Vulnerability and Risk Assessment and Identifying Adaptation Options

Sectoral Report
Water, Sanitation and Hygiene (WASH)

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Foreword

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

Nepal has been a pioneer in the development and implementation of effective adaptation policies and practices. Nepal has made a strong commitment to updating a mid-long term National Adaptation Plan (NAP) every ten years, as well as conducting a National level Vulnerability and Risk Assessment every five years to inform climate resource allocation policies. Vulnerability and Risk Assessment (VRA) was initiated to assess vulnerability and risk at the national, physiographic, province, municipal, and sector levels to inform the Government of Nepal's current NAP formulation process.

I am pleased to see that the VRA report on Water, Sanitation, and Hygiene (WASH) was prepared by identifying sector-specific current vulnerability and future risk based on a solid scientific foundation and information. This report is the result of a thorough consultation process with national and provincial stakeholders and experts. This report, I believe, provides an opportunity for policymakers, decision-makers, and practitioners to make informed decisions about sector-specific vulnerability and risk to build a climate-resilient society and reduce the impacts of climate change at the local, provincial, and federal levels.

On behalf of the Ministry of Forests and Environment, I would like to thank the distinguished Chair - the Joint Secretary of the Ministry of Health and Population, Ministry of Water Supply and Sanitation, and all the respected Health, Drinking Water, and Sanitation sector thematic group members who provided technical guidance to finalize this report. In addition, I gratefully acknowledge the assistance provided by the Climate Change Management Division, particularly Dr Radha Wagle and all technical committee members.

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

Dr Pem Narayan Kandel
Secretary
Ministry of Forests and Environment (MoFE)

Acknowledgments

The National Climate Change Policy (2019) identifies eight thematic areas and four cross-cutting areas which will be impacted by climate change. As such, there is a pressing need to understand how public and private investments might be impacted. Without adequate information on risks and vulnerability, it will be difficult to translate policy into action. To plan and implement a successful adaptation strategy, it is vital to understand the likely impacts of climate change on different sectors and communities, and, in particular, how these may evolve in the future.

A National Adaptation Plan (NAP) needs to be developed based on a strong scientific foundation and reliable evidence. This includes data and information about how the climate has evolved in the recent past and how it may further change in the future. To realise this, the MoFE has carried out detailed Vulnerability and Risk Assessments (VRAs) of the thematic areas identified by the National Climate Change Policy at the municipal, district, and regional scales. The VRA framework and methodology presented in the report are based on the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) and the NAP technical guidelines of the UNFCCC.

This VRA report contributes to the establishment of a strong baseline for climate change impacts, risks, and vulnerabilities in Nepal. In particular, it presents relevant information on social and structural vulnerabilities and risks triggered by the interaction of climate change and socio-economic, governance, political and cultural norms and practices. The report also offers a range of adaptation options for reducing root causes of vulnerability and risk.

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

Special thank goes to the technical committee members Raju Sapkota, Dr Arun Prakash Bhatta, Srijana Shrestha, Hari Pandey, Dr Indira Kandel, Gyanendra Karki, and Dr Bimal Raj Regmi who supported and facilitated the VRA process. We would also like to thank Smriti Shah, Basana Sapkota, Dr Nilhari Neupane, Dr Shiba Banskota, Apar Paudyal, Dr Ram Prasad Lamsal, Dr Pashupati Nepal, Dr Bhogendra Mishra, Regan Sapkota, Pratik Ghimire, Rojy Joshi, Bamshi Acharya, Goma Pandey, and Prashamsa Thapa, from the PIF, who provided technical insights and were involved in producing this report.

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

Dr Radha Wagle
Joint Secretary
Climate Change Management Division
Ministry of Forests and Environment (MoFE)

List of Acronyms

AC	Adaptive Capacity
AR	Assessment Report
CBS	Central Bureau of Statistics
CCA	Climate Change Adaptation
DHM	Department of Hydrology and Meteorology
DWSSM	Department of Water Supply and Sewerage Management
EWS	Early Warning System
FIETS	Financial Institution Environmental Technological and Social
LDCs	Least Developed Countries
L&D	Loss and Damage
MICS	Multi-Indicator Cluster Survey
MoFE	Ministry of Forests and Environment
MoWS	Ministry of Water Supply
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NCCP	National Climate Change Policy
OPM	Oxford Policy Management
O&M	Operation and Maintenance
PIF	Policy and Institutions Facility
SDG	Sustainable Development Goal
SE	Sensitivity and Exposure
TWG	Thematic Working Group
UNCRD	United Nations Centre for Regional Development
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Emergency Fund
VRA	Vulnerability and Risk Assessment
WASH	Water Sanitation and Hygiene
WB	World Bank
WHO	World Health Organization

Executive Summary

Nepal's Constitution states that "every person shall have the right to live in a healthy and clean environment". The government has committed to achieving the Sustainable Development Goals (SDGs) for universal access to safely managed drinking water and sanitation and has made significant progress this in the past few decades. The country has declared a plan to be Open Defecation Free (ODF) and 94.5 percent of households are already using improved sanitation. While comparing the water and sanitation coverage of Nepal from 1990 to 2000, there has been huge progress. In 1990, only 36 percent of the population had access to water supply and six percent had access to toilets. By 2000, 80 percent had gotten access to basic sanitation services.

Despite its remarkable progress, however, the WASH sector continues to face significant regional disparities in terms of both coverage and quality, as well as governance challenges. In particular, WASH services and water availability are lagging behind in the Lumbini, Karnali, and Sudurpaschim Provinces in the western part of Nepal, and in the eastern Terai region of Province two. Key challenges in the sector include the dysfunctional WASH infrastructure, poor governance, limited inclusion of women and the marginalised in water users' committees, deficient WASH plans and policies of the government, and lack of consolidated information on WASH-related data.

On top of its existing issues, the WASH sector is further threatened with climate change. Climate change has a significant impact that exacerbates water stress and insecurity, increases incidences of water-transmitted infectious diseases, slows or reverses the progress of improved WASH coverage, worsens inequalities, and undermines the achievement of related Sustainable Development Goals (SDGs) targets and human rights.

Vulnerability and Risk Assessments (VRA) are one of the major components of Nepal's National Adaptation Plan (NAP). The goal of the VRA is to enhance the adaptive capacity and build the resilience of climate-vulnerable people and communities, geographical areas, physical infrastructure, and ecosystems. This report is the VRA of Nepal's WASH sector and had the following two aims: i) assessing and ranking the sector's risks and vulnerability to climate impacts at multiple scales (district, province, and physiographic regions) through applicable frameworks; and ii) identifying of options of adaptations to these risks and vulnerabilities, so that they can be addressed. It is hoped that the findings from this assessment will assist in setting strategic priorities for the WASH sector in terms of building resilience. The assessment particularly focused on addressing where, what, and how to invest, in order to make adaptation actions effective, efficient, and impactful.

For this assessment, the country-specific framework suggested by the NAP technical guidelines was adopted, which is based on the framework suggested in IPCC's Fifth Assessment Report (AR-5). Slight modifications, however, were done to tailor it to the country's needs and priorities. The major approaches taken during the VRA include: consultative for seeking feedback from Technical Committees (TCs) and Thematic Working Groups (TWGs); integration and harmonization among sectors; integration of Gender Equality and Social Inclusion (GESI) as a cross-cutting theme in all steps; field consultations to share results, seek inputs and endorse decisions; combining qualitative and quantitative indicators for wider coverage of issues, and top-down and bottom-up approaches to consultations and data collection.

The assessment was done in the following nine steps: i) unpacking key concepts and terminologies from AR-5; ii) developing the VA and RA framework; iii) identifying key indicators for hazards, exposure and vulnerability (sensitivity and adaptive capacity); iv) exploring data sources, nature, and character; v) data collection, tabulation, filtering, and normalization; vi) weightage and composite value calculation; vii) data analysis; viii) identifying climate change impacts and risks, and ix) identifying and appraising adaptation options.

Indicators were identified based on government reports, a literature review, and expert consultations. A Technical Committee (TC) and Thematic Working Group (TWG) reviewed and provided feedback on the selection and quality of indicators. Data was normalized to make indicators coherent and comparable to each other and facilitate the computation of indices. Weights were calculated for each indicator based on results from technical expert surveys. Then, indexes for hazard, exposure, sensitivity and adaptive capacity were calculated for each district by multiplying the individual normalized value with the respective weights and adding all the products of multiplication. The vulnerability index was calculated by deducting the adaptive capacity index from the sensitivity index of the respective district. Finally, the risk index was calculated for each district by multiplying the hazard, exposure, and vulnerability indexes of the districts for the medium term (2030), and long term (2050) time frame using two Representative Concentration Pathways (RCP 4.5 and 8.5) scenarios.

The results and findings are presented briefly below.

- The studies carried out by the DHM (2017) and MoFE (2019) show that the temperature in Nepal is showing an increasing trend. There is variability in precipitation patterns. Annual maximum temperature in the country is increasing by 0.056°C/yr, while the minimum temperature is increasing by 0.002°C/yr. The average annual precipitation is expected to rise in both the short-term (2030) and long-term (2050). Average annual precipitation rates may increase by 2 to 6 percent in the medium term (2016-2045) and by 8 to12 percent in the long term (2036-2065). In addition, the average temperature may rise by 0.92 to 1.07 degrees Celsius in the medium term and by 1.30 to 1.82 degrees Celsius in the long term.

- There is strong evidence to suggest that climate change is having an impact on the quantity and quality of water available in Nepal. Springs, the major source of water in the mid-hill region of the country, are threatened. During winter months, there is a decrease in their discharge of fresh water. Drying up of water sources leads to increase in community conflicts related to these sources. Additionally, climate change impacts women and children disproportionately when it comes to the WASH sector: water fetching is considered to be primarily the task of women and children, and this responsibility comes with various physical health and opportunity costs. A reduction in the quality and quantity of available water also restricts the adoption and maintenance of good hygiene behaviours in households and communities.

- Issues related to water quality are also on the rise. These include contamination and change in quality of water sources due to different climatic and non-climatic stressors (such as direct disposal of sewage and other wastes in the river). Increased exploitation of groundwater resources in urban areas is leading to increased pollution in these resources. This pollution is often a result of natural chemical contamination such as arsenic in the Terai belt. Further, the warm and damp conditions created by extreme events can lead to an incidence of water related diseases, including skin problems and dysentery.

- The parts of the population that reside near rivers or other WASH infrastructure that are flooded every year are constantly at risk. Some groups—such as children under the age of five, pregnant and lactating women, the elderly, households living in houses that have not followed building codes, people living with a disability and people with pre-existing health conditions—are more vulnerable to the impact of climate change related disasters. Moreover, houses, drinking water supply schemes, toilets, sewerage systems and health facilities right next to riverbanks are also more vulnerable.
- The composite hazard maps included in this report show that it is mostly the Terai region that is the most likely to be impacted by climate change. Province-wise, Province two and Province one are at particular risk. Physiography-wise, the eastern hills and mountain districts are likely to be heavily impacted. Additionally, based on past trends, the hilly districts of Bagmati are also likely to experience strong impact from climate extreme events.
- Out of the districts, Rupandehi, Morang, and Kathmandu are very highly exposed to climate-induced hazards, due to high population concentration and reduced numbers of WASH services and infrastructure availability. Similarly, districts with high exposure are: Kapilbastu, Sunsari, Rautahat, Kailali, Siraha, Bara, Chitawan, Dhanusha, Jhapa, Sarlahi, Mahottari, Parsa, and Saptari. In contrast, the districts with very low exposure are Humla, Mugu, Rasuwa, Myagdi, Terhathum, Western Rukum, Darchula, Dolpa, Mustang, Manang, Kalikot, Taplejung, Jajarkot, and Jumla. These differences in levels of exposure may be attributable to differences in population size and number and concentration of infrastructures. Additionally, 17 districts are in the moderate exposure category. These are mostly concentrated in the hilly regions of all the provinces, but some are in the mountainous regions as well.
- In terms of sensitivity to climate change impacts, Karnali and Sudurpaschim Provinces are more sensitive. Multiple factors make Karnali and Sudurpaschim Province more sensitive which includes presence of sensitive population to climatic hazards; most of the water supply and sanitation services being in need of major repair or rehabilitation; lack of access to local markets; and stakeholders practicing the traditional way of promoting WASH. Out of the 13 districts in Bagmati Province, the districts of Dhading, Nuwakot, Rasuwa, Sindhupalchowk, Dolakha, Ramachhap, and Sindhuli fall into 'highly sensitive' category. The remaining six districts fall into 'low' and 'very low'. Similarly, the overall rank of 'moderate' sensitivity in Province two is due to the amount of time spent by women and children to fetch water and number of water supply schemes in need for major repair and rehabilitation.
- In terms of adaptive capacity of districts to deal with climate change related impacts, this assessment's findings show that Lalitpur, Tanahu, Kavrepalanchok, Bhaktapur, Gulmi, and Kathmandu districts have *very high* adaptive capacity, whereas the adaptive capacity of Humla, Mugu, Rasuwa, Western Rukum, Dolpa, Surkhet, Achham, Doti, Bajura, Kalikot, Kanchanpur, Jumla, Mahottari, and Bajhang is *very low*. The major indicator of adaptive capacity was the number of households with access to private taps and hand pumps. Low adaptive capacity was also related to low literacy rates (62 percent) and multidimensional

poverty (Human Development Index (HDI) of 0.427, which is below the national average of 0.49). Low adaptive capacity Karnali Province is due to only 35.9 percent of population has access to safe drinking water and 59 percent of the province's children under five suffer from malnutrition. Furthermore, the average life expectancy in Karnali is 67 years, the lowest out of all provinces. Moreover, due to the lack of access to safe drinking water in Karnali and Sudurpaschim Provinces, these two provinces suffer from the highest number of cases of water-borne illnesses in children under five.

- Karnali Province, Sudurpaschim Province, and Province two fall under the category of 'very low' adaptive capacity because of poor access to drinking water and sanitation. Furthermore, due to having the lowest number of well-functioning water supply schemes out of all the provinces, governance in the WASH sector of these provinces is not up to standard. Additionally, female representation in Water Supply User Committees (WSUCs) is limited—those who are in these committees are not allowed to make meaningful contributions, further affecting the governance of these WSUCs.

- While several factors contribute to the incidences of water-related diseases in children under the age of five, a major factor is the current functionality of water supply schemes. Nationwide, only 9,461 schemes are fully functional out of a total 42,039. Moreover, 28,495 schemes require minor/major repair or rehabilitation/reconstruction, while only 2,378 schemes have enough funds for operation and maintenance. This shows huge gaps in the governance and sustainability of water supply schemes in Nepal.

- The sensitivity and adaptive capacity indicators—such as the condition and types of physical and institutional infrastructures, their proximity to hazards, and the characteristics of the population dependent on them—were found to contribute significantly to a given district's vulnerability ranking. The findings revealed that Karnali Province is much more vulnerable to the impact of climate change than the other provinces because of its high sensitivity and low adaptive capacity. Sudurpaschim Province was also found to be highly vulnerable for similar reasons.

- Regarding future risk scenarios, the findings revealed that risks are likely to increase under both RCPs 4.5 and 8.5 in the future. Analyses showed that, in both 2030 and 2050, under RCP 4.5, almost all the Terai districts, a majority of the Siwalik, and some hilly districts will be at risk from the impact of climate change. Out of the provinces, Province two will be at very high risk due to several reasons. Districts like Bajura, Humla, Dolpa, and Mustang are expected to move towards 'low' to 'moderate' risk under RCP 8.5 in 2050 from a starting point of 'very low risk' in RCP 8.5 in 2030. Overall, the trend showed that most of the districts in Nepal will be at risk from climate change impacts. From only four districts in the 'very high risk' category at baseline, 43, 55, 27, and 65 districts will shift to come under this category under RCP 4.5 in 2030 and in 2050, and under RCP 8.5 in 2030 and in 2050 respectively.

- To have better risk management, a robust adaptation strategy needs to be adopted for reducing the impact of climate change in the sector. There are some straightforward actions and interventions that could be considered in specific contexts. These can include increased funding directed to facilitating a given community's/area's resilience against droughts, or the enforcement of stricter planning regulations on locating WASH infrastructure in flood-prone areas.

- Adaptation options in the WASH sector must be accompanied by informed and evidence-based research and a "learning-by-doing" approach that identifies and evaluates adaptation strategies. Additionally, effective adaptation to climate change requires improvements in WASH governance.
- This assessment has a few noteworthy limitations. The analysis was focused only on the district, province, and physiographic regions. Availability of data and information in the sector is a major issue. There is no systematic database on hygiene. Database generation and reporting are an essential part of the process, including monitoring.
- In the future, it is important to have evidence-based planning and decision-making, as well as understanding of vulnerability and risk. For this municipality-based rankings are crucial. The current NWASH- web and mobile application ('app'), which the government has endorsed, is expected to have a profound impact on the WASH sector. For now, however, it has limited coverage: out of the 753 local governments in Nepal, only 156 municipalities have updated information but even that is incomplete. Also, a cluster-based WASH dashboard needs to be established online to share information regarding different interventions carried out by both the government and other stakeholders to have a centralized data system.

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Chapter 1

Background and Sectoral Context

1.1 Background

Nepal's Constitution states that "every person shall have the right to live in a healthy and clean environment" (Government of Nepal, 2015). The country has committed to achieving the Sustainable Development Goals (SDGs) for universal access to safely managed drinking water and sanitation. According to the Ministry of Water Supply (MoWS) in 2018, 88 percent of the country's households had access to basic drinking water services. However, about 75 percent of water sources and 85 percent of household drinking water have faecal contamination (MICS, 2019), with only 19 percent of the population having access to safe drinking water services.

Nepal has made significant progress in providing services for water and sanitation in the past few decades. It has embarked upon an Open Defecation Free (ODF) campaign and 94.5 percent of households in the country are now using improved sanitation (MICS, 2019). In ten years, from 1990 to 2000, the country has made huge progress in its water and sanitation services. In 1990, only 36 percent of the population had access to water supply and six percent had access to toilets. In 2000, the situation improved considerably, with 80 percent having access to basic sanitation services. Currently, 94.5 percent of households have access to improved sanitation services (MICS, 2019).

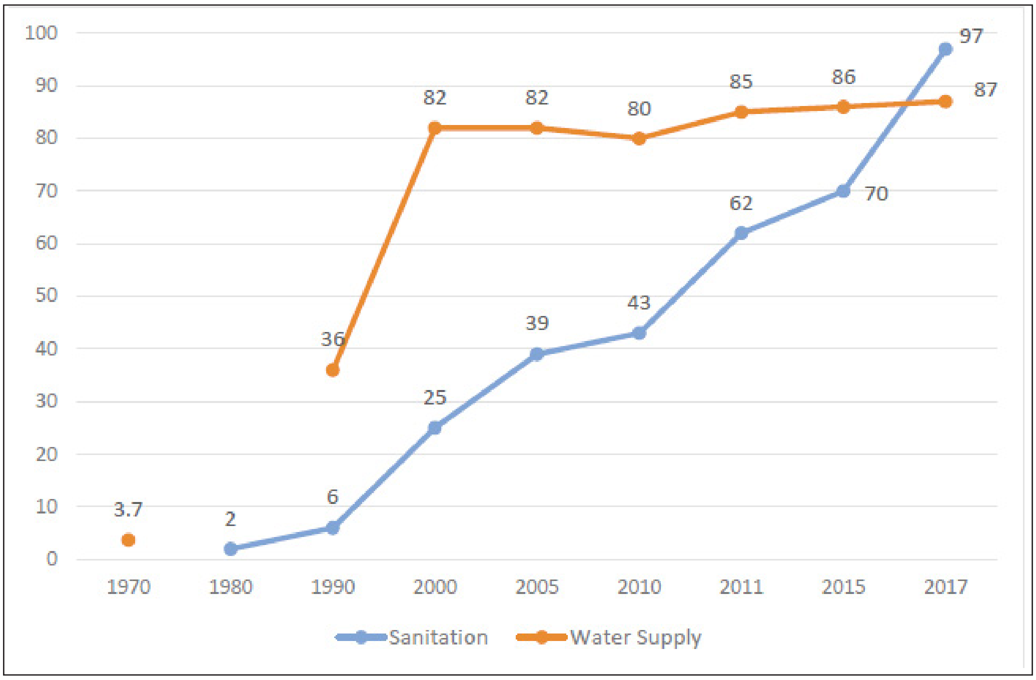

Figure 1: The trends of water supply and sanitation coverage in Nepal[1]

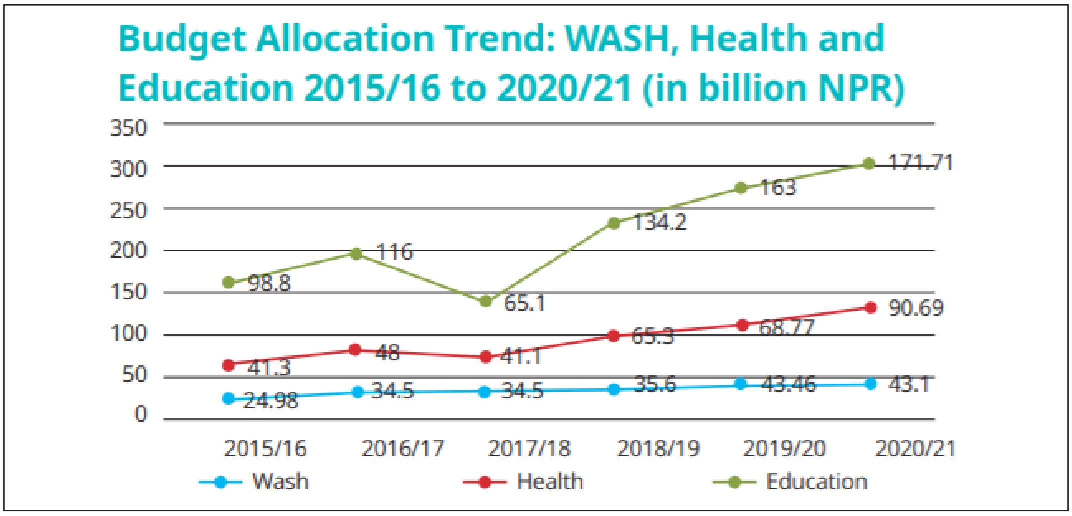

Figure 2: Budget allocation trends: WASH, health and education sectors from 2015/2016 to 2020/21 (in billion NPR)

Improved water supply, sanitation, and water resource management have contributed to the country's economic growth and poverty eradication. Proper water resource management, in particular, has had a positive impact on increasing production and productivity in Nepal's economic sectors (Sanctuary & Tropp, 2007).

The WASH sector is also important from the standpoint of human rights as it relates to water supply, sanitation, and hygiene, which are basic human needs (Noga & Wolbring, 2012). Moreover, a resilient WASH sector can result in several benefits for a country's population, such as those related to health and nutrition, socio-economic conditions, and education.

1 Source: CBS, 2011; NMIP, 2014; NMIP 2018; NSASC, 2000; SEIU, 2016

Furthermore, WASH interventions not only have an immediate impact on an individual's life, but also have a cumulative effect on the entire life course of an individual, even affecting the lives of their offspring (Mills & Cumming, 2016). According to the Statement of the Committee on the Right to Sanitation (45th session, E/C.12/2010/1), "for every dollar invested in sanitation, there is about a nine-dollar long-term benefit in costs averted and productivity gained" (UN WATER, 2020).

The government of Nepal has made considerable efforts to improve the water supply and sanitation situation in the country by formulating and enforcing several WASH policies, guidelines, and acts. Through the integrated National Rural Water Supply and Sanitation (RWSS) Policy and Strategy 2004 and the Sanitation and Hygiene Master Plan (SHMP), the government has committed to ensuring access to basic water supply and sanitation services for all people by the end of 2017 (GoN, 2011). The Ministry of Water Supply and Sanitation has prepared a long-term sectoral development plan (SDP) by identifying several thematic approaches and priority areas for future interventions. By aiming to provide basic WASH services to its entire population by 2020 and to improve service levels (medium 50% and high 50%) by the end of 2030, the government aims to considerably improve the wash sector. Additionally, Nepal has set specific targets in its SDGs for the year 2030; these include basic water supply coverage to 99 percent of households, piped water supply and improved sanitation to 90 percent of households, and the elimination of open defecation.

The government has prioritized the health and WASH sectors, making significant financial investments in them. For example, its spending on health as a share of GDP has slowly increased from 1.4 percent in FY 2015/16 to 1.8 percent in FY 2018/19. The health budget has increased from NRs. 68.78 billion (US $610.8 million) in FY 2019/20 to NRs. 90.69 billion (US $748.1 million) in FY 2020/21. In 2021, a budget of NRs 122.77 billion was allocated to the Ministry of Health and Population.

1.2 Challenges in the sector

Despite experiencing remarkable progress, Nepal's WASH sector continues to face significant regional disparities in terms of both coverage and quality, as well as resilience challenges. In particular, WASH services and water availability are lagging behind in Lumbini, Karnali, and Sudurpaschim Provinces in western Nepal, and in Province two in the eastern Terai of the country. Key challenges in the sector include the following:

- **Behaviour change**: Major challenges in sanitation and hygiene are related to existing behaviours and practices triggered by lack of access to resources and knowledge. Sustainable development and poverty eradication are linked to access, availability and affordability of water and sanitation services. Access to clean water, sanitation, and good hygiene behaviours are linked with the survival, growth, and development of individuals and communities. In the absence of such facilities, millions of children are at risk. For example, due to poor WASH conditions in the country, five waterborne diseases are included in the leading causes of death in children.

- **Poor governance**: Sustainability is a major challenge for the WASH sector in Nepal. The majority of drinking water supply schemes can not function for the expected life span of 20 years (White et al., 2015). Due to a lack of good governance in water supply schemes, only 25% of schemes are fully functional, while 39% require major repair and rehabilitation[2]. According to UNICEF, even though ODF has been declared in Nepal, 16 percent of the country still does not have access to sanitation facilities. Additionally, only 25 percent of the water supply is reported to be fully functioning. Furthermore, 91 percent of the population's poorest quintile use water sources that are contaminated with Escherichia coli (E. coli) bacteria. The risk of biological contamination is increased due to a lack of systematic water quality surveillance. Overall, a considerable proportion of the water supply schemes are dysfunctional and poorly maintained, which has a direct impact on the accessibility, quality, and reliability of water supply.

The poor functionality of water supply systems is mediated by several factors, including negligence, inadequate application of water safety principles, and the lack of capacity of the water users' committee to carry out major and minor repairs. Weak institutional, financial, and technical capacities of the users' committees in rural areas are the main obstacles to the sustainability of water supply systems (Chauhan, 2013). There is also the tendency of users as well as governing bodies to depend on external resources for maintaining and repairing the existing schemes (Budhathoki, 2019).

- **Exclusion of women and the marginalized**: There is a clear disparity between the rich and the poor in terms of access to and use of toilet facilities. According to the report by Bhandari and Grant (2005), there is a disparity between the rich and the poor when it comes to accessing piped water. Recent government policies mandate that the Water Supply Users Committee must have at least 33% female involvement. Because of established gender roles, women's and marginalized groups' participation is frequently limited to meeting quotas. Further, women's agency and participation in WASH-related policies and practices are hindered by the patriarchal system (Bhandari & Grant, 2005). Overall, it is clear that women are underserved and underrepresented in the development, operation, and maintenance of drinking water supply systems in Nepal.

- **Complex socio-structural issues**: Nepal is dealing with major socio-cultural issues, and prevalent beliefs and practices affect access to WASH. Women and girls frequently face the most difficult problems in school, health, and are ostracized from society during menstruation. Moreover, women and girls in disadvantaged communities may spend two or three hours a day collecting water for their families, impeding their development. This situation is complicated further by a deeply rooted and pervasive caste system.

- **Data management**: Data collection and management are challenging tasks for a country like Nepal. To date, there is no precise countrywide data on the WASH sector. This has resulted in a significant gap in information generation. However, it is expected that N-WASH, an app designed to collect such WASH-related data, will be critical in filling this gap.

2 Nationwide Coverage and Functionality Status of Water Supply and Sanitation in Nepal, Department of Water Supply and Sewerage, GoN.

Aside from the existing challenges in the WASH sector, climate change exacerbates the impacts, vulnerabilities, and risks experienced by this sector. Because of climate change, the frequency of extreme weather and climate-related disasters is expected to rise in Nepal (Patz et al., 2000). Additionally, weather and climate change are expected to have a significant impact on WASH-related public health issues. Floods, landslides, and droughts all have a direct impact on the reliability, assets, and functionality of water schemes and sanitation services. Reduced availability of high-quality and sufficient quantities of water can also cause hygiene-related diseases or waterborne disease outbreaks such as cholera and diarrhoea.

Chapter 2

Objectives and Scope of the Study

2.1 Objectives

The assessment of the current and projected impacts of climate change on risks and vulnerabilities associated with drinking water and sanitation is a key element for formulating sector-specific adaptation policies and plans. The overall objective of this assessment is to assist the process of formulating Nepal's National Adaptation Plan (NAP) by assessing climate-related hazards, risks, and vulnerabilities, and identifying practical adaptation options. Specific objectives include:

- Assessing risks and vulnerability to climate impacts across the drinking water and sanitation sector through applicable frameworks; ranking/categorizing associated climate risks and vulnerabilities.
- Identifying adaptation options for these risks at multiple scales (district, province, physiographic regions), to address priority climate risks and vulnerabilities.

2.2 Scope and limitations

Conducting VRA is a critical step in adaptation planning and implementation that helps identify current and potential hotspots, indicate entry points for intervention, and strengthen identification, implementation, monitoring, and evaluation of adaptation actions (IPCC, 2014). This study was designed to produce a sectoral report based on a VRA of the WASH sector with regards to climate change, with the following outputs:

- A finalized list of indicators, along with data, for the VRA
- Details of climate change related risks and vulnerabilities in the sector, with vulnerable hotspots identified

- Highly visual Geographic Information System (GIS) Illustrated Maps (including GIS files) for 77 districts, 7 provinces, and physiographic regions of Nepal
- A long-list of adaptation options for the medium-and long-term in the WASH sector, covering 77 districts and 7 provinces.

The results of this study will be useful for decision-makers, policymakers, and planners to prioritize and address vulnerable geographic areas and climate-sensitive sectors. The adaptation options that were identified will be particularly useful for local-level planners, policymakers, and implementers, particularly Palikas.

An indicator-based approach was used in this assessment. The results were drawn from the analysis of agreed-upon indicators. Following that, the identified vulnerabilities and risks were categorized and ranked. This study considered 'district' as the basic unit for data gathering since most of the relevant data was available at this level. The data was then aggregated for provinces and physiographic regions within provinces. The study also involved several consultations, feedback collection, and data and report validation.

Some limitations should also be noted. The study relied on secondary information only, since primary data collection was not within its scope. Further, due to the COVID-19 pandemic, some meetings were held virtually. The lockdown and travel restrictions also restricted field consultations.

Chapter 3

Methodology

In 2017, the government of Nepal published the VRA framework and indicators for the formulation process of its National Adaptation Plan (NAP). This framework—based on the Fifth Assessment Report (AR-5) by the Intergovernmental Panel on Climate Change (IPCC, 2014) and the Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)—has also been used in this report. In IPCC's Fourth Assessment Report (AR-4; 2017), vulnerability was a core concept that described the extent to which a natural or social system was susceptible to, and unable to cope with, adverse effects of climate change. In the latest AR-5, this concept has been replaced by the concept of risk from climate change impacts that may harm a system. Risk is seen as a result of the interaction between vulnerability, exposure, and hazard.

3.1 Framework

The aforementioned national framework unpacks the element of risk and customizes it, as applicable, to the national context. It assumes that the risk of climate-related impacts results from the interaction between climate-related hazards (including hazardous events and trends) and the exposure and vulnerability of human and natural systems. Changes in the climate system (trends and scenarios), biophysical system, and socioeconomic processes (including governance and adaptation and mitigation actions) are the drivers of hazards, exposure, and vulnerability. Within this framework, the VRA is based on measurable and quantifiable available data, both primary and secondary. Figure 3 below describes the framework adopted for this assessment.

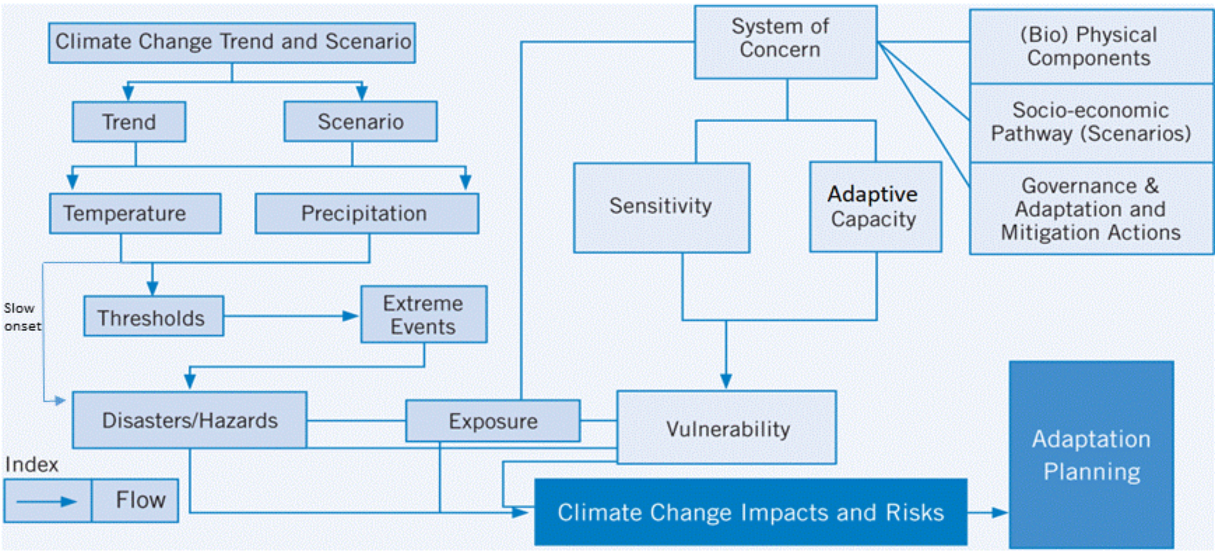

Figure 3: Climate change vulnerability and risk assessment framework[3]

In this framework, **risk** is taken as the ultimate factor measuring climate change threat or impact on human lives. It is defined as the product of hazard, exposure to hazard and vulnerability to hazard. In contrast, **vulnerability** is considered as the function of sensitivity minus adaptive capacity. These are explained by using the following equations I and II:

Equation (I) : $R = H \times E \times V$

Equation (II) : $V = S - AC$

Where,
R = risk, H = hazard, E = exposure, V = vulnerability, S = sensitivity and AC = adaptive capacity

3.2 Approach

The approach to this assessment was heavily consultative. Its information was derived and validated from feedback from a Technical Committee (TC), a Thematic Working Group (TWG), provincial governments, and local governments. The assessment put maximum effort into integrating and harmonizing the methodology, results, and findings among sectors. This involved inter-sectoral consultation and feedback collection through weekly progress review meetings, technical meetings, and bilateral/peer-wise consultations. Data was gathered using quantitative and qualitative approaches for which both types of indicators were included. Gender Equality and Social Inclusion (GESI) was duly considered as a cross-cutting theme in all steps of the study.

3 Source: MoPE, 2017 with slight modification

3.3 Methodological steps

The methodology used in this study involved nine key steps, summarized in Figure 4 below.

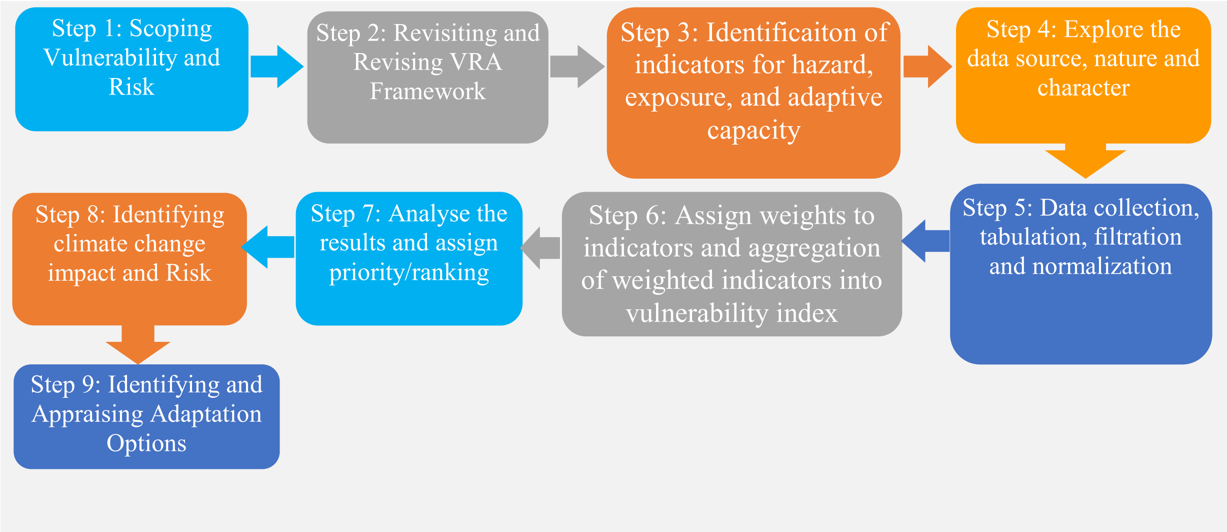

Figure 4: Steps of Vulnerability and Risk Assessment (MoPE, 2017)

Step 1: Scoping vulnerability and risk

The scoping task was an important step to set the boundaries for the VRA methodology. This process involved stocktaking of existing methodology, approaches, and frameworks for undertaking VRAs. It also helped in understanding the various concepts methodologies and terminologies used by the IPCC, NAP technical guidelines, and UNFCCC reference documents.

Step 2: Developing the VRA framework

The NAP technical guidelines allow countries to develop their country-specific frameworks for assessing vulnerability and risk. This study used the VRA framework developed by Nepal to assess and illustrate the logical linkages between hazard, exposure, vulnerability, and risk. Additionally, it included mapping of adaptation options. A 'slow onset event' was added as an amendment to the framework.

Step 3: Identifying key indicators for hazards, exposure and vulnerability (sensitivity and adaptive capacity)

This study used an indicator-based vulnerability assessment, which is among the most common and easy-to-conduct climate vulnerability assessment methods. It allows to mathematically combine key indicators into a single composite index (Luers et al., 2003). This study employed an indicator-based vulnerability assessment approach where indicators for the WASH sector were identified for hazards, exposure, sensitivity, and adaptive capacity. The report titled "Vulnerability and Risk Assessment Framework Indicators for National Adaptation Plan (NAP) Formulation Process in Nepal" and published by MoPE (2017), was the main source from where the indicators were selected. Other indicators were added as more relevant documents were reviewed. These indicators were then validated and revised based on i) the availability of required data in essential forms, ii) country priority, and iii) local feasibility. This was done after soliciting input from other thematic and cross-cutting working group members, subject matter experts (SMEs), TWG members, and TC members.

Step 4: Exploring sources. nature and character of data

This study gathered authentic, robust, and up to date quantitative and qualitative data from various secondary sources such as government documents, periodic reports, profiles, policy documents, and documents released by line ministries and departments. 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), Department of Water supply, and Sewerage Management database and reports. The nature and character of data varied with the source of data. They were available in MS Excel, Word, Comma-separated value (CSV), Geographic Information System (GIS) shapefile and grid formats. Wherever feasible, the data was validated through different data sources.

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

Data was collected from the various secondary sources mentioned in Step 4 above, ensuring that it was grounded in specific human settlements and critical infrastructure at risk. The spatial data was available in vector and raster formats, while non-spatial data was available in tabular format. Both spatial and non-spatial data was then tabulated in the uniform format. This was then compiled in Excel according to hazard, sensitivity and adaptive capacity indicators for different physiographic zones, districts, and provinces. Data filtering was done by ranking, clustering (grouping), imputing (substituting some values for missing data), and sorting data (mainly categorical and nominal data) for individual variables by different responses (e.g., gender). Data transformation was carried out where appropriate.

In order to make them consistent and comparable, all quantitative data was normalized using the following formula, which converted all values to a value ranging between 0 and 1:

$$Z_i = \frac{X_i - X_{min}}{X_{max} - X_{min}}$$

Where,

Z_i is the i[th] normalized data;

X_i is the original value of i[th] data that is being transformed;

X_{max} is the maximum value in that category/indicator; and

X_{min} is the minimum value in the indicator.

Steps 6 and 7: Weightage and composite value, and analysis

Weightage was calculated for each indicator based on expert opinions. These expert opinions were obtained using the Analytical Hierarchy Process (AHP) tool (Hossain et al., 2014; Likert, 1932), which allowed experts to score the indicators between 1 (lowest score) to 9 (highest score) based on their relative importance. Following this, exposure index, sensitivity index, and adaptive capacity index were calculated by multiplying the individual normalized value with the respective weight and finally adding all the products of multiplication. The vulnerability index was calculated by deducting the adaptive capacity index from the sensitivity index of the respective district. Finally, the risk index was calculated for each district by multiplying the hazard. Exposure, and vulnerability indexes. Districts were then grouped based on indices into five categories (based on the Jenks natural breaks method): very high, high, moderate, low, and very low. All hazards, exposure, sensitivity, adaptive capacity, vulnerability, risks, and maps were produced accordingly.

Table 1: Scores for the importance of variables (Saaty Scale)

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

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

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

Equation (III) : $AC = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i}$

Where,

AC is an aggregated indicator, e.g., aggregated adaptive capacity,
x*i* is an individual indicator of the adaptive capacity of a vulnerability component, and
w_i is the weight assigned to the corresponding indicator x_i.

The most preferred alternative is that with the minimum value of AC.

Indicator-wise weightages for exposure, sensitivity, and adaptive capacity are given in Tables 2 and 3 respectively.

Table 2: Exposure Indicators and weight

Indicators (Number of)	Weight
Total males	0.190
Total females	0.215
Piped water	0.059
Households with taps and tube wells	0.053
Gravity flow piped WS schemes	0.101
Lifting water supply schemes	0.123
Groundwater lifting with OH schemes	0.136
Handwashing stations	0.123
Total	**1**

Table 3: Sensitivity and adaptive capacity indicators and weight

Sensitivity indicators	Weight	Adaptive capacity indicators	Weight
Children diarrhoea incidence/1000	0.051	Number of household members with information on water quality using improved sources	0.092
Number of children under age five with amoebic dysentery	0.004	Number of households with private tap	0.069
Number of children under age five with bacillus dysentery	0.004	Number of households with private hand pump	0.069
Number of children under age five with pseudomonas diarrhoea	0.004	Number of households dependent on spring	0.043
Number of children under age five with malnutrition	0.029	Number of households dependent on well	0.043
Percentage of household members without drinking water on-premises	0.115	Percentage of household members with an improved drinking water source located on-premises, free of E. coli, available when needed and <=10 ppb arsenic	0.021
Number of girls and women above age 15	0.109	Number of households using boiling as water treatment	0.059
Number of female children under age 15	0.015	Number of households using beach/chlorine as water treatment	0.043
Number of male children under age 15	0.014	Number of households using water treatment as - Use a water filter	0.040
Water fetching duration between 1 hour to 3 hours	0.113	Number of households using solar disinfection as water treatment	0.013
Water fetching duration over 3 hours	0.012	Number of households with rainwater harvesting	0.061
Number of people polled water too expensive	0.009	Number of schemes with WUSC registered	0.020
Number of people polled source not accessible	0.026	Number of schemes with WSST	0.018
Percentage of household population with E. coli in household drinking water	0.128	Number of schemes with tools	0.026
Water schemes need major repair	0.044	Number of schemes with O/M fund	0.032
Water schemes need rehabilitation	0.044	Number of well-functioning schemes	0.112
Water schemes need reconstruction	0.045	Percentage of households using improved sanitation	0.043
Child faeces, thrown into the garbage	0.066	Percentage of household members with hand-washing facility where water and soap are present	0.058
Child faeces, left in the open	0.055	Percentage of total literacy	0.052
No hand-washing stations in dwellings yard or plot	0.023	Amount of tariff collected by water supply scheme in rupees	0.086
Water demand urban municipality	0.045		
Water demand rural municipality	0.045		
Total	**1**	**Total**	**1**

Step 8: Identifying climate change impact and risks

Impacts were identified using a literature review while the risk index was calculated from the hazard, exposure, sensitivity, and adaptive capacity indicators. Each risk index was converted to one of five categories: very low, low, moderate, high, and very high. These categories helped in identifying climate-vulnerable hotspots in terms of physiography, province, and district.

The vulnerability of each sub-sector and the WASH sector overall was analysed using the aggregated values of sensitivity and adaptive capacity as shown in equation IV. According to IPCC's AR-5, vulnerability is derived by subtracting adaptive capacity from sensitivity. Figure 5 illustrates the typical process and analysis of the chain of vulnerability and risk with indicator-wise data of sensitivity, adaptive capacity, and exposures.

Equation (IV) : $V = S - AC$

Where,

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

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

Equation (V): $R = H_{intensity} \times V \times E$

Where,

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

The final risk was rescaled by dividing the outcome values by the maximum risk values of all administrative units, as shown in equation VI.

Equation (VI) : $scale = \frac{R}{\max(R)}, R \in \{admin\ units\}$

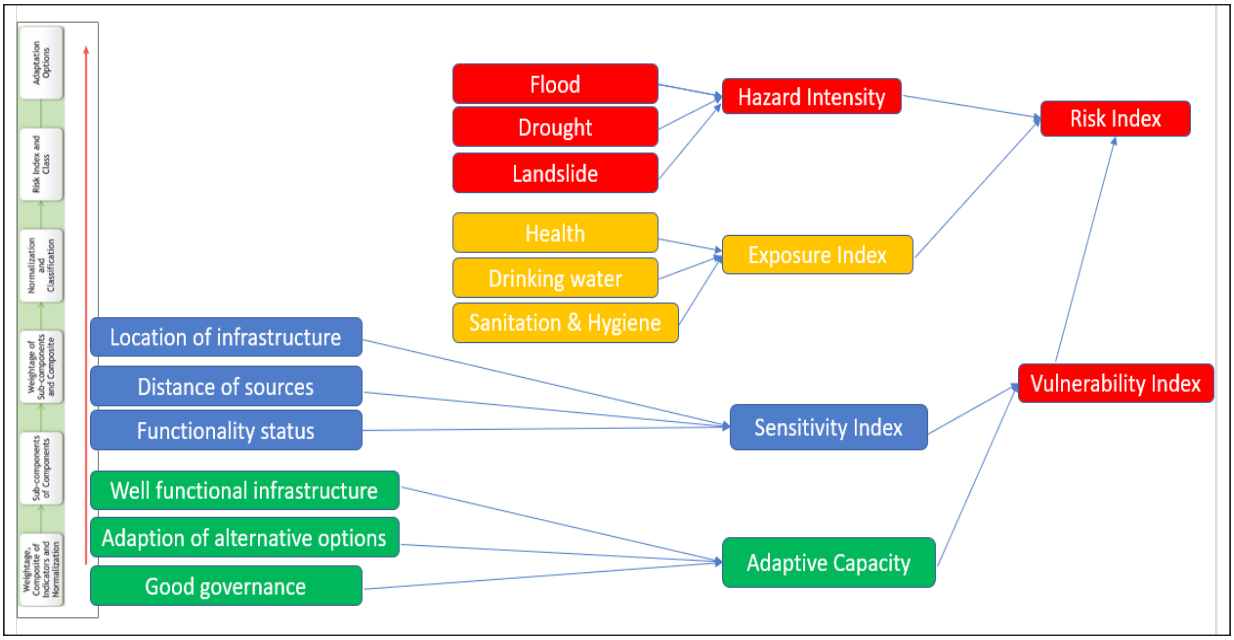

Figure 5: Example of process for calculating indexes

Step 9: Identifying and appraising adaptation options

Since there is no one-size-fits-all prescription for addressing climate change challenges, emphasis was given to place-and context-specific adaptation options in this study (IPCC, 2014). Towards this end, the study made sure that the options met one of the following states: no-regrets, low-regrets (or limited regrets), or win-win. The options included the following broader topics: (i) management and operational strategies; (ii) critical infrastructure changes; (iii) climate change integration in sectoral policies, strategies, and work plans; (iv) investment portfolio priorities; and/or (v) capacity-building. The gender equality and social inclusion (GESI) perspective was taken into account to understand if certain hazards and risk factors were more common among certain vulnerable and marginalized people—such as women, youth, and the physically deprived (e.g., people with disabilities).

The process for this step included the following:

- Potential adaptation options were identified based on the impacts, vulnerability, and risk maps and tables generated by the analysis of secondary data.
- A list of potential adaptation options was identified based on a literature review of successful adaptation practices, effective local knowledge and practices, efficient technologies, and common practices.
- A consultation was carried out with relevant experts to map effective adaptation strategies in the relevant sector and sub-sectors.
- Consultations at the province level were carried out to identify adaptation options in the context of existing risks and vulnerabilities.
- Validation of adaptation options was done through Thematic Working Groups (TWGs) and Technical Committees.
- Following all the above, the list of adaptation options was finalized.

Chapter 4

Climate Change Impacts in the WASH Sector

Climate change is one of today's most pressing issues, with the potential to harm people and economies (Stern, 2006). It can lead to a higher frequency of extreme weather events. These events, combined with land-use change, can result in higher frequencies of floods, which can impact settlements and increase their exposure to disasters (Milly et al., 2002). Climate change can also have a direct effect on groundwater by causing changes in precipitation (Taylor et al., 2013). Reductions in precipitation can lead to a loss of water sources.

In the future, the availability of quality water is expected to be quite unpredictable due to changes in precipitation, temperature increase, and increased pollution. Population growth will increase demand for water, while urbanization rates will make the availability of drinking water more stressful. In addition to compromising water sources, climate change related changes in temperature and precipitation will pose further risks, such as undermining of water supply systems and basic water needs for the growing global population. A significant impact is likely to be seen on drinking water supplies due to changes in surface water that have resulted from climate change (Bates & Kundzewicz, 2008). Additionally, short-term threats, like flash floods, and long-term impacts, like destruction of infrastructure for water delivery, are inevitable.

Nepal, in particular, is sensitive and vulnerable to climate-induced and geophysical hazards, as well as to climate change. In the Terai flood regions as well as in mountain regions, flooding is a common problem. Landslides are regarded as the second most dangerous risk related to natural and man-made activities (MoHA, 2011). Hydro-climatic hazards have been found to be key factors adversely affecting the overall water supply schemes in communities. For example, the increased frequency of landslides and erosion in the hills and mountains, along with the increased duration and depth of riverine floods and inundation in the Terai regions, have severely impacted intake structures and pipeline networks. Compared to intake structures and pipeline networks, reservoirs and treatment units have been found to be less sensitive to hazard and climate variables (Ahmad, 2018). Table 4 below shows hazards specific to the WASH sector, their respective climatic stressors, and their sector-specific impact.

Table 4: Examples of impacts of hazards on the WASH sector

Climate effect	Hazard	Impact on WASH sector
Decrease in precipitation	Drought	Reduction in raw water supply, reduced flow in rivers, less dilution/ increased concentration of the pollutant in water, challenge to hygiene practices
Increase in precipitation and severe weather	Flooding	Pollution of wells, inundation of wells, inaccessibility of water sources, flooding of latrines, damage to infrastructure, landslides around water sources, sedimentation and turbidity, challenges to the sustainability of sanitation and hygiene behaviours, waterborne diseases
Increase in temperatures	Heatwaves	Damage to infrastructure, increase in pathogens in water leading to increased risk of disease
	Melting and thawing of glaciers, snow	Seasonality of river flows affected leading to a reduction in water availability in summer

In a nutshell, climate change significantly impacts water stress and insecurity, increases incidences of water-transmitted infectious diseases, slows or reverses progress toward improved WASH coverage, exacerbates inequalities, and undermines the achievement of related Sustainable Development Goal (SDG) targets and human rights related to water, sanitation, and hygiene (WASH) services. Loss and damage caused by climate stressors have a tremendous impact on the supply and delivery of water, sanitation, and hygiene.

The section below describes the specific impact of climate change in the WASH sector generally and in Nepal.

4.1 Impact on quantity and quality of water

Climate change can impact water availability and quality in multiple ways. Loss of water sources may occur because of extreme variability in rainfall, over-extraction, and destruction of intakes or reservoirs during flood events. Droughts may increase the concentrations of chemicals and pathogens in water. Contamination may also occur because of failure of water treatment systems, source protection measures, distribution of infrastructure, as well as disruption to transport and power systems that may cause water supplies to stop functioning or prevent delivery of treatment chemicals. In Nepal, around five percent of water supply schemes were found to be dried (Helvetas, 2015) where precipitation did not hold significant ground for source yield.

Springs are the major source of water in the mid-hill region of Nepal. Despite being extremely important for meeting local needs, studies show that there has been a steady decline in discharge from springs—around 30 percent in over 30 years (Chapagain & Shrestha, 2019). Additionally, rising temperatures in the Himalayan region carry severe implications for downstream water availability in both the short and long terms. The increase in temperature, caused by global warming, severely threatens the country’s water resources. The melting and thawing of glaciers, snow, sea ice, and frozen ground leads to changes in the seasonality of river flows and reduces water availability in summer (UNICEF, 2014). It is reported that up to 50% of the average annual flows in the rivers are contributed to by melting snow and glaciers, and this contribution is now at risk from climate change.

A study conducted in the Karnali region of Nepal shows that the effect of climate change and population increase is altering the local hydrological cycle, leaving the country's water less available during times when it is required (Panthi et al., 2018). A decrease in precipitation causes droughts, leading to a reduction in raw water supplies, reduced flow in rivers, less dilution/increased concentration of pollution in water, and challenges to hygiene practices. In contrast, an increase in precipitation and severe weather causes flooding, pollution of wells, inaccessibility of water sources, flooding of latrines, damage to infrastructures, landslides around water sources, sedimentation, and turbidity. An increase in temperature causes heat waves, causing damage to infrastructures. Moreover, an increase in pathogens in water causes an increased risk of diseases.

During the winter months, there are droughts and a decrease in the discharge of fresh water. This adds to the fact that the water sector in Nepal has been affected mainly in terms of depletion of surface and groundwater sources in the mountainous and Terai regions respectively, which is affecting the sustainability of water supply systems, sanitary systems, and hygiene facilities in the country (WHO, 2015). Additionally, drying up of water sources gives rise to community conflicts related to the sources; it also adds burden to the females of the country's population because fetching water is considered to be primarily their responsibility. Lack of water also restricts maintaining good hygiene behaviours.

According to a climate change perception survey, carried out by Nepal's Centre Bureau of Statistics (CBS, 2017), 74.29 percent of the country's total households observed changes in water sources, while 84.47 percent observed a decrease in the amount of surface water. Further, 79.64 percent of households in the urban areas and 68.12 percent in the rural areas reported a decrease in water quality. A majority of households (74.56 percent) in the mountain region reported complete drying up of surface water and a high percentage (48.81 percent) in the hill regions observed complete drying up of the underground water sources.

Results from the survey further showed that 67.78 percent of households have been observing a deterioration of groundwater quality in the last 25 years, while 10.97 percent of households are not observing so. Similarly, a high percentage of households in Terai (86.48 percent) have been observing this deterioration, followed by households in hills (54.6 percent) and mountains (35.07 percent). Further, while 79.69 percent of households in the tropical zones have been observing this deterioration, none observed it in the sub-alpine zones (CBS, 2017).

4.2 Impact on health and hygiene

Floods directly affect both health and WASH systems, especially in Terai. During floods, infrastructure and services related to health, drinking water supply, and sanitation systems get damaged and disrupted. Climate change has also increased risks to the infrastructure being used in service provision. An alarming health risk arises from sewage entering drinking water supply systems, which can cause faecal contamination and result in severe gastrointestinal disorders among exposed and vulnerable communities and groups. The Terai region of Nepal is more susceptible to such problems as open defecation is prevalent in the region due to low sanitation coverage. This mismatch of sanitation coverage and dangerous climatic trends breeds a potential for run-off contamination, adding to the WASH-related health vulnerability of Terai's population (Baidya, 2017). Especially during emergencies, when services are not accessible on time, this situation can lead to even more health and sanitation problems.

The issue of worsening water quality is also on the rise as contamination and changes in quality of water sources arise with different climatic and non-climatic stressors (Panthi et al., 2018). An example of a non-climatic stressor is the direct disposal of sewage and other wastes in the river. Increasing levels of arsenic in water sources in the Terai region has also raised many health issues (Shrestha, 2017). Skin problems are also increasing due to contaminated water sources. Increased exploitation of groundwater sources in urban areas is leading to rising levels of groundwater pollution from natural chemical contamination such as arsenic in the Terai belt. Studies have also revealed that the warm and damp conditions in the region have led to increased incidences of water-related diseases.

4.3 Impact on WASH infrastructures and services

Climate change is likely to pose an increasing risk to the infrastructure used for service provision in Nepal. Water-related extreme events, exacerbated by climate change, can lead to damaged sanitation systems or flooding of sewer pumping stations. The high precipitation also may result in flood/ flash floods, which might have ability disrupt the functioning of water and sanitary systems. The ability of modern sewers to flush can be harmed. In contrast, pit latrines are vulnerable and pose a major threat of sewerage disruption during floods (Howard & Bartram, 2010).

Climate hazards such as fires, Glacier Lake Outburst Flood (GLOFs) and landslides also damage drinking water infrastructures such as water collection tanks, pipes, and distributing channels. In Nepal, landslides and floods are the most frequently occurring hazards that pose massive damages to the country's drinking water facilities. For example, a massive landslide and flood occurred on 3 September 2020 in Bhobang of the Dhorpatan municipality-9 in the Baglung district. Thus, landslide and flood washed away many drinking water spouts. Very often, destruction and contamination of drinking water and sanitation services are caused due to local flooding.

Consultations at the province and local levels also revealed that increased frequency and intensity of floods and landslides pose a major threat to the WASH infrastructure, particularly the drinking water facilities. It was argued that the annual cost of repair and maintenance for these infrastructures is increasing. One of the local government representatives claimed that they have to allocate more than 20% of their annual budget to repair and maintenance, and even this amount is not sufficient.

Nationwide, the total number of piped water supply schemes is 42,039, out of which only 9,461 are found to be functioning well. In total, 28,495 schemes require minor and/or major repairs or rehabilitation/reconstruction, and only 2,378 schemes have operation and maintenance funds. This shows a huge gap in the sustainability of water supply schemes. To achieve the WASH component of SDG 6 by 2030, it is estimated that capital investment in the country needs to triple (to reach US$1.7 trillion), with operating and maintenance costs becoming commensurately higher (Hutton & Varughese, 2016).

4.4 Impact on women, the poor and the marginalized

During droughts and other extreme events related to climate change, there is an increased pressure for sustained access to drinking water and sanitation services. Access to these services can be especially challenging for the poor and other disadvantaged groups who reside in drought-affected and other risk-prone areas. Additionally, it is expected that there will be increased competition for water resources even among elite groups. This situation is likely to result in a failure to ensure the rights of individuals and communities to have access to drinking water and sanitation.

Widespread poverty, high levels of hunger, and a lack of basic healthcare facilities and hygiene awareness (particularly in rural areas) render Nepal especially vulnerable to climate impacts. Multiple factors contribute to water-related diseases among children under the age of five, but one of the major factors is likely the compromised functionality of the water supply schemes. Data shows that out of the total number of children under five in Nepal, 345,164 had got amoebic dysentery, 143,203 bacillus dysentery, 581,233 pseudomonas diarrhoea, 11,185 cholera, and 26,910 malnutrition.

With climate change, the frequency and intensity of events accompanied by hydro-metrological factors, such as floods and landslides, are changing. Communities and infrastructure near the rivers that flood every year are always at risk. However, particular segments of the population; children under 5, pregnant and lactating women, the elderly, people living in houses that have not followed building codes, people living with a disability, people with pre-existing disease, along with houses, drinking water supply schemes, toilets, sewerage systems and health facilities lying right next to river banks are at higher risk. Provincial consultations confirmed that the impact of any disaster is higher in marginalized groups; it particularly impacts women, children, the elderly, the disabled, and the poor. Figure 6 illustrates the annual exposure to inland river flooding in Nepal that results in increasing poverty and high levels of hunger.

During drought, when water is scarce, women have little choice but to carry water home from unsafe sources and hygiene practices become compromised. Carrying heavy pots of water not only comes with the risk of exhaustion, bone damage and uterine prolapse but is also accompanied by opportunity costs, such as the time that could be spent productively going to school, working, and caring for children. Consultations with women belonging to the Musahar community near Biratnagar and Janakpur revealed that issues related to water and sanitation are the major challenges during the monsoon season and in the aftermath of disasters. According to them, women, children and elders suffer the most during these disaster events.

Their communities suffer from lack of safe drinking water, good sanitation practices, and external support, and even experiences high child mortality. One female representative said: *'women like us have to suffer the most because we have to take care of small children, arrange food for our families and take care of our belongings during disasters'.*

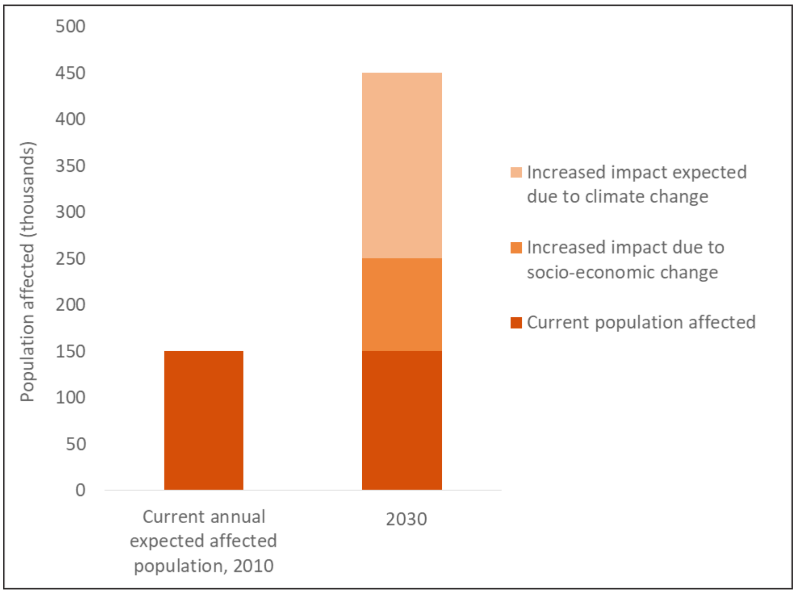

Figure 6: Annual exposure to inland river flooding

Furthermore, the rural areas of Nepal are still plagued with socio-structural and caste-based problems. In the presence of other (ethnic) groups, women and girls from the Dalit communities cannot use water supplies. This discrimination renders these marginalized groups even more vulnerable by disallowing them from using the already scarce resources. On top of this, the elites of these communities, who are in control of the resources, dictate the interest of these marginalized people. Ironically, due to the power structures within Nepal, those who need water resources and systems the most are the ones who get it the least (Regmi et al., 2016).

Chapter 5

Climate Change Hazards and Exposure

5.1 Climate change trends and scenarios

In Nepal, the annual maximum temperature is increasing by 0.056°C/yr while the minimum temperature is increasing by 0.002°C/yr. However, both trends are statistically insignificant (DHM, 2017). The minimum temperature trend is negative in a few mountainous districts like Humla and Manang, and positive in the central Tarai districts of Province Two and the middle mountainous zone across Nepal (from east to west). The increasing maximum temperature rate is consistently higher in the mountainous districts from East to West and the lowest in the Tarai districts. The Manang seems to have experienced extreme temperature conditions in terms of both minimum and maximum temperatures. It has the highest decreasing rate of minimum temperature and the highest increasing rate of maximum temperature. For illustration, see Figure 7 below.

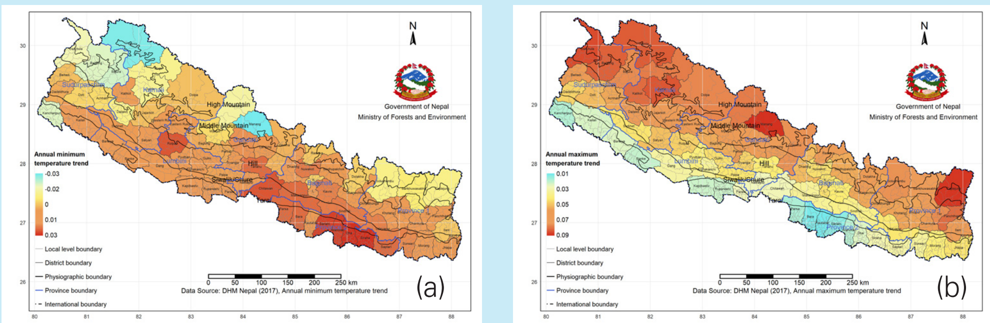

Figure 7: Annual minimum (a) and maximum (b) temperature trends in Nepal

Different precipitation trends are observed in various districts across Nepal's physiological regions and provinces. The overall trend is increasing, with Syangja (8.99mm/yr) and Bardiya (7.86mm/yr) experiencing the highest rates of increase. Gulmi, Tanahu, Nawalpur, Parasi, Banke, Dhanusa, and Kanchanpur receive more than 4mm/yr. In contrast, Kaski (-11.44mm/yr), Ilam (-9.56mm/yr), and Ramechhap (-9.56mm/yr) have experienced decreased precipitation rates between the years 1971 and 2010. A large part of Bagmati Province, the northeast part of Gandaki Province, the west part of Province One, and the south-eastern part of Karnali Province have also experienced a decreasing precipitation trend. The rate of change is between -12 to 9 mm/y across the districts. All the districts of Sudurpaschim Province show trends of increasing precipitation. The Gandaki Province has the highest variation. The Terai region of all the provinces that have this region is experiencing an increasing trend, with the highest point in Sudurpaschim Tarai and the lowest in Province Two. The trend is increasing in the Chure of Sudurpaschim and the Gandaki Provinces and decreasing in Bagmati Province. Overall, the eastern part of the country is receiving less precipitation than before, while the western part is receiving more. Compared to other provinces, Bagmati Province is experiencing the highest decreasing trend. The hilly and high-mountainous areas of Bagmati are seeing more severe precipitation rates. Additionally, there is a very clear precipitation pattern of decreasing precipitation from west to east during winter. For illustration, please see Figure 8 below.

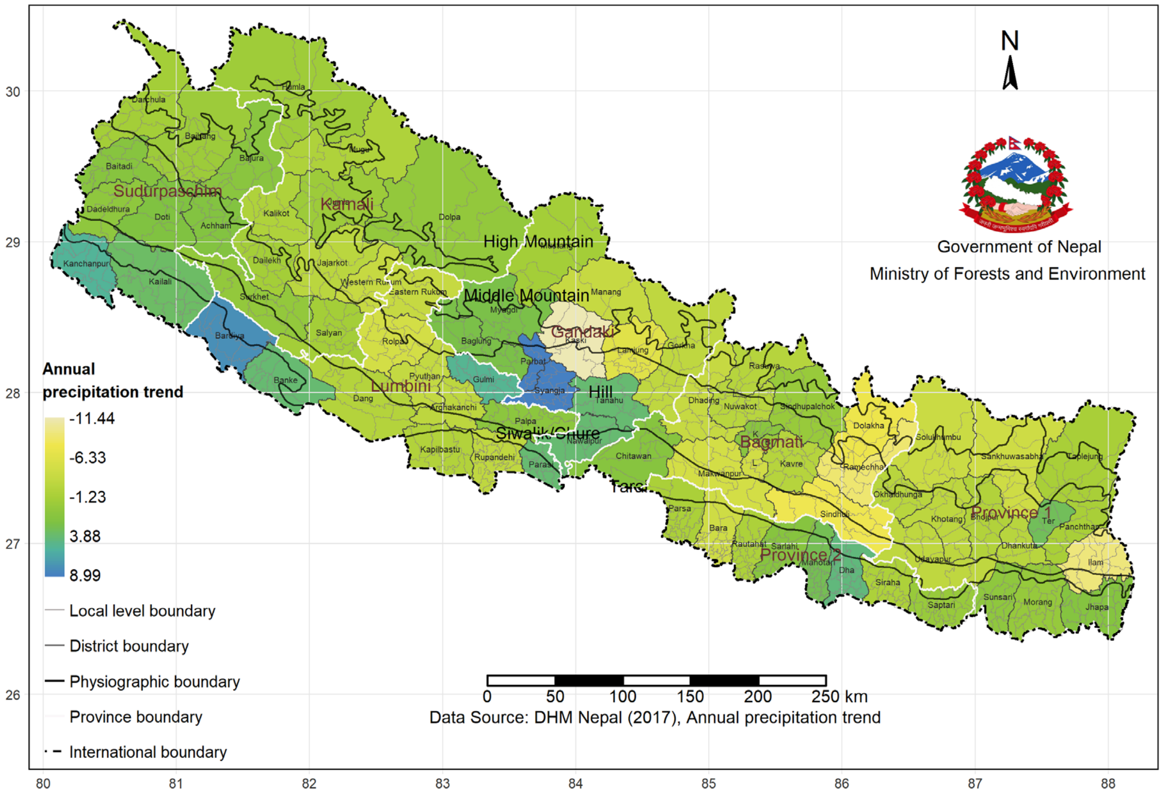

Figure 8: Annual precipitation trends in Nepal

The climate scenarios study, jointly commissioned by the Government of Nepal and ICIMOD (2019), raised grave concerns regarding accelerated climate change. The following are the major summary points of the report[4]:

4 This information on temperature and precipitation trends and scenarios is drawn from the report published by MoFE (2019).

With regards to future changes in precipitation and temperature:

- **The average annual precipitation is likely to increase in both the short-and long-term periods.** The average annual precipitation might increase by 2-6% in the medium-term (2016-2045) and by 8-12% in the long-term (2036-2065).
- **The average annual mean temperature will continue to rise in the future**. The mean temperature might increase by 0.92-1.07°C in the medium-term and 1.30-1.82°C in the long-term. Both the average annual mean temperature and the average annual precipitation will continue to climb until the end of the century. The precipitation might increase by 11-23% and the temperature might increase by 1.72-3.58°C.
- **The temperature is projected to increase for all seasons.** The highest rates of mean temperature increase are expected for the post-monsoon season (1.3-1.4°C in the medium-term and 1.8-2.4°C in the long-term) and the winter season (1.0-1.2°C in the medium-term and 1.5-2.0°C in the long-term).
- **The precipitation is projected to decrease during the pre-monsoon season.** Seasonal precipitation will increase in all seasons except the pre-monsoon season, which is likely to see a decrease of 4-5% in the medium-term. The post-monsoon season might have the highest increase in precipitation compared to the reference period, possibly going up by 6-19 % in the medium-term and 19-20 % in the long-term.

With regards to future changes related to meteorological extremes:

- Intense precipitation events (P95 and P99) are likely to increase, with extremely wet days (P99) expected to increase at a higher rate than very wet days (P95).
- Rainy days are likely to decrease in the future. The increase in precipitation intensity will coincide with the decrease in the number of rainy days.
- Consecutive dry days (CDD) may increase in the future under RCP 4.5 scenarios but may decrease under RCP 8.5.
- Consecutive wet days (CWD) may decrease in the future under RCP 4.5 scenarios but may increase under RCP 8.5. This matches the CDD trend.
- Both warm days and warm nights are likely to increase in the future. This is in conjunction with increasing temperature trends of the future.
- Both cold days and cold nights are likely to decrease in the future. This, too, is in conjunction with increasing temperature trends in the future.
- Warm spells are likely to increase in the future, as indicated by the warm spell duration index under both RCP 4.5 and RCP 8.5. This is in conjunction with increasing temperature trends and increasing warm days in the future.
- Cold spells are likely to decrease in the future, as indicated by the cold spell duration index under both RCP 4.5 and RCP 8.5. This is in conjunction with increasing temperature trends and decreasing cold days in the future.

In general, the climate throughout Nepal will be warmer and wetter in the future, except for a decrease in the duration of the pre-monsoon season. Extreme Indices related to temperature and precipitation suggest that more extreme events are likely to increase in the future. This is expected to affect livelihoods and different development sectors, such as water, energy, biodiversity, and agriculture. The country needs to prepare for these changes, design better adaptive options and implement them more sustainably (MoFE, 2019).

The Hindu Kush Himalaya Assessment Report, launched this year by ICIMOD, shows that even if global warming was limited to 1.5°C by 2100, there would be a 1.8°C rise in temperature in other parts of the world and up to 2.2°C in the mountains due to elevation-dependent warming, a phenomenon where mountains experience rapid changes with temperature rise. The report further claims that if the rising trend of global warming were unchecked, this would adversely impact the lives of not just 240 million mountain dwellers but also 1.6 billion people downstream (Wester et al., 2019).

5.2 Climate change stressors and hazards in the WASH sector

Climate stress and shocks pose a serious risk to universal access to clean water, decent sanitation, and good hygiene. It threatens to reverse progress in improving access to these essentials and push more people into extreme poverty. Droughts, floods, poor service management, weak governance, and environmental degradation all contribute to these deteriorating WASH conditions in countries like Nepal. Climate change is accelerating and amplifying these factors, increasing the unpredictability of weather patterns and making extreme weather events and natural disasters more frequent and intense. For example, the sewerage systems in Nepal's rural and urban areas are flooded with increasing frequency, contaminating water sources and the local environment. Severe droughts have already forced people to rely on alternative sources of water, which are often polluted and spread diseases.

5.2.1 Climatic stressors trend

Examination of climatic hazards in the last 49 years (1971-2019) shows an increasing trend. The trend analyses of the occurrences of 11 climatic hazards (thunderbolts, windstorms, epidemics, heavy rainfalls, landslides, floods, avalanches, hailstorms, heatwaves, cold waves, and snowstorms), shown in Figure 9 below, revealed that there was a significant increasing trend of climatic hazards, especially after 1990.

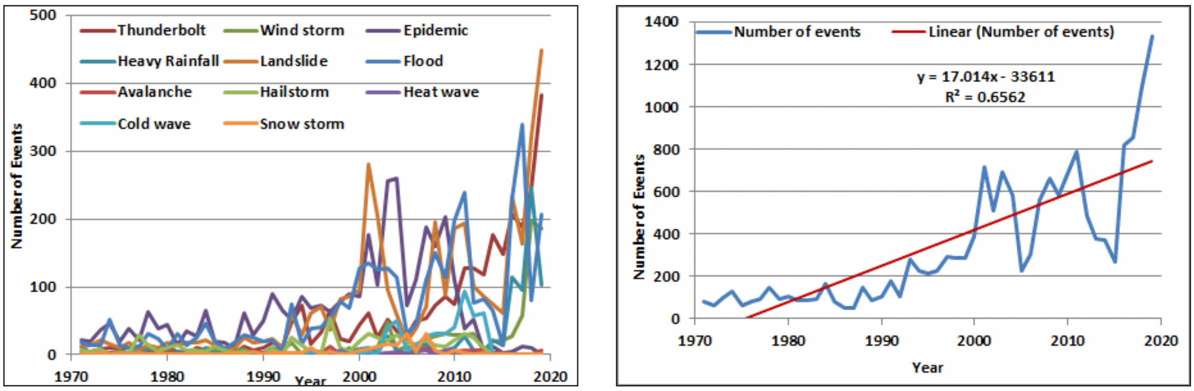

Figure 9: Trends of eleven climatic hazards in Nepal (number of events by year)

One of the hazards impacting the WASH sector is drought. Meteorological droughts are defined as events with Standardized Precipitation Index (SPI) values less than or equal to -1. For this report, the raster data of SPI from 1981 to 2019 was obtained from ICIMOD. The analysis of this data showed that the average duration of a drought was about 3.4 months (102 days) per year in Nepal. On average, about 56% of Nepal's total area was affected by drought. Figure 10 below shows the trends of drought events in drought-affected areas from 1981 to 2019. Both drought events and drought-affected areas show a decreasing, but statistically insignificant, trend.

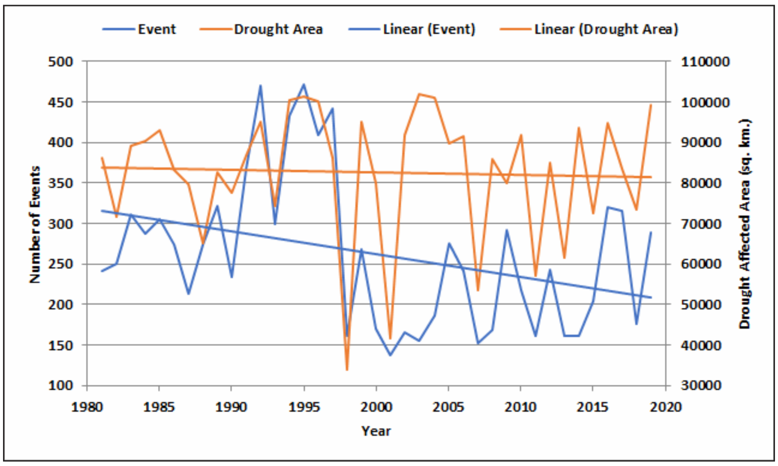

Figure 10: Trends of eleven climatic hazards in Nepal (number of events by year by drought affected area)

Floods and (rain-induced) landslides also posed serious issues in the WASH sectors of both rural and urban areas. Trend analyses revealed that Nepal had around 8% and 59% of flood-prone and landslide-prone areas respectively. In the last 49 years (1971-2019), the country suffered from 3443 flood events and 3787 landslide events.

The trend of flood events in Table 5 shows that the Terai districts—particularly Sunsari, Kailali, Morang, Jhapa, Rautahat, Bardiya, Sarlahi, and Saptari—were highly impacted by floods. In contrast, the hill and mountain districts are relatively less impacted. Different districts are classified as "Flood Hazard Hotspots" according to the level of impacts (see Figure 11). Other studies also show that, by 2030, the affected population is expected to increase by 199,000 people, and the GDP by $574 million annually, under RCP 8.5 (AQUEDUCT Scenario B). In both cases, the impact more than doubles over the 20-year reference period (World Bank Group and ADB, 2021).

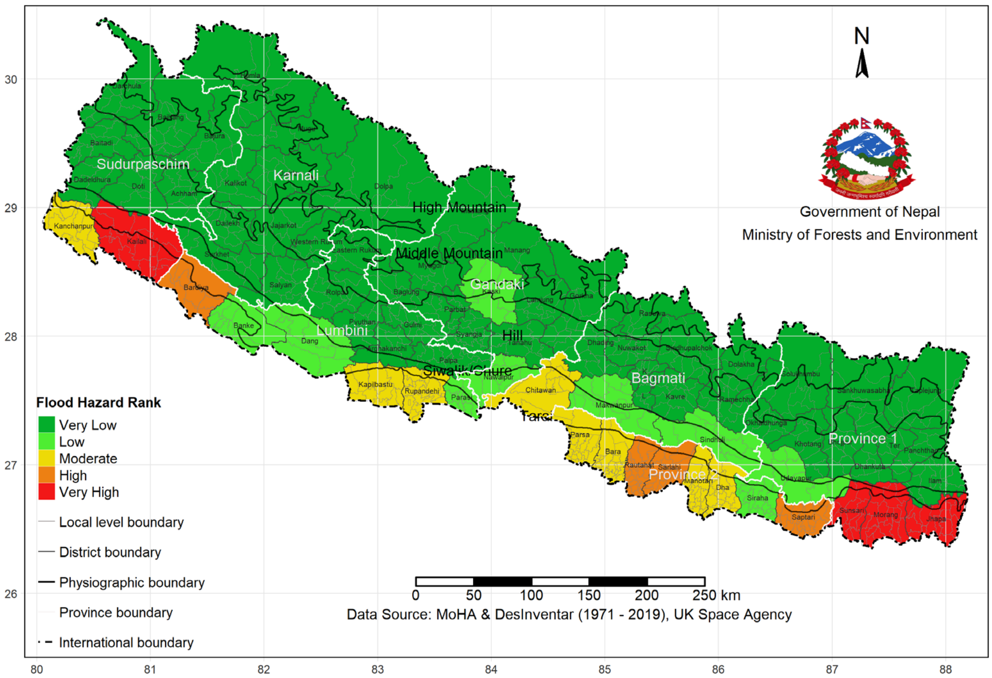

Figure 11: Flood Hazard Ranks

Table 5: District-wise ranks of flood hazard trends based on historical climate scenarios

Flood hazard rank with historical trend (1971-2019)	Districts
Very High (0.74 - 1)	Sunsari, Kailali, Morang, Jhapa
High (0.61 - 0.73)	Rautahat, Bardiya, Sarlahi, Saptari
Moderate (0.42 - 0.60)	Kapilbastu, Rupandehi, Bara, Chitawan, Dhanusha, Kanchanpur, Mahottari, Parsa
Low (0.18 - 0.41)	Makawanpur, Udayapur, Banke, Siraha, Sindhuli, Dang, Nawalpur, Kaski, Parasi
Very Low (0 - 0.17)	Dhading, Rolpa, Humla, Mugu, Rasuwa, Myagdi, Lamjung, Dolakha, Dhankuta, Terhathum, Nuwakot, Sankhuwasabha, Baglung, Western Rukum, Sindhupalchok, Gorkha, Solukhumbu, Lalitpur, Tanahu, Kavrepalanchok, Dailekh, Bhaktapur, Parbat, Pyuthan, Darchula, Syangja, Dolpa, Surkhet, Achham, Arghakhanchi, Baitadi, Palpa, Bhojpur, Salyan, Mustang, Doti, Manang, Eastern Rukum, Khotang, Okhaldhunga, Bajura, Kalikot, Taplejung, Panchthar, Jajarkot, Jumla, Bajhang, Gulmi, Ramechhap, Kathmandu, Dadeldhura, Ilam

Using a similar classification method as described above, Dhading, Sankhuwasabha, Baglung, Sindhupalchok, Dolpa, Taplejung, Rolpa, Makawanpur, Myagdi, Lamjung, Dolakha, Nuwakot, Gorkha, Solukhumbu, Kavrepalanchok, Dailekh, Darchula, Syangja, Palpa, Khotang, Bajura, Kalikot, Kaski, Jajarkot, Bajhang, Gulmi and Ilam districts were identified as "**Landslide Hazard Hotspots**" (see Figure 12).

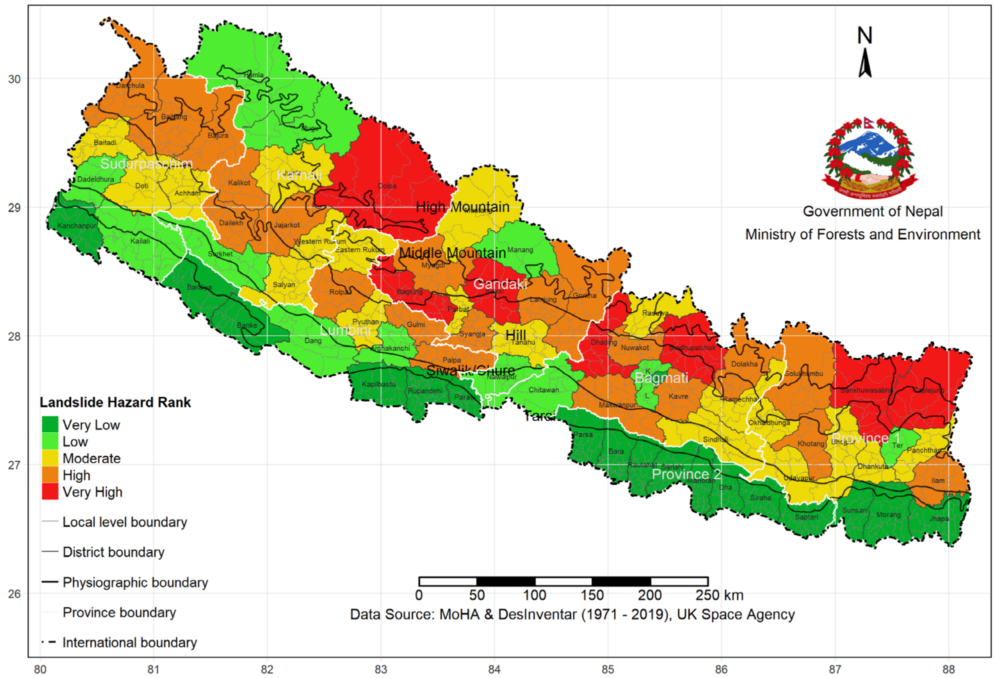

Figure 12: Landslide Hazard Rank

A province-wise comparison of 15 climatic hazard scenarios, based on the historical climate conditions, showed that Province two was the most affected by climatic hazards, followed by Province one and Gandaki Province. Similarly, a province-wide comparison of the impact of climatic hazards showed that Province two was the most impacted province, followed by Bagmati Province and Sudurpashchim Province.

Table 6 below presents the results of the Mann-Kendall test and Sen's slope for six climatic hazard events related to the WASH sector. Out of these hazards, all except drought show an increasing trend. Droughts, in contrast, show a decreasing trend. While the trends of epidemics, avalanches, hailstorms, and droughts are statistically insignificant, the trends of the other 10 hazards are significant at a 5% level.

Table 6: Mann-Kendall test statistics for linear trend of 6 climatic hazard events

Hazard	Z-statistic	P-value	Sen's Slope	Significance (5%)
Heavy rainfalls	4.53	0.00	0.25	Yes
Landslides	6.62	0.00	2.70	Yes
Floods	5.43	0.00	2.64	Yes
Heat waves	2.18	0.03	0.00	Yes
Cold waves	3.70	0.00	0.00	Yes
Droughts	-1.73	0.08	-2.39	No

IPCC's Third Assessment Report (AR-3) predicted that increasing atmospheric concentrations of greenhouse gases would result in changes in frequency, intensity, and duration of extreme events, such as morehot days, heat waves, heavy precipitation events, higher (increasing) minimum temperatures, and fewer cold days, frost days, and cold waves over nearly all land areas. In Nepal, heat waves increased in recent years in the Banke, Bara, Bardiya, Kapilbastu, Parsa, Rautahat, Rupandehi, Saptari, and Sunsari districts. These districts also witnessed an increasing trend in annual maximum temperature and warm spell duration. Additionally, many districts from the Terai region were affected by cold waves. The districts generally affected by cold waves were Mahottari, Saptari, and Rautahat. However, these districts also showed increasing trends in annual minimum temperature and a decreasing trend in cold spell duration in recent years. Hence, cold waves are expected to decrease in these districts in the future.

The recent report by the World Bank Group and Asian Development Bank (2021) on Nepal's climate risk also revealed that the current median probability of a heatwave (defined as a period of three or more days where the daily temperature is above the long-term 95th percentile of daily mean temperature) in the country is around 3%. The median estimated probability of a cold wave also sits at around 3% (defined as a period of three or more days where the daily temperature is below the long-term 5th percentile of daily mean temperature).

In this assessment, eight extreme climate event indicators were used for the WASH sector to understand the composite baseline value of the overall impact from hazards. Weightage was based on consultation with experts and reflects the importance of indicators and the degree of attributable impact (see Table 7).

Table 7: Expert weight provided to extreme climate events

Extreme events indicators	Weight
Change in Precipitation (15%)	0.15
Change in Extreme Wet Days (20%)	0.20
Change in Consecutive Dry Days (20%)	0.20
Change in Number of Rainy Days (15%)	0.15
Change in Cold Spell Duration (10%)	0.10
Change in Warm Days (10 %)	0.10
Change in temperature (10%)	0.10

The composite map (see Figure 13 below) shows that mostly the Terai region has a high value relative to the other regions. Among the provinces, it seems that Province two and Province one were highly impacted by climate-induced extreme events. Additionally, the eastern hill and mountain districts were impacted heavily The hilly districts of Bagmati Province also appear to have experienced several climate extreme events in the past.

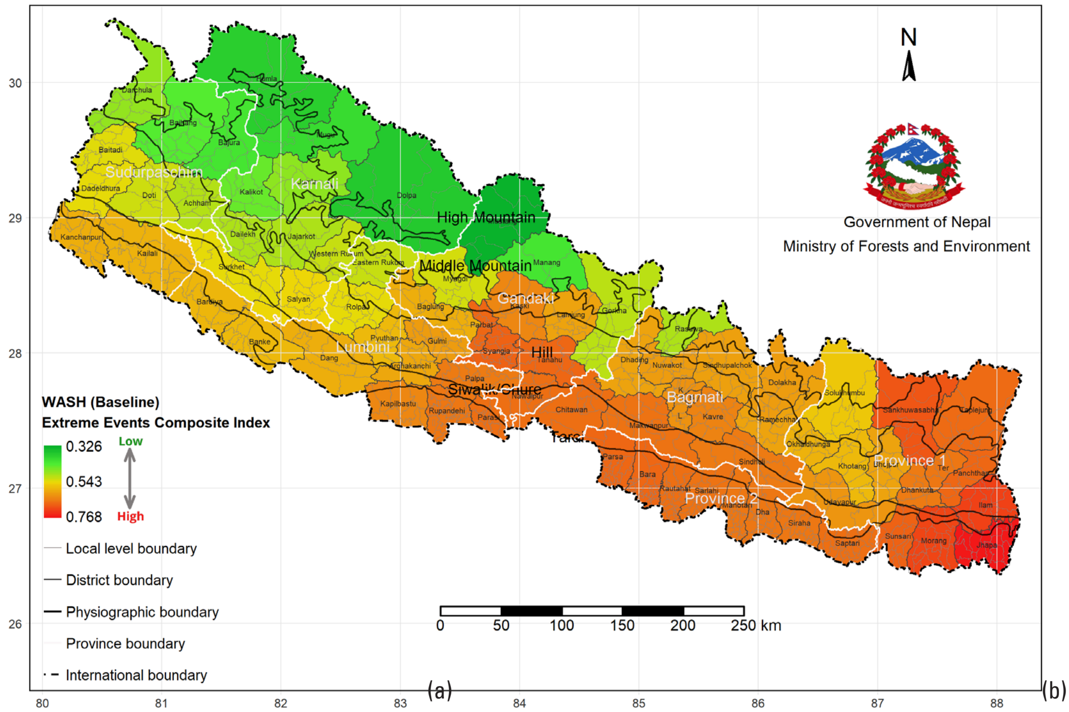

Figure 13: Extreme events composite index map (baseline)

5.2.2 Scenarios of climatic extreme events and climate-induced hazards

Climatic hazards related to the WASH sector may become more frequent, widespread, long-lasting, and/or intense under climate change. There might be multiple events at the same time across different regions, which may turn out to be catastrophic. Coupled with degrading ecosystems and biophysical processes under climate change, these hazards may create chronic stresses and catastrophic shocks. The descriptive scenarios of climatic hazards for future climate have been shown in Table 8 below.

Table 8: Descriptive scenarios of climatic hazards under future climate change

Climate hazard	Medium-term scenario	Long-term scenario
Increase in temperature	Virtually certain*	Virtually certain
Increase in precipitation	Likely	Very likely
Increase in very wet days	Likely	Very likely
Increase in extreme wet days	Very likely	Very likely
The decrease in rainy days	Very likely	Very likely
Increase in consecutive dry days	About as likely as not	About as likely as not
Increase in consecutive wet days	About as likely as not	About as likely as not
Increase in warm days and nights	Virtually certain	Virtually certain

Climate hazard	Medium-term scenario	Long-term scenario
The decrease in cold days and nights	Virtually certain	Virtually certain
Increase in warm spell duration	Virtually certain	Virtually certain
The decrease in cold spell duration	Virtually certain	Virtually certain
Increase in heat waves	Likely	Very likely
The decrease in cold waves	Likely	Very likely
Increase in heavy rainfall	Likely	Very likely
Increase in floods	Likely	Likely
Increase in landslides	Likely	Likely
Increase in droughts	About as likely as not	About as likely as not
Increase in epidemics	Likely	Likely

**Note: Virtually certain (99–100% probability); Very likely (90–100%); Likely (66–100%); About as likely as not (33–66%); Unlikely (0–33%); Very unlikely (0–10%); Exceptionally unlikely (0–1%).*

Table 8 above shows that most of the climate change hazards are likely to increase in both medium- and long-term scenarios. This means that the WASH sector will experience more severe issues and implications from climate change in the future. However, the drought scenarios show an unlikely trend in both scenarios. Out of these events, extreme wet days and rainy days are very likely to increase, indicating that there will be major issues related to drinking water and sanitation.

Extreme events related to the WASH sector were consolidated and a composite map was prepared to assess how various climate extreme indices will impact the sector. The findings show that under RCP 4.5 and RCP 8.5, the central and eastern parts of Terai, along with some parts of the hilly and mountain districts, are likely going to be more hazard-prone by 2030. In contrast, the WASH sector of Karnali Province, and Sudurpaschim Province are likely to receive less impact from climate extreme events (see Figure 14).

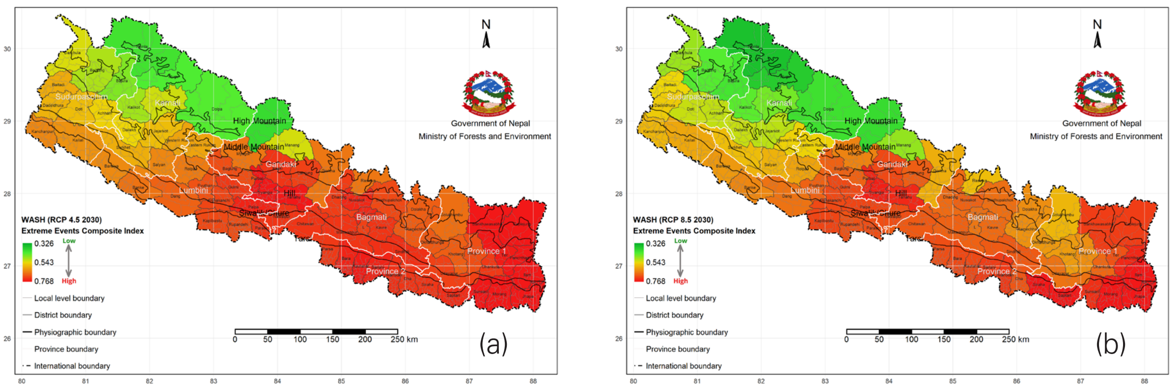

Figure 14: a) Extreme event composite index for RCP 4.5 in 2030; b) Extreme event composite index for RCP 8.5 in 2030

The findings show that, under both climate change scenarios, the extreme indices are likely to have a major impact by the year 2050 on the Terai region, Lumbini Province, Bagmati Province, Province one, and Province two, in addition to some districts of Karnali and Sudurpaschim Provinces. However, other districts in Sudurpaschim and Karnali Provinces are likely to experience some variation in terms of the impact of extreme events on the WASH sector (see Figure 15).

Consultation with stakeholders revealed that economic development and land-use changes are also likely to lead to changes in hazard patterns. Due to issues related to pavements and drainage systems, urbanization can aggravate flood problems by decreasing runoff retarding functions and accelerating flood flows. The massive expansion of urban areas could lead to increased water demand, the expansion of slum areas, solid waste management issues, and mismanagement of sewerage systems. Competition over water use can also lead to pollution of both surface and ground water, with water used for cleaning and disposal of waste entering the supply intended for consumption and environmental use. Sewage disposal into freshwater is likely to persist as a major issue in Nepal's urban areas, in addition to poor urban planning and unmanaged sewerage pipes being added to rivers as tributaries.

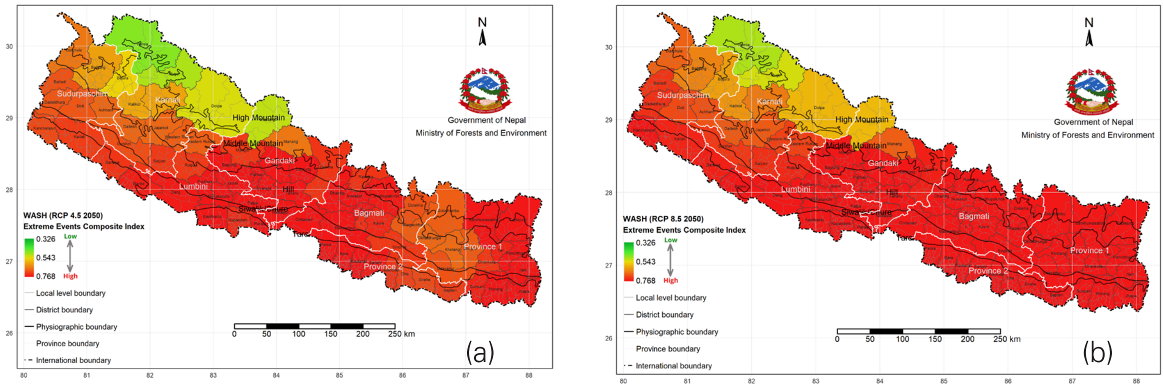

Figure 15: a) Extreme events composite index in RCP 4.5 in 2050;
b) Extreme events composite index in RCP 8.5 in 2050

These problems are likely to lead to exploitation of water resources and groundwater, and disrupt the traditional water flow systems. Additionally, the haphazard road construction in the hilly areas of Nepal and the focus of government to expand the road networks are expected to lead to more landslides and land degradation. Heavy monsoon events might cause landslides, and thus damage the water supply infrastructure in the mountainous regions of the country.

5.3 Climate change exposure in the WASH sector

Climate change impacts are intrinsically connected with public health impacts. For example, a decline in the availability of water supplies (e.g., dry boreholes), may force people to drink contaminated water (e.g., untreated surface water), leading to an increase in waterborne diseases. The pollution of wells and flooding of latrines also increase the risk of a higher incidence of infectious diseases. Communities residing in both rural and urban areas of Nepal have been exposed to several climate-induced hazards and extreme events. Floods, landslides, droughts, intense rainfall, heat waves, cold waves, warm days, warm nights, and wildfires are major hazards related to the WASH sector that stress and damage access to drinking water and sanitation services, which are essential elements for the health and hygiene of communities. A reduction in water availability makes hygiene practices more challenging and behavioural change campaigns might not be effective in areas where access to water is increasingly constrained by the changing climate.

Moreover, the poorest and most marginalized people are likely to bear a disproportionate burden of climate change impacts when accessing safe water as a result of their relatively high levels of exposure to hazards and diminished capacity to respond. All of these impacts will result in higher costs for delivering and maintaining climate-resilient services.

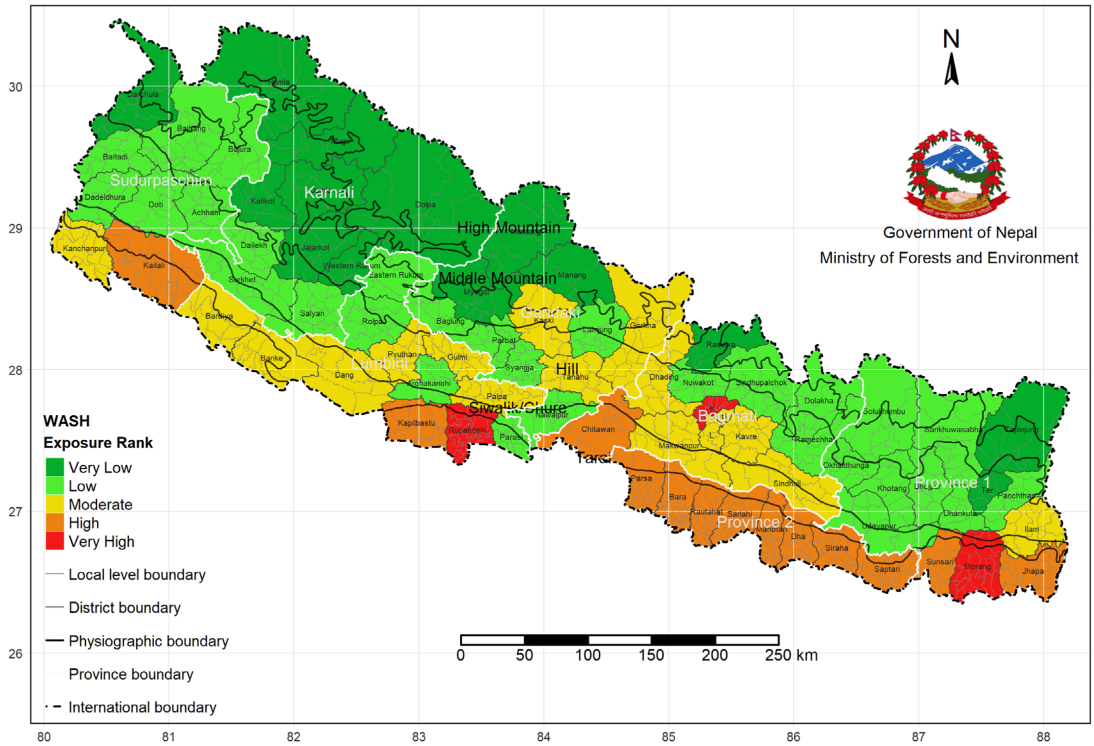

Figure 16: Map of exposure rank of Nepal

The assessment of exposure in this sector included indicators such as population variables (male and female) and WASH-related services and infrastructure. The findings show that among Nepal's districts, Rupandehi, Morang, and Kathmandu have 'very high exposure' to climate-induced hazards due to population concentration and the number and availability of WASH services and infrastructure. Districts with 'high exposure' are Kapilbastu, Sunsari, Rautahat, Kailali, Siraha, Bara, Chitawan, Dhanusha, Jhapa, Sarlahi, Mahottari, Parsa, and Saptari (see Figure 16).

A total of 30 districts were found to have 'low exposure' to climate-induced hazards. The districts with 'very low exposure' are Humla, Mugu, Rasuwa, Myagdi, Terhathum, Western Rukum, Darchula, Dolpa, Mustang, Manang, Kalikot, Taplejung, Jajarkot, and Jumla. The majority of these districts fall in Karnali. This low level of exposure may be due to population size and the number and concentration of infrastructure. Most mountainous districts also fall into this category. Further, 17 districts—mostly in the hilly districts of all the provinces (except a few mountain districts)—are in the'moderate exposure' category (see Table 9).

Out of the provinces, Bagmati Province has 'moderate' to 'low exposure' to climate stressors except for Kathmandu and Chitwan. In Gandaki Province, the districts of Kaski, Gorkha, and Tanahu fall into the 'moderate' category, while most other districts fall into the 'low exposure' category. Additionally, Manang, Mustang, and Myagdi fall into the 'very low exposure category'.

Several factors contribute to the difference in exposure of different districts of Gandaki Province, with population size and infrastructure being the major factors.

Exposure in Province one is highly varied. The Morang districts have 'very high exposure', Sunsari and Jhapa have 'high exposure', Ilam has 'moderate exposure', and the rest of the districts have 'low' to 'very low exposure'. The Terathum and Taplejung districts have 'very low exposure' as well. Again, population size has played a major role in shaping the varying exposure levels of Province One's districts.

In the majority of the districts in Terai, exposure ranged from 'high' to 'very high', including in the Kathmandu valley. Interestingly, all the districts of Province two have 'high exposure' to climate stressors. In Terai, the majority of hand pumps and water supply schemes are flooded due to their functionality being altered (reduced). Additionally, the sanitation services there are flooded, causing the water infrastructure to be easily contaminated with fecal matter. This information reflects the reality of the field. The vice-chair of Janakinandan municipality stated that "flooding is a major burden of ours that causes massive damage to water and sanitation infrastructure during the monsoon and exposes the poorest households and communities". Likewise, the Mushar communities in the Janakinandan municipality, located near the border with India, have poor sanitation and hygiene problems that are even more aggravated during the monsoon season.

Table 9: Exposure rank of districts for the drinking water and sanitation sector

Exposure Rank	District
Very High (0.683 - 1)	Rupandehi, Morang, Kathmandu
High (0.465 - 0.682)	Kapilbastu, Sunsari, Rautahat, Kailali, Siraha, Bara, Chitawan, Dhanusha, Jhapa, Sarlahi, Mahottari, Parsa, Saptari
Moderate (0.315 - 0.464)	Dhading, Makawanpur, Bardiya, Gorkha, Lalitpur, Tanahu, Kavrepalanchok, Bhaktapur, Pyuthan, Banke, Palpa, Sindhuli, Dang, Kaski, Kanchanpur, Gulmi, Ilam
Low (0.147 -0.314)	Rolpa, Lamjung, Dolakha, Dhankuta, Nuwakot, Sankhuwasabha, Baglung, Sindhupalchok, Solukhumbu, Dailekh, Udayapur, Parbat, Syangja, Surkhet, Achham, Arghakhanchi, Baitadi, Bhojpur, Salyan, Doti, Eastern Rukum, Khotang, Okhaldhunga, Bajura, Nawalpur, Panchthar, Parasi, Bajhang, Ramechhap, Dadeldhura
Very low (0.006 - 0.146)	Humla, Mugu, Rasuwa, Myagdi, Terhathum, Western Rukum, Darchula, Dolpa, Mustang, Manang, Kalikot, Taplejung, Jajarkot, Jumla

Although the exposure level of most of the mid-hill districts except Kathmandu is 'moderate', some of the water schemes and infrastructures are exposed to flash floods and landslides. These hazards damage the gravity flow water supply schemes; sometimes the entire schemes are washed away. Also due to landslides and temperature fluctuations, the pipelines either burst or get damaged.

Climate Change Vulnerability in the WASH Sector

6.1 Sensitivity

Vulnerability in the WASH sector is directly related to the sensitivity of the exposed population, resources, services, and their capacity to respond to climate change impact. Sensitivity indicators generally include population characteristics and features, infrastructure locations and conditions, access to and quality of services, and population dynamics, including socioeconomic differences. The key indicators used for measuring sensitivity in this assessment were water-borne diseases—such as child diarrhoea, amoebic dysentery, bacillus dysentery, and pseudomonas diarrhoea—and malnutrition. Household members without drinking water on premises, time taken to fetch water, number of females and children involved in fetching water, water contamination with E. coli at source and household level, and overall functionality of drinking water supply schemes were used for measuring sensitivity of the drinking water component. The number of households throwing their children's faeces into the garbage was chosen to be the indicator for sanitation. Additionally, the number of people with no access to handwashing stations was taken as an indicator for measuring sensitivity to hygiene.

As Figure 17 shows, there are only 17 wastewater treatment plants in Nepal, three of which are non-operational and six are partially operational. Therefore, there is already a huge shortage of wastewater treatment plants. Out of those available, ones that are either non-functional or partially operational increase the risk of sensitivity.

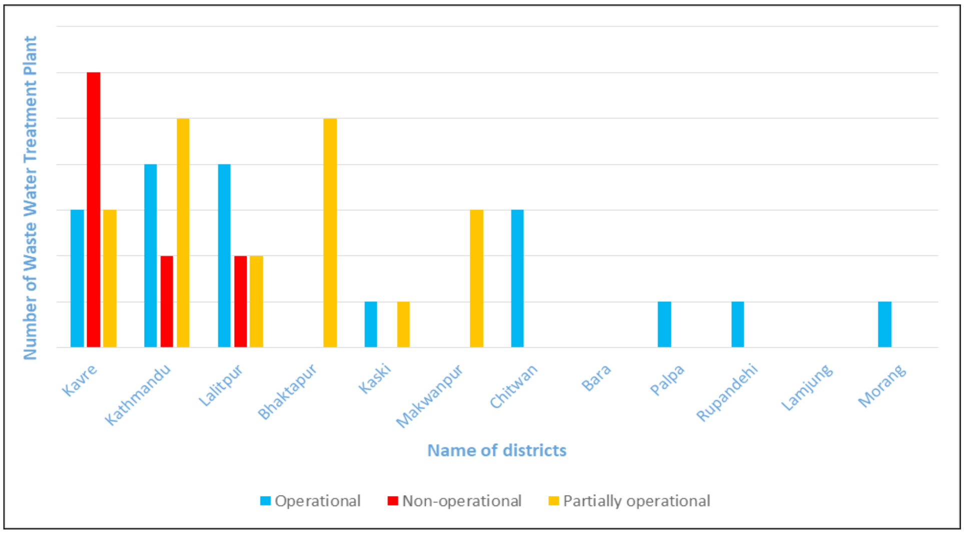

Figure 17: Functionality status of Wastewater Treatment Plants in Nepal

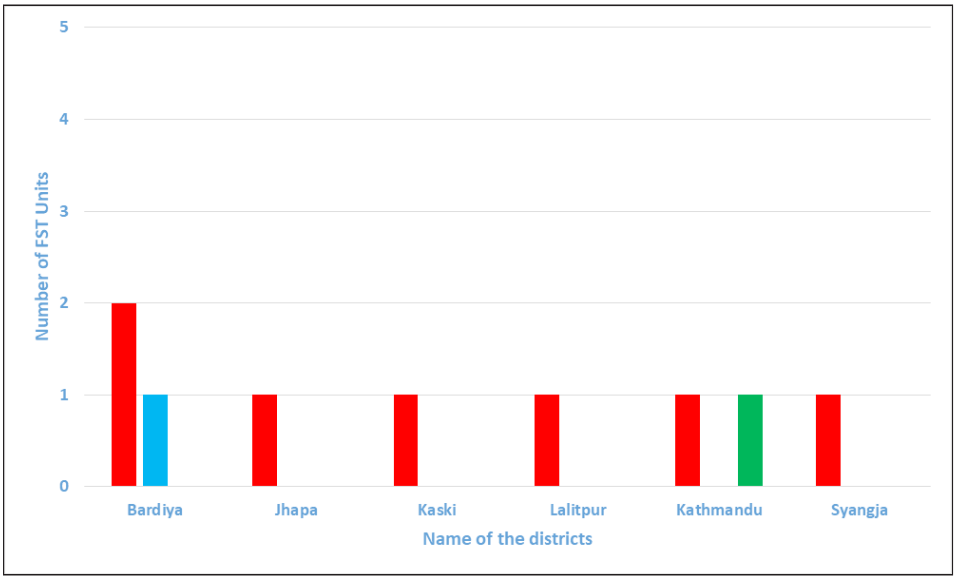

Figure 18: Functionality status of fecal sludge treatment units in Nepal

Overall, there are only five functional fecal sludge treatment units in Nepal. The country is way behind in terms of safely managing sanitation services (see Figure 18).

Based on the findings of this assessment, it is evident that the Karnali Province and Sudurpaschim Province are more sensitive to climate-induced disasters than the rest, except for Darchula. Multiple factors add to the sensitivity of these two provinces, including population exposure to climatic hazards, water supply and sanitation services being in need of major repair or rehabilitation, lack of access to local markets and the traditional way of promoting WASH. Additionally, climate-induced hazards are contributing to the non-functionality of water supply systems (see Figure 19).

In Province one, Morang falls in the 'very high sensitivity' districts, while Panchthar, Ilam, Sunsari, and Khotang fall in 'high sensitivity' districts. Okhaldhunga, Udaypur, and Dhankuta fall in the 'low sensitivity' category, while the rest of the districts of Province one fall in the 'moderate sensitivity'. In Gandaki, all districts fall in the 'moderate to low sensitivity' category, except Nawalpur and Gorkha which fall in the 'high sensitivity'. In Lumbini Province, Rupandeshi falls in the 'very high sensitivity' districts while Gulmi, Arghakhanchi, Rolpa, Banke, Dang, Kapilbastu, and Parasi fall in the 'high sensitivity' category. The remaining districts in Lumbini Province fall under 'moderate sensitivity'.

Out of the 13 districts in Bagmati Province, the districts of Dhading, Nuwakot, Rasuwa, Sindhupalchock, Dolakha, Ramachhep, and Sindhuli fall into the 'high sensitivity' category. The remaining six districts fall into 'low' and 'very low sensitivity'. The major indicators influencing the sensitivity level to be 'moderate', particularly in Province two were the water fetching time spent by women and children, and the number of water supply schemes requiring major repair and rehabilitation. Climate-induced hazards such as drought increase the number of households without drinking water on premises as well as the severity of this problem. For a summary of the sensitivity categories of different districts, please see Table 11.

Gender and socio-structural factors also contribute to increased sensitivity among certain groups. Consultations at the local level revealed that due to the drying up of water sources in Karnali Province, water has to be fetched from far away. This fetching is primarily the task of either women or children, making them subject to violence, conflict, and health issues (e.g., uterine prolapse in women).

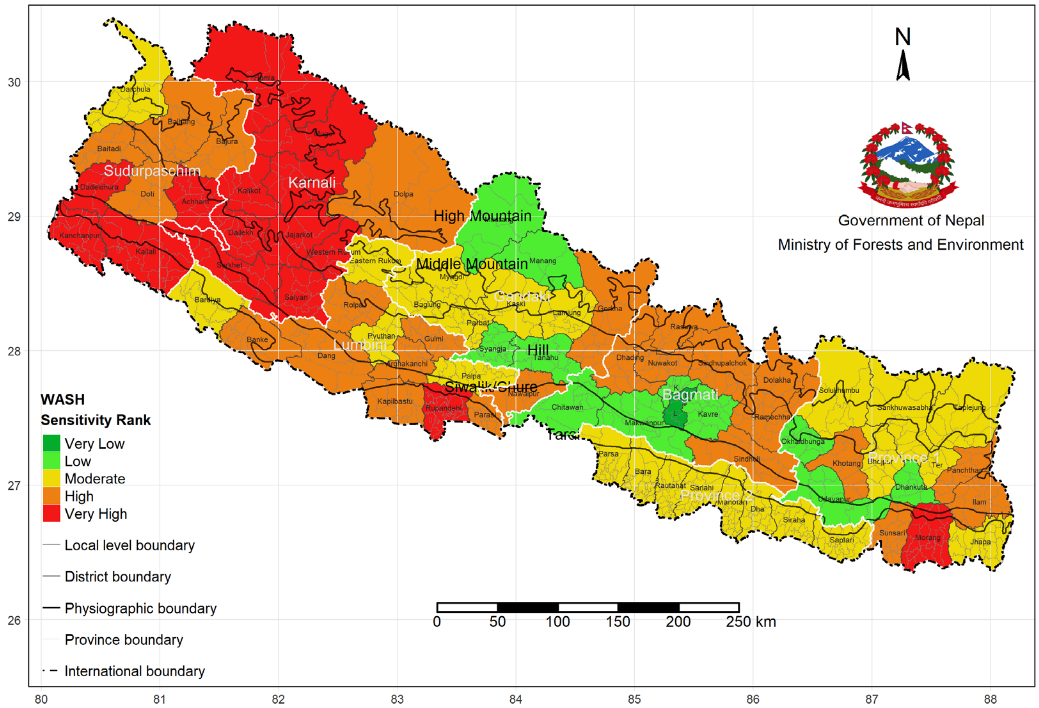

Figure 19: Map of sensitivity rank of Nepal

For groups who are poor and do not have access to drinking water sources, fetching water from far away is the only option. In such situations, people are more likely to use unimproved sources and therefore be at greater risk of diarrhoeal diseases. Additionally, certain groups are more susceptible to these diseases than others, such as children under age five, the elderly, those living with HIV, and pregnant and lactating mothers. Table 10 below shows the number of cases of waterborne diseases among children under the age of five in Karnali and Sudurpaschim Provinces. Also, mothers and caregivers who spend considerable time fetching water have less time to provide adequate care for their children. Furthermore, people who are dependent on care services in these families become more susceptible to water-borne/water-scarce diseases and compromised hygiene behaviours.

The subpopulation of children under five who are re-exposed to diarrhoeal diseases suffer from a compromised ability to absorb micronutrients essential for their physical and mental development. Essentially, repeated exposure to diarrheal diseases leads to malnutrition.

Table 10: Number of cases of water-related diseases among under-five children

Province	Children diarrhoea incidence/1000	Amoebic dysentery	Bacillus dysentery	Pseudomonas diarrhoea	Cholera	Malnutrition
Karnali	697.4	31849	17760	46794	1338	2107
Sudur- paschim	659.8	38455	19612	61494	1112	3035

In the case of Province one, Sudurpaschim, Karnali, Gandaki, Lumbini, and Bagmati Provinces, climate change has caused the depletion of surface water sources in the mountainous regions and of groundwater sources in the urban and Terai regions. This depletion affects water supply and sanitary systems, hygiene facilities, and ultimately the health of vulnerable individuals and communities.

Also, the degree of accessibility to WASH related services and infrastructure determines the level of sensitivity experienced by certain groups. For example, due to a lack of such accessibility, the population of Karnali and Sudurpaschim Provinces is sensitive. Existing disease prevalence patterns are also another factor leading to increased susceptibility of groups with compromised health to climate stressors such as high temperatures. This is particularly the case for the majority of the districts in Province two.

WASH infrastructure in Nepal is frequently exposed to hazards such as floods, landslides, and extreme temperatures. The age of the infrastructure and its status of repair and maintenance determine its level of sensitivity. In Karnali Province, due to frequent localized climate-induced hazards such as landslides, rock falls, and the drying out of water sources, there is significant damage to water schemes and hygiene facilities, which then require heavy maintenance and repair. Additionally, due to the geographical remoteness of Karnali Province and its lack of access to local markets, the water supply schemes there have been unable to be repaired, replaced, or maintained on time. This leads to non-functionality of water supply schemes and sanitation services, which in turn directly leads to biological and physical contamination of drinking water.

Table 11: Sensitivity rank of districts for the drinking water and sanitation sector

Sensitivity Rank	District
Very High (0.857 - 1)	Humla, Mugu, Western Rukum, Dailekh, Kailali, Surkhet, Achham, Rupandehi, Salyan, Morang, Kalikot, Kanchanpur, Jajarkot, Jumla, Dadeldhura
High (0.748 - 0.856)	Dhading, Rolpa, Kapilbastu, Rasuwa, Sunsari, Dolakha, Nuwakot, Sindhupalchok, Gorkha, Banke, Dolpa, Arghakhanchi, Baitadi, Sindhuli, Doti, Khotang, Bajura, Dang, Nawalpur, Panchthar, Parasi, Bajhang, Gulmi, Ramechhap, Ilam
Moderate (0.651 - 0.747)	Myagdi, Lamjung, Terhathum, Sankhuwasabha, Rautahat, Baglung, Bardiya, Solukhumbu, Parbat, Pyuthan, Darchula, Siraha, Palpa, Bhojpur, Bara, Eastern Rukum, Dhanusha, Kaski, Taplejung, Jhapa, Sarlahi, Mahottari, Parsa, Saptari
Low (0.384 - 0.650)	Makawanpur, Dhankuta, Tanahu, Kavrepalanchok, Udayapur, Syangja, Mustang, Manang, Okhaldhunga, Chitawan, Kathmandu
Very Low (0.238 - 0.383)	Lalitpur, Bhaktapur

6.2 The adaptive capacity of the sector

Adaptive capacity includes existing capacity in terms of human resources, national and international investments in emergency response and preparedness, policies and institutions, technological advances, early warning systems, hazard monitoring, and technological practices, as well as the socio-economic capability of the population in terms of their ability to access and benefit from services. The adaptive capacity indicators are mostly based on the concept of Financial, Institutional Environment, Technological, and Social Sustainability (FIETS).

In this assessment, key indicators used to measure adaptive capacity in the drinking water sector were households having access to safe drinking water on premises and free from any chemical or bacterial contamination, private taps, and hand-pumps. Additional indicators included: protected springs and wells, water purified before drinking, and the functional status of drinking water schemes. In the case of sanitation, the indicators included: people having access to improved sanitation facilities, safe disposal of excreta, and access to handwashing facilities where water and soap are present.

During the water-scarce seasons, access to alternative sources of water, such as rainwater harvesting, contributes to building the adaptive capacity of households and the local population to cope with the adverse impact of climate change. This is particularly true of the impact due to scarcity of water and water source contamination. Functionality and sustainability of drinking water schemes also contribute to building adaptive capacity. These are assured by water supply schemes with operation and maintenance guidelines. Well-functioning water supply schemes help ensure a regular and safe supply of drinking water for the local population.

Furthermore, the functionality and sustainability of WASH infrastructures are ensured by the ownership of local users, user committees' and service providers' capacity to manage the water supply schemes, transparent operation and maintenance funds regulated by water user committees, standby maintenance workers for water supply schemes, local-level availability of construction materials such as tools and spare materials, and road access to the water supply schemes for any repair and maintenance. When the governance of water supply schemes is robust, regular and quality drinking water and sanitation services are ensured even during times of climatic stress such as floods, landslides, droughts, and water shortages. Altogether, this ensures the adaptive capacity of households and communities.

Figure 20 and Table 13 show that Lalitpur, Tanahu, Kavrepalanchok, Bhaktapur, Gulmi, and Kathmandu districts fall into the'very high adaptive capacity' category. In contrast, districts, namely Humla, Mugu, Rasuwa, Western Rukum, Dolpa, Surkhet, Achham, Doti, Bajura, Kalikot, Kanchanpur, Jumla, Mahottari, and Bajhang fall under'very low adaptive capacity'. The main indicator for differentiating between the levels of adaptive capacity was the number of households having access to private taps and hand pumps. Only 35.9 percent of the population has access to safe water in Karnali5 and 59 percent of children under five suffer from malnutrition. Due to a lack of access to safe drinking water in Karnali and Sudurpaschim provinces, these provinces have the highest number of cases of water-borne diseases in children under the age of five. Furthermore, the average life expectancy in Karnali is 67 years, the lowest of all provinces. Furthermore, the literacy rate is 62 percent, 51.2 percent of people are multi-dimensionally poor

5 http://kppc.karnali.gov.np/noticefile/PPC_SDG%20Baseline%20Report%20-%20Karnali%20(1)_1601631613.pdf

and the Human Development Index (HDI) in this region is 0.427, which is below the national average of 0.49 and plays a role in having low adaptive capacity.

In Gandaki Province, the adaptive capacity is different from one district to another. Among its districts, Mustang, Manang, Myagdi, and Nawalpur fall into the 'low adaptive capacity' category, while Tanahu falls under 'high adaptive capacity'. In Province one, the Taplejung districts have 'low adaptive capacity' but the rest of the districts have'moderate' to 'high adaptive capacity'. In Bagmati Province, Rasuwa has a'very low adaptive capacity', while Dolakha, Sindhupalchok, Sindhuli, and Ramechhap have a 'low adaptive capacity'. The districts in the Kathmandu Valley (Kathmandu, Lalitpur, and Bhaktapur), and the Kavrepalanchok district have a'very high adaptive capacity'. The Lumbini Province has a mixed distribution in terms of adaptive capacity categories, of which Parasi is a 'low adaptive capacity' district.

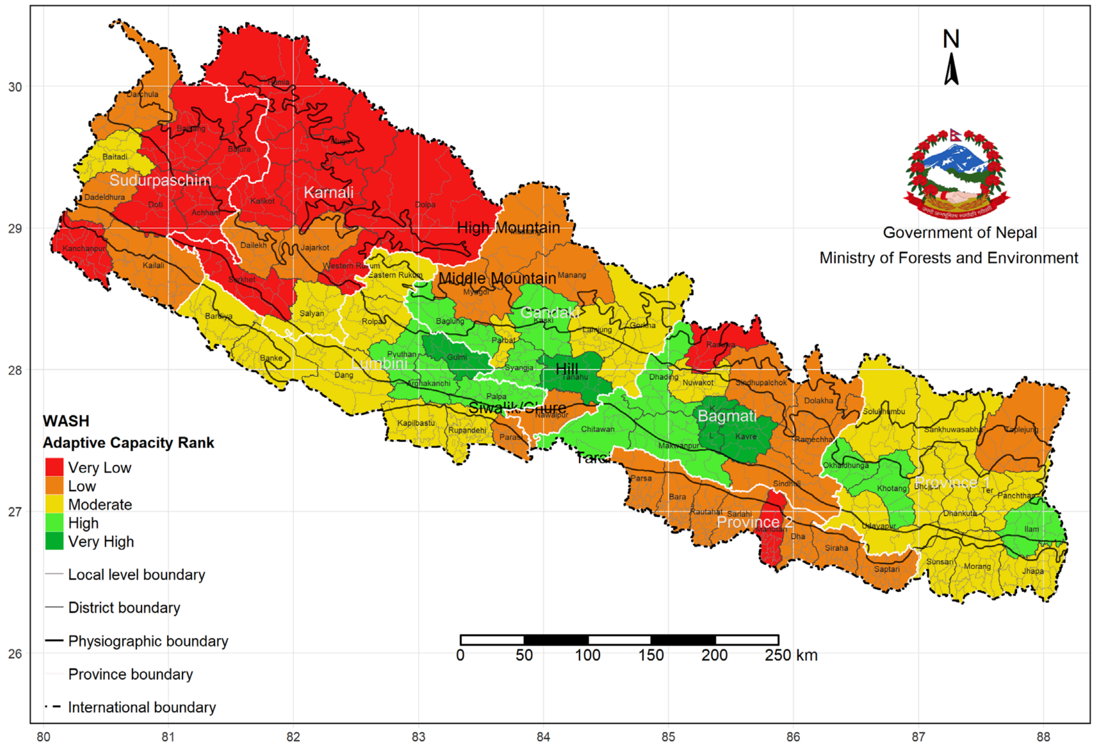

Figure 20: Map of adaptive capacity rank of Nepal

Baitadi falls under the'moderate adaptive capacity' category, while its neighbouring districts mostly have 'high' or'very high adaptive capacity'. Baitadi has 129 rainwater harvestings, while Bajhang has only eight and Doti has no rainwater harvesting at all. Furthermore, Baitadi has 379 well-functioning water supply schemes, whereas Bajhang has 171 and Doti has only 96. Similarly, Baitadi has 178 schemes that have operation and maintenance funds, whereas Bajhang has 171 and Doti has only 20.

As shown in Table 12 below, Karnali Province, Sudurpaschim Province, and Province two fall under'very low adaptive capacity' because of their limited access to drinking water and sanitation. Furthermore, governance in their WASH sector seems to be very poor because they have some of the lowest functioning water supply schemes in the country. Additionally, female representation in WSUCs is limited. The females who are in these committees are unable to make meaningful contributions, which directly affects the good governance capacities of these WSUCs. Figure 21 shows the district-wise female representation in WSUCs.

Table 12: Indicators that influence the Adaptive Capacity of Karnali Province, Province two, and Sudurpaschim Province

Province	HH with private taps and hand pumps	Protected springs and wells	Rainwater harvesting	Scheme with WUSC registered	Scheme with WSST	Schemes with tools	Schemes with O/M fund	Well-Functioning Schemes
Karnali	30102	8254	412	1346	1386	1287	296	993
Province two	413291	2024	102	146	141	140	46	113
Sudurpaschim	670825	14762	3235	7844	5817	6234	1181	5060

Rasuwa has only 201 households with private taps, while Nuwakot has 1667 household taps and 41 hand pumps. In Nuwakot, 106 springs are preserved and protected, while Rasuwa has only 54 of the same. Nuwakot has 399 well-functioning schemes, whereas Rasuwa has only 38.

Consultations at the provincial and local levels revealed that people with access to improved sanitation facilities and households practicing safe disposal of excreta or child faeces are more resilient to climatic stresses and shocks. It was shared that in Bagmati and Gandki Provinces, improved access to hand washing facilities where water and soap are present led to improved hygiene behaviours in households and communities—in particular, in children, pregnant and lactating women, the elderly, and people living with disease and disability. This encouraged households to practice hygienic behaviour even during a disaster or crisis.

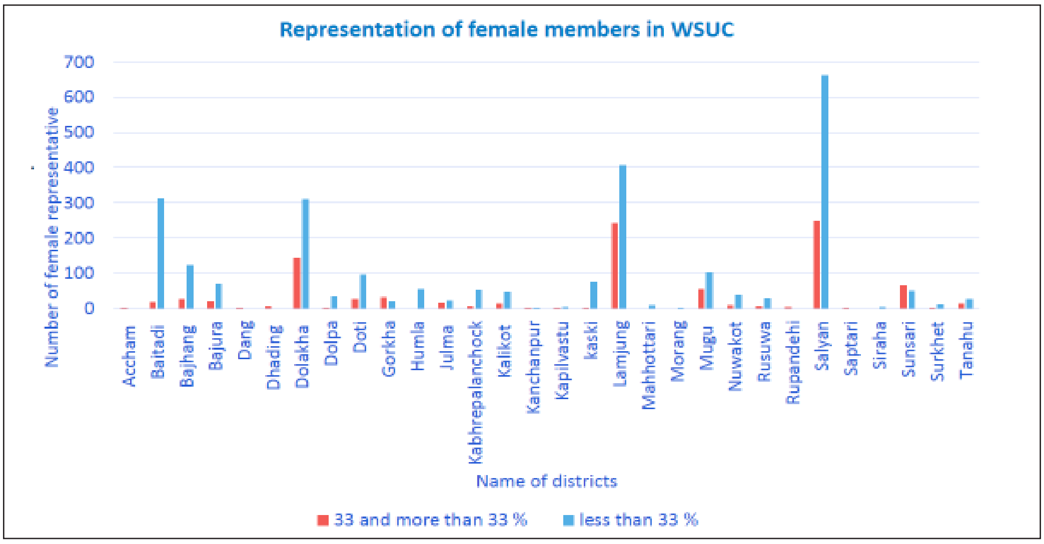

Figure 21: Representation of female members in WSUCs

Province two appears to have 'low' to'very low adaptive capacity'. Overall, only 113 water supply schemes are functioning in the province, which has 146 registered WSUCs and has 46 operation and maintenance funds. All the rivers of Nepal exit into the Terai plains, which causes flooding and inundation in several areas during the monsoon. These problems of flooding and inundation in the Terai are even more critical due to climate change in general and changes in rainfall patterns and intensity in particular. During floods, water supply schemes are directly affected. Since most of the districts in the Terai and Province Two suffer from lack of timely operation and maintenance, and insufficient funds, their communities are unable to bounce back post-disaster.

Table 13: Adaptive Capacity rank of districts for the drinking water and sanitation sector

Adaptive Capacity Rank	District
Very High (0.708 - 1)	Lalitpur, Tanahu, Kavrepalanchok, Bhaktapur, Gulmi, Kathmandu
High (0.582 - 0.707)	Dhading, Makawanpur, Baglung, Pyuthan, Syangja, Arghakhanchi, Palpa, Khotang, Okhaldhunga, Chitawan, Kaski, Ilam
Moderate (0.454 - 0.581)	Rolpa, Kapilbastu, Lamjung, Sunsari, Dhankuta, Terhathum, Nuwakot, Sankhuwasabha, Bardiya, Gorkha, Solukhumbu, Udayapur, Parbat, Banke, Baitadi, Rupandehi, Bhojpur, Salyan, Morang, Eastern Rukum, Dang, Panchthar, Jhapa
Low (0.331 - 0.453)	Myagdi, Dolakha, Rautahat, Sindhupalchok, Dailekh, Darchula, Kailali, Siraha, Sindhuli, Mustang, Bara, Manang, Dhanusha, Nawalpur, Taplejung, Jajarkot, Sarlahi, Parasi, Parsa, Ramechhap, Saptari, Dadeldhura
Very Low (0.213 - 0.330)	Humla, Mugu, Rasuwa, Western Rukum, Dolpa, Surkhet, Achham, Doti, Bajura, Kalikot, Kanchanpur, Jumla, Mahottari, Bajhang

6.3 Vulnerability in the sector

Vulnerability in this assessment is defined as the propensity or predisposition to be adversely affected. This term encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. This section presents the vulnerability index as a relative measure that results from the difference between the sensitivity and adaptive capacity of the drinking water and sanitation sector in different districts, as shown in Figure 22 and Table 14.

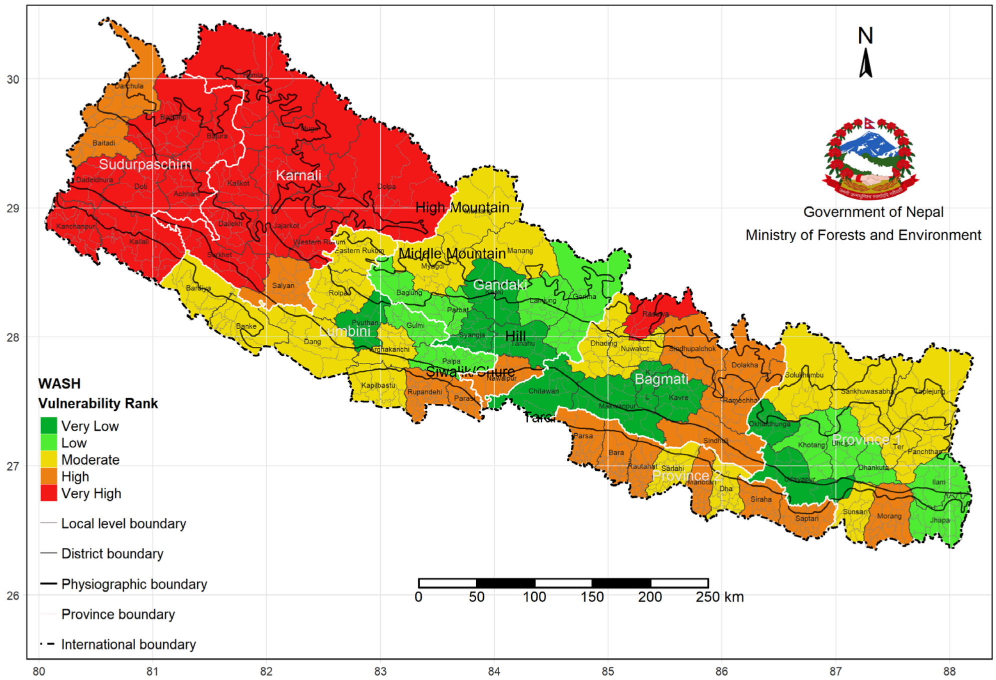

Figure 22: Map of Vulnerability rank of Nepal

The findings of the assessment revealed that among Nepal's provinces, Karnali Province is highly vulnerable because of its' high sensitivity 'and' low adaptive capacity'. The majority of the districts in Sudurpaschim Province fall into the 'high vulnerability' category, with the exception of Baitadi and Darchula, which fall into the 'high vulnerability' category. Additionally, Dolakha, Rautahat, Sindhupalchok, Darchula, Siraha, Baitadi, Rupandehi, Sindhuli, Salyan, Morang, Bara, Nawalpur, Mahottari, Parasi, Parsa, Ramechhap, and Saptari districts also fall into the 'high vulnerability' category. In the hilly and mountainous areas of the far and mid-western regions of Nepal, water scarcity is often a problem. The western regions receive the lowest amount of rainfall in the country, which leads to water scarcity, especially in the dry season. Often, water has to be fetched from far away, and this consumes a great deal of women's time, since they are the ones who are traditionally given the task. In the assessment, the key indicators of sensitivity (time taken to fetch water being more than three hours) and adaptive capacity (well-functioning schemes with good operation and maintenance) highly influenced the differences in the vulnerability ranks of different districts.

Makawanpur, Lalitpur, Tanahu, Kavrepalanchok, Udayapur, Bhaktapur, Pyuthan, Syangja, Okhaldhunga, Chitawan, Kaski, and Kathmandu have'very low vulnerability' because of their low sensitivity and higher adaptive capacity. The major indicators that influenced adaptive capacity in these districts are: having adopted alternative water storage options during dry seasons, such as rainwater harvesting; households with access to taps and hand pumps in their private space; a large number of well-functioning water supply schemes; and good operation and maintenance systems in place. These districts also have a lower burden of water-related diseases.

Table 14: Vulnerability rank of districts for the drinking water and sanitation sector

Vulnerability Rank	District
Very High (0.634 - 1)	Humla, Mugu, Rasuwa, Western Rukum, Dailekh, Dolpa, Kailali, Surkhet, Achham, Doti, Bajura, Kalikot, Kanchanpur, Jajarkot, Jumla, Bajhang, Dadeldhura
High (0.428 - 0.633)	Dolakha, Rautahat, Sindhupalchok, Darchula, Siraha, Baitadi, Rupandehi, Sindhuli, Salyan, Morang, Bara, Nawalpur, Mahottari, Parasi, Parsa, Ramechhap, Saptari
Moderate (0.292 - 0.427)	Dhading, Rolpa, Kapilbastu, Myagdi, Sunsari, Terhathum, Nuwakot, Sankhuwasabha, Bardiya, Solukhumbu, Banke, Arghakhanchi, Mustang, Manang, Eastern Rukum, Dhanusha, Dang, Taplejung, Panchthar, Sarlahi
Low (0.042 - 0.291)	Lamjung, Dhankuta, Baglung, Gorkha, Parbat, Palpa, Bhojpur, Khotang, Jhapa, Gulmi, Ilam
Very Low (0 - 0.041)	Makawanpur, Lalitpur, Tanahu, Kavrepalanchok, Udayapur, Bhaktapur, Pyuthan, Syangja, Okhaldhunga, Chitawan, Kaski, Kathmandu

In hilly areas, the availability of drinkable water is dependent on springs, from where it is transported via pipes to lower belts by a gravity flow system. Different kinds of hazards affect the delivery of safe and sustainable drinking water. The quality and functionality of the services can easily be compromised by human and natural causes. Due to lack of access and lack of regular maintenance, the majority of drinking water schemes are non-functional in the hilly areas, particularly in Karnali and Sudurpaschim Provinces. This makes these two provinces more vulnerable.

Open defecation has also been a major concern for Karnali and Sudurpaschim Provinces. Fecal contamination of water is common in the area, causing various water-related health problems. Even though ODF is achieved to some degree, traditional beliefs that menstruating women can contaminate the toilet force women in many areas to defecate outside during their monthly periods. Furthermore, child faeces is still not considered to be contagious, so its mismanagement (improper disposal) is still a major cause of drinking water contamination. Many mothers wash clothes containing child faeces in communal water taps or ponds.

In addition, province-wise comparison of districts revealed the following:
In Province one, the districts of Morang and Sunsari fall under the 'very high vulnerability' category. Solukhumbu, Sankhuwashaba, Taplejung, Panchthar, and Terhathum fall under 'high vulnerability', while Khotang and Bhojpur, Ilam, and Jhapafall come under the 'moderate' category. Dhankuta and Udayapur fall under 'low vulnerability', while Okhaldhunga falls under 'very low vulnerability' Province one (see Figure 23a).

In Province two, districts like Mahottari and Siraha fall under 'very high vulnerability'. Parsa, Bara and Saptari falls under 'high vulnerability', while Rautahat falls under 'moderate'. Sarlahi falls under 'low vulnerability', while Dhanusha falls under 'very low vulnerability' (see Figure 23b).

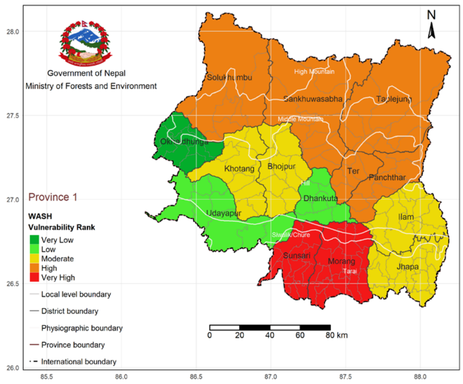

Figure 23a: Map of the vulnerability ranks of districts in Province one

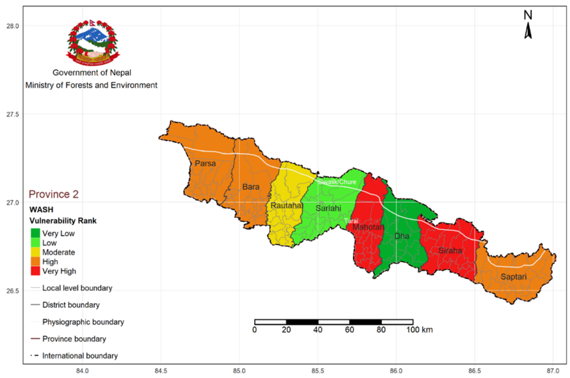

Figure 23b: Map of the vulnerability ranks of districts in Province two

In Bagmati Province, the districts of Rasuwa and Ramechaap fall under 'very high vulnerability', while Nuwakot, Sindhupalchock, Dolakha, and Sindhuli fall under 'high vulnerability'. The remaining districts fall under 'low' and 'very low vulnerability' (see Figure 24a).

In Gandaki Province, the Myagdi and Nawalpur districts falls under 'very high vulnerability', while Mustang and Manangfalls are under 'high vulnerability'. Parbat fall under 'moderate vulnerability', while Lamjung, Kaski, and Baglung fall under 'low vulnerability'. The remaining districts, Syangja and Tanahu, fall under 'very low vulnerability' (see Figure 24b).

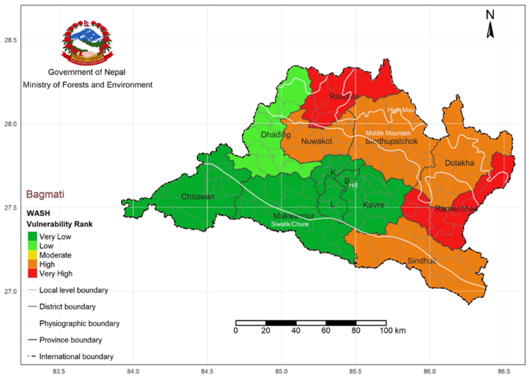

Figure 24a: Map of the vulnerability ranks of districts in Bagmati Province

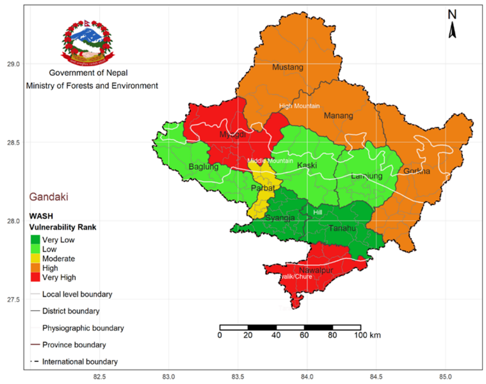

Figure 24b: Map of the vulnerability ranks of districts in Gandaki Province

In Lumbini Province, the districts of Dang, Rupandehi, and Parasi fall under 'very high vulnerability', while Bardiya, Banke, Rolpa fall under 'high vulnerability'. Kapilvastu, Arghakhanchi, Palpa, and Eastern Rukum fall under 'moderate vulnerability', while Gulmi comes under 'low vulnerability', and Pyuthan comes under 'very low vulnerability' (see Figure 25a).

In Karnali Province, the districts of Humla, and Surkhet fall under 'very high vulnerability', while Mugu and Western Rukum come under 'high vulnerability'. Jumla, Dolpa, Dailekh, and Jajarkot fall under 'low vulnerability', whereas Western Rukum, Salyan, and Dailekhis fall under 'low vulnerability' and Jajarkot falls under 'very low vulnerability' (see Figure 25b).

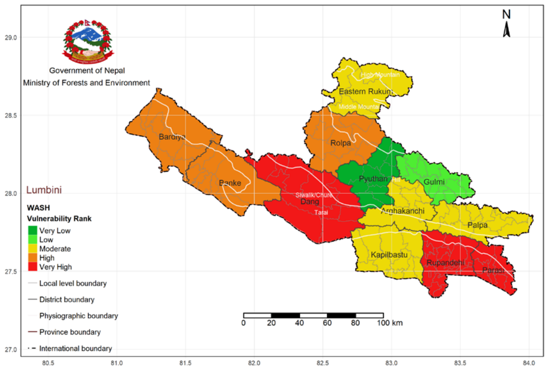

Figure 25a: Map of the vulnerability ranks of districts in Lumbini Province

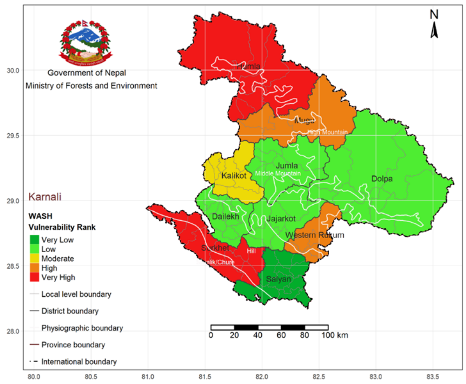

Figure 25b: Map of the vulnerability ranks of districts in Karnali Province

In the Sudurpashim Province, the Bajura and Kanchanpur districts come under 'very high vulnerability', while Dadelhdura, Doti, Achham, and Kailali fall under' high vulnerability'. Bajhang falls under 'moderate vulnerability', while Darchula falls under 'low vulnerability' and Baitadi falls under 'very low vulnerability' (see Figure 26).

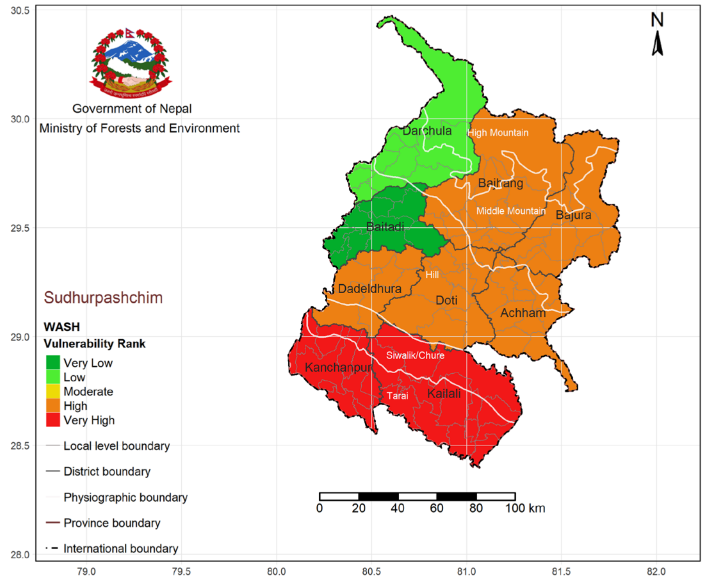

Figure 26: Map of vulnerability rank of districts in Sudurpaschim Province

Climate Change Risks and Adaptation Options in the Sector

7.1 Future climate change risks in the drinking water and sanitation sector

There is great uncertainty when considering the impacts on water resource availability. Global projections point towards increasing levels of scarcity as a consequence of changes in precipitation, increasing temperatures, increasing demand for resources, and reduced quality of resources due to pollution. Climate change also poses risks to secure water supplies in glacier feed systems. Research in the middle hills of Nepal, for instance, suggests that most highland communities are dependent on groundwater for part of the year and that these resources become stretched when demand increases for irrigation as well as for domestic purposes (Bricker, 2014). Loss of water sources may occur because of reduced rainfall, over-extraction, or because intakes or reservoirs are destroyed in flood events. Distribution infrastructure may be damaged by floods (Howard et al., 2016). Table 15 below summarizes some key hazards, vulnerabilities, and projected risks based on a literature review and consultations.

Table 15: Major issues posed by climate change, vulnerabilities in the sector, and projected risk

Issues posed by climate change	Vulnerability in the sector	Projected risk
Water shortages and drought in urban municipalities	Lack of piped water to homes of hundreds of millions of urban dwellers. Many urban municipalities are subject to water shortages and irregular supplies, with constraints on the possibility of increasing supplies. Lack of capacity and resilience in water management regimes including rural-urban linkages. Too much dependence on water resources, particularly the exploitation of groundwater.	Risks from constraints on urban water provision services to people and industry with human and economic impacts.
Geo-hydrological hazards (mud/ landslides, flood)	Local structures and networked infrastructure (piped water, sanitation, drainage) are particularly susceptible. The inability of many low-income households to move to a house on safer sites.	Risk of damage to networked infrastructure.
Water shortages and drought in rural areas	Rural people lacking access to drinking water. Lack of capacity and resilience in water management regimes (institutionally driven). Increased water demand from population pressure.	Risk of food insecurity and decrease in incomes. Decreases in household nutritional status.
Warming and drying (precipitation changes of uncertain magnitude)	Limits to coping capacity to deal with reduced water availability, increasing exposure and demand due to population increase, conflicting demands for alternative water uses, socio-cultural constraints on some adaptation options.	Risk of harm and loss due to livelihood degradation from systematic constraints on water resource use that leads to supply falling far below demand. Also, limited coping and adaptation options increase the risk of harm and loss.

This section describes the climate change risk at the district, provincial, and physiographic levels in the drinking water and sanitation sector. This assessment presents the current (baseline) and future scenarios of climate risks to drinking water and sanitation. The current (baseline) risk level was assessed at five levels: very low (0.325-0.446), low (0.447-0.542), moderate (0.543-0.606), high (0.607-0.674), and very high (0.675-0.768). Relative to the baseline scenario, future scenarios of climate risks were assessed under RCP 4.5 (intermediate scenario) and 8.5 (worst-case scenario) for two time periods: 2030 and 2050.

The findings show that four districts, namely Sankhuwasabha, Morang, Jhapa, and Ilam, fall under the category of 'very high risk' (see Figure 27 and Table 16). The flood-prone Terai region falls under 'very high' or 'high risk' zones because of high to very high exposure and sensitivity in its districts, coupled with limited adaptive capacity. Terai region is a flood-prone area of Nepal. Consultations with local government officials and local communities revealed that, due to frequent flooding in Janakpur, the majority of water supply schemes and hand pumps in the area are affected, limiting their functionality. The water supply infrastructures and toilets are flooded, which easily leads to faecal contamination of drinking water supplies. Communities have relatively less access to safe and clean drinking water during disaster events. However, if the sanitation and hygiene practices at the community level are improved, the risk might become lower than projected.

During expert consultations at the provincial level, an argument was made that increased temperatures may increase the risk of proliferation and survival of microbial pathogens in drinking-water storage and distribution systems. Stakeholders in Province one and Province two realize that inadequate (and climate-vulnerable) sanitation represents a significant and increasing threat to water quality. The challenges are expected to intensify in line with climate change projections, particularly in areas such as the Terai region that already suffer from poor infrastructure and services.

Makawanpur, Kapilbastu, Sunsari, Dhankuta, Terhathum, Rautahat, Tanahu, Kavrepalanchok, Bhaktapur, Parbat, Syangja, Siraha, Rupandehi, Palpa, Sindhuli, Bara, Chitawan, Dhanusha, Nawalpur, Kaski, Taplejung, Panchthar, Sarlahi, Mahottari, Parasi, Parsa, and Saptari fall under 'high risk'. Additionally, 23 districts fall under'moderate risk'. A further 23 districts fall under 'low' and'very low risk'. The rankings demonstrate that the level of exposure is one of the main determinants of the level of risk posed to a district. For example, districts such as Kaski, which have a higher concentration of the population, are exposed to higher levels of risk in the WASH sector, despite having higher HDI and capacity to cope than other districts.

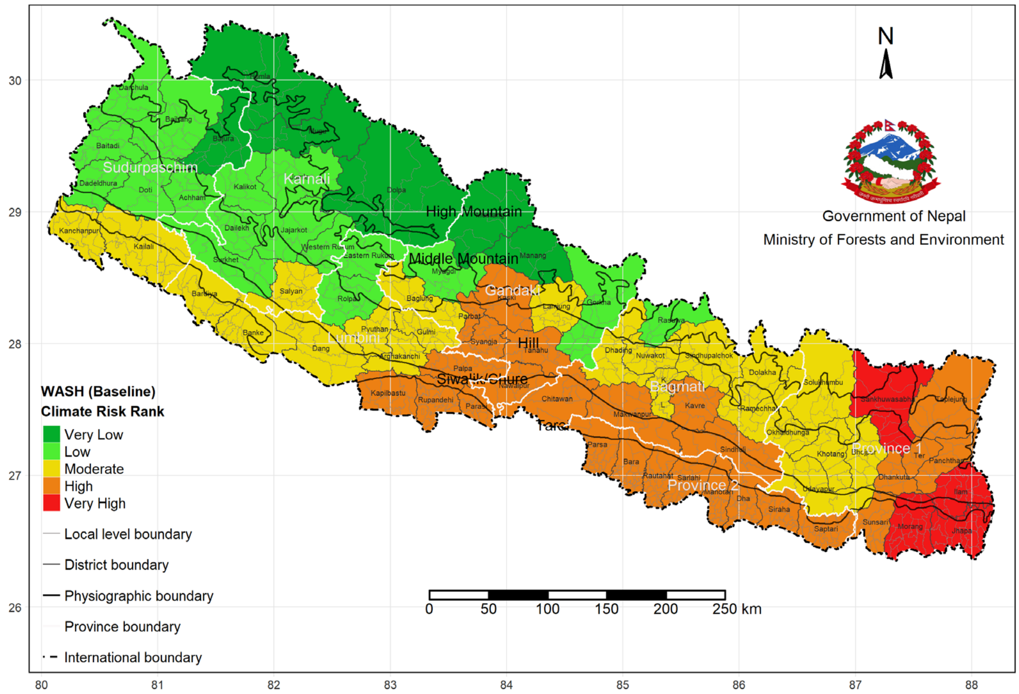

Figure 27: Map showing Climate Risk Ranks (Baseline) of Nepal's districts

Table 16: Climate Risk Ranks (Baseline/Current) for the drinking water and sanitation sector

Risk Rank	District	Percent
Very High (0.675 - 0.768)	Sankhuwasabha, Morang, Jhapa, Ilam	4
High (0.607 - 0.674)	Makawanpur, Kapilbastu, Sunsari, Dhankuta, Terhathum, Rautahat, Tanahu, Kavrepalanchok, Bhaktapur, Parbat, Syangja, Siraha, Rupandehi, Palpa, Sindhuli, Bara, Chitawan, Dhanusha, Nawalpur, Kaski, Taplejung, Panchthar, Sarlahi, Mahottari, Parasi, Parsa, Saptari	27
Moderate (0.543 - 0.606)	Dhading, Lamjung, Dolakha, Nuwakot, Baglung, Sindhupalchok, Bardiya, Solukhumbu, Lalitpur, Udayapur, Pyuthan, Banke, Kailali, Arghakhanchi, Bhojpur, Salyan, Khotang, Okhaldhunga, Dang, Kanchanpur, Gulmi, Ramechhap, Kathmandu	23
Low (0.447 - 0.542)	Rolpa, Rasuwa, Myagdi, Western Rukum, Gorkha, Dailekh, Darchula, Surkhet, Achham, Baitadi, Doti, Eastern Rukum, Kalikot, Jajarkot, Jumla, Bajhang, Dadeldhura	17
Very Low (0.325 - 0.446)	Humla, Mugu, Dolpa, Mustang, Manang, Bajura	6

Findings from the assessment reveal that risk scenarios will increase under both RCPs 4.5 and 8.5 in the future. Compared to the baseline/current risk levels, the number of districts with'very high risk' will increase—from four districts at baseline to 43 districts in the future, under RCPs 4.5 in 2030. This trend will further continue, with the number of districts with 'high risk' reaching 55 under 4.5 RCP in 2050, from 43 in 2030. The findings show that in both 2030 and 2050, under RCP

4.5, almost all the Terai districts, the majority of the Siwalik, and some hilly districts will be at risk from the impact of climate change. It was found that Province Two will be at'very high risk' for several reasons: the size of its population, the income disparity, and the number of climate extreme events such as heatwaves and flooding are going to increase considerably in the future. Bagmati also seems to be at 'high risk'. There could be multiple reasons for this, a couple of the most prominent ones being the likelihood of an increase in climate extreme events and the scale of their impact. The Terai region and the middle mountain regions of Gandaki Province, Lumbini Province, and Sudurpaschim Province are also going to be at risk from climate change impacts in the future.

These risk situations might change with changing socio-economic contexts. Demographic changes in urban areas will lead to more demand for water resources and more resources will be needed to invest in water and sanitation services. Due to the limited resources and capacity of local governments, this demand may not be met. This, in turn, will result in increased sensitivity and lower adaptive capacity in several regions, leaving them at even greater risk from climate change impacts.

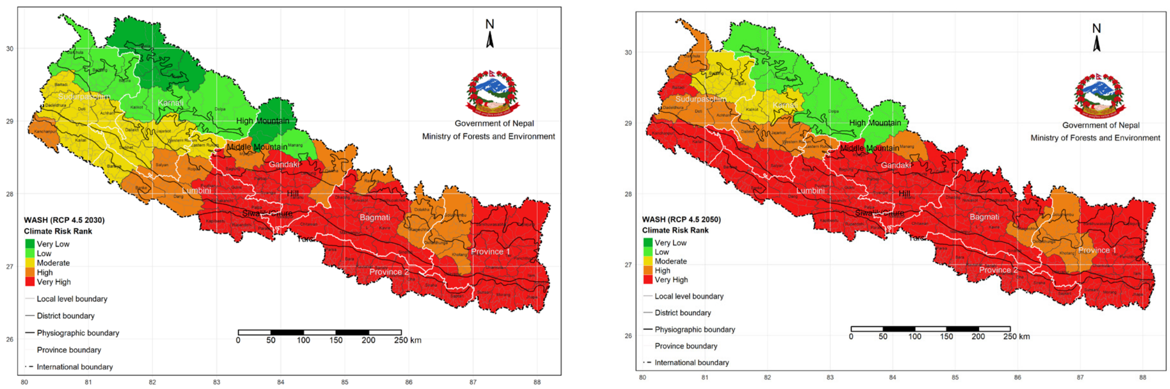

Figure 28: Risk Rank Scenarios under RCP 4.5 for 2030 (left) and 2050 (right)

Districts like Bajura, Humla, Dolpa, and Mustang are expected to move from 'very low risk' in RCP 8.5 2030 to 'low' to 'moderate risk' in RCP 8.5 2050. A majority of the districts in Sudurpaschim Province and Lumbini Province are expected to move towards 'very high' and 'high' risk from 'low' to 'moderate' risk in RCP 8.5 2050. There is an increasing trend of risk from climate change impact spreading across the districts (see Figure 29). The hilly districts are also becoming susceptible. This may be due to the potential risk of water shortages and the increasing risk of flash floods, GLOFs, landslides, et cetera.

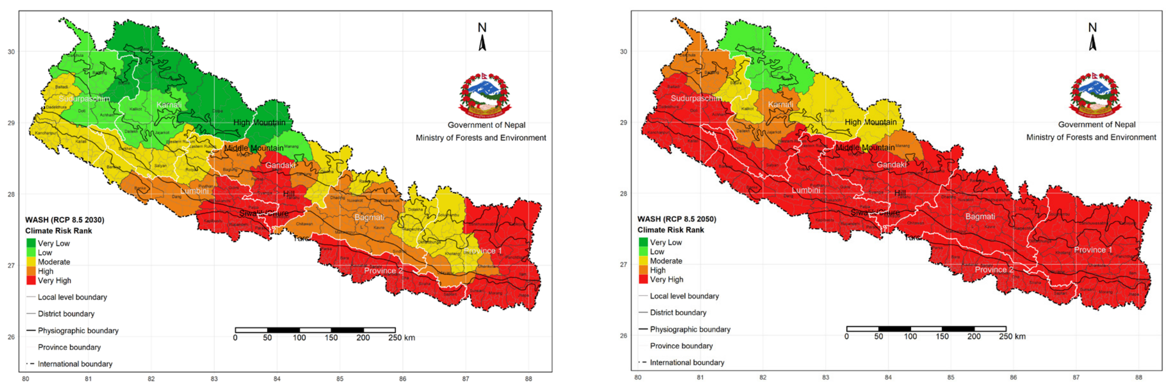

Figure 29: Risk Scenarios under RCP 8.5 for 2030 (left) and 2050 (right)

Table 17 below shows that when comparing RCP 8.5 for 2030 with 2050, almost all districts of Sudurpaschim Province, Lumbini Province, Gandaki Province, Bagmati Province, and Province one and Province two are moving towards 'high risk'. These districts currently face challenges related to drinking water. For example, in the consultations at Lumbini Province, the stakeholders mentioned that Palpa is one of the districts that are likely to have severe water shortage issues. The overall trend shows that future climate change will generally raise risk levels in the sector and will harm drinking water and sanitation.

Table 17: Number of districts with different risk scenarios under RCP 4.5 and 8.5 for 2030 and 2050

Risk Ranks	Baseline (Current)	RCP 4.5 2030	RCP 4.5 2050	RCP 8.5 2030	RCP 8.5 2050
Very high	4	43	55	27	65
High	27	13	14	18	6
Moderate	23	11	4	18	4
Low	17	7	4	9	2
Very low	6	3	0	5	0
Total	77	77	77	77	77

It is also interesting to see that the risk will increase gradually over time. Table 17 shows that only some districts will have fewer issues with climate change in the WASH sector, while all others will increasingly face challenges of different sorts. However, the changes in the demographic profile of the districts, levels of poverty, and the pace of development will also determine future vulnerability and risks. For example, population displacement due to flooding will massively increase in Terai which will lead to more vulnerable and risky settlements.

In the provincial consultations, stakeholders said that the provinces connected to the southern belt will have an increased risk of flooding in the future, due to unusual patterns of rainfall. This flooding, according to the stakeholders, will be the major cause of the destruction of water and sanitation infrastructures, polluting of water, and spread of waterborne diseases. The stakeholders in the provincial consultation for Province two also revealed that climate change and increased disaster risk will undermine their development gains, pushing the province further towards poverty and marginalization. Interestingly, during all provincial level consultations, stakeholders agreed that too much and too little water will be the major climate change related challenges in the WASH sector in the future.

7.2 Opportunities of adaptation in the sector

To deal with climate change effects in the current period, Nepal's WASH sector has developed plans, policies, and guidelines that recognize climate change and its sector-specific impacts. These also provide clear recommendations regarding what could be done to minimize the impact.

The Climate Resilient Water Safety Plans and the Sanitation Master Plan are currently in use in Nepal. The Sector Development Plan (2016-2030) and Guidelines for Disaster Risk Management and Climate Change and Adaptation to WASH in Nepal, 2019, are prepared and in use but have yet to be endorsed. Recently, the National Climate Change Policy 2019 was endorsed, which also guides the WASH sector on climate change. Identifying strategies for a climate-resilient WASH sector during consultations, the government stressed the need for projections of climate change projections, monitoring of drinking water sources, and assessment of sector-specific risks from climate change. Additionally, several adaptation measures were suggested, including community-based local adaptation plans, water tariffs for economic use of water, and water demand management.

Moreover, there are a few policy instruments in place. For example, the National Climate Change Policy (GoN, 2019) indicates that to promote water availability and accessibility, vulnerable areas and communities will be identified and capacity building on water storage and the multi-purpose water system will be promoted. It also highlights the importance of rainwater harvesting and collection of water in ponds for groundwater recharge and multi-use. The policy also mentions the adoption of climate-friendly areas and technologies for the construction of water schemes. Further, activities related to urban areas and groundwater sustainability are also proposed under this policy.

The WASH sector is making advancements by introducing several climate-smart technologies to provide clean drinking water in hard-to-reach areas. Some of the practices include protecting water sources, lifting technologies (solar and electric), advanced boring in the hilly and Terai regions, developing sustainable WASH facilities, implementing climate-resilient water safety plans, improving the capacities of water users' committees, and developing WASH marts in communities.

However, adaptation actions still need to be increased and intensified in the WASH sector. Given the risks associated with existing climate variability, there is a need to have a stronger focus on ensuring the reliability and protection of drinking water sources and modification of latrine design to reduce the risks of flooding. Where long-term investment decisions are involved—for example, with dams, treatment works, and piped networks—a greater range of variability should be considered to avoid costly mistakes (Oates et al., 2014).

Understandably, the prioritization of climate change adaptation varies from place to place. If more immediate and/or more threatening sources of risk and uncertainty are identified in any given domain of interest, these are given priority over climate change when, for example, developing coping strategies. Additionally, given that the impacts of climate change are determined by the consolidation of a wide range of factors, it is not possible to develop an all-encompassing strategy for climate change adaptation. Despite this, there are some straightforward actions and interventions that could be considered in many contexts. These include increased funding directed at facilitating a given community's/area's resilience against droughts, or at the enforcement of stricter planning regulations on locating WASH infrastructure in flood-prone areas. These, however, must be accompanied by informed and evidence-based research and a "learning-by-doing" approach that identifies and evaluates adaptation strategies. Moreover, effective adaptation to climate change requires improvements in WASH governance.

In this assessment, adaptation options were identified to address the core vulnerability and risks associated with the WASH sector by considering a set of knowledge, practices, technologies, behavioural changes, policy instruments, and financing. Table 18 below is derived from the literature review, consultations with experts, consultations at the provincial and local levels, and consolidation of best practices elsewhere.

Table 18: Adaptation options relevant for the WASH sector in Nepal

<table>
<tr><th>Key risks and vulnerabilities</th><th>Short term (1-5 years)</th><th>Midterm (1-10 years)</th><th>Long term (beyond 10 years)</th></tr>
<tr><td></td><td colspan="3">Identify and protect drinking water sources: Conservation of the catchment area for the stream source</td></tr>
<tr><td rowspan="8">• Risk that the progress to date in reducing childhood deaths from diarrheal disease is compromised
• Risk of overloading the capacity of sewer systems and water and wastewater treatment plants more often, and increased occurrences of low flows will lead to higher pollutant concentrations
• In the majority of the provinces, changing precipitation rates or melting snow and ice are altering hydrological systems, affecting water resources in terms of quantity and quality
• Too much water and too little water is increasing the risks of flooding which will destroy WASH infrastructure in the Terai region and will be the main reason for the spread of waterborne diseases impacting children, the elderly, and women.
• Increased risks of water shortages due to drying of springs, and decreases in groundwater in both rural and urban municipalities will create too much stress and burden to the population, particularly women and girls</td><td>• Identify alternative drinking water sources while constructing water supply schemes
• Map potential water recharge systems
• Adhere to guidelines for ranking climate-resilient water supply schemes</td><td>• Promote conservation practices such as collect rainwater from the ground surface, small reservoirs, and micro-catchments to augment the capacity of springs</td><td>• Promote plantation activities to develop vegetation buffer and water recharge</td></tr>
<tr><td colspan="3">Protect groundwater sources: Protect tubewells and dug wells and prevent pollution from droughts and flooding by appropriate measures</td></tr>
<tr><td>• Conduct assessment of community practices of cleaning tube wells and dug wells after flooding
• Adopt the SOPs of Ministry of Water Supply and DWSSM on cleaning tube wells and dug wells after flooding</td><td>• Replace shallow-head hand pumps with a deep-set hand pumps to collect water from deeper aquifers, which is safe and stable over various seasons</td><td>• Promote infiltration areas, wetlands, and ponds within the community, and encourage the people to collect rainwater from rooftops and use it for groundwater recharge</td></tr>
<tr><td colspan="3">Conserve and protect the catchment area of groundwater</td></tr>
<tr><td>• Identify the risks and vulnerabilities of the catchment area along with potential adaptation measures</td><td>• Improve infiltration area by improving infiltration capacity, creating artificial recharge, creating dams, wetlands, and ponds</td><td>• Promote plantation and prevent clogging of the recharge area and invasion of heavy pollution into ground reservoirs</td></tr>
<tr><td colspan="3">Promote resilient water treatment process and operations</td></tr>
<tr><td>• Carry out countrywide water source mapping for identifying potential pollutant risks, their frequency, and seasonal variations to be prepared</td><td colspan="2">• Adopt technologies for diversion of flow during high contamination, modify for excess contamination, add units for extra contamination, increase dosing of chemicals involved during extreme contamination, vary dosing of chlorine according to seasons, schedule cleaning as per variation of seasons and extreme situation of floods,use coagulation and flocculation units for high turbidity flow</td></tr>
<tr><td colspan="3">Ensure the functionality of water supply schemes: Managing leakages, detection and repair of pipes joints and valves</td></tr>
</table>

• Increased temperature and droughts in the future are likely to increase water and sanitation challenges in both urban and rural areas of Nepal • The increasing scenarios of climate-induced disasters such as floods, landslides, fires, GLOF will lead to the destruction of water pipelines, water collection tanks, drainage systems, waste management infrastructures, etc.	• Implement Climate Resilient Water Safety Plan • Monitor and keep the record of breakage of joints and pipes, and analyse for the reason for itsuch as pipeage, materials, activity around and above pipes, and climate variations	• Replace old pipes, correct weak joints, use appropriate pipe and joint materials, relocate the pipe and align to safe locations away from roads, drains, and wetlands • Promote the usage of standard pipe joining process to avoid breakages in the joints	• Develop and implement financial guidelines and allocatefunding for the repair and maintenance
	Promote water conservation and efficient use of water in households		
	• Promote rainwater harvesting and other water conservation measures;and promote reuse of wastewater from the kitchen and bathroom in the kitchen garden • Identify and conduct mapping of communities deprivedofbasic drinking water and sanitation services through WASH plan • Carry out assessment of water use patterns by people in various clusters	• Promote water storage, e.g., small multipurpose reservoirs and sand storage dams, rainwater harvesting, solar power water pumping, and water recycling	• Protect traditional ponds for using water for other purposes to reduce competition for using water from the system for other non-domestic purposes and determine an efficient way of using them
	Support in promotion of household water treatment and safe storage		
	• Conduct barrier analysis to identify the barriers to adopting water treatment options	• Prepare a capacity-building package and build the capacity of the community for various methods of water treatment at households based on availability, affordability, and usability	
	Improve sanitation and hygiene		
	• Promote raised pit latrines; septic tanks; relocation of latrines: small-scale biological systems	• Promote hygiene education in schools and colleges	• Promote climate-resilient technology, innovations, and infrastructure: 'pit latrines', 'low-flush septic systems', 'eco-san latrines' and 'high-volume septic tanks'

	Ensure the long-term resilience and sustainability of water and sanitation facilities		
	• Prepare drinking water system insurance guidelines and system insurance • Endorse operation and maintenance guideline in each water supply scheme • Implement operation and maintenance guideline in each water supply scheme	• Establish service centres in seven provinces based upon system categorization criteria • Integrate climate resilience into WASH sector strategies and plans	• Support in seeking funding from the Green Climate Fund and other sources for the provision of climate-resilient infrastructure (WASH facilities) • Prevent people from migrating by providing alternative drinking water facilities and alternative livelihood options
	Policy integration, in addition tolong-term and decentralized planning for water security		
	• Review climate change strategies and plans at the national and sub-national levels to include resilient WASH services as a key adaptation strategy • Integrate sanitation into the broader urban context. For example, sanitation infrastructure planners should consider plans for water supply (areas to be served, source of supply, water security, water recycling) and flood management (likelihood and level of flood risk can inform siting or prioritization of sanitation investment)	• Downscale climate projections and climate modellingto the local level for effective decision making in the WASH sector	• Develop guidelines for protection and conservation of various water sources as well as incentives for rainwater harvesting as important components of climate-resilient WASH • Prioritize reuse recycle and reuse of wastewater in water-sewage system planning
	Improve research and development in WASH sector		
	• Present research paper plans and policies coherent information in forms and formats that can easily be understood by non-water specialists at the local level • Organize stakeholders dialogue for evidence-informed climate-resilient WASH planning	• Improve the capacity of service providers and equip them with new knowledge and skills on climate resilient health and sanitation system • Prioritize research and development on issues related to climate change and health and sanitation • Carry out vulnerability and risk assessment in the sector periodically	• Build capacity bystrengthening the systems and structures for governance, as well as the capacity for planning based on adaptive management and integrated water resource management (IWRM) principles • Improve the resilience of WASH systems

	Support in localizing climate-resilient WASH through improved planning and institutional capacity		
	• Increase awareness and capacity of communities and local government, including local stakeholders on the need for building climate resilience in the WASH sector	• Support in integrating climate resilient WASH plan inlocal government planning and budgeting • Improve water supply to all both quality and quantity	• Ensure provision of safe and affordable water supply services to all
	Promote conservation and enhancement of traditional water sources		
	• Ensure basic sanitation services to all • Prepare integrated district WASH Plan • Promote hygiene through BBC package (inclusive of climate-resilient) at all institutional levels • Help the registration of all WSUCs and build their capacity	• • Update district WASH plan and make it climate resilient • Promote Hygiene through BBC package (inclusive of climate-resilient) at all institutional level • Capacity building of all WSUC on the climate-resilient water safety plan	• Ensure the provision of adequate and equitable sanitation services • Update district WASH plan and make it climate resilient • Promote Hygiene through BBC package (inclusive of climate-resilient) at all institutional level • Capacity building of all WSUC on effective implementation of the climate-resilient water safety plan
	Improve communication, learning, and Sharing of Knowledge aimed at building community resilience		
	• Develop a common platform for knowledge, learning, sharing, and promotion at the centre and provincial levels about climate resilience WASH	• Organize peer learning event annually (Learning andsharing includes the formation of interest groups; common website development, sector gathering; orientation of WASH actors towards new ideas/ innovations/ technologies from producers and/or suppliers side) • Establish warning systems. Early warning alerting stakeholders to impending flooding, drought, or other severe weather allows for preparation measures to be taken	• Establish an information collection and management systems useful for monitoring the resilience of households and communities • Establish an ICT system to assess, map, monitor, and evaluate the quality and quantity of water sources and their use

Chapter 8

Conclusion and Way Forward

8.1 Conclusions

Improved water supply, sanitation, and water resource management can contribute greatly to a country's economic growth and poverty eradication. Proper water resource management has a positive impact on increasing production and productivity in the economic sectors of a nation. Overall, WASH interventions offer multiple benefits in terms of health and nutrition, socio-economic conditions, and education. Furthermore, these interventions not only have an immediate impact but exert a cumulative effect that can affect the life courses of an individual and their offspring.

In a changing and unpredictable climate, extreme events pose serious threats in the form of floods, droughts, and landslides. The continuous change in weather and climate is anticipated to have a profound effect on WASH-related public health issues, especially in Nepal. The frequency of extreme weather and climate-related disasters is expected to increase in the country due to climate fluctuations. This assessment report primarily sought to identify climate change related vulnerabilities and risks in Nepal's WASH sector. It also identified and explored options for expanding adaptation options to make the sector climate-resilient.

Despite the fact that the availability and affordability of clean drinking water and sanitation are a prerequisite for sustainable development and poverty eradication, this availability and affordability was found to be a major challenge in Nepal. Inequalities among the most vulnerable, especially during emergencies/disasters, still prevail. As the impact of climate change on the WASH sector increases, the sector's risks and vulnerabilities also increase concomitantly. Therefore, understanding these vulnerabilities and risks is very important to ensure that the WASH sector is well equipped to deal with the current and future adverse impacts of climate change.

This assessment found that relatively less attention has been paid to the impacts of climate change and extreme weather conditions on the WASH sector to date. How these sector-specific effects affect Nepal's various areas and communities has also not been studied properly. Looking at the current trends and future scenarios of stressors like floods, droughts, and landslides, it can be estimated that their frequency, magnitude, and impact on Nepal are likely to be much higher in the future. As the state of the WASH sector is inextricably tied to the health and wellbeing of Nepal's people, it can be said that climate change related loss and damage in the WASH sector will also pose additional risks to the country's health and socioeconomic sectors.

Findings from this assessment showed that different districts of Nepal are variably exposed to different climate hazards and related impacts due to population concentration and concentration of WASH services and infrastructure. Exposure is high to very high in the majority of Terai districts, including the Kathmandu valley. In Terai, the majority of the hand pumps and water supply schemes are flooded, which alters the functionality of these schemes. The sanitation services are also flooded, causing the water infrastructure to become contaminated with faecal matter easily. The districts with particularly high exposure are Kapilbastu, Sunsari, Rautahat, Kailali, Siraha, Bara, Chitawan, Dhanusha, Jhapa, Sarlahi, Mahottari, Parsa, and Saptari.

The assessment also showed that a total of 30 districts have 'low exposure' to climate-induced hazards. These include Humla, Mugu, Rasuwa, Myagdi, Terhathum, Western Rukum, Darchula, Dolpa, Mustang, Manang, Kalikot, Taplejung, Jajarkot, and Jumla. The reduced exposure may be due to smaller population size and concentration of infrastructure. Most mountainous districts fall into this category. Additionally, 17 districts are in the'moderate exposure' category.

It was further found that the Karnali Province and Sudurpaschim Province are more sensitive compared to other provinces. This is due to exposure to climatic hazards, the number of water supply and sanitation services in need of repair and maintenance, lack of access to local markets and traditional ways (i.e., not modern and hygienic) of promoting WASH. In Bagmati Province, among 13 districts, Dhadhing, Nuwakot, Rasuwa, Sindhupalchock, Dolakha, Ramechhap, and Sindhuli fall under the category of districts with "high sensitivity", while the remaining six districts fall into 'low' and'very low sensitivity'. In contrast, most of the districts in Province two have'moderate sensitivity'. The major indicators influencing the sensitivity of districts in Province two are the time spent by women and children fetching water and the number of water supply schemes requiring major repair and rehabilitation.

The findings also showed that Lalitpur, Tanahu, Kavrepalanchok, Bhaktapur, Gulmi, and Kathmandu appear to have'very high adaptive capacity', whereas the adaptive capacity of Humla, Mugu, Rasuwa, Western Rukum, Dolpa, Surkhet, Achham, Doti, Bajura, Kalikot, Kanchanpur, Jumla, Mahottari, and Bara The major dominating indicator of adaptive capacity appeared to be the number of households with access to private taps and hand pumps. Additionally, 51.2 percent of people in the lower adaptive capacity districts are multi-dimensionally poor, with the region's Human Development Index (HDI) being just 0.427, which is below the national average of 0.49. Furthermore, only 35.9 percent of Karnali have access to safe drinking water. Due to lack of access to safe drinking water in Karnali Province and Sudurpaschim Province, these two provinces have the highest number of cases of water-borne diseases among children under the age of five. Malnutrition in children under five years is 59 percent in Karnali[6], while the average life expectancy in the province is 67 years, the lowest in the country.

6 http://kppc.karnali.gov.np/noticefile/PPC_SDG%20Baseline%20Report%20-%20Karnali%20(1)_1601631613.pdf

The sensitivity and adaptive capacity indicators—such as the condition and types of physical and institutional infrastructure, their proximity to hazards, and the characteristics of the population dependent on them—were found to contribute significantly to a given district's vulnerability ranking. The findings revealed that Karnali Province is much more vulnerable to the impact of climate change than the other provinces because of its high sensitivity and low adaptive capacity. Sudurpaschim Province was also found to be highly vulnerable for similar reasons.

Regarding future risk scenarios, the findings reveal that risks are likely to increase under both RCPs 4.5 and 8.5 in the future. Analyses showed that, in both 2030 and 2050, under RCP 4.5, almost all the Terai districts, a majority of the Siwalik, and some hilly districts will be at risk from the impact of climate change. Out of the provinces, Province two will be at a very high risk for several reasons. Districts like Bajura, Humla, Dolpa, and Mustang are expected to move towards 'low' to'moderate' risk at RCP 8.5 in 2050, from a starting point of'very low risk' at RCP 8.5 in 2030. Overall, the trend shows that most of the districts in Nepal will be at risk from climate change impacts. From only four districts in the'very high risk' category at baseline, 43, 55, 27, and 65 districts will shift to come under this category in RCP 4.5 in 2030 and in 2050 and RCP 8.5 in 2030 and in 2050 respectively.

Overall, this assessment showed that there is a negative impact of climate change on the WASH sector, compromising the availability and quality of drinking water and sanitation and related services. As this is directly linked to public health, the health sector is also in trouble. In the future, climate change will further aggravate outcomes in both these sectors for various reasons that are covered in earlier chapters of this report.

To have better risk management, a robust adaptation strategy needs to be adopted to reduce the impact of climate change on this sector. However, there are limits to adaptation measures. These adaptation options in the WASH sector must be accompanied by informed and evidence-based research and a "learning-by-doing" approach that identifies and evaluates adaptation strategies. Additionally, effective adaptation to climate change requires improvements in WASH governance.

8.2 The way forward

This assessment has a few noteworthy limitations. The analysis focused only on the district, province, and physiographic regions. The availability of data and information in the sector is a major issue. There is no systematic database on hygiene. Database generation and reporting are an essential part of the process, including monitoring.

In the future, it will be important to have evidence-based planning and decision-making, as well as an understanding of vulnerability and risk. For this, municipality-based rankings are crucial. The current NWASH-web and mobile application ('app'), which the government has endorsed, is expected to have a profound impact on the WASH sector. For now, however, the app has limited coverage: out of the 753 local governments in Nepal, only 156 municipalities have updated information, but even that is incomplete. Also, a cluster-based WASH dashboard needs to be established online to share information regarding different interventions carried out by both the government and other stakeholders to have a centralized data system.

References

Ahmad, T., Shrestha, A. M., Das, S. K., Darnal, K., Neupane, R., Pote, R., & Paudel, D. (2018). *Impact of climate change on WASH services: a case from Nepal.*

Baidya, M. (2017). *Climate Resilient and water sanitation and Hygiene (WASH) interventions in Nepal.*

Bates, B., Kundzewicz, Z., & Wu, S. (2008). *Climate change and water*. Intergovernmental Panel on Climate Change Secretariat.

White, P., Badu, I. R., & Shrestha, P. (2015). *Achieving sustainable water supply through better institutions, design innovations and water safety plans–an experience from Nepal.* Journal of Water, Sanitation and Hygiene for Development, 5(4), 625-631.

Bhandari, B., & Grant, M. (2007). User satisfaction and sustainability of drinking water schemes in rural communities of Nepal. *Sustainability: Science, Practice and Policy*, *3*(1), 12-20.

Bricker, S. H., Yadav, S. K., MacDonald, A. M., Satyal, Y., Dixit, A., & Bell, R. (2014). *Groundwater resilience Nepal: Preliminary findings from a case study in the Middle Hills.* Nottingham, UK, British Geological Survey.

Budhathoki, C. B. (2019). Water supply, sanitation, and hygiene situation in Nepal: A review. *Journal of Health Promotion*, *7*, 65-76.

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

Chapagain, P. S., Ghimire, M., & Shrestha, S. (2019). Status of natural springs in the Melamchi region of the Nepal Himalayas in the context of climate change. *Environment, Development, and Sustainability*, *21*(1), 263-280.

Chauhan, K. (2013). *Environmental Sustainability of Water Supply Systems implemented at RWSSP-WN.* Retrieved from: https://www.theseus.fi/handle/10024/61610

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

GoN. (2011). *Sanitation and Hygiene Master Plan.* Government of Nepal, Kathmandu, Nepal

GoN. (2015). *The Constitution of Nepal. Article 35(4).* Ministry of Law, Justice and Parliamentary Affairs, Kathmandu, Nepal

GoN. (2018). *Sanitation status of Nepal: Factsheet.* Government of Nepal, Ministry of Water and Sanitation. Department of Water Supply and Sewerage (DWSS)

GoN. (2019). *National Climate Change Policy 2076 (2019).* Government of Nepal.

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

Helvetas. (2015). *Water Use Master Plan +3R*

Howard, G., & Bartram, J. (2010). *The resilience of water supply and sanitation in the face of climate change*. Vision 2030, Technical report, World Health Organization, Geneva, Switzerland.

Howard, G., Calow, R., Macdonald, A., & Bartram, J. (2016). Climate change and water and sanitation: likely impacts and emerging trends for action. *Annual review of environment and resources*, *41*, 253-276.

Hutton, G., & Varughese, M. (2016). *The cost of meeting the 2030 sustainable Development Goal Targets on drinking Water, Sanitation, and Hygiene.*

IPCC. (2007a). *Climate change: impacts 2007, adaptation and vulnerability.* Working Group II Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC. (2014). *AR5 Synthesis Report: Climate Change.* Intergovernmental Panel on Climate Change.

Likert, R. (1932). A technique for the measurement of attitudes. *Archives of psychology*.

Luers, A. L., Lobell, D. B., Sklar, L. S., Addams, C. L., & Matson, P. A. (2003). A method for quantifying vulnerability applied to the agricultural system of the Yaqui Valley, Mexico. *Global Environmental Change*, *13*(4), 255-267.

MICS, (2019). *Multi-Indicator Cluster Survey.* Government of Nepal, National Planning Commission, Central Bureau of Statistics.

Mills, J. E., & Cumming, O. (2016). The impact of water, sanitation, and hygiene on key health and social outcomes. *Sanitation and Hygiene Applied Research for Equity (SHARE) and UNICEF*, 112.

Milly, P. C. D., Wetherald, R. T., Dunne, K. A., & Delworth, T. L. (2002). Increasing risk of great floods in a changing climate. *Nature*, *415*(6871), 514-517.

MoHA. (2009). *Nepal disaster report: The hazard scale and vulnerability*. Kathmandu: Ministry of Home Affairs (MoHA).

MoPE. (2017). *Vulnerability and Risk Assessment Framework Indicators for National Adaptation Plan (NAP) Formulation Process in Nepal.*

MoWSS. (2019). *DWSS Progress review.* Government of Nepal, Ministry of Water Supply and Sanitation, Department of Water Supply and Sewerage.

Noga, J., & Wolbring, G. (2012). The economic and social benefits and the barriers of providing people with disabilities accessible clean water and sanitation. *Sustainability*, *4*(11), 3023-3041.

Oates, N., Ross, I., Calow, R., Carter, R., & Doczi, J. (2014). Adaptation to climate change in water, sanitation and hygiene. *London: Overseas Development Institute. [Google Scholar]*.

Panthi, J., Khatiwada, K. R., Shrestha, M. L., & Dahal, P. (2019). Water poverty in the context of climate change: a case study from Karnali river basin in Nepal Himalaya. *International Journal of River Basin Management*, *17*(2), 243-250.

Patz, J. A., Engelberg, D., & Last, J. (2000). The effects of changing weather on public health. *Annual review of public health*, *21*(1), 271-307.

Sanctuary, M., Tropp, H., & Haller, L. (2007). Making Water a Part of Economic Development: The Economic Benefits of Improved Water Management and Services. *Stockholm International Water Institute (SIWI): Stockholm, Sweden.*

Shrestha, R. K. (2017). *Arsenic contamination in Groundwater, Soil, and Rice Grain of Nepal.*

Stern, N., & Stern, N. H. (2007). *The economics of climate change: The Stern Review.* Cambridge University Press.

Taylor, R. G., Scanlon, B., Döll, P., Rodell, M., Van Beek, R., Wada, Y., ... & Treidel, H. (2013). Ground water and climate change. *Nature climate change*, *3*(4), 322-329.

UN Water. (2020). Retrieved from UN WATER: https://www.unwater.org/

UNICEF. (2014). *WASH Climate Resilient Development.* UNICEF.

Wester, P., Mishra, A., Mukherji, A., & Shrestha, A. B. (2019). The Hindu Kush Himalaya Assessment: Mountains, climate change, sustainability and people (p. 627). *Springer Nature.*

White, P., Badu, I.R., & Shrestha, P. (2015). *Achieving sustainable water supply through*

WHO, N. (2015). *Review of Policy Documents on Climate Change, WASH and Public Health in Nepal.* Nepal: WHO.

World Bank Group & The Asian Development Bank. (2021). *Climate Risk Country Profile: Nepal (2021).*

Annex

Annex 1: WASH-related risk ranks of Nepal's districts overall

BASELINE

Risk rank	District
Very High (0.675 - 0.768)	Sankhuwasabha, Morang, Jhapa, Ilam
High (0.607 - 0.674)	Makawanpur, Kapilbastu, Sunsari, Dhankuta, Terhathum, Rautahat, Tanahu, Kavrepalanchok, Bhaktapur, Parbat, Syangja, Siraha, Rupandehi, Palpa, Sindhuli, Bara, Chitawan, Dhanusha, Nawalpur, Kaski, Taplejung, Panchthar, Sarlahi, Mahottari, Parasi, Parsa, Saptari
Moderate (0.543 - 0.606)	Dhading, Lamjung, Dolakha, Nuwakot, Baglung, Sindhupalchok, Bardiya, Solukhumbu, Lalitpur, Udayapur, Pyuthan, Banke, Kailali, Arghakhanchi, Bhojpur, Salyan, Khotang, Okhaldhunga, Dang, Kanchanpur, Gulmi, Ramechhap, Kathmandu
Low (0.447 - 0.542)	Rolpa, Rasuwa, Myagdi, Western Rukum, Gorkha, Dailekh, Darchula, Surkhet, Achham, Baitadi, Doti, Eastern Rukum, Kalikot, Jajarkot, Jumla, Bajhang, Dadeldhura
Very Low (0.325 - 0.446)	Humla, Mugu, Dolpa, Mustang, Manang, Bajura

RCP 4.5 2030

Risk rank	District
Very High (More than 0.674)	Dhading, Makawanpur, Kapilbastu, Lamjung, Sunsari, Dhankuta, Terhathum, Nuwakot, Sankhuwasabha, Rautahat, Baglung, Sindhupalchok, Lalitpur, Tanahu, Kavrepalanchok, Udayapur, Bhaktapur, Parbat, Pyuthan, Syangja, Siraha, Arghakhanchi, Rupandehi, Palpa, Bhojpur, Sindhuli, Morang, Bara, Chitawan, Dhanusha, Nawalpur, Kaski, Taplejung, Panchthar, Jhapa, Sarlahi, Mahottari, Parasi, Parsa, Gulmi, Kathmandu, Saptari, Ilam
High (0.607 - 0.674)	Rolpa, Rasuwa, Myagdi, Dolakha, Gorkha, Solukhumbu, Banke, Salyan, Khotang, Okhaldhunga, Dang, Kanchanpur, Ramechhap
Moderate (0.543 - 0.606)	Western Rukum, Bardiya, Dailekh, Kailali, Surkhet, Achham, Baitadi, Doti, Eastern Rukum, Jajarkot, Dadeldhura
Low (0.447 - 0.542)	Darchula, Dolpa, Manang, Bajura, Kalikot, Jumla, Bajhang
Very Low (Less than 0.447)	Humla, Mugu, Mustang

RCP 4.5 2050

Risk rank	District
Very High (More than 0.674)	Dhading, Rolpa, Makawanpur, Kapilbastu, Rasuwa, Myagdi, Lamjung, Sunsari, Dolakha, Dhankuta, Terhathum, Nuwakot, Sankhuwasabha, Rautahat, Baglung, Sindhupalchok, Bardiya, Gorkha, Lalitpur, Tanahu, Kavrepalanchok, Udayapur, Bhaktapur, Parbat, Pyuthan, Syangja, Banke, Kailali, Surkhet, Siraha, Arghakhanchi, Baitadi, Rupandehi, Palpa, Sindhuli, Salyan, Morang, Bara, Chitawan, Dhanusha, Dang, Nawalpur, Kaski, Kanchanpur, Taplejung, Panchthar, Jhapa, Sarlahi, Mahottari, Parasi, Parsa, Gulmi, Kathmandu, Saptari, Ilam
High (0.607 - 0.674)	Western Rukum, Solukhumbu, Dailekh, Darchula, Achham, Bhojpur, Doti, Manang, Eastern Rukum, Khotang, Okhaldhunga, Jajarkot, Ramechhap, Dadeldhura
Moderate (0.543 - 0.606)	Bajura, Kalikot, Jumla, Bajhang
Low (0.447 - 0.542)	Humla, Mugu, Dolpa, Mustang

RCP 8.5 2030

Risk rank	District
Very High (More than 0.675)	Kapilbastu, Sunsari, Terhathum, Sankhuwasabha, Rautahat, Tanahu, Parbat, Syangja, Siraha, Arghakhanchi, Rupandehi, Palpa, Morang, Bara, Dhanusha, Nawalpur, Kaski, Taplejung, Panchthar, Jhapa, Sarlahi, Mahottari, Parasi, Parsa, Gulmi, Saptari, Ilam
High (0.607 - 0.674)	Dhading, Makawanpur, Myagdi, Lamjung, Dhankuta, Nuwakot, Baglung, Sindhupalchok, Lalitpur, Kavrepalanchok, Udayapur, Bhaktapur, Pyuthan, Banke, Sindhuli, Chitawan, Dang, Kathmandu
Moderate (0.543 - 0.606)	Rolpa, Rasuwa, Dolakha, Western Rukum, Bardiya, Gorkha, Solukhumbu, Kailali, Surkhet, Baitadi, Bhojpur, Salyan, Eastern Rukum, Khotang, Okhaldhunga, Kanchanpur, Ramechhap, Dadeldhura
Low (0.447 - 0.542)	Dailekh, Darchula, Achham, Doti, Manang, Kalikot, Jajarkot, Jumla, Bajhang
Very Low (Less than 0.446)	Humla, Mugu, Dolpa, Mustang, Bajura

RCP 8.5 2050

Risk rank	District
Very High (More than 0.675)	Dhading, Rolpa, Makawanpur, Kapilbastu, Rasuwa, Myagdi, Lamjung, Sunsari, Dolakha, Dhankuta, Terhathum, Nuwakot, Sankhuwasabha, Rautahat, Baglung, Western Rukum, Sindhupalchok, Bardiya, Gorkha, Solukhumbu, Lalitpur, Tanahu, Kavrepalanchok, Udayapur, Bhaktapur, Parbat, Pyuthan, Syangja, Banke, Kailali, Surkhet, Achham, Siraha, Arghakhanchi, Baitadi, Rupandehi, Palpa, Bhojpur, Sindhuli, Salyan, Morang, Bara, Doti, Eastern Rukum, Khotang, Okhaldhunga, Chitawan, Dhanusha, Dang, Nawalpur, Kaski, Kanchanpur, Taplejung, Panchthar, Jhapa, Sarlahi, Mahottari, Parasi, Parsa, Gulmi, Ramechhap, Kathmandu, Saptari, Dadeldhura, Ilam
High (0.607 - 0.674)	Dailekh, Darchula, Manang, Jajarkot, Jumla, Bajhang
Moderate (0.543 - 0.606)	Dolpa, Mustang, Bajura, Kalikot
Low (0.447 - 0.542)	Humla, Mugu

Annex 2: TWG and Stakeholders Consulted

S.N.	Name	Designation	Gender
1	Prof. Dr Jageshwor Gautam	Coordinator TWG, MoHP	Male
2	Dr Samir Kumar Adhikari	Co-Coordinator, TWG, MoHP	Male
3	Mr. Rajit Ojha	Co-Coordinator, TWG, MoWSS	Male
4	Dr Meghnath Dhimal	Member, TWG, NHRC, MoHP	Male
5	Er. Rajaram Pote Shrestha	Member, TWG, WHO Nepal country office	Male
6	Ranjana Prajapati	Member, TWG, MoHP	Female
7	Prof. Bandana Pradhan	Member, TWG, IoM	Female
8	Prabhat Shrestha	Member, TWG, MoWSS	Male
9	Sheela Shrestha	Member, TWG, NHTC, MoHP	Female
10	Mahendra Dhoj Adhikari	Member, TWG, EDCD, DoHS, MoHP	Male
11	Dr Surendra Chaurasiya	Member, Management Division, DoHS, MoHP	Male
12	Dr Guna Nidhi Sharma	Member, MoHP	Male
13	Mr. Upendra K.C.	Support Staff, MoHP, WHO Nepal Country Office	Male

Annex 3: List of experts consulted

Name	Position	Organization
Ramakant Duwadi	Joint Secretary, MoWSS	MoWSS
Dr Rajit Ojha	Section Chief, DWSSM	DWSSM
Kabindra Karki	Chief, NWSSTC, MoWSS	NWSSTC, MoWSS
Rajan Raj Pandey	Ex Joint Secretariat, MoWSS, Team leader WHH	WHH
Rajeev Ghimire	Project Manager	WHH
Dandi Ram Bishwokarma	WASH Specialist, UNICEF	UNICEF
Siddhi Shrestha	WASH Specialist	UNICEF
Rajesh Manadhar	MandE advisor	UN Habitat
Pabitra Gurung	Water Resource and Energy expert	OPM
Swecchya Rajbhandari	Program Manager	Save the children
Biju Dangol	Project Manager	OXFAM
Luna Kansakar	WASH officer	GGI
Padam Lamsal	Partnership advisor	WHH
Sagar Shahi	WASH Program	NCV
Kabindra Pudasaini	WASH Program Manager	WaterAid
Chandan Pandit	Technical coordinator	OXFAM
Bodh Narayan Shrestha	WASH Officer	UNICEF

Annex 4: The outcomes of provincial consultations

Province one

Challenges posed by climate change and extreme events	Trends of the changes	Impacts and vulnerabilities	Who is or what is most impacted?	Medium-term adaptation options	Long term adaptation options
Mountain					
Snowfall Irregular rainfall and flood Melting of snow and glaciers Drying of water springs Lack of clean and safe drinking water Sanitation and hygiene issues Outbreak of diseases	Massive increase in the trends of temperature change, rainfall variability, and occurrence of hazards Impacts being observed frequently Increasing trend of loss and damage	Impact on livelihood resources: agriculture production decline, declining livestock production, poor quality of products Impacts on water resources: drying up and unavailability of water resources, which led to the migration of communities Impacts on resources: vegetation shifting, the emergence of new species, new crops- positive but many species are declining Impact on infrastructure in the mountain areas	Ethnic minorities, Dalits, women, girls, children, and elderly belonging to marginalized and poor households Communities living in rain shadow districts	Improve capacity of service providers and equip them with new knowledge and skills on climate resilient health and sanitation system Prioritize research and development on issues related to climate change and health and sanitation Protect of water resources Conserve and manage local seeds, crops, and varieties that are stress-tolerant Conduct health campaign targeting the impacted and vulnerable population	Develop necessary policy and regulations to respond effectively to climate change in a mountainous region Promote water conservation technologies for the mountains Prevent people from migrating by providing alternative drinking water facilities and alternative livelihood options

Challenges posed by climate change and extreme events	Trends of the changes	Impacts and vulnerabilities	Who is or what is most impacted?	Medium-term adaptation options	Long term adaptation options
Hills					
Rainfall variability Increase in floods and landslides Temperature rise leading to increase in droughts, forest fires and the emergence of new diseases, and spread of alien species	Temperature rise in increasing trend; both summer and winter are warmer Intense rainfall in a short duration of time Increased frequency of floods; impact of floods and landslides is massive Increased incidences of fire, windstorm, and disease outbreak	Impact on water resources: Drying of springs leading to lack of water and burden on women and girls Impact on food production: changes in rainfall pattern is creating uncertainties in rain-fed farming Habitat loss due to degradation of land, loss of soil, and landslide and flood trigger damages Health and sanitation crisis: lack of water and spread of disease during monsoon and winter Damage to roads, infrastructure such as drainage, canals An increase in water demand is contrary to the declining water yield and availability	Women, children, the elderly, ethnic groups are impacted due to additional stress and burden from fetching water and work drudgery Health issues for children, the elderly, and infant during the winter and monsoon	Protect spring sheds and water bodies for drinking water Promote soil and water management schemes Promote water conservation and storage system (conservation ponds, water collection ponds, water recharge system, water reservoirs)	Develop longer-term sustainable water management plan within the context of climate change Invest in big water storage and water recharge systems in the hills to rejuvenate and recharge the springs Carry out plantation activities Implement adaptation plans targeting the health and WASH sector
Terai					
Temperature rise Rainfall variability Disasters: flood, inundation, fire, disease outbreak	Increasing trend	Impact on water table: lower in many districts The problem of flooding, and impact water sources such as tube well, well, pond and latrines Impact on health and hygiene during the heatwave, cold wave, and flood Water scarcity also leading to health and hygiene issues.	Mostly the marginalized communities who are landless and homeless are impacted Children, the elderly, and health patient among others who are impacted	Protect groundwater and surface water from pollution and depletion Promote water conservation technologies at the community level Conserve the Churiya region for water recharge Protect wetlands and watersheds, ponds, and conservation areas	Formulate water regulatory policy and provisions Promote water-efficient technologies and water-saving schemes Promote climate-friendly design of WASH infrastructures

Province two

Challenges posed by climate change and extreme events	Trends of the changes	Impacts and vulnerabilities	Who is or what is most impacted?	Medium-term adaptation options	Long term adaptation options
The water table is low due to the degradation of Churiya Drying up of springs and other water sources e.g. streams, ponds, well, etc. A new type of disease due to loss of trees and vegetation Health and hygiene issues due to lack of water Impact due to fires, windstorms, and floods	Massive changes in weather and climate Temperatures in summer are very high Experience of heat and cold wave Flooding is a record high in recent years	Outbreaks of disease due to lack of clean drinking water Respiratory diseases due to burning of biomass Waterborne and vector-borne diseases due to temperature increase and changes in rainfall pattern leading to flooding Massive loss of life and properties due to flooding and its damage to human life, settlements, infrastructure, and services	Poor, marginalized, slum dwellers, landless are impacted. Among them are children, elderly and women, disabled population	Promote water source protection and water management technology and practices Promote integrated soil and water conservation in Churiya region Ensure safety while constructing drinking water systems and latrines Implement riverbank protection schemes and bioengineering in the Churiya region	Promote sustainable water management programme targeting to conserve and manage water Develop a master plan for Churiya conservation Implement disaster risk reduction and climate change adaptation programme in managing water resources and hygiene

Bagmati Province

Geographic areas	Challenges and risks	Impact	Adaptation options
Mountain	Extinction of indigenous and local systems Increase in the evidence of natural calamities (sudden flood, landslides) Food insecurity Poverty Increased temperature and extreme variability in rainfall Less snowfall Issues of access to drinking water	Shifting of snowline Increase in disaster events (avalanches, snowstorms, landslides) Decrease in the flow of water in the winter season Glacier Lake Outburst Floods (GLOFs) Shifting of agro-ecological zones Decrease in the availability of water Impact on the drinking water Increase in health and hygiene issues.	Rainwater harvesting and plastic ponds Cultivation inside protected structures, e.g., naturally ventilated greenhouses Promotion of integrated watershed management Awareness and capacity building of communities Repair and maintenance of drinking water systems Disease surveillance Improvement of drinking water facilities
Hills	Landslides and flash flooding are common Increase in incidences of diseases (mostly vector-borne diseases) Extreme temperature and precipitation events Malnutrition and food security issues Water and sanitation challenges in Terai	Loss and damage from climate-induced disasters Damage to drinking water and sanitation facilities An outbreak of diseases (vector and water) Drying of water springs and depletion of water sources	Promoting water-efficient technology and practices (multi-use water system, rainwater harvesting) Rehabilitation of ponds and natural springs Protection of springs by plantation nearby Promotion of integrated water management schemes Protection of tube wells Promotion of water conservation techniques Promotion of bio-engineering practices

Gandaki Province

Geographic location	Main challenges and disaster event	Impact	Midterm adaptation options	Long term adaptation options
Mountain/ hills	Air pollution and excessive carbon in atmosphere Floods Droughts Temperature rise	A decline in quality of health Water infrastructure damage Water source contamination Waterborne disease Water scarcity Wetland shrinkage and biodiversity loss Migration of mosquitoes and pests to the upper regions and resultant increase in vector-borne diseases	Waste segregation Penalty for open dumping of waste Solutions for management of waste generated from households and SMEs Community awareness Advocacy for budget allocation to counteract the disaster-induced problems Empowering community-based organizations–CFUGs, women group and youth club	Integrated urban planning for water sources, forests, and other public lands Health infrastructure development Policy development for wetland conservation Ensuring accountability and transparency in waste management at all levels

Lumbini Province

Challenges posed by climate change and extreme events	Trends of the changes	Impacts and vulnerabilities	Who is or what is most impacted?	Medium-term adaptation options	Long term adaptation options
Hills					
Landslide and floods	Increasing trend Landslide: Siddha baba, Tansen Road Flood: Badganga Fire	Infrastructure damage Road blockage Damage to irrigation facilities Damage to hydropower infrastructures Damage to water sources Damages to settlements Impact on socio-demography Gulmi resettlement (20-25 households) Impact on livelihood assets Loss of life and properties such as agricultural land Impact on human lives Loss of life due to damages Loss of life due to spread of diseases	Squatters, females, pregnant women, the elderly people, people with disability, socially excluded communities such as Dalits, ultra-poor households, and children and infants	Improve data and evidence (MIS) Invest in capacity building Promote bio-engineering (plantation of Amrisso and Bamboo) Implement WSP and contingency plans Protect water sources and arrange alternative ones for drinking water Invest in research and development, particularly for understanding water demand and other issues impacted by climate change Implement a health surveillance system Implement fire control measures, particularly protecting water pipes	Develop reallocation and resettlement plans Implement river protection works Promote rainwater harvesting and other water conservation technologies Implement water-efficient technologies and irrigation systems Conserve and manage water resources and other critical infrastructures Implement guidelines for making water resources and energy production infrastructure more climate-resilient Implement early warning systems

Terai					
Increase in temperature Rainfall variability Other extreme events, e.g., heat waves, cold waves	The frequency, intensity, and magnitude of floods, inundations, heatwaves and cold waves are increasing	Floods: Marchwar flooding Embankment of Tinau: damage to the suspension bridge Impact on the population from heatwaves, cold waves and flooding (e.g., on squatter population around Tinau) Health hazards due to extreme temperature and rainfalls; poor health and sanitation conditions of poor households Damage to infrastructure such as drinking water systems and latrines are causing water pollution and increasing incidences of diseases Damage to other infrastructures such as transmission lines, irrigation canals, roads, suspension bridges, water catchment areas and ponds	The poor households belonging to ethnic groups, Dalits are impacted Women, the elderly, the disease-prone, and children are impacted People living in flood-prone areas, e.g., the squatters and the landless, are impacted	Promote early warning systems including those for disease surveillance Build capacity of local governments Help local and provincial governments develop standard codes for building climate-resilient infrastructure	Implement resettlement plans Develop DRRM and CCA guidelines Invest in water conservation and management technologies Implement sustainable and climate-resilient WASH programmes Implement guidelines to control health hazards, particularly heat waves and cold waves Promote insurance for people and their resources

Karnali Province

Physiography	Climate-related major events	Sectoral impact from climate-related events	Medium-term adaptation options	Long term adaptation options
Mountain/hill	(Increases in) Avalanches GLOFs Floods Landslides Epidemics Cold waves Thunderbolts Animal infestations	Relocation and immigration Increase in unhygienic environments Increase in epidemics River encroachment Springs drying up Spring relocation Food insufficiency Increased temperatures Water pollution Depletion of groundwater	Bio-engineering Tree-plantation and increase greenery and park area near settlements Spring protection (Gabin wire and tree plantation) Rainwater harvesting (via common pond and privately in households) Mainstreaming climate change concerns in every development Green roads Improve access to health, (vaccines, health centre, moveable health centres, blood banks)	Squatter settlement management Integrated settlement plans Develop the building codes based on physiography to ensure climate-sensitive building construction. Increase health centres based on the physical distance and population proportions Develop policy to use the underground water resources Develop high dams and reservoirs at the basin level Consider increased climate change, especially precipitation intensity, while constructing culverts and drainage systems

Sudurpaschim Province

Physiography	Climate-related major events	Sectoral impact from climate-related events	Medium-term adaptation options	Long term adaptation options
Mountain	Increase in river flow due to melting of snow GLOFs Increase in temperatures Landslides Fires	Life and economic loss; migration, cultural transformation Decrease in tourism activities Haphazard urbanization Increase in land/air/water/noise pollution Challenges in solid waste management Loss and damage to physical infrastructure Increase in rate of child mortality Increase in gender inequality and negative impact on female health Decrease in entrepreneurship and income generation Negative impacts in school and education sector Overloading urban infrastructures Depletion of agricultural lands Change in traditional river systems Encroachment of sewerage and drain systems Depletion of the groundwater Increase in vector-borne and water-borne diseases Increase in social conflicts Impacts on good governance	Preparation and implementation of land use plans Proper implementation of environmental impact assessment (EIA) during the construction of development and physical infrastructure Awareness campaigns in society and schools about health and sanitation Implementation of the integrated solid waste management systems and sites Coordination between government, private sector, non-government organization, and relevant stakeholders Afforestation in risk-prone areas Relocation of settlements located in risk-prone areas Increase the accessibility of health services in remote areas Proper management of fecal sludge Identification and conservation of tourism spots Conservation of water resources (lake, ponds, wetland, watersheds)	Revision of national building code with the integration of climatic factor Construction of environment-friendly infrastructure Implementation of an integrated settlement plan Balanced development of infrastructure as per prior needs Afforestation Minimization of exploitation of natural resources Implement concept of groundwater recharge via recharge pits and recharge ponds Preparation of integrated masterplan and policy for infrastructure development
Hill	Landslides Increase in diseases (epidemics) Soil erosion Fires Floods and inundation Droughts			
Terai	Cold waves Heatwaves Windstorms Floods Fires Increase in diseases (epidemics) Riverbank cutting			

Annex 5: Vulnerability and Risk Index of Nepal's districts

District	Exposure	Sensitivity	Adaptive capacity	Vulnerability	Baseline context of climate extreme events	RCP4.5 2030 of climate extreme events	RCP4.5 2050 of climate extreme events	RCP8.5 2030 of climate extreme events	RCP8.5 2050 of climate extreme events	Baseline Risk	RCP4.5 2030 Risk	RCP4.5 2050 Risk	RCP8.5 2030 Risk	RCP8.5 2050 Risk
Achham	0.221	0.874	0.326	0.75	0.511	0.546	0.651	0.517	0.677	0.511	0.546	0.651	0.517	0.677
Arghakhanchi	0.313	0.815	0.598	0.317	0.582	0.697	0.784	0.69	0.848	0.582	0.697	0.784	0.69	0.848
Baglung	0.237	0.713	0.593	0.186	0.577	0.687	0.775	0.654	0.816	0.577	0.687	0.775	0.654	0.816
Baitadi	0.275	0.791	0.488	0.428	0.537	0.579	0.679	0.544	0.721	0.537	0.579	0.679	0.544	0.721
Bajhang	0.189	0.804	0.305	0.683	0.447	0.507	0.588	0.45	0.612	0.447	0.507	0.588	0.45	0.612
Bajura	0.169	0.795	0.262	0.727	0.43	0.476	0.548	0.432	0.588	0.43	0.476	0.548	0.432	0.588
Banke	0.388	0.781	0.513	0.383	0.568	0.634	0.751	0.609	0.784	0.568	0.634	0.751	0.609	0.784
Bara	0.524	0.732	0.398	0.467	0.649	0.747	0.779	0.693	0.836	0.649	0.747	0.779	0.693	0.836
Bardiya	0.389	0.737	0.515	0.32	0.572	0.605	0.723	0.593	0.755	0.572	0.605	0.723	0.593	0.755
Bhaktapur	0.386	0.239	0.793	0	0.607	0.726	0.75	0.625	0.809	0.607	0.726	0.75	0.625	0.809
Bhojpur	0.244	0.707	0.51	0.287	0.584	0.685	0.669	0.603	0.801	0.584	0.685	0.669	0.603	0.801
Chitawan	0.464	0.62	0.702	0	0.635	0.722	0.781	0.67	0.82	0.635	0.722	0.781	0.67	0.82
Dadeldhura	0.179	0.87	0.337	0.73	0.542	0.575	0.673	0.552	0.731	0.542	0.575	0.673	0.552	0.731
Dailekh	0.22	0.932	0.331	0.822	0.505	0.545	0.649	0.521	0.669	0.505	0.545	0.649	0.521	0.669
Dang	0.459	0.779	0.5	0.396	0.576	0.657	0.757	0.633	0.795	0.576	0.657	0.757	0.633	0.795
Darchula	0.14	0.738	0.345	0.543	0.491	0.532	0.625	0.496	0.656	0.491	0.532	0.625	0.496	0.656
Dhading	0.366	0.793	0.582	0.309	0.584	0.71	0.785	0.643	0.821	0.584	0.71	0.785	0.643	0.821
Dhankuta	0.251	0.643	0.536	0.166	0.616	0.716	0.717	0.648	0.84	0.616	0.716	0.717	0.648	0.84
Dhanusha	0.597	0.675	0.394	0.394	0.624	0.725	0.706	0.676	0.852	0.624	0.725	0.706	0.676	0.852
Dolakha	0.247	0.787	0.431	0.498	0.59	0.66	0.682	0.603	0.806	0.59	0.66	0.682	0.603	0.806
Dolpa	0.028	0.818	0.214	0.821	0.375	0.447	0.532	0.42	0.572	0.375	0.447	0.532	0.42	0.572
Doti	0.175	0.784	0.253	0.725	0.524	0.566	0.671	0.523	0.693	0.524	0.566	0.671	0.523	0.693
Eastern Rukum	0.197	0.673	0.454	0.314	0.52	0.585	0.663	0.548	0.702	0.52	0.585	0.663	0.548	0.702
Gorkha	0.362	0.748	0.558	0.279	0.514	0.625	0.72	0.577	0.754	0.514	0.625	0.72	0.577	0.754
Gulmi	0.373	0.809	0.803	0.042	0.592	0.717	0.805	0.691	0.841	0.592	0.717	0.805	0.691	0.841
Humla	0.037	1	0.265	1	0.388	0.426	0.481	0.364	0.508	0.388	0.426	0.481	0.364	0.508
Ilam	0.337	0.758	0.619	0.213	0.705	0.828	0.809	0.823	0.912	0.705	0.828	0.809	0.823	0.912
Jajarkot	0.127	0.868	0.41	0.634	0.507	0.565	0.652	0.515	0.669	0.507	0.565	0.652	0.515	0.669
Jhapa	0.677	0.746	0.565	0.267	0.768	0.891	0.876	0.934	1	0.768	0.891	0.876	0.934	1
Jumla	0.073	0.888	0.288	0.82	0.486	0.524	0.586	0.469	0.622	0.486	0.524	0.586	0.469	0.622
Kailali	0.522	0.928	0.366	0.772	0.575	0.601	0.708	0.581	0.745	0.575	0.601	0.708	0.581	0.745
Kalikot	0.087	0.902	0.279	0.849	0.462	0.5	0.581	0.451	0.597	0.462	0.5	0.581	0.451	0.597
Kanchanpur	0.315	0.901	0.293	0.83	0.578	0.609	0.695	0.572	0.77	0.578	0.609	0.695	0.572	0.77
Kapilbastu	0.511	0.756	0.556	0.292	0.609	0.692	0.768	0.701	0.83	0.609	0.692	0.768	0.701	0.83
Kaski	0.391	0.651	0.648	0.032	0.61	0.721	0.814	0.691	0.864	0.61	0.721	0.814	0.691	0.864
Kathmandu	1	0.384	1	0	0.601	0.738	0.766	0.637	0.812	0.601	0.738	0.766	0.637	0.812
Kavrepalanchok	0.447	0.611	0.708	0	0.613	0.721	0.738	0.646	0.834	0.613	0.721	0.738	0.646	0.834
Khotang	0.278	0.835	0.647	0.28	0.568	0.66	0.644	0.591	0.789	0.568	0.66	0.644	0.591	0.789
Lalitpur	0.462	0.339	0.757	0	0.6	0.703	0.729	0.627	0.808	0.6	0.703	0.729	0.627	0.808
Lamjung	0.169	0.704	0.557	0.222	0.585	0.702	0.8	0.66	0.836	0.585	0.702	0.8	0.66	0.836
Mahottari	0.542	0.687	0.311	0.519	0.628	0.731	0.725	0.719	0.864	0.628	0.731	0.725	0.719	0.864
Makawanpur	0.431	0.557	0.597	0	0.63	0.725	0.772	0.658	0.82	0.63	0.725	0.772	0.658	0.82

Manang	0.007	0.633	0.385	0.35	0.43	0.531	0.628	0.492	0.664	0.43	0.531	0.628	0.492	0.664
Morang	0.683	0.857	0.54	0.45	0.699	0.802	0.794	0.803	0.909	0.699	0.802	0.794	0.803	0.909
Mugu	0.04	0.978	0.284	0.944	0.41	0.445	0.505	0.382	0.528	0.41	0.445	0.505	0.382	0.528
Mustang	0.013	0.601	0.344	0.361	0.326	0.409	0.519	0.409	0.568	0.326	0.409	0.519	0.409	0.568
Myagdi	0.113	0.716	0.428	0.406	0.531	0.626	0.715	0.612	0.781	0.531	0.626	0.715	0.612	0.781
Nawalpur	0.231	0.776	0.409	0.511	0.637	0.722	0.777	0.683	0.827	0.637	0.722	0.777	0.683	0.827
Nuwakot	0.28	0.778	0.493	0.405	0.591	0.743	0.811	0.656	0.844	0.591	0.743	0.811	0.656	0.844
Okhaldhunga	0.266	0.487	0.642	0	0.574	0.666	0.649	0.595	0.79	0.574	0.666	0.649	0.595	0.79
Palpa	0.44	0.742	0.638	0.167	0.622	0.745	0.815	0.696	0.845	0.622	0.745	0.815	0.696	0.845
Panchthar	0.251	0.761	0.524	0.341	0.647	0.785	0.767	0.741	0.86	0.647	0.785	0.767	0.741	0.86
Parasi	0.283	0.805	0.372	0.598	0.637	0.722	0.777	0.683	0.827	0.637	0.722	0.777	0.683	0.827
Parbat	0.171	0.687	0.533	0.231	0.647	0.775	0.865	0.74	0.894	0.647	0.775	0.865	0.74	0.894
Parsa	0.501	0.701	0.35	0.487	0.65	0.719	0.769	0.686	0.818	0.65	0.719	0.769	0.686	0.818
Pyuthan	0.444	0.666	0.673	0.02	0.568	0.679	0.763	0.654	0.807	0.568	0.679	0.763	0.654	0.807
Ramechhap	0.286	0.797	0.378	0.58	0.585	0.67	0.664	0.6	0.797	0.585	0.67	0.664	0.6	0.797
Rasuwa	0.059	0.782	0.263	0.708	0.505	0.628	0.72	0.565	0.774	0.505	0.628	0.72	0.565	0.774
Rautahat	0.64	0.685	0.352	0.463	0.638	0.759	0.782	0.692	0.842	0.638	0.759	0.782	0.692	0.842
Rolpa	0.28	0.812	0.557	0.366	0.54	0.622	0.714	0.584	0.743	0.54	0.622	0.714	0.584	0.743
Rupandehi	0.768	0.931	0.578	0.5	0.626	0.686	0.732	0.677	0.802	0.626	0.686	0.732	0.677	0.802
Salyan	0.242	0.951	0.529	0.589	0.543	0.609	0.717	0.574	0.727	0.543	0.609	0.717	0.574	0.727
Sankhuwasabha	0.219	0.7	0.482	0.313	0.675	0.784	0.802	0.712	0.904	0.675	0.784	0.802	0.712	0.904
Saptari	0.551	0.707	0.353	0.49	0.635	0.735	0.709	0.835	0.903	0.635	0.735	0.709	0.835	0.903
Sarlahi	0.604	0.684	0.388	0.415	0.631	0.746	0.76	0.709	0.862	0.631	0.746	0.76	0.709	0.862
Sindhuli	0.386	0.816	0.453	0.508	0.616	0.728	0.718	0.667	0.846	0.616	0.728	0.718	0.667	0.846
Sindhupalchok	0.282	0.797	0.393	0.56	0.587	0.693	0.76	0.639	0.843	0.587	0.693	0.76	0.639	0.843
Siraha	0.533	0.694	0.34	0.491	0.623	0.721	0.689	0.765	0.829	0.623	0.721	0.689	0.765	0.829
Solukhumbu	0.147	0.703	0.454	0.354	0.555	0.638	0.661	0.572	0.769	0.555	0.638	0.661	0.572	0.769
Sunsari	0.648	0.803	0.53	0.39	0.657	0.763	0.744	0.729	0.873	0.657	0.763	0.744	0.729	0.873
Surkhet	0.239	0.998	0.285	0.971	0.542	0.578	0.687	0.564	0.717	0.542	0.578	0.687	0.564	0.717
Syangja	0.312	0.64	0.66	0.002	0.657	0.789	0.882	0.752	0.901	0.657	0.789	0.882	0.752	0.901
Tanahu	0.412	0.63	0.822	0	0.651	0.778	0.869	0.741	0.879	0.651	0.778	0.869	0.741	0.879
Taplejung	0.146	0.659	0.421	0.337	0.642	0.776	0.794	0.713	0.871	0.642	0.776	0.794	0.713	0.871
Terhathum	0.145	0.734	0.465	0.381	0.625	0.76	0.745	0.682	0.853	0.625	0.76	0.745	0.682	0.853
Udayapur	0.26	0.57	0.575	0.019	0.596	0.703	0.678	0.634	0.815	0.596	0.703	0.678	0.634	0.815
Western Rukum	0.061	0.889	0.232	0.894	0.52	0.585	0.663	0.548	0.702	0.52	0.585	0.663	0.548	0.702


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