate hazards and extreme events varies according to geographic and socio-demographic conditions, so do the institutional and health system capacities to adapt to and cope with the change.

In recent decades, CSDs have become serious health problem in Nepal. The noticeable effects of climate change have been found in the diseases such as VBDs, WBDs, SARI, malnutrition, mental illness, and injuries. Particularly, the impacts of climate change have been profoundly found in the distribution and outbreaks of VBDs and WBDs. With regard to VBDs, the annual incidences of incidence of scrub typhus are increasing, while incidences of dengue are varying across the regions. Although, malaria and Kala-azar cases are decreasing nationally, these VBDs have been detected in new areas, mainly in highlands of Hill and Mountain regions, and this geographical shift could be explained by either vector expansion (indigenous) or import of disease from neighboring countries. With regard to WBDs, higher incidences of cholera and AGE are observed in Tarai districts. Temporally, AGE cases have drastically increased over the past decade nationally. SARI cases have been reported in all geographical regions. Both SARI and mental illness are increasing nationally, whereas undernutrition in under-5 children is decreasing. The seasonal distribution of CSDs in Nepal with climate factors in three geographic regions of Nepal reflects that climate change impact on public health of Nepal is more apparent. The present assessment found that most of the districts in the Tarai region are highly vulnerable to climate change. Similarly, the majority of districts in the Tarai and Hill regions are highly vulnerable to all four categories of CSDs. In future, climate change will further aggravate the outcomes of CSDs by adding health complexities in different regions of the country. Given the uneven distribution of vulnerabilities and health risks to current and future climate change among geographies and populations, the implementation of context-specific risk management and adaptation measures shall address the spatial and regional vulnerabilities and risks in the health sector.

There has been an increase in average annual temperature and a decrease in annual precipitation and climate extremes including hottest day time temperature, coolest day temperature, hottest night time temperature, and coolest night temperature. The future climate in Nepal will be hotter with extremely hot days and nights, more heavy rainfall, and droughts, and associated hazards will increase adding health burdens. Climate extremes and climate-induced hazards have already escalated the sensitivity and vulnerability of Nepali people.

The national policies, programs, and activities on climate and health currently suffer from implementation challenges or slow progress. Most importantly, the maintenance of credible disease incidences data with gender information as well as complete climate data through collaborative efforts among federal, provincial, and local governments, development organizations, and local communities will be crucial for the future V &A and similar assessments in the health sector. Multi-sectoral approach and coordination shall be considered for revitalization of context-specific adaptation measures. The context-specific adaptation measures, that align with the WHO recommended six building blocks of the resilient health systems, also contribute to building climate resilience in the health sector. This assessment of V & A of CSDs is a critical starting point for understanding the disease specific vulnerabilities and risks as well as potential adaptation options to build the climate-resilience health systems.

9.2. Recommendations

The assessment has identified 12 districts in Tarai region, four in Hill, and five in Mountain that are highly vulnerable and at risk for health impacts of climate change, therefore, the government, as well as non-government development sectors, could prioritize these districts while formulating national health sector strategies, sectoral policies and annual programs. Similarly, future study could focus on these areas for in-depth analysis of disease trends and potential preventive measures. Some of the specific recommendations are given below.

Reinforce climate resilient health systems: Considering the findings of this assessment, priority should be given to the four emerging diseases that have an outbreak potential: dengue, scrub typhus, chikungunya, and zika - the last one yet to be officially reported but has a high vulnerability. Screening and case detection of emerging diseases at the Nepal-India bordering districts (particularly at the points of entry), with timely procurement and supply of rapid diagnostic kits to detect VBDs and WBDs cases is important. Furthermore, entomological surveillance should be expanded to the highland areas of Hill and Mountain to track vector dispersal. The existing programs of MoHP to minimize climate induced health problems may need to be updated in collaboration and coordination with multi-sectoral stakeholders. In the era of digital revolution, it would be helpful to have strengthened web-based climate-informed disease surveillance systems in practice with expansion of EWARS sentinel sites. Furthermore, community-focused, outreach and capacity-building programs need to be designed and implemented in the most vulnerable and at-risk districts and most vulnerable populations with a focus on context-specific adaptation measures to build climate resilient health system.

Fill the data gaps of climate sensitive diseases: The CSDs follow a specific seasonality trend and the impact on human health can be assessed through comparing weather variation and health outcomes in both the spatial and temporal scales. Therefore, the disease-specific daily or monthly data management system in uniform date format is strongly recommended. Integration of meteorological information into routine epidemiological updates such as EWARS bulletin would be helpful for analyzing climate-health interface in the context of changing climate. Additionally, the use of rigorous epidemiological and ecological methods (e.g. modeling, GIS) is recommended to predict and map vector dynamics, disease transmission, and outbreak patterns. Furthermore, collection of gender-disaggregated data is required to prepare more gender-sensitive vulnerability assessments in future.

Establish climate resilient health facilities: The health institutions in each region, should be strengthened through a step-wise holistic approach, for instance, resilient infrastructure, capable and optimal resources for screening, diagnosis, and clinical management of CSDs etc.,. Both passive and active/enhanced disease surveillance should be institutionalized, with the application of novel technology and interventions such as, point-of-care diagnostics and vaccines. The clinical and public health units in the health facilities should be functional throughout the year for surveillance based evidence generation on CSDs - specially at the time of climatic crises.

Need to invest in research and evidence generation: The disease specific climate-related studies are deficient in Nepal. Therefore, impact studies, landscape analysis of VBDs, assessment of disease burden, and identification of socio-economic determinants of CSDs need to be prioritized in the research strategies of the government units and academia. The research units of the government (such as, EDCD and NHRC at MoHP; Climate Change Management Division at MoFE; VBDRTC; Policy Research Institute, universities and academia), and non-government academic institutions could take the lead of evidence generation processes. Also, the policies analysis provides information to the decision makers on policy gaps in policy formulation and implementation. The analysis of existing policies and documents related to climate change and health impacts (mentioned under 5.1) in accordance to the trend and status of climate change on human health is required to know build a climate-resilient health system.

Increase the scope of V & A assessment in the future: This V & A assessment only focused on districts and physiographic regions. Considering the endemicity and hot-spots, there is a need of disease specific V & A assessment at the municipality level - the lowest administrative unit of Nepal for tailored adaptation options.

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Annex 1: Indicator list

Table 10. List of indicators and data sources used in V & A study

SN	Indicators	Sources
A	**Category: Hazard**	
1	Total incidence of avalanche	DHM, Desinventar, MoHA
2	Total incidence of cold wave	
3	Total incidence of epidemic	
4	Total incidence of fire	
5	Total incidence of flood	
6	Total incidence of forest fire	
7	Total incidence of landslide	
8	Total incidence of snowstorm	
9	Total incidence of storm	
10	Total incidence of heat wave	
11	Total incidence of heavy rainfall	
B	**Category: Exposure**	
1	Impact (death, injuries, missing, and property damage, destroyed) of epidemic	DHM, Desinventar, MoHA
2	Impact (death, injuries, missing, and property damage, destroyed) of landslide	
3	Impact (death, injuries, missing, and property damage, destroyed) of fire	
4	Impact (death, injuries, missing, and property damage, destroyed) of flood events	
5	Total number of non-public health facilities	HMIS
6	Total number of public health facilities	
7	Total number of health institutions (Hospital, PHC/HC, HP, SHP)	
8	Area of district with annual unhealthy $PM_{2.5}$ level	Hammer et al. 2020
9	Number of years with annual unhealthy $PM_{2.5}$ range	
10	Current monthly minimum value of daily maximum temperature (TXn)	DHM
11	Current monthly minimum value of daily minimum temperature (TNn)	
12	Current daily temperature range (DTR)	
13	Current monthly maximum consecutive 5-day precipitation (Rx5day)	

14	Current monthly maximum 1-day precipitation (Rx1day)	
15	Current Percentage of days when TN > 90th percentile (TN90p)	
16	Current percentage of days when TX < 10th percentile (TX10p)	
17	Current annual count of days when PRCP≥ 20mm (R20mm)	
18	Current monthly maximum value of daily minimum temperature (TNx)	
19	Current annual total PRCP when RR > 99p (R99pTOT)	
20	Current number of frost days (FD)	
21	Current maximum length of wet spell, maximum number of consecutive days with RR ≥ 1mm (CWD)	
22	Current maximum length of dry spell, maximum number of consecutive days with RR < 1mm (CDD)	
23	Current monthly maximum value of daily maximum temperature [TXx]	
C	**Category: Sensitivity**	
1	Rented population	CBS, 2011
2	Total number of male indigenous	
3	Total number of female indigenous population	
4	Total number of male dalit population	
5	Total number of female dalit population	
6	Total number of male population	
7	Total number of female population	
8	Total number of migrant population	
9	Population density (number per km)	
10	Percentage of rural population	
11	Percentage of urban population	
12	Poverty rate	
13	Number of poor people	
14	Population influenced per kilometer road	
15	Percentage of population with disability	
16	Percentage of households by type of house foundation (Mud)	
17	Percentage of households by type of house foundation (Wood)	
18	Percentage of households by type of house walls (Wood)	
19	Percentage of households by type of house walls (Bamboo)	

20	Percentage of households by type of house walls (Unbacked Brick)	
21	Percentage of households by type of house roof (Thatch/Straw)	
22	Percentage of households by type of house roof (Wood/Planks)	
23	Percentage of households by type of house roof (Mud)	
24	Percentage of households with selected source of drinking water (Tubewell/ Pump)	
25	Percentage of households with selected source of drinking water (Uncovered well)	
26	Percentage of households with selected source of drinking water (Spout)	
27	Percentage of households with selected type of cooking fuel (Wood/ Firewood)	
28	Percentage of households with selected type of cooking fuel (Kerosene)	
29	Percentage of female agricultural holding	
30	Total number of indigenous population	
31	Total number of Dalit population	
32	Food poverty prevalence	WFP
33	Food poverty gap	
34	Population per health institutions	HMIS, EDCD
35	Stunting	
36	Underweight	
37	Wasting	
38	Total number of expected pregnancies	
39	Number of cases of scrub typhus (2019-2021)	
40	Number of cases of malaria (2005-2020)	
41	Number of cases of dengue (2005-2020)	
42	Number of cases of kala azar (2005-2020)	
43	Zika score	
44	Chikungunya score	
45	Number of cases of JE (2005-2020)	
46	Number of cases of Cholera (2008-2020)	
47	Number of cases of AGE (2008-2020)	
48	Number of cases of SARI (2005-2020)	
49	Number of cases of undernutrition (2005-2019)	
50	Number of cases of mental illness: psychosis, anxiety, depression (2006-2020)	
51	Mean elevation	DEM, STRM
D	**Category: Adaptive capacity**	
1	Percentage of male adult literacy rate	CBS, 2011

2	Percentage of female adult literacy rate	
3	Percentage of economically active population	
4	Percentage of households with female ownership on land and house	
5	Percentage of female household head	
6	Percentage of households by ownership type of house Owned	
7	Percentage of households by type of house foundation (Cement)	
8	Percentage of households by type of house roof (Galvanized iron)	
9	Percentage of households by type of house roof (Tile/Slate)	
10	Percentage of households by type of household amenities (Radio)	
11	Percentage of households by type of household amenities (Television)	
12	Percentage of households with selected toilet facilities (Without toilet)	
13	Percentage of households with selected toilet facilities (Flush Toilet, Septic Tank)	
14	Percentage of households with selected toilet facilities (Ordinary toilet)	
15	Percentage of households with selected source of drinking water (Tap/ piped)	
16	Percentage of households with selected source of drinking water (Covered well)	
17	Percentage of households with selected source of drinking water (River/ Stream)	
18	Percentage of people with safe drinking water	
19	Life expectancy at birth	
20	Number of households with clean energy (LP gas, Biogas, electricity) for cooking	
21	GNI per capita based on purchasing power parity (PPP)	
22	Gross value added at basic price (in million)	
23	Poverty head count ratio	
24	Total number of medical practitioners, public health, nursing, paramedics, admin staff per 100,000 population	HMIS, EDCD, Health Insurance Board
25	Total number of FCHVs within catchment area	
26	Percentage of total population utilizing OPD service	
27	Total number of female population insured	
28	Total number of male population insured	

29	Percentage of population covered by government health insurance	
30	Percentage of Vitamin A coverage in severely malnourished under-5 children	
31	Percentage of children 12-23 months immunized with JE vaccine	
32	Total number of outreach clinics conducted	
33	Percentage of pregnant women who do not visit ANC check-up	
34	Number of emergency health services	
35	Nutrition programme for mother & children	
36	Food productivity (paddy, wheat, maize, millet, barley)	FAO
37	Number of households with drinking water access	DWSSM
38	Percentage of water supply coverage	
39	Number of water treatment plants	
40	Number of drinking water treatment facilities	
41	Percentage of sanitation coverage	
42	Percentage of area coverage by EWS	
43	Drought impacts and adaptation strategies	MoFE

Annex 2: Climate sensitive diseases in Nepal

Vector borne diseases (VBDs)

Malaria: Overall, malaria cases gradually decreased over the past 16 years (2005-2020). The prevalence of malaria was below 1,500 in most of the districts during this period. However, more than 3,000 cases of malaria were detected in Jhapa, Kailali and Kanchanpur during 2005-2012. Over the past decade, malaria cases were increasingly reported in new areas, both in the Hill (Dailekh, Gulmi, Lamjung, Nuwakot, Pyuthan, Salyan) and the Mountain (Bajura, Dolakha, Humla, Mugu). This geographical shift towards highlands could be the result of either vector expansion (indigenous) or import of disease from a neighboring country, adding challenges in disease elimination (Figure 32).

Figure 32. Change in incidences of malaria between two periods.

Kala-azar: The national annual incidence of Kala-azar was gradually decreasing, with 1,082 cases in 2006 and 214 in 2020. Likewise, the incidence of Kala-azar was below 500 in most of the districts during 2005-2020. During 2005-2012, Saptari, Sarlahi and Siraha reported a high number of cases, between 500 and 1,500. Over the past decade, Kala-azar cases were increasingly reported from new areas, both in the Hill (Achham, Jajarkot, Khotang, Nuwakot, Palpa, Salyan, Surkhet, Western Rukum) and the Mountain (Bajura, Sankhuwasabha) and the reason could be the same as that described for malaria above (Figure 33).

Figure 33. Changes in incidences of Kala-azar from 2019 to 2021

Japanese encephalitis (JE): JE has remained static throughout the decades, with below 1,000 total cases reported per year nationally except in 2017 when the annual incidence was 2,064. JE outbreaks were reported in Morang (Tarai) during 2005-2012 with cases over 600, but other districts throughout the nation reported less than 300 cases during this period. Other two Tarai districts (Chitwan and Rupandehi) reported more than 600 cases during 2013-2020. Certain Hill districts (Arghakhanchi, Kathmandu, Nuwakot, Palpa) have also recorded rising cases of JE (Figure 34).

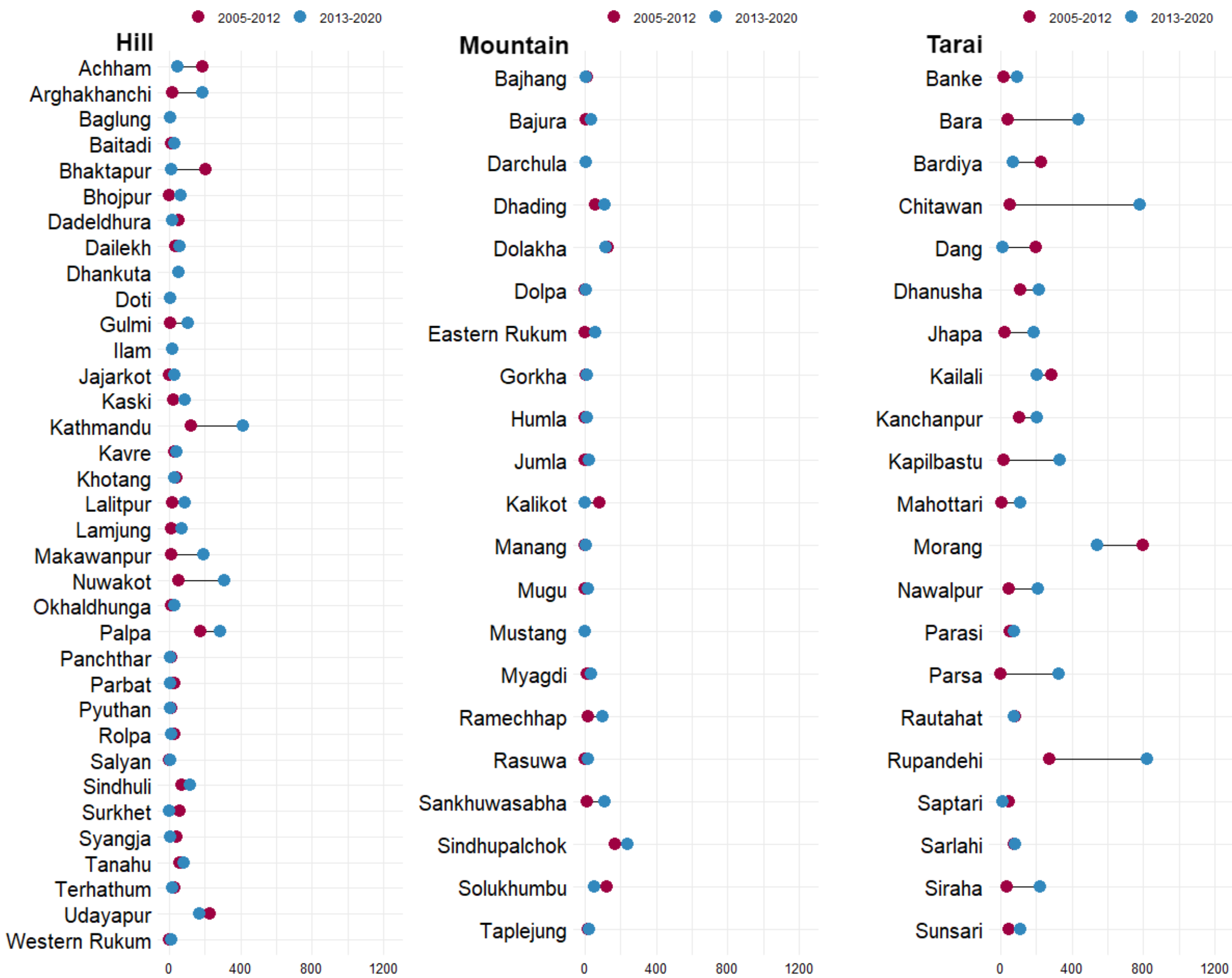

Figure 34. Changes in incidences of Japanese Encephalitis between two periods

Scrub typhus: Scrub typhus cases are gradually rising in the past three years. It was considered a rare disease in Nepal before 2019 with zero cases detected, but drastically, a high number of cases were detected in 2019 (1,600) and 2020 (1,897). According to the Early Warning and Reporting System (EWARS) data as of 10th December 2021, the total number of Scrub typhus cases reported in Nepal in 2021 was 1,483. Scrub typhus outbreaks have been sporadically reported in all geographical regions of Nepal, with more than 100 cases reported between 2019 and 2021 in Baitadi, Gulmi, Palpa, Darchula, Dhading, Dolakha, Kalikot, Kailali and Rupandehi (Figure 35).

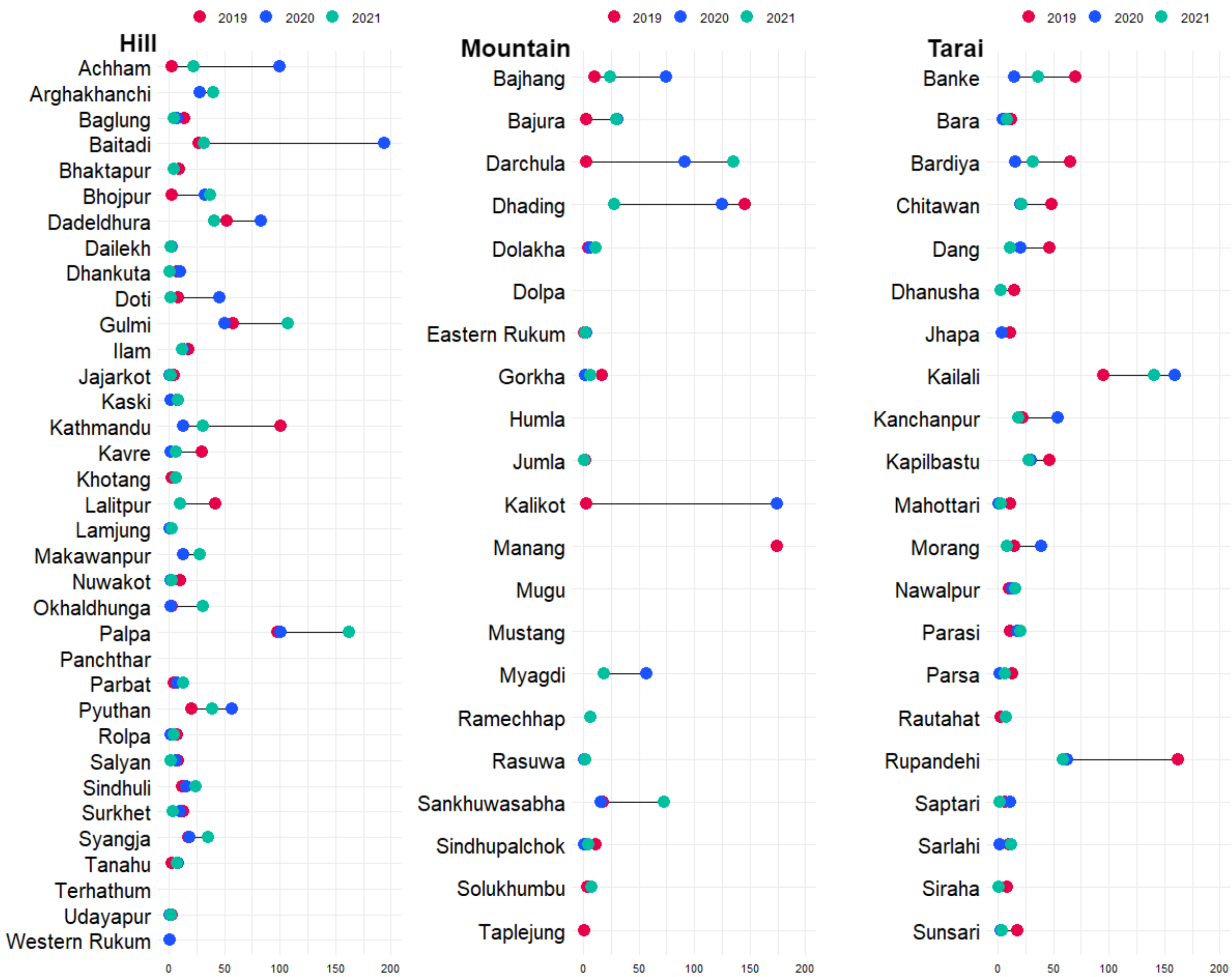

Figure 35. Changes in incidences of scrub typhus between two periods

Dengue: Dengue cases unprecedentedly surged in 2020 (FY 2076/77 BS), with reporting of 22,382 which is 32 times higher than the annual incidence of 2019 i.e., 698 cases (FY 2075/76 BS) and the highest reported incidence since 2018 (FY 2074/75 BS) was 1,128 cases. Between 2013 and 2020, dengue outbreaks were reported in Bhaktapur, Jhapa, Kaski, Kathmandu, Chitwan, and Rupandehi, with 1,000-7,000 cases (Figure 36).

Figure 36. Change in disease incidences of Dengue between two periods

Food and water-borne diseases (WBDs)

Cholera: Cholera cases are observed high in number in Tarai districts over the past decade, compared to other regions with cases between 1,000 and 3,000. During 2009-2014, cholera outbreaks were noted in Siraha and in 2009-2014, the highest number of cases occurred in Bara. Nationally, cholera incidence was highest in 2008 (18,170 cases), since then it has remained static, below 10,000 cases per year, until 2018 when the incidence again surpassed 11,000. In the past two years, the number of annual cholera cases was between 7,000 and 8,000 (Figure 37). It should be noted that the cholera cases reported by health facilities to the national health information systems are suspected cholera rather than laboratory confirmed cases.

Figure 37. Changes in incidences of Cholera between two periods

Acute Gastroenteritis (AGE): AGE cases have drastically increased over the past decade in Nepal. In 2010, total 305,256 AGE cases were recorded nationally, which increased to almost 400,000 in 2018 and 2019 (Figure 38). More AGE cases were reported in Tarai districts, over 60,000 cases during 2009-2014, mainly in Chitwan, Kapilvastu, Morang, Saptari and Siraha, and likewise in 2015-2020 in Morang and Rupandehi. AGE cases slightly decreased (by 6%) in 2020, and the probable reason for this decrease could be COVID-19 induced socio-environmental changes in the Nepali communities (Figure 38). Although the Government of Nepal declared all 77 districts of Nepal as Open Defecation Free (ODF) districts in September 2019, the recent rise in AGE cases indicates poor hygiene and contamination at household and personal levels.

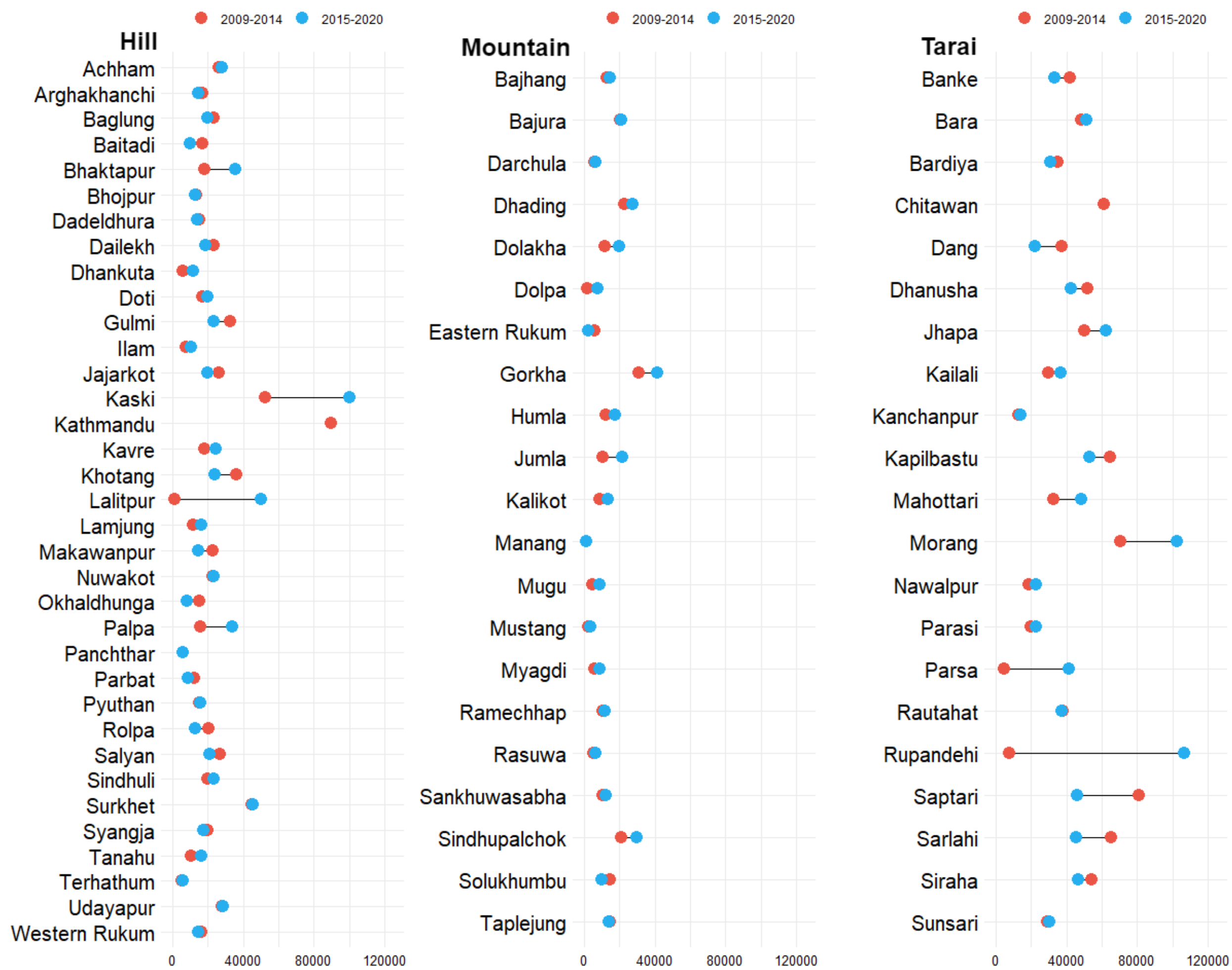

Figure 38. Figure 38. Change in AGE incidence between two periods

Respiratory illness

Severe acute respiratory illness (SARI): The incidence of SARI has been fluctuating over the past 15 years. Its annual incidence was 29,040 in 2005 which gradually decreased to as low as 4,249 and 3,882 in 2010 and 2012 respectively. The incidence of SARI cases peaked in the post-Earthquake periods (i.e., 2016 and 2017) with around 20,000 cases reported each year. Since then, SARI cases have been gradually decreasing in Nepal. The last reported annual incidence has been static, at below 5,000 in 2018-2020.

Large numbers of SARI cases were reported in Hill and Mountain districts from 2005-2012, whereas, in years after 2012, SARI cases reached all three geographical regions. While Jhapa, Western Rukum, Kalikot and Manang reported the highest number of SARI outbreaks in 2005-2012 with more than 3,000 cases in each district, Manang, Chitwan, and Morang each reported a similar number of cases in 2013-2020 (Figure 39).

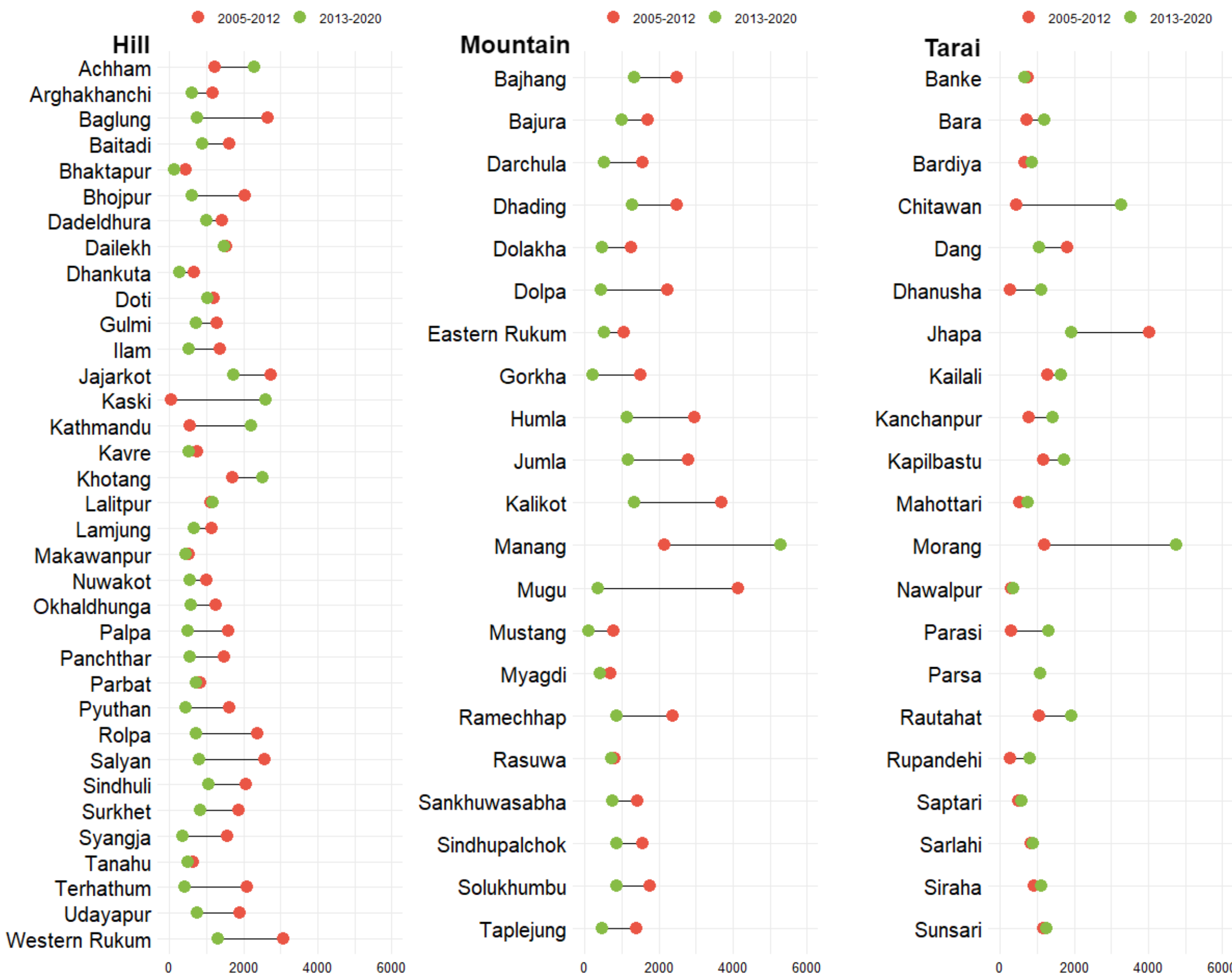

Figure 39. Changes in incidences of SARI between two periods

Other health risks

Undernutrition: The reported annual cases of undernutrition sharply decreased from nearly 54,017 in 2005 to 12,707 in 2006, then again, it reached almost 50,000 in 2009. Since then, undernutrition cases have gradually decreased year after year, with 51% reduction in 2020 (20,830 cases) compared to 2009 (Figure 40). Although undernutrition cases did not exceed 31,000 per year nationally during 2012-2018, Kaski, Kathmandu, and Lalitpur in Hill, Jumla and Mugu in Mountain, and Kanchanpur, Kapilbastu, Mahottari and Morang in Tarai had a rising burden of undernutrition.

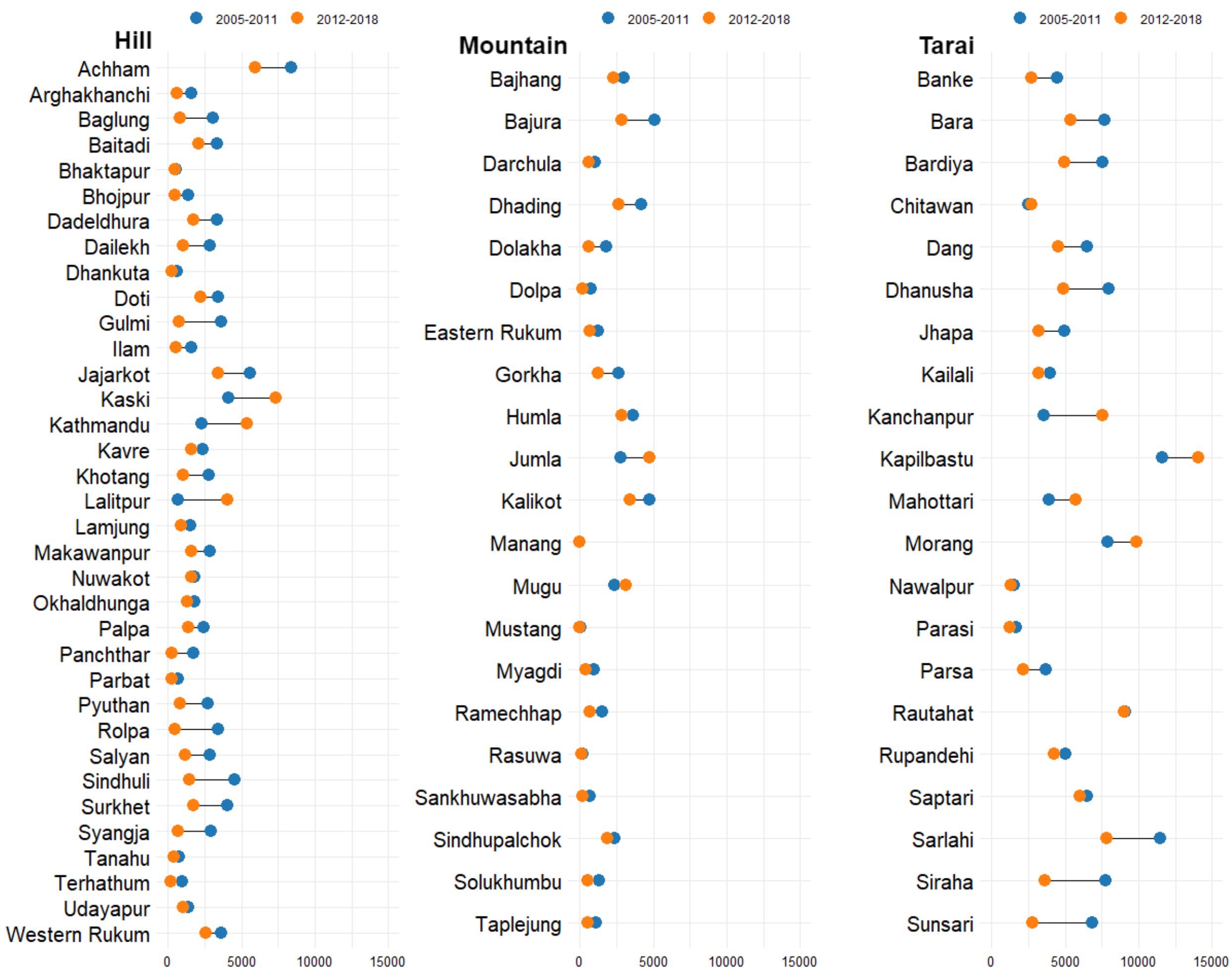

Figure 40. Changes in incidences of undernutrition between two periods

Mental illness: Recently, the leading cause of morbidity and mortality in Nepal has shifted from communicable to non-communicable diseases. The national data over the past 2005-2018 also shows a rising incidence of mental illness (IHME, 2021). The number of reported mental illness cases was below 6,585 in 2006, but it gradually increased year after year and peaked to almost 110,000 cases in 2015. The sudden hike of cases in 2015 could be linked to socio-economic upheaval in the Nepali communities caused by the major disaster situation that year (Nepal Earthquakes 2015). However, with satisfactory response measures along with extensive stakeholder involvement, the country has been able to reduce the annual incidence of mental illness by 30% in 2017 as compared to 2015 data. The last reported annual incidence of mental illness is slightly higher, around 96,000 cases in 2020 alone.

Three Hill districts (Kaski, Kathmandu and Palpa) and two Tarai districts (Chitwan and Morang) reported more than 40,000 cases of mental illness in 2013-2018 (Figure 41). Kaski had the highest incidence of mental illness even during 2007-2012 reporting period. One of the reasons for high reporting of mental illness cases in these districts could be the abundance of both public and private tertiary level healthcare facilities where most mental illness cases are diagnosed and treated.

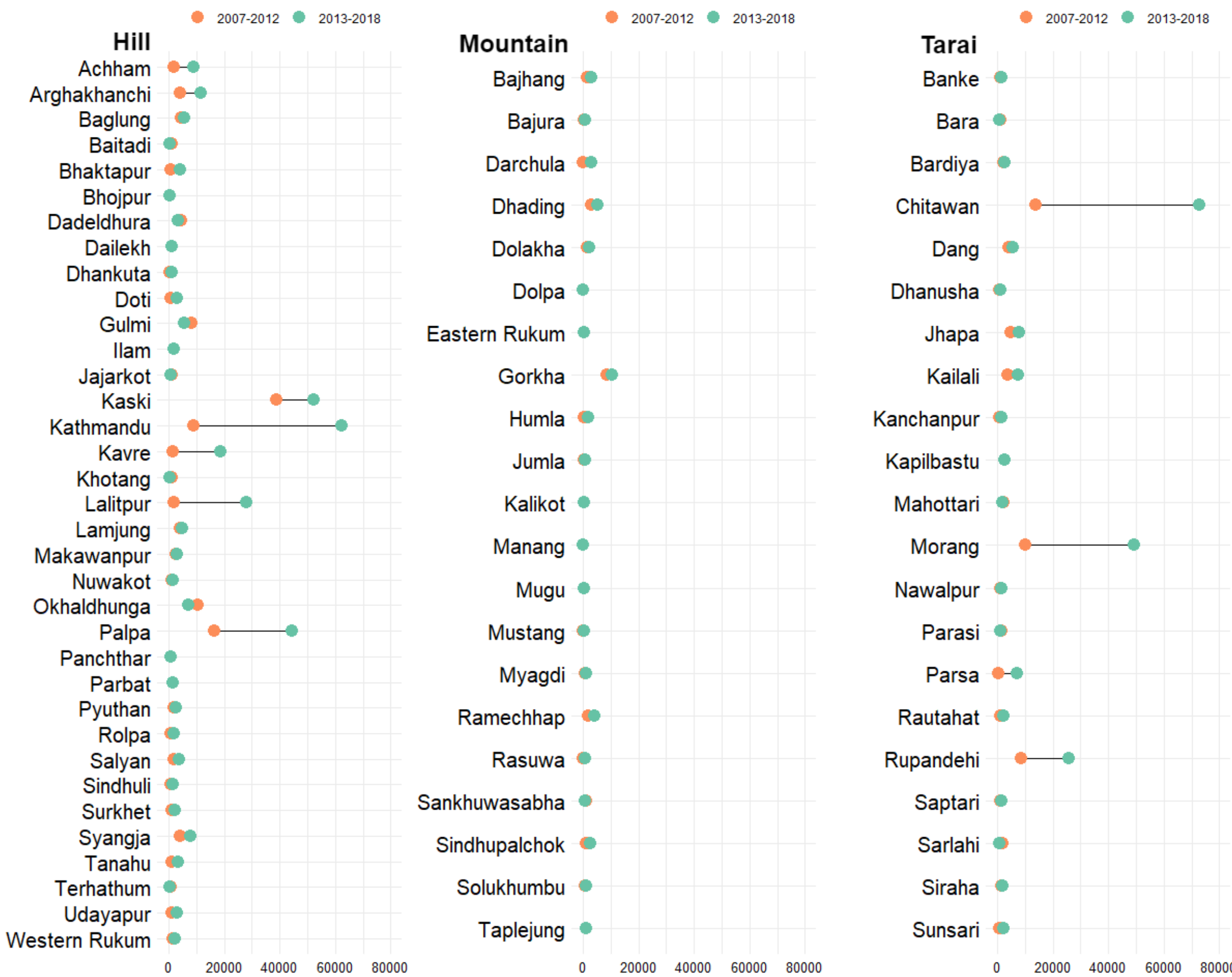

Figure 41. Changes in incidences of mental illness between two periods

Annex 3: Annual average temperature and V&A assessment

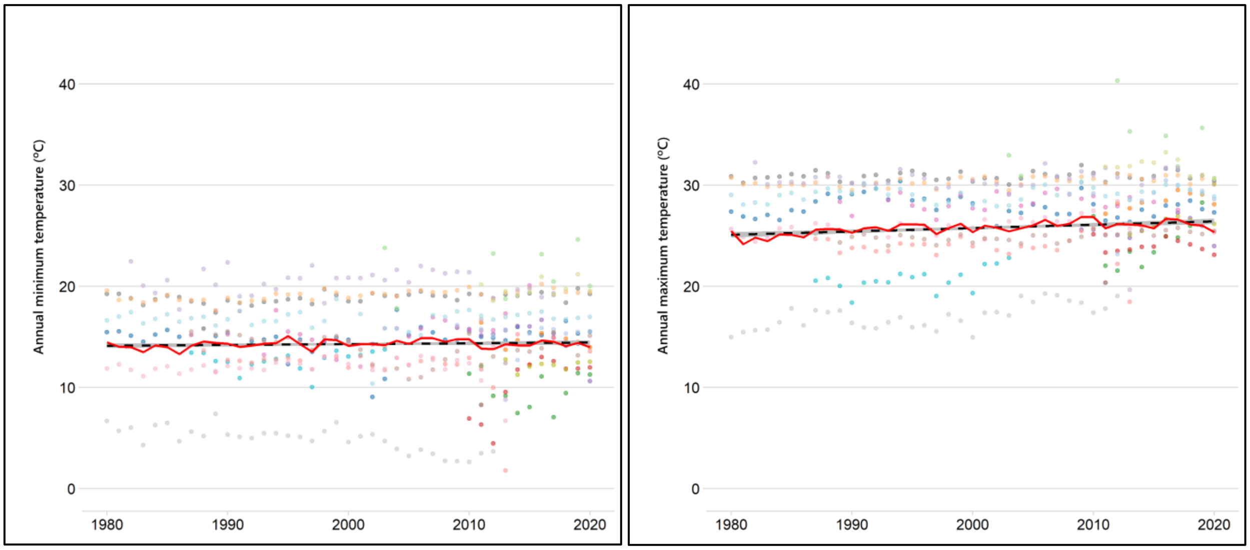

Figure 42. Trends of nationally averaged annual minimum temperature (left) and annual maximum temperature (right), dots show values of individual stations

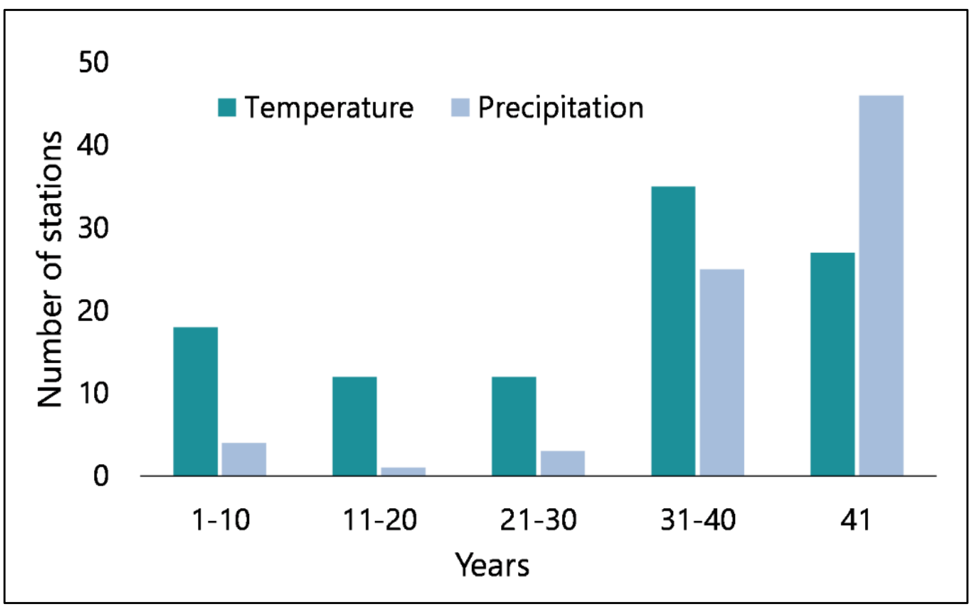

Figure 43. Precipitation and temperature data available in different stations by years

Annex 4: Climate hazards and climate extremes

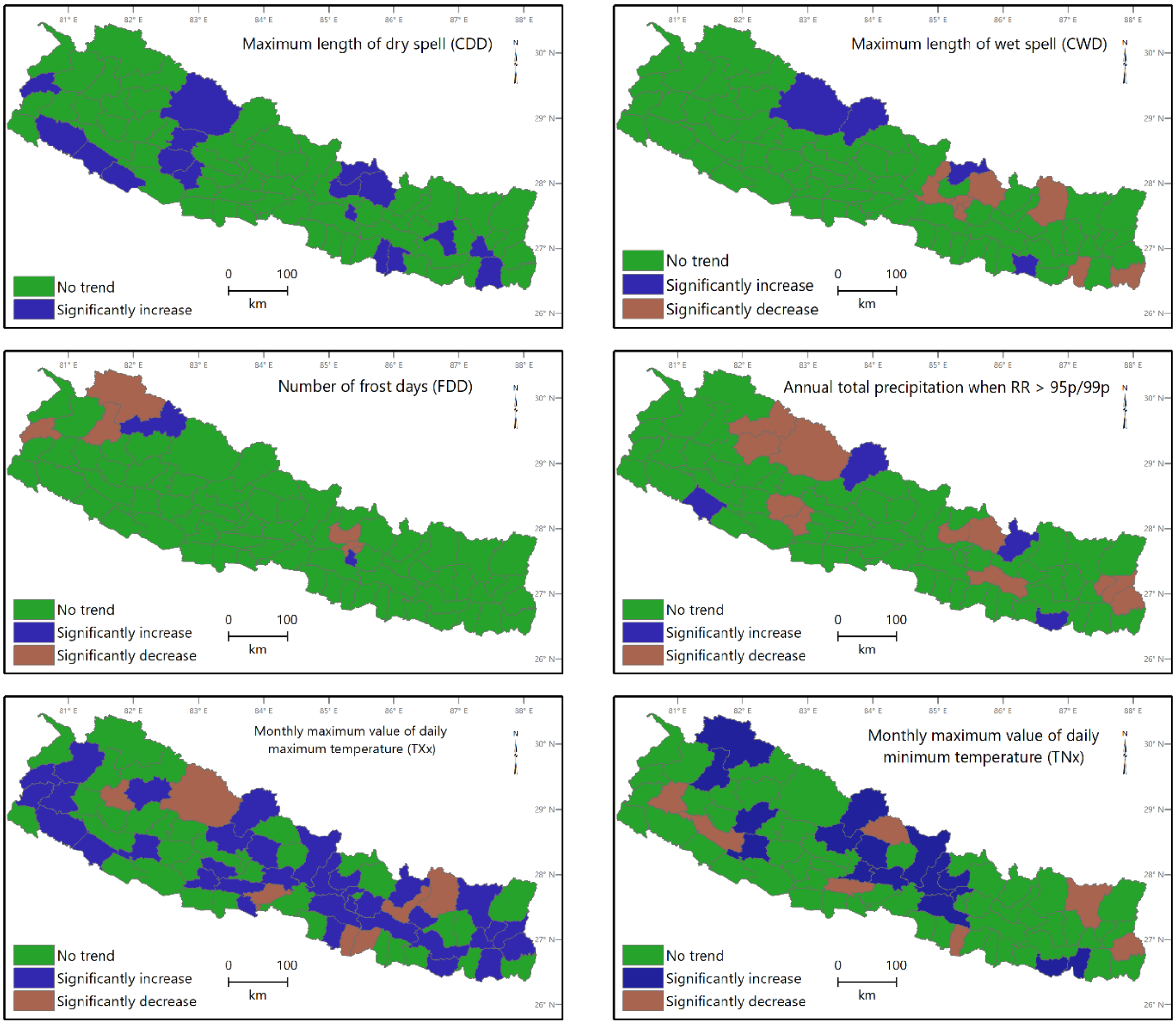

Figure 44. District level distribution of climate extreme indices

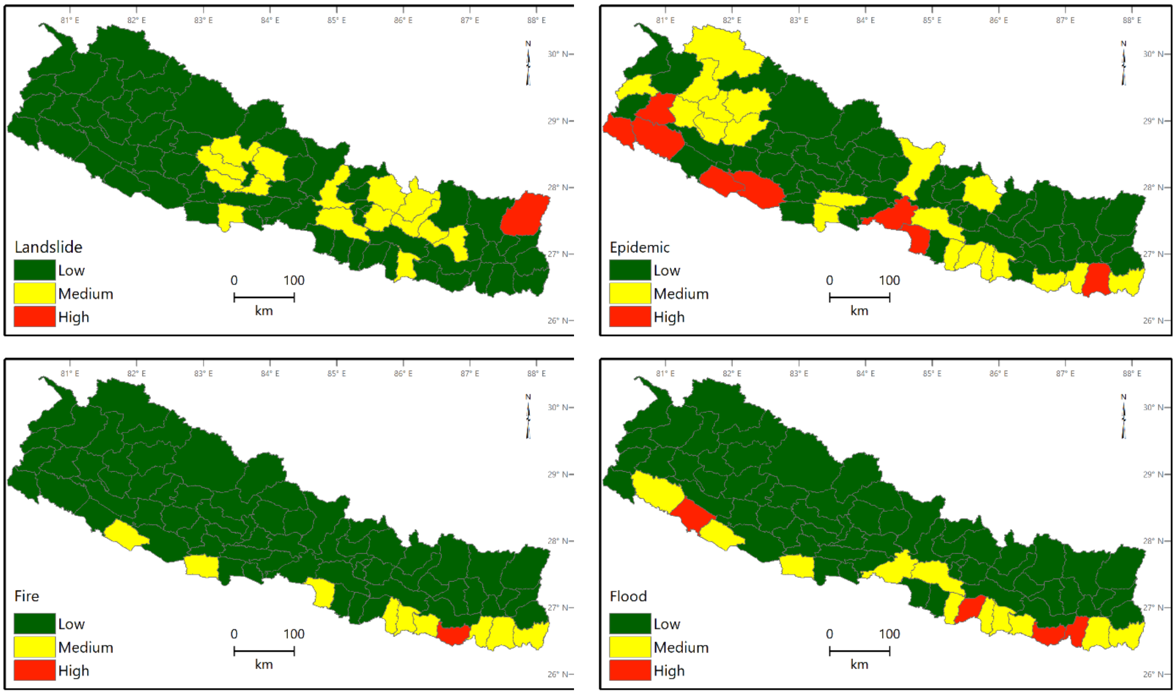

Figure 45. District wise distribution of landslides, Epidemics, Fire and Floods

Annex 5: Climate hazards, vulnerabilities and risks in health

Table 11. Table climate change related key hazards, vulnerabilities and risks

Hazard	Key vulnerabilities	Key risks	Emergent risks
Area: Terrestrial and inland systems			
Rising air, soil, and water temperature	Health response to spread of temperature sensitive vectors (insects)	Risk of novel and /or much more severe pest and pathogen outbreaks	Interactions among pests, drought, and fire can lead to new risks and large negative impacts on ecosystems.
Extreme precipitation and droughts	Crops, pasture, and husbandry are susceptible to drought and extreme precipitation.	Risk of crop failure, risk of limited food access and quality	Flood and droughts affect crop yields and quality and directly affect food access in most developing countries.
Area: Urban			
Inland flooding	Large numbers of people exposed to flood events. Particularly susceptible are people in low-income informal settlements. Much of the urban populations suffer from increased mosquito- and WBDs	Risks of deaths and injuries and disruptions to livelihoods / incomes, food supplies, and drinking water	In many urban areas, larger and more frequent flooding impacts much larger population.
Heat and cold	Particularly susceptible is a large and often increasing urban population of infants, young children, older age groups, people with chronic diseases or compromised immune system in settlements exposed to higher temperatures and unexpected cold spells.	Risk of mortality and morbidity increasing, including shifts in seasonal patterns and concentrations due to hot days with higher or more prolonged high temperatures or unexpected cold spells. Avoiding risks often most difficult for low-income groups	Duration and variability of heatwaves increase risks over time for most locations owing to interactions with multiple stressors such as air pollution
Diseases and exposure to disease vectors)	Large urban population that is exposed to food-borne and WBDs and to Malaria, Dengue, and other vector-borne diseases that are influenced by climate change	Risk due to increases in exposure to these diseases	Lack of capacity of public health system to simultaneously address these health risks with other climate-related risks such as flooding

Area: Rural			
Drought in rural areas	People lacking access to drinking and irrigation water. High dependence of rural people on natural resource-related activities.	Risk of food insecurity and decrease in incomes. Decreases in household nutritional status	Impacts on livelihoods driven by interaction including potential conflicts for access to water. Water-related diseases
Human Health			
Increasing frequency and intensity of extreme heat	Older people living in cities are most susceptible to hot days and heatwaves, as well as people with preexisting health conditions.	Risk of increased mortality and morbidity during hot days and heatwaves. Risk of mortality, morbidity, and productivity loss, particularly among manual workers in hot climates	The number of elderly people is projected to triple from 2010 to 2050. This can result in an overloading of health and emergency services.
Increasing temperatures, increased variability in precipitation	Poorer populations are particularly susceptible to climate-induced reductions in local crop yields. Food insecurity may lead to undernutrition. Children are particularly vulnerable.	Increased food insecurity for vulnerable populations. Increasing risk that progress in reducing mortality and morbidity from undernutrition may slow or reverse.	Combined effects of climate impacts, population growth, plateauing productivity gains, land demand for livestock, biofuels, persistent inequality, and ongoing food insecurity for the poor
Increasing temperatures, changing patterns of precipitation	Non-immune populations who are exposed to water- and VBDs that are sensitive to meteorological conditions	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.	Rapid climate and other environmental change may promote emergence of new pathogens.
Increased variability in precipitation	People exposed to diarrhea aggravated by higher temperatures, and unusually high or low precipitation	Risk that the progress to date in reducing childhood deaths from diarrheal disease is compromised	Increased rate of failure of water and sanitation infrastructure due to climate change leading to higher diarrhea risk

Livelihoods and Poverty			
Increasing temperatures and heat waves	Agricultural wage laborers, small-scale farmers in areas with multidimensional poverty and economic marginalization, children in urban slums, and the elderly are particularly susceptible.	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 governmental responses	Declining labor pool for agriculture coupled with new challenges for rural health care systems in LICs and MICs; aging and low-income populations without safety nets in HICs at risks
Floods and flash floods in informal urban settlements and mountain environments, destroying physical assets	High exposure and susceptibility of people, particularly children and elderly, as well as disabled in flood-prone areas. Inadequate infrastructure, culturally imposed gender roles, and limited ability to cope and adapt due to political and institutional marginalization	Risk of high morbidity and mortality due to floods and flash floods. Factors that further Increase risk may include a shift from transient to chronic poverty due to eroded human and economic assets (e.g., labor market) and economic losses due to infrastructure damage.	Exacerbated inequality between better endowed households able to invest in flood-control measures and /or insurance and increasingly vulnerable populations prone to eviction, erosion of livelihoods, and outmigration

Source: modified from IPCC AR5 (Table KR-1, page: 114-121) (Birkmann, J., R. et al., 2014).

Annex 6: Disease specific vulnerability

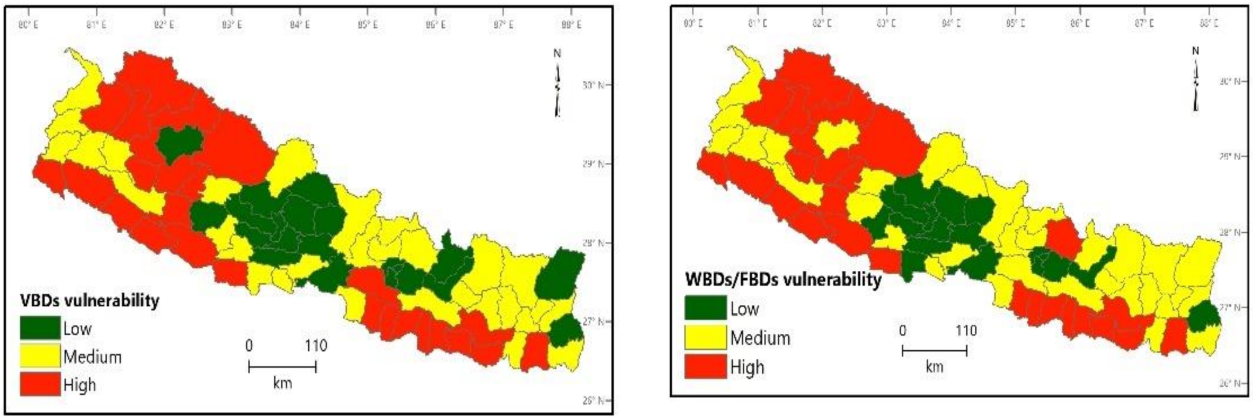

Figure 46. Distribution of WBDs/FBDs (right) vulnerability rank by districts

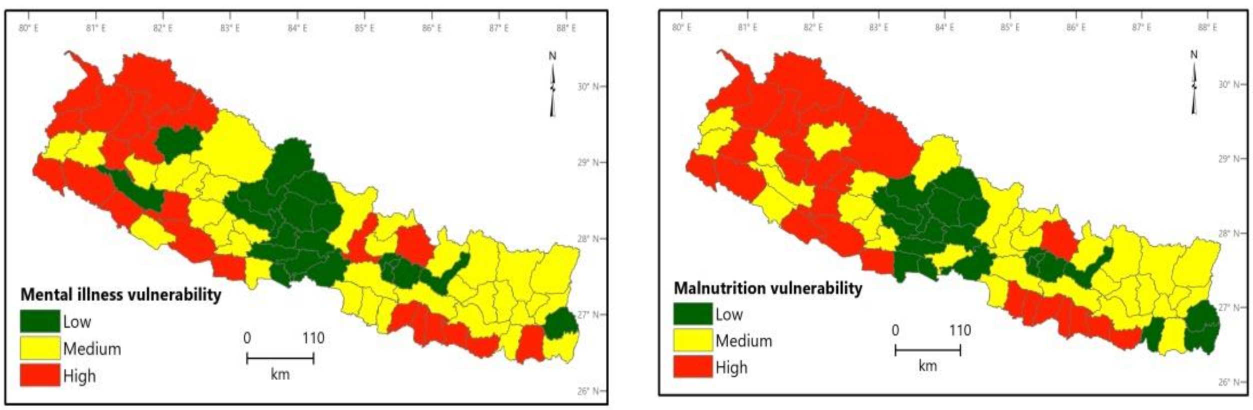

Figure 47. Distribution of mental illness (left) and malnutrition (right) vulnerability rank by districts

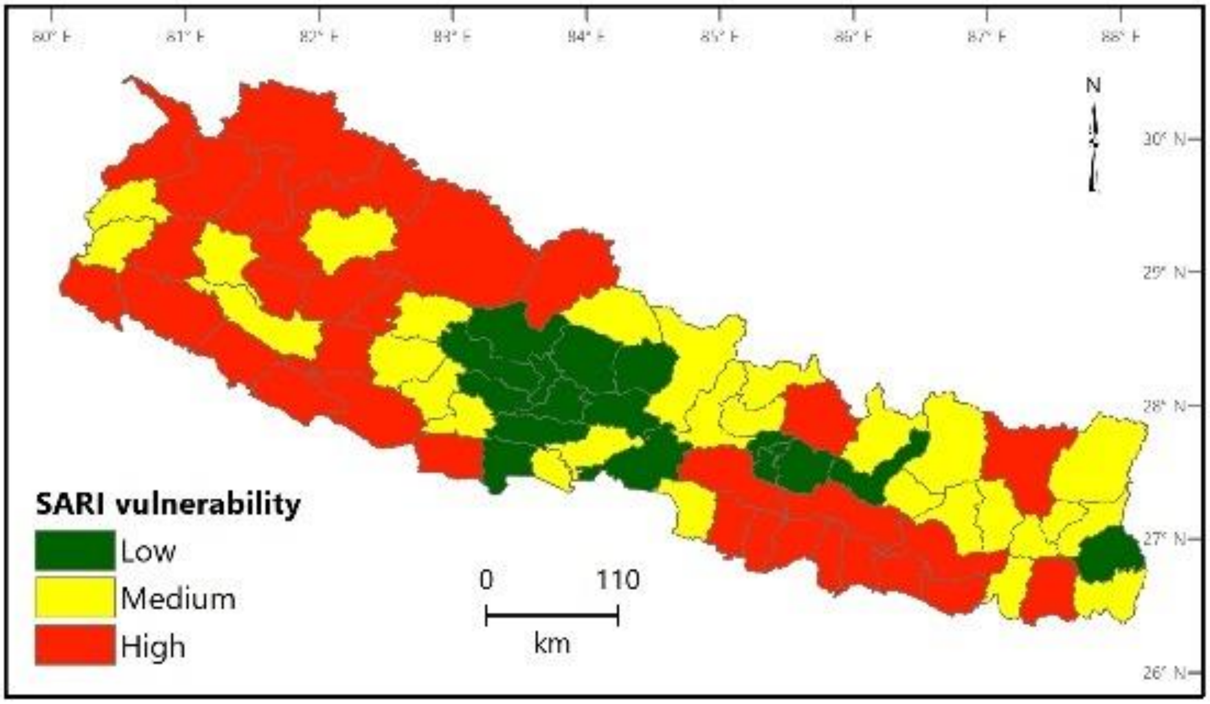

Figure 48. Distribution of SARI vulnerability rank by districts

Annex 7: Overall scores of different indicators

Table 12. Indices of hazard, vulnerability and risks

District	Hazard	Exposure	Sensitivity	Adaptive capacity	Vulnerability	Risk
Achham	0.42	0.13	0.72	0.4	0.55	0.25
Arghakhanchi	0.22	0.72	0.31	0.6	0.40	0.10
Baglung	0.43	0.39	0.20	0.7	0.16	0.07
Baitadi	0.18	0.37	0.45	0.5	0.41	0.08
Bajhang	0.20	0.64	0.46	0.3	0.70	0.15
Bajura	0.30	0.46	0.47	0.3	0.62	0.20
Banke	0.78	0.76	0.57	0.4	0.70	0.58
Bara	0.74	0.58	0.74	0.3	0.79	0.63
Bardiya	0.40	0.84	0.60	0.6	0.63	0.27
Bhaktapur	0.22	0.93	0.06	0.8	0.14	0.03
Bhojpur	0.22	0.51	0.29	0.5	0.38	0.09
Chitwan	0.41	0.76	0.58	1.0	0.31	0.13
Dadeldhura	0.19	0.41	0.32	0.4	0.41	0.08
Dailekh	0.34	0.47	0.43	0.2	0.67	0.25
Dang	0.57	0.91	0.74	0.5	0.81	0.49
Darchula	0.31	0.64	0.30	0.4	0.50	0.17
Dhading	0.71	0.76	0.42	0.4	0.59	0.44
Dhankuta	0.50	0.70	0.15	0.6	0.32	0.17
Dhanusha	0.65	0.94	0.81	0.4	0.93	0.65
Dolakha	0.30	0.75	0.24	0.8	0.24	0.08
Dolpa	0.35	0.46	0.20	0.1	0.59	0.22
Doti	0.24	0.39	0.44	0.3	0.55	0.14
Eastern Rukum	0.34	0.50	0.14	0.4	0.36	0.13
Gorkha	0.36	0.85	0.24	0.6	0.40	0.15
Gulmi	0.37	0.57	0.33	0.8	0.21	0.08
Humla	0.56	0.69	0.32	0.2	0.71	0.43
Ilam	0.26	0.28	0.19	0.5	0.22	0.06
Jajarkot	0.39	0.38	0.37	0.2	0.59	0.24
Jhapa	0.85	0.78	0.69	0.8	0.47	0.43
Jumla	0.28	0.06	0.32	0.5	0.26	0.08
Kailali	0.91	0.97	0.92	0.5	0.89	0.87
Kalikot	0.24	0.41	0.45	0.2	0.63	0.16
Kanchanpur	0.41	0.81	0.71	0.5	0.72	0.32
Kapilbastu	0.38	0.66	0.68	0.3	0.82	0.34
Kaski	0.78	0.72	0.52	1.0	0.23	0.19
Kathmandu	0.82	0.36	0.83	1.0	0.30	0.26
Kavre	0.50	0.00	0.23	0.6	0.09	0.05

Khotang	0.31	0.49	0.34	0.6	0.36	0.12
Lalitpur	0.21	0.63	0.15	0.7	0.17	0.04
Lamjung	0.25	0.70	0.06	0.7	0.15	0.04
Mahottari	0.85	0.64	0.71	0.3	0.80	0.73
Makawanpur	0.75	0.93	0.38	0.5	0.55	0.45
Manang	0.23	0.42	0.17	0.5	0.27	0.07
Morang	0.75	1.00	1.00	0.6	0.88	0.71
Mugu	0.07	0.18	0.39	0.1	0.61	0.05
Mustang	0.22	0.81	0.00	0.4	0.40	0.10
Myagdi	0.41	0.23	0.06	0.7	0.00	0.00
Nawalparasi	0.51	0.54	0.34	0.3	0.57	0.31
Nuwakot	0.08	0.66	0.26	0.4	0.49	0.04
Okhaldhunga	0.30	0.68	0.21	0.7	0.26	0.08
Palpa	0.33	0.39	0.41	0.7	0.27	0.09
Panchthar	0.35	0.77	0.23	0.5	0.41	0.15
Parasi	0.38	0.57	0.35	0.5	0.41	0.17
Parbat	0.29	0.51	0.08	0.7	0.10	0.03
Parsa	0.46	0.50	0.54	0.4	0.57	0.28
Pyuthan	0.17	0.41	0.34	0.6	0.28	0.05
Ramechhap	0.26	0.04	0.19	0.5	0.16	0.05
Rasuwa	0.31	0.60	0.05	0.4	0.35	0.11
Rautahat	1.00	0.39	0.74	0.3	0.74	0.79
Rolpa	0.28	0.29	0.31	0.5	0.31	0.09
Rupandehi	0.61	0.73	0.75	0.8	0.53	0.35
Salyan	0.30	0.57	0.39	0.3	0.61	0.20
Sankhuwasabha	0.48	0.57	0.30	0.5	0.43	0.22
Saptari	0.93	0.96	0.84	0.3	1.00	1.00
Sarlahi	0.66	0.62	0.89	0.3	0.91	0.64
Sindhuli	0.35	0.30	0.54	0.4	0.52	0.19
Sindhupalchok	0.47	0.99	0.30	0.5	0.56	0.29
Siraha	0.39	0.69	0.90	0.3	0.96	0.40
Solukhumbu	0.56	0.34	0.24	0.4	0.33	0.20
Sunsari	0.77	0.87	0.56	0.7	0.50	0.41
Surkhet	0.15	0.26	0.52	0.6	0.39	0.06
Syangja	0.43	0.60	0.17	0.7	0.19	0.09
Tanahu	0.42	0.47	0.22	0.6	0.23	0.11
Taplejung	0.68	0.50	0.19	0.6	0.26	0.19
Terhathum	0.23	0.63	0.09	0.5	0.33	0.08
Udaypur	0.60	0.79	0.56	0.4	0.68	0.44
Western Rukum	0.00	0.51	0.21	0.0	0.69	0.00

Annex 8: Predicted future risks scenarios in districts

Table 13. Table district-wise predicted change of future climate risk for three different periods under two scenarios

SSP 2-4.5 (2040)	SSP 5-8.5 (2040)	SSP 2-4.5 (2060)	SSP 5-8.5 (2060)	SSP 2-4.5 (2100)	SSP 5-8.5 (2100)
2-4 extreme events		**7 extreme events**		**7-8 extreme events**	
Dolpa	Morang	Siraha	Siraha	Banke	Kapilvastu
Humla	Sunsari	Dhanusha	Dhanusha	Bardiya	
Jumla	Jhapa	Nawalparasi_w	Saptari	Kanchanpur	
Rukum_w	Ilam	Kanchanpur	Banke	Dhanusha	
Baglung	Saptari	Saptari	Bardiya	Saptari	
Baitadi	Dhankuta	Nawalparasi_e	Arghakhanchi	Sunsari	
Bajhang	Terhathum	Rautahat	Bara	Rautahat	
Bajura	Panchthar	Rupandeshi	Morang	Sarlahi	
Dadeldhura		Sarlahi	Sunsari	Bajura	
Darchula		Kapilvastu	Dhading	Bajhang	
Dhanusha		Banke		Darchula	
Gulmi		Bardiya		Kalikot	
Jajarkot		Arghakhanchi		Salyan	
Kalikot				Surkhet	
Kanchanpur				Dailekh	
Manang				Kailali	
Mugu				Doti	
Mustang				Achham	
Myagdi				Baitadi	
Nawalparasi_w				Dadeldhura	
Palpa					
Parsa					
Salyan					
Siraha					
Surkhet					
Syangja					
Tanahu					
Achham					
Banke					
Bara					
Bardiya					
Chitwan					
Dailekh					
Doti					
Kailali					
Kapilvastu					
Mahottari					

Nawalparasi_E Nuwakot Parbat Rautahat Rolpa Rupandeshi Saptari Sarlahi					
5-7 extreme events		**8 extreme events**		**9 extreme events**	
Arghakhanchi Bhaktapur Dang Dhading Gorkha Kabhrepalanchok Kaski Kathmandu Lalitpur Lamjung Makawanpur Pyuthan Rukum_East Dolakha Morang Rasuwa Sindhuli Sunsari Bhojpur Dhankuta Jhapa Khotang Okhaldhunga Ramechhap Sankhuwasabha Sindhupalchok Solukhumbu Terhathum Udayapur	Dolpa Siraha Gorkha Bhojpur Sankhuwasabha Taplejung Dhanusha Mustang Parsa Syangja Chitwan Mahottari Nawalparasi_e Nuwakot Parbat Bhaktapur Kaski Kathmandu Lalitpur Lamjung Sindhuli Khotang Okhaldhunga Sindhupalchok Udayapur Humla Baglung Bajura Gulmi Manang Mugu	Parsa Syangja Baglung Bajura Gulmi Palpa Baitadi Bajhang Dadeldhura Darchula Kalikot Salyan Surkhet Chitwan Mahottari Bara Achham Dailekh Kailali Doti Bhaktapur Kathmandu Lalitpur Dang Pyuthan Morang Sunsari	Nawalparasi_w Kanchanpur Rautahat Rupandeshi Sarlahi Kapilvastu Syangja Baglung Bajura Gulmi Palpa Bajhang Darchula Kalikot Salyan Mahottari Dailekh Kailali Doti Bhaktapur Kathmandu Lalitpur Dang Pyuthan Humla Jumla Rukum_West Mugu Tanahu Jajarkot Myagdi Nuwakot Parbat	Siraha Arghakhanchi Bara Morang Dhading Syangja Mahottari Dang Pyuthan Humla Jumla Mugu Tanahu Jajarkot Rolpa Gorkha Jhapa Manang Dolpa	Banke Kanchanpur

	Nawalparasi_w Palpa Tanahu Bara Rautahat Rupandeshi Sarlahi Arghakhanchi Dhading Kabhrepalanchok Makawanpur Dolakha Ramechhap Solukhumbu		Rolpa Gorkha Kaski Lamjung Makawanpur Rukum_East Rasuwa Jhapa Udayapur Kabhrepalanchok Sindhuli Ramechhap Ilam		
8-9 extreme events		**9-10 extreme events**		**10-12 extreme events**	
Taplejung Ilam Panchthar	Jumla Rukum_w Baitadi Bajhang Dadeldhura Darchula Jajarkot Kalikot Myagdi Salyan Kapilvastu Dang Pyuthan Rukum_e Rasuwa Kanchanpur Surkhet Achham Banke Bardiya Dailekh Kailali Rolpa Doti	Humla Jumla Rukum_w Manang Mugu Tanahu Jajarkot Myagdi Nuwakot Parbat Rolpa Gorkha Kaski Lamjung Dhading Makawanpur Rukum_e Rasuwa Jhapa Dhankuta Bhojpur Udayapur Taplejung Panchthar Dolpa Mustang Kabhrepalanchok	Nawalparasi_e Parsa Chitwan Achham Manang Dhankuta Bhojpur Panchthar Dolpa Mustang Dolakha Terhathum Sankhuwasabha Khotang Okhaldhunga Sindhupalchok Solukhumbu Baitadi Dadeldhura Taplejung	Nawalparasi_w Rupandeshi Kapilvastu Baglung Gulmi Palpa Bhaktapur Kathmandu Lalitpur Rukum_w Nuwakot Parbat Kaski Lamjung Makawanpur Rukum_e Rasuwa Kabhrepalanchok Sindhuli Ilam Nawalparasi_e Chitwan Panchthar Mustang	Bardiya Surkhet Dailekh Achham Rupandeshi Dhanusha Saptari Sunsari Bajura Darchula Kailali Doti Dadeldhura Siraha Morang Dang Nawalparasi_w Parsa Rautahat Sarlahi Bajhang Kalikot Salyan Baitadi Bara Dhading Jumla

		Sindhuli Dolakha Terhathum Sankhuwasabha Khotang Okhaldhunga Sindhupalchok Ramechhap Solukhumbu Ilam		Terhathum Sindhupalchok Solukhumbu Taplejung Myagdi Ramechhap Parsa Dhankuta Bhojpur Dolakha Sankhuwasabha Khotang Udayapur Okhaldhunga	Mugu Jhapa Palpa Lamjung Rasuwa Nawalparasi_e Chitwan Terhathum Sindhupalchok Dhankuta Bhojpur Udayapur Okhaldhunga Syangja Mahottari Pyuthan Humla Tanahu Jajarkot Gorkha Baglung Gulmi Bhaktapur Kathmandu Lalitpur Nuwakot Parbat Kaski Makawanpur Kabhrepalanchok Sindhuli Ilam Panchthar Taplejung Myagdi Ramechhap Dolakha Sankhuwasabha Khotang Arghakhanchi

					Rolpa Manang Dolpa Rukum_w Rukum_e Mustang Solukhumbu

Annex 9: Major climate change events

Table 14. Key events of climate change in Nepal

Date	Activities
1992	Nepal signed in the UNFCCC conference in Rio de Janeiro, Brazil and committed to reduce the anthropogenic emission
11/12/1997	Nepal adopted the Kyoto Protocol
14/12/2005	Nepal implement the greenhouse gas emission timeframe
1996-2006	Ministry of Population and Environment (MoPE) was designated as a focal point to implement the provisions of the UNFCCC
2004	Prepared the First National Communication and submitted to UNFCCC
2009	Established Climate Change Council chaired by the Rt. Hon. Prime Minister
2009	Kalapatthar Declaration
2009	Climate change appeared to be a national development issue
2010	Established Climate Change Management in MoFE
2010	Established Multi-stakeholder Climate Change Initiatives Coordination Committee (MCCICC) in 2010, chaired by the Honourable Minister of MoSTE
2010	Prepared the National Adaptation Programme of Action (NAPA)
2011	Prepared First Climate Change Policy
2011	Prepared National Framework on Local Adaptation Plan of Action (LAPA)
2013	National Planning Commission prepared the budget for first National Climate Change Communication
2014	Prepared the Second National Communication (SNC)
2015	First Climate Change V & A from in Health Sector of Nepal
2015	Environmental management and climate change have been addressed in the Constitution of Nepal
2015	Constitution of Nepal declares the right to live in healthy environment
2018	Health National Adaptation Plan (2017-2021) approved
2019	Amendments in Climate Change Policy with eight sectors & four cross-cutting areas
2020	Second Nationally Determined Contributions (NDC)
2021	COP 26 declarations by Nepal
2021	MoHP Commitments for building climate resilient and low carbon health system

Annex 10: Participants of consultation meeting 28th December 2021

S.N.	Name	Gender	Designation
1	Dr. Shyam Sundar Yadav	M	Chief Specialist, MoHP
2	Dr. Sangeeta Kaushal Mishra	F	Coordinator, TWG, MoHP
3	Dr. Samir Kumar Adhikari	M	Co-Coordinator, TWG, MoHP
4	Dr. Meghanath Dhimal	M	Member, TWG, NHRC, MoHP
5	Raja Ram Pote Shrestha	M	Member, TWG, WHO
6	Kunj Prasad Joshi	M	Member, TWG, NHTC
7	Dr. Krishna Prasad Paudel	M	Member, TWG, EDCD
8	Dr. Rudra Prasad Marasini	M	Director, MoHP
9	Dr. Manisha Rawal	F	Director, MoHP
10	Sushil Sharma	M	Director, CBS
11	Dr. Tara Nath Pokhrel	M	Division Chief, MoHP
12	Yeshoda Aryal	F	Chief Public Health Administrator, MoHP
13	Upendra Dhungana	M	Chief
14	Bhim Prasad Sapkota	M	Sr. Public Health Administrator, MoHP
15	Ram Gopal Kharbuja	M	Joint Secretary
16	Srijana Shrestha	F	Under Secretary, MoFE
17	Sunil Tiwari	M	Engineer, MoWS
18	Dr. Anu Shakya	F	Deputy Health Administrator, EDCD, MoHP
19	Sudharshan Humagain	M	Meteorologist, DHM, MoEWRI
20	Dr. Nod Narayan Chaudhary	M	H. Edu. Administrator, NHEICC , MoHP
21	Ranjana Prajapati	F	Computer Officer, MoHP
22	Chandra Bahadur Sunar	M	Public Health Inspector, HMIS, MoHP, DoHS, MoHP
23	Sonam Singh	M	PHO, DoHS, MoHP
24	Amrita Gyawali	F	PHO, MoHP
25	Dr. Usha Kiran	F	NPO, WHO
26	Dr. Manish Baidya	M	Disease Surveillance Officer, WHO
27	Upendra K.C.	M	Environmental Health Associate, WHO
28	Dinesh Bhandari	M	Environment Health Consultant, NHRC, MoHP
29	Dr. Yadav Prasad Joshi	M	Team Leader, GIIS
30	Dr. Uttam Babu Shrestha	M	Director, GIIS
31	Dr. Suraj Bhattarai	M	Research Fellow, GIIS
32	Dr. Sujata Shrestha	F	Research Fellow, GIIS
33	Sanjeev Poudel	M	Research Associate, GIIS
34	Bibek Raj Shrestha	M	Research Associate, GIIS

Annex 11: Glossary

Adaptation: Adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to the expected climate and its effects.

Adaptive capacity: Ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

Climate: Average weather (in a narrow sense) or (more rigorously) statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.

Climate change: Change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean or variability of its properties that persist for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions, or persistent anthropogenic changes in the composition of the atmosphere or land use. Article 1 of the United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods”. UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

Climate change risk: Potential for adverse consequences of a climate-related hazard, or of adaptation or mitigation responses to such a hazard, on lives, livelihoods, health and wellbeing, ecosystems and species, economic, social and cultural assets, services (including ecosystem services) and infrastructure.

Climate projection: Simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases and aerosols generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission, concentration or radiative-forcing scenario used, which is in turn based on assumptions concerning, for example, future socioeconomic or technological developments that may or may not be realized.

Climate variability: Variations in the mean state and other statistics (e.g. standard deviations, occurrence of extremes) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability) or to variations in natural or anthropogenic external forcing (external variability).

Disaster: Serious disruption of the functioning of a community or society at any scale due to hazardous events interacting with conditions of exposure, vulnerability or capacity, leading to one or more human, material, economic or environmental losses or impacts.

Early warning system: Set of technical, financial and institutional capacities needed to generate and disseminate timely and meaningful warning information to enable individuals,
Communities and organizations threatened by a hazard to prepare to act promptly and appropriately to reduce the possibility of harm or loss.

Exposure: Presence of people, livelihoods, species or ecosystems, environmental functions, services or resources, infrastructure, or economic, social or cultural assets in places and settings that could be adversely affected.

Extreme weather event: Event that is rare at a particular place and time of year. Definitions of "rare" vary, but an extreme weather event would normally be as rare as or rarer than the 10^{th} or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of "extreme weather" may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g. drought or heavy rainfall over a season).

Hazard: Potential occurrence of a natural or human-induced physical event, trend or physical impact that may cause loss of life, injury, other health impact, or damage to or loss of property, infrastructure, livelihoods, service provision, ecosystems or environmental resources.

Health systems: Ensemble of all public and private organizations, institutions and resources mandated to improve, maintain or restore health and incorporate disease prevention, health promotion, and efforts to influence other sectors to address health concerns in their policies.

Impacts: Consequences of realized risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather and climate events), exposure and vulnerability. Impacts generally refer to effects on lives, livelihoods, health and well-being, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure. Impacts may be referred to as consequences or outcomes, and can be adverse or beneficial.

Resilience: Ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.

Risk: The probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard.

Risk assessment: Qualitative or quantitative scientific estimation of risks.

Scenario: Plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g. rate of technological change, prices) and relationships. Scenarios are neither predictions nor forecasts but are useful to provide a view of the implications of developments and actions.

Vulnerability: Conditions determined by physical, social, economic and environmental factors or processes that increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

Definitions are adopted from IPCC, 2014