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Climate Change Scenarios for Nepal

National Adaptation Plan

February 2019

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FOREWORD

The Government of Nepal (GoN) is committed to responding to climate change risks and impacts through integrated policies and affirmative action. The GoN, as a party to the United Nations Framework Convention on Climate Change (UNFCCC), initiated the National Adaptation Plan (NAP) formulation process in September 2015. The NAP process was established to build on the country's rich experience in addressing adaptation via the National Adaptation Programme of Action (NAPA), and through it, to address medium-term and long-term adaptation. The process aims at addressing the impacts of climate change by building adaptive capacities and resilience, and by facilitating the integration of climate change adaptation into development planning. The NAP formulation process in Nepal is led by the Ministry of Forests and Environment (MoFE). The MoFE has formed with seven Thematic Working Groups and two cross-cutting working groups, which focus on the major climate change-sensitive sectors, in the NAP formulation process.

This report, Climate Change Scenarios for Nepal, has been developed through the collaborative efforts of the MoFE, the Department of Hydrology and Meteorology (DHM), the International Centre for Integrated Mountain Development (ICIMOD), FutureWater, the NAP expert team, Action on Climate Today, and Practical Action. It used select Global Circulation Models (GCMs) from Coupled Model Inter comparison Project Phase 5 (CMIP5) datasets of the IPCC's Fifth Assessment Report (AR5). Future climate change scenarios were analysed for the medium-term period (2016–2045) – corresponding with the 2030s – and the long-term period (2036–2065) – corresponding with the 2050s – with respect to the reference period 1981–2010, as identified by the process.

Overall, the report's findings suggest that future precipitation and temperatures will be higher than in the reference period. In particular, variables related to temperature are expected to increase continuously throughout the twenty-first century. Extreme climate events, especially those corresponding to temperature, are likely to be more frequent, longer-lasting, and more severe. These changes may have a serious and adverse impact on sectors such as water, energy, biodiversity, agriculture, and consequently on the livelihoods of millions. These findings can contribute significantly in devising future policies and plans pertaining to the socioeconomic and environmental sectors in Nepal.

On behalf of the MoFE, I appreciate the efforts of DHM,ICIMOD and individuals from the other organizations involved in preparing this document, and the members of the thematic and cross-cutting working groups for guiding the process.

I sincerely thank Himalayan Adaptation, Water and Resilience Research (HI-AWARE) and Rural Livelihood and Climate Change Adaptation in Himalayas (HIMALICA) projects led by ICIMOD, Action on Climate Today (ACT), a UK AID-funded initiative led by Oxford Policy Management Limited (OPML), and Practical Action for providing funding and technical support.

Bishwa Nath Oli, PhD
Secretary

PREFACE

The impacts of climate change on different sectors constitute a serious threat to Nepal's economy and society. In order to plan and implement a successful adaptation strategy, it is vital to understand the patterns of a changing climate and, in particular, how they are likely to evolve in the future. Accordingly, the Ministry of Forests and Environment (MOFE), Government of Nepal, initiated the National Adaptation Plan (NAP) formulation process in September 2015 to develop medium- and long-term adaptation strategies.

Adaptation plans need to be developed on the basis of a strong scientific foundation and reliable evidence. This includes data and information about how the climate has changed in the past and how it may likely change in the future. The Department of Hydrology and Meteorology (DHM) has supported the NAP formulation process by studying and publishing a report in June 2017 on climatic trends in Nepal using historical data. The report presented here, Climate Change Scenarios for Nepal, has been prepared with technical inputs from the International Centre for Integrated Mountain Development (ICIMOD) and the DHM. It aims to highlight varied climate change scenarios for Nepal and is designed particularly for the NAP formulation process.

This report foregrounds changes in precipitation and temperature for the medium-term (2016–2045) and long-term periods (2036–2065) – periods corresponding to the 2030s and 2050s respectively – with respect to the reference period (1981–2010) as laid out by the NAP formulation process. Its findings suggest that temperature variables are expected to increase continuously throughout the 21st century. Mean temperature could rise by 0.9–1.1 degrees Celsius (^{0}C) in the medium-term period and 1.3–1.8 ^{0}C in the long-term period. Consequently, extreme climate events are likely to be more frequent and severe.

The DHM has a mandate from the Government of Nepal to monitor all hydrological and meteorological activities in Nepal. The scope of work includes the collection and dissemination of hydro-meteorological data and monitoring of river hydrology, climate, climate change, agrometeorology, sediment, water quality, limnology, snow hydrology, glaciology, wind, and solar energy. Public and aviation weather forecasts and flood forecasts are the regular services provided by the DHM.

ICIMOD was established in 1983 as a regional, intergovernmental knowledge-sharing centre serving the eight member countries of the Hindu Kush Himalaya – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. It aims at helping mountain people of the region understand changes arising from globalization and climate change and assisting them in adapting to these changes and making the most of new opportunities.

The DHM and ICIMOD have been collaborating for several years on issues related to hydrology, monitoring environmental processes, the development of early warning systems for floods, and climatic changes and their impacts. The two institutions are delighted to publish this report. We would like to thank Rishi Ram Sharma, Archana Shrestha, Indira Kandel, and Bikas Nepal from the DHM, who provided technical guidance and were involved in this study. We would also like to thank Arun B. Shrestha, Santosh Nepal, Saurav Pradhananga, Vishwas Chitale, Bimal Regmi, and Giovanna Gioli from ICIMOD, who were involved in the NAP formulation process. Santosh Nepal, Saurav Pradhananga, Arthur Lutz, Archana Shrestha, and Arun B. Shrestha conducted the technical analysis for this report. Thanks are also due to the NAP expert team, which provided valuable suggestions for the preparation of the report.

We sincerely believe that the data, methods, and information about the future climate scenarios for Nepal, including climatic extremes, presented in this study will prove very valuable, not only in improving our understanding of the impacts of climate change but also in preparing adaptation plans for different sectors in Nepal accordingly.

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Director General, DHM

Maheshwar Dhakal, PhD
Chief, Climate Change Management Division, MoFE

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Director General, ICIMOD

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LIST OF ACRONYMS

ACT	Action on Climate Today
AR5	Fifth Assessment Report
CCI	Commission for Climatology of the World Meteorological Organization's World Climate Data and Monitoring Programme
CDD	Consecutive Dry Days
CLIVAR	Climate Variability and Predictability Programme of the World Climate Research Programme
CMIP5	Coupled Model Intercomparison Project Phase 5
COP	Conference of the Parties
CSDI	Cold Spell Duration Index
CWD	Consecutive Wet Days
CWG	Cross-cutting Working Groups
DHM	Department of Hydrology and Meteorology, Nepal
ECDF	Empirical Cumulative Distribution Functions
ETCCDI	Expert Team on Climate Change Detection and Indices
GCM	Global Circulation Model
GPCC	Global Precipitation Climatology Centre
IPCC	Intergovernmental Panel on Climate Change
IDRC	International Development Research Centre
JCOMM	Joint World Meteorological Organization-Intergovernmental Oceanographic Commission Technical Commission for Oceanography and Marine Meteorology
LAPA	Local Adaptation Plans of Action
LDC	Least Developed Countries
LEG	LDC Expert Group
MoFE	Ministry of Forests and Environment, Nepal
MoPE	Ministry of Population and Environment, Nepal
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
QM	Quantile Mapping
RCM	Regional Climate Model
RCPs	Representative Concentration Pathways
TWG	Thematic Working Groups
WFDEI	WATCH Forcing Data ERA - Interim
WSDI	Warm Spell Duration Index
UNFCCC	United Nations Framework Convention on Climate Change

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EXECUTIVE SUMMARY

The Government of Nepal has recognized climate change adaptation as fundamental to safeguarding vulnerable communities, ecosystems, and relevant climate-sensitive sectors from the impacts of climate change. The National Adaptation Plan (NAP) process was initiated in Nepal in September 2015, as mandated by the Conference of the Parties to the United Nations Framework Convention on Climate Change at its Sixteenth Session (COP 16) in Cancun in 2010. The NAP will build on the experience of preparing and implementing the National Adaptation Programme of Action (NAPA) 2010, and will formulate plans to address the medium-term and long-term adaptation needs of the country.

The key to successful adaptation is to anticipate how the climate will evolve in the future. This report provides medium-term and long-term climate change scenarios for Nepal, which are modelled representations of an evolving climate. The study used select Global Circulation Models (GCMs) from the CMIP5 dataset, which also forms the physical science basis of the IPCC's Fifth Assessment Report (AR5). The GCMs were selected based on multiple criteria, covering all combinations of cold, warm, dry, and wet conditions, and provide a range of possible changes in the future based on the ensemble and climate change indices.

The Fifth Assessment Report identified four scenarios, or Representative Concentration Pathways (RCPs) – RCP2.6, RCP4.5, RCP6, and RCP8.5. Each of them represent different volumes of greenhouse gas emissions, and hence varied levels of their concentrations in the atmosphere in the year 2100, implying a particular development trajectory taken. Each RCP is denoted by its respective total radiative forcing – or energy imbalance, measured in watts per meter squared – in the year 2100 relative to 1750. For instance, RCP4.5 denotes a radiative forcing of 4.5 Wm-2. There is a direct causal relationship between the level of radiative forcing and eventual average warming in the long run.

Of these four RCPs, two possible trajectories – RCP4.5 and RCP8.5 – were chosen as representations of extreme future scenarios based on different socioeconomic and developmental trajectories. Future climate change scenarios were analysed for the medium-term period (2016–2045) and the long-term period (2036-2065) – periods corresponding with the 2030s and 2050s respectively – with respect to the reference period 1981–2010, as laid out by the National Adaptation Plan process.

Key findings

The major findings of the study are the following:

A. Regarding changes in precipitation and temperature in future periods:

1. Average annual precipitation is likely to increase in both the medium-term and long-term periods. Average annual precipitation is likely to increase by 2–6% in the medium-term period and by 8–12% in the long-term period. [Table 8, Figure 8, Section 4.2]

2. Average annual mean temperature is likely to rise. Mean temperature could increase by 0.9–1.1 degrees Celsius (°C) in the medium-term period and 1.3–1.8 °C in the long-term period. [Table 8, Figure 7, Section 4.1]

3. Both the average annual mean temperature and the average annual precipitation are projected to increase until the end of the century. Precipitation could increase by 11–23%, and mean temperature might increase by 1.7–3.6 °C by 2100. [Table 8, Section 4.2]

4. 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 period, and 1.8–2.4 °C in the long-term period) and the winter season (1.0–1.2 °C in the medium-term period, and 1.5–2.0 °C in the long-term period). [Table 10, Section 4.2]

5. Precipitation is projected to increase, barring the pre-monsoon season. 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 period. The post-monsoon season might have the highest increase in precipitation with respect to the reference period, possibly going up by 6–19% in the medium-term and 19–20% in the long-term. [Table 10, Section 4.2]

6. Projections about precipitation in the future have a large degree of uncertainty, greater than temperature projections. The uncertainty in temperature projections in this report is smaller than regarding precipitation. Agreement between different climate models is larger for temperature, as compared to precipitation. Collectively, these results suggest that projections regarding temperature-related changes are more certain than the projected changes in precipitation. [Table 11, Figure 10, Section 4.3]

B. Regarding changes related to climate extremes in future periods:

1. Intense precipitation events are likely to increase in frequency, with extremely wet days (P99) expected to increase at a higher rate than very wet days (P95). [Table 12, Figures 11 and 12, Section 4.4.1]

2. The number of rainy days is likely to decrease in the future. This, in combination with the increase in precipitation intensity, is likely to create more water-related hazards in the future. [Table 12, Figure 13, Section 4.4.1]

3. Future changes in consecutive dry days (CDD) and consecutive wet days (CWD) varies with the RCP scenarios. The RCP4.5 scenario projects a likely increase in CDD, while the extreme scenario RCP8.5 projects a likely decrease. In agreement with this trend, CWD is projected to decrease under the RCP4.5 scenario, and is likely to increase under RCP8.5. [Table 12, Figures 14 and 15, Section 4.4.1]

4. Both warm days and warm nights are likely to increase in the future. The number of warm days will rise sharply, from 36 days to 60 days a year in the medium-term, and to 68 days a year in the long-term period, under the RCP4.5 scenario. This is in concurrence with increasing temperature trends in the future. [Table 12, Figures 16 and 17, Section 4.4.2]

5. Both cold days and cold nights are likely to decrease in future. The number of cold days decline by 42–53% under the RCP4.5 scenario over the two periods in this study. This too is in concurrence with increasing temperature trends. [Table 12, Figures 18 and 19, Section 4.4.2]

6. The duration of warm spells, of at least six days of high maximum temperatures, are likely to increase sharply in the future under both RCP4.5 and RCP8.5 scenarios. This is in conjunction with increasing temperature trends and increasing warm days of the future periods. [Table 12, Figure 20, Section 4.4.2]

7. The duration of cold spells are likely to decrease in the future as indicated by the cold spell duration index under both RCP4.5 and RCP8.5 which is in conjunction with increasing temperature trends and decreasing cold days of the future periods. [Table 12, Figure 21, Section 4.4.2]

The study suggests that in general, the climate in all of Nepal will be significantly warmer and wetter in the future, except for a decrease in precipitation during the pre-monsoon season. Indices of climate extremes related to temperature and precipitation suggest that more extreme events are likely in the future. This is expected to affect different developmental sectors, such as water, disaster management, energy, biodiversity, agriculture, health, urban planning and livelihoods. A better understanding of these changes will help to design better adaptation strategies, and implement them in a more sustainable manner.

1. INTRODUCTION

1.1. Background of the NAP Process

The Government of Nepal has recognized climate change adaptation as fundamental to safeguarding vulnerable communities, ecosystems, and relevant sectors. To address this challenge, Nepal prepared the National Adaptation Programme of Action (NAPA) in September 2010 as a way of addressing the impacts made by climate change. Nepal also prepared the National Framework on Local Adaptation Plans of Action (LAPA) to implement adaptation actions at the local level and to ensure integration of climate change adaptation into every level of the national planning process. The National Adaptation Process (NAP) has been initiated in Nepal as mandated by the Conference of the Parties to the United Nations Framework Convention on Climate Change at its Sixteenth Session (COP 16), which will build on the experiences of preparing and implementing NAPAs. The conference of the parties to the UNFCCC at its 17th session (COP17) held in Durban, South Africa issued the initial guidelines for the NAP formulation. As per its mandate, the LDC Expert Group (LEG) prepared the NAP Technical Guidelines to provide guidance to Least Developed Countries (LDCs) on the NAP formulation process.

The NAP intends to develop adaptation strategies needed to tackle the effects of climate change on vulnerable communities and ecosystems. The NAP formulation process in Nepal is led by the Ministry of Forests and Environment (MoFE) (Formarly Ministry of Population and Environment). The MoFE has engaged seven Thematic Working Groups (TWGs) and two Cross-cutting Working Groups (CWGs), which cover the major sectors sensitive to climate change.

The objective of the NAP process is to reduce vulnerability to the impacts of climate change by building adaptive capacity and resilience. It seeks to facilitate a coherent integration of climate change adaptations into new as well as existing policies, programmes and activities, giving particular and appropriate attention to the processes and strategies of development planning within all relevant sectors and at all levels of planning. Understanding the urgency of enhancing initiatives to address medium-term and long-term adaptation needs, the Government of Nepal, Ministry of Forests and Environment (MoFE) – the focal point for UNFCCC – launched the NAP formulation process in September 2015. This has paved the way to explore supports, to promote wider participation and engagement of partners, and to involve professionals in the NAP process (MoPE, 2016).

To understand the impacts of climate change on different sectors, the historical trends and future climate scenarios of different climatic parameters need to be assessed. This assessment provides a basis to design adaptation pathways based on the likely climate change trajectories under different climate and socio-economic development scenarios. As climate change may affect different sectors in non-uniform ways, a study of possible climate change scenarios, including future climate extremes, would be very useful in quantifying risks including vulnerabilities in each sector. However, as the climate projections have a large degree of uncertainty arising from different sources (such as representation of atmospheric process by GCMs and future socio-economic and development pathways), understanding uncertainties of these projections is essential for informed decision making by policy makers.

1.2. About this Study

The study used select GCMs from the Coupled Model Intercomparison Project Phase (CMIP 5) dataset of the recent Fifth Assessment Report (AR5) of Intergovernmental Panel on Climate Change (IPCC). The

GCMs were selected based on the skill of the models to represent the annual cycle of precipitation and temperature in Nepal as well as their suitability in forecasting a range of possible changes based on climate change indices.

The objective of this study is to analyze the climate change scenarios of Nepal in the medium-term and the long-term periods, i.e., by 2030 and 2050 as defined by the NAP process. The specific objectives are:

i) to estimate the changes in precipitation and temperature patterns for the respective future periods in districts and physiographic zones of Nepal at the annual and seasonal levels, and

ii) to analyze select climate extreme indices for two RCP scenarios in order to understand the magnitude of changes in the respective future periods.

2. CURRENT STATE OF CLIMATE CHANGE STUDIES IN NEPAL

Climate change is a serious threat to Nepal. The impact of climate change has been observed in various sectors, such as water, forestry, biodiversity, agriculture, and cryosphere. Impact on these sectors is very likely to affect the livelihood of local communities. As suggested by IPCC (2013), climate-related changes, such as variability in temperature, precipitation, and extreme weather events, can affect the environment and a wide range of sectors, such as water, disaster risk reduction, agriculture, industry, as well as recreational activities.

Temperature has been increasing in Nepal in the past few decades. The maximum temperature in Nepal increased at a rate of 0.06 °C/year between 1978 and 1994, with higher rates at stations located at higher altitudes. Warming in winter has been especially pronounced (Shrestha et al., 1999). Similarly, a decreasing trend in cool days and cold nights and an increasing trend in warm nights has been observed (Baidya et al., 2008). Studies carried out in various parts of Nepal and river basins also suggest similar direction of changes. In the eastern Koshi river basin, maximum temperature has increased by 0.058 °C/year over the last four decades (Nepal, 2016). Another study indicated that daily maximum temperature increased by 0.1 °C/decade on average between 1975 and 2010 and the minimum by 0.3 °C/decade (Shrestha et al., 2017). In Karnali, both minimum and maximum temperatures were found to be increasing, and the increase in pre-monsoon season was significantly higher with 0.08 °C/year (Khatiwada et al., 2016).

Regarding change in precipitation, however, there is still a lack of a clear trend. One study found that there were no distinct trends in precipitation in the Nepal Himalayas between 1959 and 1994 (Shrestha et al., 2000). Using data from 1961-2006, another study found an increasing trend in total and heavy precipitation (Baidya et al., 2008). In the Gandaki river basin, the post-monsoon, pre-monsoon, and winter rainfalls are reportedly decreasing at a significant rate in most of the basin, but monsoon rainfall is increasing throughout the basin (Panthi et al., 2015). In the hill region, the annual rainfall is increasing, but the trends for rainy days are unclear. In the eastern Koshi river basin, Nepal (2016) found an increasing trend in annual precipitation at 22 of 36 stations and a decreasing trend at 14 stations, but the results were significant at only three stations (two increasing and one decreasing). Similarly, Shrestha et al. (2017) report that the frequency and intensity of weather extremes are increasing in the Koshi river basin. Localized trends in precipitation in the Koshi catchment have also been detected, although the findings lacked a basin-wide significance (Sharma et al., 2000). In the Karnali river basin, Khatiwada et al. (2016) show that the average precipitation in the basin is heterogeneous, and the trend for most of the stations is decreasing. The precipitation shows decreasing trend by 4.91 mm/year, i.e., around 10% on average.

A recent study by DHM Nepal (DHM, 2017) on observed climate trend analysis for the period of 1975-2014 suggests a significant positive trend in annual maximum temperature data at the rate of 0.056 °C/year. All Nepal minimum temperature trend is increasing at the rate of 0.02 °C/year, which is significant during the monsoon season only. This study, too found the precipitation trends to be less clear. Only in a few districts, the pre-monsoon and monsoon precipitations show significant upward trends, whereas pre-monsoon precipitation shows a significant negative trend in the High Himalayan region. The number of rainy days is increasing significantly mainly in the northwestern districts. Very wet and extremely wet days are decreasing significantly, mainly in the northern districts. Trends in warm days and warm nights show significant increase in the majority of the districts. Similarly, warm spell duration is increasing significantly in the majority of the districts.

Pre-monsoon precipitation is significantly increasing in the lowlands and the central Himalayan regions, while monsoonal precipitation is increasing in middle mountains in the western region and central high mountains (Karki et al., 2017). In contrast, post-monsoon precipitation is significantly decreasing across all of Nepal, while winter precipitation is decreasing only in the western middle mountain region. The study suggests that the intensification of different precipitation indices over distinct parts of the country indicates region-specific risks of floods, landslides, and droughts.

The climate scenarios data based on GCM and Regional Climate Models (RCMs) also suggest a continuous warming trend until the end of the century for the whole Himalayan region (Lutz et al., 2014), including Nepal (NCVST, 2009; Nepal, 2016; Rajbhandari et al., 2016). Although a change in precipitation is highly variable among the climate models, most of the models indicate an increase in precipitation towards the end of the century. Table 1 shows the results from the climate change scenarios studies in Nepal of selected basins. Overall, most of the studies suggest that the magnitude of change might vary depending upon the climate models used, selection of data period, and methodological approach. These changes are likely to affect hydrological regimes, water resources, and water-related hazards (floods and flash floods) in the future. However, assessment and studies are available only on catchment basis and information specific to the whole of Nepal based on AR5 of IPCC is still lacking.

Table 1: Climate change scenarios from previous studies

Study area	Climate data	Study period		Major findings	Reference
		Reference	Future		
Koshi river basin	8 GCMs (RCP4.5 and RCP8.5)	1961-1990	2021-2050	5-25% increase in monsoon precipitation.	(Rajbhandari et al., 2016)
Koshi river basin	PRECIS RCM (A1B)	2000-2010	2040-2050 2086-2096	14% increase in precipitation. 4 °C increase in temperature by the end of the century.	(Nepal, 2016)
Nepal	15 GCMs, 2 RCMs (A2,A1B,B2)	1970-1999	2030s, 2060s, 2090s	3.0-6.3 °C, with a multi-model mean of 4.7 °C, by the 2090s. +43 to +80 %, with a multi-model mean of +8%, by the 2090s.	(NCVST, 2009)
Koshi river basin	10 General Circulation Models (B1, A1B and A2).	1971-2000	2011-2030 (2020s), 2046-2065 (2055)s, 2080-2099 (2090s)	Length of the wet and dry spell is expected to increase and decrease respectively. Maximum number of days with heavy precipitation is expected to decrease during the 2020s. For some variables, there is no consensus between GCMs about the direction of changes.	(Agarwal, Babel, & Maskey, 2014)
Koshi river basin	10 GCMs (B1, A1B and A2)	1971-2000	2011-2030 (2020s), 2046-2065 (2055)s, 2080-2099 (2090s)	Increase in seasonal, annual minimum and maximum temperature throughout the century. The increase in temperature is likely to be higher in the mountains than in the plains. The temperature of the coldest day, coldest night, warmest day and warmest night are also expected to increase.	(Agarwal et al., 2016)

Tama Koshi river basin	HADCM3 (SRES A2 and B2) and CGCM3 for (SRES A2 and A1B scenarios) downloaded through statistical downscaling	1960-1990	2010–2019 2020–2029 2030–2039 2040–2049 2050–2059	The mean temperature is projected to increase at a rate of 0.025 °C/year, while mean precipitation is projected to increase at a rate of 5.6 mm/year until 2050.	(Khadka, Babel, Shrestha & Tripathi, 2014)
Tama Koshi river basin	MIROC-ESM, MRI-CGCM3, and MPI-ESM-M GCMs for RCP4.5 and RCP8.5	1975-2004	2015–2039 (the 2030s), 2040–2069 (the 2060s), 2070–2099 (the 2090s)	The minimum and maximum temperature are projected to increase by 6.33 and 3.82 ºC respectively by 2100. The projected precipitation varies from -8% to +25%.	(Shrestha, Bajracharya, & Babel, 2016)

Temperature has been increasing in Nepal in the past few decades. The maximum temperature in Nepal increasing at the rate of 0.02 ºC/year, which is significant during the monsoon season only. This study, too found the precipitation trends to be less clear. Only in a few districts, the pre-monsoon and monsoon precipitations show significant upward trends, whereas pre-monsoon precipitation shows a significant negative trend in the High Himalayan region. The number of rainy days is increasing significantly mainly in the northwestern districts. Very wet and extremely wet days are decreasing significantly, mainly in the northern districts. Trends in warm days and warm nights show significant increase in the majority of the districts. Similarly, warm spell duration is increasing significantly in the majority of the districts.

3. METHODOLOGICAL APPROACH OF FUTURE SCENARIOS ANALYSIS

Summary of the methodological approach

With the introduction of CMIP5 GCMs as a part of the IPCC Fifth Assessment Report, new GCM data with an improved representation of climate processes are now available. Selecting relevant climate models from the pool of approximately 100 GCMs and four RCPs for the area of interest is a challenging task. The selection criteria could vary based on the objective of the study and subjects chosen. This section details the process for selecting relevant GCMs. We used a three-step methodology for choosing the relevant models for Nepal as suggested by Lutz et al. (2016), which considers: i) long-term changes in future precipitation and temperature, ii) changes in future climatic extremes, and iii) the ability of the model to replicate annual cycle of historic precipitation and temperature of Nepal. To understand the projected future changes in Nepal for the NAP purpose, the models were selected for two Representative Concentration Pathways (RCPs) — RCP4.5 and RCP8.5 — keeping in mind the uncertainties of the projected future changes. The results are presented for a change in precipitation and temperature for districts and physiographic zones in the medium-term period 2016-2045 and the long-term period 2036-2065, respectively corresponding with the specifications of 2030s and 2050s by the NAP process. The future projection is provided in the range suggested by RCP4.5 and RCP8.5 so that adaptation plans can be proposed with consideration of these possible ranges of future changes. In addition, we also looked at the period of 2071-2100 to understand how the climate might change by the end of the century. Select climate extreme indices were also analyzed for the same time periods. The future climate scenarios are helpful in providing a range of projected climate change and in proposing adaptation strategies for various sectors that might get affected.

A detailed description of the methods is provided below.

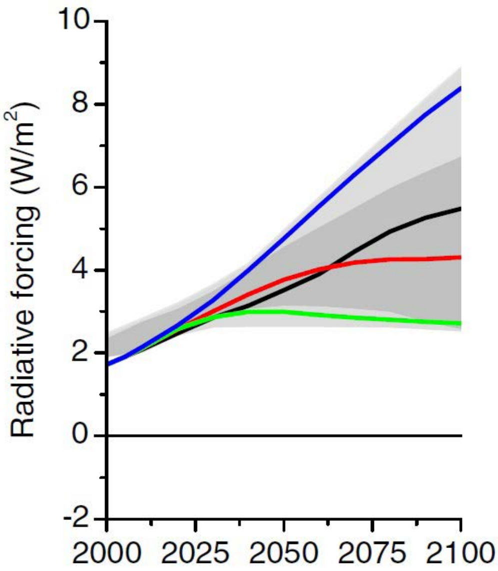
3.1. Representative Concentration Pathways

The IPCC Fifth Assessment Report has endorsed representative concentration pathways (RCPs) to project global future climate scenarios. The four RCPs represent the possible trajectories of greenhouse gas concentration depending on the level of future emissions. The four RCPs together span the range of radiative forcing values for the year 2100 from 2.6 to 8.5 W/m^2 (Figure 1 and Table 2). Climate modellers use the time series of future radiative forcing from the four RCPs for their experiments to produce climate scenarios and related climate variables, such as precipitation and temperature (Moss et al., 2010). The four selected RCPs were considered to be representative of the literature and included one mitigation scenario (RCP2.6), two medium stabilization scenarios (RCP4.5 and RCP6), and one very high baseline emission scenario (RCP8.5) (van Vuuren et al., 2011).

Table 2: Description and visualization of the four representative concentration pathways (RCPs) (van Vuuren et al., 2011).

RCP8.5	Rising radiative forcing pathway leading to 8.5 W/m^2 (~1370 ppm CO_2eq) by 2100
RCP6	Stabilization without overshoot pathway to 6 W/m^2 (~850 ppm CO_2eq) at stabilization after 2100
RCP4.5	Stabilization without overshoot pathway to 4.5 W/m^2 (~650 ppm CO_2eq) at stabilization after 2100
RCP2.6	Peak in radiative forcing at ~3 W/m^2 (~490 ppm CO_2eq) before 2100 and then decline (the selected pathway declines to 2.6 Wm^2 by 2100

Figure 1: RCPs. Blue: RCP8.5, Black: RCP6, Red: RCP4.5, Green: RCP2.6 (van Vuuren et al., 2011).



As it is very difficult to pinpoint the exact future projections at this moment, the four RCP scenarios provide a possible range of future based on socio-economic development and policy response.

3.2. Approaches to Scenarios Analysis

For the purpose of developing climate scenarios of Nepal, we have used an ensemble approach of choosing four GCMs, which provide a range of possible future scenarios for RCP4.5 and RCP8.5 instead of pinpointing a change in just one future direction. While some approaches provide a future change in a definite value (such as 2.5 °C by 2050), an ensemble approach provides a possible range of change by considering the chosen RCPs. This approach has been used by Lutz (2016) to select representative climate models for the Himalayan region.

To develop adaptation strategies, a robust information on future climate change is required. At the same time, the adaptation options need to be flexible enough to account for the uncertainties in climate projections. It is difficult to suggest what the future will look like at a certain point of time, as it depends on socio-economic development, global climate change negotiations, as well as national and international policies that can all affect the magnitude of greenhouse gases emission, mitigation, and adaptation practices. Development of adaptation options and related plans need to consider uncertainties and remain flexible. Ensemble approaches are, thus, the most prudent way of projecting possible changes in the future.

3.3. Types of Climate Models and Downscaling

GCMs are used to simulate global atmospheric processes. These models are operated at a spatial resolution ranging from approximately 100 to 250 km^2. Since GCMs tend to neglect regional heterogeneity (such as climatic processes), these resolutions are too general to carry out any specific assessment at regional scales (such as at a catchment level). Therefore, these GCMs are further downscaled to a finer resolution. Downscaling techniques can be divided into two groups: Dynamic downscaling and empirical-statistical downscaling (Wilby and Wigley, 1997). Dynamic downscaling uses Regional Climate Models (RCMs) where the GCM usually provides the boundary conditions for an RCM that has a nested domain within the GCM domain and it operates at a resolution of 10-50 km^2. Empirical-statistical downscaling is based on the statistical relationship between large-scale predictors (climate model data) and local-scale observations (Fowler et al., 2007; Maraun et al., 2010; Wilby and Wigley, 1997).

Quantile mapping is one among many approaches in empirical-statistical downscaling (Bo et al., 2007; Déqué, 2007; Themeßl et al., 2011a), and it is based on the principle of comparing distributions of a climatic variable in a dataset of historical observations and climate model control runs and subsequently defining an error function to correct for biases for each quantile in the distribution. This error function is applied to a future climate model run to correct future climate data. The approach can be based on empirical or fitted probability distributions (Piani et al., 2010; Themeßl et al., 2011b). The quantile mapping was tested as a best performing method for mountainous region in Europe (Themeßl et al., 2011a). This study uses quantile mapping as applied by Themeßl et al. (2011a) to downscale the GCMs data using empirical probability distributions described in sections below.

3.4. Selection of Representative Concentration Pathways

We selected two ensembles containing four GCM runs from the CMIP5 database. One ensemble for the medium stabilization scenarios RCP4.5 and the other for the very high radiative forcing scenario RCP8.5. The mitigation scenario leading to a very low radiative forcing level (RCP2.6) was not included. It is unlikely that this RCP can be met, as it requires an immediate drastic decline of emissions followed by ongoing carbon sequestration in the second half of the 21st century. By selecting RCP4.5 and RCP8.5, we cover the possible range of radiative forcing resulting from RCP4.5, RCP6, and RCP8.5.

3.5. Reference Climate Dataset

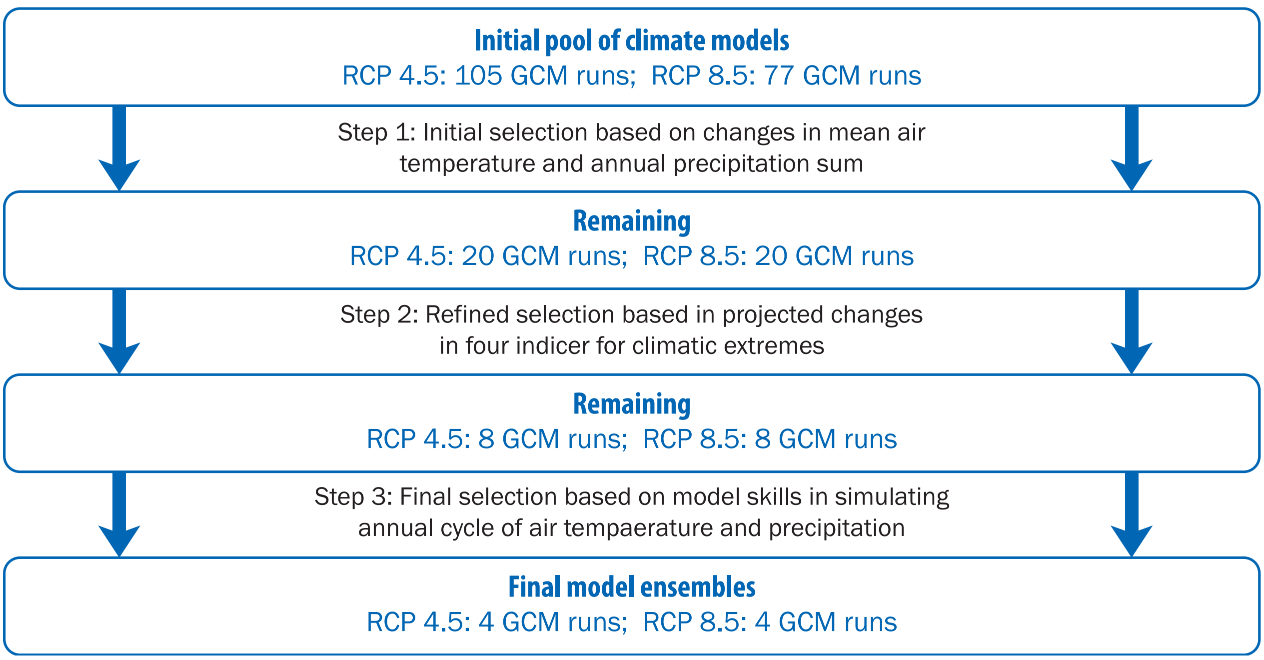
For reference climate dataset, the dataset generated by Lutz and Immerzeel (2015) as a part of the HI-AWARE project is used. The reference climate dataset is developed from the Watch Forcing Data ERA-Interim (WFDEI) dataset (Weedon et al., 2014) which is based on the WATCH methodology (Weedon et al., 2011), integrated with the ERA-Interim dataset (Dee et al., 2011). Precipitation in the WFDEI dataset is bias-corrected using the Global Precipitation Climatology Centre (GPCC) dataset (Schneider et al., 2013). In addition, precipitation data is corrected using observed glacier mass balance data according to the methodology developed by (Immerzeel et al., 2015, 2012). The air temperature data is bias-corrected with data from observed stations from the region. The raw daily mean air temperature from WFDEI dataset is spatially interpolated from 50 km grid to 1 km spatial resolution vertical temperature lapse rate. Precipitation data in WFDEI are interpolated from 50 km to 1 km grid by a cubic spline interpolation. This dataset is one of the complete dataset (precipitation, maximum and minimum temperature) for a longer period of time available for whole Nepal at a higher resolution (10 km grid) with a different level of bias corrections. The detailed methodological approach is explained in (Lutz et al., 2016).

3.6. Selection of Climate Models

The number of GCMs available for climate change projections is rapidly increasing. For example, the CMIP3 archive (Meehl et al., 2007), which was used for the IPCC Fourth Assessment Report (IPCC, 2007) contains outputs from 25 different GCMs, whereas the CMIP5 archive (Taylor et al., 2012) — which was used for the IPCC Fifth Assessment Report (IPCC, 2012) — contains outputs from 105 GCMs for RCP4.5 and 77 for RCP8.5. These GCMs often have multiple ensemble members, resulting in an even larger number of available model runs. Consideration of all the models and ensemble members for downscaling is challenging due to the limitation of computational and human resources. In practice, it is typical to select one climate model or a small ensemble of climate models. The selection of representative models for the region of interest can be based on multiple criteria.

For this study, we used an advanced envelop-based selection approach described by Lutz et al. (2016) to select a representative ensemble of GCMs. This approach follows three steps as shown in Figure 2.

Figure 2: **Climate model selection procedure (Lutz et al., 2016).**



3.6.1. Initial Selection Based on Changes in Mean Air Temperature and Annual Precipitation Sum

The initial selection is based on the range of projections of change in mean air temperature (ΔT) and annual precipitation sum (ΔP) between 1981-2010 and 2036-2065 for the six GCMs grid cells that cover the whole of Nepal (Figure 3). The detailed description of this process has been outlined by (Lutz et al., 2016; Terink et al., 2017). A short description is provided below. For the model runs included in RCP4.5 and RCP8.5 separately, the 10th and 90th percentile values for ΔT and ΔP are determined after resampling all GCM data to the same 2.5°x2.5° grid cell. These values represent the four corners of the spectrum of projections for temperature and precipitation change, i.e. "cold and dry", "cold and wet", "warm and dry," and "warm and wet". The proximity of the model runs to the 10th and 90th percentile values is derived from the percentile rank scores of the model runs corresponding to their projections for ΔT and ΔP with respect to the entire range of projections in the ensemble. The initial selection results in 5 model runs x 4 corners = 20 model runs for each RCP (Figure 4).

Figure 3: GCM grids covering the entire map Nepal (average annual precipitation over Nepal from 1981-2010)

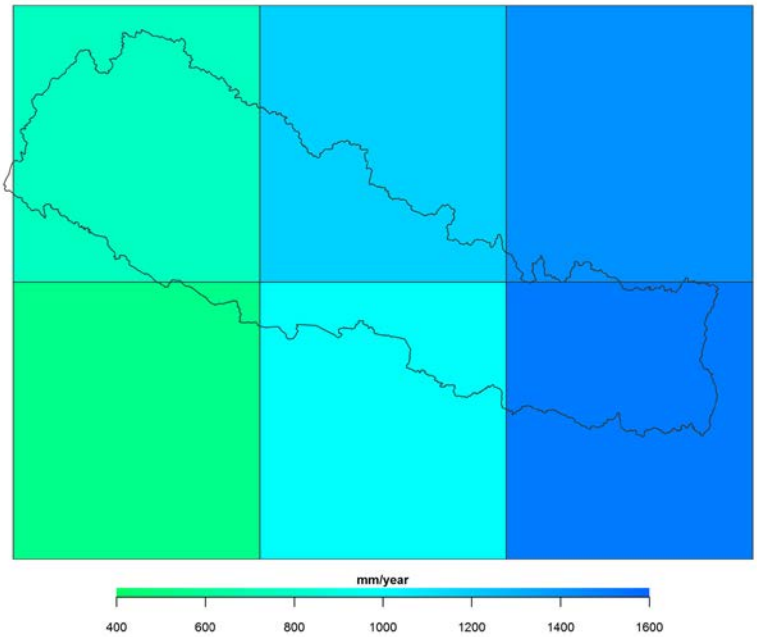
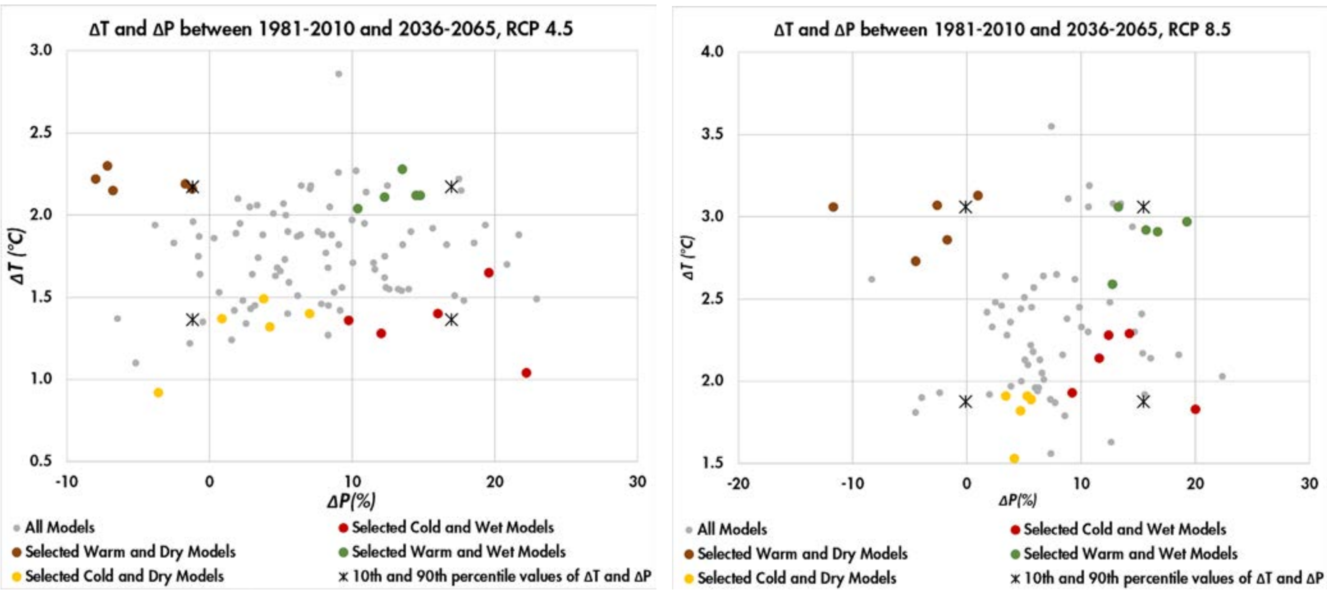


Figure 4: Changes in mean air temperature and annual precipitation sum for RCP4.5 (left) and RCP8.5 (right) CMIP5 GCM runs for Nepal. Models selected during step 1 are indicated with colored dots.



3.6.2. Refined Selection Based on Projected Changes in Four Indices of Climatic Extremes

The number of model runs remaining after the initial selection process is further reduced during the refined selection. In this step, the model runs are evaluated for their projections of changes in climatic extremes. Models with monthly time steps are ignored as the downscaling process of the model requires daily time steps. The changes in climatic extremes for air temperature and precipitation were evaluated by considering the changes in two ETCCDI indices for both air temperature and precipitation (Peterson, 2005). For characterization of changes in air temperature extremes, changes in the warm spell duration index (WSDI) and the cold spell duration index (CSDI) were analyzed. For characterization of changes in precipitation extremes, the precipitation due to very wet days (R95pTOT) and the number of consecutive dry days (CDD) were considered (Table 3).

Table 3: Description of ETCCDI indices used in step 2 of the climate model selection procedure

Meteorological variable	ETCCDI index	Index description
Precipitation	R95pTOT	precipitation due to very wet days (> 95th percentile)
Precipitation	CDD	consecutive dry days: maximum length of a dry spell (P < 1 mm)
Air temperature	WSDI	warm spell duration index: count of days in a span of at least six days where TX > 90th percentile (TX_{ij} is the daily Tmax on day i in period j)
Air temperature	CSDI	Cold spell duration index: count of days in a span of at least six days where TN < 10th percentile (TN_{ij} is the daily Tmin on day i in period j

For the five models initially selected for each corner (Step 1), the two relevant indices are both ranked and given scores 1 to 5. The model with the lowest change in the select extreme index is ranked 1 whereas the model with the highest change is ranked 5. Based on the final score, the two models with the highest scores are selected. As shown in Table 5, for example, in the cold and dry projection, the two relevant indices are CSDI (for temperature) and CDD (for precipitation). Model CCSM4_r1i1p1 (RCP4.5) shows 68.3% decrease in CSDI giving it the highest rank of 5, whereas it shows 7.6 % increase in CDD giving it the ranking of 4 within the 5 selected models for that projection (Table 4). Similarly, in the warm and wet projection, the two relevant indices are WSDI (for temperature) and R95p (for precipitation). Here, model CanESM2_r3i1p1 (RCP4.5) shows 263.4% increase in WSDI giving it the rank of 3, whereas it shows 58.4 % increase in R95p giving it the ranking of 5 within the 5 selected models for that projection (Table 4). The combined score for each model is then calculated by averaging the P index rank and T index rank scores. The models with the two highest combined scores are thus selected for the next step. For each RCP in 4 corners, at least two models (8 in total) are selected. These models are validated to historic climate reference product in the next step.

3.6.3. Final Selection Based on Model's Skill in Simulating the Annual Cycle of Air Temperature and Precipitation

The final selection of the models is based on how well the climate models represent historic precipitation and temperature cycles. For this, HI-AWARE climate reference dataset is used (Lutz and Immerzeel, 2015). For precipitation sum, the bias between the GCM run and the reference dataset is calculated on annual basis and for the summer monsoon season (June-September). As about 80% of the precipitation falls during the monsoon season in Nepal, monsoon bias will outweigh other biases originating in other periods. For mean air temperature, the annual, summer and winter bias is used. The biases for precipitation are expressed as a percentage and the biases for air temperature are expressed as degrees Celsius. As shown in Table 5, for all the models selected from the previous steps, biases in precipitation and temperatures are calculated for the reference period of each model with a reference period of HI-AWARE climate reference dataset (Lutz and Immerzeel, 2015).

Table 4: **GCM runs analyzed during the refined selection Step 2. Models selected for Step 3 are indicated with green color**

RCP	Projection	Model	ΔP (%)	ΔT (°C)	ΔCSDI (%)	ΔCDD (%)	ΔWSDI (%)	ΔR95p (%)	P_{index} Rank	T_{index} Rank	Combined Score
RCP4.5	Cold, Dry	NOAA_GFDL_GFDL-ESM2M_r1i1p1	0.87	1.37	-52.4	4.3	308.2	19.4	3	3	3
		inmcm4_r1i1p1	-3.59	0.92	-24.2	11.4	182.1	1.9	1	5	3
		NOAA_GFDL_GFDL-ESM2G_r1i1p1	4.23	1.32	-49.0	-2.0	372.6	21.5	2	1	1.5
		CCSM4_r1i1p1	3.79	1.49	-68.3	7.6	403.9	26.6	5	4	4.5
		CCSM4_r2i1p1	7.01	1.40	-68.3	0.7	274.8	26.4	4	2	3
	Cold, wet	bcc-csm1-1_r1i1p1	16.00	1.40	-68.6	-8.6	295.7	46.8	2	5	3.5
		IPSL-CM5B-LR_r1i1p1	22.21	1.04	-75.2	-10.8	193.8	22.5	4	1	2.5
		MRI-CGCM3_r1i1p1	12.03	1.28	-87.3	-8.3	224.0	39.2	5	4	4.5
		CESM1-BGC_r1i1p1	9.75	1.36	-66	-3.9	326.1	24.0	1	2	1.5
		GISS-E2-R_r6i1p3	19.58	1.65	-73.5	-6.7	412.8	32.8	3	3	3
	Warm, Dry	MIROC-ESM-CHEM_r1i1p1	-1.22	2.16	-97.1	-4.7	643.5	1.0	5	1	3
		CMCC-CMS_r1i1p1	-1.70	2.19	-93.5	23.4	322.4	-0.3	1	5	3
		MPI-ESM-LR_r3i1p1	-6.77	2.15	-85.7	14.3	515.9	-1.4	4	2	3
		MPI-ESM-LR_r1i1p1	-7.98	2.22	-94.1	20.5	513.0	2.2	3	4	3.5
		MPI-ESM-LR_r2i1p1	-7.16	2.30	-91.8	20.1	444.5	-3.1	2	3	2.5
	Warm, wet	CanESM2_r1i1p1	14.77	2.12	-91.3	8.7	226.2	57.1	1	4	2.5
		CanESM2_r2i1p1	14.48	2.12	-89.0	-2.9	306.3	38.7	4	2	3
		CanESM2_r3i1p1	13.51	2.28	-95.3	6.5	263.4	58.4	3	5	4
		CanESM2_r5i1p1	12.27	2.11	-92.0	-9.8	236.5	40.3	2	3	2.5
		CSIRO-Mk3-6-0_r2i1p1	10.38	2.04	-88.0	-4.7	597.8	25.4	5	1	3
RCP8.5	Cold, Dry	NOAA_GFDL_GFDL-ESM2G_r1i1p1	3.40	1.91	-49.0	-2.0	372.6	21.5	2	1	1.5
		EC-EARTH_r9i1p1	4.70	1.82	-84.7	-2.5	694.9	29.0	4	2	3
		inmcm4_r1i1p1	4.15	1.53	-24.2	11.4	182.1	1.9	1	3	2
		EC-EARTH_r2i1p1	5.29	1.91	-90.5	1.9	764.3	45.1	5	5	5
		NOAA_GFDL_GFDL-ESM2M_r1i1p1	5.62	1.89	-52.4	4.3	308.2	19.4	3	4	3.5
	Cold, wet	bcc-csm1-1_r1i1p1	20.01	1.83	-68.6	-8.6	295.7	46.8	2	5	3.5
		CESM1-BGC_r1i1p1	9.22	1.93	-84.0	-3.2	448.5	29.0	1	4	2.5
		CNRM-CM5_r1i1p1	11.59	2.14	-88.6	-0.1	341.5	2.0	3	3	3
		CSIRO-Mk3-6-0_r7i1p1	12.41	2.28	-91.7	3.3	625.5	12.8	5	1	3
		CSIRO-Mk3-6-0_r1i1p1	14.23	2.29	-91.1	6.6	721.2	-0.3	4	2	3
	Warm, Dry	CMCC-CMS_r1i1p1	-2.60	3.07	-93.5	23.4	322.4	-0.3	1	2	1.5
		MIROC-ESM-CHEM_r1i1p1	0.96	3.13	-97.1	-4.7	643.5	1.0	5	5	5
		MPI-ESM-LR_r3i1p1	-1.72	2.86	-85.7	14.3	515.9	-1.4	4	1	2.5
		MPI-ESM-LR_r2i1p1	-11.69	3.06	-91.8	20.1	444.5	-3.1	3	3	3
		MPI-ESM-LR_r1i1p1	-4.49	2.73	-94.1	20.5	513.0	2.2	2	4	3
	Warm, wet	CanESM2_r2i1p1	15.68	2.92	-89.0	-2.9	306.3	38.7	4	2	3
		CanESM2_r5i1p1	19.26	2.97	-92.0	-9.8	236.5	40.3	1	5	3
		CanESM2_r1i1p1	16.70	2.91	-91.3	8.7	226.2	57.1	2	4	3
		CanESM2_r3i1p1	13.26	3.06	-95.3	6.5	263.4	58.4	3	3	3
		CSIRO-Mk3-6-0_r10i1p1	12.74	2.59	-90.5	5.6	826.6	37.4	5	1	3

Table 5: Biases between GCM runs (2036-2065) and reference climate dataset (1981-2010) for Nepal

RCP	Projection	model	P bias total (%)	P bias monsoon (%)	T bias total (˚C)	T bias monsoon (˚C)	T bias winter (˚C)	P bias total normalized	P bias monsoon normalized	T bias total normalized	T bias monsoon normalized	T bias winter normalized	P bias score	T bias score	Combined score
RCP4.5	Cold, Dry	NOAA_GFDL_GFDL-ESM2M_r1i1p1	11.3	12.2	0.0	0.7	-0.3	0.20	0.21	0.01	0.25	0.05	0.20	0.08	0.28
		inmcm4_r1i1p1	-3.7	-13.9	-2.3	-0.7	-2.8	0.07	0.24	0.63	0.24	0.57	0.15	0.52	0.67
		CCSM4_r1i1p1	21.5	17.1	-1.1	0.0	-2.9	0.38	0.29	0.30	0.00	0.60	0.34	0.30	0.63
		CCSM4_r2i1p1	21.4	20.5	-1.0	0.0	-2.6	0.38	0.35	0.26	0.01	0.53	0.37	0.26	0.63
	Cold, wet	bcc-csm1-1_r1i1p1	-30.9	-48.1	-0.6	1.2	-3.4	0.55	0.81	0.16	0.43	0.69	0.68	0.36	1.05
		MRI-CGCM3_r1i1p1	-53.0	-58.7	-0.5	0.5	-2.2	0.95	0.99	0.13	0.17	0.44	0.97	0.22	1.19
	Warm, Dry	MIROC-ESM-CHEM_r1i1p1	6.7	-14.8	0.4	0.6	-0.2	0.12	0.25	0.12	0.19	0.04	0.18	0.12	0.30
		CMCC-CMS_r1i1p1	-0.5	-10.0	-0.3	1.0	-2.3	0.01	0.17	0.07	0.34	0.47	0.09	0.24	0.33
		MPI-ESM-LR_r3i1p1	11.2	12.4	-3.3	-2.9	-4.7	0.20	0.21	0.89	1.00	0.95	0.21	0.93	1.14
		MPI-ESM-LR_r1i1p1	14.4	12.9	0.1	0.4	-0.9	0.26	0.22	0.03	0.14	0.18	0.24	0.09	0.33
	Warm, wet	CanESM2_r2i1p1	-35.7	-39.4	-3.6	-2.0	-4.9	0.64	0.67	0.98	0.69	1.00	0.65	0.91	1.57
		CanESM2_r3i1p1	-38.6	-42.6	-3.7	-2.1	-4.7	0.69	0.72	1.00	0.73	0.96	0.70	0.92	1.62
		CSIRO-Mk3-6-0_r2i1p1	-56.0	-59.2	-0.8	1.3	-3.1	1.00	1.00	0.20	0.44	0.63	1.00	0.37	1.37
RCP8.5	Cold, Dry	EC-EARTH_r2i1p1	-12.0	-15.5	-2.8	-3.6	-1.9	0.22	0.27	0.70	0.98	0.36	0.24	0.68	0.92
		NOAA_GFDL_GFDL-ESM2M_r1i1p1	11.3	12.2	0.0	0.7	-0.3	0.21	0.21	0.01	0.20	0.05	0.21	0.06	0.27
	Cold, wet	bcc-csm1-1_r1i1p1	-30.9	-48.1	-0.6	1.2	-3.4	0.57	0.83	0.15	0.34	0.64	0.70	0.32	1.02
		CNRM-CM5_r1i1p1	-18.3	-25.2	-4.1	-2.1	-5.4	0.34	0.43	1.00	0.57	1.00	0.38	0.89	1.28
		CSIRO-Mk3-6-0_r7i1p1	-54.5	-58.2	-0.8	1.2	-2.8	1.00	1.00	0.19	0.32	0.53	1.00	0.31	1.31
		CSIRO-Mk3-6-0_r1i1p1	-52.2	-54.3	-0.8	1.3	-3.1	0.96	0.93	0.19	0.35	0.58	0.95	0.32	1.27
	Warm, Dry	MIROC-ESM-CHEM_r1i1p1	6.7	-14.8	0.4	0.6	-0.2	0.12	0.25	0.11	0.15	0.04	0.19	0.10	0.29
		MPI-ESM-LR_r2i1p1	18.2	17.6	-2.9	-2.7	-3.7	0.33	0.30	0.70	0.74	0.69	0.32	0.71	1.03
		MPI-ESM-LR_r1i1p1	14.4	12.9	0.1	0.4	-0.9	0.26	0.22	0.02	0.11	0.16	0.24	0.08	0.32
	Warm, wet	CanESM2_r2i1p1	-35.7	-39.4	-3.6	-2.0	-4.9	0.66	0.68	0.90	0.54	0.92	0.67	0.81	1.48
		CanESM2_r5i1p1	-38.0	-40.5	-3.5	-1.8	-4.7	0.70	0.70	0.87	0.49	0.87	0.70	0.77	1.47
		CanESM2_r1i1p1	-37.8	-40.7	-3.5	-1.9	-4.7	0.69	0.70	0.87	0.52	0.88	0.70	0.78	1.48
		CanESM2_r3i1p1	-38.6	-42.6	-3.7	-2.1	-4.7	0.71	0.73	0.91	0.57	0.88	0.72	0.82	1.54
		CSIRO-Mk3-6-0_r10i1p1	-54.4	-57.9	-2.9	-3.7	-2.2	1.00	0.99	0.71	1.00	0.40	1.00	0.71	1.70

In Table 5, for example, in cold and dry projection, for the GFDL-ESM2M_r1i1p1 model (RCP8.5) the bias in total annual and monsoon precipitation is 11.3% and 12.2% respectively, whereas the biases in average annual temperature, monsoon temperature, and winter temperature are 0 °C, 0.7 °C, and 0.3 °C respectively. Similarly, in warm and wet projection, for the CanESM2_r5i1p1 model (RCP8.5) the biases in total annual and monsoon precipitation are 38% and 40.5% respectively, whereas the biases in average annual temperature, monsoon temperature, and winter temperature are 3.5 °C, 1.8 °C, and 4.7 °C respectively. After calculating the biases for selected models from Step 2, the values are normalized (each bias value expressed as a fraction of the largest bias value) within the ensemble for both RCP4.5 and 8.5 separately. The bias score for each model is then calculated by averaging the P bias score and T bias score (Table 5). Finally, a combined score is calculated by summing the resulting two values. Four models with the lowest combined bias score are thus chosen each for RCP4.5 and RCP8.5. In this way, four models representing four corners of the spectrum of projections for RCP4.5 and RCP8.5 are chosen.

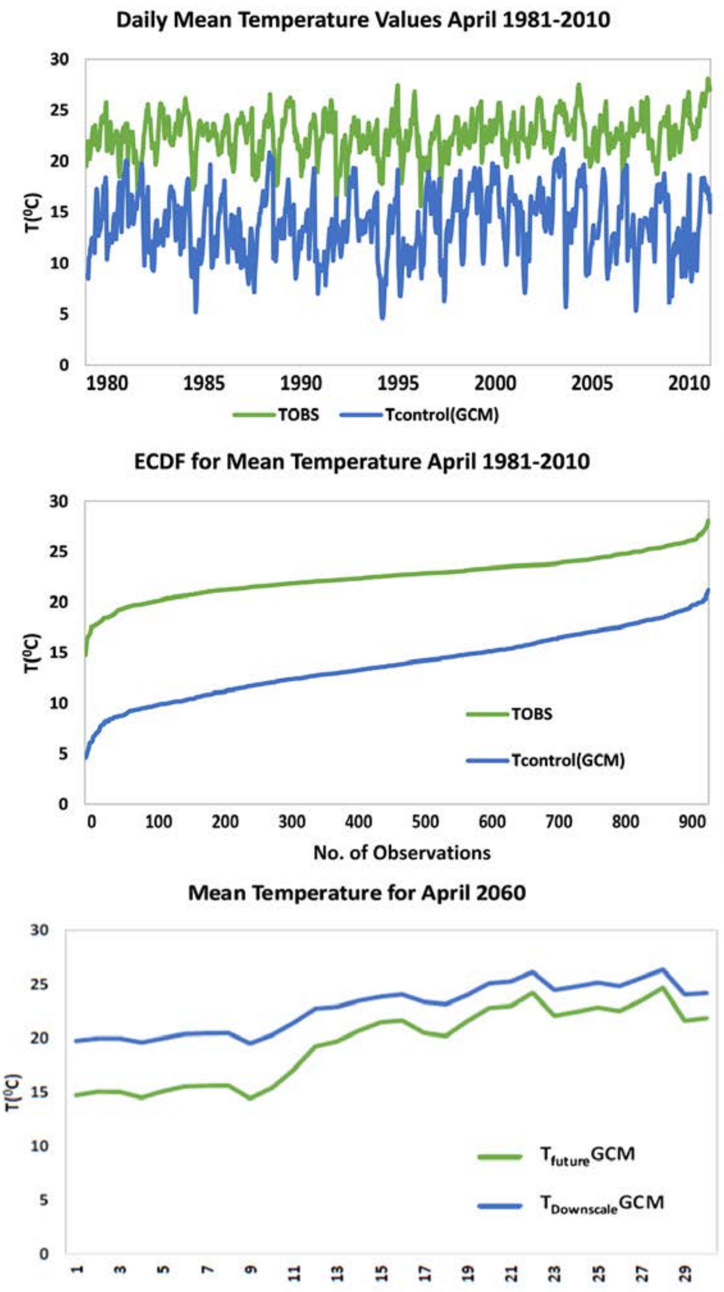
3.7. Climate Model Downscaling

Among the different statistical downscaling approaches, quantile mapping (QM) method has been found to be the most reliable in the mountainous region (Theme ßl et al., 2011b). Quantile mapping approach has already been applied in catchment scales in the central Himalayas (Immerzeel et al., 2013). Because of its robustness and good performance in the mountainous areas, quantile mapping approach has been selected to downscale the climate change scenarios for the purpose of the NAP process in Nepal.

Quantile mapping is applied on a daily basis. The GCM data are compared with observed reference dataset to estimate the bias. The bias information is then applied to the future dataset to create bias corrected dataset. Figure 5 below shows an illustrated example of QM methodology. For a detailed description, readers are suggested to refer to Lutz et al. (2016) and Terink et al. (2017).

Figure 5 shows an example of the quantile mapping methodology for one of the selected grids of reference dataset and corresponding GCM grid. The upper panel shows all the daily temperature observations in April during 1981-2010. For both distributions, an empirical cumulative distribution function (ECDF) has been constructed (middle panel). With both ECDFs, the correction function can

Figure 5: Illustrative example of GCM signal downscaling by Quantile Mapping for one grid cell. Upper panel: All daily observations and GCM control run values for days for April during the control period (1981-2010). Middle panel: Empirical cumulative distribution functions (ECDF) constructed for observations and GCM control run values in the upper panel. Lower panel: Future daily temperature for 2060 April as from raw GCM input and corresponding corrected downscaled values.



be determined to correct GCM values from the future run to downscaled values (lower panel). If for example, the GCM future run projects T = 20 °C on 15 April 2060 (lower panel), then this value can be looked up in the ecdf from the GCM values in the control run (middle panel) and the corresponding value from the ecdf for observations can be determined (e.g. T = 23 °C). Thus, the downscaled value will be 23°C (lower panel). This is done for all daily values.

For the purposed study, the downscaling procedure is as follows:

1) GCM runs for the reference period (1981-2010) are resampled and smoothed.

2) Time series for a given month is developed for both observed dataset and GCM. Bias is calculated for the GCM dataset from the reference period.

3) The bias calculated from Step 2 is applied over the whole period of the GCM (1981-2100) in order to develop downscaled GCM dataset.

3.8. Uncertainty Analysis

Climate projection is bound to have certain levels of uncertainties due to representation of atmospheric processes and future socio-economic development pathways, although efforts continues to reduce the uncertainties. Understanding uncertainty in climate change projections is very important for informed decision making. To develop any adaptation plans, uncertainties in precipitation and temperature have to be taken into account. As suggested by IPCC (2007), some indication of uncertainty in the projections can be obtained by comparing the responses among models. The range and ensemble standard deviation are used as a measure of uncertainty in modelled response. Agreement between multiple models can be a source of information in an uncertainty assessment. In addition, according to the AR5 of IPCC (2013), the ensemble mean is a useful quantity to characterize the average response to external forcings, but does not convey information on the robustness of this response across models, its uncertainty and likelihood or its magnitude related to unforced climatic variability.

The climate change projections in this report are based on ensembles of 8 representative GCMs selected using the advanced envelop-based selection approach described by Lutz et al. (2016). Uncertainty analysis for projections of precipitation and temperature in this report are calculated based on the following approaches:

1) Agreement on decrease or increase in the change of climatic variables among multiple models compared to the reference period.

2) The uncertainty range is estimated by ensemble standard deviation and coefficient of variation among the models.

3) The uncertainties are represented by the inter-quantile range among the models for RCP4.5 and RCP8.5.

3.9. Future Climate Extremes

The global climate change can affect a number of components of the hydrological system, such as precipitation and temperature patterns and its magnitude, including extremes. The changes in the parameters can affect different sectors such as water resources, energy, and biodiversity. Many studies have suggested that extreme weather events are likely to be more frequent, which poses a serious threat to the livelihoods of the people living in the Himalayan region (IPCC, 2012). Information about future climatic extremes can help to better understand the risks in different sectors and design adaptation practices for different thematic areas. Statistically, extremes are considered low-probability events differing greatly from typical occurrences. The IPCC defines extremes as 1-10% of the largest or smallest values of a distribution (Trenberth et al., 2007).

The joint CCI/CLIVAR/JCOMM Expert Team (ET) on Climate Change Detection and Indices (ETCCDI) has identified 27 core indices (11 for precipitation and 16 for temperature) for the study of extreme climate events (Alexander et al., 2006). The NAP process has defined eleven indices (five for precipitation and six for temperature) of climate extreme to understand the historic and future change of climatic parameters. These indices have been selected as they represent most important climate change indicators in Nepal. These extreme indices for the historic period are available in DHM (2017). Table 6 shows the definition of these indices along with their dimension. A number of studies have used indices suggested by ETCCDI (Donat et al., 2013; You et al., 2011), including in Nepal (Manandhar et al., 2012; Rajbhandari et al., 2017).

Table 6: Eleven selected climate indices for the NAP

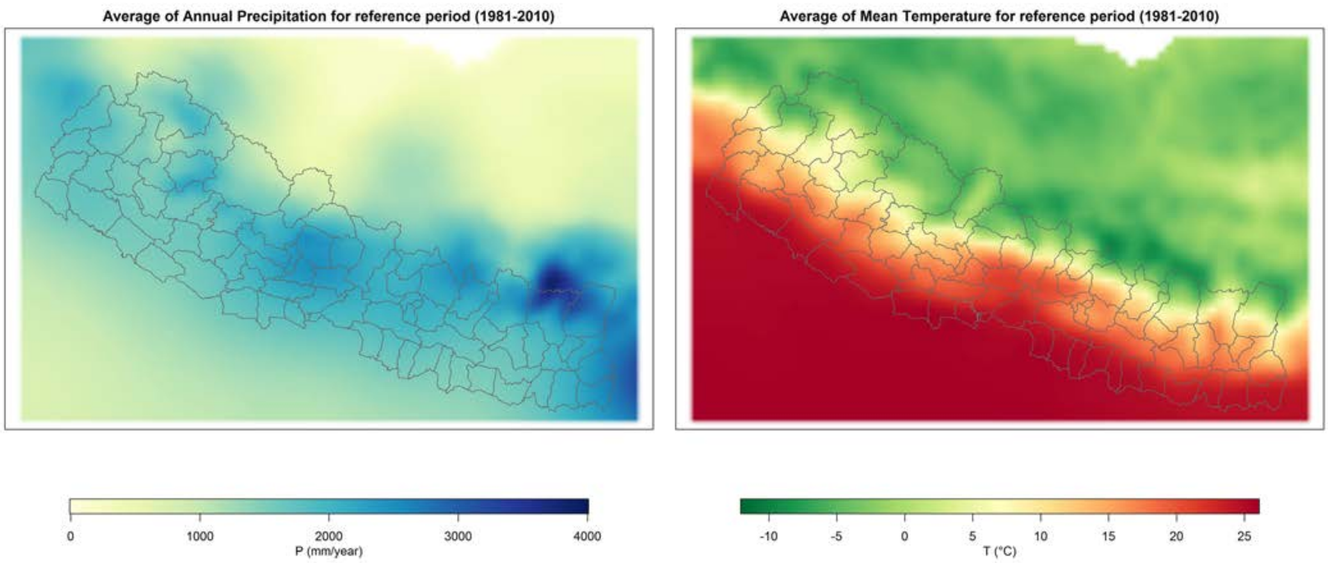
SN	Indices	Definition
1	Very wet days (P95)	Annual total days when the precipitation is higher than 95 percentile
2	Extreme wet days (P99)	Annual total days when the precipitation is higher than 99 percentile
3	Number of rainy days	Annual total days when the precipitation is > 1 mm
4	Consecutive dry days	Maximum length of consecutive days with daily precipitation < 1mm
5	Consecutive wet days	Maximum length of consecutive days with daily precipitation >1mm
6	Warm days	Percentage of days when maximum temperature >90th percentile
7	Warm nights	Percentage of days when minimum temperature >90th percentile
8	Cold days	Percentage of days when maximum temperature <10th percentile
9	Cold nights	Percentage of days when minimum temperature <10th percentile
10	Warm spell duration index	Annual count of days with at least 6 consecutive days when maximum temperature > 90th percentile
11	Cold spell duration Index	Annual count of days with at least 6 consecutive days when minimum temperature < 10th percentile

4. FUTURE CLIMATE SCENARIOS OF NEPAL

By applying the model selection and downscaling approach as described in previous sections, climate scenarios for temperature (mean, maximum, and minimum) and precipitation were developed for the whole of Nepal at 10 km resolution. The climate scenarios are prepared by comparing two future periods with the reference period 1981-2010. The average annual mean temperature and annual precipitation for the 2030s as medium-term period were calculated by taking the average of future period from 2016-2045. Similarly, for the period representing the 2050s as long-term period, average of future period from 2036-2065 were taken. Additional scenarios representing the end of the century (2071-2100) were also carried out. The future scenarios for precipitation and temperature were carried out at the annual and seasonal level for 77 districts and five physiographic divisions.

Figure 6 shows the average annual precipitation and average annual mean temperature during the reference period (1981-2010). There is a spatial variability of precipitation distribution in which the eastern and central part receive higher precipitation.

Figure 6: Average annual values for precipitation (left) and mean temperature (right) during the reference period (1981-2010)



As shown in Table 7, about 77% of the precipitation falls during the monsoon season. The mean temperature data suggests that the average mean temperature is 12 °C. The average winter mean temperature is 4.6 °C and the average summer mean temperature is 17.7 °C. The lower elevation areas are warmer than the mountains.

Table 7: Average precipitation and mean temperature of Nepal for different seasons during the reference period (1981-2010).

Seasons	Average precipitation		Mean temperature
	mm	%	(ºC)
Winter (Dec-Feb)	84	5	4.6
Pre-monsoon (Mar-May)	232	13	12.5
Monsoon (Jun-Sep)	1418	77	17.7
Post-monsoon (Oct-Nov)	96	5	11.4
Annual	**1830**	**100**	**12.1**

4.1. Temperature Scenarios

Figure 7: Projected changes in average annual mean temperature between the reference period (1981-2010) and the medium-term (2016-2045) and the long-term (2036-2065) periods for RCP4.5 and RCP8.5 model ensembles

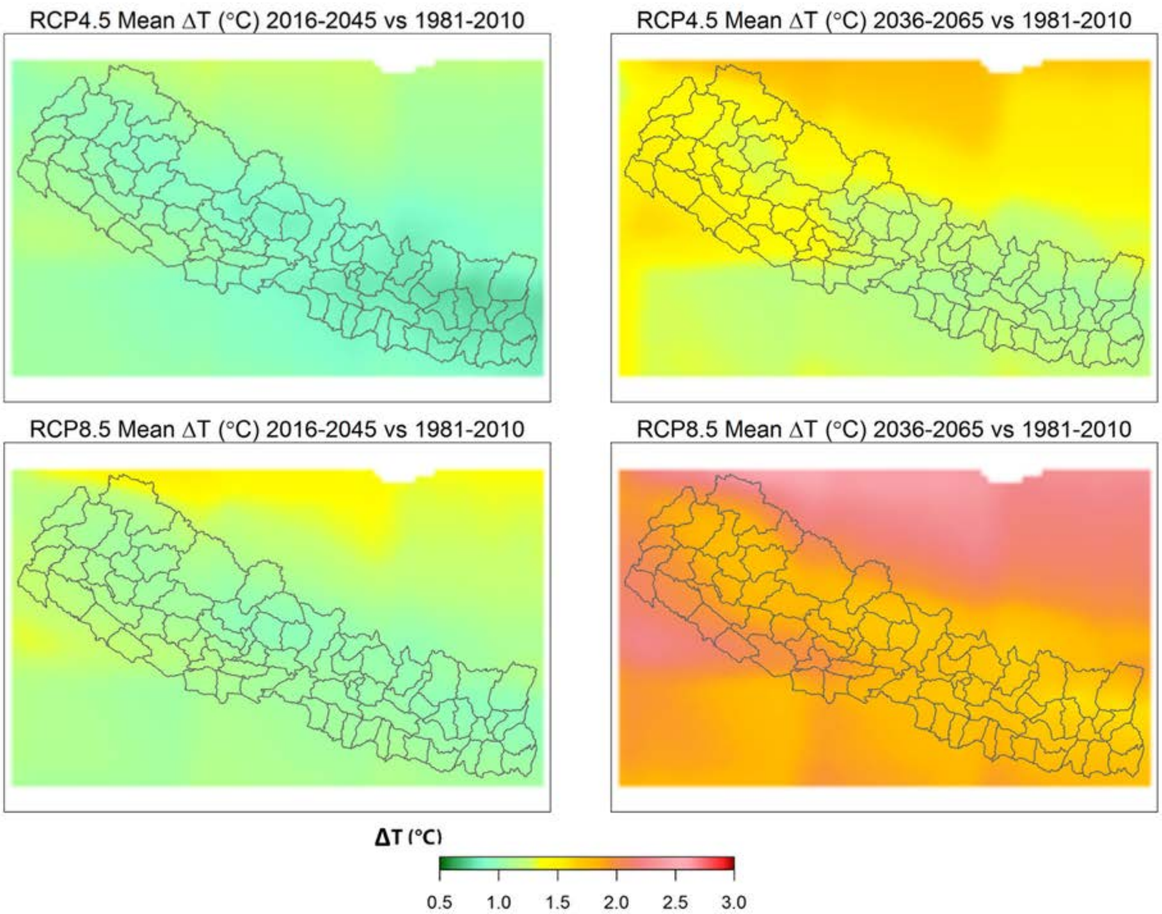
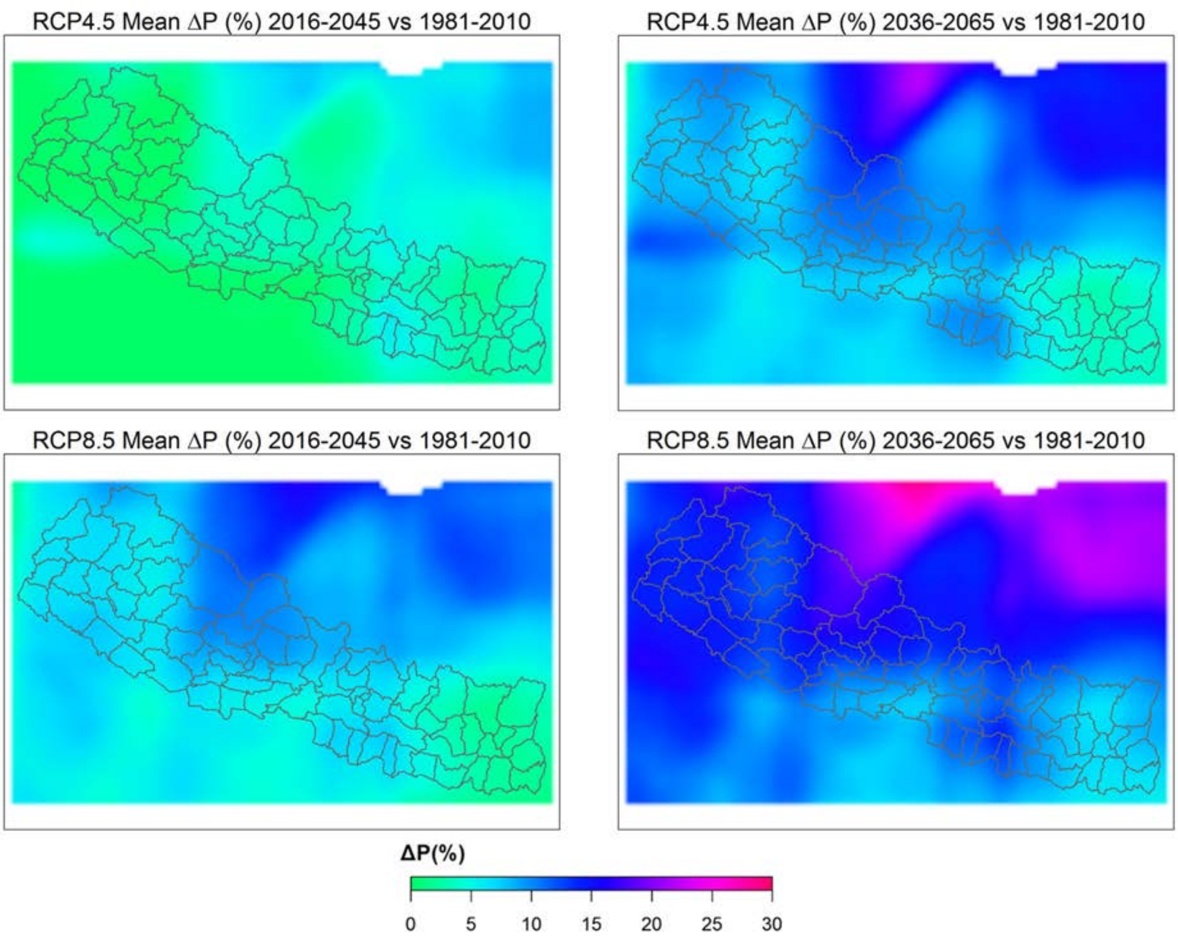


Figure 7 shows projected changes in average annual mean temperature of the two future periods with respect to the reference period. The upper panel shows the changes for RCP4.5 in the medium-term (left) and long-term period (right) as compared with the reference period (1981-2010). In the medium-term period, the average annual mean temperature change is projected to increase by 0.92 °C, whereas, in the long-term period, it is likely to increase by 1.72 °C in average. However, there is a spatial variation of projected changes in which the western region is likely to increase than the eastern. There is a slightly higher temperature trend in the high mountains than other regions in both the medium-term and long-term scenarios. The lower panel of Figure 7 shows the projected changes for RCP8.5 in the medium-term (left) and long-term scenarios (right). In the medium-term period, the average temperature change is projected to be 1.07 °C warmer whereas, in the long-term period, it is likely to be 1.82 °C warmer in average. In general, RCP8.5 will be warmer than RCP4.5 for both periods. Table 8 shows the average change in value for different physiographic zones.

4.2. Precipitation scenarios

Figure 8 shows projected changes in average annual precipitation (in %) based on ensemble mean of select 4 GCMs between the reference period and the two future periods. The upper panel shows the changes for RCP4.5 in the medium-term (left) and the long-term periods (right) compared with the reference period (1981-2010). In the medium-term period, the average annual precipitation change is projected to increase by 2.1%, whereas, in the long-term period, it is likely to increase by 7.9%. However, there is a spatial variation of projected changes in which the central and western regions are likely to be wetter than the eastern. The lower panel of Figure 8 shows the projected changes for RCP8.5 in the medium-term (left) and the long-term periods (right). In general, the RCP8.5 will be wetter by 6.4% in the medium-term period and 12.1% in the long-term period. Precipitation is likely to increase in the central and western parts in both the short-term and the long-term periods. In both scenarios, the eastern part is subject to lower increase, which is mainly due to the fact that the precipitation volume is the highest in the eastern part as monsoon enters

Figure 8: **Projected changes in average annual precipitation from the reference period (1981-2010) to the medium-term (2016-2045) and the long-term (2036-2065) periods for RCP4.5 and RCP8.5 model ensembles.**



from the eastern region (Figure 6). The change in % value may be low, but the overall precipitation volume is high compared to other regions. The average annual change in precipitation for two future periods and two RCPs for 77 districts are provided in Table 1 of the Annex.

Table 8 shows the average change in precipitation and temperature for the whole of Nepal based on ensemble mean of select 4 GCMs. It shows that the precipitation is likely to increase in the range of 2.1 to 7.9 % for RCP4.5 and 6.4 to 12.1% for RCP8.5 with respect to the reference period. Similarly, the temperature may increase in the range of 0.92 to 1.3 °C for RCP4.5 and 1.07 to 1.82 °C for RCP8.5 with respect to the reference period by the middle of the century. The average annual change in mean temperature for two future periods and two RCPs for 77 districts are provided in Table 2 of the Annex. For the end of the century scenarios, both precipitation and temperature is likely to increase by 23% and 3.58 °C respectively.

Table 8: Multi-model ensemble mean of change in precipitation and temperature in the medium-term and the long-term periods for the whole of Nepal

	RCP4.5			RCP8.5		
Time Period	2016-2045	2036-2065	2071-2100	2016-2045	2036-2065	2071-2100
Change in precipitation (%)	2.1	7.9	10.7	6.4	12.1	23.0
Change in temperature (°C)	0.92	1.3	1.72	1.07	1.82	3.58

Table 9 shows a change in average annual precipitation and mean temperature for different physiographic zones. The changes in precipitation are higher in the high mountains than other regions for most of the periods. The high mountains also seem to be warming at a higher rate than the rest of the regions of Nepal except Terai and Siwalik in RCP8.5. Similarly, Table 10 shows the change in precipitation and temperature for different seasons. In the medium-term period, the pre-monsoon precipitation is expected to decrease for both RCP4.5 and RCP8.5. The winter precipitation is projected to decrease for RCP4.5 but increase for RCP8.5. Monsoon precipitation is projected to increase for both RCPs. In the long-term period, almost all seasons indicate an increase in precipitation, except the pre-monsoon for RCP8.5. Maximum precipitation increase is observed during the post-monsoon season followed by the monsoon season.

Table 9: Multi-model ensemble mean of change in precipitation and temperature in the medium-term and the long-term period for different regions of Nepal

	RCP4.5			RCP8.5		
Time Period	**2016-2045**	**2036-2065**	**2071-2100**	**2016-2045**	**2036-2065**	**2071-2100**
Change in precipitation (%)						
High Mountain	2.6	9.5	12.6	8.0	14.4	25.1
Middle Mountain	1.7	7.6	10.3	6.3	12.4	21.7
Hill	2.1	7.2	9.9	5.8	11.2	22.6
Siwalik	1.6	7.4	9.9	5.8	11.1	21.9
Terai	2.1	7.3	10.2	5.4	10.6	22.7
Change in temperature (°C)						
High Mountain	0.95	1.36	1.79	1.09	1.86	3.61
Middle Mountain	0.89	1.27	1.66	1.04	1.76	3.44
Hill	0.9	1.26	1.69	1.06	1.8	3.56
Siwalik	0.94	1.29	1.72	1.1	1.87	3.66
Terai	0.93	1.29	1.73	1.11	1.87	3.69

The end of the century period also suggests an increase in precipitation for all seasons except the pre-monsoon season. Similarly, the temperature is projected to increase in all seasons. The maximum increase is in the post-monsoon season followed by the winter season in both the medium-term and the long-term periods. The end of the century period also suggests a continuous increase in temperature for all seasons.

Table 10: Multi-model ensemble mean of change in precipitation and temperature in the medium-term and the long-term periods for different seasons

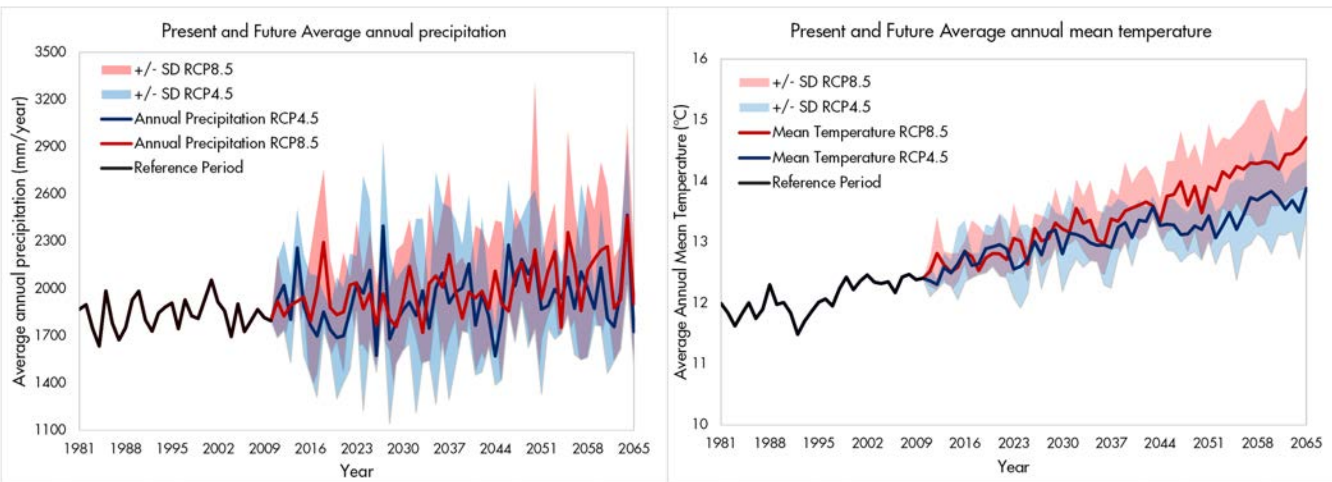
Time period	RCP4.5			RCP8.5		
	2016-2045	2036-2065	2071-2100	2016-2045	2036-2065	2071-2100
Change in precipitation (%)						
Winter	-5.8	13.6	24.4	7.2	5.0	20.9
Pre-monsoon	-5.0	-7.4	-7.8	-4.0	4.2	-3.1
Monsoon	2.7	9.4	12.4	7.8	13.6	27.1
Post-monsoon	18.6	20.3	16.5	6.0	19.0	22.9
Change in temperature (ºC)						
Winter	1.0	1.5	2.1	1.2	2.0	4.0
Pre-monsoon	0.7	1.0	1.2	1.0	1.6	3.4
Monsoon	0.8	1.1	1.4	0.8	1.5	3.0
Post-monsoon	1.3	1.8	2.5	1.4	2.4	4.5

4.3. Uncertainty Analysis in Precipitation and Temperature

Four models for RCP4.5 and RCP8.5 were used for the climate scenarios for the medium-term and the long term periods. These models have a large degree of uncertainty and variability arising from different assumptions of physical processes and socio-economic development pathways. In this section, uncertainty analysis of select GCMs for temperature and precipitation are described.

Figure 9 shows the multi-model ensemble of precipitation and temperature for RCP4.5 and RCP8.5 from 1981 to 2065. In the left figure, a slight increase in average annual precipitation can be seen throughout the period. The magnitude of change is higher in RCP8.5 compared to RCP4.5 which is also indicated in Table 8. In the right figure, there is a continuous increase in temperature until 2065, with higher magnitude in RCP8.5 than RCP4.5. However, the variability among the model projections is larger for both RCPs in precipitation than in temperature (Figure 9 and Table 11). This can be perceived by the higher value of

Figure 9: Multi-model ensemble of precipitation and temperature under RCP4.5 (blue) and RCP8.5 (red) for the period of 1981-2065. The colored band represents the standard deviation resulting from the select GCMs. The black line represents the reference period.



the coefficient of variation in precipitation than in temperature in Table 11. For example, the coefficient of variation among the models for precipitation in the medium-term period is 303% for RCP4.5 and 78% for RCP8.5 suggesting that the range of projected changes in precipitation is large where the changes vary from -3.6 to 11.2%. In case of temperature, the co-efficient of variation among the models in the medium-term period is 32% where the changes varies from 0.62 to 1.25 °C. Here, in the case of precipitation, having a higher coefficient for variation for RCP4.5 than for RCP8.5 means that there is a less agreement between the models in RCP4.5 than RCP8.5.

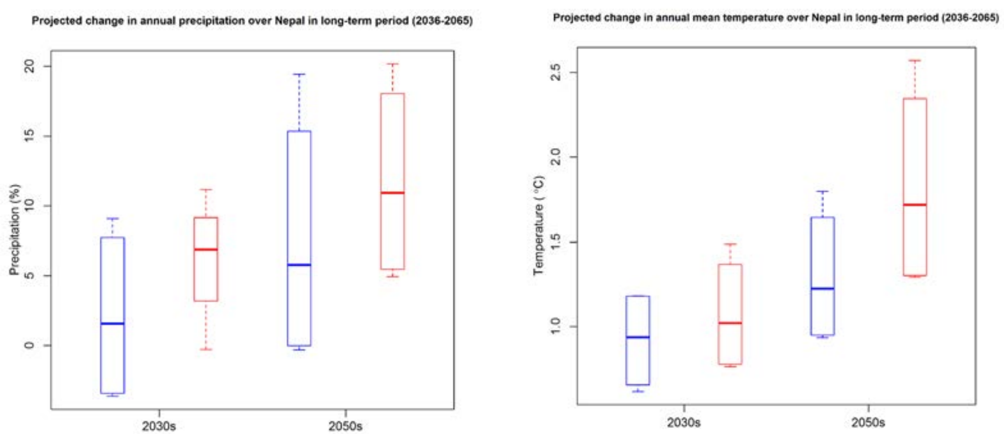
Table 11 shows that all GCMs indicate an increase in values in future periods compared to the reference period for temperature for both RCPs. However, for precipitation, 5 out of 8 models show an increase for the medium-term period and 7 out of 8 models show an increase for the long-term period. This suggests that these models show higher agreement for future projections for temperature than precipitation as shown by co-efficient of variation.

Table 11: Change in precipitation and temperature for selected individual GCMs

RCPs	Models	Change in precipitation (%)		Change in temperature (°C)	
		Medium-term	Long-term	Medium-term	Long-term
RCP4.5	bcc-csm1-1_rcp45_r1i1p1	6.3	19.4	0.69	0.96
	CanESM2_rcp45_r2i1p1	9.1	11.3	1.18	1.49
	GFDL-ESM2M_rcp45_r1i1p1	-3.2	-0.3	0.62	0.93
	MIROC-ESM-CHEM_rcp45_r1i1p1	-3.6	0.3	1.18	1.80
RCP8.5	bcc-csm1-1_rcp85_r1i1p1	6.6	20.2	0.76	1.29
	CanESM2_rcp85_r5i1p1	11.2	15.9	1.25	2.12
	GFDL-ESM2M_rcp85_r1i1p1	7.1	6.0	0.79	1.31
	MIROC-ESM-CHEM_rcp85_r1i1p1	-0.3	4.9	1.49	2.57
Average		4.2	9.7	1.0	1.6
Standard deviation		5.7	8.2	0.3	0.6
Co-efficient of variation		137%	84%	32%	37%

Similarly, Figure 10 shows the box-and-whisker plots for inter-model agreement on the projected change in precipitation and temperature. The inter-quantile range is higher in RCP8.5 than RCP4.5 for temperature but is smaller in RCP8.5 than in RCP4.5 for precipitation. Moreover, the inter-quantile range is larger for precipitation than for temperature. This also suggests higher variability among models in precipitation than in temperature.

Figure 10: Projected change in precipitation (%) and temperature (°C) for medium-term and long-term periods for RCP4.5 (blue) and RCP8.5 (red)



4.4. Climatic Extreme Indices

4.4.1. Precipitation Extreme Indices

This section describes the change in five extreme precipitation indices that are selected as the major climate change indicators for Nepal (Table 6). The change in the future periods are determined by first calculating the average of annual values for the reference period and two future periods. Then the changes are calculated by finding the difference for the short-term and long term periods from the reference period as the percentage of the reference period value.

Figure 11: Projected changes (%) in P95 days from the reference period (1981-2010) to the medium-term (2016-2045) and the long-term (2036-2065) periods for RCP4.5 and RCP8.5 model ensembles

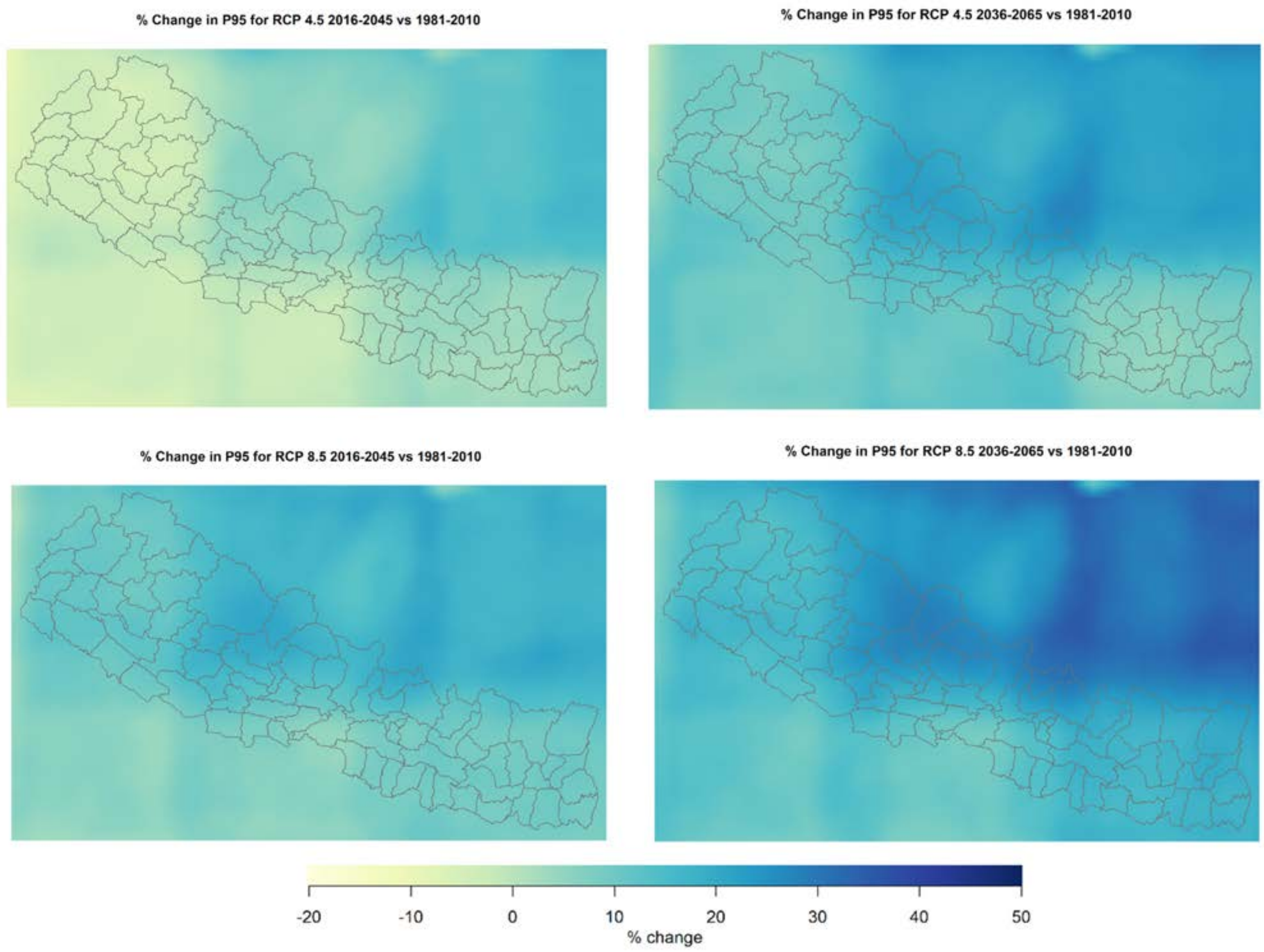


Figure 11 and Table 11 show the percentage change in annual total days when the precipitation is higher than 95 percentile (P95), indicating very wet (rainy) days for the medium-term and the long-term periods of RCP4.5 and RCP8.5. In the reference period, the number of mean annual very wet days are 18.1 in total. In the medium-term period, the very wet days are likely to increase in the eastern and central regions (in RCP4.5) and in the western and central regions (in RCP8.5). Overall, the increase is about 1.5% (0.3 days) for RCP4.5 and about 12.1% (2.2 days) for RCP8.5. In the long-term period, the increase is mostly concentrated around the central region. The projected increase is about 12% (2.2 days) for RCP4.5 and 18.6% (3.4 days) for RCP8.5. The average % change in P95 days for two future periods and two RCPs for 77 districts are provided in Table 3.1 of the Annex.

Figure 12: Projected changes (%) in P99 days from the reference period (1981-2010) to the medium-term period (2016-2045) and the long-term period (2036-2065) for RCP4.5 and RCP8.5 model ensembles

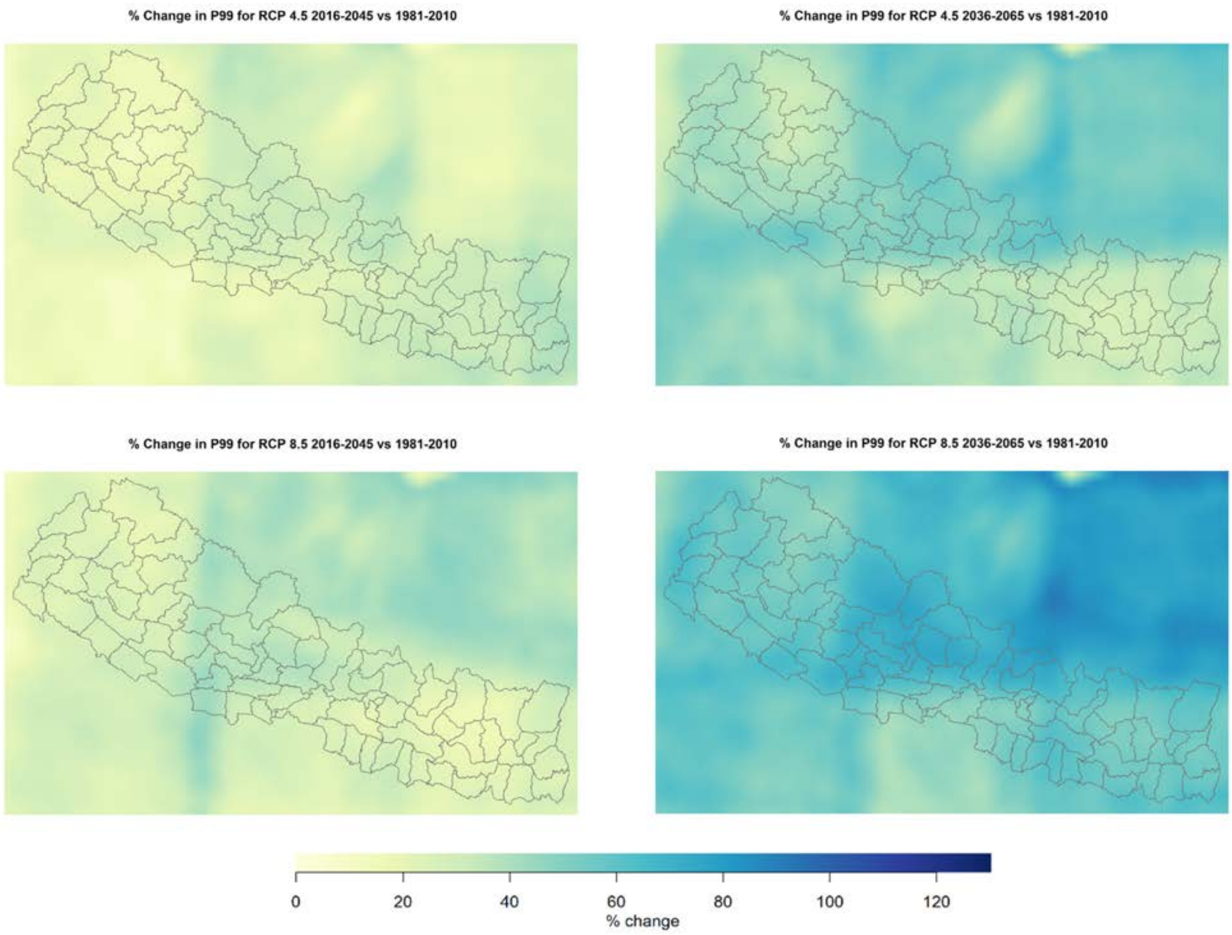


Figure 12 and Table 12 show that the percentage change in annual total days when the precipitation is higher than 99 percentile (P99), indicating extremely wet (rainy) days for the medium-term and the long-term periods of RCP4.5 and RCP8.5. In the reference period, the number of mean annual extremely rainy days are 3.5 in total. In the medium-term period, the extremely wet days are likely to increase over the whole of Nepal. Overall, the increase is about 26.3% (0.9 days) for RCP4.5 and about 28% (1 day) for RCP8.5. In the long-term period, the increase is visible across Nepal, with the highest increase in central region for both scenarios. The projected increase is about 41.3% (1.4 days) for RCP4.5 and 59.8% (2.1 days) for RCP8.5. An increase in P95 and P99 days (Figure 9 and Figure 10) signifies the increased likelihood of extreme events in both the medium-term and the long-term periods, which implies that flash floods and other water-induced hazards like landslides and soil erosion might occur more frequently. The average % change in P99 days for two future periods and two RCPs for 77 districts are provided in Table 3.2 of the Annex.

Table 12: Percentage change in precipitation and temperature indices in the medium-term and the long-term periods

Indices	No. of mean annual days in the reference period	RCP4.5				RCP8.5			
		Medium-term		Long-term		Medium-term		Long-term	
		%	Days	%	Days	%	Days	%	Days
P95	18.1	1.5	0.3	12	2.2	12.1	2.2	18.6	3.4
P99	3.5	26.3	0.9	41.3	1.4	28	1.0	59.8	2.1
Rainy days	166.4	-1.8	-3	-1	-1.7	-0.9	-1.6	-0.5	-0.8
CDD	45.3	6	2.7	2.4	1.1	-1.6	-0.7	-2.9	-1.3
CWD	78.1	-4.2	-3.3	-1.3	-1	3.1	2.5	2.2	1.7
Warm days	36.5	64.5	23.9	87.3	32.3	71.4	26.4	124.7	46.1
Warm nights	36.5	81.4	30.5	115.7	43.3	101.0	37.8	159.2	59.6
Cold days	36.5	-42	-15.4	-52.6	-19.3	-55.8	-20.5	-75	-27.5
Cold nights	36.5	-40.7	-15	-53.5	-19.7	-54.1	-19.9	-74	-27.3
Warm spell duration index	17.6	110	19.3	149	26.2	157.4	27.6	244.8	43
Cold spell duration index	20.3	-51.8	-10.5	-63.9	-12.9	-55.1	-11.2	-73.3	-14.8

Figure 13: Projected changes (%) in number of rainy days from the reference period (1981-2010) to the medium-term (2016-2045) and the long-term periods (2036-2065) for RCP4.5 and RCP8.5 model ensembles

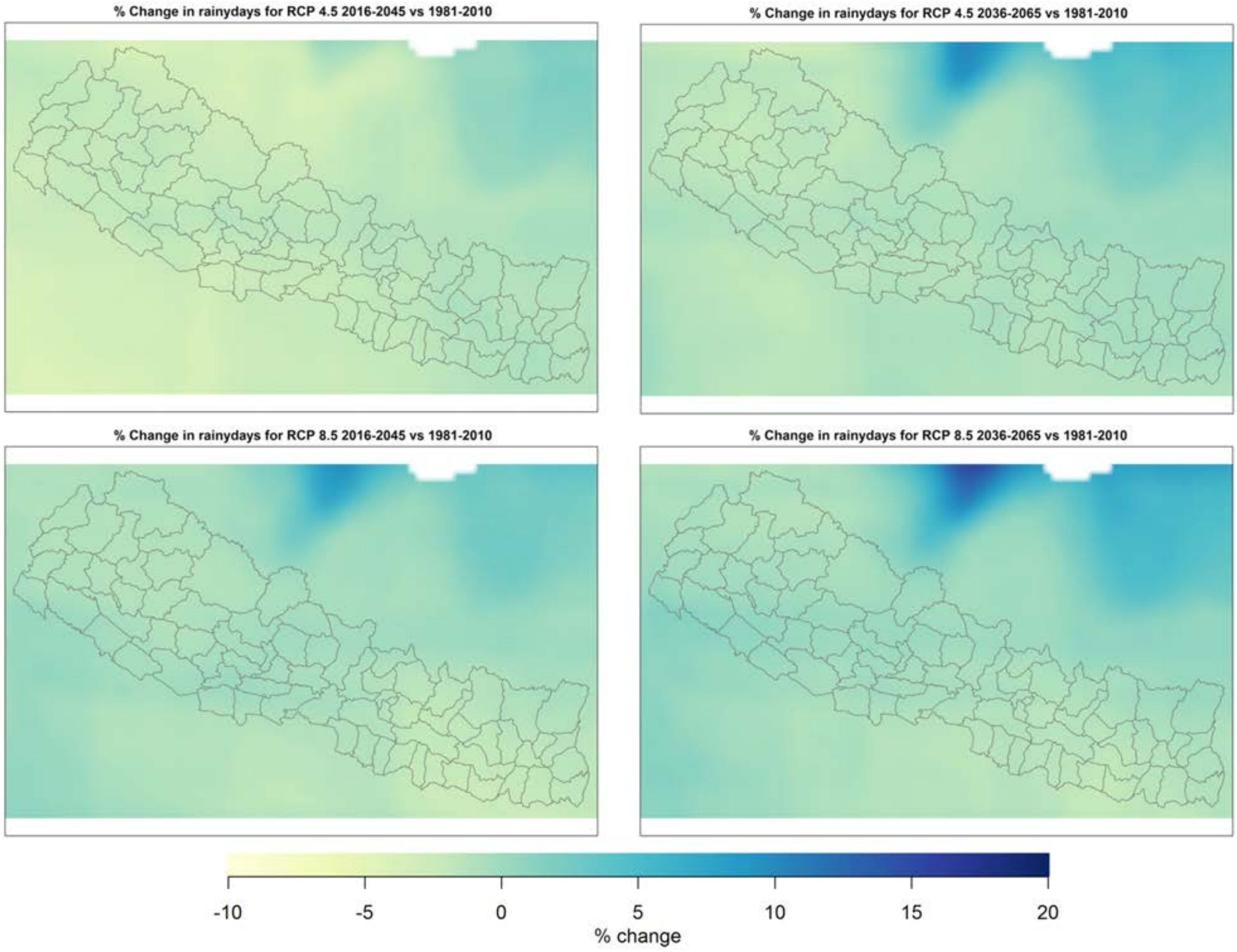


Figure 13 and Table 12 show that the percentage change in the number of rainy days (>1mm) for the medium-term and the long-term periods of RCP4.5 and RCP8.5. In the reference period, the number of mean annual rainy days are 166.4 days in total. In the future periods, the number of rainy days is likely to decrease all over Nepal. In the medium-term period, the decrease in the number of rainy days is about 1.8% (3 days) for RCP4.5 and about 0.9% (1.6 days) for RCP8.5. During the long-term period, the decrease in the number of rainy days is about 1% (1.7 days) for RCP4.5 and about 0.5% (0.8 days) for RCP8.5. The average % change in number of rainy days for two future periods and two RCPs for 77 districts are provided in Table 3.3 of the Annex.

Figure 14: Projected changes (%) in consecutive dry days from the reference period (1981-2010) to the medium-term (2016-2045) and the long-term periods (2036-2065) for RCP4.5 and RCP8.5 model ensembles.

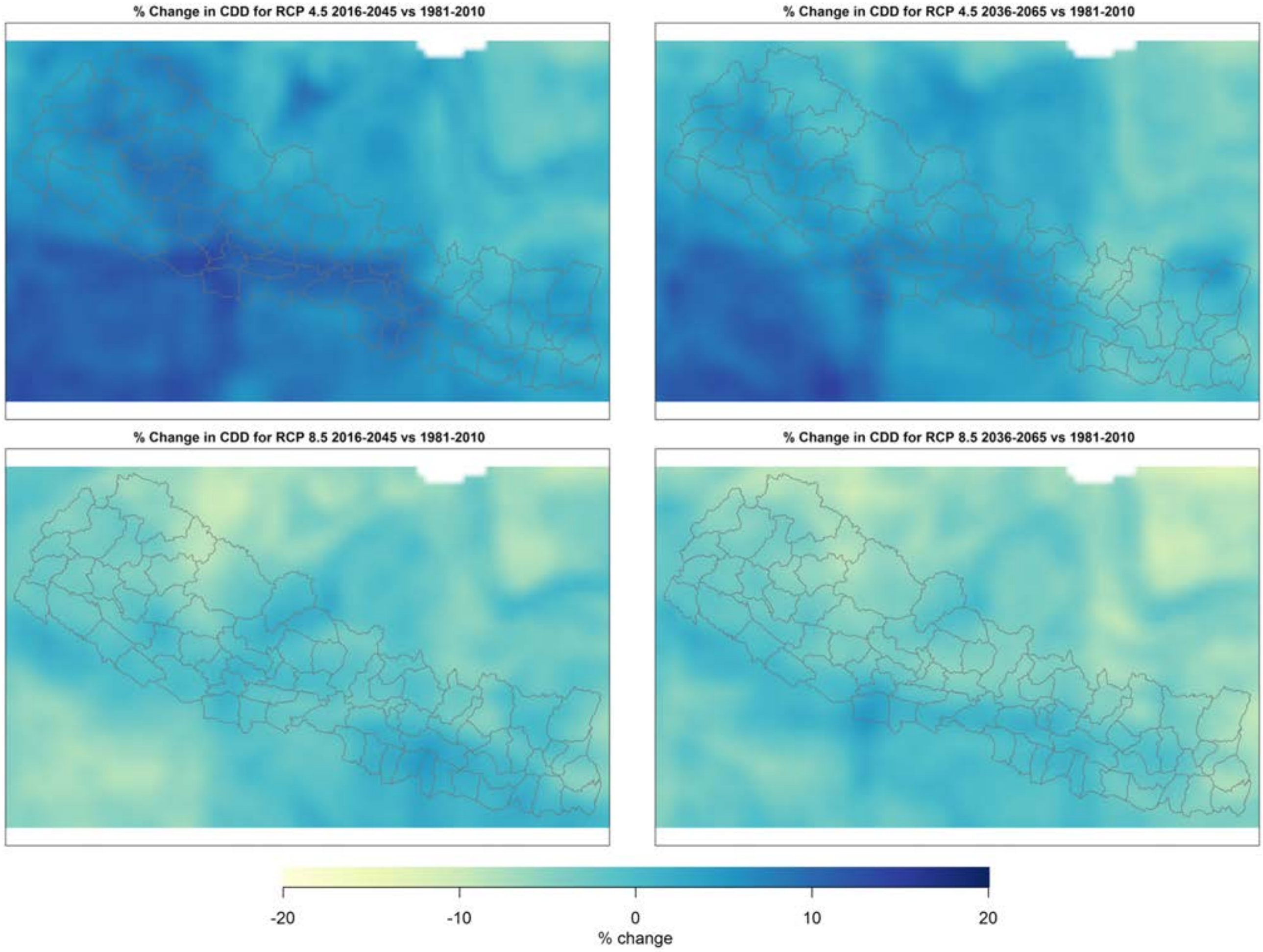


Figure 14 shows the percentage change in consecutive dry days (CDD) when the total daily precipitation is lower than 1 mm for the medium-term and long-term periods of RCP4.5 and RCP8.5. In the medium-term period, CDD is likely to increase in the whole of Nepal for RCP4.5, whereas it may slightly decrease for RCP8.5. In the reference period, the number of mean annual consecutive dry days are 45.3 in total. Overall, CDDs are likely to increase by 6% (2.7 days) for RCP4.5 and decreased by 1.6% (0.7 days) for RCP8.5 as compared to the reference period. In long-term period, CDD is likely to increase by 2.4% (1.1 days) for RCP4.5 and decreased by 2.9% (1.3 days) for RCP8.5, as shown in Table 12. The average % change in CDD for two future periods and two RCPs for 77 districts are provided in Table 3.4 of the Annex.

Figure 15: Projected changes (%) in consecutive wet days from the reference period (1981-2010) to the medium-term (2016-2045) and the long-term periods (2036-2065) for RCP4.5 and RCP8.5 model ensembles.

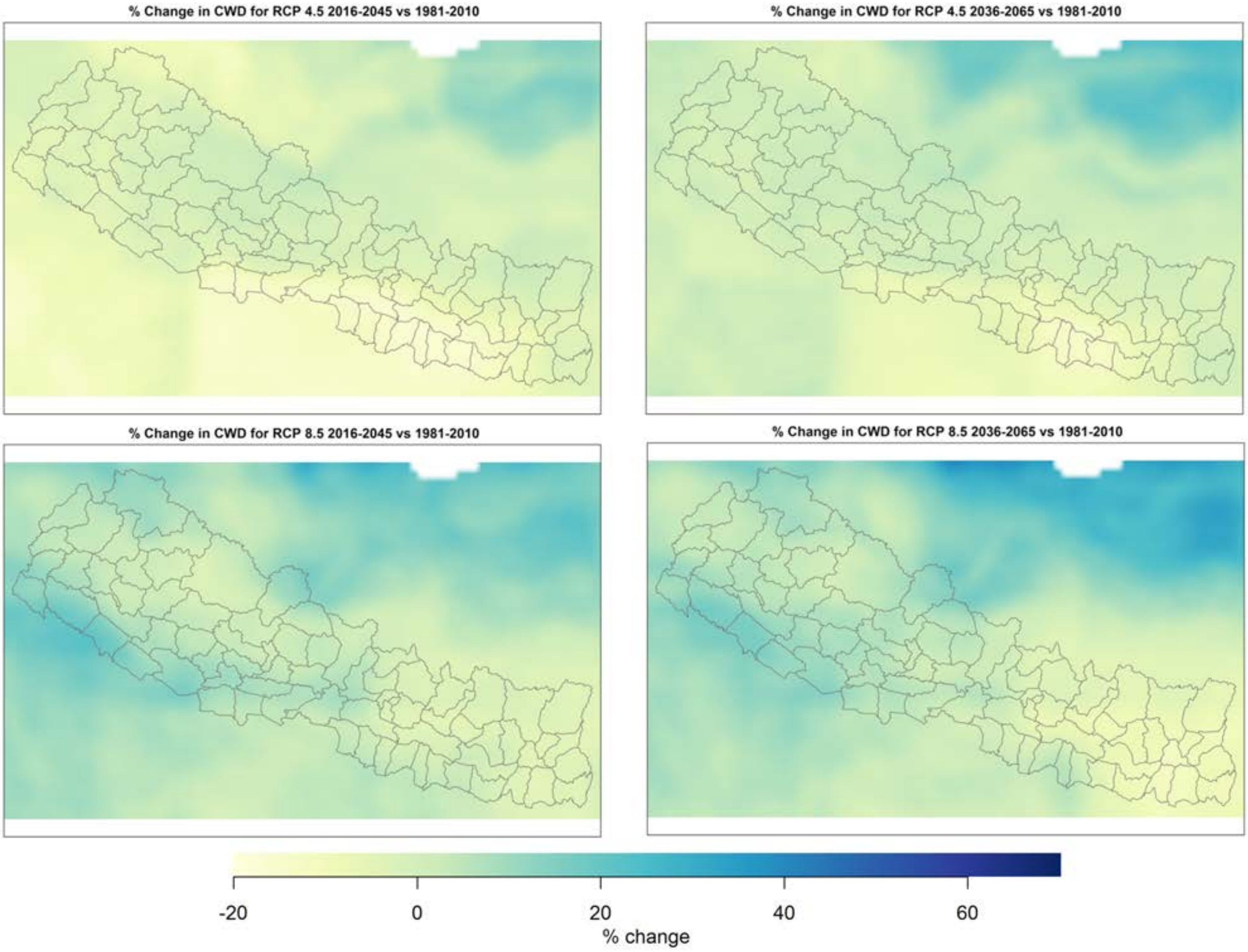


Figure 15 shows the percentage change in consecutive wet days (CWD) when the total daily precipitation is greater than 1 mm for the medium-term and the long-term periods of RCP4.5 and RCP8.5. In the reference period, the number of mean annual consecutive wet days are 78.1 in total. In contrast to CDD, CWD is likely to decrease in the medium-term and the long-term periods of RCP4.5, however, it is increased for RCP8.5. In the medium-term period, CWD is likely to decrease in the whole of Nepal by 4.2% (3.3 days) for RCP4.5 and increase by 3.1% (2.5 days) for RCP8.5. In long-term period, CWD is likely to decrease by 1.3% (1 days) for RCP4.5 and increase by 2.2% (1.7 days) for RCP8.5, as shown in Table 12. An increase in CWD in the long-term period of RCP8.5 might be associated with the increase in precipitation amount in RCP8.5 (compared to 4.5) (Figure 8). The average % change in CWD for two future periods and two RCPs for 77 districts are provided in Table 3.5 of the Annex.

4.4.2. Temperature Extreme Indices

The ensemble of 4 GCMs each for RCP4.5 and RCP8.5 suggest that temperature rise will be in the range of 1.3 °C to 1.82 °C (Table 8) for the medium-term and the long-term periods. This section describes the change in six temperature indices (Table 6).

Figure 16: Projected changes (%) in warm days from the reference period (1981-2010) to the medium-term (2016-2045) and the long-term periods (2036-2065) for RCP4.5 and RCP8.5 model ensembles.

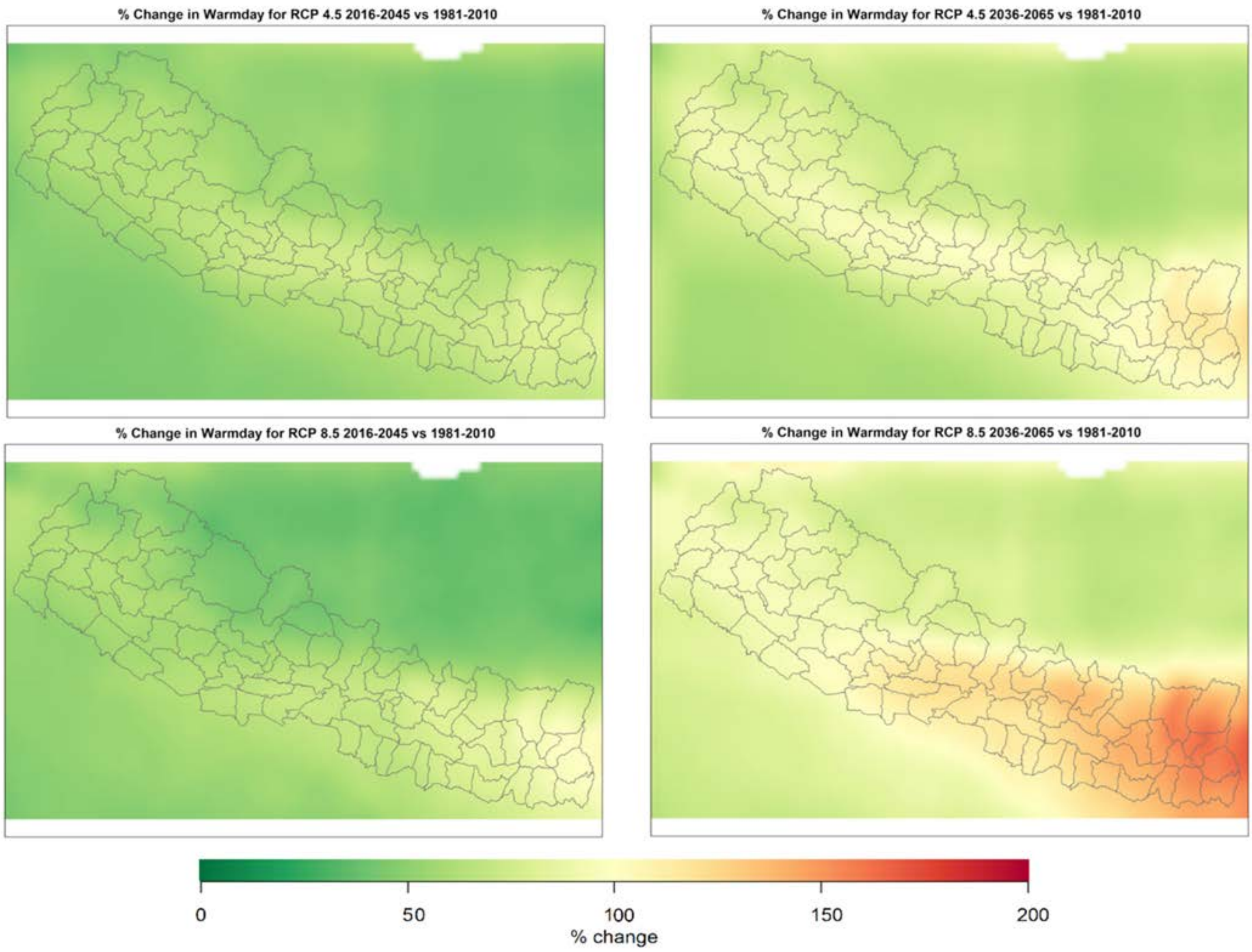


Figure 16 shows the percentage change in warm days when the maximum temperature is higher than the 90th percentile of the reference maximum temperature for the medium-term and long-term periods of RCP4.5 and RCP8.5. In the reference period, the number of mean annual warm days are 36.5 in total. In the medium-term period, warm days are likely to increase across Nepal, with the eastern part registering an increase by a higher magnitude. The warm days will increase by 64.5% (23.9 days) for RCP4.5 and by 71.4% (26.4 days) for RCP8.5. In the long-term period, the eastern part of Nepal (Figure 16, lower right panel) will be affected more by the increase in temperature, as the increase is expected to be 87.3% (32.3 days) and 124.7% (46.1 days) for RCP4.5 and RCP8.5 respectively, as shown in Table 12. The increase in warm days can be attributed to the overall rise in temperature in the future periods. The average % change in warm days for two future periods and two RCPs for 77 districts are provided in Table 4.1 of the Annex.

Figure 17: Projected changes (%) in warm nights from the reference period (1981-2010) to the medium-term (2016-2045) and the long-term future periods (2036-2065) for RCP4.5 and RCP8.5 model ensembles

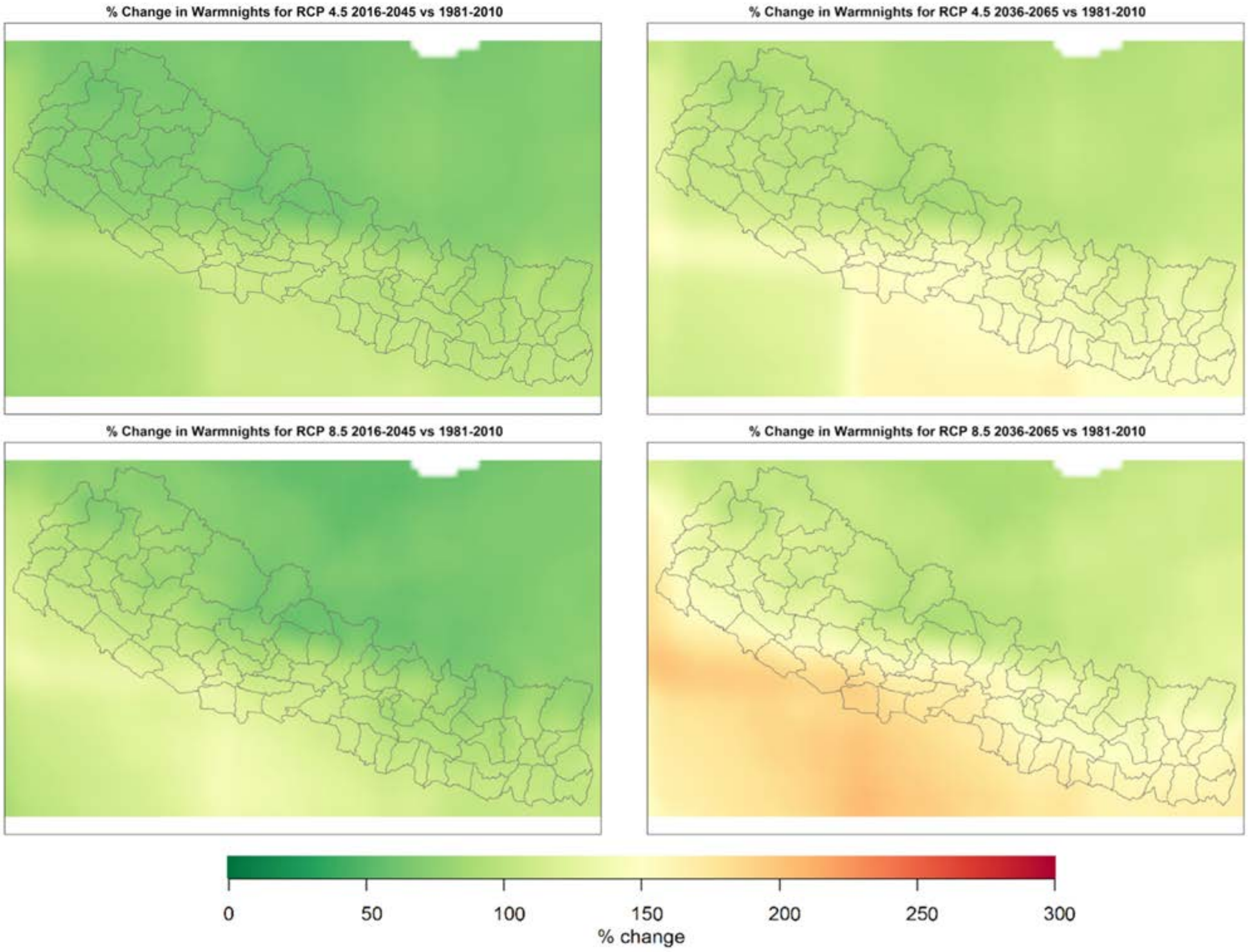


Figure 17 and Table 12 show the percentage change in warm nights when the minimum temperature is higher than the 90th percentile of the reference minimum temperature for the medium-term and the long-term periods of RCP4.5 and RCP8.5. In the reference period, the number of mean annual warm nights are 36.5 in total. In the medium-term period, warm nights are likely to increase across Nepal, with the eastern part and the lower elevation areas showing a higher magnitude of increase. The warm nights will increase by 81.4% (30.5 days) for RCP4.5 and by 101% (37.8 days) for RCP8.5. Warm nights are likely to increase across Nepal in the long-term period as well, with the lower elevation areas registering an increase of a higher magnitude than the hills and mountains. Warm nights are likely to increase by 115.7% (43.3 days) for RCP4.5 and by 159.2% (59.6 days) for RCP8.5. The increase in warm nights can be attributed to the rise in the minimum temperature in the future. The average % change in warm nights for two future periods and two RCPs for 77 districts are provided in Table 4.2 of the Annex.

Figure 18: Projected changes (%) in cold days from the reference period (1981-2010) to the medium-term (2016-2045) and the long-term future periods (2036-2065) for RCP4.5 and RCP8.5 model ensembles

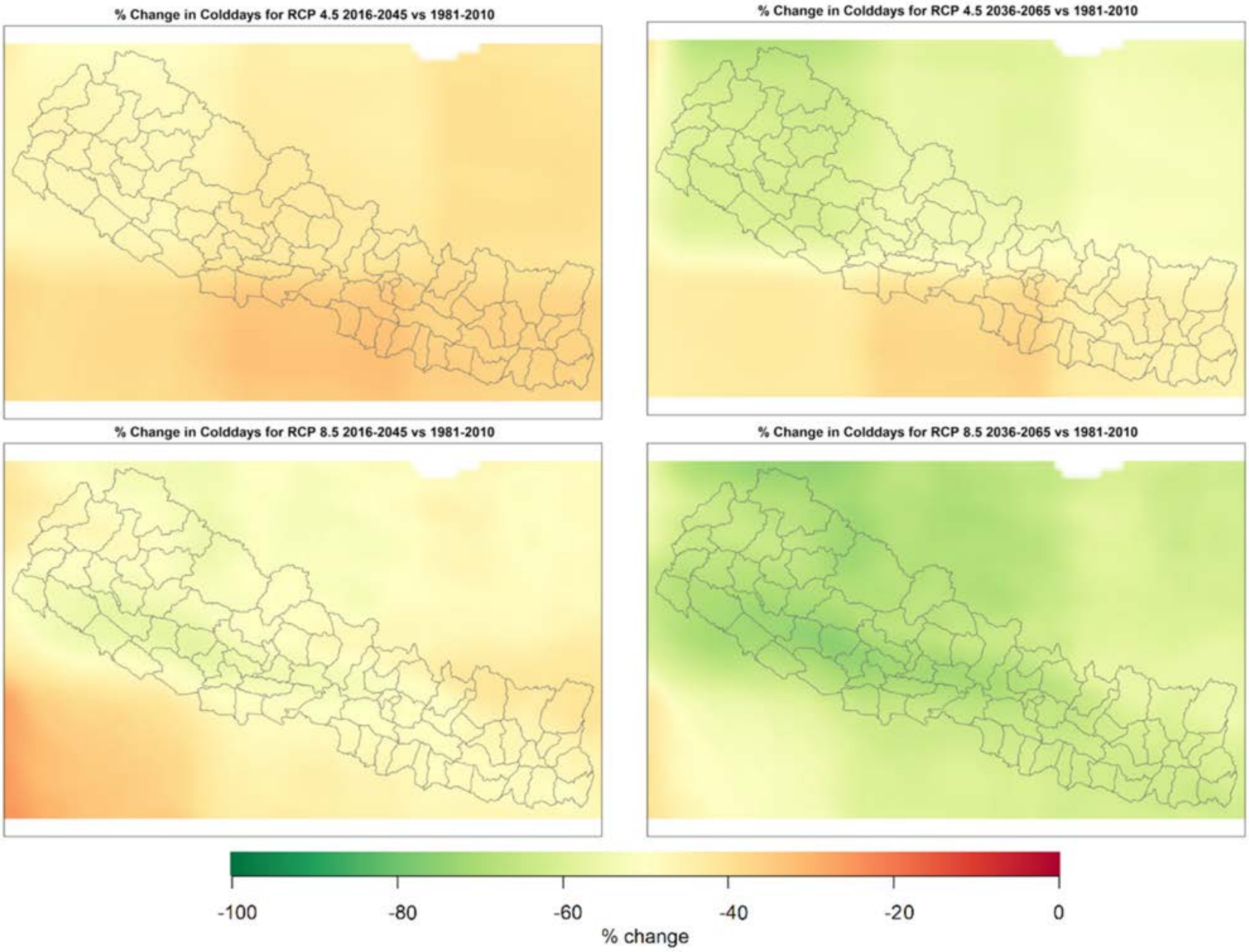


Figure 18 and Table 12 show the percentage change in cold days when the maximum temperature is lower than the 10th percentile of the reference maximum temperature for the medium-term and long-term periods of RCP4.5 and RCP8.5. In the reference period, the number of mean annual cold days are 36.5 in total. In the medium-term period, cold days seem to be decreasing with a higher magnitude in RCP8.5 than in RCP4.5. Cold days may decrease by 42% (15.4 days) for RCP4.5 and by 55.8% (20.5 days) for 8.5. In the long-term period, cold days seem to be decreasing across Nepal, with a higher magnitude of change in the western region than in the eastern. Cold days are likely to decrease by 52.6% (19.3 days) for RCP4.5 and by 75% (27.5 days) for RCP8.5. The decrease in cold days might be associated with the increase in temperature as shown in Table 7. The average % change in cold days for two future periods and two RCPs for 77 districts are provided in Table 4.3 of the Annex.

Figure 19: Projected changes (%) in cold nights from the reference period (1981-2010) to the medium-term (2016-2045) and the long-term periods (2036-2065) for RCP4.5 and RCP8.5 model ensembles

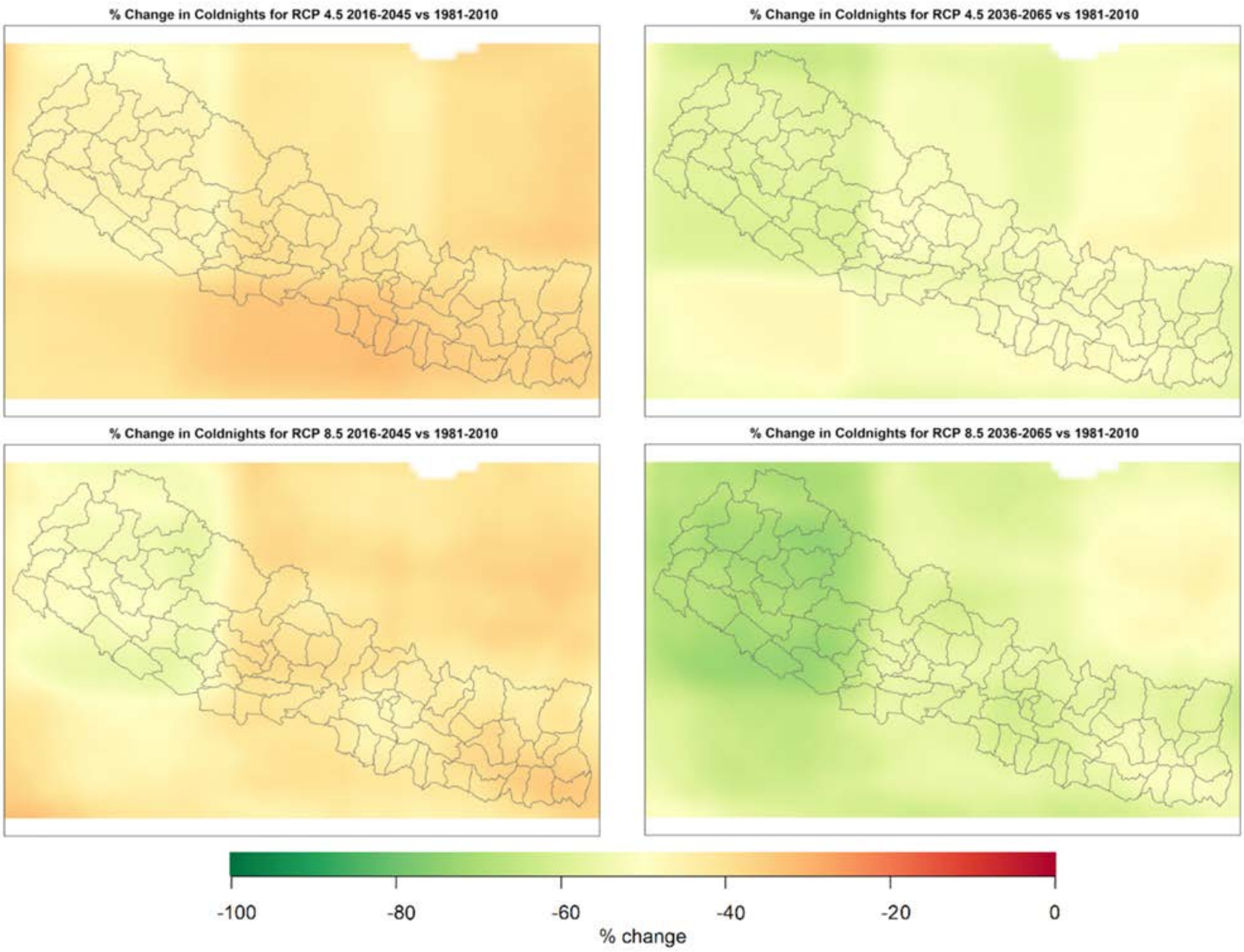


Figure 19 and Table 12 show the percentage change in cold nights when the minimum temperature is lower than the 10th percentile of the reference minimum temperature for the medium-term and the long-term scenarios of RCP4.5 and RCP8.5. In the reference period, the number of mean annual cold nights are 36.5 in total. In the medium-term period, cold nights seem to be decreasing in both RCP4.5 and 8.5, with a higher magnitude in the western part than in the eastern. Overall, cold nights are likely to decrease by 40.7% (15 days) for RCP4.5 and by 54.1% (19.9 days) for RCP8.5. In the long-term period, cold days seem to be decreasing across Nepal, with a higher magnitude of change registered in the western part. Overall, cold nights are likely to decrease by 53.5% (19.7 days) for RCP4.5 and by 74% (27.3 days) for RCP8.5. The decrease in cold nights might be associated with the increase in temperature as shown in Table 7. The average % change in warm nights for two future periods and two RCPs for 77 districts are provided in Table 4.4 of the Annex.

Figure 20: Projected changes (%) in warm spell duration index from the reference period (1981-2010) to the medium-term (2016-2045) and the long-term periods (2036-2065) for RCP4.5 and RCP8.5 model ensembles.

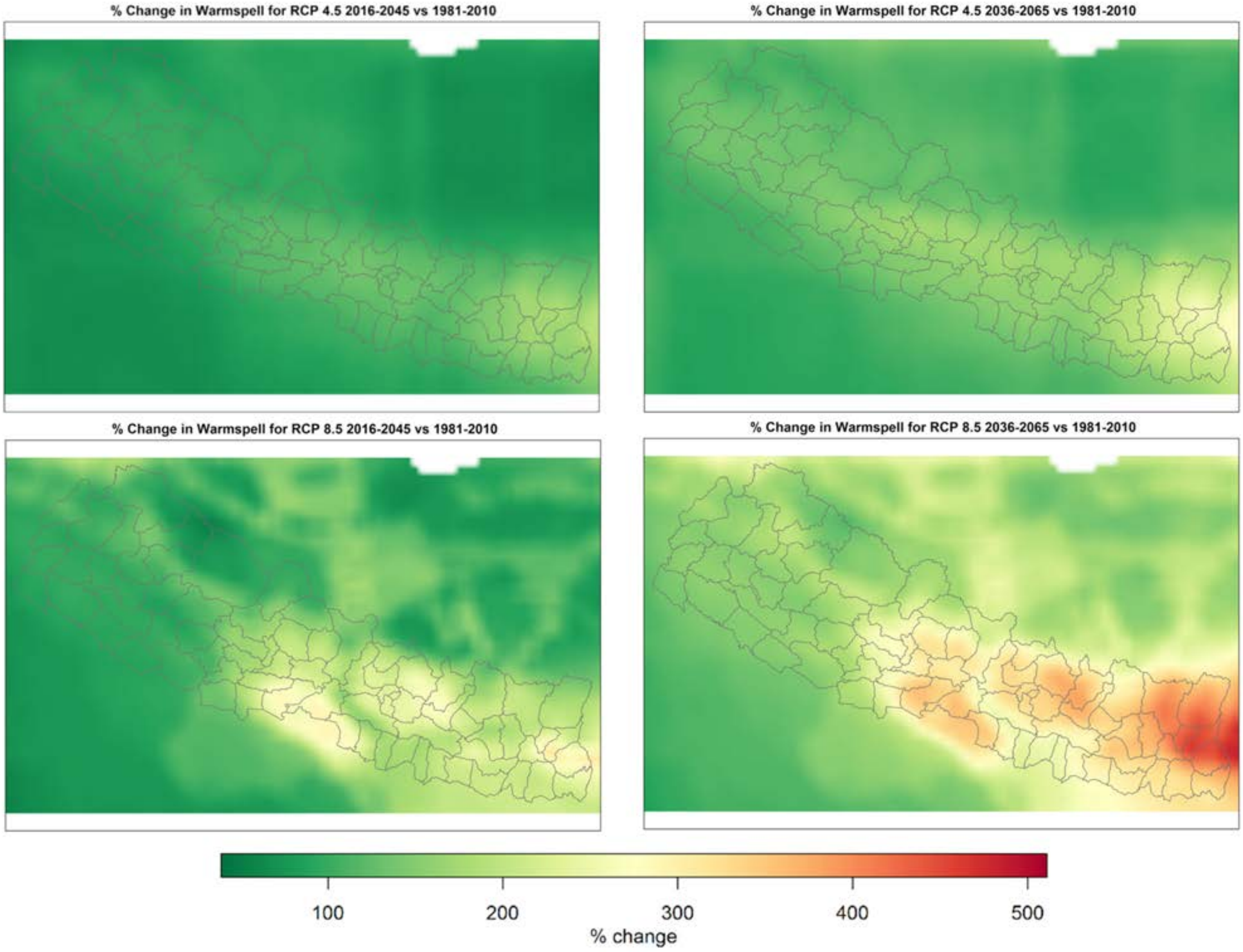


Figure 20 and Table 12 show the percentage change in warm spell duration index (WSDI) for RCP4.5 and RCP8.5 scenarios when the daily maximum temperature is higher than the 90th percentile of the maximum temperature of the reference period for at least six consecutive days. In the reference period, the number of mean annual days when maximum temperature was higher than 90th percentile for six or more days are 17.6 in total. In the medium-term period, warm spell is likely to increase across Nepal in both scenarios, although the magnitude of increase is higher in the central and the eastern parts in RCP8.5. On average, increase in WSDI is expected to be 110% (19.3 days) for RCP4.5 and 157% (27.6 days) for RCP8.5. WSDI is likely to increase across Nepal in the long-term period as well, with a higher magnitude of increase in the eastern part similar to the medium-term period. On average, WSDI is expected to have increased by 149% (26.2 days) for RCP4.5 and by 245% (43 days) for RCP8.5 in long-term period. In both scenarios and periods, warm spell is likely to hit the eastern part severely. WSDI figures in Nepal show the most conspicuous change among the extreme indices for the scenarios under consideration, as the range of increase is between 50-500 % with respect to the reference period. The surge in the warm spell might be associated with the increase in the average temperature, as indicated in Table 7. The average % change in WSDI for two future periods and two RCPs for 77 districts are provided in Table 4.5 of the Annex.

Figure 21: Projected changes (%) in cold spell duration index from the reference period (1981-2010) to the medium-term (2016-2045) and the long-term periods (2036-2065) for RCP4.5 and RCP8.5 model ensembles.

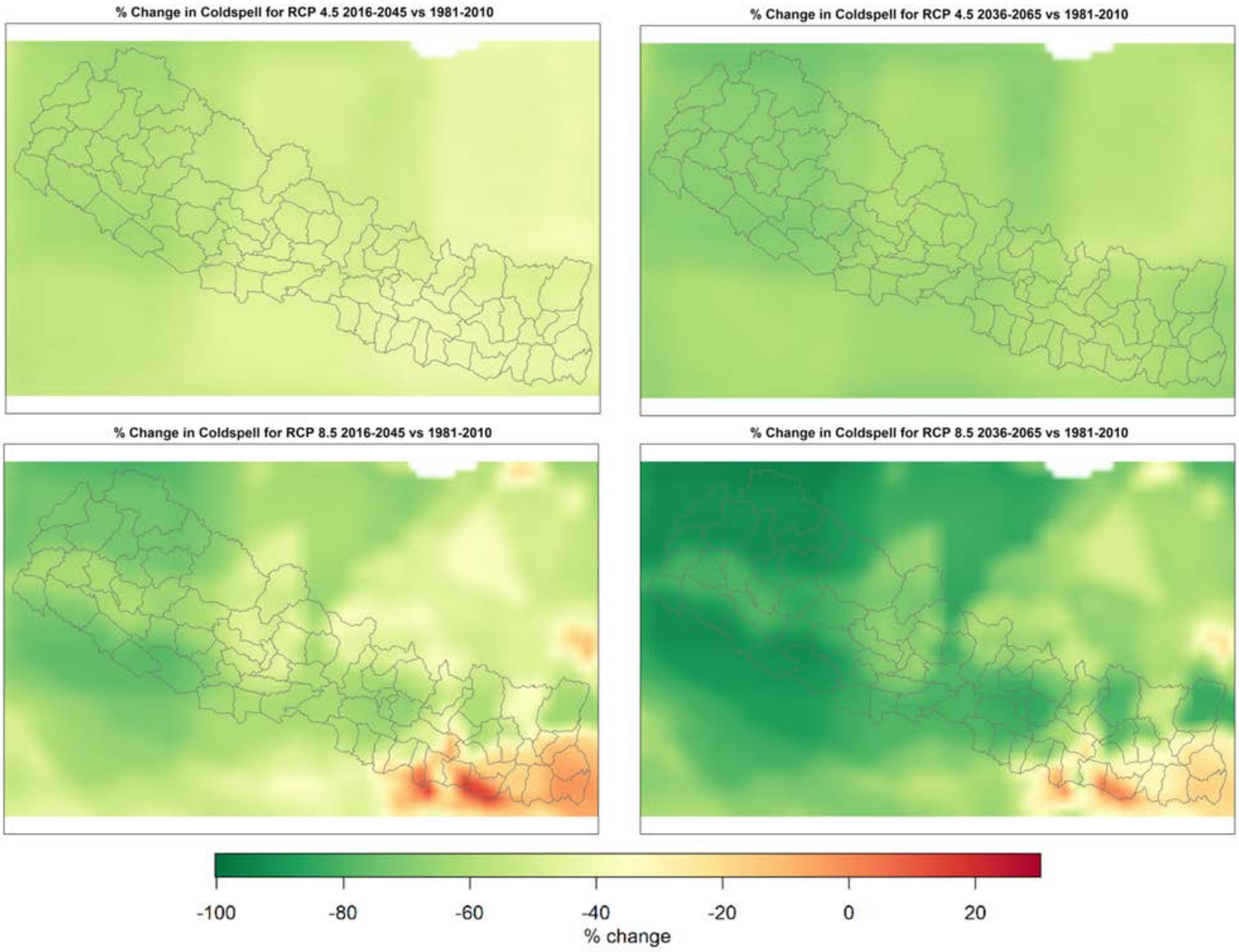


Figure 21 and Table 12 show the percentage change in cold spell duration index (CSDI) for RCP4.5 and RCP8.5 scenarios when the minimum temperature is lower than the 10th percentile of the minimum temperature of the reference period for at least six consecutive days. In the reference period, the number of mean annual days when minimum temperature was lower than 10th percentile for six or more days are 20.3 days in total. In the medium-term period, cold spells are likely to decrease across Nepal except for a few patches of increase in the eastern part. The decrease is most prominent in the western part. On average, a decrease in CSDI is expected to be 52% (10.5 days) for RCP4.5 and 55% (11.2 days) for RCP8.5. CSDI is likely to decrease across Nepal in the long-term period as well, except for a few patches of increase in the eastern part. The magnitude of increase is seen to be higher in the western part. On average, CSDI is expected to have decreased by 64% (12.9 days) for RCP4.5 and by 73% (14.8 days) for RCP8.5. The average % change in CSDI for two future periods and two RCPs for 77 districts are provided in Table 4.6 of the Annex.

5. SUMMARY

Trends over 1975–2005 indicate that Nepal has been warming by about 0.6 degrees Celsius (°C) per decade, at least three times as high as the global average. How the climate will evolve in the future will crucially affect communities, ecosystems, livelihoods, and key sectors such as agriculture, water, and energy.

This study provides information about temperature and precipitation patterns in the medium term (2016–45) and long-term (2036–65). It used select Global Circulation Models (GCMs) from the CMIP5 dataset of the IPCC's Fifth Assessment Report (AR5) to provide results of the climate scenarios for Nepal in the medium-term and long-term. It shows results that are similar to previous studies that examined changes in temperature and rainfall in the future. However, its projections about the magnitude of change might be different from theirs, depending upon the choice of GCMs and selection methodology. .

It indicates a range of possible changes in the future, based on 11 indices of climate extremes, six indices pertaining to temperature and five for precipitation. Two possible concentration pathways, RCP4.5 and RCP8.5, based on different socioeconomic developmental trajectories, were chosen to identify extreme scenarios of the future. These scenarios were analysed for the medium-term (2016–2045) and the long-term (2036–2065) periods, corresponding with the 2030s and the 2050s respectively, as laid out by the National Adaptation Plan process.

This report provides detailed information about changes in annual precipitation and temperature patterns for the respective periods in all districts and physiographic zones at the annual and seasonal level (see Annexures, p 39 onwards). Second, the selected indices of climatic extremes were analysed to understand the magnitude of change in the future. Such information would be crucial in designing region- or ecosystem-specific adaptation plans and strategies for different districts of Nepal.

The key findings of the study are presented below. The crux of its findings is that the climate in Nepal will be warmer and wetter by mid-century, and those trends can continue to the end of the century. Extreme events are also likely to increase.

- **Average annual precipitation is likely to increase** in both the medium-term and long-term periods, under both scenarios. The monsoon, post-monsoon, and winter seasons may receive higher precipitation, but pre-monsoon precipitation might decline for both future periods and RCPs.
- **Average annual mean temperature will continue to rise,** by about 0.9–1.1 °C in the medium-term period and 1.3–1.8 °C in the long-term period.
- **Winter and post-monsoon temperatures will increase** at a higher rate than in other seasons for both future periods and RCPs.
- **The rise in temperature will be sharper** in the high mountains than in areas at lower elevations. This finding is consistent with elevation-dependent warming found in already observed data.
- **Future projections have a large degree of uncertainty.** The uncertainty in temperature is smaller than precipitation. Additionally, all models agree about increases in temperature in the future while there is variability among the models. Most models show increase in precipitation, few models

also show a decrease in precipitation. Collectively, these results suggest that temperature-related changes are more certain than precipitation.

- **Extreme events might become more frequent** in the future.
- **Extremely wet days** (P99) **and very wet days** (P95) are **likely to increase** in the future, compared to the reference period.
- **The number of rainy days will decrease** under both RCP scenarios, with a higher rate in the medium-term than in the long-term.
- **The number of warm days and warm nights will increase consistently** in the future. The number of warm days might increase in the range of 2.3–3.9 days in the medium-term period. The number of warm nights is also likely to increase in the future, in the range of up to 5 days in the long-term period.
- **Cold days and cold nights will decrease** mainly due to the increase in average temperature in the future. Cold days might decrease up to 2.4 days and cold nights might decrease by 2.3 days in the long-term period.
- **Warm spells will likely increase substantially** in the future, by 19–27 days in the medium-term period, and by 26–43 days in the long-term period.
- **Cold spells might decrease substantially** in the future, by 10–11 days in the medium-term period, and by 13–15 days in the long-term period.

Overall, the findings from the study suggest that precipitation and temperature will be higher in the future than in the reference period. Specifically, temperature variables are expected to increase continuously throughout the century. Annual precipitation might increase overall but vary seasonally. Extreme climatic events, especially related to temperature, are likely to be more frequent and more severe. As stated, these changes would have a serious impact on different sectors, such as water, energy, biodiversity, agriculture, and livelihoods.

It must be pointed out that there is still a large uncertainty in the projection of future climate trends due to a number of factors. The scientific understanding of atmospheric processes, especially in the Himalayan region, is still limited. Future developmental pathways that the world will embrace are uncertain; they depend on many socioeconomic decisions, energy choices, and the political discourse around climate negotiations for the global reduction of greenhouse gases and their compliance. Countries have already formed agreements to reduce greenhouse gas emissions, such as the 2016 Paris Agreement to check the rise in global average temperature to well below 2 °C above pre-industrial levels, and further, to pursue efforts to limit the temperature increase to 1.5 °C. Such goals would lead to changes in socioeconomic development pathways in the future. Therefore, the results of this assessment should be taken as indicative, rather than absolute, while designing adaptation options and strategies, and the uncertainties should not be ignored. Having said that, this study's indicative results capture a wide range of future climate variability, and would be extremely pertinent in helping policy makers design appropriate adaptation plans and strategies for the years to come. In other words, the underlying uncertainties should always be considered while designing adaptation plans.

6. REFERENCES

Agarwal, A., Babel, M.S., Maskey, S., 2014. Analysis of future precipitation in the Koshi river basin, Nepal. J. Hydrol. 513, 422–434. DOI:10.1016/j.jhydrol.2014.03.047

Agarwal, A., Babel, M.S., Maskey, S., Shrestha, S., Kawasaki, A., Tripathi, N.K., 2016. Analysis of temperature projections in the Koshi River Basin, Nepal. Int. J. Climatol. 36, 266–279. DOI:10.1002/joc.4342

Alexander, L. V., Zhang, X., Peterson, T.C., Caesar, J., Gleason, B., Klein Tank, A.M.G., Haylock, M., Collins, D., Trewin, B., Rahimzadeh, F., Tagipour, A., Rupa Kumar, K., Revadekar, J., Griffiths, G., Vincent, L., Stephenson, D.B., Burn, J., Aguilar, E., Brunet, M., Taylor, M., New, M., Zhai, P., Rusticucci, M., Vazquez-Aguirre, J.L., 2006. Global observed changes in daily climate extremes of temperature and precipitation. J. Geophys. Res. Atmos. 111, 1–22. DOI:10.1029/2005JD006290

Baidya, S.K., Shrestha, M.L., Sheikh, M.M., 2008. Trends in daily climatic extremes of temperature and precipitation in Nepal. J. Hydrol. Meteorol. 5, 38–51.

Boe, J., Terray, L., Habets, F., Martin, E., 2007. Statistical and dynamical downscaling of the Seine basin climate for hydro-meteorological studies. Int. J. Climatol. 27, 1643–1655. DOI:10.1002/joc.1602

Deque, M., 2007. Frequency of precipitation and temperature extremes over France in an anthropogenic scenario: Model results and statistical correction according to observed values. Glob. Planet. Change 57, 16–26. DOI:10.1016/j.gloplacha.2006.11.030

DHM, 2017. Observed Climate Trend Analysis in the Districts and Physiographic Zones of Nepal (1971-2014).

Donat, M.G., Alexander, L. V., Yang, H., Durre, I., Vose, R., Caesar, J., 2013. Global land-based datasets for monitoring climatic extremes. Bull. Am. Meteorol. Soc. 94, 997–1006. DOI:10.1175/BAMS-D-12-00109.1

Fowler, H.J., Blenkinsop, S., Tebaldi, C., 2007. Linking climate change modelling to impacts studies : recent advances in downscaling techniques for hydrological modelling. Int. J. Climatol. 1547–1578. DOI:10.1002/joc.1556

Immerzeel, W.W., Pellicciotti, F., Bierkens, M.F.P., 2013. Rising river flows throughout the twenty-first century in two Himalayan glacierized watersheds. Nat. Geosci. 6, 742–745. DOI:10.1038/ngeo1896

Immerzeel, W.W., Pellicciotti, F., Shrestha, A.B., 2012. Glaciers as a Proxy to Quantify the Spatial Distribution of Precipitation in the Hunza Basin. Mt. Res. Dev. 32, 30–38. https://doi.org/10.1659/MRD-JOURNAL-D-11-00097.1

Immerzeel, W.W., Wanders, N., Lutz, A.F., Shea, J.M., Bierkens, M.F.P., 2015. Reconciling high-altitude precipitation in the upper Indus basin with glacier mass balances and runoff. Hydrol. Earth Syst. Sci. 19, 4673–4687. https://doi.org/10.5194/hess-19-4673-2015

IPCC, 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK.

IPCC, 2007. Climate change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Mitigation of climate change. Geneva, Switzerland.

Karki, R., Hasson, S., Schickhoff, U., Scholten, T., Böhner, J., 2017. Rising Precipitation Extremes across Nepal. Climate 5, 4. DOI:10.3390/cli5010004

Khadka, D., Babel, M.S., Shrestha, S., Tripathi, N.K., 2014. Climate change impact on glacier and snow melt and runoff in Tamakoshi basin in the Hindu Kush Himalayan (HKH) region. J. Hydrol. 511, 49–60. DOI:10.1016/j.jhydrol.2014.01.005

Khatiwada, K., Panthi, J., Shrestha, M., Nepal, S., 2016. Hydro-Climatic Variability in the Karnali River Basin of Nepal Himalaya. Climate 4, 17. DOI:10.3390/cli4020017

Lutz, A.F., 2016. Impact of climate change on the hydrology of High Mountain Asia. Faculty of Geosciences, Utrecht Studies in Earth Sciences, Universiteit Utrecht, The Netherlands

Lutz, A.F., Immerzeel, W.W., 2015. HI-AWARE Reference Climate Dataset for the Indus , Ganges and Brahmaputra River Basins. FutureWater 34.

Lutz, A.F., Immerzeel, W.W., Shrestha, A.B., Bierkens, M.F.P., 2014. Consistent increase in High Asia's runoff due to increasing glacier melt and precipitation. Nat. Clim. Chang. 4, 587–592. DOI:10.1038/nclimate2237

Lutz, A.F., ter Maat, H.W., Biemans, H., Shrestha, A.B., Wester, P., Immerzeel, W.W., 2016. Selecting representative climate models for climate change impact studies: an advanced envelope-based selection approach. Int. J. Climatol. 36, 3988–4005.

Manandhar, S., Pandey, V.P., Kazama, F., 2012. Hydro-climatic trends and people's perceptions: Case of Kali Gandaki River Basin, Nepal. Clim. Res. 54, 167–179. DOI:10.3354/cr01108

Maraun, D., Wetterhall, F., Chandler, R.E., Kendon, E.J., Widmann, M., Brienen, S., Rust, H.W., Sauter, T., Themeßl, M., Venema, V.K.C., Chun, K.P., Goodess, C.M., Jones, R.G., Onof, C., Vrac, M., Thiele-Eich, I., 2010. Precipitation downscaling under climate change: Recent developements to bridge the gap between dynamical models and the end user. Rev. Geophys. 48, 1–38. DOI:10.1029/2009RG000314

Meehl, G.A., Covey, C., Taylor, K.E., Delworth, T., Stouffer, R.J., Latif, M., McAvaney, B., Mitchell, J.F.B., 2007. THE WCRP CMIP3 Multimodel Dataset: A New Era in Climate Change Research. Bull. Am. Meteorol. Soc. 88, 1383–1394. DOI:10.1175/BAMS-88-9-1383

MoPE, 2016. Intended Nationally Determined Contributions (INDC). Ministry of Population and Environment. Government of Nepal, (February), 1–12.

Moss, R.H., Edmonds, J.A., Hibbard, K.A., Manning, M.R., Rose, S.K., van Vuuren, D.P., Carter, T.R., Emori, S., Kainuma, M., Kram, T., Meehl, G.A., Mitchell, J.F.B., Nakicenovic, N., Riahi, K., Smith, S.J., Stouffer, R.J., Thomson, A.M., Weyant, J.P., Wilbanks, T.J., Moss, RH, Edmonds, JA, Hibbard, KA, Manning, MR, Rose, SK, van Vuuren, DP, Carter, TR, Emori, S, Kainuma, M, Kram, T, Meehl, GA, Mitchell, JFB, Nakicenovic, N, Riahi, K, Smith, SJ, Stouffer, RJ, Thomson, AM, Weyant, JP & Wilbanks, T., 2010. The next generation of scenarios for climate change research and assessment. Nature 463, 747–756. DOI:10.1038/nature08823

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

Nepal, S., 2016. Impacts of climate change on the hydrological regime of the Koshi river basin in the Himalayan region. J. Hydro-Environment Res. 10, 76–89. DOI:10.1016/j.jher.2015.12.001

Panthi, J., Dahal, P., Shrestha, M., Aryal, S., Krakauer, N., Pradhanang, S., Lakhankar, T., Jha, A., Sharma, M., Karki, R., 2015. Spatial and Temporal Variability of Rainfall in the Gandaki River Basin of Nepal Himalaya. Climate 3, 210–226. DOI:10.3390/cli3010210

Peterson, T.C., 2005. Climate change indices. WMO Bull. 54, 83–86.

Piani, C., Weedon, G.P., Best, M., Gomes, S.M., Viterbo, P., Hagemann, S., Haerter, J.O., 2010. Statistical bias correction of global simulated daily precipitation and temperature for the application of hydrological models. J. Hydrol. 395, 199–215. DOI:10.1016/j.jhydrol.2010.10.024

Rajbhandari, R., Shrestha, A.B., Nepal, S., Wahid, S., 2016. Projection of Future Climate over the Koshi River Basin Based on CMIP5 GCMs. Atmos. Clim. Sci. 6, 190–204. DOI:10.4236/acs.2016.62017

Rajbhandari, R., Shrestha, A.B., Nepal, S., Wahid, S., Ren, G.-Y., 2017. Extreme climate projections over the transboundary Koshi River Basin using a high resolution regional climate model. Adv. Clim. Chang. Res. 8, 199–211. DOI:10.1016/j.accre.2017.08.006

Schneider, U., Becker, A., Finger, P., Meyer-Christoffer, A., Ziese, M., Rudolf, B., 2013. GPCC's new land surface precipitation climatology based on quality-controlled in situ data and its role in quantifying the global water cycle. Theor. Appl. Climatol. 115, 15–40. https://doi.org/10.1007/s00704-013-0860-x

Sharma, K.P., Moore, B., Vorosmarty, C.J., 2000. Anthropogenic, Climatic, and Hydrologic Trends in the Kosi Basin, Himalaya. Clim. Change 47, 141–165. DOI:10.1023/A:1005696808953

Shrestha, A.B., Bajracharya, S.R., Sharma, A.R., Duo, C., Kulkarni, A., 2017. Observed trends and changes in daily temperature and precipitation extremes over the Koshi river basin 1975–2010. Int. J. Climatol. 37, 1066–1083. DOI:10.1002/joc.4761

Shrestha, A.B., Wake, C.P., Mayewski, P.A., Dibb, J.E., 2000. Precipitation fluctuations in the Himalaya and its vicinity: An analysis based on temperature records from Nepal. Int. J. Clim. 20, 317–327. DOI:10.1002/(SICI)1097-0088(20000315)20:3<317::AID-JOC476>3.0.CO;2-G

Shrestha, A.B., Wake, C.P., Mayewski, P.A., Dibb, J.E., 1999. Maximum temperature trends in the Himalaya and its vicinity: An analysis based on temperature records from Nepal for the period 1971-94. J. Clim. 12, 2775–2786. DOI:10.1175/1520-0442(1999)012<2775:MTTITH>2.0.CO;2

Shrestha, S., Bajracharya, A.R., Babel, M.S., 2016. Assessment of risks due to climate change for the Upper Tamakoshi Hydropower Project in Nepal. Clim. Risk Manag. 14, 27–41. DOI:10.1016/j.crm.2016.08.002

Taylor, K.E., Stouffer, R.J., Meehl, G.A., 2012. An Overview of CMIP5 and the Experiment Design. Bull. Am. Meteorol. Soc. 93, 485–498. DOI:10.1175/BAMS-D-11-00094.1

Terink, W., Immerzeel, W.W., Lutz, A.F., Droogers, P., Khanal, S., Nepal, S., Shrestha, A.B., 2017. Hydrological and Climate Change Assessment for Hydropower development in the Tamakoshi River Basin, Nepal 31, 1–93.

Themeßl, M.J., Gobiet, A., Heinrich, G., 2011a. Empirical-statistical downscaling and error correction of regional climate models and its impact on the climate change signal. Clim. Change 112, 449–468. DOI:10.1007/s10584-011-0224-4

Themeßl, M.J., Gobiet, A., Leuprecht, A., 2011b. Empirical-statistical downscaling and error correction of daily precipitation from regional climate models. Int. J. Climatol. 31, 1530–1544. DOI:10.1002/joc.2168

Trenberth, K.E., Jones, P.D., Ambehje, P., Bojariu, R., Easterling, D., Tank, A.K., Parker, D., Rahimzadeh, F., Renwick, J.A., Rusticucci, M., Soden, B., Zhai, P., 2007. Observations: surface and atmospheric climate change In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge Univ. Press. Cambridge, United Kingdom New York, NY, USA 235–336.

van Vuuren, D.P., Edmonds, J., Kainuma, M., Riahi, K., Thomson, A., Hibbard, K., Hurtt, G.C., Kram, T., Krey, V., Lamarque, J.F., Masui, T., Meinshausen, M., Nakicenovic, N., Smith, S.J., Rose, S.K., 2011. The representative concentration pathways: An overview. Clim. Change 109, 5–31. DOI:10.1007/s10584-011-0148-z

Weedon, G.P., Balsamo, G., Bellouin, N., Gomes, S., Best, M.J., Viterbo, P., 2014. Data methodology applied to ERA-Interim reanalysis data. Water Resour. Res. 50, 7505–7514. https://doi.org/10.1002/2014WR015638

Weedon, G.P., Gomes, S., Viterbo, P., Shuttleworth, W.J., Blyth, E., Österle, H., Adam, J.C., Bellouin, N., Boucher, O., Best, M., 2011. Creation of the WATCH Forcing Data and Its Use to Assess Global and Regional Reference Crop Evaporation over Land during the Twentieth Century. J. Hydrometeorol. 12, 823–848. https://doi.org/10.1175/2011JHM1369.1

Wilby, R.L., Wigley, T.M.L., 1997. Downscaling general circulation model output: a review of methods and limitations. Prog. Phys. Geogr. 21, 530–548. DOI:10.1177/030913339702100403

You, Q., Kang, S., Aguilar, E., Pepin, N., Flugel, W.A., Yan, Y., Xu, Y., Zhang, Y., Huang, J., 2011. Changes in daily climate extremes in China and their connection to the large scale atmospheric circulation during 1961-2003. Clim. Dyn. 36, 2399–2417. DOI:10.1007/s00382-009-0735-0

ANNEXURE

1. Change in Precipitation (%) for districts of Nepal from the reference period (1981-2010)

S.N.	District Name	Reference Period (mm)	RCP4.5		RCP8.5	
			2016-2045	2036-2065	2016-2045	2036-2065
1	Achham	1581	0.29	8.08	6.62	14.06
2	Arghakhanchi	1898	1.9	8.73	7.03	11.65
3	Baglung	2145	3.31	10.41	9.12	14.49
4	Baitadi	1786	0.05	7.86	6.44	14.07
5	Bajhang	1625	0.87	8.97	6.78	14.4
6	Bajura	1473	0.57	8.47	6.53	14.03
7	Banke	1498	1.66	8.64	6.42	12.69
8	Bara	1717	2.21	9.54	7.05	11.41
9	Bardiya	1551	1.15	9.33	7.33	14.53
10	Bhaktapur	2106	2.28	7.97	6.51	10.58
11	Bhojpur	1891	2.27	3.32	2.28	6.87
12	Chitwan	1974	0.41	6.92	4.72	7.69
13	Dadeldhura	1702	0.07	8.04	6.39	14.25
14	Dailekh	1532	-0.11	7.33	6.37	13.31
15	Dang	1619	1.1	7.62	6.7	12.36
16	Darchula	1801	0.53	8.67	6.55	13.98
17	Dhading	2060	2.51	8.37	6.8	10.82
18	Dhankuta	1916	2.79	3.34	2.24	6.92
19	Dhanusa	1529	5.16	7.26	5.89	10.9
20	Dolakha	2188	3.55	6.15	4.82	10.48
21	Dolpa	1359	3.21	11.55	10.14	17.04
22	Doti	1716	0.22	8.05	6.58	14.05
23	Eastern Rukum	1822	1.69	9.15	8.55	15.38
24	Gorkha	1971	2.87	9.23	8.08	12.84
25	Gulmi	2089	2.85	9.36	7.74	12.05
26	Humla	1546	0.68	8.65	6.96	14.19
27	Ilam	2458	3.51	3.77	2.07	7.41
28	Jajarkot	1793	-0.09	7.08	6.04	12.59
29	Jhapa	2450	3.18	3.72	1.82	6.54
30	Jumla	1896	-0.32	6.91	5.99	12.26
31	Kailali	1673	0.08	8.21	7.05	14.19
32	Kalikot	1575	-0.16	7.23	5.98	12.9

33	Kanchanpur	1625	-0.2	8.1	6.15	14.27
34	Kapilbastu	1735	0.05	7.55	6.19	10.03
35	Kaski	2437	3.4	10.66	9.47	14.63
36	Kathmandu	2094	2.33	8.03	6.35	10.4
37	Kavre	2038	3.31	7.87	6.33	11.63
38	Khotang	1717	2.88	4.07	3.01	7.67
39	Lalitpur	2056	1.97	7.9	6.1	10.38
40	Lamjung	2255	3.13	9.88	8.69	13.38
41	Mahottari	1550	5.51	8.95	7.1	12.62
42	Makwanpur	1958	1.62	8.16	6.15	10.2
43	Manang	1721	3.03	10.59	9.49	15.29
44	Morang	2015	2.88	3.53	2.12	6.49
45	Mugu	1466	0.09	7.7	7.03	13.26
46	Mustang	1126	3.67	12.28	10.18	16.6
47	Myagdi	2053	3.48	11.18	9.91	16.09
48	Nawalpur	1997	0.54	7.44	5.43	8.47
49	Nuwakot	2069	3.01	8.48	6.6	10.79
50	Okhaldhunga	1780	3.52	4.78	3.86	9.14
51	Palpa	2118	1.58	8.34	6.34	9.8
52	Panchthar	2235	3.52	3.68	2.21	7.79
53	Parasi	1997	0.54	7.44	5.43	8.47
54	Parbat	2410	3.32	10.12	8.69	13.02
55	Parsa	1743	1.39	8.81	6.34	10.08
56	Pyuthan	1847	2.62	9.3	8.37	13.78
57	Ramechhap	1987	3.61	5.41	4.47	10.03
58	Rasuwa	2054	4.33	9.6	7.91	13.09
59	Rautahat	1649	2.64	9.68	6.73	11.21
60	Rolpa	1764	2.1	8.91	8.3	14.53
61	Rupandehi	1825	0.23	7.48	5.56	8.85
62	Salyan	1614	0.77	7.73	6.35	12.93
63	Sankhuwasabha	2721	2.1	3.42	2.22	7.13
64	Saptari	1567	3.26	4.57	3.76	7.87
65	Sarlahi	1639	4.17	9.83	6.87	12.27
66	Sindhuli	1768	4.63	7.53	6.06	11.87
67	Sindhupalchok	2241	4.42	8.92	6.86	12.32
68	Siraha	1521	4.46	5.86	4.87	9.45
69	Solukhumbu	2180	2.84	4.96	3.76	8.87
70	Sunsari	1773	2.49	3.58	2.68	6.59
71	Surkhet	1602	0.11	7.87	6.89	13.96
72	Syangja	2401	2.97	9.52	7.8	11.54
73	Tanahu	2319	2.5	8.86	6.91	10.4
74	Taplejung	2607	3.45	4.31	2.68	8.32
75	Tehrathum	2064	3	3.27	1.99	7.23
76	Udayapur	1653	3.37	4.58	3.55	7.93
77	Western Rukum	1822	1.69	9.15	8.55	15.38

2. Change in Temperature (°C) for districts of Nepal from the reference period (1981-2010)

S.N.	District Name	Reference Period (°C)	RCP4.5		RCP8.5	
			2016-2045	2036-2065	2016-2045	2036-2065
1	Achham	14.9	0.98	1.4	1.11	1.88
2	Arghakhanchi	19.7	1.02	1.37	1.14	1.97
3	Baglung	12.1	0.92	1.32	1.03	1.82
4	Baitadi	14.4	1.01	1.43	1.15	1.94
5	Bajhang	2.7	0.97	1.38	1.1	1.85
6	Bajura	4.7	0.95	1.35	1.08	1.81
7	Banke	24.6	1.09	1.47	1.21	2.06
8	Bara	25.1	0.86	1.16	1.06	1.77
9	Bardiya	24.5	1.07	1.51	1.2	2.04
10	Bhaktapur	16.4	0.84	1.15	1.01	1.7
11	Bhojpur	14.8	0.77	1.11	0.97	1.64
12	Chitwan	23.6	0.87	1.16	1.05	1.78
13	Dadeldhura	17.7	1.05	1.49	1.19	2.01
14	Dailekh	15	0.96	1.38	1.1	1.85
15	Dang	22.8	1.03	1.37	1.16	1.97
16	Darchula	4	0.99	1.41	1.13	1.9
17	Dhading	15.5	0.88	1.23	1.02	1.77
18	Dhankuta	17.2	0.79	1.13	0.99	1.68
19	Dhanusa	24.4	0.87	1.24	1.08	1.83
20	Dolakha	6.5	0.82	1.15	1	1.68
21	Dolpa	-2.7	0.97	1.4	1.09	1.89
22	Doti	14	1.01	1.44	1.15	1.94
23	Eastern Rukum	9	0.93	1.34	1.07	1.82
24	Gorkha	5.7	0.88	1.25	0.99	1.74
25	Gulmi	17.3	0.97	1.35	1.09	1.92
26	Humla	-3	1.05	1.5	1.21	2.01
27	Ilam	16.9	0.79	1.13	0.99	1.66
28	Jajarkot	10	0.93	1.32	1.07	1.79
29	Jhapa	24.2	0.83	1.18	1.03	1.74
30	Jumla	2.3	0.92	1.32	1.06	1.78
31	Kailali	22.9	1.06	1.51	1.19	2.01
32	Kalikot	7.6	0.93	1.33	1.07	1.79
33	Kanchanpur	24.6	1.09	1.53	1.24	2.09
34	Kapilbastu	25.1	0.96	1.26	1.11	1.89
35	Kaski	9	0.86	1.25	0.97	1.72
36	Kathmandu	16.5	0.86	1.18	1.02	1.73
37	Kavre	16.3	0.82	1.13	1.02	1.71
38	Khotang	15.9	0.79	1.13	0.99	1.67
39	Lalitpur	14.9	0.81	1.1	1.01	1.68
40	Lamjung	11.1	0.85	1.23	0.96	1.7
41	Mahottari	24.5	0.87	1.22	1.09	1.83

42	Makwanpur	20.7	0.83	1.13	1.03	1.73
43	Manang	-3.6	0.88	1.29	0.99	1.75
44	Morang	23.2	0.84	1.2	1.04	1.76
45	Mugu	0	0.99	1.42	1.14	1.91
46	Mustang	-2.4	0.94	1.37	1.06	1.86
47	Myagdi	4.9	0.87	1.28	0.98	1.74
48	Nawalpur	23.4	0.9	1.2	1.07	1.84
49	Nuwakot	16.5	0.88	1.22	1.02	1.76
50	Okhaldhunga	14.6	0.79	1.14	1	1.68
51	Palpa	19.7	0.96	1.3	1.1	1.91
52	Panchthar	14.3	0.77	1.11	0.98	1.64
53	Parasi	23.4	0.9	1.2	1.07	1.84
54	Parbat	16.5	0.91	1.28	1.02	1.81
55	Parsa	25	0.86	1.15	1.06	1.78
56	Pyuthan	17.7	1.01	1.39	1.13	1.96
57	Ramechhap	10.6	0.81	1.16	1.01	1.71
58	Rasuwa	0.7	0.88	1.26	1	1.74
59	Rautahat	25.2	0.85	1.16	1.05	1.76
60	Rolpa	14.3	0.98	1.38	1.11	1.9
61	Rupandehi	24.7	0.92	1.23	1.1	1.89
62	Salyan	18.4	0.99	1.4	1.12	1.91
63	Sankhuwasabha	7.3	0.8	1.14	1	1.68
64	Saptari	24	0.85	1.22	1.06	1.79
65	Sarlahi	24.7	0.85	1.17	1.06	1.77
66	Sindhuli	19.7	0.83	1.17	1.04	1.75
67	Sindhupalchok	7.8	0.85	1.2	1.01	1.72
68	Siraha	24.2	0.86	1.23	1.07	1.8
69	Solukhumbu	1.7	0.82	1.16	1.01	1.69
70	Sunsari	23.4	0.83	1.19	1.04	1.75
71	Surkhet	19.1	1	1.42	1.13	1.91
72	Syangja	19.3	0.93	1.29	1.05	1.85
73	Tanahu	21.3	0.91	1.25	1.04	1.82
74	Taplejung	2.5	0.84	1.19	1.04	1.74
75	Tehrathum	15.4	0.77	1.11	0.98	1.64
76	Udayapur	19.9	0.81	1.17	1.02	1.72
77	Western Rukum	9	0.93	1.34	1.07	1.82

3 Change in Precipitation Indices

3.1. Change in Very Wet Days (P95) (%) for districts of Nepal from the reference period (1981-2010)

S.N.	District Name	Reference Period (days)	RCP4.5		RCP8.5	
			2016-2045	2036-2065	2016-2045	2036-2065
1	Achham	17.6	-3.72	8.52	10.91	15.61
2	Arghakhanchi	18.4	1.90	14.11	13.21	19.14
3	Baglung	18.2	4.54	19.47	16.66	23.71
4	Baitadi	17.5	-3.74	9.10	11.06	14.88
5	Bajhang	17.8	-3.85	9.13	10.80	14.50
6	Bajura	18	-3.86	8.61	10.22	14.89
7	Banke	18.5	-1.73	9.64	9.91	13.72
8	Bara	18.6	1.74	12.96	8.61	13.17
9	Bardiya	18.1	-2.07	10.63	10.44	14.59
10	Bhaktapur	18.6	3.26	13.42	9.61	17.67
11	Bhojpur	18.3	3.20	5.48	9.25	17.11
12	Chitwan	18.3	-1.36	11.75	5.95	10.43
13	Dadeldhura	17.7	-3.70	9.29	11.20	15.27
14	Dailekh	17.8	-3.61	9.10	11.84	16.39
15	Dang	18.4	-1.88	10.12	11.64	15.98
16	Darchula	17.7	-3.16	9.78	10.61	14.74
17	Dhading	18.3	4.52	17.23	13.55	20.45
18	Dhankuta	18.1	3.43	5.59	9.56	17.84
19	Dhanusa	18.2	2.78	6.41	9.39	16.86
20	Dolakha	18.1	5.74	10.57	10.92	20.16
21	Dolpa	18	4.45	18.26	18.26	25.38
22	Doti	17.7	-3.42	9.07	11.40	15.86
23	Eastern Rukum	17.9	0.94	13.71	17.43	22.57
24	Gorkha	18.4	5.46	19.99	15.66	24.74
25	Gulmi	18.4	3.74	16.64	13.70	19.78
26	Humla	18	-3.53	9.64	10.93	16.43
27	Ilam	18.1	4.45	6.52	9.65	18.00
28	Jajarkot	17.9	-3.27	9.98	12.22	17.20
29	Jhapa	18.4	3.73	6.52	9.17	17.63
30	Jumla	18	-3.84	9.24	11.75	17.53
31	Kailali	18	-2.83	10.03	11.72	16.68
32	Kalikot	17.9	-4.08	8.15	10.14	15.34
33	Kanchanpur	17.9	-3.76	9.72	11.37	16.06
34	Kapilbastu	18.5	-0.89	11.67	8.90	14.53
35	Kaski	18.1	5.00	20.42	16.28	24.84
36	Kathmandu	18.5	3.37	14.06	11.17	18.78
37	Kavre	18.3	3.82	11.72	8.72	17.05
38	Khotang	18.1	3.32	5.42	9.32	16.51
39	Lalitpur	18.9	2.58	12.27	8.61	14.63
40	Lamjung	18.2	5.00	20.01	14.90	24.07

41	Mahottari	18.3	3.28	9.04	9.47	16.78
42	Makwanpur	18.5	1.61	12.40	8.22	12.98
43	Manang	18.2	6.05	21.27	17.50	27.28
44	Morang	18.5	2.96	6.06	9.75	17.69
45	Mugu	18	-1.62	11.51	12.86	18.97
46	Mustang	18	6.25	21.42	18.51	27.31
47	Myagdi	18.1	5.27	21.31	19.35	26.89
48	Nawalpur	18.4	-0.84	12.29	7.42	11.58
49	Nuwakot	18.3	5.78	17.23	14.71	22.58
50	Okhaldhunga	18	4.26	6.48	8.96	16.92
51	Palpa	18.6	0.81	13.94	10.29	14.75
52	Panchthar	18.1	4.76	6.72	10.57	19.36
53	Parasi	18.4	-0.84	12.29	7.42	11.58
54	Parbat	18.2	4.12	17.88	13.78	20.54
55	Parsa	18.4	-0.50	11.72	6.47	10.39
56	Pyuthan	18.2	3.07	15.12	15.34	21.24
57	Ramechhap	18.1	4.59	7.95	9.88	18.27
58	Rasuwa	18.1	11.53	22.78	19.15	29.21
59	Rautahat	18.5	2.18	12.78	8.74	13.96
60	Rolpa	18	1.28	13.55	16.88	22.21
61	Rupandehi	18.4	-1.08	12.61	8.19	12.31
62	Salyan	18	-1.49	9.88	13.28	17.09
63	Sankhuwasabha	18.3	4.43	8.71	10.44	18.80
64	Saptari	18.4	2.36	5.17	8.69	15.66
65	Sarlahi	18.4	3.17	11.46	8.72	15.46
66	Sindhuli	18.2	3.72	8.41	9.61	17.16
67	Sindhupalchok	18.2	7.43	16.39	13.81	24.42
68	Siraha	18.2	2.55	5.35	8.94	15.92
69	Solukhumbu	18	5.76	9.94	10.93	19.45
70	Sunsari	18.4	2.55	5.26	9.38	16.92
71	Surkhet	17.9	-2.82	9.77	11.92	16.30
72	Syangja	18.1	3.22	16.37	12.32	18.29
73	Tanahu	18.1	2.30	15.99	11.07	17.08
74	Taplejung	18.1	5.97	9.63	11.01	20.67
75	Tehrathum	17.9	4.35	6.32	10.38	19.37
76	Udayapur	18.1	2.86	5.16	9.39	16.19
77	Western Rukum	17.9	0.94	13.71	17.43	22.57

3.2. Change in Extreme Wet Days (P99) (%) for districts of Nepal from the reference period (1981-2010)

S.N.	District Name	Reference Period (days)	RCP4.5		RCP8.5	
			2016-2045	2036-2065	2016-2045	2036-2065
1	Achham	3.6	17.37	40.30	25.95	54.95
2	Arghakhanchi	3.5	26.06	49.47	41.39	68.46
3	Baglung	3.6	29.56	49.11	36.58	70.52
4	Baitadi	3.4	19.67	41.49	25.31	59.87
5	Bajhang	3.6	19.81	39.57	23.63	56.18
6	Bajura	3.8	16.27	35.37	23.50	53.78
7	Banke	3.3	25.82	55.04	31.28	64.23
8	Bara	3.2	29.41	37.42	25.31	53.12
9	Bardiya	3.4	20.11	45.52	27.68	57.05
10	Bhaktapur	3.2	28.34	40.03	25.24	55.42
11	Bhojpur	3.5	32.09	28.68	16.65	51.64
12	Chitwan	3.5	21.76	37.09	27.27	48.37
13	Dadeldhura	3.4	20.06	42.12	25.41	60.66
14	Dailekh	3.6	15.81	39.58	25.24	54.60
15	Dang	3.5	22.08	50.28	34.92	65.51
16	Darchula	3.6	19.41	40.63	25.59	57.71
17	Dhading	3.5	29.16	47.30	31.67	65.53
18	Dhankuta	3.4	33.74	30.91	20.18	53.96
19	Dhanusa	3	33.83	31.97	24.06	59.64
20	Dolakha	3.4	29.77	38.31	21.13	60.67
21	Dolpa	3.6	28.07	49.42	38.33	67.85
22	Doti	3.5	19.78	42.34	23.80	56.13
23	Eastern Rukum	3.7	21.65	44.82	33.71	63.30
24	Gorkha	3.5	31.55	51.62	33.16	69.91
25	Gulmi	3.5	27.96	49.58	37.80	69.09
26	Humla	3.8	15.50	34.40	21.19	48.90
27	Ilam	3.3	38.72	33.50	25.47	54.81
28	Jajarkot	3.7	16.58	39.22	24.85	54.84
29	Jhapa	3.2	38.87	34.64	26.43	58.81
30	Jumla	3.7	14.73	35.68	24.08	53.92
31	Kailali	3.4	18.31	42.12	25.37	55.65
32	Kalikot	3.9	12.71	33.26	22.42	50.88
33	Kanchanpur	3.2	20.01	39.97	22.52	61.21
34	Kapilbastu	3.5	19.72	41.28	40.58	56.92
35	Kaski	3.5	31.59	51.49	36.98	73.52
36	Kathmandu	3.3	29.73	42.65	27.50	57.76
37	Kavre	3.2	27.81	35.70	23.66	56.36
38	Khotang	3.4	31.53	27.91	16.84	52.14
39	Lalitpur	3.3	24.21	33.58	20.55	50.23
40	Lamjung	3.6	31.79	51.06	35.68	72.48
41	Mahottari	3.1	32.57	33.62	27.56	61.20
42	Makwanpur	3.3	24.98	35.70	22.19	49.75

43	Manang	3.5	32.09	53.15	31.67	68.09
44	Morang	3.3	33.94	31.81	23.73	57.08
45	Mugu	3.8	17.26	37.59	25.26	51.49
46	Mustang	3.5	31.60	54.33	36.89	70.56
47	Myagdi	3.5	29.66	49.73	35.86	72.92
48	Nawalpur	3.4	21.36	38.10	30.22	50.37
49	Nuwakot	3.4	34.31	53.65	32.68	68.96
50	Okhaldhunga	3.4	31.37	28.58	16.94	53.56
51	Palpa	3.4	26.49	46.31	35.30	59.65
52	Panchthar	3.5	38.37	33.74	25.98	54.89
53	Parasi	3.4	21.36	38.10	30.22	50.37
54	Parbat	3.4	30.62	51.68	38.07	71.28
55	Parsa	3.4	25.04	35.60	25.56	47.95
56	Pyuthan	3.8	26.43	49.05	39.49	70.28
57	Ramechhap	3.3	31.04	32.95	19.38	57.24
58	Rasuwa	3.4	35.62	57.55	31.62	76.24
59	Rautahat	3.1	31.53	38.96	27.07	55.85
60	Rolpa	3.7	24.04	48.11	34.31	65.80
61	Rupandehi	3.5	18.94	33.88	30.78	47.67
62	Salyan	3.5	21.86	46.76	27.64	59.72
63	Sankhuwasabha	3.6	33.72	34.44	19.85	57.92
64	Saptari	3.4	33.47	30.53	22.50	57.08
65	Sarlahi	3	30.69	36.47	29.01	60.08
66	Sindhuli	3.2	30.98	31.76	22.82	58.66
67	Sindhupalchok	3.4	32.41	50.62	28.97	68.91
68	Siraha	3.1	33.58	30.70	21.70	57.10
69	Solukhumbu	3.4	32.02	37.73	20.83	58.65
70	Sunsari	3.3	32.97	31.21	22.35	55.82
71	Surkhet	3.6	18.48	42.16	27.24	56.45
72	Syangja	3.3	29.16	51.81	37.59	67.99
73	Tanahu	3.4	27.45	49.72	36.62	64.10
74	Taplejung	3.7	36.99	36.25	29.55	60.71
75	Tehrathum	3.6	37.23	33.84	23.79	55.99
76	Udayapur	3.3	31.60	28.21	19.11	54.44
77	Western Rukum	3.7	21.65	44.82	33.71	63.30

3.3. Change in No. of Rainy Days (%) for districts of Nepal from the reference period (1981-2010)

S.N.	District Name	Reference Period (days)	RCP4.5		RCP8.5	
			2016-2045	2036-2065	2016-2045	2036-2065
1	Achham	146.1	-2.07	-1.89	-1.03	-0.17
2	Arghakhanchi	150.1	-2.45	-1.48	0.12	-0.13
3	Baglung	168.2	-1.44	-0.74	-0.43	0.08
4	Baitadi	150.2	-1.99	-1.72	-0.93	-0.37
5	Bajhang	158.5	-1.99	-1.83	-1.04	-0.75
6	Bajura	157.7	-2.03	-1.81	-1.12	-0.71
7	Banke	138.4	-2.01	-1.10	-0.40	0.15
8	Bara	147	-1.97	-0.64	-1.07	-1.23
9	Bardiya	134.4	-2.05	-0.97	-0.22	0.75
10	Bhaktapur	168.3	-1.62	-1.05	-1.14	-0.86
11	Bhojpur	185.3	-1.15	-0.39	-1.52	-0.89
12	Chitwan	156.4	-2.25	-1.17	-0.62	-0.86
13	Dadeldhura	140.9	-2.22	-1.67	-0.87	-0.18
14	Dailekh	149.4	-1.96	-1.61	-1.06	0.13
15	Dang	145	-2.07	-1.23	-0.33	-0.29
16	Darchula	161	-1.90	-1.59	-0.86	-0.61
17	Dhading	175.2	-1.55	-0.80	-0.62	-0.53
18	Dhankuta	180.3	-0.78	-0.36	-1.87	-1.30
19	Dhanusa	153.3	-1.57	-1.14	-2.14	-1.61
20	Dolakha	182.5	-1.08	-0.59	-1.58	-0.74
21	Dolpa	164.3	-2.32	-1.39	-0.80	-0.26
22	Doti	143.8	-2.06	-1.79	-0.89	-0.17
23	Eastern Rukum	161.2	-2.00	-1.25	-0.75	0.22
24	Gorkha	191.3	-1.50	-0.77	-0.36	-0.25
25	Gulmi	160.4	-1.90	-1.07	-0.34	-0.17
26	Humla	166.3	-2.66	-1.61	-0.79	-0.88
27	Ilam	189	-1.11	-0.23	-1.54	-0.79
28	Jajarkot	160	-1.98	-1.66	-1.09	-0.08
29	Jhapa	182.2	-1.11	-0.55	-1.76	-1.00
30	Jumla	169.7	-1.81	-1.50	-1.10	-0.44
31	Kailali	136.2	-2.08	-1.39	-0.25	0.58
32	Kalikot	157.4	-1.77	-1.71	-1.18	-0.33
33	Kanchanpur	132.8	-2.54	-1.33	-0.34	0.54
34	Kapilbastu	141.3	-2.91	-1.36	-0.45	-0.50
35	Kaski	189.4	-1.61	-0.82	-0.22	-0.04
36	Kathmandu	167.5	-1.55	-0.91	-1.11	-0.78
37	Kavre	165.7	-1.79	-1.09	-1.69	-1.34
38	Khotang	174.4	-0.87	-0.31	-1.86	-1.40
39	Lalitpur	161.7	-1.85	-0.85	-1.35	-1.19
40	Lamjung	192	-1.63	-0.94	-0.38	-0.29
41	Mahottari	150.7	-1.70	-1.11	-2.03	-1.46
42	Makwanpur	155.7	-1.91	-0.76	-0.96	-1.05

43	Manang	189.1	-1.82	-0.94	-0.27	-0.10
44	Morang	173.8	-0.75	-0.52	-1.97	-1.34
45	Mugu	166.6	-2.35	-1.58	-0.91	-0.71
46	Mustang	163.2	-2.26	-0.97	-0.41	0.18
47	Myagdi	176.3	-1.73	-0.87	-0.34	0.20
48	Nawalpur	153.8	-2.25	-1.13	-0.42	-0.58
49	Nuwakot	174.2	-1.38	-0.84	-1.05	-0.75
50	Okhaldhunga	172.1	-0.79	-0.32	-1.85	-1.39
51	Palpa	158.2	-2.01	-1.16	-0.14	-0.21
52	Panchthar	193.3	-1.18	-0.24	-1.44	-0.78
53	Parasi	153.8	-2.25	-1.13	-0.42	-0.58
54	Parbat	179	-1.68	-1.02	-0.22	-0.14
55	Parsa	147	-2.05	-0.63	-0.95	-1.44
56	Pyuthan	152.7	-2.04	-1.12	-0.45	-0.25
57	Ramechhap	176	-1.04	-0.54	-1.77	-1.09
58	Rasuwa	188.9	-1.16	-0.34	-0.52	-0.37
59	Rautahat	147.2	-1.97	-0.84	-1.23	-1.19
60	Rolpa	153.9	-1.70	-1.05	-0.76	0.07
61	Rupandehi	143.9	-2.38	-0.96	-0.51	-0.53
62	Salyan	149.6	-1.66	-1.21	-0.75	0.34
63	Sankhuwasabha	216.4	-1.10	-0.17	-0.95	-0.22
64	Saptari	163.6	-1.07	-0.75	-2.31	-1.86
65	Sarlahi	148.9	-1.93	-1.20	-1.68	-1.35
66	Sindhuli	159	-1.43	-0.79	-1.85	-1.36
67	Sindhupalchok	181.7	-1.43	-0.70	-1.43	-0.84
68	Siraha	158.3	-1.30	-0.85	-2.24	-1.82
69	Solukhumbu	193.7	-1.08	-0.39	-1.26	-0.49
70	Sunsari	169.4	-0.89	-0.55	-2.04	-1.49
71	Surkhet	143.6	-1.88	-1.49	-0.69	0.38
72	Syangja	176.6	-1.86	-1.26	-0.42	-0.40
73	Tanahu	177.5	-1.94	-1.29	-0.57	-0.52
74	Taplejung	224.6	-1.01	-0.18	-0.78	-0.06
75	Tehrathum	192.4	-1.09	-0.30	-1.59	-0.81
76	Udayapur	168.6	-0.96	-0.42	-2.05	-1.68
77	Western Rukum	161.2	-2.00	-1.25	-0.75	0.22

3.4. Change in Consecutive Dry Days (CDD) (%) for districts of Nepal from the reference period (1981-2010)

S.N.	District Name	Reference Period (days)	RCP4.5		RCP8.5	
			2016-2045	2036-2065	2016-2045	2036-2065
1	Achham	48.1	6.03	3.69	-3.24	-2.51
2	Arghakhanchi	48.2	11.35	6.89	1.09	1.68
3	Baglung	42.4	6.93	4.43	-0.39	-3.74
4	Baitadi	47.5	5.36	3.02	-3.18	-3.06
5	Bajhang	44.9	6.85	3.91	-3.20	-3.93
6	Bajura	43.9	7.12	3.13	-3.10	-3.50
7	Banke	54.2	7.46	3.70	-0.53	-0.05
8	Bara	58.3	7.90	5.03	1.70	-0.17
9	Bardiya	54.4	5.94	3.93	-1.10	-0.54
10	Bhaktapur	44.9	9.48	3.12	-3.86	-2.32
11	Bhojpur	41.3	2.91	-1.33	-1.18	-1.58
12	Chitwan	49.5	9.43	6.18	-1.99	0.68
13	Dadeldhura	50.4	4.41	1.63	-2.40	-2.48
14	Dailekh	47.0	7.71	4.63	-1.43	-2.62
15	Dang	51.6	11.30	6.10	-0.43	-0.49
16	Darchula	45.9	4.55	2.18	-4.25	-5.00
17	Dhading	41.1	8.25	5.14	-2.18	-3.47
18	Dhankuta	44.8	1.96	-0.39	-0.95	-1.78
19	Dhanusa	57.9	4.90	0.09	2.39	-0.35
20	Dolakha	43.0	1.58	-3.88	-2.70	-4.18
21	Dolpa	42.3	4.43	1.19	-4.15	-5.18
22	Doti	49.0	5.51	3.34	-3.23	-2.92
23	Eastern Rukum	43.6	7.69	1.71	-3.70	-4.55
24	Gorkha	36.0	4.96	3.54	-2.07	-4.34
25	Gulmi	44.3	10.24	6.68	1.50	-2.14
26	Humla	39.8	6.68	0.36	-5.34	-6.03
27	Ilam	43.8	1.94	-2.31	-4.18	-6.08
28	Jajarkot	42.9	8.87	4.55	-2.46	-3.17
29	Jhapa	49.3	2.94	-0.79	-1.41	-5.52
30	Jumla	40.5	6.97	0.78	-5.24	-5.96
31	Kailali	53.1	5.20	2.70	-2.31	-1.55
32	Kalikot	43.9	8.07	4.48	-4.11	-4.90
33	Kanchanpur	54.8	5.50	2.56	-2.42	-1.45
34	Kapilbastu	54.1	12.66	8.27	0.34	3.69
35	Kaski	37.3	5.43	3.56	-0.83	-3.63
36	Kathmandu	44.5	10.53	3.88	-2.72	-2.75
37	Kavre	48.0	8.28	3.15	-0.67	0.15
38	Khotang	45.9	2.01	-2.07	-0.28	-0.62
39	Lalitpur	48.3	9.50	4.90	0.32	2.53
40	Lamjung	35.6	5.43	4.61	-1.60	-4.31
41	Mahottari	58.6	6.20	1.88	4.03	0.92
42	Makwanpur	51.5	8.73	6.34	0.27	0.98

43	Manang	36.6	4.56	3.14	0.10	-1.77
44	Morang	51.8	2.99	-0.66	-0.34	-4.86
45	Mugu	41.1	5.84	-0.27	-6.61	-6.31
46	Mustang	41.9	2.62	1.90	0.20	-2.14
47	Myagdi	40.7	5.51	3.14	1.04	-2.31
48	Nawalpur	50.5	9.43	4.72	-2.23	0.26
49	Nuwakot	41.4	9.32	4.34	-1.63	-3.46
50	Okhaldhunga	47.2	2.75	-1.59	-0.47	-1.25
51	Palpa	47.2	10.33	5.84	-1.82	-1.54
52	Panchthar	40.4	4.09	-0.54	-2.68	-5.57
53	Parasi	50.5	9.43	4.72	-2.23	0.26
54	Parbat	40.6	7.84	4.77	-0.46	-4.70
55	Parsa	58.0	6.15	4.34	0.03	-0.24
56	Pyuthan	47.1	11.16	6.01	0.36	-1.93
57	Ramechhap	45.7	3.14	-2.23	-1.49	-2.48
58	Rasuwa	38.0	4.17	1.13	-1.86	-4.35
59	Rautahat	58.9	9.48	5.49	1.91	0.40
60	Rolpa	46.2	8.75	3.80	-1.69	-3.45
61	Rupandehi	54.6	8.47	3.69	-0.90	1.16
62	Salyan	48.4	7.97	4.81	-0.11	-2.63
63	Sankhuwasabha	31.9	3.31	0.95	-0.33	-3.63
64	Saptari	55.4	3.84	-1.59	1.34	-3.38
65	Sarlahi	58.4	8.49	4.30	3.46	0.85
66	Sindhuli	53.4	7.43	2.23	2.49	0.09
67	Sindhupalchok	41.1	4.74	0.11	-1.24	-2.94
68	Siraha	56.6	3.86	-2.34	1.59	-2.93
69	Solukhumbu	38.9	0.95	-2.72	-2.99	-4.25
70	Sunsari	52.6	4.12	-1.04	1.99	-2.46
71	Surkhet	50.2	5.75	3.36	-1.56	-2.08
72	Syangja	41.0	9.36	5.92	-0.08	-3.69
73	Tanahu	39.8	9.92	6.55	-0.19	-3.83
74	Taplejung	31.5	3.80	2.16	-2.28	-6.26
75	Tehrathum	40.0	4.33	-0.27	-0.84	-3.77
76	Udayapur	49.9	4.56	-0.67	1.24	-1.37
77	Western Rukum	43.6	7.69	1.71	-3.70	-4.55

3.5. Change in Consecutive Wet Days (CWD) (%) for districts of Nepal from the reference period (1981-2010)

S.N.	District Name	Reference Period (days)	RCP4.5		RCP8.5	
			2016-2045	2036-2065	2016-2045	2036-2065
1	Achham	67.7	-3.84	-0.97	3.65	5.87
2	Arghakhanchi	71	-5.50	-1.05	10.01	6.51
3	Baglung	82.9	0.83	1.49	2.33	5.44
4	Baitadi	67.7	-3.60	0.57	4.46	3.35
5	Bajhang	67.1	-3.50	0.09	3.71	3.89
6	Bajura	65.3	-3.01	0.65	3.60	5.37
7	Banke	60.5	-3.27	-0.26	12.65	12.35
8	Bara	64.6	-13.62	-6.67	3.04	-0.33
9	Bardiya	55.7	-4.41	-0.28	17.51	16.16
10	Bhaktapur	91.9	-3.42	-3.09	-0.31	-4.38
11	Bhojpur	97.9	-6.90	-4.24	-2.32	-8.83
12	Chitwan	68.7	-11.34	-5.00	5.45	2.43
13	Dadeldhura	62	-5.16	-0.04	8.59	7.87
14	Dailekh	70.8	-1.66	1.80	2.28	5.67
15	Dang	67.4	-2.36	-0.51	11.92	10.77
16	Darchula	68	-2.20	1.70	5.13	3.95
17	Dhading	84.4	-2.54	0.34	6.34	2.55
18	Dhankuta	92.4	-8.34	-5.46	-5.41	-11.88
19	Dhanusa	68.9	-16.26	-13.83	1.33	0.44
20	Dolakha	102.8	-2.17	-0.48	-2.55	-4.36
21	Dolpa	67.2	0.77	2.42	1.03	4.43
22	Doti	65.2	-3.61	-0.54	6.52	6.70
23	Eastern Rukum	79.9	0.27	2.13	2.12	6.05
24	Gorkha	89.6	-1.29	0.67	2.86	1.89
25	Gulmi	79.1	-2.04	0.19	6.68	5.93
26	Humla	50.7	-5.55	-0.18	9.26	9.02
27	Ilam	101.9	-3.34	0.17	-3.44	-8.76
28	Jajarkot	77.6	-0.34	2.54	1.58	3.86
29	Jhapa	101.4	-3.21	0.67	-3.52	-9.39
30	Jumla	78	-0.46	1.92	0.42	2.24
31	Kailali	58.2	-3.49	0.29	14.59	14.16
32	Kalikot	72.4	-1.76	1.27	1.55	3.66
33	Kanchanpur	53.8	-6.18	-0.34	12.99	10.32
34	Kapilbastu	60.8	-13.03	-5.94	6.94	6.55
35	Kaski	86.9	-0.13	1.29	2.24	3.88
36	Kathmandu	90.6	-3.73	-3.10	-1.48	-4.29
37	Kavre	92.3	-9.33	-6.40	-2.91	-4.77
38	Khotang	90.9	-8.85	-5.75	-1.52	-8.96
39	Lalitpur	84.2	-11.59	-8.00	-2.48	-5.54
40	Lamjung	86.8	-0.70	1.04	3.65	4.14
41	Mahottari	66.6	-16.75	-13.28	2.07	4.29
42	Makwanpur	72.5	-13.72	-7.27	1.46	-1.26

43	Manang	78.9	1.66	2.57	4.91	7.94
44	Morang	92.8	-5.91	-2.75	-4.73	-10.71
45	Mugu	59	-1.64	1.15	3.16	4.26
46	Mustang	56.9	1.11	4.17	8.93	11.28
47	Myagdi	83.6	1.47	2.45	1.37	6.00
48	Nawalpur	68.4	-10.61	-5.24	5.84	4.10
49	Nuwakot	92.4	-1.69	-1.38	1.63	-1.56
50	Okhaldhunga	96.3	-7.03	-4.64	-4.32	-9.69
51	Palpa	73.7	-2.79	0.58	8.07	6.04
52	Panchthar	103.9	-5.02	-1.55	-4.66	-10.35
53	Parasi	68.4	-10.61	-5.24	5.84	4.10
54	Parbat	86.3	-1.27	-0.95	2.79	2.52
55	Parsa	65.1	-13.74	-6.32	3.18	0.63
56	Pyuthan	74.6	-2.52	-0.41	8.00	7.44
57	Ramechhap	100.6	-5.50	-3.47	-4.23	-7.69
58	Rasuwa	101.6	-0.42	1.16	-0.20	-3.58
59	Rautahat	63.5	-14.11	-7.16	1.82	0.34
60	Rolpa	75.9	-1.29	-0.19	4.98	8.36
61	Rupandehi	63.2	-13.48	-7.60	5.43	5.83
62	Salyan	71.7	-1.50	1.54	6.43	9.14
63	Sankhuwasabha	121	0.16	-0.41	-2.72	-6.21
64	Saptari	80.5	-14.01	-9.99	-0.16	-9.35
65	Sarlahi	65.2	-15.76	-11.86	1.04	2.01
66	Sindhuli	82.5	-14.14	-10.31	-2.48	-6.08
67	Sindhupalchok	103.4	-2.63	-1.27	-2.03	-3.29
68	Siraha	73.6	-15.93	-12.78	2.48	-5.28
69	Solukhumbu	108.4	-1.35	-0.75	-2.33	-6.74
70	Sunsari	88	-10.24	-5.95	-3.71	-11.16
71	Surkhet	67.1	-3.35	-0.22	6.65	9.28
72	Syangja	83.8	-0.66	0.33	4.27	1.57
73	Tanahu	81	-0.88	1.89	5.47	2.59
74	Taplejung	129.4	-1.09	-1.41	-3.44	-7.26
75	Tehrathum	102.7	-5.17	-2.39	-4.70	-9.57
76	Udayapur	82.4	-12.85	-9.44	0.06	-9.35
77	Western Rukum	79.9	0.27	2.13	2.12	6.05

4. Change in Temperature Indices

4.1. Change in Warm Days (%) for districts of Nepal from the reference period (1981-2010)

S.N.	District Name	Reference Period (days)	RCP4.5		RCP8.5	
			2016-2045	2036-2065	2016-2045	2036-2065
1	Achham	37.5	6.35	9.17	6.29	9.63
2	Arghakhanchi	36.9	6.77	8.87	6.39	10.89
3	Baglung	37.2	7.00	9.46	5.63	10.31
4	Baitadi	37.2	6.23	8.93	6.21	9.50
5	Bajhang	37.1	5.97	8.06	5.48	8.82
6	Bajura	37.2	6.14	8.28	5.67	9.05
7	Banke	36.6	5.37	7.65	5.82	9.42
8	Bara	36.7	6.49	8.17	6.90	11.35
9	Bardiya	37.1	5.54	8.06	5.69	9.14
10	Bhaktapur	36.4	7.08	9.16	7.58	12.74
11	Bhojpur	37.1	7.79	10.48	8.84	14.71
12	Chitwan	36.9	6.84	8.53	7.06	11.70
13	Dadeldhura	37.3	6.05	8.73	6.03	9.32
14	Dailekh	37.5	6.37	9.19	6.26	9.63
15	Dang	36.5	5.85	7.99	6.19	9.96
16	Darchula	37	5.86	8.03	5.57	8.89
17	Dhading	37.2	7.33	9.48	6.66	11.76
18	Dhankuta	37	8.12	10.97	9.13	15.22
19	Dhanusa	36.6	6.59	8.71	7.54	12.59
20	Dolakha	36.8	6.71	9.28	7.63	12.90
21	Dolpa	36.8	5.72	7.54	4.38	8.10
22	Doti	37.4	6.35	9.15	6.25	9.59
23	Eastern Rukum	37.4	6.47	8.86	5.42	9.18
24	Gorkha	36.8	6.43	8.56	5.57	9.98
25	Gulmi	37.2	7.13	9.50	6.21	11.14
26	Humla	37.1	5.52	7.53	4.96	8.56
27	Ilam	37.3	7.95	11.19	9.87	15.73
28	Jajarkot	37.3	6.41	8.92	5.80	9.22
29	Jhapa	37.5	7.48	10.28	9.48	15.02
30	Jumla	37.2	6.18	8.23	5.26	8.76
31	Kailali	37.3	5.71	8.34	5.62	8.84
32	Kalikot	37.2	6.30	8.62	5.87	9.19
33	Kanchanpur	37.3	5.25	7.42	5.52	8.49
34	Kapilbastu	36.4	5.96	7.55	6.56	10.38
35	Kaski	37	6.67	9.00	5.37	9.91
36	Kathmandu	36.8	7.20	9.31	7.27	12.54
37	Kavre	36.5	7.10	9.10	7.59	12.46
38	Khotang	36.9	7.65	10.30	8.51	14.31
39	Lalitpur	36.6	6.97	8.80	7.14	11.72
40	Lamjung	36.9	6.91	9.32	5.65	10.36

41	Mahottari	36.6	6.51	8.37	7.10	11.88
42	Makwanpur	36.8	6.93	8.68	6.97	11.57
43	Manang	36.8	5.59	7.40	4.37	8.08
44	Morang	37.3	7.63	10.36	8.93	14.94
45	Mugu	37.1	5.92	7.83	4.75	8.34
46	Mustang	36.8	5.63	7.43	4.43	8.18
47	Myagdi	37.1	6.27	8.36	4.96	9.06
48	Nawalpur	36.9	6.78	8.45	7.01	11.56
49	Nuwakot	37.1	7.33	9.64	6.89	12.30
50	Okhaldhunga	36.8	7.09	9.58	8.38	13.66
51	Palpa	37.3	7.31	9.21	6.90	11.84
52	Panchthar	37.4	8.13	11.40	9.94	16.00
53	Parasi	36.9	6.78	8.45	7.01	11.56
54	Parbat	37.4	7.29	9.77	6.08	11.15
55	Parsa	36.8	6.45	8.03	7.02	11.39
56	Pyuthan	36.8	6.76	9.35	6.06	10.48
57	Ramechhap	36.6	6.75	9.13	7.94	12.99
58	Rasuwa	36.8	6.09	8.36	5.41	9.94
59	Rautahat	36.5	6.43	8.16	6.67	11.03
60	Rolpa	37.1	6.68	9.56	5.78	9.88
61	Rupandehi	36.7	6.29	7.82	6.67	10.90
62	Salyan	37.3	6.27	9.12	5.78	9.49
63	Sankhuwasabha	37	7.61	10.61	8.52	14.69
64	Saptari	36.8	7.02	9.37	7.98	13.49
65	Sarlahi	36.5	6.56	8.37	6.95	11.50
66	Sindhuli	36.5	7.01	9.21	7.74	12.76
67	Sindhupalchok	36.7	6.91	9.44	7.17	12.50
68	Siraha	36.7	6.78	9.08	7.79	13.05
69	Solukhumbu	37	6.57	9.05	7.27	12.51
70	Sunsari	37	7.51	10.00	8.48	14.31
71	Surkhet	37.3	6.11	8.98	5.91	9.35
72	Syangja	37.3	7.40	9.73	6.51	11.72
73	Tanahu	37.2	7.49	9.76	6.83	12.13
74	Taplejung	37	7.32	10.49	8.40	14.39
75	Tehrathum	37.3	8.30	11.45	9.80	16.03
76	Udayapur	36.9	7.50	10.05	8.33	14.06
77	Western Rukum	37.4	6.47	8.86	5.42	9.18

4.2. Change in Warm Nights (%) for districts of Nepal from the reference period (1981-2010)

S.N.	District Name	Reference Period (days)	RCP4.5		RCP8.5	
			2016-2045	2036-2065	2016-2045	2036-2065
1	Achham	37.6	7.00	10.34	9.55	13.03
2	Arghakhanchi	37.7	10.87	14.73	12.24	17.81
3	Baglung	37.2	7.82	11.00	8.56	12.73
4	Baitadi	37.7	7.20	10.60	9.76	13.33
5	Bajhang	37.1	6.46	9.36	8.00	11.17
6	Bajura	37.1	6.60	9.60	8.24	11.47
7	Banke	37.5	9.76	13.46	12.19	17.62
8	Bara	37.7	10.39	14.67	10.81	16.16
9	Bardiya	37.6	7.93	11.45	11.30	15.60
10	Bhaktapur	37.4	9.82	13.80	8.99	13.98
11	Bhojpur	37.6	9.36	13.32	9.25	14.50
12	Chitwan	37.6	10.42	14.64	11.13	16.79
13	Dadeldhura	37.6	7.28	10.77	10.26	13.91
14	Dailekh	37.7	6.95	10.26	9.41	12.85
15	Dang	37.3	10.35	13.99	12.35	18.02
16	Darchula	37.1	6.63	9.68	8.33	11.59
17	Dhading	37.5	9.42	13.03	9.33	14.28
18	Dhankuta	37.5	9.79	13.88	9.81	15.22
19	Dhanusa	37.2	10.19	14.56	10.63	16.19
20	Dolakha	37.4	8.84	12.54	8.00	13.01
21	Dolpa	37.7	6.63	9.43	7.20	10.61
22	Doti	37.5	6.94	10.26	9.60	13.05
23	Eastern Rukum	37.3	6.96	10.03	8.52	12.04
24	Gorkha	37.4	7.72	10.80	7.57	11.73
25	Gulmi	37.4	9.56	13.16	10.33	15.47
26	Humla	37.2	6.43	9.32	7.54	10.65
27	Ilam	37.9	9.83	13.91	10.16	15.72
28	Jajarkot	37.4	6.80	9.92	8.77	12.11
29	Jhapa	37.7	10.26	14.47	10.35	16.07
30	Jumla	37.2	6.59	9.54	8.12	11.37
31	Kailali	37.4	7.21	10.68	10.77	14.36
32	Kalikot	37.1	6.68	9.76	8.44	11.71
33	Kanchanpur	37.2	8.05	11.83	11.57	15.67
34	Kapilbastu	37.7	11.13	15.20	13.10	18.97
35	Kaski	37.5	7.40	10.51	7.65	11.61
36	Kathmandu	37.6	9.70	13.67	9.13	14.15
37	Kavre	37.9	9.70	13.74	8.94	14.11
38	Khotang	37.7	9.38	13.29	9.19	14.43
39	Lalitpur	38	9.13	13.07	8.38	13.29
40	Lamjung	37.4	7.80	10.99	8.05	12.23
41	Mahottari	37.2	10.54	15.15	10.85	16.41
42	Makwanpur	37.7	9.85	13.87	9.93	15.15

43	Manang	37.3	6.14	8.85	5.93	9.28
44	Morang	37.8	10.22	14.49	10.37	15.98
45	Mugu	37.3	6.69	9.66	8.05	11.40
46	Mustang	37.3	6.37	9.11	6.48	9.89
47	Myagdi	37.4	6.59	9.49	7.16	10.71
48	Nawalpur	37.6	10.66	14.92	11.51	17.24
49	Nuwakot	37.5	9.62	13.39	9.29	14.27
50	Okhaldhunga	37.7	9.14	12.93	8.64	13.78
51	Palpa	37.3	10.44	14.61	11.18	16.85
52	Panchthar	37.6	9.72	13.77	9.92	15.44
53	Parasi	37.6	10.66	14.92	11.51	17.24
54	Parbat	37.5	8.95	12.45	9.35	14.15
55	Parsa	37.9	10.45	14.70	11.09	16.64
56	Pyuthan	37.3	9.74	13.19	11.03	16.00
57	Ramechhap	37.5	9.01	12.76	8.28	13.35
58	Rasuwa	37.6	7.48	10.33	6.95	11.09
59	Rautahat	37.5	10.28	14.63	10.58	15.87
60	Rolpa	37.1	8.01	11.24	9.90	14.10
61	Rupandehi	37.7	10.89	15.23	12.27	18.05
62	Salyan	37.7	7.62	11.00	10.20	14.30
63	Sankhuwasabha	37.3	9.15	12.95	8.58	13.75
64	Saptari	37.5	10.07	14.37	10.53	16.02
65	Sarlahi	37.4	10.35	14.70	10.43	15.80
66	Sindhuli	37.8	9.69	13.72	9.36	14.64
67	Sindhupalchok	37.7	9.06	12.68	8.48	13.35
68	Siraha	37.4	9.97	14.20	10.42	15.88
69	Solukhumbu	37	8.37	11.95	7.59	12.51
70	Sunsari	37.7	10.07	14.36	10.43	15.95
71	Surkhet	37.9	7.10	10.50	10.04	13.63
72	Syangja	37.5	9.95	13.80	10.22	15.61
73	Tanahu	37.7	10.41	14.48	10.60	16.22
74	Taplejung	37.4	8.95	12.60	8.29	13.48
75	Tehrathum	37.5	9.71	13.77	9.83	15.31
76	Udayapur	37.7	9.74	13.84	9.84	15.22
77	Western Rukum	37.3	6.96	10.03	8.52	12.04

4.3. Change in Cold Days (%) for districts of Nepal from the reference period (1981-2010)

S.N.	District Name	Reference Period (days)	RCP4.5		RCP8.5	
			2016-2045	2036-2065	2016-2045	2036-2065
1	Achham	35.7	-4.67	-6.02	-5.19	-6.79
2	Arghakhanchi	36.3	-4.21	-5.19	-5.35	-7.08
3	Baglung	36.5	-4.30	-5.51	-5.30	-7.01
4	Baitadi	35.6	-4.62	-5.88	-4.83	-6.42
5	Bajhang	36.7	-4.72	-6.12	-4.81	-6.45
6	Bajura	36.7	-4.75	-6.14	-4.89	-6.54
7	Banke	36	-4.65	-5.66	-5.08	-6.78
8	Bara	36.2	-3.32	-3.75	-4.80	-6.26
9	Bardiya	36.4	-4.74	-6.02	-5.48	-7.14
10	Bhaktapur	36.5	-3.62	-4.18	-4.94	-6.54
11	Bhojpur	36.2	-3.62	-4.40	-4.67	-6.07
12	Chitwan	36.8	-3.65	-4.24	-5.07	-6.62
13	Dadeldhura	35.7	-4.68	-5.93	-5.08	-6.66
14	Dailekh	36	-4.71	-6.08	-5.43	-7.04
15	Dang	35.9	-4.42	-5.41	-5.09	-6.83
16	Darchula	36.8	-4.73	-6.15	-4.76	-6.41
17	Dhading	36.8	-4.12	-5.01	-5.13	-6.83
18	Dhankuta	36.2	-3.64	-4.44	-4.75	-6.14
19	Dhanusa	36.3	-3.58	-4.33	-4.91	-6.27
20	Dolakha	36.7	-3.84	-4.72	-4.68	-6.14
21	Dolpa	38	-4.48	-5.83	-5.22	-6.94
22	Doti	35.6	-4.64	-5.98	-5.08	-6.67
23	Eastern Rukum	36.6	-4.55	-5.90	-5.29	-6.98
24	Gorkha	37.1	-4.26	-5.42	-4.94	-6.62
25	Gulmi	36.6	-4.32	-5.40	-5.51	-7.26
26	Humla	37.9	-4.87	-6.38	-5.14	-6.92
27	Ilam	36.5	-3.66	-4.49	-4.66	-6.04
28	Jajarkot	36.4	-4.70	-6.09	-5.32	-6.97
29	Jhapa	36.6	-3.68	-4.54	-4.89	-6.27
30	Jumla	37.2	-4.74	-6.17	-5.14	-6.82
31	Kailali	36	-4.69	-6.04	-5.44	-7.01
32	Kalikot	36.4	-4.72	-6.09	-5.08	-6.72
33	Kanchanpur	35.8	-4.72	-5.78	-5.22	-6.75
34	Kapilbastu	36.5	-3.76	-4.45	-4.90	-6.52
35	Kaski	36.9	-4.22	-5.43	-5.06	-6.79
36	Kathmandu	36.6	-3.79	-4.39	-5.06	-6.69
37	Kavre	36.3	-3.58	-4.12	-4.98	-6.51
38	Khotang	36.3	-3.62	-4.42	-4.74	-6.16
39	Lalitpur	36.4	-3.40	-3.79	-4.90	-6.42
40	Lamjung	36.8	-4.25	-5.43	-4.88	-6.61
41	Mahottari	36.3	-3.55	-4.20	-4.85	-6.27
42	Makwanpur	36.7	-3.47	-3.93	-4.98	-6.51

43	Manang	37.7	-4.23	-5.50	-4.92	-6.63
44	Morang	36.4	-3.69	-4.55	-4.87	-6.27
45	Mugu	37.9	-4.76	-6.23	-5.23	-6.95
46	Mustang	37.9	-4.25	-5.53	-5.01	-6.73
47	Myagdi	36.8	-4.21	-5.42	-5.00	-6.70
48	Nawalpur	36.6	-3.66	-4.28	-5.03	-6.58
49	Nuwakot	36.7	-4.12	-4.95	-5.08	-6.82
50	Okhaldhunga	36.3	-3.64	-4.44	-4.83	-6.23
51	Palpa	36.5	-4.02	-4.83	-5.26	-6.92
52	Panchthar	36.6	-3.67	-4.50	-4.62	-6.02
53	Parasi	36.6	-3.66	-4.28	-5.03	-6.58
54	Parbat	37	-4.28	-5.39	-5.26	-7.03
55	Parsa	36.3	-3.39	-3.88	-4.87	-6.35
56	Pyuthan	36.3	-4.38	-5.62	-5.55	-7.29
57	Ramechhap	36.6	-3.76	-4.54	-4.80	-6.24
58	Rasuwa	36.9	-4.28	-5.35	-4.78	-6.42
59	Rautahat	36.1	-3.28	-3.67	-4.75	-6.15
60	Rolpa	36.4	-4.55	-5.94	-5.69	-7.42
61	Rupandehi	36.5	-3.57	-4.14	-4.95	-6.47
62	Salyan	36.4	-4.77	-6.11	-5.64	-7.37
63	Sankhuwasabha	36.9	-3.84	-4.66	-4.41	-5.85
64	Saptari	36.5	-3.63	-4.41	-4.87	-6.24
65	Sarlahi	36.3	-3.41	-3.88	-4.79	-6.22
66	Sindhuli	36.6	-3.63	-4.30	-4.92	-6.36
67	Sindhupalchok	36.5	-4.05	-4.89	-4.86	-6.43
68	Siraha	36.4	-3.60	-4.38	-4.86	-6.22
69	Solukhumbu	37	-3.89	-4.73	-4.34	-5.79
70	Sunsari	36.4	-3.69	-4.51	-4.89	-6.28
71	Surkhet	36.2	-4.72	-6.10	-5.58	-7.19
72	Syangja	36.9	-4.28	-5.27	-5.34	-7.11
73	Tanahu	36.8	-4.21	-5.12	-5.37	-7.10
74	Taplejung	37.1	-3.85	-4.68	-4.19	-5.60
75	Tehrathum	36.5	-3.67	-4.48	-4.66	-6.06
76	Udayapur	36.5	-3.66	-4.48	-4.89	-6.28
77	Western Rukum	36.6	-4.55	-5.90	-5.29	-6.98

4.4. Change in Cold nights (%) for districts of Nepal from the reference period (1981-2010)

S.N.	District Name	Reference Period (days)	RCP4.5		RCP8.5	
			2016-2045	2036-2065	2016-2045	2036-2065
1	Achham	36.7	-4.52	-5.80	-5.14	-7.04
2	Arghakhanchi	36.8	-4.38	-5.65	-4.58	-6.19
3	Baglung	37	-4.18	-5.17	-4.14	-5.88
4	Baitadi	36.5	-4.57	-5.75	-5.05	-6.96
5	Bajhang	35.9	-4.56	-5.63	-5.23	-7.06
6	Bajura	35.9	-4.54	-5.64	-5.31	-7.16
7	Banke	36.8	-4.72	-5.93	-5.57	-7.29
8	Bara	36.9	-3.28	-5.06	-4.55	-6.00
9	Bardiya	36.7	-4.67	-5.94	-5.33	-7.15
10	Bhaktapur	37.2	-3.88	-5.37	-4.72	-6.11
11	Bhojpur	37.4	-3.85	-5.28	-3.97	-5.41
12	Chitwan	36.9	-3.68	-5.42	-4.27	-5.81
13	Dadeldhura	36.6	-4.54	-5.78	-4.91	-6.80
14	Dailekh	36.9	-4.53	-5.82	-5.05	-6.94
15	Dang	36.8	-4.61	-5.84	-5.46	-7.13
16	Darchula	36	-4.61	-5.71	-5.07	-6.90
17	Dhading	37	-4.02	-5.42	-4.27	-5.84
18	Dhankuta	37.4	-3.80	-5.35	-3.81	-5.33
19	Dhanusa	37	-3.53	-4.93	-4.21	-5.73
20	Dolakha	37.1	-3.97	-5.11	-4.39	-5.66
21	Dolpa	36.9	-4.47	-5.49	-4.77	-6.49
22	Doti	36.4	-4.54	-5.76	-5.00	-6.86
23	Eastern Rukum	36.8	-4.64	-5.85	-5.22	-6.99
24	Gorkha	37.5	-4.15	-5.28	-4.07	-5.73
25	Gulmi	36.9	-4.07	-5.25	-4.01	-5.68
26	Humla	36.2	-4.77	-5.94	-5.16	-6.94
27	Ilam	37.3	-3.70	-5.40	-3.71	-5.40
28	Jajarkot	36.5	-4.55	-5.79	-5.23	-7.08
29	Jhapa	37	-3.58	-5.30	-3.47	-5.16
30	Jumla	36	-4.53	-5.70	-5.46	-7.27
31	Kailali	36.8	-4.56	-5.86	-5.01	-6.87
32	Kalikot	36.1	-4.51	-5.64	-5.31	-7.18
33	Kanchanpur	36.8	-4.52	-5.83	-4.86	-6.79
34	Kapilbastu	36.8	-3.88	-5.34	-4.44	-6.04
35	Kaski	37.6	-4.08	-5.08	-4.04	-5.77
36	Kathmandu	37	-4.02	-5.45	-4.69	-6.11
37	Kavre	37	-3.67	-5.27	-4.67	-6.05
38	Khotang	37.1	-3.76	-5.17	-3.80	-5.23
39	Lalitpur	37.2	-3.54	-5.23	-4.73	-6.09
40	Lamjung	37.5	-4.11	-5.18	-3.96	-5.67
41	Mahottari	37.1	-3.45	-5.01	-4.32	-5.83
42	Makwanpur	37.1	-3.46	-5.25	-4.63	-6.09

43	Manang	38.1	-4.17	-5.20	-4.32	-6.05
44	Morang	37	-3.68	-5.27	-3.60	-5.23
45	Mugu	36.1	-4.59	-5.76	-5.56	-7.28
46	Mustang	37.7	-4.16	-5.18	-4.15	-5.87
47	Myagdi	37.5	-4.11	-5.03	-4.04	-5.80
48	Nawalpur	36.7	-3.68	-5.37	-4.17	-5.72
49	Nuwakot	37.1	-3.99	-5.31	-4.41	-5.90
50	Okhaldhunga	37.1	-3.73	-5.16	-4.04	-5.46
51	Palpa	36.7	-3.98	-5.42	-4.06	-5.62
52	Panchthar	37.5	-3.76	-5.44	-3.89	-5.56
53	Parasi	36.7	-3.68	-5.37	-4.17	-5.72
54	Parbat	37.2	-3.93	-5.02	-3.84	-5.48
55	Parsa	36.9	-3.37	-5.20	-4.37	-5.92
56	Pyuthan	36.9	-4.68	-5.88	-5.04	-6.76
57	Ramechhap	37.3	-3.84	-5.23	-4.28	-5.68
58	Rasuwa	37.3	-4.17	-5.22	-4.09	-5.59
59	Rautahat	36.8	-3.28	-4.91	-4.40	-5.81
60	Rolpa	36.8	-4.67	-5.96	-5.42	-7.16
61	Rupandehi	36.5	-3.57	-5.29	-4.09	-5.62
62	Salyan	36.5	-4.59	-5.89	-5.33	-7.16
63	Sankhuwasabha	37.3	-4.00	-5.37	-4.35	-5.77
64	Saptari	36.8	-3.61	-4.94	-4.01	-5.53
65	Sarlahi	36.8	-3.37	-4.97	-4.41	-5.85
66	Sindhuli	37.1	-3.58	-5.12	-4.29	-5.73
67	Sindhupalchok	37.1	-4.15	-5.26	-4.37	-5.69
68	Siraha	36.9	-3.54	-4.85	-4.08	-5.59
69	Solukhumbu	37.2	-4.02	-5.18	-4.29	-5.57
70	Sunsari	36.8	-3.68	-5.08	-3.66	-5.14
71	Surkhet	36.9	-4.54	-5.85	-5.09	-6.97
72	Syangja	37.1	-3.93	-5.20	-3.90	-5.49
73	Tanahu	37.1	-3.97	-5.34	-4.01	-5.59
74	Taplejung	37.4	-3.94	-5.50	-4.22	-5.81
75	Tehrathum	37.6	-3.84	-5.47	-4.02	-5.66
76	Udayapur	36.7	-3.64	-5.03	-3.76	-5.20
77	Western Rukum	36.8	-4.64	-5.85	-5.22	-6.99

4.5. Change in Warm Spell Duration Index (WSDI) (%) for districts of Nepal from the reference period (1981-2010)

S.N.	District Name	Reference Period (days)	RCP4.5		RCP8.5	
			2016-2045	2036-2065	2016-2045	2036-2065
1	Achham	20.8	91.34	135.13	96.72	155.51
2	Arghakhanchi	19.9	104.03	139.49	147.26	211.94
3	Baglung	16.6	116.07	162.48	164.16	260.80
4	Baitadi	21.1	90.78	132.30	94.50	151.37
5	Bajhang	19.6	93.25	124.28	103.08	160.68
6	Bajura	19.1	97.22	128.98	116.03	173.89
7	Banke	23.1	75.24	110.89	92.38	149.88
8	Bara	17.7	113.11	145.85	194.67	268.03
9	Bardiya	23.1	73.86	107.61	92.91	150.01
10	Bhaktapur	15.5	124.65	157.84	246.15	337.93
11	Bhojpur	13.1	157.66	208.51	194.32	368.55
12	Chitwan	17.2	122.33	154.18	245.54	324.59
13	Dadeldhura	21.5	86.36	126.29	97.90	155.68
14	Dailekh	20.8	91.07	135.11	95.86	154.81
15	Dang	22.3	85.43	122.38	103.04	160.82
16	Darchula	19.9	91.13	123.10	108.69	166.41
17	Dhading	15.8	126.78	166.34	204.87	305.00
18	Dhankuta	13.3	174.59	231.34	241.53	388.39
19	Dhanusa	17.1	108.10	135.55	204.16	279.84
20	Dolakha	14.5	121.04	165.66	226.55	344.10
21	Dolpa	17.3	96.46	126.47	96.08	166.03
22	Doti	20.9	91.91	135.78	97.22	156.36
23	Eastern Rukum	18.7	101.93	140.24	113.70	178.73
24	Gorkha	15.7	109.27	148.42	157.65	250.70
25	Gulmi	17.8	115.28	154.97	165.78	250.38
26	Humla	20	85.48	112.66	103.26	165.03
27	Ilam	13	169.74	238.94	278.50	429.77
28	Jajarkot	19.6	99.07	138.07	103.54	162.80
29	Jhapa	14.3	148.86	200.82	228.62	341.28
30	Jumla	18.9	98.99	129.66	108.96	168.39
31	Kailali	22.4	78.10	114.57	95.38	151.96
32	Kalikot	19.4	99.37	134.99	108.11	165.24
33	Kanchanpur	23.1	74.53	105.19	89.69	140.08
34	Kapilbastu	21	92.12	122.19	136.94	190.37
35	Kaski	15.5	113.84	158.29	188.67	288.92
36	Kathmandu	15.5	128.35	162.18	232.21	326.28
37	Kavre	15.3	131.29	164.52	247.17	334.42
38	Khotang	13.7	147.12	192.87	196.06	343.54
39	Lalitpur	15.2	127.79	157.12	241.42	328.55
40	Lamjung	15.4	118.53	166.06	189.83	297.34
41	Mahottari	17.5	106.65	134.68	174.57	244.16
42	Makwanpur	16	127.05	159.72	196.03	284.33

43	Manang	15.4	97.89	129.02	138.57	214.31
44	Morang	15	144.70	194.86	219.01	334.83
45	Mugu	19	94.85	122.43	90.28	151.55
46	Mustang	15.8	97.66	127.93	112.41	189.22
47	Myagdi	16.1	104.59	143.98	151.03	237.18
48	Nawalpur	17.9	116.31	146.88	267.83	340.29
49	Nuwakot	15.5	129.83	171.54	226.27	321.76
50	Okhaldhunga	14.8	129.30	170.51	226.67	337.89
51	Palpa	18.2	117.87	147.61	227.52	303.92
52	Panchthar	12.7	171.94	245.52	257.75	449.49
53	Parasi	17.9	116.31	146.88	267.83	340.29
54	Parbat	16.5	119.79	167.32	192.05	292.87
55	Parsa	18	113.81	146.23	269.77	337.50
56	Pyuthan	19.7	100.21	141.95	121.21	195.59
57	Ramechhap	15	121.95	162.90	229.41	335.91
58	Rasuwa	14.7	104.86	150.58	167.29	274.85
59	Rautahat	17.5	113.97	145.88	170.94	238.11
60	Rolpa	19.4	102.89	148.92	104.66	178.20
61	Rupandehi	19.3	105.50	132.94	193.91	257.38
62	Salyan	21.4	86.34	129.53	97.38	163.28
63	Sankhuwasabha	13.5	147.87	207.53	195.18	384.45
64	Saptari	16.2	116.89	153.27	213.97	302.86
65	Sarlahi	17.2	113.38	144.41	179.74	248.32
66	Sindhuli	15.7	122.63	158.99	213.83	301.27
67	Sindhupalchok	15.1	120.27	165.18	236.89	343.72
68	Siraha	16.7	109.45	141.91	210.79	292.37
69	Solukhumbu	14.7	121.08	165.67	177.01	302.34
70	Sunsari	15.1	137.65	181.28	211.23	320.63
71	Surkhet	21.5	85.95	128.45	96.15	157.08
72	Syangja	17.2	121.05	160.04	201.96	291.28
73	Tanahu	16.9	125.66	163.82	217.15	305.11
74	Taplejung	13	144.06	210.40	175.38	387.15
75	Tehrathum	13.1	175.89	246.28	258.83	439.13
76	Udayapur	14.8	139.32	183.65	231.07	338.28
77	Western Rukum	18.7	101.93	140.24	113.70	178.73

4.6. Change in Cold Spell Duration Index (CSDI) (%) for districts of Nepal from the reference period (1981-2010)

S.N.	District Name	Reference Period (days)	RCP4.5		RCP8.5	
			2016-2045	2036-2065	2016-2045	2036-2065
1	Achham	21.8	-60.00	-67.17	-61.38	-80.23
2	Arghakhanchi	21.2	-52.57	-63.46	-63.93	-81.69
3	Baglung	19.8	-51.40	-62.12	-49.87	-70.09
4	Baitadi	21.2	-59.93	-67.64	-70.83	-90.75
5	Bajhang	19.8	-60.14	-68.04	-72.72	-92.16
6	Bajura	20.1	-60.21	-68.03	-72.51	-91.73
7	Banke	22.6	-63.29	-69.15	-76.82	-91.33
8	Bara	21.8	-44.68	-62.44	-57.82	-75.37
9	Bardiya	22.6	-62.71	-69.58	-72.44	-89.71
10	Bhaktapur	20.5	-48.10	-60.97	-66.21	-84.82
11	Bhojpur	19.4	-44.60	-60.40	-43.07	-59.48
12	Chitwan	20.8	-47.45	-64.48	-61.72	-80.39
13	Dadeldhura	21.5	-59.92	-67.40	-61.97	-81.18
14	Dailekh	21.8	-59.78	-67.15	-61.02	-79.82
15	Dang	22.9	-59.18	-67.45	-75.19	-90.20
16	Darchula	19.7	-60.57	-68.57	-72.68	-92.06
17	Dhading	19	-50.06	-63.70	-58.27	-77.15
18	Dhankuta	20.2	-44.82	-62.11	-23.09	-37.59
19	Dhanusa	21	-41.57	-57.25	-24.63	-41.52
20	Dolakha	19.9	-44.68	-56.36	-49.78	-66.11
21	Dolpa	20	-53.88	-63.12	-58.60	-78.55
22	Doti	21.5	-60.06	-67.56	-62.63	-81.60
23	Eastern Rukum	21.8	-55.81	-65.90	-61.34	-80.08
24	Gorkha	17.9	-49.78	-62.27	-46.87	-67.12
25	Gulmi	20.2	-49.32	-62.21	-53.66	-73.24
26	Humla	19.4	-62.35	-71.07	-74.43	-92.72
27	Ilam	19.4	-43.26	-63.71	-7.41	-22.08
28	Jajarkot	21	-58.60	-67.91	-64.22	-83.62
29	Jhapa	20	-42.64	-63.48	-2.95	-17.59
30	Jumla	20.5	-57.89	-68.10	-71.93	-90.84
31	Kailali	22	-61.50	-68.44	-67.75	-86.58
32	Kalikot	20.6	-59.56	-67.63	-68.90	-88.30
33	Kanchanpur	21.7	-61.13	-68.16	-66.22	-86.47
34	Kapilbastu	22.4	-49.95	-63.44	-63.38	-82.23
35	Kaski	18.8	-48.89	-60.59	-49.84	-70.92
36	Kathmandu	19.9	-48.85	-61.75	-65.36	-84.10
37	Kavre	20.5	-43.99	-61.03	-66.03	-82.87
38	Khotang	19.3	-43.42	-59.81	-46.78	-63.54
39	Lalitpur	20.1	-43.94	-61.09	-65.72	-83.42
40	Lamjung	18.3	-48.41	-61.37	-56.11	-76.25
41	Mahottari	21.3	-41.06	-58.44	-18.47	-35.78
42	Makwanpur	20.9	-45.59	-62.80	-64.41	-81.91

43	Manang	17.9	-50.58	-61.23	-56.25	-77.23
44	Morang	20.5	-43.74	-62.34	-11.51	-25.15
45	Mugu	20.8	-57.87	-67.42	-72.53	-91.29
46	Mustang	18.2	-49.69	-60.60	-50.86	-71.68
47	Myagdi	19.4	-49.33	-59.61	-47.55	-68.38
48	Nawalpur	20.6	-47.16	-63.70	-61.89	-80.44
49	Nuwakot	19.3	-48.29	-60.49	-60.22	-79.07
50	Okhaldhunga	19.4	-42.80	-59.18	-46.13	-62.37
51	Palpa	19.9	-47.46	-62.57	-54.77	-73.49
52	Panchthar	19.4	-43.73	-63.65	-13.36	-27.40
53	Parasi	20.6	-47.16	-63.70	-61.89	-80.44
54	Parbat	19	-47.70	-60.76	-46.25	-66.60
55	Parsa	21.6	-45.44	-63.48	-58.49	-77.69
56	Pyuthan	22	-56.36	-66.23	-66.75	-84.60
57	Ramechhap	20.2	-44.30	-59.29	-50.23	-66.38
58	Rasuwa	17.3	-50.00	-61.64	-46.84	-64.80
59	Rautahat	21.1	-42.90	-60.22	-40.32	-58.10
60	Rolpa	22.3	-56.34	-67.51	-66.17	-84.27
61	Rupandehi	21.2	-47.10	-63.82	-61.43	-80.19
62	Salyan	22	-60.94	-69.88	-72.04	-89.67
63	Sankhuwasabha	19.5	-47.38	-61.35	-38.77	-54.07
64	Saptari	20.5	-42.36	-57.90	4.22	-10.62
65	Sarlahi	20.6	-42.63	-59.58	-41.98	-62.07
66	Sindhuli	20.9	-41.91	-58.95	-38.99	-54.26
67	Sindhupalchok	19.8	-48.88	-60.13	-54.67	-71.49
68	Siraha	20.5	-41.87	-56.81	-4.57	-20.83
69	Solukhumbu	18.4	-45.52	-58.08	-57.13	-76.70
70	Sunsari	20.4	-42.75	-59.57	-17.52	-31.71
71	Surkhet	21.8	-60.76	-68.01	-63.02	-81.08
72	Syangja	19.2	-46.90	-61.41	-45.85	-66.11
73	Tanahu	19.6	-47.33	-62.31	-59.94	-79.20
74	Taplejung	17.9	-45.60	-63.65	-62.07	-81.20
75	Tehrathum	19.8	-45.57	-63.74	-24.83	-39.49
76	Udayapur	19.8	-42.36	-58.60	-28.43	-43.72
77	Western Rukum	21.8	-55.81	-65.90	-61.34	-80.08

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